



# Modes of Ventilation

Flow Family SW 4.7

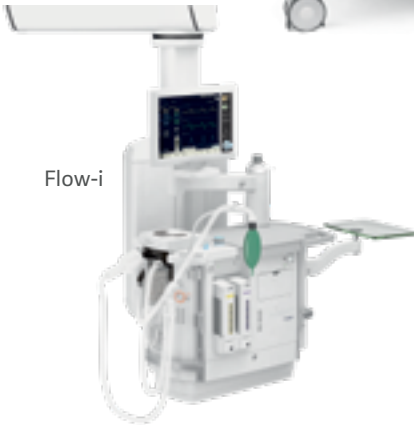


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# Introduction

## Flow Family systems



# Introduction

Mechanical ventilation can be required when a patient is unable to achieve adequate ventilation and gas exchange. A suitable ventilation pattern must be adapted to address the patient's need for oxygenation and CO<sub>2</sub> elimination. The Flow Family systems provide ventilation modes which clinicians can customize to the patients' requirements.

## Important

This pocket guide only covers select topics and must not replace the user's manual.

## Summary of ventilation modes

Controlled modes	Supported mode	Combined mode
VC	PS	SIMV: VC-PS PC-PS
PC		
PRVC		

### Manual ventilation

Manual ventilation

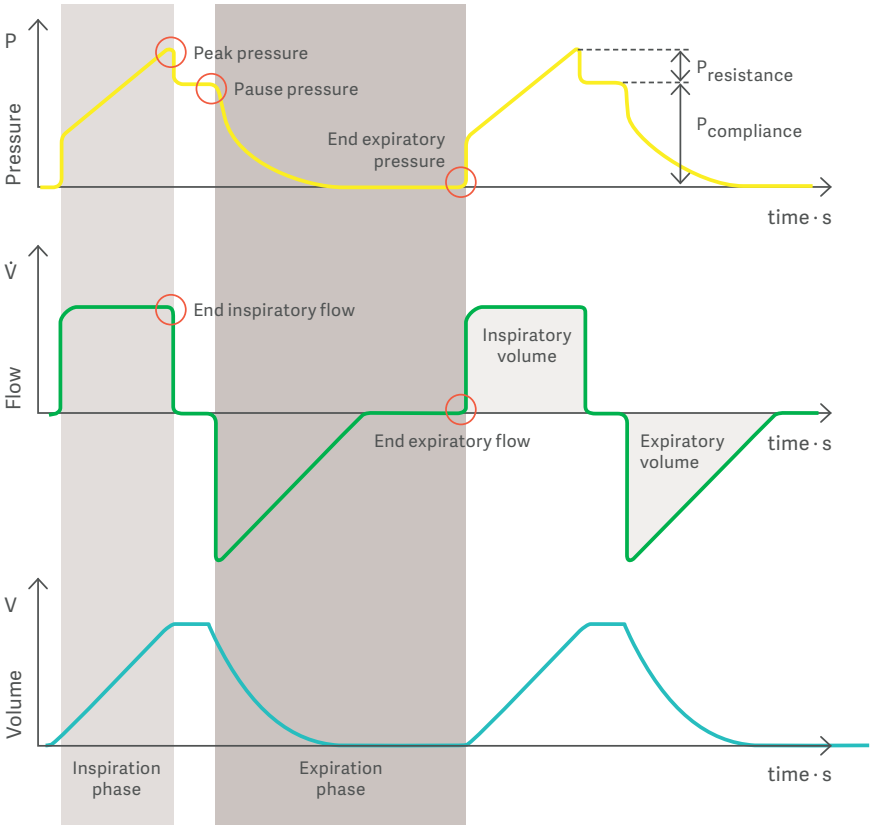
AFGO

Emergency ventilation

# Introduction

## Flow pattern – Volume Control ventilation

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, the flow is high and will be reduced and reach baseline at the end of expiration.

