POCKET GUIDE

MAQUET

Servo*i*

MODES OF VENTILATION

CRITICAL CARE

GETINGE

CONTENT

Mechanical ventilation is required when a patient is unable to achieve adequate ventilation and thereby gas exchange. The ventilation pattern must be adapted to suit the patient's need for oxygenation and CO2 elimination. The Servo*i* Ventilator system provides ventilation modes, which clinicians can tailor to the patient's need.

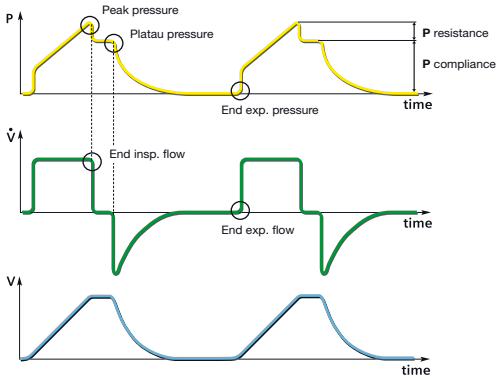
Note: This Pocket Guide only covers selected topics and cannot replace the User's manual and the Service manual. For detailed information please always refer to the latest corresponding User's manual and/or instructions for use.

Abbreviations	
VC	***V****olume* ***C****ontrol*
PC	***P****ressure* ***C****ontrol*
PRVC	***P****ressure* ***R****egulated* ***V****olume* ***C****ontrol*
PS	***P****ressure* ***S****upport*
CPAP	***C****ontinuous* ***P****ositive* ***A****irway* ***P****ressure*
VS	***V****olume* ***S****upport*
SIMV	***S****ynchronized* ***I****ntermittent* ***M****andatory* ***V****entilation*

Flow Pattern

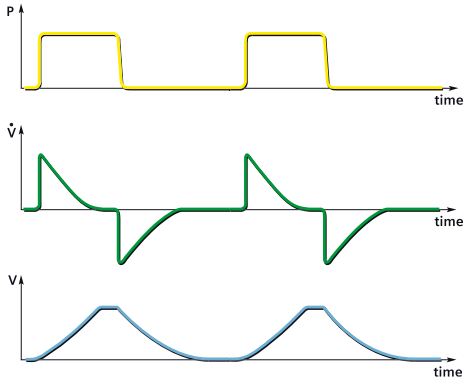
The Flow Pattern in Volume Control and SIMV (VC) is constant during inspiration. During the pause time the flow is zero.

At the beginning of expiration, flow is large. It gets smaller and smaller and reaches zero by the end of expiration.



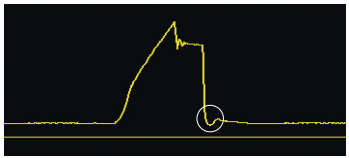
P = Pressure
V̇ = Flow
V = Volume

In Pressure Control, Pressure Regulated Volume Control (PRVC), Pressure Support, Volume Support, SIMV (PRVC) with Pressure Support and SIMV (PC) with Pressure Support the flow is decelerating and the pressure is constant.



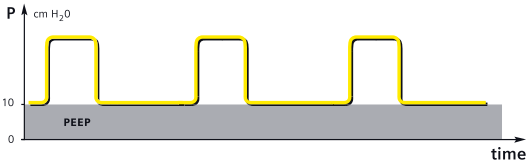
Time Constant Valve Controller™

To reduce the resistance in the beginning of expiration the expiratory valve has a controlling algorithm, the Time Constant Valve Controller™, which continuously calculates the elastic and resistive forces of the respiratory system. The initial opening of the expiratory valve is adapted to keep resistance as low as possible while strictly maintaining the set PEEP in the airway.



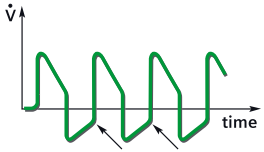
PEEP

A Positive End Expiratory Pressure is maintained in the alveoli to prevent the collapse of the airways. An “optimal PEEP level” has been used for a long time to protect the lung.



Auto PEEP

If the respiratory rate is set high or the expiratory time is not long enough there is a risk for auto PEEP. The patient does not have enough time to exhale and it is evident on the flow curve that flow will not return to zero before the next breath starts.

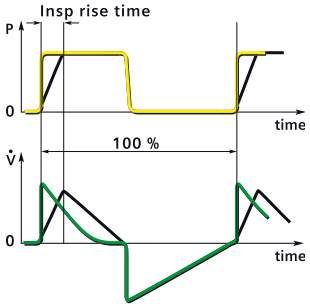


There are different ways to check if the patient has an auto PEEP:

- The flow will not go back to zero before next inspiration starts.
- V̇ee is not zero, see 2nd page of Additional values on the User Interface.
- Total PEEP = set PEEP + Auto PEEP, press Expiratory Hold to see total PEEP on 2nd page of Additional values on the User Interface.

Inspiratory rise time

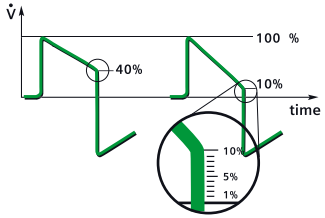
Inspiratory rise time: Time to peak inspiratory flow or pressure at the start of each breath as a percentage of the respiratory cycle time or in seconds. The Inspiratory rise time is adjustable from a very fast response, where the patient basically performs only the triggering work, to a more controlled delivery, where the patient can interact during the inspiration.



