

Radcal Corporation
®

XLPRO Version 4.10

Add-In for Excel

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4071281 Rev: 4.10, Nov 2010

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Introduction

Radcal's Radiation Monitors are joined with Excel, Microsoft Windows' spreadsheet program, to transform your Radiation Monitor and computer into an integrated data-capture and report-generation system. Radcal's add-in provides two-way communication through your computer's Universal Serial Bus (USB) to the 9010, 9015, 9095, 9096, 4083, 4085, 4086 or 2086 Radiation Monitors. The 9096 is called the "Accu-Pro"; the 4085 version 5.20 or greater (4086) is the "Accu-kV"; the 2086 is the "Accu-Dose". Functions are provided to control the basic operation of the Radiation Monitor in *Rate*, *Max-Rate*, *Dose*, *Last-Dose*, *Pulse*, *Pulsed-Radiation* and *kVp* measurement modes, with an additional capability to customize the output for your particular application. XLPRO is available while you are using Excel; it actually becomes a part of Excel with its own menu of commands. Once XLPRO is open, all of the power of Excel is available, including statistics, graphics and macros written in Visible Basic for Applications. Macros may be used to automate access to the Radiation Monitor and to facilitate data entry and processing.

Note: This program only operates properly when the specified locale is English (United States). In the Windows Start menu, select Settings, Control Panel and then choose English (United States) as your locale under Regional Settings (or Options). A valid Rainbow Technologies Sentinel SuperPro key must be plugged into one of your USB ports in order for the program to communicate with the Radiation Monitor.

Overview of XLPRO

*Note: This version of XLPRO has significant differences compared to versions of 9000XL prior to 2.00. THOSE FAMILIAR WITH SUCH OLDER VERSIONS ARE STRONGLY ADVISED TO READ THE SECTIONS OF THE INCLUDED MANUAL ENTITLED **The Settings Area AND Appendix B: Waveforms** BEFORE TRYING TO USE THIS VERSION. The old Get Reset Data, Initialize Worksheet and Reload Worksheet commands have been replaced with the Modify Settings Area, Update Settings Area and Copy or Move Settings Area commands. Some kVp modes now contain graphs and spectral information on the ripple. This version upgrades version 4.06 of XLPRO and also supports the 9096, 4086 and 2086 instruments.*

As is generally true for Microsoft Excel, data and the results of calculations are placed into "worksheets", one or more of which are grouped into a "workbook". Each workbook has a file name for access from the Windows operating system and must be stored in an appropriate "folder" (directory). Workbooks derived from 9000PXL.xlt, 9096PXL.xlt, 4085PXL.xls or the Sample Templates, which are delivered with XLPRO, contain a worksheet named "Settings", together with one or more operational worksheets with user-defined names. These operational worksheets will store the data that result from making measurements with the Radiation Monitor under the control of XLPRO. Each operational worksheet must contain a "Settings Area", which is a 30-row by 3-column area at a user-selected location, that specifies the details of the interface to the instrument. Executing one of the XLPRO commands generates the Settings Area as a copy of the Settings Area of the Settings sheet, and the Settings Area remains a permanent part of the operational worksheet even after Excel closes.

The operational worksheet can be as simple as a normal Excel worksheet with an added Settings Area or as complicated as a user-customized template containing multiple places for data entry and the results of numerous calculations involving these entries, including graphical outputs. (See the worksheets named Radiographic, Special or Mobile in 9095 Sample Template.xls for typical templates with multiple inputs and outputs.) One of the advantages of XLPRO is your ability to use the power of Microsoft Excel to organize and process the results of radiation measurements using the supported Radiation Monitors. However, for simple data-collection applications no involved templates are required, and the results of radiation measurements can be placed at user-selected positions in a normal Excel worksheet. Only your imagination limits this flexibility.

Once XLPRO has been installed on your computer with a valid key and the instrument has been connected to a USB port, operating your instrument from XLPRO is a simple menu-driven procedure. When you open a worksheet with a Settings Area (or open the Settings sheet), XLPRO loads automatically, and the menu item *XLPRO* appears between the *Window* and *Help* menu items on the standard Excel menu bar. Various commands in this menu permit you to generate, modify or move the Settings Area, as well as to perform the measurements that your instrument supports.

Note: The 4083/5/6 do not support ion-chamber measurements; the 2086 has no kV-related outputs. Other instruments may provide both kinds of measurements.

When you execute one of these measurement commands with a valid SuperPro key plugged into one of your Universal Serial Bus (USB) ports, XLPRO first establishes communication with the instrument over the USB and then instructs it to perform the commanded measurement. At this time you should expose the appropriate sensor to the desired type of radiation. The instrument then transmits the results of this exposure back to XLPRO, which places them on the worksheet at a location based on the cell selected just before issuing the measurement command. Some measurements will require multiple cells for data output, whereas sometimes only a single cell is needed. XLPRO can convert the units for the dose-related results to any of the usual radiation and time units based on parameters in the Settings Area.

Note: XLPRO will not communicate with the instrument if a valid SuperPro key is not plugged into one of your USB ports at the time that a measurement command is issued.

Guide to this manual

Note: This manual assumes a working knowledge of Microsoft Excel and Microsoft Windows.

The manual begins with the installation of XLPRO software and the connection of your computer to a Radcal Radiation Monitor. Under the **Starting XLPRO** subsection of the **Installation** section, we describe how to obtain the *XLPRO* menu item, as well as summarizing under **The XLPRO menu and SuperPro key** subsection the commands accessible through this menu and the need to use the SuperPro key properly. The subsection **Turning the instrument on and off** concerns the effects of cycling power on the instrument and the query: “Do you want to keep auto activation?”, which appears when you close a workbook.

The section entitled **The Settings Area** generally describes the Settings Area and under the subsection **Creation of the Settings Area** tells you how to create a Settings Area on an operational worksheet from a Settings sheet or how to move an existing Settings Area. The **Modification of the Settings Area** subsection describes how to modify an existing Settings Area using the *Settings Area Values* user form and also describes essential modifications of the Settings Area in order to establish communication with the instrument. Finally the subsection **How to create a Settings Area in an existing workbook** is primarily intended for users who have workbooks that were designed to operate with versions of 9000XL prior to 2.00 and instructs them on modifications needed to be compatible with this version of XLPRO.

*Note: Both the **Installation** section and **The Settings Area** section contain brief descriptions of their relevant topics. They then refer to various appendices for more detailed descriptions. The user who wishes a detailed understanding of XLPRO is encouraged to read these appendices.*

The section entitled **Tutorial** leads you through making measurements in all modes except those modes with waveforms, which are handled in **Appendix B**. A sample of the tutorial process is in the sheet named TEST in 9000 Sample Template.xls. The TEST button on the instrument produced all inputs except for the kVp modes for the 9010 or 9015, where the Accu-kV simulator is also required to generate a kV waveform.

The **Glossary** section defines various terms that are peculiar to XLPRO and provides a partial index to related terms and appendices.

Appendix A describes the XLPRO error messages and actions to be taken if they appear.

Appendix B is a tutorial for the modes with waveforms. Typical examples from the 9010 are in the sheet named Waveforms in 9000 Sample Template.xls; 9095 examples are in 9095 Sample Template.xls. Also described are the **Erase Data command** and the **Area Clear command**.

Appendix C provides a detailed description of the commands accessible from the *XLPRO* menu. These commands are grouped as **Measurement operations**, **Utility commands** and **Settings Area commands**. Also described is the *Settings Area Values* user form, which operates in conjunction with the *Modify Settings Area* command. The *kVp Mode* user form is described under **Spreadsheet Operation and kV Mode** as a part of the *Settings Area Values* user form.

Appendix D concerns using XLPRO with a Keithley 35080 kV divider as an input to a 9010/9015 instrument.

Appendix E relates to the three sample templates in 9000 Sample Template.xls (or in 9095 Sample Template.xls). Under the subsection **Macros** are described a macro to modify the Settings Area and another one to prompt for possible deletion of auto activation when the workbook closes. Detailed descriptions of the three templates are given in the workbook.

Appendix F describes how to control XLPRO through Excel macros interface using Visual Basic for Applications. The available commands and methods to change the Settings Area are covered.

Appendix G deals with backward compatibility with templates written in the old Excel Macro-4 language. **Note the requirement to save old templates in the format of your version of Excel.**

Appendix H concerns limitations on the name of the installation folder, particularly if a workbook contains macros written in the old Excel Macro-4 language. There is also a discussion of the necessary linking to 9000Macro.xls if an operating workbook is copied to a folder other than the installation folder. If the required linking is lost, you will get the Microsoft Excel error message: “Cannot find ‘pathname\9000XLMacro.xls’!InitS.”. **Note the warning about overwriting old versions of 9000XL in C:\9000XL.**

Appendix I relates to the auto-activation feature of XLPRO when an operational worksheet is opened and to methods of removing this feature based on the query: “Do you want to keep auto activation?” when the workbook is closed.

Appendix J summarizes the algorithm for calculating the Fourier-Transform-based kVp and the practical kV for the 9010/9015. (For the 9095/9096/4083/4085/4086 the instrument itself performs these calculations and transmits their results to XLPRO.) The appendix includes a discussion of various parameters required for ripple determination and their definition in the Settings sheet. The subsection **Bandwidth-correction parameters** deals with the need to switch some parameter values between the 4081 version of the Accu-kV and later 4082 versions and does not apply to later instruments. The subsection **Pulse-width considerations** discusses the required waveform width for accurate ripple determination, and the **Pulse-width measurement** subsection defines the technique and parameters for this measurement. These capabilities are not available in the Standard Edition of 9000XL-Version 2.11, which does not support the later instruments.

Installation

System requirements

IBM-PC compatible laptop or desktop personal computer with a Universal Serial Bus
VGA graphics
Graphics-capable printer
Microsoft Windows 98 SE, 2000, XP, Vista, or Windows 7
Microsoft Excel 97 or later
Radcal Radiation Monitor 9010/15 (firmware 2.1 or later), 9095/6, 4083/5/6 or 2086

Installing the XLPRO software and sample worksheets

Note: The software installation uses Microsoft's Windows Installer Service, which is standard in Windows 2000. If your operating system has not yet been upgraded to use Windows Installer Service, this upgrade will first run automatically at the time of installation.

Note: The following installation actually installs three programs - namely, XLPRO as well as the drivers for the instrument's USB interface and for the SuperPro protection key. Remove any USB connections associated with these drivers during installation.

1. Insert the CD-ROM with XLPRO-USB software. This version 4.10 will overwrite version 4.06. If you also want version 3.15, reload it after installing version 4.10.
2. If a dialog does not display "Welcome to the InstallShield Wizard for Radcal XLPRO-USB", find *setup.exe* on the CD-ROM root directory and launch it.
3. Click on *Next*. The installation then proceeds to the *Sentinel Protection Installer 7.3.2*. When this installation completes, click *OK* in the dialog entitled *Sentinel Protection Installer 7.3.2 Setup completed successfully*.
4. In the *Select Destination Folder* dialog in the case of new template files, use either C:\Program Files\Radcal\XLPRO-USB\ as given in the dialog or any name allowed by the Windows operating system. For old template files using Excel-4 macros, use C:\9000XL\ and see Appendix H of the detailed manual. Click on *Next*.
5. The next dialog permits you to avoid installing the shortcuts and files that are related to instrument types that you are not using. Choose amongst 9096, 9095, 2086, 4083, 4085 and 9000 for any undesired types, click on the associated button and select *This feature will not be available* to avoid installing this instrument type. The default selection is *This feature will be installed on local hard drive*. For the 4086 use the 4085 selection. Click on *Next*, and then click on *Install*.
6. Follow the on-screen prompts to complete the installation.

7. Plug the instrument and the SuperPro key that was delivered with your CD-ROM into your USB ports. Different instrument types may require different keys. The plug-and-play feature will automatically associate these devices with their drivers.

Note: The setup file can also be downloaded into a temporary folder. Double left clicking on setup.exe launches the Wizard to install XLPRO; after the installation it can be deleted.

Note: If you have already installed XLPRO with a version number of 2.0 or above, the Wizard may require you to remove it before installing a new revision. In this case perform this uninstall and then install the new version. You do not need to uninstall RadcalRadiationMonitor Driver Set or Sentinel Protection Installer 7.3.2.

Installed-file descriptions

Note: The basic templates can be the starting point for user-customized worksheets.

A single setup.exe file distributes the software. When this file is executed, it causes the following files to be added to the installation folder if all instrument types are installed:

Readme.txt	Installation notes and procedure
9000XLMacro.xls	Main macro file for XLPRO
9000XL.xlm	Macro-4 file as a bridge to versions of 9000XL before 2.00
9000XLold.xlm	Version 1.20a of 9000XL in Macro-4 language
9000PXL.xlt	Basic template for XLPRO with 9010 or 9015
9000 Sample Template.xls	Examples of 9010 custom templates and tutorial outputs
9096PXL.xlt	Basic template for XLPRO with 9096
9095PXL.xlt	Basic template for XLPRO with 9095
9095 Sample Template.xls	Examples of 9095 custom templates and typical outputs
9096 Sample Template.xls	Examples of 9096 custom templates
4085PXL.xlt	Basic template for XLPRO with 4085
4085 Sample Template.xls	Example of 4085 custom template and typical waveforms
4083PXL.xlt	Basic template for XLPRO with 4083
4083 Sample Template.xls	Example of 4085 custom template and typical waveforms
2086PXL.xlt	Basic template for XLPRO with 2086

The following files are placed in the Manuals sub-folder:

XLPROManual.pdf	This full XLPRO manual in Adobe Acrobat format
XLPROInstallation.pdf	Installation notes in Adobe Acrobat format
Enable Macros.doc	How to enable macros in Excel 2007 and Excel 2010

The following files are added to the Windows System folder:

9000XL4.dll	Interface functions to the instrument
DETKVP.dll	Routines to process kV waveforms

The installation of the USB drivers also adds files to the Windows System folder. Copies of their installation files are in the Sentinel SuperPro and USB Drivers sub-folders.

Connecting the instrument to a computer

For the 9095-version 4.15 and later and the 9096/4085/4086/2086 instruments, which support a direct USB interface, just connect the USB cable between the computer and the instrument. For other instruments, connect the USB-to-serial adapter to the computer's USB and connect the instrument's RS-232 connector directly to the adapter or use the supplied cable. The Model 8301 has a 9-pin female connector on the adapter end and a 9-pin male connector on the instrument end. Then turn on your Radiation Monitor, and wait for the instrument's self-test to complete.

Uninstalling

The Windows *Add/Remove Programs* utility in the *Control Panel* can be used to uninstall XLPRO-USB and its USB drivers. These programs are listed separately as *Radcal XLPRO_USB*, *RadcalRadiationMonitor Driver Set* and *Sentinel Protection Installer 7.3.2*. They can be uninstalled independently of each other. You also can uninstall XLPRO from *Start, Programs, Radcal Corporation, Uninstall XLPRO-USB*.

Starting XLPRO

Double left clicking on either the *XLPRO9096* desktop icon or *XLPRO9096* listed in *Programs, Radcal Corporation* as part of the *Start* menu will open a copy of 9096PXL.xlt in Excel and launch the XLPRO program. (Use *XLPRO9000* to obtain 9000PXL.xlt for the 9000, or *XLPRO4085* to get 4085PXL.xlt for the 4085/4086, or *XLPRO2086* to get 2086PXL.xlt for the 2086.) Alternatively, you can navigate with Windows Explorer to the folder containing a workbook that has been set up to operate with XLPRO and double left click on its file name.

During the loading process you may be asked by Excel twice if you want to enable macros. Answer *Enable Macros* to both prompts. After the first prompt, 9000XLMacro.xls loads for a noticeable time, and then, after the second prompt, the additional menu item labeled *XLPRO* appears between the *Window* and *Help* menu items on the standard Excel menu bar. If the automatic loading and running of the macros in 9000XLMacro.xls are objectionable, possibly because of error messages when XLPRO is not available, see **Appendix I: Eliminating Auto Activation**. Under *Tools, Macro, Security* do NOT set the *Security Level* higher than *Medium*. Enabling macros in Excel 2007 and Excel 2010 (Windows XP, Windows Vista or Windows 7) is a little more complicated - see *Enable Macros.doc* on the CD and in the *Manuals* sub-folder.

If you wish to rename the workbook and save it, select *File* on the Excel menu bar, followed by *Save As*, browse to the desired folder for the workbook and give it a new name; then click *Save*.

Note: Be careful to rename any file with an .xls extension if you do not want to overwrite the old file when Excel closes or when you perform the File, Save function in Excel.

The XLPRO menu and SuperPro key

Put the mouse pointer on the XLPRO menu item and left click once, or press ALT-X on the keyboard. The menu items that will appear are *Measure Rate*, *Measure Max Rate*, *Measure Dose*, *Measure Last Dose*, *Measure Pulse*, *Measure Pulsed Radiation*, *Measure kVp*, *Set Auto Zero*, *Clear Auto Zero*, *Erase Data*, *Area Clear*, *Release Comm Link*, *Modify Settings Area*, *Update Settings Area*, *Copy or Move Settings Area*, and *Hide or Unhide Settings Sheet*. Most of these commands have accelerator keys, which are underlined, and they also can be activated directly from the keyboard with CONTROL-SHIFT plus the letter to the right of the command. See **Appendix C: XLPRO Menu & User Forms** for a detailed explanation of these commands.

