SAR-830 series
Small Animal Ventilators
Instruction Manual

Read instructions carefully before operating this device.

❶ *This device is not to be used for Human Life Support applications.*

❷ *To avoid possible electrical shock, do not operate this device if is wet or has had liquids spilled onto it.*

❸ *Service or calibration procedures should only be performed by qualified personnel familiar with the electrical hazards of line-powered devices.*

CWE, Inc.

25 St.Paul's Road
Ardmore PA 19003 U.S.A.
(610)642-7719 FAX (610)642-1532

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:

CWE, Incorporated
Technical Support
25 St.Paul's Road
Ardmore, PA 19003 U.S.A.
(610)642-7719

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.

1.0 INTRODUCTION

The SAR-830 series are ventilators for use with small animals up to about 1.5kg in body weight. These ventilators operate 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. Model SAR-830/P includes end-inspiratory pressure control, permitting *pressure-cycled* ventilation in addition to the standard *volume-cycled* ventilation. Models with an "A" suffix contain a built-in air pump; otherwise a source of compressed air or other gas (3-20psi) is required for operation. All SAR-830 models are compatible with anesthesia and oxygen. Halothane and 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 (SAR-830/P models) are set using calibrated 10-turn dials. Inspiratory airflow is set using a front-panel flowmeter/regulator. All models have a built-in digital interface for controlling the ventilator from an external computer.

The SAR-830 can serve as a master 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 to be used with animals up to dog-size by selecting the appropriate external valve assembly.

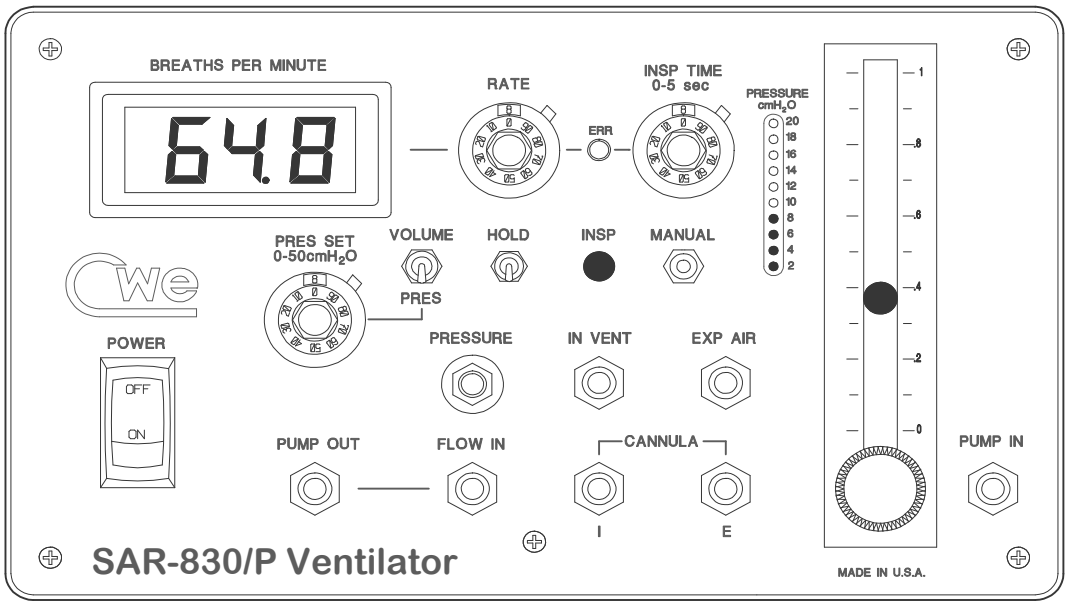


Figure 1: Model SAR-830/P Front Panel

2.0 VENTILATOR CONNECTIONS AND SETUP

Setting up the SAR-830 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.

A suitable source of compressed air or breathing gas is connected to the **FLOW IN** port. If your model has a built-in air pump ('A' suffix), 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: If the built-in air pump is being used, do not apply a pressure to the PUMP IN port. A collapsible bag with a gas mixture can, however, be connected to this port.***

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.

On pressure-cycled models ('P' suffix), 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 (SAR-830/P)

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_2O by dialing in 2.400 (remember that each turn of the 10-turn dial is 5cmH_2O).
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 (all models)

Two adjustments are required to set any desired tidal volume (VT): **INSPIRATORY FLOW RATE**, and **INSPIRATORY TIME** (T_I). 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_I). Once T_I is decided upon, the **INSPIRATORY FLOW** rate is set to deliver the desired volume in the alotted time. The Tidal Volume Tables enable looking up these values, or they can be calculated using simple equations derived as follows:

Basic equations:

$VT = Flow \times T_I$	(volume = flow X time)
$T_I = (1 / RR) / 2$	(TI = reciprocal of resp rate, divided by 2)
	(assumes 50% inspiration)
Flow = VT / TI	(flow = volume divided by time)

Derived equations:

Since T_I 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:

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

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

Flow (ml/min) = 2 X VT X RR (2 X tidal volume X resp rate)

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

This scheme provides extraordinary 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_I. The only constraint is that T_I not exceed the available time as determined by the **RATE** setting. If T_I attempts to overlap 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 ½ 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/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.

