

# Instruction Manual

# SAR-830/AP

## Small Animal Ventilator



***Read instructions carefully before operating this device.***

- 1 This device is not to be used for Human Life Support applications.
- 2 To avoid possible electrical shock, do not operate this device if it is wet or has had liquids spilled onto it.
- 3 Service or calibration procedures should only be performed by qualified personnel familiar with the electrical hazards of line-powered devices.



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## **STATEMENT OF WARRANTY**

IF THIS INSTRUMENT FAILS WITHIN A PERIOD OF ONE YEAR FROM THE DATE OF DELIVERY OR INSTALLATION, CWE, INC. WILL, AT ITS OPTION, REPAIR OR REPLACE IT FREE OF CHARGE. THIS WARRANTY EXCLUDES DAMAGE INCURRED THROUGH MISUSE OR ACCIDENT. CWE, INC. DOES NOT ASSUME ANY LIABILITY FOR ANY CONSEQUENTIAL DAMAGES RESULTING FROM THE USE OF THIS INSTRUMENT.

DEFECTIVE UNITS SHOULD BE RETURNED TO THE FACTORY ALONG WITH A NOTE DESCRIBING THE NATURE OF THE FAULT. THIS WARRANTY IS APPLICABLE TO THE ORIGINAL PURCHASER OF THE INSTRUMENT ONLY, AND IS NOT TRANSFERABLE.

## **FACTORY SERVICE**

Out of warranty or damaged instruments may be returned to the factory freight prepaid for service at prevailing rates. Upon request, a written or verbal quotation for such service will be issued after examination of the unit but prior to commencing repairs or service. Address requests for service or technical information to:

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Technical Support  
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## **LIFE SUPPORT POLICY**

Instruments manufactured by CWE, Incorporated are not authorized for use as critical components in human life support devices or systems. "Life support devices or systems", as used herein, are devices or systems whose failure to perform, whether through misuse, failure, or proper operation, can reasonably be expected to result in significant injury to the operator or subject persons.

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## 1.0 INTRODUCTION

The SAR-830/AP ventilator is for use with small animals up to about 1.5kg in body weight. This ventilator operates using the *flow-time* principle; a constant airflow is gated into the animal for a set time, thus producing a known tidal volume. This approach permits great flexibility in ventilation, since respiratory rate (RR), inspiratory time ( $T_i$ ), and airflow are independently set, and can all be adjusted while the ventilator is running. The SAR-830/AP includes end-inspiratory pressure control, permitting *pressure-cycled* ventilation in addition to the standard *volume-cycled* ventilation. The SAR-830/AP ventilator is compatible with anesthesia and oxygen. Isoflurane® vaporizers are available as an option.

A full set of controls and readouts is provided. Respiratory rate is set and monitored using a digital readout. Inspiratory time and pressure are set using calibrated 10-turn dials. Inspiratory airflow is set using a front-panel flowmeter/regulator. The SAR-830/AP has a built-in digital interface for controlling the ventilator from an external computer.

The SAR-830/AP can serve as a host controller for ventilating up to four additional animals. This is accomplished using external valve assemblies (CTP-VA series) which plug into a rear-panel expansion connector. Flowmeter manifolds are available for individually adjusting the inspiratory airflow to each animal using a single air source. This feature also permits the SAR-830/AP to be used with animals up to about 10kg in weight by selecting the appropriate external valve assembly.

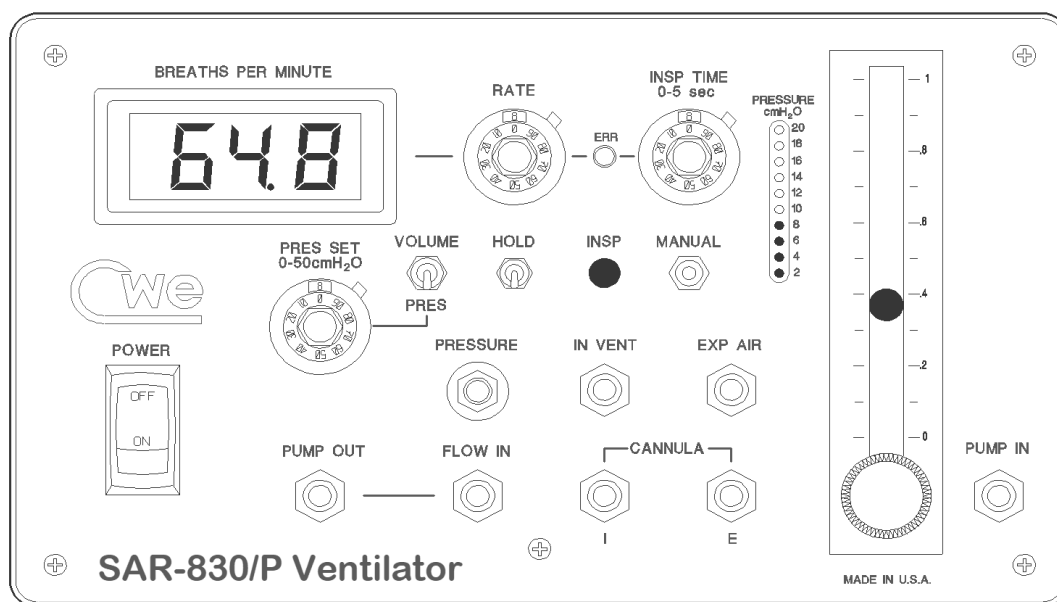


Figure 1: Model SAR-830/P Front Panel

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## 2.0 VENTILATOR CONNECTIONS AND SETUP

Setting up the SAR-830/AP is straightforward. Of the seven tubing ports on the front panel (see Figure 1), only three are required for basic ventilator operation: the 'I' and 'E' CANNULA ports, and the FLOW IN port. The remaining ports have special functions described later.