Measure Rate, *Measure Max Rate*, *Measure Dose*, *Measure Last Dose*, *Measure Pulse*, *Measure Pulsed Radiation* and *Measure kVp* are the measurement modes. (See **Tutorial** below.) Only these measurement functions require the instrument to be connected and turned on, and an appropriate radiation exposure of its sensor should follow them in order to obtain measurement results. *Set Auto Zero* and *Clear Auto Zero* control the auto-zero function in the instrument for low-level ion-chamber measurements. The 4083 does not support any dose-related measurements. For the 4085/4086, dose or relative-dose-rate measurements occur as a part of *Measure kVp*. The 2086 does not support *Measure kVp*.

When you try to execute the first measurement command after opening the workbook, a three-line title window appears. The third line gives the status of the protection key. If you purchased XLPRO and plugged the delivered SuperPro key into one of your USB ports or used the key for a valid demonstration copy of the software, the third line will contain *Serial No: nnnnn* or *DEMO S/N: nnnnn*, respectively, where nnnnn is the serial number of the key, and the command will execute. Otherwise the command will not execute and one of the following status lines appears:

KEY ERROR 3 – you forgot to plug in the key

INVALID KEY S/N: nnnnn – you used an invalid key

DEMO OVER S/N: nnnnn – your demonstration copy has expired

If later you remove the key or the demonstration copy expires, you will get Error Message 25: *Invalid key or expired demo*. If you try to execute a measurement command again without a valid key or if you have executed the *Release Comm Link* command just prior to the measurement command, the title window will reappear with the appropriate status line.

Erase Data and *Area Clear* are used to reduce or eliminate large amounts of data associated with instrument waveforms. (See **Appendix B: Waveforms**.) *Release Comm Link* clears the USB connection and restores the 9096, 9095, 2086, 4085 and 4086 to their earlier states. *Modify Settings Area*, *Update Settings Area*, *Copy or Move Settings Area* and *Hide or Unhide Settings Sheet* provide or modify the Settings Area or Settings sheet. The Settings Area on an operational worksheet controls the performance of XLPRO. See **The Settings Area** below.

As with Excel without XLPRO installed, cursor movement in the worksheet is accomplished with either the mouse or the keyboard while *Ready* is present on the Excel status bar at the bottom of the screen. A valid key is not required to manipulate Excel worksheets.

Turning the instrument on and off

Whenever XLPRO first accesses the instrument from an operational worksheet as a result of executing a measurement command, a reset function puts the instrument into a known state. If power is then cycled on a 9010 or a 9015, the state may revert to an earlier one, and strange results can appear for later measurements. To force a new reset after cycling power, either change the worksheet to another one set up to run XLPRO or execute the *Release Comm Link* command from the XLPRO menu before performing a measurement. For the 9096/9095/4085/4086/2086 at this stage manual control is locked out, preventing power cycling without first executing *Release Comm Link* and restoring the prior operating state.

If XLPRO has accessed a 9000-series instrument after any execution of the *Release Comm Link* command, closing Excel will turn it off. For the 9010/9015 some, but not all, user settings will be restored when its power is turned on again; the 9096, 9095, 2086, 4085 and 4086 restore all settings. When you close Excel or a workbook derived from one of the template files, the query: “Do you want to keep auto activation?” appears. See **Appendix I: Eliminating Auto Activation**; generally you should answer *Yes*.

The Settings Area

Description

The Settings Area, referenced by its top-left cell named `_RCTL`, is a 30-row by 3-column area of each operational worksheet for the storage of parameters that relate to communication with the instrument, its operating mode and the format of the data written to the worksheet. This area must be created in all new operational worksheets using the *Copy or Move Settings Area* command prior to attempting to communicate with the instrument. You may place the Settings Area in any blank region of the worksheet by selecting its top-left cell before executing the *Copy or Move Settings Area* command, which also can move the Settings Area to a new blank location within a worksheet. **Do not add or delete rows or columns within an existing Settings Area.**

Note: The instrument does not have to be turned on if all that you want to do is create, update, move or modify the Settings Area. Only executing measurement commands requires an operating instrument and a valid SuperPro key.

Creation of the Settings Area

In order to prepare a new operational worksheet for use with XLPRO, a Settings Area must be created on that sheet. Once a Settings Area has been created, it remains a part of the sheet unless manually deleted, and it need not be recreated every time that the sheet is used. However, it can be modified as described below, as well as moved to different locations, but the operational settings never change themselves, even after closing and reopening Excel or using the Settings Area of other worksheets. Only the local Settings Area controls XLPRO for a given worksheet, without regard to any other Settings Areas within the workbook.

Workbooks based on new templates (9096PXL.xlt, 9095PXL.xlt, 9000PXL.xlt, 2086PXL.xlt or 4085PXL.xlt) contain a sheet labeled Settings. (Old-template workbooks do not have a Settings sheet but already have a Settings Area installed. See also **How to create a Settings Area in an existing workbook.**) The Settings sheet contains the default Settings Area, which can be copied to individual operational worksheets in the same workbook but does not otherwise control XLPRO. This default Settings Area may be modified with the *Modify Settings Area* function.

Note: The Settings Area and Settings sheet for the various instrument types differ from each other. As described below, you can use the Modify Settings Area command to switch between instrument types, but it is easier to base your templates on the “.xlt” file for the instrument that you are using.

To prepare a new operational worksheet, first open or create a fresh sheet in a workbook with a Settings sheet. Select the top-left cell for the Settings Area, and execute the *Copy or Move Settings Area* command. Now the Settings Area from the Settings sheet of this workbook will appear in the selected location. The *Modify Settings Area* command can then be used to modify this local Settings Area, and the *Copy or Move Settings Area* command now ignores the Settings sheet (except for corrupt local Settings Areas) and only moves the local Settings Area. If the area

where the Settings Area is to be copied or moved is not blank, you will be asked if you want to overwrite a 30-row by 3-column area; answer *OK* to do so. If you answer *Cancel* or the Settings sheet was selected, nothing further happens. An uncorrupted old Settings Area is disregarded.

Modification of the Settings Area

*Note: Although the contents of the cells in the Settings Area can be edited directly in Excel, this procedure is not recommended, because apparently-small discrepancies in syntax or format may cause XLPRO not to recognize the entry. With proper care, macros can write to the Settings Area. (See **Appendix F: Macro Programming**.)*

The *Modify Settings Area* command allows the Settings Area for the active worksheet to be modified. Executing the command displays a user form labeled *Settings Area Values* with several differently-colored areas for input, usually containing selectable option buttons. The current choices in the local Settings Area are also the selections in the displayed user form. Changing these selections and then clicking *OK* (or pressing ENTER) will modify the associated Settings Area to correspond to the new selections and reset the instrument at the next measurement command. Clicking *Cancel* (or pressing ESCAPE) will cause your changes to be ignored.

The major divisions of the user form are *Measurement Units and Pulsed-Radiation Mode*, *Spreadsheet Operation and kV Mode*, *kV Spreadsheet Parameters*, *Atmospheric Corrections* and *Device Index*. The meanings of the various selections are described in **Appendix C: XLPRO Menu & User Forms**. However, in order to establish communication with the instrument before making a measurement, you must properly select the instrument type. Under *kV Spreadsheet Parameters* the box labeled *Scale/Instrument Selection* contains a list of 14 devices for measuring kV. Select 9096, 9095, 2086, 4085 or 4083 for a 9096, 9095, 2086, 4085 (including 4086) or 4083, respectively. Otherwise select a different one to refer to the 9010/9015 and its kV sensor. The wrong selection produces a warning when trying to communicate.

If you have only one Radcal device connected to your USB, you can ignore the selection under *Device Index*; a value of 0 will be automatically used. Otherwise you must enter the index between 0 and 9 of the particular device that you want to address. If the instrument type that is defined in the Settings Area does not match the one addressed by your choice of index, XLPRO will attempt to find the smallest index that produces such a match. For multiple devices of the same type on the USB, you will need to observe which instrument responds to XLPRO in order to choose the correct index. If you accept an index, its value is entered to the right of *Device Index* in the local Settings Area, and this index is used henceforth.

Note: The user form has no selection choices for baud rate, because XLPRO automatically tries all default baud rates, including 9,600 and 19,200 for the 9010/9015, where firmware versions 3.27 and later support 19,200 baud. If you did not select one of these values in setting up your 9010/9015, you can type your selected value into the cell to the right of Baud: in the Settings Area. When communication is established to the 9010/9015, XLPRO writes the successful baud rate into the Settings Area. The later instruments use fixed baud rates, and there is no baud entry.

How to create a Settings Area in an existing workbook

If your existing workbook contains a Settings sheet, just follow the procedure under **Creation of the Settings Area**. Otherwise there are two methods to add a Settings sheet to a workbook without one. If your workbook does not contain internal macros (in contrast to using a macro workbook), then it is easiest to copy the sheets in your workbook into a renamed version of 9000PXL.xlt, 9095PXL.xlt, 9096PXL.xlt, 2086PXL.xlt or 4085PXL.xlt. Alternatively you can copy the Settings sheet and its macros from one of these template files into your workbook.

Copying your worksheets into a renamed template

Note: The following process does NOT copy any Visual Basic macros that may have been a part of your workbook. You must copy them manually into the .xlt file as described below BEFORE overwriting the original workbook. It is safest to keep a copy of that workbook.

If you are using a 9010 or a 9015, double click on the *XLPRO9000* desktop icon to open 9000PXL.xlt, and enable the macros to open 9000XLMacro.xls in Excel. (For the other instruments use their icon to open the appropriate template.) Then open your existing workbook using the *File, Open* function in Excel and select the cell on the sheet where you wish to place the upper-left corner of the Settings Area. Execute the *Copy or Move Settings Area* command.

The query: “No Settings sheet in this workbook. Look for one in an open workbook?” should appear. Answer *OK*. If you used one of the template files above, Excel will ask you if you want to delete permanently the blank sheet that is now activated. If you do not want this extra blank sheet, answer *OK* or *Delete*; otherwise answer *Cancel*, and the sheet name becomes *Template*. You will then be returned to your originally-selected cell for the Settings Area in your workbook now with a Settings sheet, and Excel will ask you if you want to replace the original file with the new one. Responding with *No* or *Cancel* produces the message: “Closing file without changes and aborting.”; then answer *OK* to clear Excel. If you responded with *Yes*, the new version with a Settings Area and Settings sheet will overwrite the original file, and the modified workbook remains open in Excel.

A Settings sheet now exists in your new workbook, and you can follow the procedure under **Creation of the Settings Area** to generate a Settings Area on any other sheet. Be sure to save your new workbook to preserve any further changes.

Copying a Settings sheet into your workbook from a template file

Double click on the desktop icon for your instrument type to open its template, and enable the macros to open 9000XLMacro.xls in Excel, which will also rename the template file. Now open your existing workbook using the *File, Open* function in Excel, and rename it using *File, Save As* if you do not want it to be overwritten. Then return to the renamed template by selecting its name under *Window* on the Excel menu bar.

Right click on the name of the Settings sheet in the renamed template. In the dialog box, select *Move or copy* and check *Create a copy*. In the *To book:* drop-down list find and select the name

of your revised workbook. In the *Before sheet*: drop-down list select the position at which you want to place the Settings sheet in the revised workbook. Click *OK*. The Settings sheet should now appear in your revised workbook at your selected position, and you can follow the procedure under **Creation of the Settings Area** to generate a Settings Area on any sheet in the workbook.

Note: The following procedure also can be used to copy any Visual Basic macros in your original workbook to one of the .xlt files by interchanging the references to “renamed template” and “revised workbook”; Auto-Close now refers to one of your macros.

If you wish to implement the deletion of the *Auto_Activate* command as described in **Appendix I: Eliminating Auto Activation**, you must copy the *Auto_Close* macro from the renamed template to your revised workbook. To do this, return to the renamed template by selecting it under *Window* on the Excel menu bar. Then select *Tools* on the menu bar, and proceed with *Macro, Macros*, and select *Auto_Close*, followed by *Edit*. (Be sure to select the *Auto_Close* macro that is not preceded by a file name such as *9000XLMacro.xls*.) On the Visual Basic Editor menu bar, select *Edit*, followed by *Select All* and then *Copy*. Return to the Settings sheet of your revised workbook, and use *Tools, Macro, Macros* to obtain the *Macro* dialog box. If your revised workbook contains macros, select one of them, click *Edit* to open the code listing, move the cursor to the end of the list, and select *Paste* under *Edit*; the *Auto_Close* macro should appear at the end of the list. Return to a sheet of your revised workbook.

Note: If your workbook already contains an Auto_Close subroutine, you must copy the code from the Auto_Close macro in the renamed template into this existing subroutine, being sure to delete any extra Auto_Close() and End Sub statements.

If your existing workbook does not contain any macros, you must create a code module by using *Tools, Macro, Macros* to obtain the *Macro* dialog box, enter *s* in the *Macro name:* box, select *Create* to open the newly-created code module, move the cursor to its end, and select *Paste* under *Edit*. After the *Auto_Close* macro appears at the end of the module, select *Sub s()* through *End Sub* and press DELETE on the keyboard to remove the unused subroutine. Return to a sheet of your revised workbook.

Be sure to save your revised workbook in the proper folder.

Tutorial

Preparing for your first measurement

This section assumes that you have completed the steps in **Installation** and have a 6-cc ion chamber connected to a 9000-series instrument. Its TEST button can simulate exposures that will be put into the worksheet. The sheet *TEST* in *9000 Sample Template.xls* illustrates the results from performing this tutorial on a 9010; the 9095/6/2086 give similar results for ion-chamber-related measurements, whereas the 4083/5/6 make no ion-chamber-related measurements.

Note: The 9095/6, 4083/5/6, 2086 lock out all manual operation whenever XLPRO has control. No ion-chamber measurements occur without an ion chamber present.

Double left click on the *XLPRO9000* desktop icon to open *9000PXL.xlt*, and also enable macros to open *9000XLMacro.xls* in Excel. Click on *File* on the Excel menu bar and select *Save As*. Enter *TEST.XLS* in the *File name:* box, and check that the *Save in:* entry represents the desired folder (or browse to find that folder). Then click *Save* to rename and save the workbook.

Now left click on the *Sheet1* tab at the bottom of the screen. (If you right click on this tab, a dialog box will appear to allow you to rename this sheet.) Select cell A1 in the top-left corner of the blank sheet, and press ALT-X to open the XLPRO menu. Left click on *Copy or Move Settings Area* to generate a Settings Area with its top-left corner in the selected cell A1. Now move the cursor to cell E1 with the arrow keys or the mouse. This worksheet is now prepared to accept XLPRO data. Ensure that the instrument is turned on and past self-test.

Note: Instead of ALT-X and a selection letter that is not case sensitive, CTRL-R, CTRL-M, CTRL-D, CTRL-L, CTRL-P, CTRL-N and CTRL-K can be used to execute the XLPRO main menu functions of Rate, Max Rate, Dose, Last Dose, Pulse, Pulsed Radiation and kVp without accessing the XLPRO menu. The capital letters imply that in this case you must press the SHIFT key as well as the CONTROL key with the selection letters.

Example of Rate mode

Open the XLPRO menu with the key combination ALT-X or by clicking once on XLPRO on the menu bar. Press R (or r) to select *Measure Rate* mode. Notice that the word “Ready” in the bottom-left corner of the Excel display changes to “Waiting for instrument to be ready” and then to “Capturing data . . . use esc key to terminate.” Soon thereafter cell E1 will contain a number and cell F1 will contain R/min. Press and hold the TEST button. The number in the cells below E1 will increase to some stable value which is near the normal reading that you see on the instrument’s display when you press the TEST button. Release the TEST button and the reading will return to near zero. Press Esc(ape) to capture the rate at a given moment and to exit *Measure Rate* mode.

Because the Settings Area parameter *Operating Mode - Cell Update* is set to *Incremental*, each updated reading appears in a new cell directly below E1. The incrementing of the reading into the

next cell down continues until you terminate the measurement mode by pressing Esc(ape). If the Settings Area parameter were set to *Overwrite*, the updated reading would stay in cell E1.

Note: The number displayed by the 9000-series instrument and the number displayed on the computer screen may not match exactly. The difference arises from the fact that the instrument does not perform a correction for the effects of temperature and pressure on an unsealed ion chamber. However, because the XLPRO default Atmospheric Corrections parameter is set to Automatic, XLPRO will correct the reading from the instrument for temperature and pressure (temperature only if no pressure transducer is installed), unless you selected Uncorrected for Atmospheric Corrections - Temperature and Pressure in the Settings Area. Correction is to a standard pressure and temperature of 101.3 kPa and 295.15 K (22 °C) respectively.

Example of Max Rate mode

Select cell G1, open the XLPRO menu with the key combination ALT-X and press M to select *Measure Max Rate* mode. Notice that the word “Ready” in the bottom-left corner of the Excel display changes to “Waiting for instrument to be ready” and then to “Capturing data . . . use esc key to terminate.” Soon thereafter cell G1 contains a small number and cell H1 contains R/min. Briefly press the TEST button. A larger reading will appear in the cell below G1 with the units in the cell below H1. Press the TEST button again for a slightly longer time. The display will update with the higher peak rate that the instrument sees, with the data cell continuing to move downward in column G. Press the TEST button very briefly. There will be no change in the displayed value, because the peak rate did not exceed the last captured value. Press and hold the TEST button. The numbers in column G will increase to some maximum value and stabilize. This represents the maximum output rate of the TEST button. Release the TEST button; the peak rate will remain on both the computer display and the instrument’s incrementing display. Press Esc(ape) to stop data collection in *Measure Max Rate* mode.