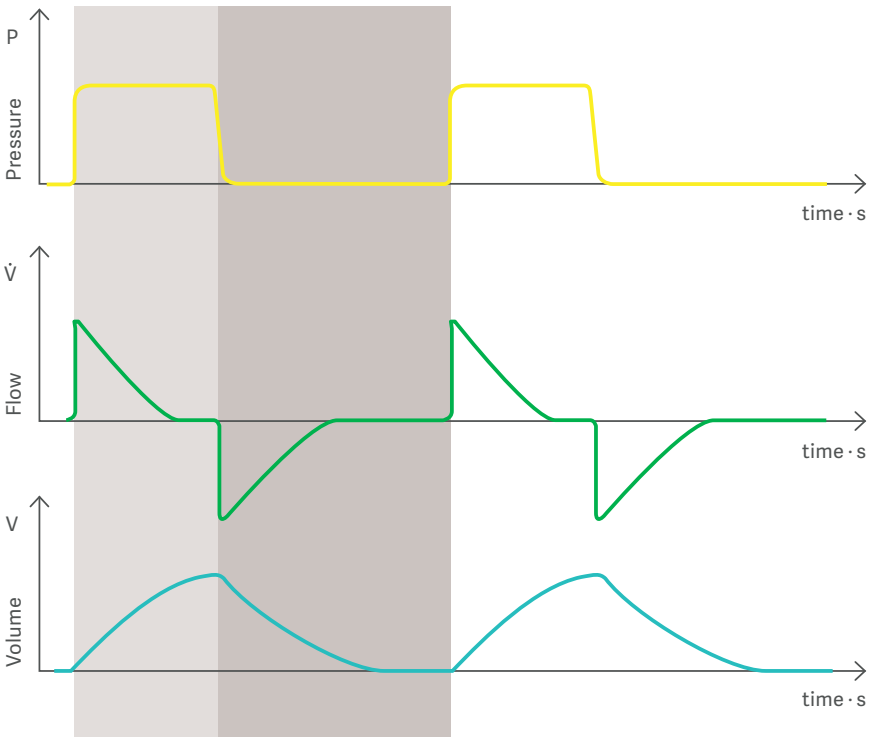


# Introduction

## Flow pattern

### – Pressure Control ventilation

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



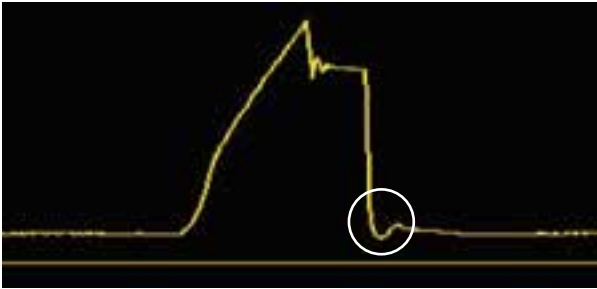
# Introduction

## Fast PEEP/expiration valve

The PEEP/expiration valve of the Flow anesthesia machine has a rapid control system which allows for an extremely fast and accurate response.

At the start of expiration, the valve opens fully for a brief moment to facilitate a fast expiration.

The pressure in the breathing system then transiently drops below the set PEEP value, while the intrapulmonary pressure is kept above PEEP.



# Introduction

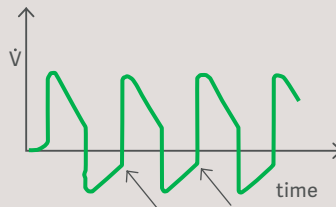
## Important ventilatory settings

### PEEP

Positive End Expiratory Pressure (PEEP) can be set in the range of 0 to 50 cmH<sub>2</sub>O. A Positive End Expiratory Pressure is maintained in the alveoli and may prevent collapse of the airways.

#### 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 on the Flow machine if the patient has an auto-PEEP:

- The Exp. flow will not go back to zero before the next inspiration starts.
- V<sub>ee</sub> (End expiratory flow) is not zero; see Additional Values on the User Interface.
- Total PEEP = set PEEP + Auto-PEEP. Press "Exp. Hold" for approximately 5 seconds to see total PEEP on 3rd page of Additional values in the User Interface.

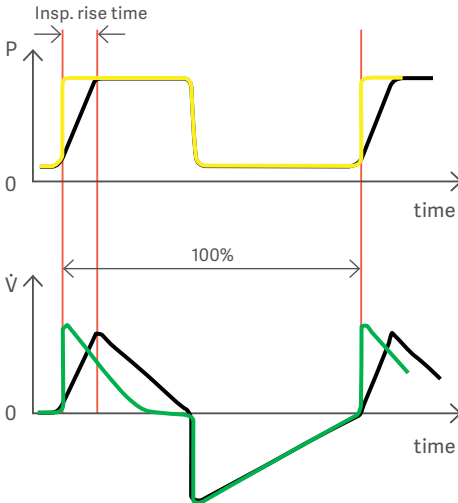


# Introduction

## Inspiratory rise time

Inspiratory rise time is the time it takes to reach peak inspiratory flow or pressure at the start of each breath, and is expressed either as a percentage of the respiratory cycle time or in seconds. The flow and pressure rise time can be adjusted to optimize the inspiratory flow pattern.