Connect the PUMP OUT port to the FLOW IN port with a short length of flexible tubing. In this case, the air pump is drawing room air in through the PUMP IN port.

**NOTE:** Do not apply a pressure to the PUMP IN port. Anesthetic mixtures, oxygen, or other gasses can be connected through a blow-by system using a "T" connector. See page 17 for a diagram.

The 'I' and 'E' CANNULA ports are connected to a 'Y' connector using the supplied tubing. The distal end of this 'Y' connects directly to the endotracheal tube. Note that the length of this tubing has no effect on ventilatory dead space.

A tube should connect the distal 'Y' connector to the PRESSURE port on the front panel. This port is used to monitor airway pressure.

Be sure that the LINE VOLTAGE SELECTOR switch (rear panel) is set correctly. Plug the line cord into the receptacle on the rear panel and plug the other end into a grounded power receptacle.

When the POWER switch is turned on, the digital rate meter should be lit, indicating that the unit is receiving power.

## 2.1 SIMPLE SETUP USING PRESSURE MODE

In PRESSURE mode, the ventilator will deliver inspiratory flow to the animal until the desired end-inspiratory pressure (as set on the PRES SET dial) is reached. When this pressure is reached, inspiratory flow is terminated, and the ventilator begins expiration.

Using this feature, you can quickly set up the ventilator without having to worry about the details of tidal volume setting. The procedure is described below:

1. Set the RESPIRATORY RATE to 50-60 (rat) or 90-100 bpm (mouse).
2. Set the PRES SET dial to (typically) 12cmH<sub>2</sub>O by dialing in 2.400 (remember that each turn of the 10-turn dial is 5cmH<sub>2</sub>O).
3. Switch the VOLUME/PRES switch to PRES to select pressure mode.
4. Reduce inspiratory flow so the flowmeter shows minimal flow (knob clockwise). Gradually increase flow (knob counterclockwise) until the INSP light is on for about ½ of the time (i.e., 50% inspiration).
5. If the ERR light blinks, then increase flow, since it is taking too long for inflation to occur with the set respiratory rate.

6. The ventilator will now automatically deliver just enough volume to inflate the lungs to the set pressure on each breath.

## 2.2 SETTING TIDAL VOLUME

Two adjustments are required to set any desired tidal volume (VT): **INSPIRATORY FLOW RATE**, and **INSPIRATORY TIME (T<sub>I</sub>)**. The Tidal Volume Tables in the Appendix provide a lookup guide for making these adjustments, or the values can be easily calculated. Some simple considerations will aid in understanding the process. For example, at a respiratory rate of 60 br/min, 1.0 second is available for the entire respiratory cycle. If we choose a 50% inspiratory/expiratory ratio, then 0.5 second is available for inspiration (T<sub>I</sub>). Once T<sub>I</sub> is decided upon, the **INSPIRATORY FLOW** rate is set to deliver the desired volume in the allotted time. The Tidal Volume Tables enable looking up these values, or they can be calculated using simple equations derived as follows:

### **Basic equations:**

$$VT = \text{Flow} \times T_I \quad (\text{volume} = \text{flow} \times \text{time})$$

$$T_I = (60 / RR) / 2 \quad (T_I = \text{reciprocal of resp rate, divided by 2})$$

(assumes 50% inspiration),

simplifying to:

$$T_I = 30 / RR$$

$$\text{Flow} = VT / T_I \quad (\text{flow} = \text{volume divided by time})$$

### **Derived equations:**

Since T<sub>I</sub> is in seconds, and the flow rate is set in ml/minute, the following will automatically give the flow rate that should be set on the flowmeter:

$$\text{Flow (ml/min)} = (60 \times VT) / T_I$$

If a 50% inspiration/expiration ratio is assumed, determining insp flow further simplifies to the following:

$$\text{Flow (ml/min)} = 2 \times VT \times RR \quad (2 \times \text{tidal volume} \times \text{resp rate})$$

Where VT is in ml and RR is in breaths/minute.

This scheme provides flexibility over the mechanics and timing of respiration. Once set up for a given VT, it is a simple matter to increase or decrease volume by changing the flow rate, or by increasing or decreasing T<sub>I</sub>. The only constraint is that T<sub>I</sub> does not exceed the available time as determined by the **RATE** setting. If T<sub>I</sub> attempts to overlap

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the next breath, the ERR light will blink as a warning that either  $T_I$  or RESP RATE should be reduced.

## 3.0 OPERATING CONTROLS AND READOUTS

### 3.1 RATE KNOB AND METER

This knob adjusts the respiratory rate. The actual rate is displayed on the digital rate meter. The range of this control is approximately 5 - 190 breaths/minute. The knob itself is uncalibrated.

**NOTE: Faster or slower rates can be achieved using the DATA INTERFACE control inputs.**

### 3.2 INSPIRATORY TIME ( $T_I$ ) KNOB

This ten-turn dial sets the duration of inspiration from zero to five seconds. Each turn of the dial thus represents  $\frac{1}{2}$  second, or 500mS.