If the Settings Area *Operating Mode - Cell Update* parameter were set to *Overwrite*, the updated readings would stay in cell G1.

Example of Dose mode

Select cell I1, open the XLPRO menu with the key combination ALT-X and press D to select *Measure Dose* mode. Notice that the word “Ready” in the bottom-left corner of the Excel display changes to “Waiting for instrument to be ready” and then to “Capturing data . . . use esc key to terminate.” Soon thereafter cell I1 contains a number and cell J1 contains R. Press and hold the TEST button. The reading in the cells of column I will begin to increase. At each update of the instrument’s display you will see an update of the number in column I. Release the TEST button and the reading will stop increasing. Press and hold the TEST button again. The number in column I will again begin to increase. Press Esc(ape) to stop data collection in *Measure Dose* mode.

If the Settings Area *Operating Mode - Cell Update* parameter were set to *Overwrite*, the updated readings would stay in cell I1.

Example of Last Dose mode

Select cell K1, open the XLPRO menu with the key combination ALT-X and press L to select *Measure Last Dose* mode. Notice that the word “Ready” in the bottom-left corner of the Excel display changes to “Waiting for instrument to be ready” and then to “Capturing data . . . use esc key to terminate.” Soon thereafter a dialog box titled *Trigger Data Capture* will appear. Cell K1 now contains a number near zero and cell L1 contains R. Press and hold the TEST button. While still holding the TEST button down, click *OK* on the dialog box or press ENTER on the keyboard. The reading will change to the instantaneous integrated dose value at the time you clicked *OK*, and the dialog box will be reactivated with the next cell in column K selected. At each clicking of *OK* in the dialog box, the number in column K will be updated and the selection will advance one row. Release the TEST button, then click *OK* to update the displayed value. Clicking *OK* after this last update will cause no increase in the displayed values. Press Esc(ape) to stop data collection in *Measure Last Dose* mode.

If the Settings Area *Operating Mode - Cell Update* parameter were set to *Overwrite*, the updated readings would stay in cell K1.

Example of Pulse mode

Select cell M1, open the XLPRO menu with the key combination ALT-X and press P to select *Measure Pulse* mode. Notice that the word “Ready” in the bottom-left corner of the Excel display changes to “Waiting for instrument to be ready” and then to “Capturing data . . . use esc key to terminate.” Nothing changes in M1 now, because the instrument has been set into pulse mode and is waiting for an input large enough to trigger its pulse circuits. Briefly press the TEST button. After a slight pause the value of the exposure will appear in cell M1 and with R in N1. Notice that the “Capturing data . . . use esc key to terminate” message still appears. In the Settings Area the *Operating Mode* parameter *Capture Mode* is set to *Auto* as the default, and XLPRO has kept the instrument in the pulse mode waiting for another pulse. Briefly press the TEST button again. The new data are entered in the next row down. Press Esc(ape) to exit the *Measure Pulse* mode.

If the Settings Area *Operating Mode - Cell Update* parameter were set to *Overwrite*, the updated readings would stay in cell M1. If the *Capture Mode* were set to *Manual*, the *Pulse* mode would exit after the first measurement.

Pulse-width output (9096/2086 only)

The 9096 and 2086 can provide values of both dose per pulse and its width. The *Dose* and *Width* check boxes in the *Settings Area Values* user form under *Auto-Dose Outputs* allow the user to select one or both of these outputs. If both outputs were selected in the above example, the pulse width would appear in cell O1 with its units of ms or s in cell P1.

Example of *Pulsed Radiation* mode

Select cell O1, open the XLPRO menu with the key combination ALT-X and press S. In the *Measurement Units and Pulsed-Radiation Mode* section of the *Settings Area Values* form, select /pulse for *Time* units and *micro* for *Scale*, and then click *OK* to enter these choices. To simulate operation, press and hold the TEST button throughout the following procedure.

The operation of the 9000-series instruments and XLPRO in the *Measure Pulsed Radiation* mode depends on the version number of your instrument's firmware. This version number is shown in the Settings Area after any measurement operation under *Monitor Configuration - ROM Ver.* Find your version number and then follow the appropriate section below.

Versions prior to 3.23 (9010/9015)

Note: In earlier versions of XLPRO this mode was referred to as the Cine mode. All properties of the Cine mode, including frame rate, are set by the user in the instrument's Setup menu. Only one such setting is permitted. The Cine mode does not continually update.

Reopen the XLPRO main menu with the key combination ALT-X and press N. Notice that the word "Ready" in the bottom-left corner of the Excel display changes to "Waiting for instrument to be ready" and then to "Capturing data . . . use esc key to terminate." Soon thereafter if the TEST button was continuously depressed, a number will appear in cell O1 after a brief interval and $\mu\text{R/pls}$ will appear in cell P1. "Ready" will then return to the status bar as the *Measure Pulsed Radiation* mode exits with the selected data cell incrementing by one row. Now release the TEST button. Press Esc(ape) to exit the *Measure Pulsed Radiation* (Cine) mode before completion.

If the *Capture Mode* had been set to *Manual* instead of *Auto*, start an exposure and execute the *Measure Pulsed Radiation* (Cine) command in the same manner as above. After the *Trigger Data Capture* dialog box appears, press ENTER on the keyboard (or click *OK*) to capture the data and exit this mode. If the Settings Area *Operating Mode - Cell Update* parameter were set to *Overwrite*, the updated readings would stay in cells O1 and P1.

Note: These pulsed-radiation outputs are the dose rate divided by the frame rate, which is shown to the right of Pulse Rate in the Settings Area.

Versions 3.23 through 3.99 (9010/9015)

Note: These versions of the firmware allow six preset parameter sets that the user has entered into the instrument's Setup menu. These parameter sets include the expected pulse rate, as well as "exposure threshold", "delay" and "acquire", and are indexed from 0 to 5. Dose is accumulated during a time corresponding to an integral number of pulses and then converted to dose per pulse by dividing by the pulse rate. (See the 9000-series Operator's Manual.) The output continuously updates until Esc(ape) is pressed.

In the *Settings Area Values* user form select the index for the desired parameter set by opening the drop-down list box under *Pulse Rate/Index* in the *Measurement Units and Pulsed-Radiation*

Mode section. The entries 0, 0.25 and 0.5 will select index 0, whereas entries 1 through 5 select the same-numbered index; any higher value selects index 5. Click *OK* to enter your choice.

The rest of the operation of XLPRO is similar to that of earlier versions, except that the value of the preset pulse rate will appear in the Settings Area to the right of *Units*, with the selected index followed by *Index* to the right of *Pulse Rate*. Esc(ape) is required to exit this mode.

Versions 4.0 and later (9095/9096/2086)

Note: These versions do not have preset pulse rates or exposure thresholds but use the values from lists stored in XLPRO and accessible through the Settings Area Values user form. The acquire delay and acquire interval in pulses can be entered through this user form.

In the *Settings Area Values* user form select the pulse rate from the drop-down list box under *Pulse Rate/Index* in the *Measurement Units and Pulsed-Radiation Mode* section. Similarly select an exposure threshold, and enter the desired acquire delay and acquire interval in pulses. Click *OK* to record your choice. The operation of XLPRO from this point forward is the same as that for versions 3.23-3.99, with the values of the entered parameters appearing in the above order separated by hyphens in the Settings Area to the right of *Pulse Rate*; nothing appears after *Units*.

Versions 4.10 and later, 2086 and 9096 support the value of zero for the pulse rate. For this selection the instrument will determine the rate from the dose waveform for rates below 16 pulses per second and place the measured result in the column to the right of the dose-rate measurement.

Example of brief *kVp* modes for the 9010 and 9015

Note: These examples require that a C-OPT Analog Signal Capture board be installed in your 9010/9015 Radiation Monitor and that an Accu-kV or its simulator be connected to the Analog In banana plugs. (See the 9000-series Operator's Manual for more details.)

These *kVp* modes encompass brief and full modes, each of which has a *Fluoro* sub-mode, and their output depends on check boxes under *kV Spreadsheet Parameters - Configuration*. The brief modes, which enter a single row of data into the worksheet, are further divided into *Brief*, *Peak* and *Practical*, depending on the method of calculating the *kVp* from the *kV* waveform. The *Brief* mode uses the value from the 9010/9015 for *kVp*, whereas the *Peak* mode derives *kVp* from a Fourier Transform of part of the *kV* waveform. The *Practical* mode computes a weighted average of the entire *kV* waveform with weighting toward higher-*kV* values. (See **Appendix J: FT and Practical *kV* Algorithms**.) The full modes, which enter multiple rows of data into the worksheet, include graphs of the *kV* waveform and its frequency spectrum. This portion of the tutorial covers only the brief modes. See **Appendix B: Waveforms** for a description of the full modes and **Brief *kVp* modes for the 9096/9095/4083/4085/4086** for these instruments.

Select cell Q1, open the XLPRO menu with the key combination ALT-X and press S. In the *Measurement Units and Pulsed-Radiation Mode* section of the *Settings Area Values* user form, select /min for *Time* units and 1 for *Scale*. Under *kVp Mode* in the *Spreadsheet Operation and kV Mode* section select *Brief* (or *Peak* or *Practical*). (The check boxes for *Dental-ms*, *Dental-pulses*

and *Waveforms* are greyed out, because they apply only to the 9096, 9095, 4086, 4085 and 4083 instruments.) Click *OK* to enter these choices, reopen the XLPRO menu with the key combination ALT-X, and press K to execute the *Measure kVp* command.

Note: For the kVp Mode selection you may choose Prompt, which causes a dialog box to appear when you execute the Measure kVp command to ask you to select a kVp mode.

Brief mode

When you execute the *Measure kVp* command, “Ready” in the bottom-left corner of the Excel display changes to “Waiting for instrument to be ready” and then to “Capturing data . . . use esc key to terminate.” Nothing happens in Q1 immediately, because the instrument is waiting for an input large enough to trigger its pulse circuits. After the arrow appears on the instrument’s display, make a brief exposure with the x-ray machine or trigger the kV-waveform simulator. After a slight pause, the dose, duration and kVp with their units appear in the six cells Q1 through V1, and the data row advances. Press Esc(ape) to exit.

If the Settings Area *Operating Mode - Cell Update* parameter were set to *Overwrite*, the updated readings would stay in cells Q1 through V1. If the *Capture Mode* were set to *Manual* instead of *Auto*, the *kVp* mode would exit after the first measurement.

Note: If not all of Dose, Time and kVp were checked under kV Spreadsheet Parameters - Configuration, then only those functions checked produce outputs in row 1 starting with cell Q1. At least one must be checked to avoid an error message. Units for pulse duration (Time) are always milliseconds. The instrument always provides Dose and Time values.

Brief-Fluoro mode

Open the XLPRO menu with the key combination ALT-X and press S. Under *kVp Mode* in the *Spreadsheet Operation and kV Mode* section check *Fluoro*. Then click *OK*, reopen the XLPRO menu with the key combination ALT-X, and press K to execute the *Measure kVp* command. Notice “Ready” has again eventually changed to “Capturing data . . . use esc key to terminate.” Immediately the instrument will begin sending data to the worksheet in the form of a rate number in cell Q2 and a kVp number in cell S2, and the data row will then advance. Make a continuous exposure with the x-ray machine or the waveform simulator. During the exposure press Esc(ape) on the computer keyboard. The data capture will end, and the rate and kVp at the time Esc(ape) was pressed will be left as the last display.

If the Settings Area *Operating Mode - Cell Update* parameter were set to *Overwrite*, the updated readings would stay in cells Q2 through T2. If the *Capture Mode* were set to *Manual* instead of *Auto*, the *kVp* mode would exit after the first measurement.

Note: If not both Dose and kVp were checked under kV Spreadsheet Parameters - Configuration, then only those functions actually checked will produce outputs in row 2 starting with cell Q2. At least one must be checked to avoid an error message. Time is greyed out, because a width measurement is not made for fluoro operation.

Peak and Practical modes

These additional brief modes operate in the same fashion as the *Brief* mode above, except for the method of computing the kV output. The displayed units distinguish these modes, both of which have “ms-9000” for their width units. The kV units for the *Practical* mode are “kV-Prac.” and for the *Peak* (Fourier Transform) mode are “kVp-FTn”, where n is 0, 1 or 2 as described under **Bandwidth-correction parameters in Appendix J: FT and Practical kV Algorithms**. For the *Brief* mode, the units are just “ms” and “kVp”, whereas in the full kVp modes the first row uses “ms-9000” and “kVp-9000” to indicate instrument outputs for width and kVp. The kV units in the full kVp modes are the same as the brief *Practical* and *Peak* modes above for the outputs from the Practical and Fourier Transform algorithms.

Brief kVp modes for the 9096/9095/4083/4085/4086

These instruments also have brief and full kVp modes, which have the optional sub-modes of *Fluoro*, *Dental-ms* or *Dental-pulses* as selected from check boxes under *Spreadsheet Operation and kV Mode - kVp Mode*. The brief modes, which enter a single row of up to 10 cells of data into the worksheet, are further divided into *Peak* and *Practical*, depending on the instrument's method of calculating the kVp output from the kV waveform. The *Peak*, *Full* and *Brief* modes derive kVp from the Fourier Transform of a 100-ms section of the kV waveform, whereas the *Practical* mode computes a biased average of the same part of the waveform. (See **Appendix J: FT and Practical kV Algorithms**.) The full modes, which enter multiple rows of data into the worksheet, include graphs of the kV waveform and its frequency spectrum and also for the 9095/6, 4085/6 of (relative) dose rate and mA. This portion of the tutorial covers only the brief modes. See **Appendix B: Waveforms** for a description of the full modes and the *Full* check box.

Note: The 9095/6 and 4083/5/6 have no full Fluoro mode; they have only the brief Fluoro mode. If Fluoro is checked, the Waveforms and Full check boxes are always greyed out.

For these instruments, the choice between the full and brief modes results from selections under *kV Spreadsheet Parameters - Waveforms* in the *Settings Area Values* user form. The brief modes only occur if no box is checked in this section, which results automatically from checking the *Brief* box and thus selecting for the 9096/9095/4085/4086 the brief *Peak* mode. The boxes labeled *Full* and *Brief* are greyed out for the 4083, because they do not apply to it.

The entries in the single row of data for the brief modes depend on the selections under *kV Spreadsheet Parameters - Configuration* in the user form. The box *Conv Dose*, which applies to the 9095/9096, usually causes dose to arise from the dose converter; it is greyed out for the 4083/4085. The boxes *kV Dose* and *Rel Dose*, which apply to the 9096/4085/4086, cause dose to come from the kV sensor; they are greyed out for the 9095/4083. For *kV Dose* the energy-compensated, calibrated diode provides the dose output; for *Rel Dose* it is relative dose rate from the kV detectors, which is also the 9095 *Conv Dose* output if no ion chamber is present. Both boxes cannot be checked simultaneously. If the *Fluoro* box is checked for the 9096, checking any of *Conv Dose*, *kV Dose* or *Rel Dose* causes dose to come from the dose converter if it is present; otherwise dose arises from the diode when *kV Dose* is checked and as relative dose rate for other selections.

If an mAs probe is connected to the 9096/9095/4085/4086, one of the outputs is the measured mAs if the *mAs* box is checked. Only the 9096, 9095, 4086 and 4085 support the mAs probe, and this box is greyed out for the 4083 or for no mAs probe present.

Except for the 4083, the *Dental* sub-modes use one of the eight intensity thresholds indexed under *Spreadsheet Operation and kV Mode - Dental Threshold* in the *Settings Area Values* user form; index 0 refers to the normal pulse-mode threshold, index 1 uses 10 times this threshold, and each subsequent index increases the threshold by a further factor of 2 to 2.5. *Dental-ms* displays pulse width in milliseconds, whereas *Dental-pulses* displays the number of pulses in the waveform, usually at the line frequency. For the 4083, the user sets the dental threshold in the instrument itself and must use its *DENTAL* pushbutton to enter the dental mode. The number of pulses is only displayed for average pulse-repetition rates between 45 and 66 Hz.

This section of the user form has an input for *Filtration (mm)* to enter beam filtration in mm of Al (>1 mm) or Cu (<1 mm); for the 9096 and 4085 versions after 5.11 *Auto* causes the instrument to measure this filtration for diagnostic sensors. This value corrects the kV for filtration deviations from 2.5 mm of Al, in which case an F (or A for *Auto*) appears in the lower-left corner of the instrument display. No filtration correction is applied to the mammographic sensors or the 4083.

The outputs on the brief row are in the same order as the *Configuration* column, and omitted selections do not cause blank spaces. Measurement units are provided unless *Omit* was selected under *Spreadsheet Operation and kV Mode - Units Display*. The 4083 has two potential outputs, whereas the 4085/9095 have four. If only one dose source is selected for the 9096, it too has a maximum of four outputs. With units displayed the number of required cells is twice these values.

The 9096 can output dose from both the dose converter and the kV sensor. If the units of the two dose outputs are totally identical, which selecting *Rescale* or *Omit* under *Spreadsheet Operation and kV Mode - Units Display* assures, the ratio of the kV-sensor dose to the converter dose replaces the second set of dose units or follows the second dose value for omitted units. Thus the dual-dose case can use as many as six cells for omitted units and ten cells with displayed units.

For general operation of the 9096/9095/4083/4085/4086 brief modes see **Example of brief kVp modes for the 9010 and 9015**. Do not expose the sensor to x-rays if you see W in the lower-left corner of the instrument display.