The Inspiratory rise time must be set to a comfortable value for the patient and this can be evaluated by the shape of the flow and pressure curves.



### Note

The Inspiratory rise time is shown in seconds if:

- the Flow Family machine is configured for Insp. time in seconds.
- the Flow Family machine is ventilating in Pressure Support.

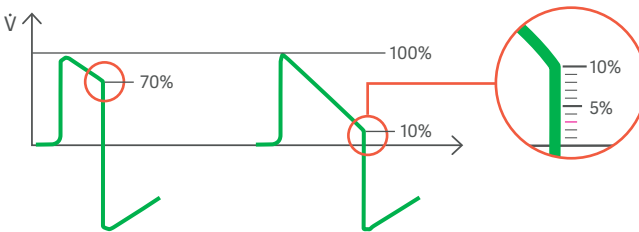
The Inspiratory rise time is shown in percentage in all controlled modes of ventilation if:

- the Flow Family machine is configured for the I:E ratio.

# Introduction

## End Inspiration

End Inspiration is the point at which inspiration changes to expiration in spontaneous and supported modes of ventilation. A decrease of the inspiratory flow to a preset level causes the Flow Family machine to switch to expiration. This preset level is measured as a percentage of the maximum flow during inspiration.



### Important

Set the End Inspiration settings correctly to avoid hyperinflation of the lungs and increased work of breathing. It is possible to set the End Inspiration from 1% to 80% of the inspiratory peak flow for both adults and infants (default values are 50% for adults and infants).

If the inspiration ends too early, the patient might not receive an adequate tidal volume.

If the pressure increases 3 cmH<sub>2</sub>O above the set Pressure Support level above PEEP, the Flow Family machine changes from inspiration to expiration.

# Introduction

## Trigger sensitivity setting

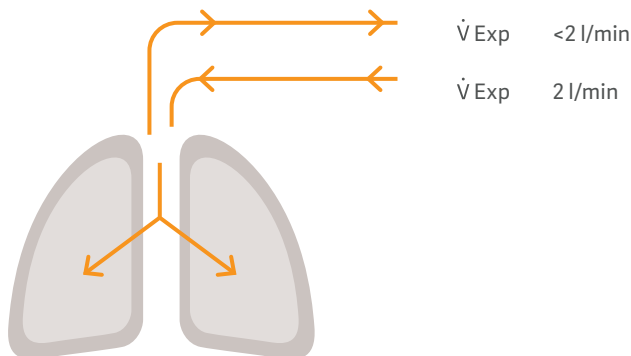
Trigger sensitivity determines the level of patient effort needed to trigger the Flow Family machine to begin a new breath.

Trigger sensitivity can be set as either flow triggering ("Trigg. Flow") or pressure triggering ("Trigg. Pressure").

Auto-triggering of the Flow Family machine is a false triggering event, when the patient is not initiating the breath.

### Important

The trigger level should be set as sensitive as possible without activating auto-triggering.



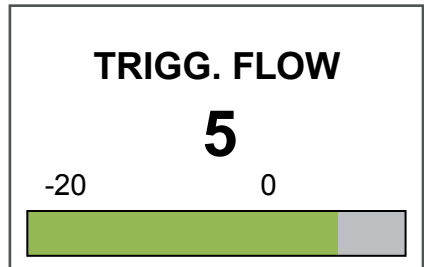
The Flow Family machine continuously delivers flow during expiration, which is measured at the expiratory channel.

- Flow: 2 l/min (~33 ml/s)

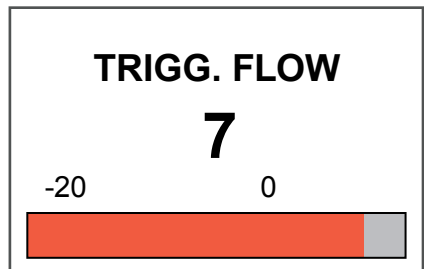
When the difference between the inspiratory and the expiratory flow equals the preset flow trigger level, a new inspiration will be initiated.

# Introduction

The flow trigger sensitivity setting is divided into percentage increments of 10, with each step increasing the trigger sensitivity.

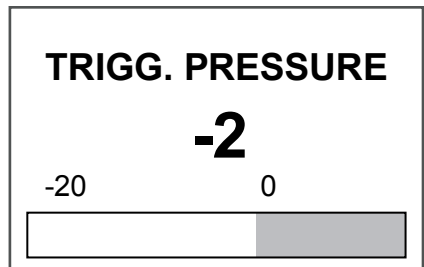


If the trigger is set in caution (red) area, the patient only has to inhale a very small portion of the trigger flow to trigger a breath — there is a risk for auto-triggering.