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.

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).

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 to ventilate multiple animals, or larger animals than can be accommodated using the SAR-830 internal valves. Up to four CTP-VA series assemblies can be connected in parallel for multiple animal ventilation setups.

3.9 VOLUME/PRESSURE SWITCH (SAR-830/P models only)

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 (SAR-830/P models only)

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_2O, or 5cmH_2O per turn of the dial.

3.11 ANALOG PRESSURE OUT (SAR-830/P models only)

This BNC jack provides an analog voltage corresponding to the airway pressure. The scale factor is 50mV/cmH_2O. This signal is also available on pin 15 of the **DATA INTERFACE** (rear panel).

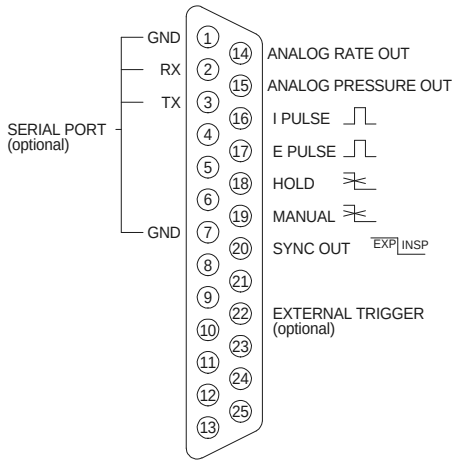
3.12 DATA INTERFACE (rear panel)

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, 100µS pulse at start of inspiration
Pin 17	Expiratory Pulse, 100µS 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

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 ('A' suffix models only). 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 Halothane or other anesthetic gasses, it may be necessary to collect or scrub the gas coming out this port.

4.7 PRESSURE (SAR-830/P models only)

This female Luer-lok® 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/P models provides exceptional reliability and stability. To insure correct ventilator operation, the transducer's calibration should be checked at least every six months.

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 ± .005V.

❹ Apply a constant pressure (say 20 cmH_2O) to the transducer. Adjust the **TRANSDUCER SPAN** trimpot, if necessary, until the meter reading is correct. The scale factor is 50mV/cmH_2O.

❺ 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 four basic configurations of the SAR-830 series meet 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 OPTION 041: Mouse-size components

This option provides special miniature internal components, a 100cc/min flowmeter, and a special reduced-volume external tubing set. This has been specially designed and field-tested for ventilating mice, neonatal rats, and other very small animals with tidal volumes in the 0.1cc - 1.0cc range.

6.2 ANESTHESIA SETUPS

CWE, Inc. can provide complete anesthesia setups for small animal use. A simple system comprises an SAR-830 series ventilator, a Floutec® or Isotec® vaporizer, and an external flowmeter. The simplest configuration involves connecting the **OUTPUT** of the anesthesia vaporizer to the **FLOW IN** port of the ventilator. For small animals, the SAR-830 internal airpump can be used as the vaporizer pressure source. A preferred method uses a rubber compliance bag (breathing bag) as a reservoir from which the ventilator draws its gas. This places minimal stress on the vaporizer, and allows the ventilator to draw in gas as required. A diagram is included here illustrating the various configurations.

7.0 EXPANDING THE SAR-830 SYSTEM

One of the most powerful features of the SAR-830 series is its expandability. By simply plugging in an additional valve assembly, an additional animal can be ventilated. Although the SAR-830 is primarily a rodent ventilator, this expansion feature allows much 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	Cat, Rabbit
CTP-VA-4	EFM-1-20	Dog, Goat