The Inspiratory flow profile has to be set to a comfortable value for the patient and can be evaluated by the shape of the flow and pressure curves. Inspiratory rise time % is applicable in all the controlled modes of ventilation (if configured for I:E ratio setting). Inspiratory rise time in seconds is applicable in Pressure Support, CPAP and Volume Support.

Inspiratory Cycle-off

Inspiratory Cycle-off is the point at which inspiration changes to expiration in spontaneous and supported modes of ventilation.



It is important to set a proper Inspiratory Cycle-off to avoid hyper-inflation of the lungs and increased work of breathing. If inspiration is too long, the patient tries to exhale by increasing the pressure and this may result in too short a time for expiration. This problem may give an Auto PEEP and increased work of breathing. Therefore it is important to check the pressure and flow curves e.g. if the end expiratory flow does not return to zero before next breath starts, the patient will have an Auto PEEP. If the Inspiratory Cycle-off cuts off inspiration too early, the patient will not get enough tidal volume.

Trigger Sensitivity

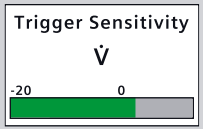
This determines the level of patient effort to initiate the inspiratory flow, how much additional work of breathing the patient has to create to start the inspiration. A delay in gas delivery tends to increase the work of breathing. Trigger sensitivity can be set in flow or pressure triggering. Normally flow triggering is preferable as the work of breathing should be as low as possible, without self-triggering. Immediate sensing of inspiratory effort from the patient is mandatory in achieving synchronicity between the patient and the ventilator.

The ventilator continuously delivers a flow during each expiration

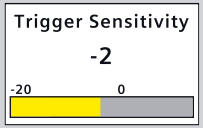
- In Adult the flow during expiration is 33 ml/sec (2 l/min)
- In Infant the flow during expiration is 8 ml/sec (0.5 l/min)

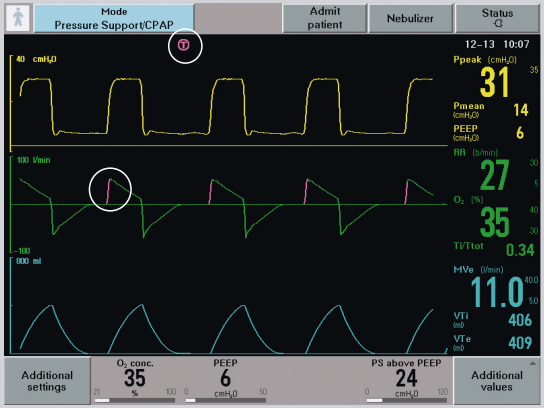
When the patient makes an inspiratory effort, the expiratory flow transducer in Servo*i*, senses a decrease in the continuous expiratory flow. When the difference between the inspiratory and expiratory flow equals the preset flow trigger level the ventilator will start a new inspiration.

The flow Trigger sensitivity setting is divided in steps of 10%; each step increases Trigger sensitivity. In the red area the patient only has to inhale a very small part of the trigger flow to trigger a breath – risk for self triggering.

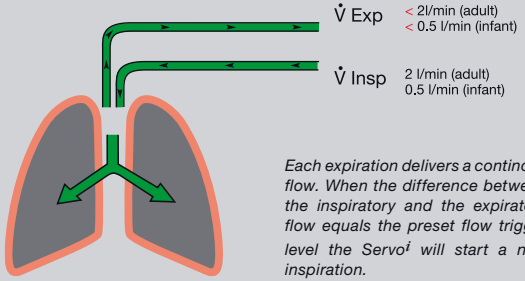


The pressure Trigger sensitivity can be set within the range 0-20 cmH_2O. To initiate a breath the patient has to create the negative pressure that is set as Trigger sensitivity. The higher the negative Trigger pressure is set on the ventilator, the more work of breathing the patient must perform. The Trigger sensitivity should be set as sensitive as possible without causing self triggering – auto triggering.

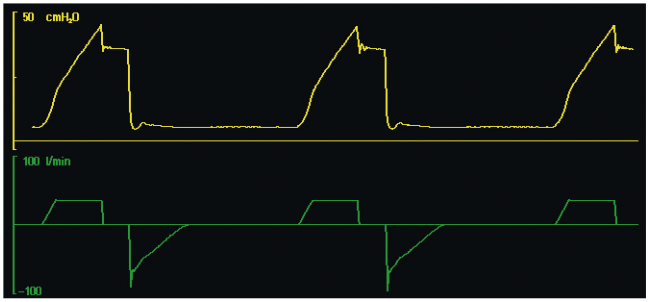




When the patient triggers a breath a purple T appears between the text message and the alarm message areas. The initial part of the pressure or flow curves changes to purple to indicate when the patient triggers the breath. If the breath is flow-triggered the flow curve shows the purple color but if the breath is pressure-triggered, then the pressure curve shows the purple color.



*Each expiration delivers a continous flow. When the difference between the inspiratory and the expiratory flow equals the preset flow trigger level the Servo*i* will start a new inspiration.*



Volume Control – VC

In this controlled mode of ventilation the ventilator delivers the preset tidal volume with a constant flow during the preset inspiratory time with the preset pause time and at the preset respiratory rate.

The Peak Pressure can vary from breath to breath if the patients Compliance and Resistance changes.

If we have a tight system the inspired tidal volume should be the same as the expired tidal volume. The time for inspiration and expiration can be configured to be set in I: E ratio or in seconds.