**NOTE: This control takes precedence over the RATE setting. Be careful not to set  $T_I$  to a time greater than  $1/\text{rate}$ , or the indicated rate will be erroneous. If this condition exists, the ERROR light will blink.**

### 3.3 HOLD SWITCH

When switched to HOLD, the ventilator is put into a constant expiration mode. To resume normal ventilation, switch to the NORM position. This function is also available on the DATA INTERFACE.

### 3.4 MANUAL INSPIRATION PUSHBUTTON

Pressing this pushbutton causes inspiration to occur, regardless of the state of the ventilator. Inspiration persists as long as the pushbutton is depressed. This function is useful for generating a sigh, or temporary hyperinflation. This function is also available on the DATA INTERFACE.

### 3.5 SYNC OUT JACK (rear panel)

This BNC jack provides a TTL-compatible logic signal corresponding to the current phase of ventilation. Inspiration is logic LOW and expiration is logic HIGH. This signal is also available on pin 20 of the DATA INTERFACE (rear panel).

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### 3.6 RATE OUT JACK (rear panel)

This BNC jack provides an analog voltage directly proportional to the respiratory rate. The scale factor is 10mV/breath/minute. This signal is also available on pin 14 of the **DATA INTERFACE** (rear panel).

### 3.7 FLOWMETER

The rotameter-type flowmeter on the front panel is used to set and monitor the **INSPIRATORY FLOW RATE**. Flow is measured from the center of the float ball. The knob at the bottom adjusts the flow. The standard range of 1.0 liter/minute is useful for most rodent-sized animals. Other ranges are available for larger or smaller animals.

### 3.8 EXTERNAL VALVE JACK (rear panel)

This 4-pin jack is used to connect an **EXTERNAL VALVE ASSEMBLY** to the ventilator for ventilating additional animals. Any of the CTP-VA series valves may be used, enabling the SAR-830/AP to ventilate multiple animals, or larger animals than can be accommodated using the SAR-830/AP internal valves. One CTP-VA-3 or up to four CTP-VA-1 assemblies can be connected in parallel for multiple animal ventilation setups.

### 3.9 VOLUME/PRESSURE SWITCH

This switch selects whether the ventilator is operating in **VOLUME** or **PRESSURE** mode. In **VOLUME** mode, the normal tidal volume controls are in effect. In **PRESSURE MODE**, each inspiration will continue until the set end-inspiratory pressure has been reached.

### 3.10 PRESSURE SET DIAL

This ten-turn dial sets the end-inspiratory pressure when the ventilator is operated in **PRESSURE** mode. The range of the control is 0 - 50cmH<sub>2</sub>O, or 5cmH<sub>2</sub>O per turn of the dial.

### 3.11 ANALOG PRESSURE OUT

This BNC jack provides an analog voltage corresponding to the airway pressure. The scale factor is 50mV/cmH<sub>2</sub>O. This signal is also available on pin 15 of the **DATA INTERFACE** (rear panel).

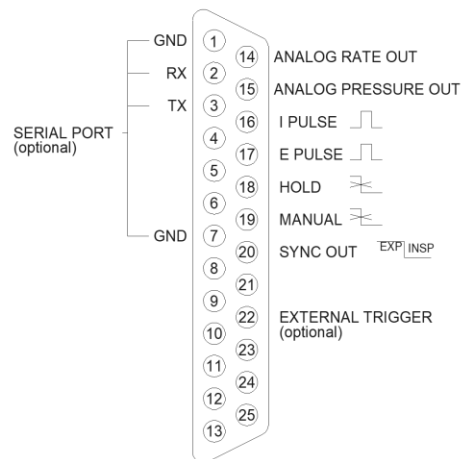
### 3.12 DATA INTERFACE (rear panel)

This DB-25 connector provides access to a number of monitoring outputs and control inputs. Using these inputs, it is possible to control the ventilator from an external device such as a computer. All the logic inputs are TTL-compatible. The output signals have the same properties as described elsewhere in this manual. The correct mating connector is a DB-25 male connector.

#### Standard SAR-830 DATA INTERFACE connections:

Pin 1	Ground
Pin 14	Analog Rate Output
Pin 15	Analog Pressure Output
Pin 16	Inspiratory Pulse, 100 $\mu$ S pulse at start of inspiration
Pin 17	Expiratory Pulse, 100 $\mu$ S pulse at start of expiration
Pin 18	HOLD Input (NORM=HIGH, HOLD=LOW)
Pin 19	MANUAL Input (NORM=HIGH, MAN INSPIRATION=LOW)
Pin 20	SYNC OUT (EXP=HIGH, INSP=LOW)

## SAR-830 DATA PORT



Required connector is  
DB25P male plug



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## 4.0 PORT CONNECTIONS

### 4.1 PUMP IN

This is the inlet port for the internal air pump ('A' suffix models only). Normally, room air will be drawn in through this port. Other gasses can be used, but pressure sources should not be directly connected here. If gas mixtures are being used, use a flexible gas collection bag as a collapsible reservoir.

### 4.2 PUMP OUT

This is the outlet port for the internal air pump. To use the internal air pump as the ventilator pressure source, connect this port to the adjacent **FLOW IN** port.