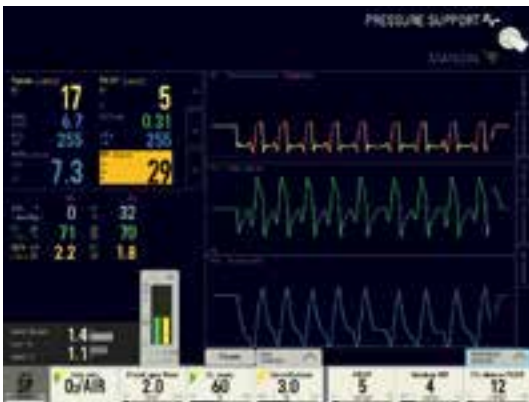
The pressure trigger sensitivity can be set within the range 0 to -20 cmH<sub>2</sub>O. To initiate a breath the patient has to create the negative pressure below PEEP to trigger a breath.

The higher the negative trigger pressure is set on the Flow Family machine, the more work of breathing the patient must perform.



# Introduction

When the patient triggers a breath, a purple text message appears on the upper part of the waveform area. It is also indicated on the initial part of the pressure or flow curves, as shown below.



## Note

1. If a breath is flow-triggered, a purple color indicator appears on the flow curve.
2. If a breath is pressure-triggered, a purple color indicator appears on the pressure curve.

# Controlled modes

## Volume Control

In Volume Control the Flow Family machine delivers the preset tidal volume with a constant flow during inspiration.



The peak pressure can vary from breath to breath if the patient's compliance and resistance change.

# Controlled modes

In a circle system without leakage, the inspired tidal volume should be nearly identical to the expired tidal volume. The time for inspiration and expiration can be configured so that it is set to display an I:E ratio or inspiration time (Ti) in seconds.



## Example

The flow during Volume Control ventilation is constant. The percentage of Insp. rise time is seen in the information area in the "Set ventilation mode" menu. (The inspiratory rise time is the time to peak inspiratory flow at the start of each breath, and is shown as a percentage of the respiratory cycle).

### How to calculate the flow

#### Example:

Preset Insp. Min. Volume = 6 l/min

Insp. time = 25%

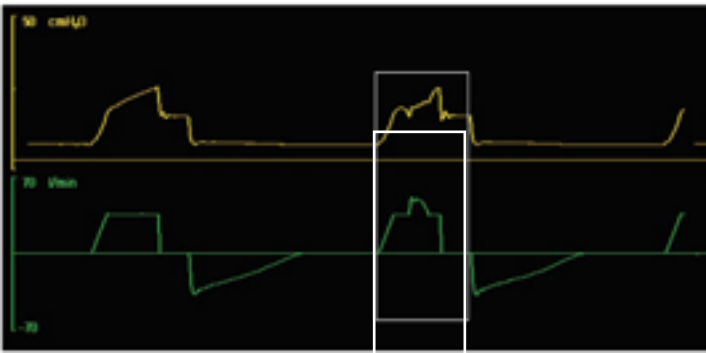
Inspiratory flow result:

$$\frac{6 \times 100}{25} = 24 \text{ l/min}$$

# Controlled modes

It is very important to set a sensitive triggering level to allow the patient to breathe spontaneously. If the patient is making an inspiratory effort during the expiratory phase, an assisted breath is delivered with the tidal volume set on the Flow Family machine.

In some cases, the patient may demand a higher tidal volume/flow than what is set on the Flow Family machine (for example: if the patient is in pain).



## Important

Always set the alarm limits for Pressure (Ppeak) to appropriate ranges.



# Controlled modes

## Pressure Control

In this controlled mode of ventilation, the Flow Family machine delivers a flow that maintains the preset pressure, respiratory rate, and inspiratory time. The delivered volume is a result of the difference between the set Pressure Control above PEEP and PEEP, the driving pressure.



During inspiratory time the pressure is constant and the flow is decelerating. If for any reason pressure decreases during inspiration, the flow from the Flow Family machine will immediately increase to maintain the set inspiratory pressure. The maximum available flow is 200 l/min (3.3 l/s). The volume can vary from breath-to-breath with the patient's compliance and resistance change.

### Important

Always set the alarm limits for Exp. Minute Volume to appropriate ranges.