Example
In Servo^{i} you can select if you want to set the tidal volume or the minute volume. The flow during volume control ventilation is constant. The insp. time in % is seen in the information area in the menu Set ventilation mode. Inspiratory rise time: Time to peak inspiratory flow at start of each breath as a percentage of the respiratory cycle time.

How to calculate the flow

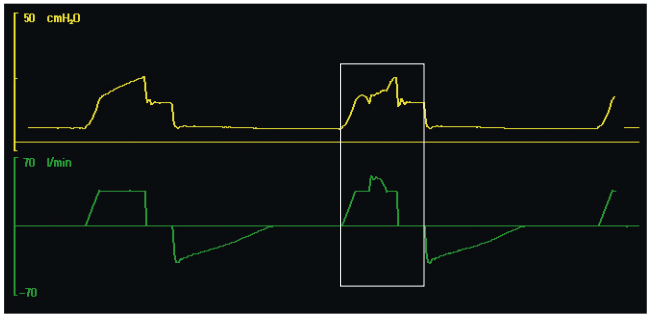
Example:
Preset Insp. Min. Volume = 6 l/min
Insp.time = 25%

Gives inspiratory flow $\frac{6 \times 100}{25} = 24$ *l/min*

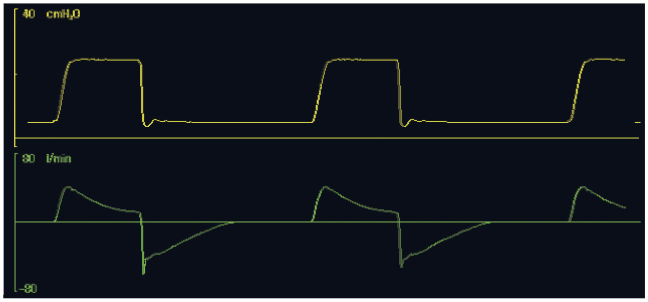
It is very important to set a sensitive triggering level to give the patient the possibility to breathe by himself as soon as possible. If the patient is making an inspiratory effort during the expiratory phase, he will get an assisted breath with the same tidal volume as set on the ventilator. Immediate sensing of inspiratory effort from the patient is mandatory in achieving synchronicity.

In some cases, the patient may demand a higher tidal volume/flow than is set on the ventilator e.g. if the patient has pain, has an increased temperature, has change in the respiratory drive.

The flow-adapted Volume Controller™ will always work with the patient and deliver the extra volume requested. If the patient decreases airway pressure by 2 cmH_2O during the inspiratory phase the ventilator switches to Pressure Support and delivers a flow profile adapted to the patient's immediate needs.



Flow-adapted Volume Control



Pressure Control – PC

In this controlled mode of ventilation the ventilator delivers a flow to maintain the preset pressure at a preset respiratory rate and during a preset inspiratory time.

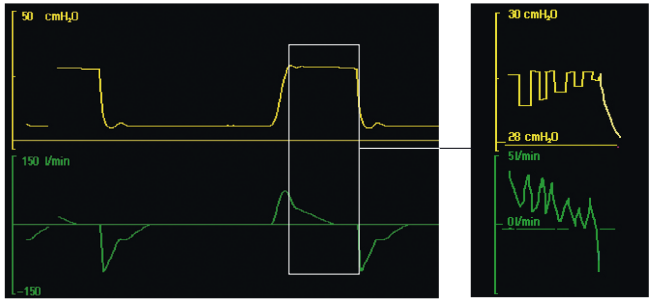
The pressure is constant during the inspiratory time and the flow is decelerating. If for any reason pressure decreases during inspiration the flow from the ventilator will immediately increase to maintain the set inspiratory pressure.

The maximum available flow is 3.3 l/sec – 200 l/min for Adult and 0.56 l/sec – 33 l/min for Infant. The volume can vary from breath to breath if the patient's compliance and resistance changes. It is very important to set the alarm limits for expired minute volume to adequate levels.

Inspiratory rise time in PC is the time to peak inspiratory pressure and flow of each breath. Settings can be in the range 0–20% of the respiratory cycle time - from an extremely fast response to a low initial inspiratory flow.

Example:
Respiratory rate 15, the time for 1 breath is 60/15 = 4 sec

$$\textit{Inspiratory rise time } 10\% = \frac{4x10}{100} = 0.4 \text{ sec}$$

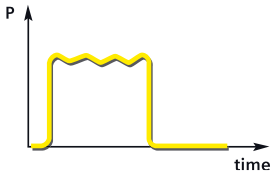


The Servo*i* will sense the smallest deviations in pressure. A decrease in pressure will occur when there is a leakage in the breathing system, at the endotracheal tube, or in the lungs e.g. pneumothorax, fistula.

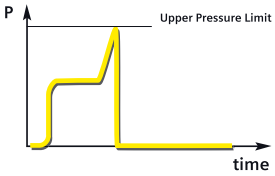
When previously collapsed airways are starting to open the pressure decreases and the alveoli are opened by a precise increase in flow.

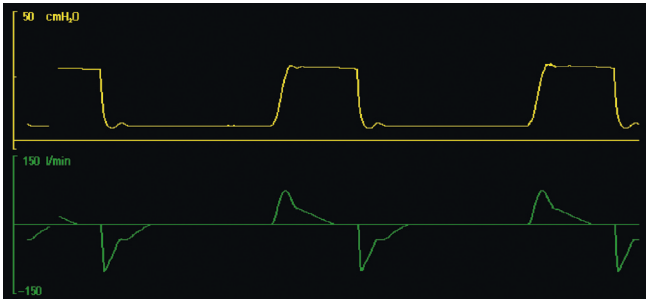
Active expiratory valve

If a patient tries to exhale during the inspiration, pressure increases. When it increases 3 cmH_2O above the set inspiratory pressure level, the expiratory valve opens and regulates the pressure down to the set inspiratory pressure level.