Glossary: XLPRO Terms

ACQUIRE DELAY

Delay in pulses to start averaging the output in the pulsed-radiation mode of versions 3.23 and later. For 9010/9015 defined as a preset parameter. For 9095 enter in the *Acquire delay (pulses)* box in the *Measurement Units and Pulsed-Radiation Mode* section of the *Settings Area Values* user form. See **Example of Pulsed Radiation mode** under **Tutorial**.

ACQUIRE INTERVAL

Width in pulses for averaging the output in the pulsed-radiation mode of versions 3.23 and later. For 9010/9015 defined as a preset parameter. For 9095/9096/2086 enter in the *Acquire interval (pulses)* box in the *Measurement Units and Pulsed-Radiation Mode* section of the *Settings Area Values* user form. See **Example of Pulsed Radiation mode** under **Tutorial**.

AREA CLEAR

Deletes all the data produced by the full-kVp mode, including all Excel charts and pictures. Select the light-green cell. Prompts for *OK*. Access at the XLPRO menu.

AUTO

Repetitive data capture for *Pulse* and *kVp* modes, where the instrument keeps providing data to the worksheet until escape is pressed. For the *Pulsed Radiation* mode, inhibits the *Trigger Data Capture* dialog box and causes immediate data capture. Change under *Spreadsheet Operation - Capture Mode* of the *Settings Area Values* user form. See *Manual and Capture Mode*.

AUTO ACTIVATION

Causes XLPRO to load and run automatically when a worksheet with a recorded Settings Area is opened. See **Appendix I: Eliminating Auto Activation** to remove this feature.

AUTOMATIC

Enables automatic temperature and pressure corrections to the instrument readings. Select under *Atmospheric Corrections - Temperature and Pressure* of the *Settings Area Values* user form. See *Settings Area Values* user form in **Appendix C: XLPRO Menu & User Forms** and *Fixed*.

BAUD RATE

Displays successful baud rate when communication to the instrument is established. User may manually enter trial values to the right of *Baud* under *Comm* in the Settings Area. 9010/9015 only.

BRIEF-FLUORO kVp MODES

Comprise *Brief*, *Peak* and *Practical* with *Fluoro* checked, which creates a single-row, 1- to 6-column capture of kVp Fluoro data in the worksheet, comprising kVp and/or dose rate and/or average mA depending on the selections in *kV Spreadsheet Parameters - Configuration* of the *Settings Area Values* user form. Select under *kVp Mode* in the *Spreadsheet Operation and kV Mode* section of the *Settings Area Values* user form or in response to the *kVp Mode* dialog box.

BRIEF kVp MODES

Comprise *Brief*, *Peak* and *Practical* with *Fluoro* not checked, which creates a single-row, 1- to 8-column capture of kVp Pulse data in the worksheet, comprising kVp and/or duration and/or dose and/or mAs depending on the selections in *kV Spreadsheet Parameters - Configuration* of the *Settings Area Values* user form. Select under *kVp Mode* in the *Spreadsheet Operation and kV Mode* section of the *Settings Area Values* user form or in response to the *kVp Mode* dialog box.

CAPTURE MODE

Select *Auto* (default) or *Manual* under *Spreadsheet Operation - Capture Mode* of the *Settings Area Values* user form. See *Manual* and *Auto*.

CELL UPDATE

Allows selection of *Incremental* or *Overwrite* for data captured into the worksheet by XLPRO. Change under *Spreadsheet Operation - Cell Update* in the *Settings Area Values* user form.

CONFIGURATION

Data-capture selections in brief kVp modes as various combinations of *Dose*, *Time*, *kVp* and *mAs*. At least one value must be selected for brief modes. Data is written to the worksheet from left to right with a separate column for the numeric value and the units designator. For example, the option *Dose+Time+kVp* would require six columns across for the three numeric values and the three unit designators. Change with check boxes under *kV Spreadsheet Parameters - Configuration* in the *Settings Area Values* user form.

COPY OR MOVE SETTINGS AREA

Will put the top-left corner of the Settings Area at the current cursor location. If a Settings Area does not exist on this worksheet, copies the Settings Area from the Settings sheet to the specified location. If a Settings Area does exist, then moves it to the new location. Nothing happens if you used the Settings sheet or the 30-row by 3-column required area is not blank, except for the old Settings Area. Access at the XLPRO menu.

DEMO OVER S/N

Status line showed that the demo key expired. See **The XLPRO menu and SuperPro key**.

DEMO S/N

Status line showed that SuperPro key is demo type. See **The XLPRO menu and SuperPro key**.

DENTAL kVp MODES

Raise the trigger threshold for intensity to reject pre-heat pulses. Check *Dental-ms* or *Dental-pulses* under *Spreadsheet Operation and kV Mode - kVp Mode* in the *Settings Area Values* user form. See **Brief kVp modes for the 9096/9095/4083/4085/4086** under **Tutorial**.

DENTAL THRESHOLD

For the 9095/6 and 4085/6, index to the raised trigger threshold for intensity used in the Dental kVp modes. Select in *Dental Threshold* list box under *Spreadsheet Operation and kV Mode* in the *Settings Area Values* user form. See **Tutorial - Brief kVp modes for the 9096/9095/4083/4085/4086**.

DEVICE INDEX

Select an index from 0 to 9 to address a particular USB device; ignored if only one device is present. Change in *Device Index* section of the *Settings Area Values* user form.

DISABLED

See Low Sensitivity and **Measurement operations** in **Appendix C**.

DOSE, MEASURE

Dose-mode data capture. Begins data capture at location of cursor. Subsequent reading will either *Overwrite* previous readings at the location of the cursor or *Incremental* down one cell in the cursor column for each update of the display. Pressing Esc(ape) stops data capture. Access at the XLPRO menu. See Cell Update.

ENABLED

When *Enabled* is displayed, the instrument's measurement is corrected for low-level current offsets which were measured and stored during the running of the Auto-Zero function. See the instrument's Operator's Manual for a detailed description of the High-Sensitivity (Auto-Zero) function and its use. See High Sensitivity and **Measurement operations** in **Appendix C**.

ERASE DATA

Removes the column data produced by the full-kVp mode and replaces its Excel charts with fixed-content pictures. Select light-green cell. Prompts for *OK*. Access at the XLPRO menu.

EXPOSURE THRESHOLD

Index to threshold to start exposure for the pulsed-radiation mode for versions 3.23 and later. For 9010/9015 defined as a preset parameter. For 9096/9095 set in the *Exposure Threshold* list box in the *Measurement Units and Pulsed-Radiation Mode* section of the *Settings Area Values* user form. See **Example of Pulsed Radiation mode** under **Tutorial**.

FILTRATION

For the 9095/6 and 4085/6, entry to correct measured kV for beam filtration in mm of Al or Cu. Set in *Filtration (mm-Al)* list box under *Spreadsheet Operation and kV Mode* in the *Settings Area Values* user form. See **Tutorial - Brief kVp modes for the 9096/9095/4083/4085/4086**.

FIXED

Correct dose readings to 101.3 kPa and 295.15 K (22 C) for user-set temperature and pressure. Input fixed temperature and pressure at the *Measured/Set* entry boxes in the *Atmospheric Corrections* section of the *Settings Area Values* user form. See Automatic and Uncorrected.

FULL-FLUORO kVp MODE

For the 9010/9015 only, creates a 4-column, multiple-row capture of kV fluoro data. Number of rows depends on pulse duration with a maximum of 5466. The first row is the same as the brief-kVp modes. See **Appendix B: Waveforms** for other header and waveform details, as well as method to enable full-kVp modes. Check the *Fluoro* box under *kVp Mode* in the *Spreadsheet Operation and kV Mode* section of the *Settings Area Values* user form or in response to the *kVp Mode* dialog box.

FULL kVp MODE

Creates a 6- to 10-column, multiple-row capture of kV data. Number of rows and columns differ between 9010/15 and 9095/6, 4083/5/6 and depend on pulse duration. Maximum number of rows is 32006. For the 9010/9015 the first row duplicates the brief-kVp modes. See **Appendix B: Waveforms** for other header and waveform details, as well as method to enable full-kVp modes. Do not check the *Fluoro* box under *kVp Mode* in the *Spreadsheet Operation and kV Mode* section of the *Settings Area Values* user form or in response to the *kVp Mode* dialog box.

HIGH SENSITIVITY

Allows selection of *Enabled* for the High-Sensitivity (Auto-Zero) function when making measurements. See the instrument's Operator's Manual for detailed description of the High-Sensitivity (Auto-Zero) function. Command in the XLPRO menu, which is greyed out if Auto-Zero is already enabled. See Low Sensitivity and **Measurement operations** in **Appendix C**.

INCREMENTAL

Updates are stepped to the next row below the previous cursor position. Change under *Cell Update* in the *Operating Mode* section of the *Settings Area Values* user form. See Cell Update.

INVALID KEY S/N

Status line indicated that SuperPro key is not valid. See **The XLPRO menu and SuperPro key**.

KEY ERROR

Status line indicated that SuperPro key failed. See **The XLPRO menu and SuperPro key**.

kVp, MEASURE

kVp-mode data capture. See Brief kVp Modes, Brief-Fluoro kVp Modes, Dental kVp Modes, Full kVp Mode and Full-Fluoro kVp Mode. If *Prompt* is chosen under *Spreadsheet Operation and kV Mode - kVp Mode* in the *Settings Area Values* user form, a dialog box prompts for the selection of *Full*, *Brief*, *Peak* or *Practical*, with a check boxes to select *Fluoro*, *Dental-ms* or *Dental-pulses*, when the command is executed. See **Example of brief kVp modes for the 9010 and 9015** and **Brief kVp modes for the 9096/9095/4083/4085/4086** under **Tutorial** and **Appendix B: Waveforms**. For the 9010/9015 this measurement requires the C-OPT and a kV measuring device connected to the Analog In banana jacks. Access at the XLPRO menu.

LAST DOSE, MEASURE

Data capture for the total-dose mode. After dose is begun, each selection of *OK* in the *Trigger Data Capture* dialog box updates the worksheet cell with the total dose at that instant. Access at the XLPRO menu.

LOW SENSITIVITY

Allows selection of *Disabled* for the High-Sensitivity (Auto-Zero) function when making measurements. See the instrument's Operator's Manual for a detailed description of the Auto-Zero function. Command in XLPRO menu, which is greyed out if High-Sensitivity (Auto-Zero) is already disabled. See High Sensitivity and **Measurement operations** in **Appendix C**.

MANUAL

Single-measurement capture mode. The instrument outputs data to the worksheet and then XLPRO exits the measurement mode. Change under *Spreadsheet Operation - Capture Mode* of the *Settings Area Values* user form. See Auto and Capture Mode.

MAX RATE, MEASURE

Data capture for the peak-rate mode. Begins data output at location of cursor and keeps updating when maximum increases until Esc(ape) is pressed. Access at the XLPRO menu.

MEASURED/SET

When *Fixed* is selected in *Atmospheric Corrections - Temperature and Pressure*, the values of temperature and pressure entered here are used to correct the dose readings for temperature and pressure. Enter in the *Measured/Set* boxes in the *Atmospheric Corrections* section of the *Settings Area Values* user form. See Fixed.

MODIFY SETTINGS AREA

Modifies the Settings Area of the active worksheet. Displays the *Settings Area Values* user form with five differently-colored areas for input, usually containing selectable option buttons. The current choices in the local Settings Area are also the selections in the displayed user form. Changing these selections and then clicking *OK* (or pressing ENTER) will modify the associated Settings Area to correspond to the new selections and reset the instrument at the next measurement command. Clicking *Cancel* (or pressing ESCAPE) will cause any changes to be ignored. Access at the XLPRO menu.

OMIT

Omit units display; *Rescale* is implied. Only the numeric value will be written to the worksheet. This mode is useful when worksheet space is limited. You can manually put a text description of the units in one place in the worksheet rather than have it displayed after each numeric value. Change under *Spreadsheet Operation - Units Display* of the *Settings Area Values* user form. See Rescale and Pass-thru.

OVERWRITE

Data updates are to the same cell location. Updates are written over the previously written data at the cursor position. Change under *Spreadsheet Operation - Cell Update* of the *Settings Area Values* user form. See Cell Update.

PASS-THRU

Measurement units displayed by the instrument pass directly to the worksheet. Change under *Spreadsheet Operation - Units Display* of the *Settings Area Values* user form. See Rescale.

PULSED RADIATION, MEASURE

Data capture for pulsed radiation (cine) with output in dose/pulse. Access at the XLPRO menu.

PULSE, MEASURE

Resets the instrument's internal dose, and then captures and holds the dose of the next pulse that exceeds a threshold level. Access at the XLPRO menu. See Auto, Manual and Capture Mode.

PULSE RATE

Defines the expected pulse rate for the pulsed-radiation (cine) mode from a predefined list. Select in the *Pulse Rate/Index* list box in the *Measurement Units and Pulsed-Radiation Mode* section of the *Settings Area Values* user form. See **Example of Pulsed Radiation mode** under **Tutorial**.

RATE, MEASURE

Rate-mode data capture. Begins data output at location of cursor. Access at the XLPRO menu.

RADIATION

Select units for radiation from Gy, R, Sv and C/kg. Change under *Measurement Units and Pulsed-Radiation Mode - Radiation* in the *Settings Area Values* user form.

RELEASE COMM LINK

Clears the active USB link and forces an instrument reset for the next measurement command. Executing measurement commands from different sheets also forces an instrument reset, as does any 9096/9095/4085 measurement command. Access at the XLPRO menu.

RESCALE

When the option *Units Display - Rescale* is selected, the incoming data are re-scaled based on the user selection in *Measurement Units - Scale*. (That is, assume that the instrument is reading 1 R/min. If *Measurement Units - Scale* is set to *milli* and *Rescale* is selected, the data would be written to the worksheet as 1000 mR/min.) Change under *Spreadsheet Operation - Units Display* of the *Settings Area Values* user form. See *Omit and Pass-thru*. Does not apply to coulombs.

SCALE - kVp Parameters

Allows selection of the 9096, 9095, 2086, 4085 (includes 4086) or 4083 or, for the 9010/9015, one of 10 scaling factors for the kV data from the instrument. Those choices are *DAccu-kV*, *MAccu-kV*, *WR*, *CT*, *KM*, *LM*, *1-D*, *2-D*, *3-D*, and *User*. Change with check boxes under *kV Spreadsheet Parameters - Scale* in the *Settings Area Values* user form.

SCALE - Measurement Units

Change desired scaling units when *Operating Mode - Rescale* is selected. The selections are Giga, Mega, kilo, 1 (default), milli, micro, nano and pico. Change under *Measurement Units and Pulsed-Radiation Mode - Scale* in the *Settings Area Values* user form. See *Rescale*.

SCREEN TRACKING

When set to *Yes* and *Incremental* is selected, the cursor moves to the next cell where data will be put by XLPRO. When set to *No*, the cursor stays in the starting cell. For unusually-slow computer systems this parameter may need to be set to *No* to avoid loss of data as Excel updates the cell. Change under *Spreadsheet Operation - Screen Tracking* of the *Settings Area Values* user form.

TEMPERATURE AND PRESSURE

Allows user selection of *Automatic*, *Uncorrected* or *Fixed* correction of instrument readings for an unsealed ion chamber. Select under *Temperature and Pressure* in the *Atmospheric Corrections* section of the *Settings Area Values* user form. Does not apply to the 4083/4085/4086.

TIME

Select units of time from /s, /min, /h and /pulse. Change under *Measurement Units and Pulsed-Radiation Mode - Time* in the *Settings Area Values* user form.

UNCORRECTED

Do not correct dose readings for temperature and pressure. Select under *Temperature and Pressure* in the *Atmospheric Corrections* section of the *Settings Area Values* user form. See Fixed and Automatic.

UNITS DISPLAY

Change measurement units and their display to *Omit*, *Pass-thru* or *Rescale* under *Spreadsheet Operation - Units Display* of the *Settings Area Values* user form.

UPDATE SETTINGS AREA

Install the Auto_Activate command and *Pulse Rate* in an active worksheet with a Settings Area. If select its top-left cell, restores _RCTL to the Names Collection. Access at the XLPRO menu.

USER SCALING/WAVEFORM SELECTION

Two boxes allow entries that differ for the 9010/9015 and the 9096/9095/4083/4085/4086. For the 9010/9015, the box *User Gain/Delay (ms)* contains the gain part of the kV scaling, with the box *User Offset/Width (ms)* containing the offset. For the 9096/9095/4083/4085/4086, the boxes contain the delay in ms for starting the waveform transmission and its width, respectively. See ***Settings Area Values* user form** in **Appendix C: XLPRO Menu & User Forms**

USER SETTINGS

When *kV Spreadsheet Parameters - Scale - User* has been selected, a gain and offset can be applied to the kV data for the 9010/9015. This selection is useful when using an invasive kV divider or a non-invasive divider for which the standard settings are not appropriate. Even a non-kV device which has a 0- to 5-V output proportional to the signal being measured may be used. The correct units of measurement could be designated in the worksheet. Change in the *Settings Area Values* user form. See User Scaling/Waveform Selection.