### 4.3 FLOW IN

This is the main pressure inlet for the ventilator. The compressed air (or other gas) introduced here is the source of inspiratory airflow. This pressure should be within the range 3-20psi. The output of most anesthesia machines can be connected to this port.

### 4.4 CANNULA 'I' AND 'E'

These ports connect to the animal's tracheal tube through flexible tubing, and a distal 'Y' connector. The 'I' port provides airflow during inspiration. The 'E' port accepts passive expiratory airflow during expiration. Since airflow is unidirectional through the tubing connected to these ports, the tubing length does not contribute to dead space. In practice, the tubing lengths should be kept as short as practicable to minimize flow resistance and the compressible volume of the system.

### 4.5 EXPIRED AIR

This port can be used to collect or analyze expired air. If desired, Positive End-Expiratory Pressure (PEEP) can be introduced by placing a tube connected to this port under a suitable depth of water.

## 4.6 INSPIRATORY VENT

This is where excess inspiratory airflow goes during expiration. During ventilator operation, a constant inspiratory airflow is established. This flow is gated either into the animal through the 'I' port, or out the **INSP VENT** port. If you are using Isoflurane or other anesthetic gasses, it may be necessary to collect or scrub the gas coming out this port.

## 4.7 PRESSURE

This female Luer® connection provides the inlet to the internal airway pressure transducer. This should be connected to a tap close to the animal's tracheal tube. Check this tubing periodically to be sure condensed moisture or other fluids have not entered it. Any blockages will prevent proper operation of pressure-cycled ventilation.

## 5.0 PRESSURE TRANSDUCER CALIBRATION

The solid-state pressure transducer installed in the SAR-830/AP models provides exceptional reliability and stability. This is factory calibrated and will not normally need to be adjusted.

**CAUTION!** Do not apply pressures than 10psi to the **PRESSURE** port. Permanent damage to the transducer will result.

**CAUTION!** Do not allow water or other fluids to enter the **PRESSURE** port. If condensation is a problem, consider installing a moisture trap in the tubing leading to the transducer. Moisture in the transducer will cause zero offsets to occur and will affect the accuracy of the transducer.

Calibration is performed as follows. The **TRANSDUCER ZERO** and **SPAN** trimpots are located on the rear panel of the ventilator.

- ❶ Allow the ventilator to warm up for at least 10 minutes before proceeding.
- ❷ Connect a manometer to the **PRESSURE** port. Connect a voltmeter to the **ANALOG PRESSURE OUT** jack on the rear panel.
- ❸ With the manometer open to atmosphere (zero pressure), adjust the **TRANSDUCER ZERO** trimpot until the observed reading is  $0.000V \pm .005V$ .

- ④ Apply a constant pressure (say 20 cmH<sub>2</sub>O) to the transducer. Adjust the **TRANSDUCER SPAN** trimpot, if necessary, until the meter reading is correct. The scale factor is 50mV/cmH<sub>2</sub>O.
- ⑤ Repeat steps 3 and 4 above, if necessary, until the readings are correct for both zero and the calibration pressure.

## 6.0 OPTIONS

Although the SAR-830/AP meets most small animal ventilation needs, it is possible to customize the ventilator for special purposes. The most common optional configurations are listed below.

### 6.1 MOUSE KIT: Mouse-size components

The Mouse Kit comprises a special small-diameter tubing set and a 100 ml/min flowmeter on a stand. The **FLOWMETER** is connected between the **PUMP OUT** and **FLOW IN** ports and allows finer adjustment of **INSPIRATORY FLOW**, suitable for mice or other small animals.

### 6.2 ANESTHESIA SETUPS

CWE, Inc. can provide complete anesthesia setups for small animal use. A simple system comprises an SAR-830/AP ventilator, an anesthetic vaporizer, and an external flowmeter. The simplest configuration involves connecting the **OUTPUT** of the anesthesia vaporizer to the **PUMP IN** port of the ventilator using a “T” connector. This *blow-by* configuration allows the ventilator to draw in the gas it needs from the stream passing across the “T” connector. This places minimal stress on the vaporizer. A diagram is included here (page 17) showing the preferred connections.

## 7.0 EXPANDING THE SAR-830/AP SYSTEM

One of the most powerful features of the SAR-830/AP is its expandability. By simply plugging in an additional valve assembly, an additional animal can be ventilated. Although the SAR-830/AP is primarily a rodent ventilator, this expansion feature allows larger animals to be ventilated by adding the appropriate **EXTERNAL VALVE ASSEMBLY**. For each additional animal, you need a valve assembly, a flowmeter/regulator, and an air source. The following table shows which valve assemblies and flowmeters to use for various animals:

Valve Assembly	Flowmeter	Animal
CTP-VA-1	EFM-1-100	Mouse
CTP-VA-1	EFM-1-1	Rat, Guinea pig
CTP-VA-3	EFM-1-2.5	Rabbit (up to 10kg max)