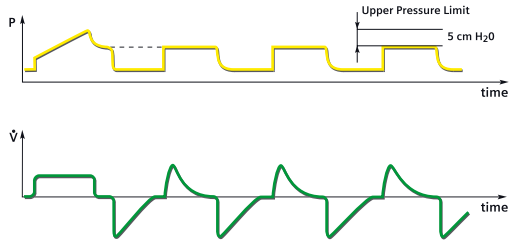
If the pressure increases to the set upper pressure limit e.g. the patient is coughing, the expiratory valve opens and the ventilator switches to expiration.





Pressure Regulated Volume Control – PRVC

PRVC is a controlled mode of ventilation which combines the advantages of Volume Controlled and Pressure Controlled Ventilation. The Servo*i* delivers the preset tidal volume with the lowest possible pressure. The first breath delivered to the patient is a Volume Controlled breath. The measured plateau pressure is used as the pressure level for the next breath.The pressure is constant during the set inspiratory time and the flow



is decelerating. The set tidal volume is achieved by automatic, breath-by-breath pressure regulation. The ventilator will adjust the inspiratory pressure control level, according to the mechanical properties of the airways/lung/thorax, to the lowest possible level to guarantee the preset tidal volume.

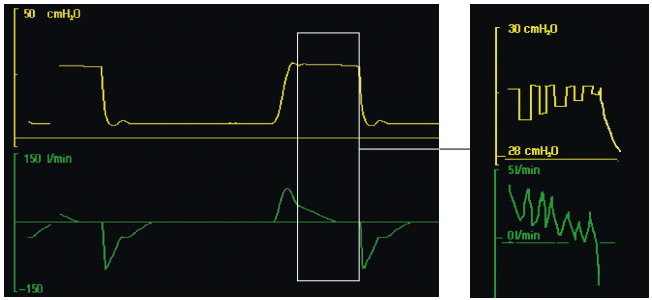
If the measured tidal volume increases above the preset, the pressure level decreases in steps of maximum 3 cmH_2O between consecutive breaths until the preset tidal volume is delivered.

If the measured tidal volume decreases below the preset, the pressure level increases in steps of maximum 3 cmH_2O between consecutive breaths until the preset tidal volume is delivered.

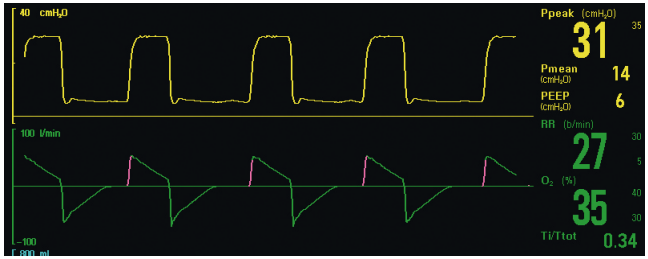
Maximum available pressure level is 5 cmH_2O below preset upper pressure limit.

If the pressure reaches 5 cmH_2O below the upper pressure limit the ventilator will deliver as much volume as possible with this pressure. In the same time the information “Regulation Pressure Limited” (in the alarm message area) will inform the user that the set volume cannot be delivered with the set upper pressure limit. The alarm limit for expired minute volume will also alert the user if properly set.

The Servo*i* will sense the smallest deviations in pressure. If it appears that previously collapsed units of the lung are starting to open in the late phase of inspiration the pressure tends to decrease, this is compensated by a precise increase in flow and the alveoli are opened.



Terminal airway resistance decreases in discrete steps as pressure is applied. By immediately sensing the pressure drop that could be induced by an opening avalanche, Servo*i* provides proper flow to balance and further enhance the opening process.



Pressure Support – PS

This is a spontaneous mode of ventilation. The patient initiates the breath and the ventilator delivers support with the preset pressure level and a decelerating flow. The patient regulates the respiratory rate and the tidal volume with support from the ventilator.

In Pressure Support the set inspiratory pressure support level is kept constant and there is a decelerating flow. The patient triggers all breaths. If the mechanical properties of the lung/thorax and patient effort change, delivered tidal volume will be affected. You then have to regulate the pressure support level to get the desired ventilation.

The higher the preset inspiratory pressure level from the ventilator the more gas flows into the patient. As the patient becomes more active the pressure support level may be gradually reduced.

The Trigger sensitivity has to be set properly for the patient without increase of the work of breathing. The patient has to inhale freely.

The Inspiratory rise time has to be set to a comfortable value for the patient. This is the time to reach the peak inspiratory flow or pressure at the start of each breath in seconds.

Normally in supported modes the Inspiratory rise time should be increased from the default settings and give more comfort to the patient.

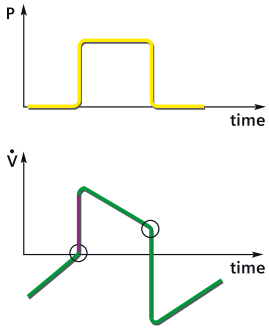
Inspiratory Cycle-off is the point at which inspiration changes to expiration. It is possible to set from 1% – 40% of inspiratory peak flow for both infants and adults.

