Applications Note

FLUKE® Biomedical

Successfully using the Model 8000 NERO® mAx to evaluate dental x-ray machine timer performance

Information in this article applies to

Model 8000 NERO mAx firmware release 2.3 or higher.

Introduction

The more that is known about the characteristics of the x-ray machine under test, the easier it is to achieve reasonable results in a timely manner. For instance, if it is known that the x-ray machine does not utilize a filament preheat, the use of a measurement delay is probably unnecessary. However, if the x-ray machine is known to have a filament preheat, a measurement delay is most likely needed. If the x-ray machine's timer is set in pulses, using the NERO mAx in its pulse counting mode (%kV set to 1ϕPULSE) will yield exposure time results in pulses. If the x-ray machine's timer is set in fractions of seconds or milliseconds, a %kV setting of ZERO, 75%, 80% or 90% may be applicable (depending upon manufacturers specifications or other criteria). Typically, for single-phase self-rectified dental units a %kV setting of 1ϕPULSE or ZERO is used. For dental x-ray units with three phase or high frequency generators, the %kV should be set to 75%, 80% or 90%..

Making a measurement

1. Insert the **W/Al** filter card into the detector and set it to the **50 – 100** kV range.
2. Set the detector on a flat, stable surface and position the x-ray tube so that the cone just touches the detector's top surface.

   Note: *The NERO mAx detector's ion chamber is located at the detector's top surface. Do not depress the top of the ion chamber. This can cause incorrect exposure measurements.*

   Make sure that the detector is aligned along the axis of the x-ray tube and that the tube is perpendicular to the detector's top surface and is centered over the detector crosshairs.
3. Turn on the NERO mAx and select **RADIO** mode.
4. Select **LOW** sensitivity.
5. Set the measurement delay to **0** milliseconds.
6. If the x-ray machine's timer is set in pulses, set the %kV to **1ϕPULSE**. If the x-ray machine's timer is set in seconds, fractions of seconds or milliseconds, set %kV to **ZERO, 75%, 80% or 90%** (depending upon manufacturers specifications or other criteria).
7. Press the **ENTER** button and wait for the **MAKE EXPOSURE** prompt.
8. Make an exposure.
9. If the measured exposure time or number of pulses is within the allowed tolerance, the x-ray machine probably does not have a filament preheat or a malfunctioning timer and the results of the exposure are probably correct.

   If the measured exposure time or number of pulses is significantly less than the set exposure time or pulses, the x-ray machine may have a filament preheat or a malfunctioning timer. When this occurs, a measurement delay can be used to determine whether a filament preheat is used or if the timer is malfunctioning. For a solution, see **"What to do if the measured exposure time is too short".**

   If the measured exposure time or number of pulses is significantly longer than the set exposure time or pulses, the x-ray machine may have a filament preheat or its timer is malfunctioning. For a solution, see **"What to do if the measured exposure time is too long".**

What to do if the measured exposure time is too short

Short exposure times may be caused by a timer that is malfunctioning or filament preheat characteristics. To determine whether a short measured exposure time is due to a malfunctioning timer or filament preheat characteristics:

1. If the NERO mAx is still displaying the results of the last exposure, press the **MODE** key to return to the menu screen.
2. Set the %kV to **ZERO**.
3. Press the **ENTER** button and wait for the **MAKE EXPOSURE** prompt.
4. Make an exposure.
5. Record the displayed exposure time.
6. Press the **MODE** key to return to the menu screen.
7. ***Enter a NEGATIVE measurement delay greater than the exposure time measured with no delay.*** For instance, if the measured exposure time of the previous exposure was 18 milliseconds, enter a delay of ***-20*** **milliseconds**. Generally, rounding the delay up to the nearest ten milliseconds is adequate. A negative delay instructs the NERO mAx not to include the delay time in the measured exposure time.
8. **Error! No sequence specified.**Set the %kV to that used for the first exposure, prior to setting the %kV to ZERO.
9. Press the **ENTER** button and wait for the **MAKE EXPOSURE** prompt.
10. Make an exposure.
11. If the measured exposure time or number of pulses is within the allowed tolerance, this x-ray machine probably has a filament preheat and the measurement delay is sufficient to skip over the effects of the preheat.

    If the NERO mAx displays a "DELAY TOO LONG" error message, the x-ray machine's timer may be malfunctioning. This error message is displayed if no x-rays are detected within one second after the delay time has elapsed. When a measurement delay is used, the NERO mAx waits for up to one second after the delay time has elapsed for an exposure to resume. If no x-rays are present after this time, the "DELAY TOO LONG" error message is displayed.

What to do if the measured exposure time is too long

Long exposure times may be caused by a timer that is malfunctioning or filament preheat characteristics. To accurately determine the cause of long measured exposure times requires examination of the machine's output radiation and/or kV waveforms.