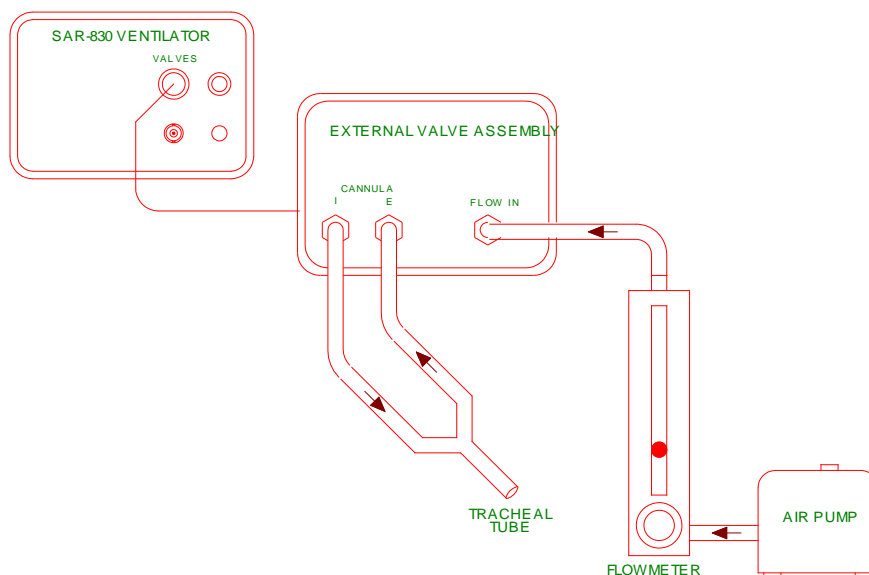


Figure 2: Expanding the SAR-830/AP with an **EXTERNAL VALVE ASSEMBLY**

When adding more than one **EXTERNAL VALVE ASSEMBLY**, an electrical cable adapter is required (Part No. MVA-4). This part provides four expansion jacks for adding the valve assemblies. With multiple animal setups, a **FLOWMETER MANIFOLD** (Part No. EFM-4-x) is useful. With this manifold, one air source can be used for all the animals being ventilated.

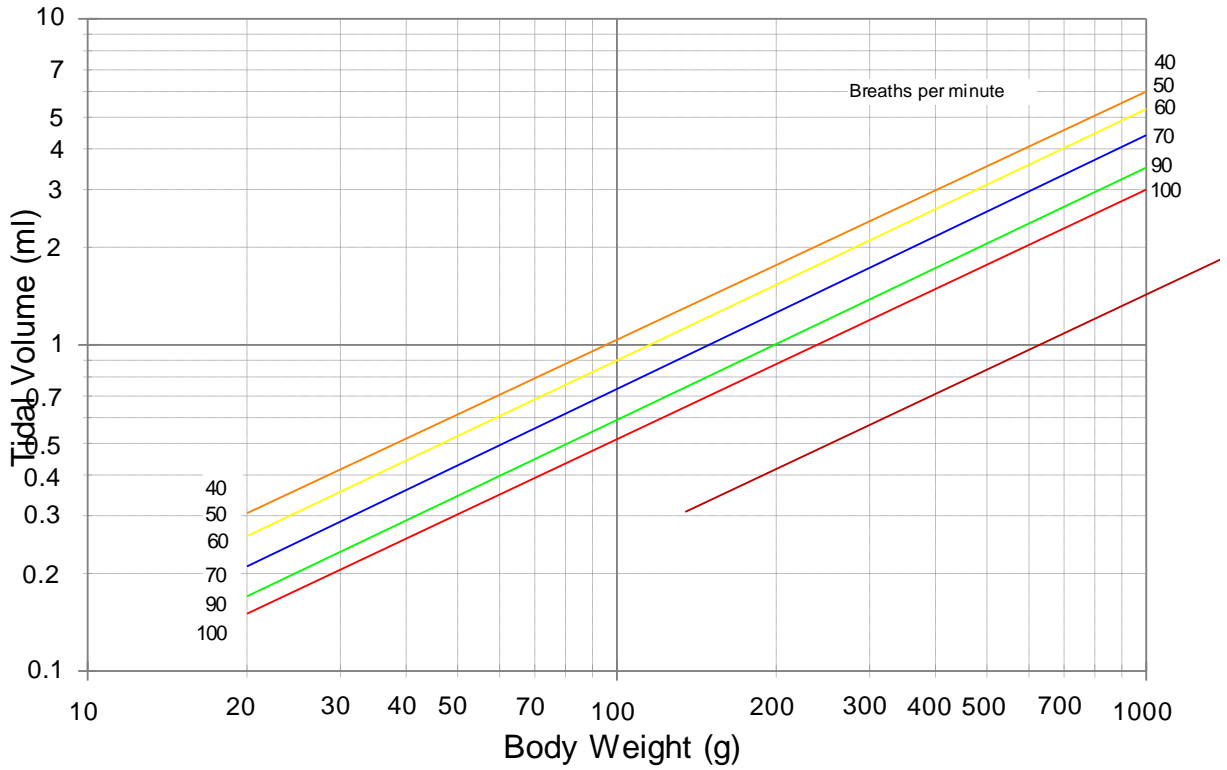
Note that each additional valve assembly becomes another ventilator. Any such additional ventilator stations will have identical timing to the host SAR-830/AP, but the tidal volume of each can be set independently by adjusting the individual inspiratory airflows.