WAVEFORMS

Select desired waveforms for the 9096/9095/4083/4085/4086 under *kV Spreadsheet Parameters - Waveforms* in the *Settings Area Values* user form. See **Brief kVp modes for the 9096/9095/4083/4085/4086** under **Tutorial** and **Appendix B: Waveforms**

Appendix A: Error messages and troubleshooting

1. *Protection for this sheet must be turned off before proceeding.*
You tried to copy or update a Settings Area in a protected worksheet. Remove protection. Your password may be required.
2. *No open workbook has a Settings sheet.*
You tried to copy a Settings Area from a non-existent Settings sheet, and no open workbook could provide one. Open a workbook with a Settings sheet.
3. *The Settings Area was not properly recorded.*
The Settings Area is corrupted. Use the *Copy or Move Settings Area* command to copy a new one from the Settings sheet to the worksheet. Delete any remnants.
4. *No recorded Settings Area or bad selection of data cell.*
Either this worksheet does not have a recorded (_RCTL) Settings Area, or you did not select a worksheet cell for data entry. Copy a Settings Area to this sheet or select a proper cell (i.e. not a chart). If a Settings Area really is present on this sheet, select its top-left cell and execute the *Update Settings Area* command.
5. *Protection of Settings Area prevented its modification.*
Your worksheet is protected in the Settings Area, which must be available to XLPRO. Remove sheet protection or at least unlock the Settings Area. XLPRO tries to unlock when the sheet first opens, but this will fail for password protection.
- 6A. *No recognized devices are connected to the USB.*
The USB drivers found no Radcal devices connected to the USB. Try again. Then connect (or re-connect) the instrument or USB-to-serial adapter to the USB.
- 6B. *Entered baud rate is not supported.*
For the 9010/9015 you manually entered a baud rate that Windows does not allow.
- 6C. *Communication to the instrument failed. Check USB connection and unit power.*
The instrument did not respond properly to reset or measurement commands. Be sure that it is turned on and connected to the USB. For the 9010/9015, first verify in the Setup menu that Baud Rate is not off and is set to 9600 or 19200 or to an allowed value equal to that in the local Settings Area. (See the 9000 Operator's Manual for a description of how to change Baud Rate.) Then if the instrument is properly connected to the adapter and turned on, rotate its thumbwheel, which causes the instrument to look for an active serial port from the adapter, and try again to communicate. If *Serial Test* in the Setup menu responds with *RTS not positive*, then the instrument does not see an active port.
- 6D. *Error of type x for USB-n.*
Driver errors found. Try again. Re-connect the USB device or re-load the drivers.

7. *Instrument firmware is too old.*
Contact Radcal to update your instrument's firmware, which predates version 2.1.
8. *Bad instrument configuration data.*
The instrument responded improperly to reset. Try again. If problem persists, contact Radcal for repair.
9. *Bad entry for [name]*
Entries in the Settings Area are corrupted, possibly because of manual entries. Execute *Modify Settings Area* to restore the Settings Area. If that fails, see **Settings Area commands** in Appendix C.
10. *Auto-zero failed. Try again or disable.*
You tried to enable the 9010/9015 Auto-Zero function and the instrument was unable to obtain a stable result, possibly as a result of its just being turned on. Wait a few minutes and try again, or give up on using the Auto-Zero function.
11. *Data cell is within Settings Area.*
Your selected cell for data entry would result in the Settings Area being corrupted. You must select a different cell or move the Settings Area.
12. *No allowed kVp mode was selected.*
Check one of the mode choices under *kVp Mode* in the *Settings Area Values* user form or in response to the *kVp Mode* dialog box.
13. *No allowed kVp scale was selected.*
Check one of the choices under *Scale* (type of measuring device) in the *kV Spreadsheet Parameters* section of the *Settings Area Values* user form.
14. *No allowed kVp configuration was selected.*
For the brief kVp Modes at least one of *Dose*, *Time* and *kVp* must be selected. Make a selection from the check boxes under *Configuration* in the *kV Spreadsheet Parameters* section of the *Settings Area Values* user form.
15. *No FFT settings are present.*
You requested a kVp mode that requires the Fast Fourier Transform, which in turn uses various parameters from the Settings sheet under the heading *DEFAULT*. Copy the Settings sheet from one of the template files to your workbook and replace any currently-present Settings sheet. See **Appendix B: Waveforms**.
16. *Too few recorded samples for FFT.*
The instrument's kV waveform was too short to perform the Fourier Transform analysis. Increase the length of the exposure or do not use this kVp mode.
17. *Non-numeric control parameters for FFT.*
You requested a kVp mode that requires the Fast Fourier Transform, which uses

Settings-sheet parameters that have become corrupted. Copy the Settings sheet from 9000PXL.xlt to your workbook and replace your current Settings sheet.

18. *Instrument data is unreadable.*
The kV-waveform data from the instrument contains non-numeric characters. The instrument is probably defective. Contact Radcal for repair information.
 19. *This 9000 does not support kVp.*
You tried to make a kV measurement with a 9010/9015 that does not have a C-OPT analog signal-capture board. Contact Radcal to upgrade your instrument.
 20. *Data area outside maximum sheet size.*
The data area extends beyond the Excel row limit of 65,536 or column limit of 256 (IV). Select a starting data row higher up in the worksheet or a column to the left.
 21. *Improper cell selection for clearing old data.*
For the Area Clear function you did not select the top-left, light-green cell in a full-kVp data set. Select the proper cell in a full-kVp data set. Or you are trying to add full-kVp data to a non-blank area that Area Clear does not recognize.
 22. *This Pulse Rate is invalid.*
For firmware versions 4.0 or later in the pulsed-radiation mode, you did not enter one of the predefined pulse rates. Select one of the values in the *Pulse Rate* list box in the *Settings Area Values* user form. Zero requires version 4.10 or later.
 23. *Improper cell selection or column data already erased.*
For the Erase Data function you did not select the top-left, light-green cell in a full-kVp data set, or alternatively this function has already been run for this data set. Select the proper cell in a fresh full-kVp data set.
 24. *Data-transmission error. Try again.*
The correct number of bytes was not received. If frequent, re-boot your computer.
 25. *Invalid key or expired demo.*
You do not have a valid or unexpired SuperPro key plugged into a USB port.
- Excel *Cannot find 'pathname\9000XLMacro.xls'!InitS*
Either there is not a link to 9000XLMacro.xls or the Excel *Security Level* is too high. See **Appendix H: Folder Naming and File Copying** or the note in **Appendix I: Eliminating Auto Activation**.
- 9000 *9000 ERR, ----Vp, +++++ Vp, ????? Vp, etc.*
These messages indicate that the instrument could not make the requested measurement. Observe the error messages on the instrument's display and refer to the 9000-series Operator's Manual for their meaning.

Appendix B: Waveforms

To choose a waveform-producing mode, select a cell for the top-left corner of the data area, open the XLPRO menu with the key combination ALT-X and press S. For the 9010/9015, under *kVp Mode* in the *Spreadsheet Operation and kV Mode* section select *Full*. For the *Fluoro* mode, check the *Fluoro* box (9010/9015 only). For the 9095/9096/4083/4085/4086, select at least one entry under *Waveforms* in the *kV Spreadsheet Parameters* section. Make a choice under *kV Spreadsheet Parameters - Scale/Instrument Selection* to describe your instrument or type of kV-divider, such as the 9096 or the diagnostic version of the Accu-kV. (See **Appendix C: XLPRO Menu & User Forms**.) Then click *OK* to enter these choices, reopen the XLPRO menu with the key combination ALT-X, and press K to execute the *Measure kVp* command. The selected data cell will become light green. Except for the header-only mode with zero width, one measurement is made for each execution of the *Measure kVp* command.

If your selected data cell was already light green from a prior measurement and nothing is below its data area, you will be asked whether you want to clear the old data. *OK* causes the new results to replace the old ones; *Cancel* aborts the measurement. Otherwise if the data area from one row above the selected cell to the end of the sheet with the width of the header is not blank, *Error-21* appears, in which case manually clear this data area or select a blank portion of the worksheet. (The header-only mode only looks at the six rows by eight columns of the header.)

Note: For the kVp Mode selection you may choose Prompt, which causes a dialog box to appear when you execute the Measure kVp command to ask you to select a kVp mode. Further operation for the 9095/6 and 4083/5/6 differs from that for the 9010/ 9015.

9010 and 9015

A six-column, multiple-row capture of kV-waveform data appears. The number of rows depends on the pulse duration with a maximum 5466. The first row is the output described under **Tutorial - Example of brief kVp modes for the 9010 and 9015** and depends on the choice of *Conv Dose*, *Time* and *kVp* in *kV Spreadsheet Parameters - Configuration*. A two-column output in which the first column is time in milliseconds and the second is the kV at that time follows the next four rows plus a row of column labels; a second pair of columns gives the frequency spectrum of the ripple in Hz and kV. The kV waveform and frequency spectrum are graphed from these outputs.

The four header rows below the first row contain pairs of outputs, together with labels describing the output. The first pair are kVp values from the Fourier Transform of the ripple in the latter part of the waveform and from the weighted average of the entire waveform using the *PPV* algorithm. The former measures the peak of the waveform, while the latter scales to image quality. (See **Appendix J: FT and Practical kV Algorithms**.) The second pair are the average kV and the peak-to-peak ripple toward the end of the waveform. The third pair are the frequency of the largest amplitude in the ripple spectrum and an estimate of the pulse-repetition rate if the waveform repetitively crosses the baseline, such as for half-wave and pulsed-fluoro machines. The last pair are the width of the pulse that was stored in the instrument's memory and the number of distinct pulses in that waveform; this line is blank for *Fluoro* modes, which do not measure width.

Note: For compatibility with prior versions of 9000XL, the header will have only one row (plus a row of column labels) and the spectral information will be omitted if there is no Settings sheet or if cell F1 of the Settings sheet does not contain DEFAULT. If you wish to force this old format with a Settings sheet, modify the word DEFAULT in cell F1.

9096/9095/4083/4085/4086 kV-Pulse Mode

An eight-column, multiple-row capture of waveform data appears when at least one entry was checked under *Waveforms* or, except for the 4083, the *Full* mode was selected. The number of rows depends on the pulse duration with a maximum of 32006. These instruments have no full *Fluoro* mode.

The data start with an eight-column header with labels or units for each output. The first row has converter-dose outputs, with the second row having dose outputs from the kV sensor. These outputs are dose, dose per second, dose per mAs and dose per pulse. The third row contains the width of the pulse that was stored in the instrument's memory, the number of distinct pulses in that waveform, an estimate of the pulse-repetition rate if the waveform repetitively crosses the baseline, followed by the ratio of kV-sensor dose to converter dose. The fourth row has the instrument's kVp value using the Fourier Transform of the ripple in the latter part of the waveform, followed by its average value and XLPRO's weighted average of kV for the entire waveform using the *PPV* algorithm, ending with the peak ripple frequency. (The PPV output is only available if *kV* was checked under *Waveforms*.) The Fourier Transform measures the peak of the waveform, while PPV scales to image quality. (See **Appendix J: FT and Practical kV Algorithms**.) The fifth row contains filtration thickness and half-value layer in mm of Al, followed by average mA and mAs. The sixth row has the date as dd.mm.yyyy and time of the measurement to the nearest second. Outputs that are not available produce N/A in their cell.

The selections under *kV Spreadsheet Parameters - Waveforms* of the *Settings Area Values* user form and the entries for *Delay (ms)* and *Width (ms)* in this same section determine the subsequent outputs. If *Width* is zero, then the header is the only output, and the selected cell advances downward by seven rows after the measurement. Further exposures will generate new header information at this point without the need to execute the *Measure kVp* command again, and like the brief modes this process repeats until Esc(ape) is pressed.

If *Width* is not zero, the sixth row also contains various column headings, followed by up to six columns with as many as 32000 rows with waveform data from the instrument's memory with an offset given by *Delay* and an extent given by *Width*. The first column is time in ms; the next is kV at that time; the third is relative dose rate or dose rate; and the fourth is instantaneous mA. Because Excel can plot no more than 32000 points in a single series, the data are decimated 2:1 if there are more than 32000 samples (2.458 s for the 9095/6, 4085/6 or 2.389 s for the 4083) in the waveform; the maximum width is 4.915 s or 4.779 s, respectively. An additional pair of columns contains the frequency spectrum of the ripple in Hz and kV, which XLPRO generates from the latter part of the kV waveform if the Settings sheet is present with DEFAULT in cell F1. Waveforms not checked under *kV Spreadsheet Parameters - Waveforms* are omitted, and *kV* and *Spectrum* are both required to obtain a spectrum. For the 9095/6, 4085/6, selecting *Full* selects all waveforms with the user choosing between *Rel Dose Rate* and *kV Dose Rate* for the 9096, and

the instrument's bandwidth-corrected Fourier Transform produces its kVp output. As many as five graphs may arise from these waveforms. The graph labeled *Accu-kV Waveform* shows kV versus time with a red *kVp* line at the instrument's value of kVp and a green *Practical kV* line at the instrument's biased average of kV. For ripple frequencies above 1 kHz the red kVp line can exceed the peak of the waveform because the ripple amplitude is corrected for instrument bandwidth. The *SPECTRUM MAGNITUDE* graphs show the frequency spectrum of the ripple with different full scales. Except for the 4083, the *(RELATIVE) DOSE RATE* and *mA Waveform* graphs illustrate these values versus time, with red lines for the values of *Avg. Rate* and *Avg. mA*.

If *kV Dose Rate* was selected under *kV Spreadsheet Parameters - Waveforms* of the *Settings Area Values* instead of *Rel Dose Rate* for the 9096, 4086 or the 4085 with firmware version number 5.10 or later, *RELATIVE DOSE RATE* becomes *DOSE RATE*. Then this graph shows dose per second from the energy-compensated diode with the dose units including prefix of the second row of the header. (To select these units, see ***Measurement Units and Pulsed-Radiation Mode*** under ***Settings Area Values user form*** in Appendix C.) The dose-rate values are normalized such that the total dose over the width-measuring portion of the waveform equals the calibrated dose shown in the header. The *Avg. Rate* is this dose divided by the waveform width.

Fluoro mode

When the 9010/9015 is placed in the *Fluoro* mode, it outputs waveform data immediately and continuously updates these waveforms in the form of 110-ms samples. Because XLPRO accepts and analyzes only the first sample of the waveforms in the *Fluoro* mode, its output will be zero if the instrument was not exposed to radiation at the time that the *Measure kVp* command was executed. Thus in order to measure a piece of the fluoro waveform after the exposure has been running, be sure to start the exposure before executing the *Measure kVp* command. To view the leading edge of a fluoro waveform, do not use the *Fluoro* mode.

The 9095, 9096, 4083, 4085 and 4086 have only the brief *Fluoro* mode, which does not produce waveforms. However, they display waveforms up to nearly 5 seconds in duration in *kV-Pulse* mode, and this mode can be used to observe both the leading edge and the equilibrium portion of a fluoro waveform. The *Dental-ms* and *Dental-pulses* modes exclude the brief *Fluoro* mode.

Erase Data command

This command, which is accessible at the XLPRO menu or by CONTROL-SHIFT E, removes the data from the waveform modes in a swath with the width of the header from five rows below the selected cell to the last row of the data set and replaces the Excel charts with fixed-content pictures. (Any date and time values are preserved.) The remaining data consist of the five rows of header information and the pictures, which no longer depend on the old column data. You must select the light-green cell at the top-left corner of a waveform data area; otherwise *Error-23* occurs. You will be asked whether you wish to erase the column data; answer *OK* to execute the command and *Cancel* to abort.

Area Clear command

This command, which is accessible at the XLPRO menu or by CONTROL-SHIFT A, deletes all the data produced by the waveform modes from the row of the selected cell to the last row of the data set, including all Excel charts and pictures. You must select the light-green cell at the top-left corner of a waveform data area; otherwise *Error-21* occurs. You will be asked whether you wish to clear the old data; answer *OK* to execute the command and *Cancel* to abort.

Note: This command can also be used for full-kVp data using the old format where spectral information is not present. In that case, select the top-left cell of the data area, and a two-column-wide swath will be cleared from the row below the selected cell to the end of the worksheet. The first row, which looks like the output from the brief kVp mode, will remain and can be deleted manually. Do not stack measurement sets one above the other.

Examples

The sheet *Waveforms* in *9000 Sample Template.xls* shows the output for the 9010 waveform mode using the Accu-kV without *Fluoro* being checked. This sheet contains a number of waveforms that have been captured from different types of generators with an ion chamber present.

The *Waveforms* sheet in *9095 Sample Template.xls* shows outputs for the 9095 in the *Full* mode. The data area with its top-left cell in E1 contains the original data set, including the values of kV versus time and its ripple spectrum, which peaked at 2 kHz. A second measurement was made with the top-left cell in N1. Then with this cell selected, the Erase Data command was executed, removing the long data columns and leaving only the header rows and the waveform and spectrum graphs. Because a 6-cc ion chamber was present as shown by cell C26, the dose output in the first row has units of *mR*, indicating that this measurement arose from the ion-chamber output after correction as cell C27 for the temperature and pressure in cells C29 and C30. A mAs meter was present and also showed high-frequency ripple during the waveform. If cell C26 contains “None”, then no ion chamber was present, and the dose units would become *rel*, indicating that this measurement arose from the relative dose rate of the kV sensor. Note that the values in the Settings Area always refer to the last measurement on the sheet.

Appendix C: XLPRO Menu & User Forms

XLPRO menu

XLPRO is accessed through the Excel menu bar as the menu item XLPRO, which is usually to the immediate left of Help. This menu item can also be accessed using the keyboard sequence ALT-X. The commands are grouped as nine measurement functions, three utility commands and four commands for the Settings Area. Most commands can be executed directly from the keyboard using the sequence CONTROL-SHIFT plus the letter shown to the right of the command in the menu item or underlined below.