It is important that the inspiration and expiration is adapted to the patient. If the Cycle-off fraction is too short the patient will be left without proper support for a period of the breath. It is important to avoid phases with nearly no flow and late notches in the inspiratory flow curve. If this is the case, the Inspiratory Cycle-off should be increased.

If the patient fails weaning it may be due to delayed termination of the inspiratory support. If the inspiratory part of the breath is prolonged, the patient will recruit his expiratory muscles and cycle the ventilator to expiration by an increase in pressure. This process utilizes patient energy and may shorten the time for expiration. This may induce Auto PEEP, increase work of breathing and cause lost trigger efforts by an increased internal threshold to triggering. In this case the Inspiratory Cycle-off should be increased. It is important to monitor the corresponding tidal volume levels.

Pressure and flow curves

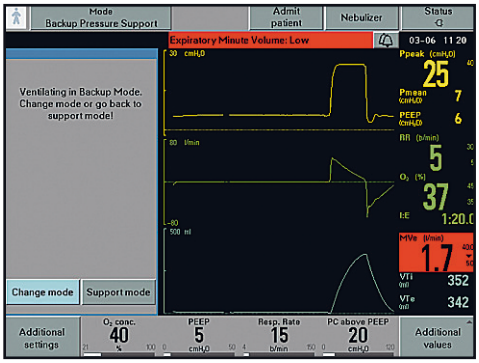
Inspiration starts when the patient triggers a breath and gas flows into the patient's lungs at a constant pressure. Since the pressure provided by the ventilator is constant, the flow will decrease until the Inspiratory Cycle-off is reached and then the expiration starts. Depending on how the Inspiratory rise time is set, the flow will be very fast rising or slower in the beginning of the breath.



Expiration starts:

- When the inspiratory flow decreases to the preset Inspiratory Cycle-off level.
- If the upper pressure limit is exceeded.
- If the inspiration exceeds 2.5 seconds in Adult range and 1.5 seconds in Infant.
- If the flow drops to a flow range between 25% of the peak flow and lower limit for Inspiratory Cycle-off fraction level and the time spent within this range exceeds 50% of the time spent in between the start of the inspiration and the entering this range.

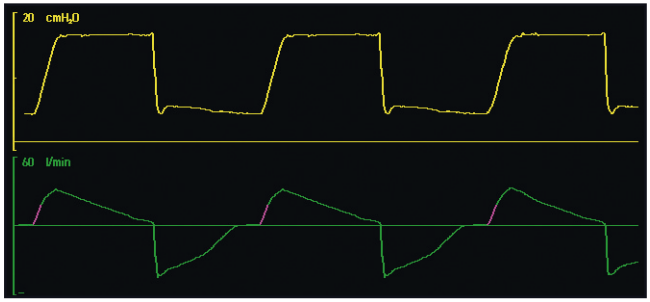
If the apnea alarm limit is reached the ventilator will automatically switch to the Back-up Mode, Pressure Controlled Ventilation. The Inspiratory Pressure level can be set from 5 to 120 cmH_2O - PEEP for Adult and 5 to 80 cmH_2O - PEEP for Infant and as default is 20 cmH_2O for Adult and 10 cmH_2O for Infant. The I: E ratio, Respiratory Rate and Inspiratory rise time are set to the default settings. Alarms will alert staff of the change, the User Interface will display the message “Ventilating in Back-up Mode. Change mode or go back to support mode!”



The user has to decide if the patient can breath spontaneously or not and the user has to select:
- Support mode
- Change mode

Continuous Positive Airway Pressure – CPAP

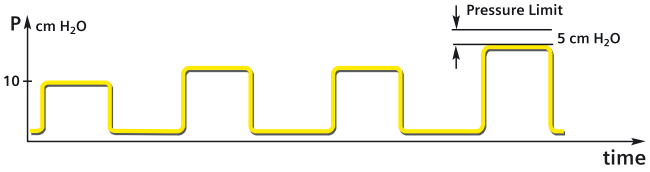
The mode Continuous Positive Airway Pressure is used when the patient is breathing spontaneously. CPAP works in exactly the same way as Pressure Support, but the pressure support level is set to zero.



Volume Support – VS

Volume Support is a spontaneous mode; the patient has to initiate the breath and the ventilator delivers support in proportion to the inspiratory effort and the target volume. This mode of ventilation avoids ventilator induced hyperinflation, but compensates and adapts to changes in respiratory load. The set tidal volume will be delivered to the patient with different support from the ventilator depending on the patient’s activity. If the patient’s activity increases the Inspiratory pressure support will decrease provided the set tidal volume is maintained. If the patient breathes below the set tidal volume the inspiratory pressure support will increase. The inspiratory flow will be decelerating.

The start-up sequence is 4 breaths. The first breath is given with a support of 10 cmH_2O. From that breath the ventilator continually calculates and regulates the pressure needed to deliver the preset tidal volume. During the remaining 3 breaths, the maximum pressure increase is 20 cmH_2O for each breath. After the start-up sequence, if the delivered

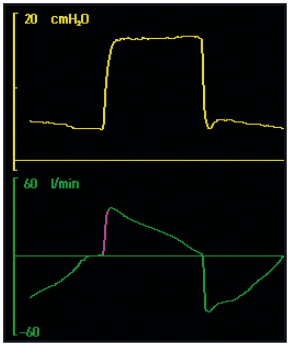


tidal volume is below the set tidal volume the pressure support level is increased in steps of maximum 3 cmH_2O breath by breath until the preset tidal volume is delivered. If the delivered tidal volume is above the set tidal volume the pressure support level is decreased in steps of maximum 3 cmH_2O until the preset tidal volume is delivered.