## 8.0 ORDERING INFORMATION

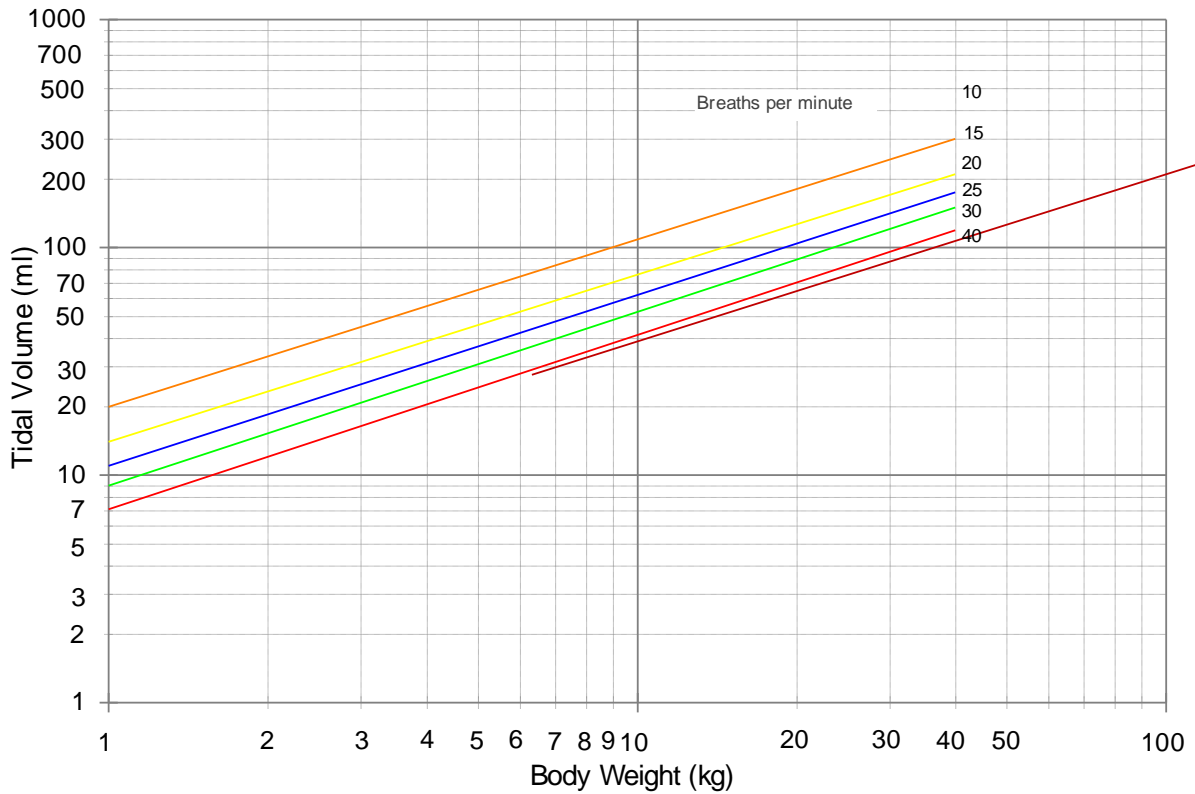
PART N°	MODEL	DESCRIPTION
12-02100	SAR-830/AP	Small Animal Ventilator, Volume/ Pressure cycled (with internal pump), 115/230V operation
12-04000	CTP-VA-1	Solenoid Valve Assembly, mouse to Guinea pig size (same as SAR internal)
12-05000	CTP-VA-3	Solenoid Valve Assembly, rabbit to cat size (up to 10kg max)
12-10010	MVA-4	Multi-valve electrical adapter for adding up to 4 external valve assemblies
12-10020	EFM-1	Flowmeter/regulator with stand, specify range: 100ml, 1, 2.5, 5, 10, or 20 l/min
12-10021	EFM-4	Flowmeter/regulator manifold w/ 4 flowmeters, with stand, specify range
12-01020	Mouse Kit	Includes flowmeter with stand, tubing set for body weight 10g – 100g
13-21031	TRACH-1	Endotracheal tube, flexible Teflon w/ Luer connector (mouse), 20 gauge, pk of 5
13-21032	TRACH-2	Endotracheal tube, flexible Teflon w/ Luer connector (rat), 14 gauge, pk of 5
12-01114	“W” Connector	Pack of 2 “W” Connectors
12-91001	Tiny Test Balloon	Latex Test Balloon, tiny/ extra-small, mouse, approximate volume 1cc (pack of 5)
12-91002	Small Test Balloon	Latex Test Balloon, small, rat, approximate volume 5ml (pack of 5)
12-91003	Large Test Balloon	Latex Test Balloon, large, rabbit size, approximate volume 20ml (pack of 5)
11-10000	CAPSTAR-100	End-tidal CO <sub>2</sub> Analyzer, complete with accessory pack, 115/230V operation
13-13000	Isoflurane Kit	Vaporizer, Isoflurane 0.5 - 5.0% with flowmeter on stand

APPENDIX 1: TIDAL VOLUME VS. BODY WEIGHT CHARTS

Tidal Volume Chart



Tidal Volume Chart



**APPENDIX 2: TIDAL VOLUME TABLES**

Flow Rate (cc/min)