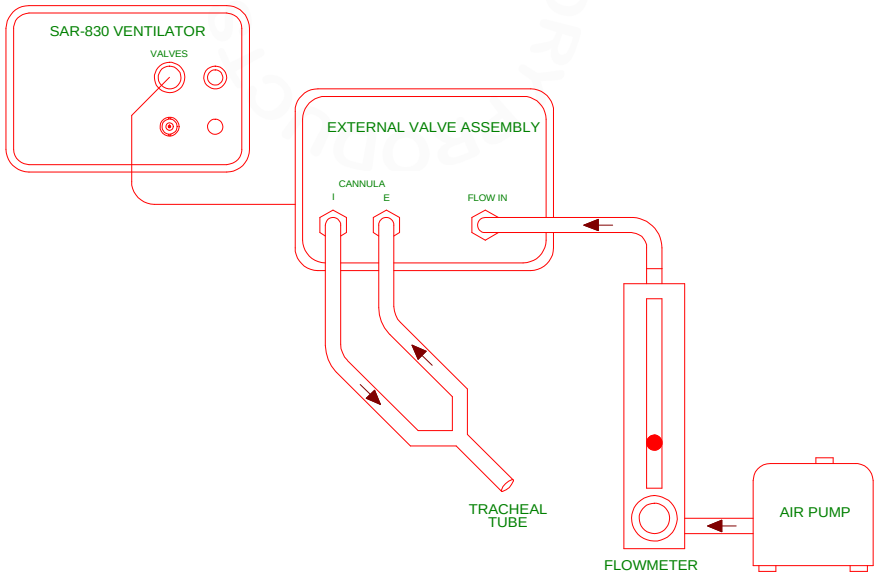


*Figure 2: Expanding the SAR-830 with an **EXTERNAL VALVE ASSEMBLY***

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, but the tidal volume of each can be set independently by adjusting the individual inspiratory airflows.