The nine measurement functions are:

- Measure Rate
- Measure Max Rate
- Measure Dose
- Measure Last Dose
- Measure Pulse
- Measure Pulsed Radiationu
- Measure kVp
- High Sensitivityy
- Low Sensitivityy

The three utility commands are:

- Erase Data
- Area Clear
- Release Comm Link

The four commands for manipulating the Settings Area are:

- Modify Settings Area
- Update Settings Area
- Copy or Move Settings Area
- Hide or Unhide Settings Sheet

Measurement operations

The *Measure Rate*, *Measure Max Rate*, *Measure Dose*, *Measure Last Dose*, *Set Auto Zero* and *Clear Auto Zero* commands disregard the selection for *Spreadsheet Operation - Capture Mode*. The *Measure Rate*, *Measure Max Rate*, *Measure Dose* and *Measure Pulse* commands go directly to making measurements, whereas the *Measure Pulsed Radiationu* command does so only when *Auto* is the selected parameter for *Spreadsheet Operation - Capture Mode*.

The *Measure Pulsed Radiationu* command for the case where the *Capture Mode* is set to *Manual* and the *Measure Last Dose* command have a dialog box associated with them. This dialog box, *Trigger Data Capture*, prompts the user to select *OK* or *Cancel*. Selecting *OK* will download the values accumulated to the time of the selection of *OK* into the worksheet, but data accumulation

continues in the instrument. Selecting *Cancel* terminates data collection. For the old *Cine* mode in *Manual* mode, selecting *OK* will close the capture window and complete the measurement.

The *Measure Rate*, *Measure Max Rate*, *Measure Dose*, *Measure Last Dose* and *Measure Pulsed Radiation* (except in the old *Cine* mode) commands keep acquiring data from the instrument until Esc(ape) is pressed on the keyboard. The *Measure Pulse* command and the brief *Measure kVp* modes also keep acquiring data if the *Capture Mode* is set to *Auto*, but in *Manual* only one measurement is performed. The old *Cine* command and the full *Measure kVp* modes always exit after one measurement.

The selections under *Spreadsheet Operation - kVp Mode* in the *Settings Area Values* user form (accessed by the *Modify Settings Area* command) determine the result of executing the *Measure kVp* command. If you select *Full*, *Brief*, *Peak* or *Practical* (with or without also checking *Fluoro*, *Dental-ms* or *Dental-pulses*), then data acquisition starts immediately upon executing the *Measure kVp* command. Otherwise, if you select *Prompt*, the *Measure kVp* command has the *kVp Mode* dialog box associated with it that prompts you to select a format for data capture. These formats are also *Full*, *Brief*, *Peak* or *Practical* with check boxes for *Fluoro*, *Dental-ms* and *Dental-pulses*. After selecting one of these formats from the dialog box, clicking *OK* will cause the measurement to begin. For *Cancel*, the command exits with *Error-12*, which *OK* clears..

The *High* and *Low Sensitivity* commands cause the sensitivity to toggle between *Enabled* and *Disabled*. (If high sensitivity is disabled, then *Low Sensitivity* is greyed out in the *XLPRO* menu item, and executing *High Sensitivity* enables it. The opposite happens for high sensitivity initially enabled.) For the 9010/9015, the high sensitivity causes the instrument to initiate an auto-zero sequence, which will result in additional precision in some measurement modes but which may take a minute or two to complete once initiated. If the auto-zero function is enabled, then the sequence will be initiated whenever a measurement is made and the instrument is not already in the auto-zero state. If the auto-zero function is disabled, then the instrument's auto-zero mode will be cancelled if it is not already cleared. Disabling the auto-zero mode takes only a short time. When Excel closes, the instrument's auto-zero mode is cancelled just before turning it off. The 4083/4085/4086 do not use auto zero, and its dose-related commands will be greyed out.

The 9095 always adjusts the converter zero current and then measures it at power turn on. If high sensitivity is enabled, the zero current is also measured before any ion-chamber measurement for three seconds, and its value is updated if the change in this current is below about 100 fA. If high sensitivity is disabled, the only zero measurement is that made at power turn on. The zero current is always subtracted from the total measured current. The 9096/2086 always measure zero before a dose measurement, and the sensitivity level controls the time spent averaging the zero.

For the 9010/9015/4083, *XLPRO* establishes communication with the instrument, retrieves its identification and configuration information, including temperature and pressure, and places them in the *Settings Area* whenever a measurement command is executed from an operational sheet with a name different from that of the sheet of the prior measurement command. This update also occurs for the first measurement command after the workbook opens or after *Release Comm Link* was executed. For the 9095/6 and 4085/6, this update always occurs whenever any measurement command is executed. The *Settings Area* reflects the values at the time of the last update.

Settings Area Values user form

The command *Modify Settings Area* (CONTROL-SHIFT S) opens the *Settings Area Values* user form. This form has five differently-colored major selection areas — *Measurement Units and Pulsed-Radiation Mode*, *Spreadsheet Operation and kV Mode*, *kV Spreadsheet Parameters*, *Device Index* and *Atmospheric Corrections* — which are used to interact with XLPRO and to change the operational behavior of the program. The current choices in the local Settings Area are also the selections in the displayed user form. Changing these selections and then clicking *OK* (or pressing ENTER) will modify the associated Settings Area to correspond to the new selections and reset the instrument at the next measurement command. Clicking *Cancel* (or pressing ESCAPE) will cause any changes that you made to be ignored.

Measurement Units and Pulsed-Radiation Mode

The *Measurement Units* part of this section has three subsections to control the type of radiation units or time units and the scale of these units. The radiation units that may be selected are Grays, Roentgens, Sieverts and Coulombs/kilogram. Selectable time units are per-second, per-minute, per-hour or per-pulse. The scale-factor settings allow a very broad range to be selected — pico, nano, micro, milli, kilo, Mega, Giga or unity. The 4083 and relative dose rate ignore these entries.

The values selected under *Measurement Units* are applicable only if *Rescale* or *Omit* has been selected under *Spreadsheet Operation - Units Display*. Then the chosen scale factors are applied to the selected base radiation and time units to re-scale the instrument's output. For example, if *Gy*, */min* and *nano* are selected, XLPRO will display dose-rate measurements as nano-Grays per minute. Similarly if */pulse* is selected, the outputs from *Measure Rate* and *Measure Max Rate* will be displayed as dose per pulse at the rate in the *Pulse Rate* list box.

The effect of the entry and list boxes in the *Pulsed-Radiation Mode* subsection depends on the version of the instrument's firmware and differs between the 9010/9015 and the 9095/6. For the 9010/9015, the boxes labeled *Exposure Threshold*, *Acquire delay (pulses)* and *Acquire interval (pulses)* are greyed out and not used. The *Pulse Rate/Index* list box determines the value in the Settings Area to the right of *Pulse Rate*. (See **Example of Pulsed Radiation mode** under **Tutorial**.) For versions prior to 3.23, selecting */pulse* will always result in an output of dose per pulse at the specified pulse rate in the *Pulsed Radiation* mode. For later versions, the *Pulse Rate/Index* list box indexes parameter sets stored in the instrument to define its output, and the dose per pulse is not re-scaled when */pulse* is selected. The 4083/5/6 ignore these entries.

For the 9095/9096/2086, the *Pulse Rate/Index* list box gives the pulse-rate value directly. A rate of zero is allowed for firmware versions 4.10 and later, in which case the instrument determines the pulse rate from the dose waveform for rates below 16 pulses per second. The *Exposure Threshold* list box indexes one of ten dose-rate starting thresholds, which are defined in the 9095/9096/2086, whereas the *Acquire delay (pulses)* and *Acquire interval (pulses)* boxes allow the entry of the delay and width in pulses (0 to 255) for the *Pulsed Radiation* mode. Except that these entries replace parameter sets stored in the instrument, operation is similar to version 3.24 of the 9010/9015.

Spreadsheet Operation and kV Mode

The *Spreadsheet Operation* part of this section has five subsections to control spreadsheet behavior: *Units Display*, *Capture Mode*, *Screen Tracking*, *Auto-Dose Outputs* and *Cell Update*.

Units Display controls the application and display of measurement units. If *Units Display* is set to *Pass-thru*, then dose measurements will not be re-scaled, and the units sent by the instrument will be displayed. If *Units Display* is set to *Rescale*, then dose measurements will be re-scaled according to the settings made under *Measurement Units*, and the units will be displayed with the measurement. If *Units Display* is set to *Omit*, then measurements will also be re-scaled, but the units will not be displayed with the measurement.

Capture Mode applies to specific measurement operations with a different meaning depending on the operation. For *Measure Pulse* and the brief *Measure kVp* operations, if *Capture Mode* is set to *Auto*, then repetitive measurements will be made; but, if *Capture Mode* is set to *Manual*, then only one measurement occurs. For *Measure Pulsed Radiation*, if *Capture Mode* is set to *Auto*, then the measurement is made after a fixed time delay; but, if *Capture Mode* is set to *Manual*, then the *Trigger Data Capture* dialog box controls the measurement in a similar fashion to that for *Measure Last Dose*. *Capture Mode* does not affect any other measurement operations.

Screen Tracking controls the screen behavior during the display of data. If *Screen Tracking* is set to *Yes*, then the screen will scroll to ensure that the most recent measurement is always visible. If *Screen Tracking* is set to *No*, then the screen will not scroll, even though measurements are being added to the worksheet. If constant screen motion is annoying, disable *Screen Tracking*.

Auto Dose Outputs selects *Dose* and/or *Width* for the *Pulse*-mode outputs for the 9096/2086.

Cell Update controls the cell in which the next measurement is displayed. If *Cell Update* is set to *Incremental*, then the next measurement will be displayed in the cell one row below the cell for the last measurement, resulting in a column of values. If *Cell Update* is set to *Overwrite*, then the next measurement will overwrite the last measurement in the current cell, resulting in only one cell having the most recent value.

The *kV Mode* part of this section controls the data-capture format for the 9010/9015 and the operation of the 9095/6 and 4083/5/6 after executing the *Measure kVp* command. For the 9010/9015, the *Dental Threshold* and *Filtration* list boxes, as well as the *Dental-ms* and *Dental-pulses* check boxes, are greyed out and not used. The selections under *kVp Mode* determine the data-capture format. The *Full* selection is described in **Appendix B: Waveforms**. If you select *Brief*, *Peak* or *Practical*, then you have chosen a brief *kVp* Mode described in **Example of brief *kVp* modes for the 9010 and 9015** under **Tutorial**. If you check the *Fluoro* box, the instrument operates in its *Fluoro* mode as described in **Fluoro mode** under **Appendix B: Waveforms**.

Because the 9095/6 and 4083/5/6 provide the kV values directly, these selections actually control instrument operation after executing the *Measure kVp* command. In contrast to the 9010/9015, the selection between brief and full *kVp* modes occurs under *kV Spreadsheet Parameters*. (See **Appendix B: Waveforms**.) As seen in **Tutorial - Brief *kVp* modes for the**

9096/9095/4083/4085/4086, checking *Peak* under *kVp Mode* outputs the peak of the ripple from the bandwidth-corrected Fourier Transform, whereas the *Practical* selection yields a biased average of kV. For the 4083, the *Full* and *Brief* check boxes are greyed out; otherwise checking *Full* selects all waveforms, and checking *Brief* removes all waveforms. One of *Fluoro*, *Dental-ms* or *Dental-pulses* may be checked to evoke these modes. If a *Dental* mode is used, select one of the eight thresholds in the *Dental Threshold* list box (not 4083). To correct measured kV for the filtration in a diagnostic x-ray beam enter the value of mm of Al (>1 mm) or Cu (<1 mm) in the *Filtration (mm)* box (not 4083). Checking *Auto* causes the instrument to measure the filtration.

For all instruments, if you select *Prompt* under *kVp Mode*, the *Measure kVp* command invokes the *kVp Mode* dialog box that prompts you to make the above selections. After this selection from the dialog box is made, clicking *OK* will cause the measurement to begin. If you click *Cancel*, the command exits with *Error-12*, which you can clear with *OK*.

kV Spreadsheet Parameters

The *kV Spreadsheet Parameters* section has the following four subsections to control *kVp* modes: *Configuration*, *Waveforms*, *Scale/Instrument Selection* and *User Scaling/Waveform Selection*.

Configuration controls the output in the single-row brief mode in response to the *Measure kVp* command using check boxes that allow any combination of four types of measurements — *Dose* (not 4083), *Time*, *kVp* and *mAs* (not 4083) — to be displayed. *Dose* is further divided into *Conv Dose* (not 4085), *Rel Dose* and *kV Dose*. For the 9095/9096 *Conv Dose* obtains dose from the converter connected to the dose sensor. For 9096/4085/4086 *Rel Dose* gives relative dose rate from the kV detectors; for *kV Dose*, dose is a calibrated output from a diode connected to the kV sensor. For the 9096 only converter dose and a dose from the kV sensor can both be selected. *Time* is omitted for *Fluoro* modes, where mAs becomes average mA. For the brief modes at least one box must be checked. Except for the 9010/9015, the instrument generates all of these outputs. For the 9010/9015, the instrument always generates directly the values for total dose (*Conv Dose*) and duration (*Time*), but the value of kVp depends on the data-capture format selected under *kVp Mode*. For *Full* and *Brief*, this value also comes directly from the instrument. For *Peak*, XLPRO derives this value from the Fourier Transform of the ripple in the latter part of the waveform and provides a good measure of the peak of the waveform. For *Practical*, the weighted average of the entire waveform using the *Practical-kV* algorithm in XLPRO provides this value, which scales to image quality. See **Appendix J: FT and Practical kV Algorithms**.

The *Waveforms* subsection does not apply to the 9010/9015 and is greyed out in that case. Five check boxes allow you to select combinations of *kV*, *Spectrum*, *Rel Dose Rate* (not 4083), *kV Dose Rate* (9096/4085) and *mA* (not 4083) for graphical output. The dose outputs have the same sources as in *Configuration* for *Rel Dose Rate* and *kV Dose Rate*. Except for the kV spectrum, the instrument provides these waveforms; *Spectrum* will be greyed out if *kV* is not checked. Checking none of these boxes selects a brief *kVp* mode. (See **Tutorial - Brief kVp modes for the 9096/9095/4083/4085/4086** and **Appendix B: Waveforms - 9096/9095/4083/4085/4086**.)

Scale/Instrument Selection may select the 9096, 9095, 2086, 4085 (includes 4086) or 4083 instruments; otherwise it is a 9010/9015 with one of the ten sensors: *DAccu-kV*, *MAccu-kV*, *WR*,

CT, KM, LM, User (rounds to 0.001), *1-D, 2-D* and *3-D*. They differ in their default values of Gain and Offset, which are applied to the measured kV according to:

$$\text{Displayed kV} = \text{Gain} * \text{Measured kV} + \text{Offset}$$

The following table shows default values for Gain and Offset:

Setting	Gain	Offset
DAccu-kV	32.77	0
MAccu-kV	32.77	0
WR	100	40
CT	100	60
KM	10	0
1-D	100	42
2-D	100	55
3-D	1	65
User	1	0

User Scaling/Waveform Selection for the 9010/9015 allows you to enter other values for Gain and Offset in the entry boxes labeled *User Gain* and *User Offset*. The default values for the diagnostic and mammographic *Accu-kV* scales never need to be changed, but the other scales, some of which are for the Keithley dividers, may need adjustment. (See **Appendix D: Keithley kV-Divider Filter-Pack Support**.) The *User* selection for *Scale* can be useful when using an invasive kV divider or a non-invasive divider for which the standard settings are not appropriate; then enter the desired Gain and Offset under *User Scaling/Waveform Selection*. Even a non-kV device which has a 0- to 5-V output proportional to the signal being measured may be used. The correct units of measurement could be designated in the worksheet.

User Scaling/Waveform Selection for the 9095/6 and 4083/5/6 controls via the *Delay (ms)* and *Width (ms)* entry boxes the initial delay for the transmission of waveforms from the instrument and the width of these waveforms. These entries allow the selection of part of the waveforms for display or analysis, which reduces data-transmission time. (This time per waveform for the 9095 is about 2.4 times as long as the accumulation time; for the 4083 about 7 times as long; and about 0.7 times for the 4085/9095(USB)/9096. Zeros are always suppressed.) If *Width (ms)* is zero but at least one box was checked under *Waveforms*, the five-row header appears without any graphs.

Device Index and baud rate

Note: If you connect only one Radcal device to your USB, you can ignore the Device Index.

The USB driver counts the number of Radcal devices connected to the USB and gives each one an index number from 0 to 9. The *Device Index* section allows you to specify an index and thus address a particular device. If your specified index does not refer to the same instrument type as that defined by *Scale* under *kV Spreadsheet Parameters*, then XLPRO will try to find the lowest index that produces such a correspondence. For multiple devices of the same type on the USB, you will need to observe which instrument responds to XLPRO in order choose the correct index.

If you accept an index, its value is entered to the right of *Device Index* in the local Settings Area, and this index is used henceforth. If you have only one Radcal device connected to your USB, you can ignore the selection under *Device Index*; a value of 0 will be automatically used.