I Time (sec)	Typ Rate	Flow Rate (cc/min)									
		100	200	300	400	500	600	700	800	900	1000
0.1	300	0.2	0.3	0.5	0.7	0.8	1.0	1.2	1.3	1.5	1.7
0.2	150	0.3	0.7	1.0	1.3	1.7	2.0	2.3	2.7	3.0	3.3
0.3	100	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
0.4	75	0.7	1.3	2.0	2.7	3.3	4.0	4.7	5.3	6.0	6.7
0.5	60	0.8	1.7	2.5	3.3	4.2	5.0	5.8	6.7	7.5	8.3
0.6	50	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
0.7	43	1.2	2.3	3.5	4.7	5.8	7.0	8.2	9.3	10.5	11.7
0.8	38	1.3	2.7	4.0	5.3	6.7	8.0	9.3	10.7	12.0	13.3
0.9	33	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0
1.0	30	1.7	3.3	5.0	6.7	8.3	10.0	11.7	13.3	15.0	16.7
1.1	27	1.8	3.7	5.5	7.3	9.2	11.0	12.8	14.7	16.5	18.3
1.2	25	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
1.3	23	2.2	4.3	6.5	8.7	10.8	13.0	15.2	17.3	19.5	21.7
1.4	21	2.3	4.7	7.0	9.3	11.7	14.0	16.3	18.7	21.0	23.3
1.5	20	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0
1.6	19	2.7	5.3	8.0	10.7	13.3	16.0	18.7	21.3	24.0	26.7
1.7	18	2.8	5.7	8.5	11.3	14.2	17.0	19.8	22.7	25.5	28.3
1.8	17	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0
1.9	16	3.2	6.3	9.5	12.7	15.8	19.0	22.2	25.3	28.5	31.7
2.0	15	3.3	6.7	10.0	13.3	16.7	20.0	23.3	26.7	30.0	33.3
2.1	14	3.5	7.0	10.5	14.0	17.5	21.0	24.5	28.0	31.5	35.0
2.2	14	3.7	7.3	11.0	14.7	18.3	22.0	25.7	29.3	33.0	36.7
2.3	13	3.8	7.7	11.5	15.3	19.2	23.0	26.8	30.7	34.5	38.3
2.4	12	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0
2.5	12	4.2	8.3	12.5	16.7	20.8	25.0	29.2	33.3	37.5	41.7
2.6	12	4.3	8.7	13.0	17.3	21.7	26.0	30.3	34.7	39.0	43.3
2.7	11	4.5	9.0	13.5	18.0	22.5	27.0	31.5	36.0	40.5	45.0
2.8	11	4.7	9.3	14.0	18.7	23.3	28.0	32.7	37.3	42.0	46.7
2.9	10	4.8	9.7	14.5	19.3	24.2	29.0	33.8	38.7	43.5	48.3
3.0	10	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0
3.1	10	5.2	10.3	15.5	20.7	25.8	31.0	36.2	41.3	46.5	51.7
3.2	9	5.3	10.7	16.0	21.3	26.7	32.0	37.3	42.7	48.0	53.3
3.3	9	5.5	11.0	16.5	22.0	27.5	33.0	38.5	44.0	49.5	55.0
3.4	9	5.7	11.3	17.0	22.7	28.3	34.0	39.7	45.3	51.0	56.7
3.5	9	5.8	11.7	17.5	23.3	29.2	35.0	40.8	46.7	52.5	58.3
3.6	8	6.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0
3.7	8	6.2	12.3	18.5	24.7	30.8	37.0	43.2	49.3	55.5	61.7
3.8	8	6.3	12.7	19.0	25.3	31.7	38.0	44.3	50.7	57.0	63.3
3.9	8	6.5	13.0	19.5	26.0	32.5	39.0	45.5	52.0	58.5	65.0
4.0	7	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7
4.1	7	6.8	13.7	20.5	27.3	34.2	41.0	47.8	54.7	61.5	68.3
4.2	7	7.0	14.0	21.0	28.0	35.0	42.0	49.0	56.0	63.0	70.0
4.3	7	7.2	14.3	21.5	28.7	35.8	43.0	50.2	57.3	64.5	71.7
4.4	7	7.3	14.7	22.0	29.3	36.7	44.0	51.3	58.7	66.0	73.3
4.5	7	7.5	15.0	22.5	30.0	37.5	45.0	52.5	60.0	67.5	75.0
4.6	7	7.7	15.3	23.0	30.7	38.3	46.0	53.7	61.3	69.0	76.7
4.7	6	7.8	15.7	23.5	31.3	39.2	47.0	54.8	62.7	70.5	78.3
4.8	6	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0
4.9	6	8.2	16.3	24.5	32.7	40.8	49.0	57.2	65.3	73.5	81.7
5.0	6	8.3	16.7	25.0	33.3	41.7	50.0	58.3	66.7	75.0	83.3

## APPENDIX 2, cont'd: TIDAL VOLUME TABLES

Flow Rate (cc/min)