# Controlled modes

Inspiratory rise time in PC is the time to reach the peak inspiratory pressure of each breath. The settings range of the total respiratory cycle time is zero to 20%

## Example

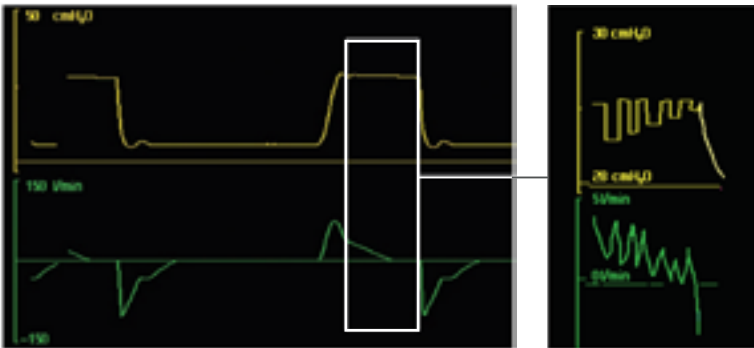
Respiratory rate 15, the time for  
1 breath cycle is  $60/15 = 4$  sec

Inspiratory rise time 10%:

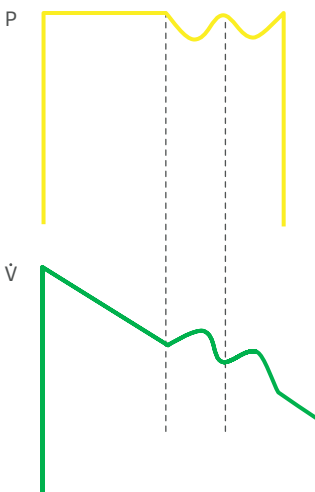
$$\frac{4 \times 10}{100} = 0.4 \text{ sec}$$

# Controlled modes

The Flow Family machines immediately detect even the smallest of deviations in pressure during inspiration, and compensate with an increase in flow during the breath.



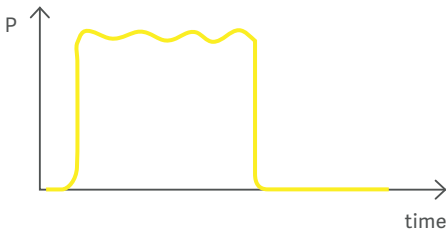
A decrease in pressure will occur when there is a leakage in the breathing system, at the endotracheal tube, or in the lungs (e.g. pneumothorax or fistula). When previously collapsed airways are beginning to open, the pressure decreases and the alveoli are opened by a precise increase in flow.



# Controlled modes

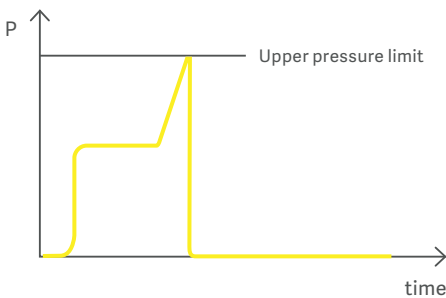
## Active expiratory valve

When a patient attempts to exhale during inspiration, the pressure increases. Once the pressure increases to 3 cmH<sub>2</sub>O above the set inspiratory pressure level, the expiratory valve will open and regulates the pressure back down to the set inspiratory pressure level.



## Upper pressure limit

If the pressure increases to the set upper pressure limit, e.g. the patient is coughing, the expiratory valve opens and the Flow Family machine returns to expiration.



# Controlled modes

## Pressure Regulated Volume Control (PRVC)

PRVC is a controlled mode of ventilation that combines the advantages of both volume-control and pressure-controlled ventilation. The Flow Family machine will in turn deliver the preset tidal volume at the lowest possible pressure.