The inspiratory pressure support level automatically adapts to changes in lung/thorax mechanical properties and patient effort. To evaluate the patient's own work of breathing it is easy to go into the trend and look at the airway pressure. When the airway pressure declines, the patient is taking over more of the respiratory work.

By combining Volume Support with compressible volume compensation, flow variations which can induce high pressure drops across the endotracheal tube are compensated for on-line by a proper increase in pressure delivery.

The Inspiratory rise time has to be set to a comfortable value for the patient. This is the time to reach the peak inspiratory flow or pressure at the start of each breath in seconds. Normally in supported modes the Inspiratory rise time should be increased from the default settings and thus give more comfort to the patient. Inspiratory Cycle-off is the point at which inspiration changes to expiration.



It's important that the inspiration and expiration is adapted to the patient. If the Cycle-off fraction is too short the patient will be left without proper support for a period of the breath. It's also important to avoid phases with nearly no flow and late notches in the inspiratory flow curve. If this is the case, Inspiratory Cycle-off should be increased.

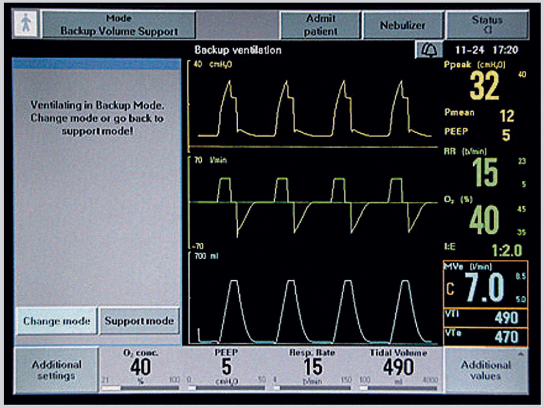
If the patient fails weaning it may be due to delayed termination of the inspiratory support. If the inspiratory part of the breath is prolonged, the patient will recruit his expiratory muscles and cycle the ventilator to expiration by an increase in pressure.

This process utilizes patient energy and may shorten the time for expiration. This may induce Auto PEEP, increase work of breathing and cause lost trigger efforts by an increased internal threshold to triggering. In this case the Inspiratory Cycle-off should be increased.

Pressure and flow curves

Inspiration starts when the patient triggers a breath and gas flows into the patient's lungs at a constant pressure. Since the pressure provided by the ventilator is constant, the flow will decrease until the Inspiratory Cycle-off is reached and then the **expiration** starts.
Depending on how the Inspiratory rise time is set, the flow will be very fast rising or slower in the beginning of the breath.

Expiration starts:
- When the inspiratory flow decreases to the preset Inspiratory Cycle-off level.
- If the upper pressure limit is exceeded.
- If the inspiration exceeds 2.5 seconds in Adult range and 1.5 seconds in Infant.
- If the flow drops to a flow range between 25% of the peak flow and lower limit for Inspiratory Cycle-off fraction level and the time spent within this range exceeds 50% of the time spent in between the start of the inspiration and the entering this range.



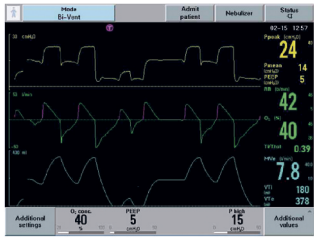
If the apnea alarm limit is reached the ventilator will automatically switch to the Back-up Mode, Volume Controlled Ventilation, with the same tidal volume as in Volume Support. During Back-up ventilation default settings are used for I:E ratio, Respiratory rate and Inspiratory rise time.

Alarms will alert staff of the change, the User Interface will display the message"Ventilating in Back-up Mode. Change mode or go back to support mode!"

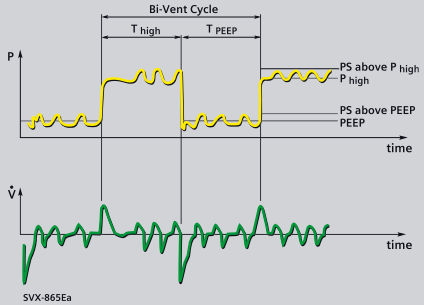
The user has to decide if the patient can breathe spontaneously or not and the user has to select: Support mode or Change mode.

Bi-Vent

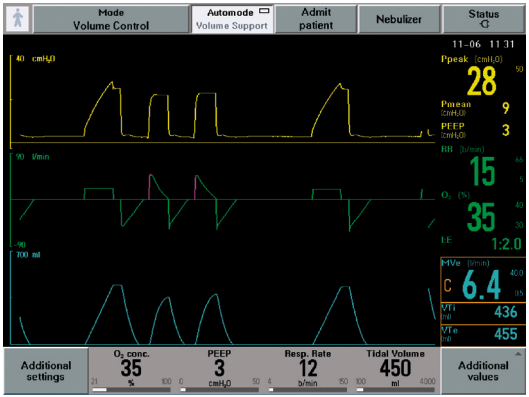
The Bi-Vent mode is a pressure controlled breathing mode giving the patient the opportunity for unrestricted spontaneous breathing. In this mode the ventilator uses two shifting pressure levels and the patient can breathe spontaneously at both these levels. It is also possible to support the patient with Pressure Support at both pressure levels.



