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<b>Operating the Respiratory Gating Apparatus</b>		
Investigator: Jan Markowski	Location:	Revision: 00

**1.0 PURPOSE:**

The quality of scanned MicroCT images can be improved by triggering scan acquisition at regular intervals defined by the breathing cycle of a live specimen. This non-invasive image enhancement method can be accomplished with the use of a Respiratory Gating Apparatus (RGA) in conjunction with an Interval Generator, a PowerLab/4SP acquisition unit, and a computer with Chart software. As a forewarning, scanning procedures will take longer to perform with the use of the Respiratory Gating Apparatus.

**2.0 SCOPE:**

This document defines how to make the appropriate RGA connections and describes how the acquisition protocols differ from typical protocols. It does not outline how to use Chart, GE eXplore scan software, or any other processes associated with performing a safe and successful scan.

**3.0 RESPONSIBILITIES:**

The individual who will be performing the scan of the specimen on the host console is responsible for ensuring that all scans are conducted in accordance to standard scanning procedures notwithstanding the use of the additional equipment (RGA, PowerLab/4SP AU, etc.)

**4.0 DEFINITIONS:**

Diaphragm – The elastic PVC material on the pressure bed.  
 Pressure Bed – The device that a specimen lies on during the scan.  
 Protocol – Text file containing scan parameters  
 RGA – Respiratory Gating Apparatus

**5.0 REFERENCES:**

Brauer, M., Towner, R. A., Renaud, I., Janzen, E. G., and Foxall, D. L., "In vivo proton nuclear magnetic resonance imaging and spectroscopy studies of halocarbon-induced liver damage," Magn Reson Med. 9, pp. 229-39 (1989).

Ford, N. L., et al, "Prospective Respiratory-Gated Micro-CT Of Free Breathing Rodents", Med. Phys. 2005 (accepted)

**6.0 EQUIPMENT:**

- BNC (50Ω) cables
- BNC T connectors (1 Male/2 Female)
- Computer with Chart installed, USB/SCSI interface
- Interval Generator 1830
- Pressure Bed
- PowerLab/4SP Acquisition Unit
- Respiratory Gating Apparatus

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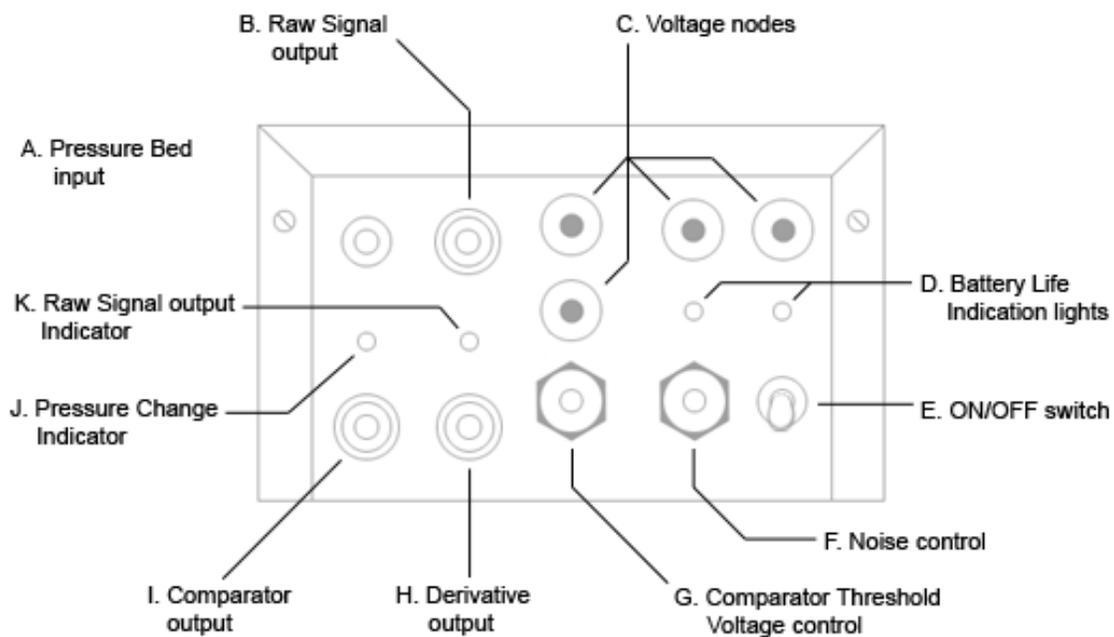
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**7.0 SPECIFICATIONS:**

**7.1 POWER SUPPLY**

Two 9V batteries

**7.2 RGA INTERFACE PANEL**



**Figure 7.1: Respiratory Gating Apparatus (front view)**

**A. PRESSURE BED INPUT**

Receives signals from the pressure transducer.

**B. RAW SIGNAL OUTPUT**

Outputs the raw signal received from the diaphragm to the PowerLab/4SP AU.

**C. VOLTAGE NODES**

Used for obtaining a voltage reading of the threshold voltage or a battery's voltage.