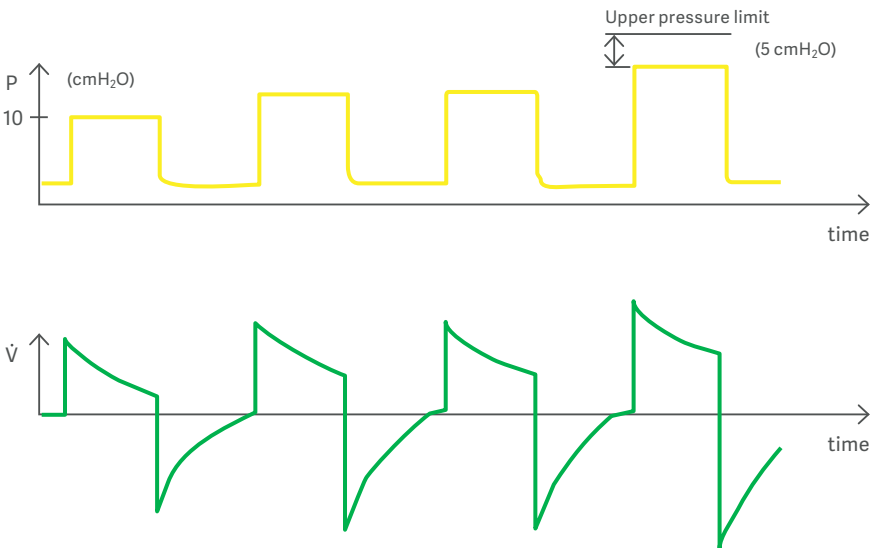


### Important

PRVC is not recommended when there is a leakage present in the patient's breathing circuit.

# Controlled modes

The first breath delivered to the patient in PRVC is a Volume Controlled breath. The measured pause pressure is used as the pressure level for the next breaths.



The set tidal volume is achieved by automatic, breath-by-breath regulation.

The Flow Family machine adjusts the inspiratory pressure level as low as possible to achieve the preset tidal volume. The delivered pressure is a result of the mechanical properties of the airways/lungs/thorax.

# Controlled modes

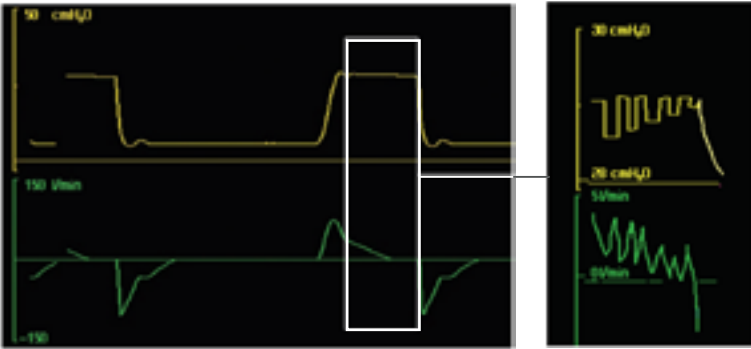
If the measured tidal volume deviates from the preset tidal volume, the pressure level decreases/increases between consecutive breaths (in steps with a maximum of 3 cmH<sub>2</sub>O) until the preset tidal volume is delivered.



If the pressure reaches 5 cmH<sub>2</sub>O below the preset upper pressure limit, the Flow Family machine will deliver the largest available volume and produces an audible alarm. In conjunction, an alarm message reading: "Regulation Pressure Limited" will be displayed in the alarm message area to inform the user that the desired volume cannot be delivered within its set ranges. The alarm limit for expired minute volume will also alert the user if appropriately configured.

# Controlled modes

The Flow Family machines will sense even the smallest deviations in pressure. If previously collapsed alveoli of the lung are beginning to open-up at the completion of inspiration, the pressure tends to decrease as well. This will be compensated by a precise increase in flow.



Terminal airway resistance decreases in distinct, downward steps as pressure is applied. By immediately sensing the pressure decrease that could be induced by an opening of alveolus, the Flow Family machine provides adequate flow to ensure balance and further enhance the opening process.



# Supported mode

## Pressure Support

Pressure Support is a spontaneous mode of ventilation. The patient initiates the breath and the Flow Family machine delivers support within the preset pressure settings. With support from the Flow Family machine, the patient determines the frequency and duration of the assistive breaths.



In Pressure Support the patient triggers all breaths, with the preset inspiratory Pressure Support level kept constant and a decelerating flow. The delivered volume is a result of the difference between set Pressure Support above PEEP and PEEP, the driving pressure.

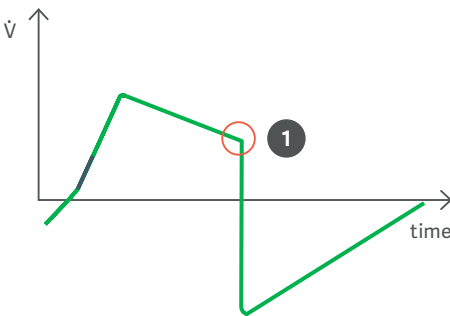
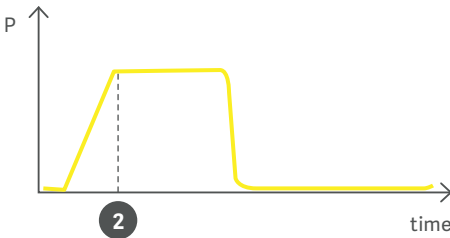
# Supported mode

The tidal volume delivered is a result of the mechanical properties of the lung thorax and patient effort. Adjust the Pressure Support level to obtain the desired ventilation.