Example:
P_{high} is set to 2 sec and PEEP is set to 4 sec and this will give you 6 sec for the Bi-Vent cycle. The mandatory rate will be 60/6 = 10 breaths per minute. The Bi-Vent cycle may be shifted somewhat depending on the patient and the ventilator settings since the ventilator continuously synchronizes with the patient's breathing. Since Bi-Vent is a controlled mode of ventilation, back-up ventilation is not available.



Every Bi-Vent cycle has time for the P_{high} and for the PEEP level. The time for P_{high} can be set 0.2 – 10 sec and the time for PEEP can be set 0.2 – 10 sec. This means that you can set the mandatory rate from 3-150 breaths per minute.



Automode®

Automode is an interactive mode of ventilation. The combined control and support function of the ventilator adapts to the patient's breathing capacity. Automode allows the patient to go into a support mode automatically if he triggers the ventilator, thereby better adapting ventilation to patient effort. If the patient is not making any breathing effort the ventilator will deliver controlled breaths.

Automode gives both the patient and clinician an optimal means of commencing the weaning period at the time of initiating ventilator therapy.

Essentially the ventilator works in two modes: control or support. When the patient, in control mode, makes an inspiratory effort, the ventilator reacts by supplying a supported breath.

Three different coupling modes combining control and support are available:

Volume Control ⟺ Volume Support

PRVC ⟺ Volume Support

Pressure Control ⟺ Pressure Support

The start-up algorithm for Automode will protect against false triggering. The ventilator initially adapts with the adjustable Trigger Timeout. Trigger Timeout is the maximum allowed apnea time in Automode before controlled ventilation is activated. This means that for the spontaneously breathing patient the Trigger Timeout limit increases successively.

The patient has to breathe 10 breaths in a row before the ventilator will wait the whole Trigger Timeout period before switching to controlled ventilation. If the patient triggers fewer breaths the ventilator will decrease the time when it switches to controlled ventilation. The time before the ventilator switches from support to controlled ventilation will be shorter and shorter the fewer breaths the patient triggers. If the patient breathes more than 10 breaths in a row and then stops it will take the set Trigger Timeout, e.g. 7 seconds, before the ventilator initiates controlled ventilation.

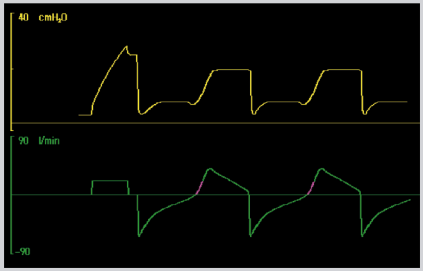
Patient activity can be seen by looking at the trend, which will indicate the activity of the patient over 24 hours.

Early detection and adaptation to patient effort promotes spontaneous breathing and early weaning. At the first sensing of spontaneous effort, Automode delivers supported breaths adapted to patient's effort, instead of a controlled mechanically pre-programmed pattern.

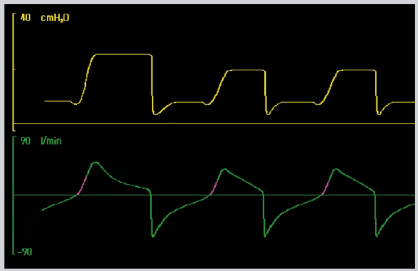
Synchronized Intermittent Mandatory Ventilation – SIMV

During SIMV the patient receives mandatory breaths controlled by the ventilator. These mandatory breaths are synchronized with the breathing efforts of the patient. The patient can breathe spontaneously in between the mandatory breaths. The spontaneous/pressure supported breath is defined by setting the Pressure Support level above PEEP.

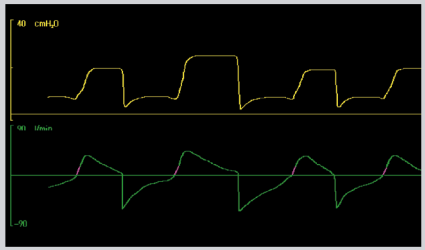
There are three different SIMV modes:
- SIMV Volume Control and Pressure Support
- SIMV Pressure Control and Pressure Support
- SIMV PRVC and Pressure Support



SIMV VC + Pressure Support



SIMV PC + Pressure Support



SIMV PRVC + Pressure Support

	SIMV(VC)+PS	SIMV(PRVC)+PS	SIMV(PC)+PS
PC above PEEP			X
tidal volume / minute volume	X	X	
SIMV rate	X	X	X
Breath cycle time	X[1]	X[1]	X[1]
I:E ratio / Inspiration time	X	X	X
Inspiratory rise time	X	X	X
Pause time	X		

1 Only when the ventilator is configured for I:E ratio setting

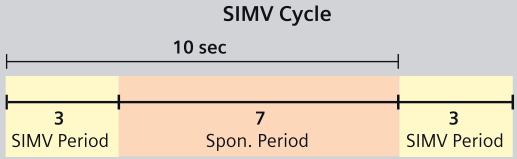
The mandatory breath is defined by the basic settings (as shown in table above): minute volume/tidal volume (depending on configuration), PC above PEEP, I:E ratio, Inspiration time (depending on configuration), Pause time, Inspiratory rise time and Breath cycle time.

Note: In the minute volume configuration the tidal volume is determined by minute volume divided by SIMV rate.

Breath Cycle Time (Breath Cycle T)

This is the length of the total respiratory cycle of the mandatory breath. The total time for inspiration, pause and expiration.
Note: This is if the Servo^i is configured for setting the inspiratory time by setting the I:E ratio.