- BLACK – ground
- RED – positive terminal of battery A
- WHITE – negative terminal of battery B
- GREEN – threshold voltage node

**D. BATTERY LIFE INDICATION LIGHTS**

Both lights indicate the battery life of the RGA. If both lights are on, the batteries need to be changed.

**E. ON/OFF SWITCH**

Turn the unit ON or OFF.

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**F. NOISE CONTROL**

Potentiometer adjusts the noise level in the raw signal.

**G. COMPARATOR THRESHOLD VOLTAGE CONTROL**

Potentiometer adjusts for the threshold voltage that will trigger the output of a comparator voltage. The comparator voltage is used as a reference for triggering the x-ray shutter.

**H. DERIVATIVE OUTPUT**

Outputs the derivative control signal based on the raw signal.

**I. COMPARATOR OUTPUT**

Outputs a comparator signal dependant on the threshold voltage.

**J. PRESSURE CHANGE INDICATOR**

Green light blinks at the instant there is an increased pressure change.

**K. RAW SIGNAL OUTPUT INDICATOR**

Green light blinks each time a signal is outputted from the RAW SIGNAL OUTPUT.

**7.3 PRESSURE BED**

The pressure bed has an elastic PVC material that serves as the pressure sensor. An OFF switch can be located on the sensor cable. To maximize the strength of the input signal, a specimen should be placed on the pressure bed so that its central breathing point is centered on the diaphragm. The central breathing point is located below the posterior end of the ribs extending into the abdominal area.

**8.0 PROCEDURES:**

**8.0.1 CONNECTION SETUP**

*The order in which connections are made between the RGA and any external components is irrelevant. All connections are made with BNC (50Ω) connector cables and BNC T connectors unless otherwise specified. Connections can be performed while any units are ON.*

1. Connect the **Raw Signal Output** port of the RGA to **CH1** of the PowerLab/4SP.
2. Connect the **Comparator Output** port of the RGA to **CH2** of the PowerLab/4SP.
3. Connect the **External** port of the Pulse Train Model 1831 to **CH2** of the PowerLab/4SP.
4. Connect the **Variable Output** port of the Pulse Train Model 1831 to **CH3** of the PowerLab/4SP.
5. Connect **CH3** of the PowerLab/4SP to the **Enc** port located at the back of the X-Ray Shutter Control Unit (XSCU) of the scanner.
6. Connect the clear Pressure Bed sensor cable to the **Pressure Bed Input** of the RGA.

**8.0.2 SCAN PREPARATION**

1. Place the specimens abdominal point on the diaphragm. If the specimen is small (such as a mouse) it may need to be secured firmly to the pressure bed so that a stronger signal can be acquired. A respiratory pressure signal greater than 20 mV is

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required for good triggering, but a signal of 30-40 mV is desired to ensure no triggers are missed.

2. In order to acquire the signals in Chart, make sure that the PowerLab/4SP AU is ON before running Chart software.
3. Click **Start** to begin acquiring signals.
4. Adjust the **Delay** on the Pulse Train Module 1831. This value is the time between the beginning of the comparator signal and the beginning of the trigger signal. The trigger should be adjusted to the point where image capturing is desirable. Usually at the resting point of the breathing cycle.

### 8.0.3 SCAN INTERMISSION

*Between scans, turn OFF the RGA since it will not be triggering the x-ray shutter for scanning. This helps to extend the life of the RGA with the same set of batteries.*

### 8.0.4 CHANGING BATTERIES

*A battery change should be performed when both "battery life indication" lights are ON.*

1. Make sure the RGA is OFF.
2. Remove screws on the front panel.
3. Slide off the top encasement.
4. Replace the 9V batteries.
5. Reassemble the RGA.

## 8.1 CONTINGENCIES:

### 8.1.1 NO SIGNAL DISPLAY ON COMPUTER

If there is no data being acquired from the Chart software, it is probably because the PowerLab/4SP unit was OFF when Chart was executed. To resolve this problem:

- a. make sure the PowerLab/4SP unit is ON
- b. Rerun Chart
- c. Click **Start**.

## 9.0 PROTOCOL DEVIATIONS:

*Respiratory-gated protocols will deviate from typical ungated protocols so that image acquisitions are triggered and high image quality is preserved.*

### 9.1 INTEGRATION TIME

The INTEGRATION TIME is dependant on the respiratory cycle of the specimen and will typically have a smaller value than in ungated protocols. Small animals such as mice have very short respiratory cycles, which will require shorter integration times than larger animals such as rats.

### 9.2 FRAMES

The FRAMES value should be increased to compensate for the short integration time. This increases the x-ray dose and reduces the noise in the image.

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**9.3 TRIGGER**

The TRIGGER must be set to EDGE. For ungated protocols it is set to INTERNAL.

**10.0 REVIEWS AND REVISIONS:**

This procedure shall be reviewed for compliance and effectiveness and revised as necessary

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