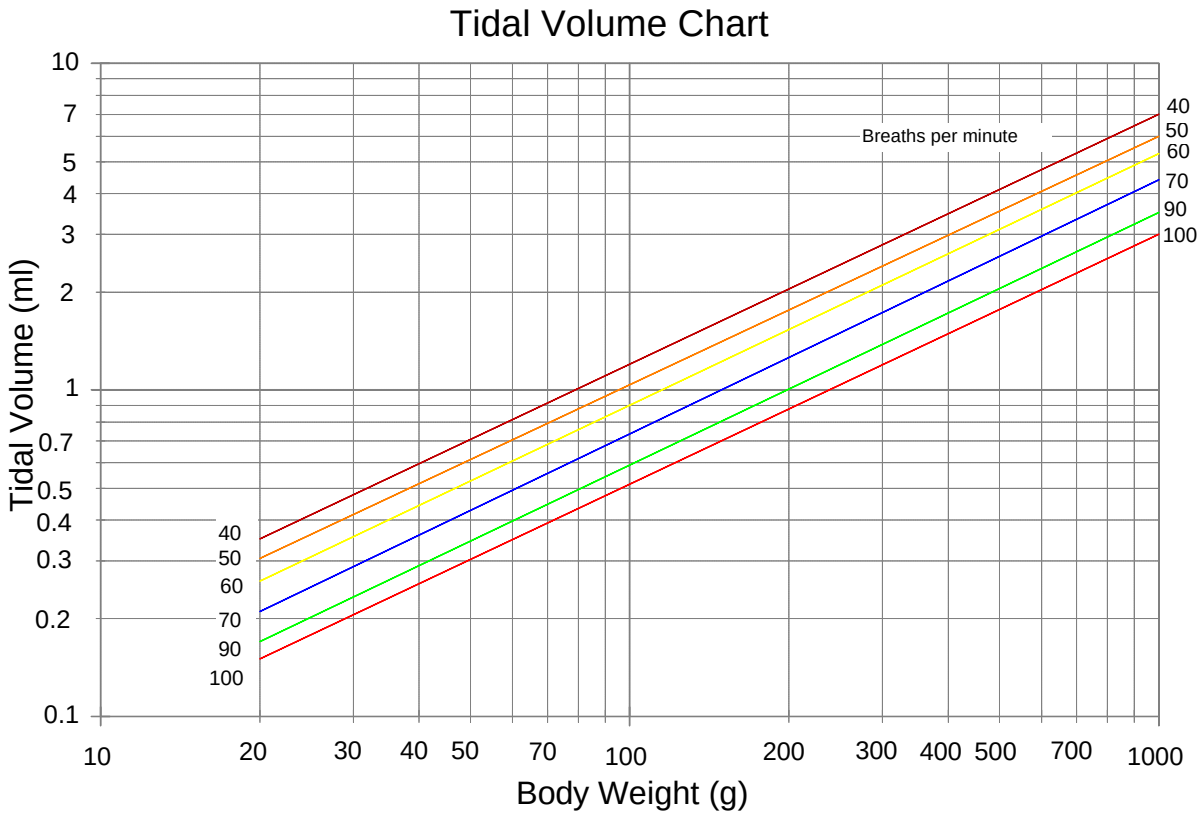
8.0 ORDERING INFORMATION

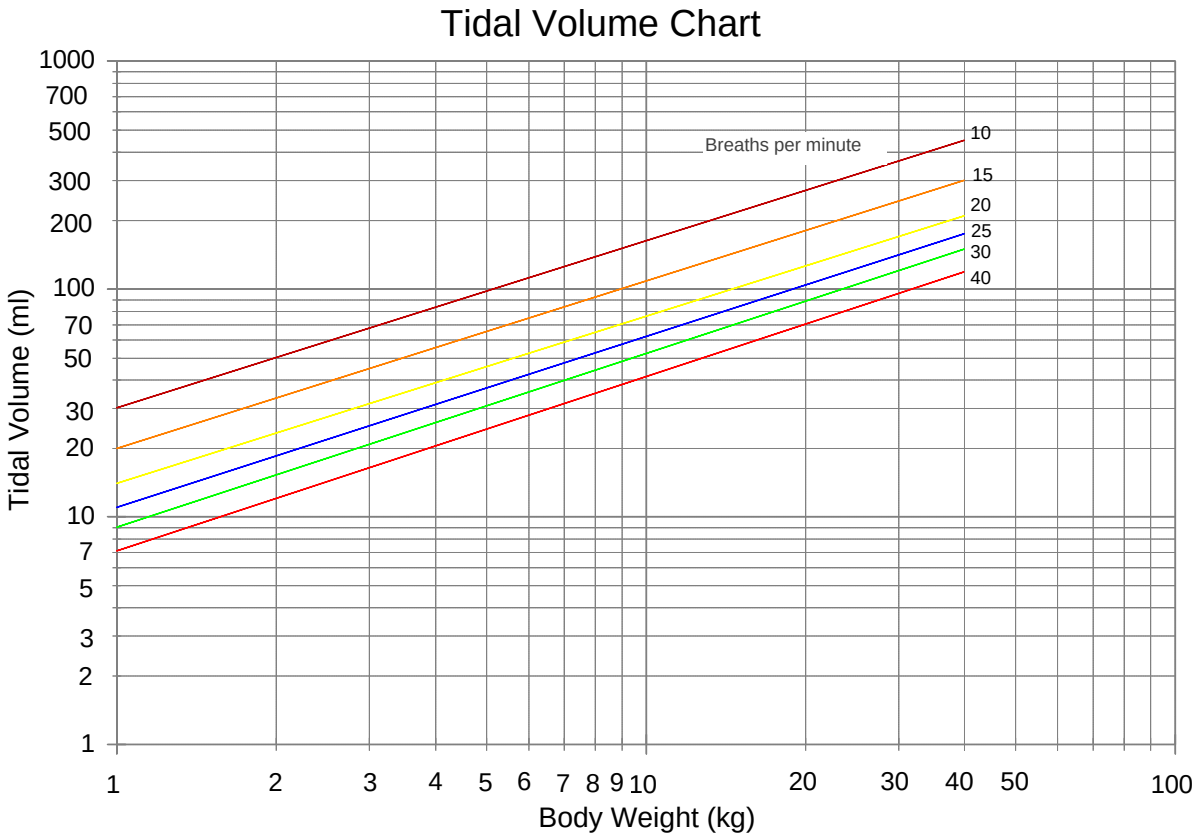
PART N^{o}	MODEL	DESCRIPTION
12-01000	SAR-830	Small Animal Ventilator (without air pump), 115/230V operation
12-01100	SAR-830/A	Small Animal Ventilator (with internal air pump), 115/230V operation
12-02000	SAR-830/P	Small Animal Ventilator, Volume and Pressure cycled (without air pump), 115/230V operation
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, cat to small dog size
12-06000	CTP-VA-4	Solenoid Valve Assembly, dog to goat size
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
12-10030	OPTION 020	External Air Pump, 0-1.5l/min range
12-10033	OPTION 024	External Air Pump, 0-25l/min range
12-10040	OPTION 031	Digital Mass Flowmeter, 0-1 l/min
12-10041	OPTION 032	Digital Mass Flowmeter, 0-10 l/min
12-10043	OPTION 0311	Flow regulating needle valve for OPTION 03 digital mass flowmeters
12-01020	OPTION 041	SAR-830 special smaller internal valves for body weight 10g-100g

11-10000	CAPSTAR-100	End-tidal CO_2 Analyzer, complete with accessory pack, 115/230V operation
15-10000	MicroCapstar	End-tidal CO_2 Analyzer for mice, complete with accessory pack

13-12000	Halothane Kit	Vaporizer, Halothane 0.5 - 5.0% with flowmeter on stand
13-13000	Isoflurane Kit	Vaporizer, Isoflurane 0.5 - 5.0% with flowmeter on stand
13-10110	1 liter bag	Rubber rebreathing bag, 1 liter, with tube fittings
13-10120	3 liter bag	Rubber rebreathing bag, 3 liter, with tube fittings

APPENDIX 1: TIDAL VOLUME VS. BODY WEIGHT CHARTS





APPENDIX 2: TIDAL VOLUME TABLES

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 factors.