The SIMV cycle in seconds is calculated as follows: 60 seconds divided by the SIMV rate. The SIMV cycle is divided into a SIMV period and a spontaneous period.

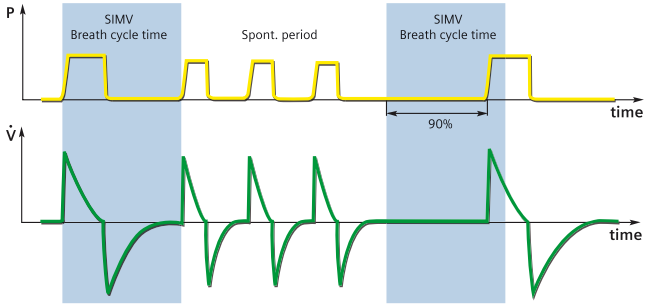


Example:
Following settings are made:
SIMV rate 6
Breath Cycle time 3 sec
I:E ratio 1:2

The time for the mandatory breath is
3 sec = SIMV period
I:E ratio 1:2 = 1 sec for inspiration,
2 sec for expiration

The time for one SIMV cycle is 60 sec divided by the set SIMV rate. In this example 60/6 = 10 sec

The time for the spontaneous period is 10-3 = 7 sec



If the patient is not breathing at all only the mandatory breaths will be delivered. When the patient starts to breathe he will get the Pressure Support in the spontaneous period and if triggering in the SIMV period the set mandatory breath will be delivered. In the next SIMV period the ventilator will wait for the patient to trigger but if the patient has not triggered within the first 90% of the breath cycle time (SIMV period) a mandatory breath will be delivered.

REFERENCES AND SUGGESTED READING

Amato MB, Barbas CS, Medeiros DM, et al. Effect of a protective-ventilation strategy on mortality in the acute respiratory distress syndrome. N Engl J Med 1998; 338:347-54.

Böhm S, Lachmann B. Pressure-control ventilation. Putting a mode into perspective. Int J Int Care 1996;3:12-27

Paul E. Marik, MD; and Jim Krikorian, RRT. Pressure-Controlled Ventilation in ARDS: A Practical Approach. Chest 1997; 112:1102-6.

Suter PM, Fairley HB, Isenberg MD. Optimum end-expiratory airway pressure in patients with acute pulmonary failure. N Engl J Med 1975; 292:284–289.

Hickling KG, Walsh J, Henderson S, et al: Low mortality rate in adult respiratory distress syndrome using low-volume, pressure-limited ventilation with permissive hypercapnea: A prospective study. Crit Care Med 22:1568-1578, 1994

Esteban A, Alia I, Gordo F, et al. Prospective Randomized Trial Comparing Pressure-Controlled Ventilation and Volume-Controlled Ventilation in ARDS. Chest 2000; 117:1690–1696.

Ranieri M, Giuliani R, Fiori T, et al.: Volume-pressure curve of the respiratory system predicts effects of PEEP in ARDS: "occlusion" versus "constant flow" technique. Am J Respir Crit Care Med 1994, 149:19–27.

H Roth, M Quintel, R Tillmans, et al.: Interactive ventilation: first experience with patient controlled weaning by using a Siemens –SV300 Automode ventilator. Crit Care 1998,2 (suppl 1):P81

Masaji Nishimura, Dean Hess, and Robert M. Kacmarek. The Response of Flow-triggered Infant Ventilators. Am J Crit Care Med Vol 152. pp 1901-1909, 1995

Holt SJ, Sanders RC, Thurman TL, Heulitt MJ. An evaluation of Automode, a computer-controlled ventilator mode, with the Siemens Servo 300A ventilator, using a porcine model. Respir Care 2001 Jan;46 (1):26-36

Marini JJ. Pressure-targeted, lung-protective ventilatory support in acute lung injury. Chest 1994: 105: 109S–115S.

A. Piotrowski MD, W. Sobala MD, et al. Patient-initiated, pressure-regulated, volume-controlled ventilation compared with intermittent mandatory ventilation in neonates: a prospective, randomised study. Int.Care Med (1997) 23: 975-981

Keenan Heather, MD, Martin Lynn, MD, Volume Support Ventilation in Infants and children: Analysis of a Case Series. Respir. Care 1997;3:281 – 287.

Ramet J., Suvs B., et al. Weaning Outcome in Children According to the Pre-weaning ventilatory Modes. Respiratory and Critical Care Medicine, 1995;151(4):A424.

Ramet J., Idrissi S., et al. The Effects of Pressure Regulated Volume Control Ventilation on Sedation Requirements. Respiratory and Critical Care Medicine, 1995;151(4):A744.

Apostolakos Michael J., MD, Levy Paul C. MD. et al. New Modes of Mechanical Ventilation.
Clin Pulm Med 1995;2:121-128.

Hazelzet Jan A. MD, Petru Ronald MD. et al. New Modes of Mechanical Ventilation for Severe Respiratory Failure. Critical Care Medicine 1993;9(Suppl.):S366-S367.

Tremblay LN., Slutsky AS., The role of pressure and volume in ventilator induced lung injury. Applied Cardiopulmonary Pathophysiology. 1996 6:179-190.

MAQUET

Maquet Critical Care AB
SE-171 95 SOLNA
Sweden
Phone: +46 8 730 73 00
www.maquet.com/criticalcare

Order No. 66 14 692 E315E
Printed in Sweden
WS 1203 5.
Rev.01 English
December 2003
Price: Group 1

GETINGE