If excessive measured exposure times are due to filament preheat effects as shown in the first waveform of the following example, the NERO mAx Excel Add-In may be used to determine the appropriate measurement delay to use. To determine the correct measurement delay to use:

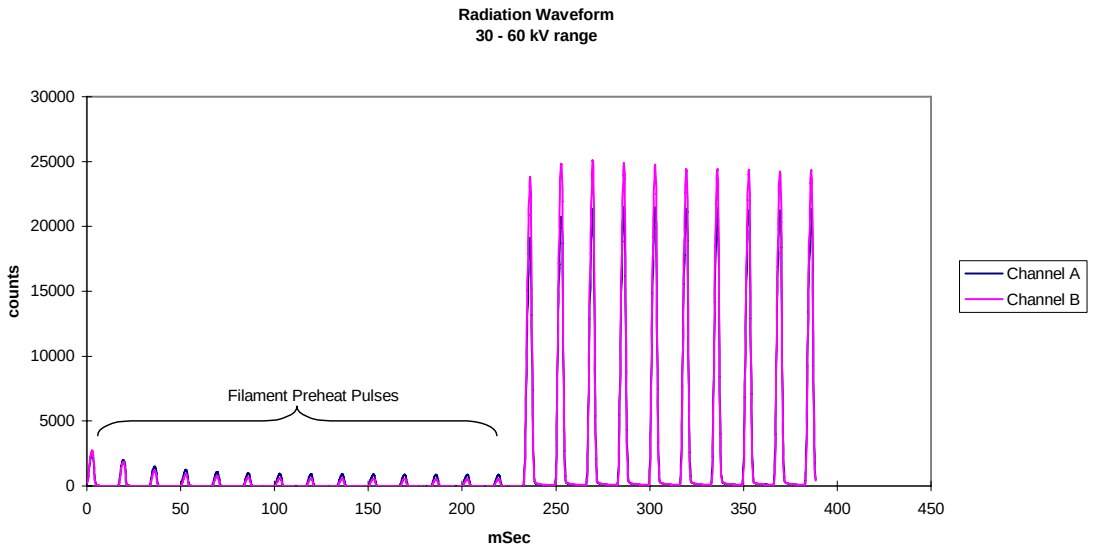
1. If the NERO mAx is still displaying the results of the last exposure, press the **MODE** key to return to the menu screen.
2. Connect a computer to the NERO mAx and start the NERO mAx Excel Add-In. Information on installation and use of the NERO mAx Excel Add-In may be found in the NERO mAx Excel Add-In manual.
3. Open a new Excel workbook by clicking on **File** then **New** and selecting **Workbook** from the "New" menu box or click on the "New" toolbar icon.
4. Click on worksheet cell **A1**.
5. Press the **ENTER** button on the **NERO mAx** and wait for the **MAKE EXPOSURE** prompt.
6. Make an exposure.
7. After the exposure results are displayed in the first row of the Excel worksheet, click on **NERO mAx** and select **Retrieve Rad Waveform**.
8. After the radiation waveform is displayed, examine the waveform for preheat characteristics such as those shown in the first waveform of the following example. If no preheat effects are present; the x-ray machine's timer may be malfunctioning.

9. Determine the measurement delay time that is adequate to skip over the preheat portion of the output waveform. The delay should terminate after the last pulse of the filament preheat.
10. If the NERO mAx is still displaying the results of the last exposure, press the **MODE** key to return to the menu screen.
11. Enter the measurement delay needed to skip over the filament preheat effects. Enter a ***NEGATIVE*** delay if the delay time is not to be included in the measured exposure time.
12. Press the **ENTER** button and wait for the **MAKE EXPOSURE** prompt.
13. Make an exposure.
14. If the measured exposure time or number of pulses is not within the allowed tolerance, the x-ray machine's timer may be malfunctioning and further examination of the output waveform can be used to confirm the results.

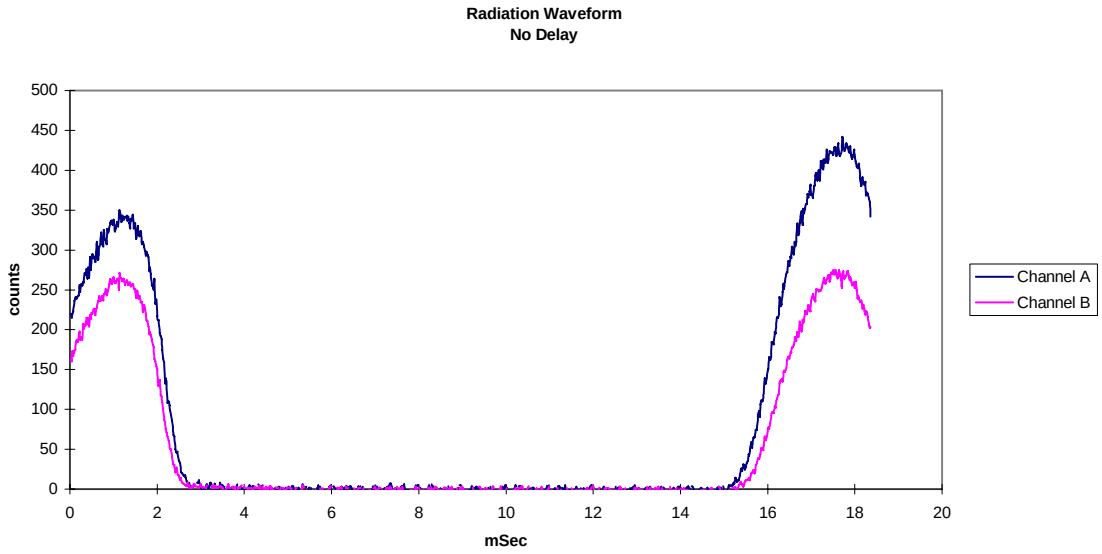
    A digital storage oscilloscope may also be connected to the scope output on the rear panel of the NERO mAx readout to view radiation output waveforms. Information on using the NERO mAx scope output may be found in section 3.2 of the NERO mAx instruction manual.