Time (sec)	Typ Rate	200	400	600	800	1000	1200	1400	1600	1800	2000
0.2	150	0.7	1.3	2.0	2.7	3.3	4.0	4.7	5.3	6.0	6.7
0.4	75	1.3	2.7	4.0	5.3	6.7	8.0	9.3	10.7	12.0	13.3
0.6	50	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
0.8	38	2.7	5.3	8.0	10.7	13.3	16.0	18.7	21.3	24.0	26.7
1.0	30	3.3	6.7	10.0	13.3	16.7	20.0	23.3	26.7	30.0	33.3
1.2	25	4.0	8.0	12.0	16.0	20.0	24.0	28.0	32.0	36.0	40.0
1.4	21	4.7	9.3	14.0	18.7	23.3	28.0	32.7	37.3	42.0	46.7
1.6	19	5.3	10.7	16.0	21.3	26.7	32.0	37.3	42.7	48.0	53.3
1.8	17	6.0	12.0	18.0	24.0	30.0	36.0	42.0	48.0	54.0	60.0
2.0	15	6.7	13.3	20.0	26.7	33.3	40.0	46.7	53.3	60.0	66.7
2.2	14	7.3	14.7	22.0	29.3	36.7	44.0	51.3	58.7	66.0	73.3
2.4	13	8.0	16.0	24.0	32.0	40.0	48.0	56.0	64.0	72.0	80.0
2.6	12	8.7	17.3	26.0	34.7	43.3	52.0	60.7	69.3	78.0	86.7
2.8	11	9.3	18.7	28.0	37.3	46.7	56.0	65.3	74.7	84.0	93.3
3.0	10	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0	90.0	100.0
3.2	9	10.7	21.3	32.0	42.7	53.3	64.0	74.7	85.3	96.0	106.7
3.4	9	11.3	22.7	34.0	45.3	56.7	68.0	79.3	90.7	102.0	113.3
3.6	8	12.0	24.0	36.0	48.0	60.0	72.0	84.0	96.0	108.0	120.0
3.8	8	12.7	25.3	38.0	50.7	63.3	76.0	88.7	101.3	114.0	126.7
4.0	7	13.3	26.7	40.0	53.3	66.7	80.0	93.3	106.7	120.0	133.3
4.2	7	14.0	28.0	42.0	56.0	70.0	84.0	98.0	112.0	126.0	140.0
4.4	7	14.7	29.3	44.0	58.7	73.3	88.0	102.7	117.3	132.0	146.7
4.6	7	15.3	30.7	46.0	61.3	76.7	92.0	107.3	122.7	138.0	153.3
4.8	6	16.0	32.0	48.0	64.0	80.0	96.0	112.0	128.0	144.0	160.0
5.0	6	16.7	33.3	50.0	66.7	83.3	100.0	116.7	133.3	150.0	166.7
5.2	6	17.3	34.7	52.0	69.3	86.7	104.0	121.3	138.7	156.0	173.3
5.4	6	18.0	36.0	54.0	72.0	90.0	108.0	126.0	144.0	162.0	180.0
5.6	5	18.7	37.3	56.0	74.7	93.3	112.0	130.7	149.3	168.0	186.7
5.8	5	19.3	38.7	58.0	77.3	96.7	116.0	135.3	154.7	174.0	193.3
6.0	5	20.0	40.0	60.0	80.0	100.0	120.0	140.0	160.0	180.0	200.0
6.2	5	20.7	41.3	62.0	82.7	103.3	124.0	144.7	165.3	186.0	206.7
6.4	5	21.3	42.7	64.0	85.3	106.7	128.0	149.3	170.7	192.0	213.3
6.6	5	22.0	44.0	66.0	88.0	110.0	132.0	154.0	176.0	198.0	220.0
6.8	4	22.7	45.3	68.0	90.7	113.3	136.0	158.7	181.3	204.0	226.7
7.0	4	23.3	46.7	70.0	93.3	116.7	140.0	163.3	186.7	210.0	233.3
7.2	4	24.0	48.0	72.0	96.0	120.0	144.0	168.0	192.0	216.0	240.0
7.4	4	24.7	49.3	74.0	98.7	123.3	148.0	172.7	197.3	222.0	246.7
7.6	4	25.3	50.7	76.0	101.3	126.7	152.0	177.3	202.7	228.0	253.3
7.8	4	26.0	52.0	78.0	104.0	130.0	156.0	182.0	208.0	234.0	260.0
8.0	4	26.7	53.3	80.0	106.7	133.3	160.0	186.7	213.3	240.0	266.7
8.2	4	27.3	54.7	82.0	109.3	136.7	164.0	191.3	218.7	246.0	273.3
8.4	4	28.0	56.0	84.0	112.0	140.0	168.0	196.0	224.0	252.0	280.0
8.6	3	28.7	57.3	86.0	114.7	143.3	172.0	200.7	229.3	258.0	286.7
8.8	3	29.3	58.7	88.0	117.3	146.7	176.0	205.3	234.7	264.0	293.3
9.0	3	30.0	60.0	90.0	120.0	150.0	180.0	210.0	240.0	270.0	300.0
9.2	3	30.7	61.3	92.0	122.7	153.3	184.0	214.7	245.3	276.0	306.7
9.4	3	31.3	62.7	94.0	125.3	156.7	188.0	219.3	250.7	282.0	313.3
9.6	3	32.0	64.0	96.0	128.0	160.0	192.0	224.0	256.0	288.0	320.0
9.8	3	32.7	65.3	98.0	130.7	163.3	196.0	228.7	261.3	294.0	326.7
10.0	3	33.3	66.7	100.0	133.3	166.7	200.0	233.3	266.7	300.0	333.3



APPENDIX 3: TYPICAL VENTILATOR SETTINGS FOR RODENTS

Body Weight (g)	Tidal Volume (ml)	Resp Rate (br/min)	Insp Flow (ml/min)	Insp Time (s)	Dial Setting (turns)
30	0.22	90	40	0.33	0.67
50	0.40	75	60	0.40	0.80
100	0.90	60	110	0.50	1.00
200	1.70	50	170	0.60	1.20
300	2.30	50	230	0.60	1.20
500	4.00	40	320	0.75	1.50

**Note:** Settings above are suggested guidelines. You will probably need to adjust the settings for your particular animal, depending on its condition, anesthesia, or other factor