The higher the preset inspiratory pressure level from the Flow Family machine, the more gas that will flow into the patient. As the patient becomes more responsive, the Pressure Support level could be gradually reduced.

## Pressure and flow curves

Inspiration is supported by a constant preset pressure when activated by patient effort. Since the pressure provided by the Flow Family machine is constant, the flow will decrease until the inspiratory cycle off (1) is reached and then the expiration starts. Depending on how the Inspiratory rise time (2) is set, the pressure will either rise very quickly or slowly at the beginning of the breath.



# Supported mode

## Expiration will start:

- once the inspiratory flow decreases to the preset End inspiration level.
- if the pressure increases 3 cmH<sub>2</sub>O or 10% above the Pressure Support level (highest value applicable).
- if the upper pressure limit is exceeded.
- if the inspiration exceeds 2.5 s in Adult range and 1.5 s 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.

## Important

1. The trigger sensitivity should be optimally set for the patient without increasing the work of breathing.
2. The Inspiratory rise time should be increased or decreased from the default settings to a value most conducive for the patient.
3. As the patient breathes more independently, the pressure support level could be gradually reduced.
4. It is important to monitor the Tidal Volume sizes and the Respiratory Rate.
5. The apnea alarm should always be set to suit the situation of the individual patient.
6. Ensure that the alarm limits for the expiratory Minute Volume and Respiratory Rate are appropriately set.

# Supported mode

## Backup Pressure Support

If the apnea alarm limit is reached, the Flow Family machine automatically switches to backup mode for Pressure Support, which is Pressure Control.



# Supported mode

If there is no patient effort when the apnea time is reached, the Flow Family machine will automatically switch to Pressure Support Backup. The touch buttons along the lower right corner adjust the respiratory rate and PC above PEEP. The Flow Family machine will return back to Pressure Support if the patient begins to trigger the Flow Family machine again.



# Combined mode

## Synchronized Intermittent Mandatory Ventilation (SIMV)

During SIMV, the patient will receive mandatory breaths that are either controlled or assisted by the Flow Family machine. These mandatory breaths are synchronized with the breathing efforts of the patient who can breathe spontaneously between the mandatory breaths.

A mandatory breath is defined by the basic settings (mode of ventilation, breath cycle time, respiratory pattern and volumes/pressures). The SIMV rate is the frequency of the mandatory breaths per minute.

The spontaneous/pressure-supported breath is defined by setting the Pressure Support level above PEEP and the cycle off percentage. When the user gradually decreases the SIMV rate, the patient has more and more time for the spontaneous/pressure-supported breaths.

There are two different SIMV modes:

- SIMV (Volume Control) + Pressure Support
- SIMV (Pressure Control) + Pressure Support

# Combined mode

SIMV (Volume Control)  
+ Pressure Support



SIMV (Pressure Control)  
+ Pressure Support



# Combined mode

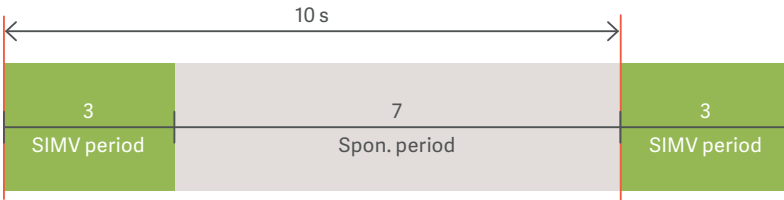
## Breath Cycle Time (Breath Cycle T)

This is the length of the total respiratory cycle of the mandatory breath (i.e. the total time for inspiration, pause and expiration).

### Note

The Breath Cycle Time is only applicable if the machine is configured for setting the inspiratory time by setting the I:E ratio.