The selection in *kV Spreadsheet Parameters - Scale/Instrument Selection* defines the unique baud rates that will be used to communicate with each of the three instrument types, which consist of the 9095/9096, the 2086, the 4083/4085, and the 9010/9015. If none of the allowed baud rates produce the expected response after trying all available indexes, you will see the message: *Selected instrument type was not found. Do you want to try another type?* If you answer *No*, the scan stops; otherwise the set of baud rates corresponding to the next type is tried, with the message reappearing if the attempt fails. The above message can thus appear twice.

If the type of a properly-responding instrument differs from that chosen under *kV Spreadsheet Parameters*, a message appears asking you if you want to revise the Settings Area. An answer of *No* aborts further operation. Otherwise the Settings Area is changed to correspond to the instrument, and the *Settings Area Values* user form appears to allow you to make any additional changes; you must exit it with *OK* to have a proper Settings Area.

By default the 9010/9015 use 9,600 baud, which is the highest rate available in firmware versions before 3.27; later firmware versions support 19,200 baud. The largest available value provides the best communication with these instruments; XLPRO automatically tries both rates. However, if an unusually slow computer is being used to run XLPRO, then it may be necessary to reduce the baud rate. In that case manually enter the baud rate to the right of *Baud*: in the Settings Area; this baud rate must match that set in the instrument. (See the 9000-series Operator's Manual for setting its baud rate.) The 9096/9095, 2086 and 4083/4085 do not support variable baud rates.

Atmospheric Corrections

The *Atmospheric Corrections* section controls the application of correction factors to radiation measurements to compensate for the effects of variations in the current temperature (T in C) and pressure (P in kPa) on an unsealed ion chamber. Three correction modes are available: *Automatic*, *Uncorrected* and *Fixed*. The correction, if applied, uses the following equation:

$$\text{Displayed value} = (101.3/P) * ((T + 273.15)/295.15) * \text{Instrument value}$$

If *Automatic* is selected, XLPRO obtains the temperature and pressure measured by the instrument and places these values in the Settings Area. For temperatures between -20 and 50 C these values are used to correct any measurements made by the instrument prior to display. If the temperature and/or pressure is not available due to the absence of the required 9010/9015 option or for other reasons, then XLPRO will use the values in the instrument's setup menu. The defaults of these user-set values are 22 C and 101.3 kPa, which are also the values used by the 9096/9095/2086 for dose-related measurements. The values in *Measured/Set* reflect the values of temperature and pressure in the Settings Area. The 4083/4085/4086 ignore these corrections.

If *Uncorrected* is selected, XLPRO displays the instrument's measurement as reported without correction. The *Measured/Set* values operate as though *Automatic* were selected.

If *Fixed* is selected, XLPRO uses the user-defined values of temperature and pressure entered into *Measured/Set* in the *Atmospheric Corrections* section to derive the correction factors, which will then be applied to the displayed values.

Utility commands

The utility commands are *Erase Data*, *Area Clear* and *Release Comm Port*.

The *Erase Data* command removes the data produced by the full-kVp mode in a six- or eight-column-wide swath from five rows below the selected cell to the end of the data set and replaces its Excel charts with fixed-content pictures. See **Appendix B: Waveforms**.

The *Area Clear* command deletes all the data produced by the full-kVp mode from the row of the selected cell to the end of the data set, including all Excel charts and pictures. See **Appendix B: Waveforms**.

The *Release Comm Link* command closes the link over the USB to the instrument. If a measurement command is executed after this command, then XLPRO will re-establish communication with the instrument, retrieve its identification and configuration information (including temperature and pressure), and place them in the Settings Area. If a measurement command is not executed after clearing the serial port, the instrument will not turn off when Excel closes. This command also causes the instrument settings for the 9096/9095/2086/4085/4086 to be returned to their values before XLPRO established communication.

Settings Area commands

The four commands for manipulating the Settings Area are *Modify Settings Area*, *Update Settings Area*, *Copy or Move Settings Area* and *Hide or Unhide Settings Sheet*.

The *Modify Settings Area* command gives you access to the *Settings Area Values* user form. The content of this user form was described under **Settings Area Values user form** above.

The *Update Settings Area* command is generally run as part of the modification of an old template. It adds (or restores) the *Auto_Activate* command to the sheet's Names Collection, changes the old *Frame Rate* to *Pulse Rate* in the Settings Area, converts notation from serial ports to the USB, and updates the XLPRO version number. If the coordinates (RCTL) of the top-left cell of the Settings Area are not in the sheet's Names Collection but a Settings Area really exists on this sheet, selecting its top-left cell allows this command to restore these coordinates. See also **Appendix I: Eliminating Auto Activation**.

Using the selected cell for the top-left corner of the local Settings Area, the *Copy or Move Settings Area* command either copies the Settings Area from the Settings sheet to a sheet without a Settings Area or moves an existing Settings Area to a new location on the same sheet. See **Creation of the Settings Area** under **The Settings Area**. If the region required for the Settings Area is not blank, you will get the query: *Do you want to overwrite this 30-row by 3-column area?* Answering *OK* overwrites, and *Cancel* aborts further operation. If the first and last rows of

the Settings Area do not contain the expected entries, possibly as a result of adding or deleting rows within the Settings Area, this command produces the query: *Replace any local Settings Area with the one in the Settings sheet? Cancel* aborts further operation, and *OK* recopies the Settings Area from the Settings sheet to the position of the old Settings Area. The old corrupted Settings Area will be completely overwritten (unless it contained extra rows), and any changes to this local Settings Area must be repeated. Deliberately deleting the first row of a local Settings Area causes this command to replace the remainder of this Settings Area from the Settings sheet.

If a Settings Area must be copied from the Settings sheet but no such sheet exists in your workbook, you will get the query: *No Settings sheet in this workbook. Look for one in an open workbook? Cancel* aborts further operation, and *OK* proceeds to the next step. If an open workbook with a Settings sheet is available, you can automatically copy this sheet into your existing workbook by following the procedure in **Copying your worksheets into a renamed template** under **The Settings Area**. **Be sure to copy manually any macros in your original workbook into the new one.**

The *Hide or Unhide Settings Sheet* command initially hides the Settings sheet. (It is still present but not visible.) Executing the command again causes the Settings sheet to reappear. Further executions toggle the visibility on and off in this fashion.

Appendix D: Keithley kV-Divider Filter-Pack Support

Filter packs for older Keithley 35080 dividers are easily handled by Radcal's XLPRO software. In addition to the four standard filter packs (WR, K-edge Mammo, Linear Mammo and CT), three additional selections (1-D [32867C], 2-D [32865C] and 3-D [32869C]) are available for the indicated older filter packs. The gain and offset for these selections match the values for the older filter packs. You simply need to select these filter packs and proceed as with any of the standard packs using the *Settings Area Values* user form or macro commands.

The new Mobile Filter Pack Option (37946C) has the same gain and offset settings as the WR filter pack. Thus, simply select the WR filter pack from the *Settings Area Values* user form or with macro commands and proceed with the measurement.

Note: These capabilities apply only to the 9010 or the 9015; the later instruments do not support any of the Keithley dividers.

The chart below is provided for reference.

Filter Pack		kV/V Gain	Step	kV Offset	Step
37617C	WR	100±3	0.1	40±10	0.5
37355C	K-edge Mammo	10±1.5	0.05	0±2	0.1
37351C	Linear Mammo	100±3	0.1	0±2	0.1
33551C	CT	100±3	0.1	55±5	0.5
32867C	50-90kVp	100±3	0.1	40±10	0.5
32865C	65-135kVp	100±3	0.1	55±5	0.5
32689C	75-150kVp	100±3	0.1	55±5	0.5
37946C	Mobile	100±3	0.1	40±10	0.5

Appendix E: Worksheets in 9000 Sample Template.xls

The three sample worksheets in the workbook 9000 Sample Template.xls delivered with XLPRO have been designed to demonstrate the ease of use of XLPRO with Excel and a formatted worksheet. These worksheets capture dose and rate from a 9010 or 9015 with an Accu-kV divider attached and implement typical QA measurements and data-collection requirements for a radiology department. The degree of macro automation used in these worksheets is minimal, which makes it very easy for users to modify the sheets to fit their individual data-collection needs. The workbook 9095 Sample Template.xls provides similar information for the 9095.

Most of the usefulness of these worksheets comes from the formulas and graphs that are in the worksheets themselves. The user places the cursor at the cell into which a measurement is to be inserted and then initiates a measurement through a control-key sequence. This control-key sequence initiates communication with the radiation monitor through the XLPRO control interface. Once XLPRO inserts the measurement into the cell, control is returned to the user. The user then ensures that the cursor is in the correct cell for the next measurement and initiates a new measurement. This sequence continues until all the required measurements are completed.

For each section of these worksheets, there is a setup area to input machine parameters, a data-collection area for either manual or automatic data collection, and a comment area to outline the results of the test and the action to be taken. All three of these worksheets come with the protection property of Excel turned on so that only the data-entry areas of the worksheet are unprotected and modifiable by the user. You can easily turn the protection property off if you need to modify other areas.

The sheet labeled *Worksheet Information* provides detailed descriptions of the various entries on sheets for a strictly-radiographic room or station (*Radiographic*), for a fluoroscopic or radiographic room (*Special*), and for a mobile x-ray machine (*Mobile*). The workbook also contains sheets with representative waveforms and test data, as well as the usual Settings sheet.

You should keep in mind when modifying these worksheets that there are items such as the Settings Area and intermediate calculation areas which are located outside of the main worksheet. These areas must not be broken by inserting rows into the middle of them.

Macros

The workbook contains the macros listed below. The Auto_Open subroutine initializes combination CONTROL-SHIFT keys to run their associated subroutines. These subroutines first determine the cell at the top-left corner of the Settings Area and use these coordinates to record the initial settings for *Scale* and *Cell Update*. Then they modify the Settings Area as needed and execute the appropriate 9000XLMacro.xls macro (e.g. MacroRunMaxRate), which does not exit if no argument is passed to the macro. The subroutines end after restoring the Settings Area to its initial configuration and advancing the selection by one row. The Auto_Close subroutine allows you to delete the *Auto_Activate* commands when the workbook closes.

```

Sub Auto_Open()
    Application.OnKey "+^o", "RateOverwrite"
    Application.OnKey "+^f", "FluorokVpOverwrite"
End Sub

Sub RateOverwrite()
    On Error GoTo Quit    'Trap no Settings Area or its write protection.
    'Find the coordinates of the top-left cell of the Settings Area.
    r1 = ActiveSheet.Names("_RCTL").RefersToRange.Row
    c1 = ActiveSheet.Names("_RCTL").RefersToRange.Column
    'Store current values from the Settings Area.
    incr = Cells(r1 + 10, c1 + 2)
    units = Cells(r1 + 6, c1 + 2)
    'Modify the Settings Area.
    Cells(r1 + 10, c1 + 2) = "Overwrite"
    Cells(r1 + 6, c1 + 2) = ""
    'Run the Max-Rate macro.
    Application.Run "9000XLMacro.xls!MacroRunMaxRate"
    'Restore the Settings Area to its old values and advance one row.
    Cells(r1 + 10, c1 + 2) = incr
    Cells(r1 + 6, c1 + 2) = units
    ActiveCell.Offset(1, 0).Select
Quit:
    If (Err) Then Call MsgBox("No recorded Settings Area or it is protected.", _
        vbCritical, "Local Error")
    On Error GoTo 0
End Sub

Sub Auto_Close()
    If (Right(ActiveWorkbook.Name, 3) = "xlt") Then Exit Sub
    i = 0
    On Error Resume Next
    For j = 1 To ActiveWorkbook.Sheets.Count    'Look for Auto_Activates.
        ws = ActiveWorkbook.Sheets(j).Name
        If (ws <> "Settings") Then i = Sheets(j).Names("Auto_Activate").Index
    Next j
    On Error GoTo 0
    If (i = 0) Then Exit Sub    'Avoid query if no Auto_Activates are present.
    If (MsgBox("Do you want to keep auto activation?", vbYesNo) <> vbNo) Then Exit Sub
    On Error Resume Next
    For j = 1 To ActiveWorkbook.Sheets.Count    'Delete Auto_Activates.
        ws = ActiveWorkbook.Sheets(j).Name
        If (ws <> "Settings") Then Sheets(j).Names("Auto_Activate").Delete
    Next j
    On Error GoTo 0
End Sub

```

Appendix F: Macro Programming

Interface to macro commands

The Excel-macro interface using Visual Basic for Applications can control XLPRO. The accessible macros in XLPRO listed below can be addressed with the command:

Application.Run "9000XLMacro.xls!" & MacroName, EscMode

The list of accessible *XLPRO* operations and their corresponding macro names are:

Operation	MacroName
Measure Rate	"MacroRunRate"
Measure Max Rate	"MacroRunMaxRate"
Measure Dose	"MacroRunDose"
Measure Last Dose	"MacroRunLastDose"
Measure Pulse	"MacroRunPulse"
Measure Pulsed Radiation	"MacroRunCine"
Measure kVp (general)	"MacroRunKVP"
Full	"MacroRunFullPulse"
Brief	"MacroRunBriefPulse"
Peak	"MacroRunFTPulse"
Practical	"MacroRunPracticalPulse"
Full Fluoro	"MacroRunFullFluoro"
Brief Fluoro	"MacroRunBriefFluoro"
Peak Fluoro	"MacroRunFTFluoro"
Practical Fluoro	"MacroRunPracticalFluoro"
Erase Data	"MacroEraseData" with no EscMode
Area Clear	"MacroAreaClear" with no EscMode
Release Comm Port	"Release" with no EscMode

Note: Control auto-zero operation through the cell with $dr = 11$ in the Settings Area.

Except for the last three commands, EscMode is an optional integer argument that can override the number of repetitions, which is normally controlled by the command itself or *Capture Mode*.

Changes to the Settings Area

You can write directly to the Settings Area, and then XLPRO will automatically use the new settings when the next measurement command is executed. In order to modify the Settings Area, you must first determine the address of the cell in its top-left corner. The following subroutine finds these coordinates, after checking that this sheet has a Settings Area which is not write protected, and then sets the *Radiation* units to *R*.

```

Sub ModifySettings()
    On Error GoTo Quit    'Trap no Settings Area or its write protection.
    'Find the coordinates of the top-left cell of the Settings Area.
    r1 = ActiveSheet.Names("_RCTL").RefersToRange.Row
    c1 = ActiveSheet.Names("_RCTL").RefersToRange.Column
    'Set the Radiation units in the Settings Area to R.
    Cells(r1 + 4, c1 + 2) = "R"
Quit:
    If (Err) Then Call MsgBox("No recorded Settings Area or it is protected.", _
        vbCritical, "Local Error")
    On Error GoTo 0
End Sub

```

In general a position in the Settings Area can be referenced by Cells(r1 + dr, c1 + dc), where r1 and c1 are the coordinates of the top-left cell and dr and dc given below.

9010/9015 Parameter	Parameter for other instruments	dr	dc
Radiation	Radiation	4	2
/Time	/Time	5	2
Scale	Scale	6	2
Pulse Rate	Pulse Rate	7	2
Units Display	Units Display	9	2
Cell Update	Cell Update	10	2
Auto Zero	High Sensitivity	11	2
Capture Mode	Capture Mode	12	2
Screen Tracking	Screen Tracking	13	2
kVp Mode	kVp Mode	14	2
Not used	Waveforms	15	1
kVp Configuration	kVp Configuration	15	2
kVp Scale	kVp Scale	16	2
kVp Gain	Start delay	17	2
kVp Offset	Width	18	2
Not used	Filtration	19	2
Device Index	Dental threshold	20	2
Baud Rate	Device Index	21	2
Atmospheric Correction	Atmospheric Correction	27	2
Atm Temperature	Atm Temperature	28	2
Atm Pressure	Atm Pressure	29	2

The values stored in the Settings Area by this method must conform to the format that XLPRO expects. The acceptable values are visible in the Settings Area after the *Modify Settings Area* command has changed the settings. Numbers and text can be entered directly into the worksheet, because the third column of the Settings Area has been formatted as text.

Appendix G: Bridge to Macro-4.0 Programs

The file 9000XL.XLM, which had the same name in versions of 9000XL before 2.00, provides a bridge to connect macros written in Excel Macro-4 language to this version of XLPRO. This file is also written in the old language to be compatible with the calling syntax of old macros. You must adhere to folder-naming restrictions in **Appendix H: Folder Naming and File Copying**. If you are generating new templates, use Visual Basic and see **Appendix F: Macro Programming**.

Note: When you close or save any of these old templates, Excel will ask you if you want to overwrite or update them with the latest Excel format. Be sure to click YES in response to these queries. DO NOT SAVE OLD TEMPLATES AS MICROSOFT EXCEL 4.0 WORKSHEETS BUT ALWAYS IN THE FORMAT OF YOUR VERSION OF EXCEL.

The list of XLPRO operations supported by 9000XL.XLM and their macro names are:

Operation	Macro Name
Measure Dose	MacroRunDose(EscMode)
Measure Rate	MacroRunRate(EscMode)
Measure Last Dose	MacroRunLastDose(EscMode)
Measure Max Rate	MacroRunMaxRate(EscMode)
Measure Pulse	MacroRunPulse(EscMode)
Measure Cine	MacroRunCine(EscMode)
Measure kVp (general)	MacroRunKVP(EscMode)
Brief	MacroRunBriefPulse(EscMode)
Full	MacroRunFullPulse(EscMode)
Brief Fluoro	MacroRunBriefFluoro(EscMode)
Full Fluoro	MacroRunFullFluoro(EscMode)
Initialize Worksheet	MacroInitSheet()
Reload Worksheet	MacroReloadSheet()

Note: Be sure to include: =RUN(“C:\9000XL\9000XL.XLM’!Auto_Open”) in a Macro-4 function that is automatically called when the template opens. Then precede the above Macro Names for the given operations with: =’9000XL.XLM’! in subsequent functions. EscMode is an optional integer argument as discussed in Appendix F. The file 9000GEN.XLM, which was part of version 1.20a, followed these conventions.