Examples

The radiation waveform below is from a single-phase dental x-ray machine (Gendex GX-770) that utilizes a filament preheat. The exposure time on this generator set in pulses (instead of milliseconds) but does not include the filament preheat pulses. For instance, when the exposure time control is set for 10 pulses, the generator actually outputs 24 pulses, 14 of which are filament preheat pulses.



Below is an example of what the NERO mAx "sees" when making a measurement without a delay on this type of generator. Note that the NERO mAx only sees two pulses during the filament preheat period. This is because the intensity of the remaining filament preheat pulses is so low that they fall below the detectability limit of the NERO mAx. This causes the NERO mAx to stop acquiring data, ending the measurement after the first two pulses resulting in a measured exposure time of 18.36 milliseconds.



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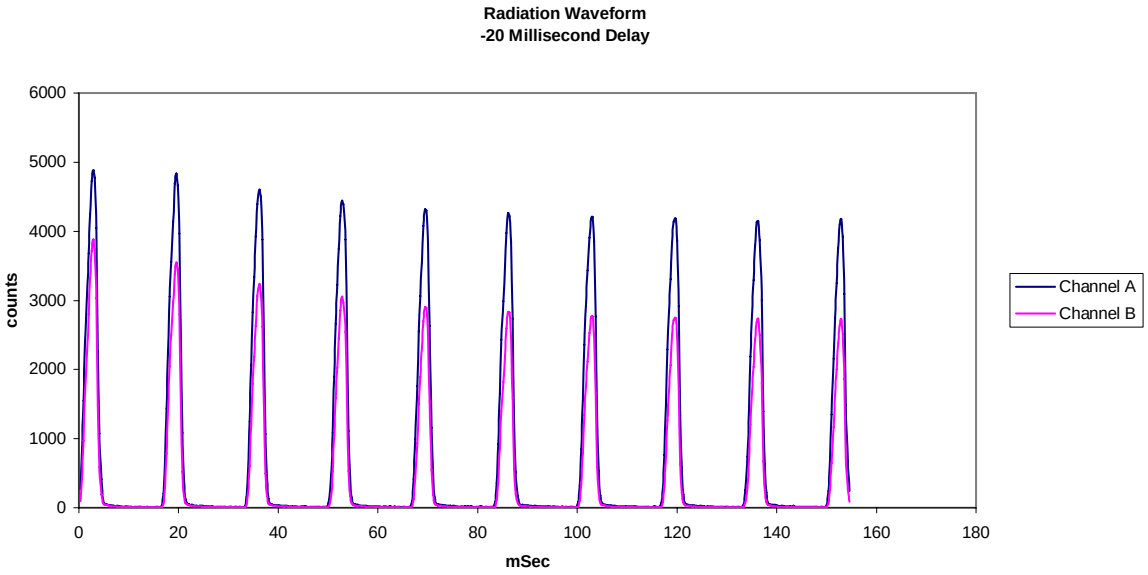
To accurately assess this generator's performance, a measurement delay should be used to skip over the filament preheat pulses. The radiation waveform below shows the effect of using a – 20 millisecond delay. Again, the x-ray generator was set for 14 pulses but the measurement delay caused the NERO mAx to skip the first 2 preheat pulses and only record the desired portion of the generator's output.



The NERO mAx Excel Add-In may be used to view radiation and kV waveforms to determine the optimum measurement delay to use. Information on using the NERO mAx Excel Add-In to view waveforms may be found in the NERO mAx Excel Add-In manual. In addition, a digital storage oscilloscope may be connected to the scope output on the rear panel of the NERO mAx readout to view radiation output waveforms. Information on using the NERO mAx scope output may be found in section 3.2 of the NERO mAx instruction manual.

Technical assistance

For technical assistance, please contact Fluke Biomedical, 6045 Cochran Road, Cleveland OH 44139, USA, tel 440.248.9300, fax 440.349.2307, email rmsinfo@flukebiomedical.com, or internet www.flukebiomedical.com/rms.

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FLOWCHART:
HOW TO USE THE MODEL 8000 NERO mAx TO EVALUATE DENTAL X-RAY MACHINE TIMER PERFORMANCE