## SIMV cycle



**In this illustration, the following settings are shown:**

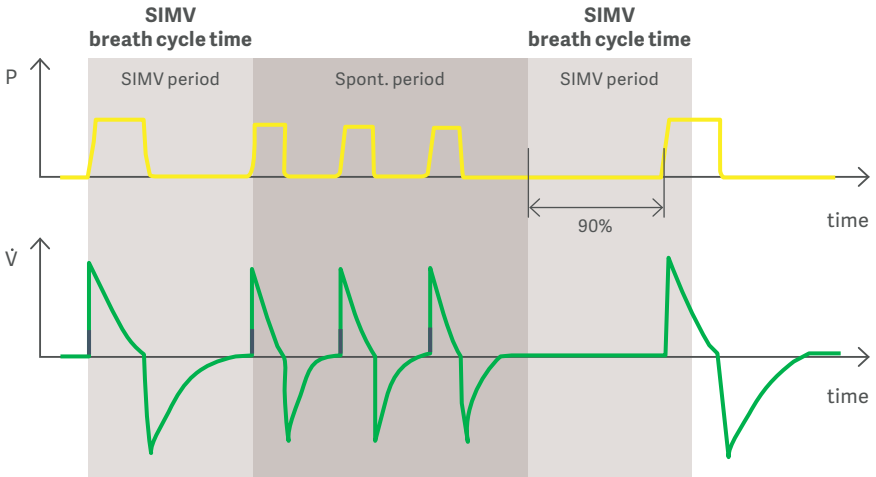
1. SIMV rate = 6.
2. Breath cycle time = 3 (the time for the mandatory breath).
3. The SIMV cycle in seconds is calculated as follows: 60 seconds divided by the SIMV rate – in this illustration  $60/6 = 10$  s.
4. The SIMV cycle is divided into an SIMV period and a spontaneous period.
5. The time for the spontaneous period is  $10\text{ s} - 3\text{ s} = 7\text{ s}$ .

**The time for the mandatory breath is:**

6.  $3\text{ s} = \text{SIMV period}$ .
7. I:E ratio 1:2 = 1 s for inspiration and 2 s for expiration.



# Combined mode



When the patient starts to breathe, Pressure Support is delivered during the spontaneous period. If triggering occurs in the SIMV period, the set mandatory breath is delivered and the Flow Family machine will wait during the next SIMV period for the patient to trigger. However, if the patient has not triggered within the first 90% of the breath cycle time (SIMV period), a mandatory breath will then be delivered.

# Manual ventilation

In addition to mechanical ventilation, the user may also choose to utilize the Flow Family machine to ventilate a patient manually.

To access a manual mode, press the upper right-hand corner of the interface or the ventilation settings tab located in the lower right corner.

On the left side of the window, you will find the manual ventilation options.



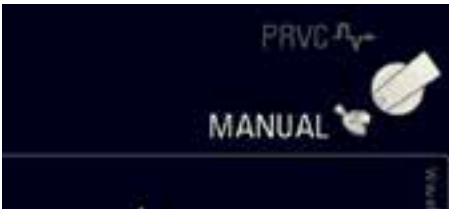
# Manual ventilation

After selection, flip the man/auto switch to manual.



# Manual ventilation

Manual ventilation is highlighted in the upper right corner.



The set pressure limit (APL) is displayed at the bottom left of the screen.

The APL pressure can be set anywhere between a value corresponding to a fully open valve (for spontaneous breathing) and 80 cmH<sub>2</sub>O. At values above 30 cmH<sub>2</sub>O, an increased tactile resistance can be felt and a slight audible click can be heard at each 5 cmH<sub>2</sub>O interval.



# Manual ventilation

The gas mix, fresh gas flow, O<sub>2</sub> concentration and agent are highlighted (active) in a light gray color.

The setting for the controlled ventilation (on the bottom right) is inactive and shown in a darker gray, but can still be adjusted (although inactive until return to auto ventilation).



# Additional Fresh Gas Outlet (AFGO)

The Flow Family machines can be equipped with an Additional Fresh Gas Outlet (AFGO) option. This option allows for the connection of breathing systems such as a Jackson-Rees, Bain or Mapleson system.

When AFGO is engaged, the active settings are highlighted in orange up on the interface.



# Emergency ventilation

In the rare circumstance of a total power (mains power and up to 90 minutes of battery backup) or system failure, the patient can be manually ventilated with the use of the manual ventilation bag by activating the Emergency Ventilation system.

This system's components include:

- an emergency ventilation on/off switch.
- an O<sub>2</sub> gas supply knob and flowmeter.
- an emergency APL valve regulator.
- clear and simple instruction for accessing this function.

## Important


During Emergency Ventilation, the Flow Family machine cannot deliver anesthetic agents.

If the Emergency Ventilation system is activated while the anesthesia system is in operation, the user interface panel and machine will be shut down.

The Emergency Ventilation system is activated by turning "ON" the activation switch and setting an oxygen flow. The oxygen flow can be dialed up to a maximum of 10 l/min. The pressure level is adjusted by the mechanical APL regulator.



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