Because 9000XL.XLM automatically launches C:\9000XL\9000XLMacro.xls, which in turn initializes itself and then always uses the values in the local Settings Area, MacroInitSheet and MacroReloadSheet have no purpose. To avoid errors if they are called, 9000XL.XLM accepts these commands but returns without doing anything.

Because the Settings Area has the same format as in the earlier versions of XLPRO, macros to modify the Settings Area should work without any changes. 9000SET.XLM is not supported.

Appendix H: Folder Naming and File Copying

When installing XLPRO, the installation wizard will prompt for a folder name for the installation and recommend C:\Program Files\Radcal\XLPRO-USB\ as the default name. Sub-folders exist for the manuals and USB drivers. For all Excel workbooks derived from the new templates, such as 9000PXL.xlt and 9000 Sample Template.xls, any folder name acceptable to the Windows operating system may be used. However, care must be taken with workbooks containing macros written for versions of 9000XL prior to 2.00, because explicit path and file information is hard-coded into Macro-4 files like 9000GEN.XLM and 9MAMMAC.XLM. For these workbooks use C:\9000XL\ as the installation folder instead of the default name; for versions of 9000XL before version 2.00, C:\9000XL\ must always have been used.

Note: If a version of 9000XL prior to 2.00 is already located in C:\9000XL\, loading 9000XL into this folder will overwrite any earlier version of 9000XL.XLM. In order to preserve version 1.20a of 9000XL, 9000XLold.XLM is also installed but not used.

New workbooks running 9000XLMacro.xls directly may be copied to other folders from the installation folder through the *File, Save As* function in Excel, if first they were opened from the installation folder to create a link to 9000XLMacro.xls. If the clipboard is used to copy and then paste a workbook into a new folder, a copy of 9000XLMacro.xls will also need to be placed in the new folder, because this link will not follow the folder change. To avoid this extra copy and establish this link manually, remove any protection in the copied workbook, select *Edit, Links, Change Source* from the Excel menu bar, browse to a copy of 9000XLMacro.xls and click *OK*; then save the file, close it and re-open it in Excel with the new link. Workbooks from different folders may be used in the same session of Excel, as long as multiple copies of 9000XLMacro.xls are not present, indicating that the Excel *File, Save As* method or re-linking are preferred.

If you have copied a workbook to a folder where 9000XLMacro.xls is not available, opening a worksheet with a recorded Settings Area will produce the Microsoft Excel error message: *Cannot find 'pathname\9000XLMacro.xls'!InitS*. Click *OK* to proceed. Then if you no longer wish to use this workbook with XLPRO and do not want to be bothered by this error message, see **Appendix I: Eliminating Auto Activation**.

Additional restrictions apply to old templates using the Macro-4 language. Old templates like 9RADIOGR.XLS, 9MOBILE.XLS and 9SPECIAL.XLS that use 9000GEN.XLM as their dedicated Macro-4 file may be copied to other folders, if you also copy 9000GEN.XLM to that folder or establish a link to it as above for 9000XLMacro.xls. However, 9000XLMacro.xls and 9000XL.XLM must be located in C:\9000XL\. Similar restrictions apply to any template with a dedicated Macro-4 file, such as 9MAMMTST.XLS that uses 9MAMMAC.XLM. This lack of folder-naming flexibility for old templates is one reason for generating (or modifying) macros to run directly with 9000XLMacro.xls as described in **Appendix F: Macro Programming**. See also the example of a simple direct-running macro using Visual Basic for Applications in **Macros** under **Appendix E: Worksheets in 9000 Sample Template.xls**.

Appendix I: Eliminating Auto Activation

Whenever you move from one worksheet with a recorded Settings Area to another or first open such a worksheet in Excel, an *Auto_Activate* command in that worksheet's Names Collection causes 9000XLMacro.xls to load (if it is not already loaded) and various macros to run automatically. This name is part of all Settings worksheets and is added to local worksheets when *Copy or Move Settings Area* executes. This command produces the auto-activation feature.

If a workbook has been completely loaded with data and will no longer be used with XLPRO, the auto-activation feature can generate annoying error messages, particularly if the file has been copied to a folder or computer where XLPRO is not available. Thus, when you close a workbook that has been derived from one of the delivered templates, you will be asked: *Do you want to keep auto activation?*. If you select *No*, then the *Auto_Activate* commands will be eliminated from all worksheets in the workbook except the Settings sheet. *Yes* leaves the commands unchanged and is the usual response to this query.

Note: Workbooks derived from templates from versions of 9000XL prior to 3.00 will query instead: Do you want to delete auto activation?. OK will eliminate Auto_Activate commands, and Cancel will leave them unchanged.

If you later want to restore the auto-activation feature for a given worksheet, open that worksheet and execute the *Update Settings Area* command from the XLPRO menu. This command also insures that the eighth row of the Settings Area reads *Pulse Rate* instead of the old *Frame Rate*. You may need to select first the Settings sheet to cause 9000XLMacro.xls to load.

If you have copied a workbook to a folder where 9000XLMacro.xls is not available and have not deleted the *Auto_Activate* commands, opening a worksheet with a recorded Settings Area will produce the Microsoft Excel error message: *Cannot find 'pathname\9000XLMacro.xls'!InitS*. Click *OK* to proceed. Then if you no longer wish to use this workbook with XLPRO and do not want to be bothered by this error message, close the workbook from Excel and answer *No* to the query: *Do you want to keep auto activation?*. In response to the Microsoft Excel query: *Do you want to save the changes you made to 'filename'?*, answer *Yes*. Then when you re-open this workbook, the Excel error message will no longer appear unless you select the Settings sheet.

Note: The above error message from Excel will also appear if you selected High as the Security Level under Tools, Macro, Security. In that case Excel will not let you run the macros that are a part of XLPRO. After changing the Security Level, you must close and re-open Excel for the new Security Level to take effect.

Appendix J: *FT* and *Practical* kV Algorithms

The *FT* algorithm computes kVp using the Fourier Transform of a selected region of the kV waveform. For these selected samples, the major ac components are combined with the average kV to estimate the effects of ripple, leading to a measurement of the “average” peak voltage. This averaging process suppresses the effects of noise, which can result in serious errors for routines that use only small data samples. The measured kVp defines a threshold value near 75% of kVp to determine the width of the waveform. The number of pulses in the entire waveform is counted, and XLPRO displays the value of the average pulse-repetition rate. XLPRO also uses the entire waveform to determine PPV employing the weighted-average *Practical* algorithm of Kramer, Selbach and Iles.

Various parameters to control XLPRO calculations are located in columns E and G of the Settings sheet. When the cells in these columns are blue, they contain default values. Although you may change these values, in which case they turn pink, it is usually not necessary. Cells E2:E11 control the Fourier Transform calculation, with default values in F2:F11. Parameters describing the Accu-kV--9000 system are in E13:E21 and G15:G18, with defaults in F13:F21 and H15:H18. (See also **Bandwidth-correction parameters** below.) Coefficients for calculating practical kV are in F24:I32, with coefficients for correcting non-linear effects being in E34:H36.

Note: For the 9095/6 and 4083/5/6 the calculations leading to peak voltage and width are made within the instrument and do not involve XLPRO and the transmitted kV waveform.

Selection of the region for kVp measurement

First the algorithm defines the region over which the kVp will be determined using *Initial Delay* (Tb), *End Delay* (Te), *Width* (Tw) and *Pulses in window* (nw); makes a rough estimate of the kVp using a moving average over a time given by *Initial Interval* (Tint); and then selects kV values that exceed either the *Upper threshold* or the *Lower threshold* expressed as fractions of the rough kVp. In the process of selecting the above-threshold data for further processing, the average of the selected samples is computed, as well as the width of the pulse above the *Noise threshold* (Vn) in E8, which lies below the base threshold of the Accu-kV. (This threshold for the diagnostic Accu-kV is 38 kV and is 22 kV for the mammographic version.) For Keithley-divider choices of kVp *Scale*, the *Noise threshold* is the value in E8 divided by 4 plus *Offset*.

This selection occurs in three steps and uses “compressed” time measured only when the kV value exceeds the relevant threshold. The first step eliminates leading and trailing samples that are below Vn, as well as samples during the first Tb of compressed time. The second step removes samples during Te from the trailing part of the step-1 sample selection and defines the selection window looking from there toward the start of the data samples. This window extends no further in compressed time than Tw (or nw pulses for pulse-repetition rates between 45 and 66 Hz with at least three pulses) or the beginning of the step-1 data, whichever occurs first. Step 3 selects only those samples that exceed the raised threshold determined at the end of step 2.

If the number of non-zero samples in the waveform indicates that too few samples will be selected, the narrow-pulse or very-narrow-pulse modes are used. These modes permit narrow pulses to be analyzed with compromises in the kVp-measurement process.

During step one the width and number of radiation pulses for the entire waveform are determined. The pulse-repetition rate results from dividing the number of pulses minus 0.7 by the pulse width. These values are displayed to the right of *Rate=* and *Pulses=* in the full-kVp data area.

Also during step one the kV data above V_n for the entire waveform are placed in a histogram. Then PPV is computed as the weighted average of the values in the histogram using the weighting functions of Kramer, et al., and placed in the data area to the right of *PPV=* with units of “kV-Prac.”. These weighting functions are fifth-order polynomials in kV with different coefficients for different kV ranges, and they may determine an exponent rather than the function directly. For the 9095/6 and 4083/5/6, XLPRO derives only this header value from the transmitted kV waveform.

In step 2 a running average of kV values over T_{int} is computed. (This time interval is also used to determine if enough samples have been selected.) The largest of these averages is found, and the value of the raised threshold used in step 3 is a fraction of this largest average. The **green line** on the “Accu-kV Waveform” graph represents the average value of these step-3 samples. For 9095/6 and 4085/6 the instrument’s *kV practical* output is this average using the lower threshold.

Ripple and kVp determination

The algorithm then computes the Fourier Transform using the selected samples. The peak amplitude in the resulting frequency spectrum defines the fundamental frequency of the ripple, and this amplitude becomes the zero-to-peak ripple that is added to the average kV to determine kVp. The resultant kVp is the quantity in the cell to the right of *Peak=* and is shown as the **red line** on the “Accu-kV Waveform” graph. The two “SPECTRUM MAGNITUDE” graphs display the frequency spectrum of the ripple. The peak-to-peak ripple appears in the data area to the right of *Ripple=*, with its fundamental frequency to the right of *Pk Freq=*. For the 9095/4083/4085 the peak and practical values from the instrument are displayed instead of the ripple amplitude.

The absolute value of the entry in cell E2 determines the largest frequency used in the spectrum and kVp calculations. When this cell contains a positive frequency for an Accu-kV choice for kVp *Scale*, the above spectrum is corrected for the Accu-kV--9000 bandwidth, including non-linear effects in kVp for frequencies above the value in cell E34. If cell E2 contains a negative value, the bandwidth and non-linear corrections are omitted. A zero value in cell E2 eliminates the ripple correction to the average kV and forces the use of the *Upper threshold* in cell E9 for computing the step-3 average, which becomes the kVp value to the right of *Peak=*. For the 9095/4083/4085 E2 effects only the graphed spectrum with fixed bandwidth corrections, if any; the instrument’s value of kVp always includes a correction for its finite bandwidth.

For other than Accu-kV/9096/9095/4083/4085 choices for the kVp *Scale*, the sign dependence of the value in E2 reverses. Thus, the default case provides the bandwidth correction only for them.

Bandwidth-correction parameters

The bandwidth-correction parameters for the 9010/9015 and some of them for the 4083 are located in colored columns in rows 13 through 18 of the Settings sheet. None of them apply to the 9096/9095/4085. When default values have been entered in the Settings sheet, the corresponding cells will be blue; otherwise they turn pink. Some of these parameters are different between the 4081 and most (later) versions of the 4082. For the 4081, the values in cells E15:E18 are used with defaults in F15:F18, whereas the 4082/4083 values are in G15:G18 with defaults in H15:H18. Common parameters for the 9010/9015 are in E13:E14 with defaults in F13:F14. The values in E14 and G17 are replaced by zero for the 4083, which ignores E13.

XLPRO has several methods of determining which set of parameters to use for the 9010/9015. If the two sets of parameters are equal or if cells G15:G18 do not contain numbers (or are all -1), then the values in E15:E18 are used. The 4082 produces a pedestal near 0.5 kV when otherwise its output would be zero; if this pedestal is found for 10 ms without interruption, XLPRO uses the parameters in G15:G18. Conversely if an output below 0.3 kV is found for 10 continuous milliseconds after the pulse starts, the values in E15:E18 are used. If both or neither of these conditions are found, this criterion is ignored, and, if no other method defines the proper cells, the bandwidth correction is turned off. The 4083 always uses G15:G18.

If E15:E18 have been selected, BW-1 is written into E1; if G15:G18 were selected, BW-2 appears in E1. When no bandwidth correction is used for any reason, E1 will contain BW-0. The units for kVp from the Fourier Transform become “kVp-FTn”, where n is 0, 1 or 2 as BW-n above. If BW-n is present in E1 from an earlier measurement using the same operational sheet, then this value will select the proper parameter cells if no other criteria apply. If you perform a measurement from a different sheet, the old values in E1 of the Settings sheet will be lost.

Thus to define the bandwidth-correction parameters, you can usually follow this procedure:

1. If you know that you are using a 4081, enter the default values from F15:F18 into E15:E18 and place the same values in G15:G18.
2. If you know that you are using a 4082, enter the default values from H15:H18 into G15:G18 and place the same values in E15:E18.
3. If you do not know the instrument type, make an exposure in the full-kVp mode that is brief enough not to fill the 9000 memory. Then note the presence of BW-1 or BW-2 in E1 of the Settings sheet, and follow step 1 above for BW-1 or step 2 for BW-2.
4. If you are using a 9096 or 9095 or a 4083 or a 4085, ignore this entire selection.

Pulse-width considerations

Generally the default values in cells F2:F11 and F20 for the normal-mode timing should be entered into the corresponding cells in column E as follows:

Cell	Function	Value
E2	Max. Freq. (Hz)	3500 Hz (4000 Hz for the 9095/4083/4085)
E3	Initial Delay (ms)	Tb = 20 ms
E4	End Delay (ms)	Te = 7 ms
E5	Width (ms)	Tw = 100 ms
E6	Pulses in window	nw = 7 pulses
E7	Initial Interval (ms)	Tint = 3 ms
E8	Noise threshold (kV)	Vn = 20 kV
E9	Upper threshold	0.9
E10	Lower threshold	0.7
E11	FT-resolution control	3
E20	Duplicate width	0.17 us

The compressed time that is required for the recommended normal mode is $2 \cdot T_b + T_e + T_{int}$, which for the default values becomes 50 ms. For a waveform that is continuously above the base threshold, this time becomes the minimum waveform width for the normal mode; a width of 130 ms usually gives good results. For $\frac{1}{2}$ -wave machines the total required width is about 200 ms, depending on the fraction of the time that the pulses actually exceed the base threshold. This total width corresponds to about 10 pulses at 50 Hz or 12 pulses at 60 Hz; 15 pulses at 60 Hz for a width of 250 ms usually give good results. For waveforms that rise slowly or have other leading-edge transients such that they have not reached their equilibrium value before T_b of compressed time, the pulse should be wide enough such that a width of T_w (or n_w pulses) does not include the distorted leading edge. (Note that T_w or n_w are timed from the end of the waveform.)

In the narrow-pulse mode, the default value of T_b becomes 5 ms, with T_e 3.5 ms and n_w 3. These values permit pulses with a compressed time down to about 12.5 ms to be analyzed with reduced accuracy. Shorter pulses down to 2 ms use the very-narrow-pulse mode with $T_b = T_e = 0$ and $T_{int} = 2$ ms, which totally eliminates rejection of transients on the leading and trailing edges. Short pulses not only produce noisier averages, but also compromises are made in the sample selection. For pulses too short for a kVp measurement, there may still be width and PPV outputs.

Generally it is recommended that the waveform be wide enough to cause operation in the normal mode. However, the output of a capacitive-discharge machine can provide an exception to this rule. In that case the peak of the waveform may occur before the end of T_b in the normal mode, and furthermore the step-2 selection from the end of the pulse may exclude the peak. Thus for these waveforms the pulse width should be set near 40 ms to force the narrow-pulse mode in order to include the peak in the selected samples. For wider waveforms increasing T_e can move the measurement window toward the beginning of the waveform. Try to avoid the very-narrow-pulse mode.

Pulse-width measurement

Except for the pulse-counting mode, the pulse width is measured at a threshold equal to the larger of 75% of the measured kVp or the base threshold. (When the value in cell E2 is zero, the kVp is the step-3 average.) For the pulse-counting (nw) mode and any failures to measure kVp, the base threshold is always used. For the mammographic version the base threshold is 22 kV, whereas for the diagnostic version the base threshold is 38 kV. Cell E19, which contains 0.75 by default, controls the width threshold. In the 9095/6 and 4083/5/6 these parameters are fixed in the instrument.