



TekMedika Pvt. Ltd.

## INSPIRE-100



***A Streamlined Emergency  
Respiration Assist Device***

# INSPIRE-100

(Patent Pending)

*Is it right for you?*

*Need adult respiratory support?*

*Budget Friendly?*

*Support from Initiation to Weaning?*

*No compressed air or piped Oxygen?*

*Connect to O<sub>2</sub> Cylinder or Concentrator?*

*Full range of Respiration parameters?*

*Breath Synchronization for Patient Comfort?*

*Remote monitoring capability?*

*Handle harsh-uncontrolled Environment?*

*Easy-to-use System?*

# *Setting the Context*

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The Motivation

The Problem Statement

# Respiration Assist Devices

Categories – Usage and Pricing

Features

Less than Rs 50,000



CPAP

Less than Rs 1 Lakh



BiPAP

**AFFORDABLE**  
feature set for PHC,  
Small Clinic, and  
Ambulance Use?

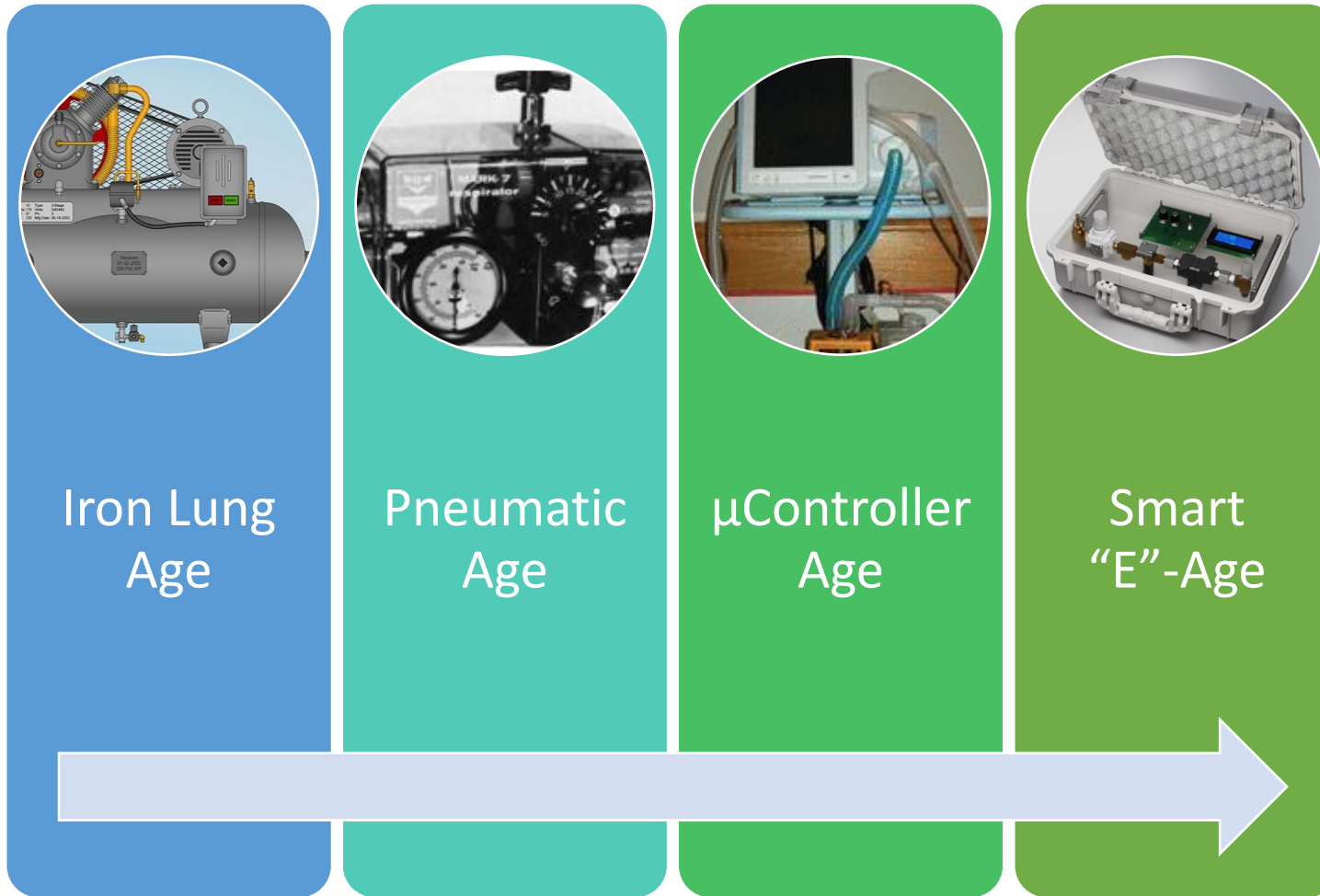
Big Hole

Rs 12 Lakhs ++



ICU Ventilator

# Evolution of Ventilators



## Most-used Ventilation Modes have not changed

- Volume and Pressure Control
- Control BPM, I/E, VT and PS
- Monitor pressures and flow
- Safety Alarm systems

## Diminishing Returns from what has evolved ...

- Exotic Ventilation modes
- Multitude of Sensors
- Fancy Touch-screen LCD Displays

# *INSPIRE-100 Details*

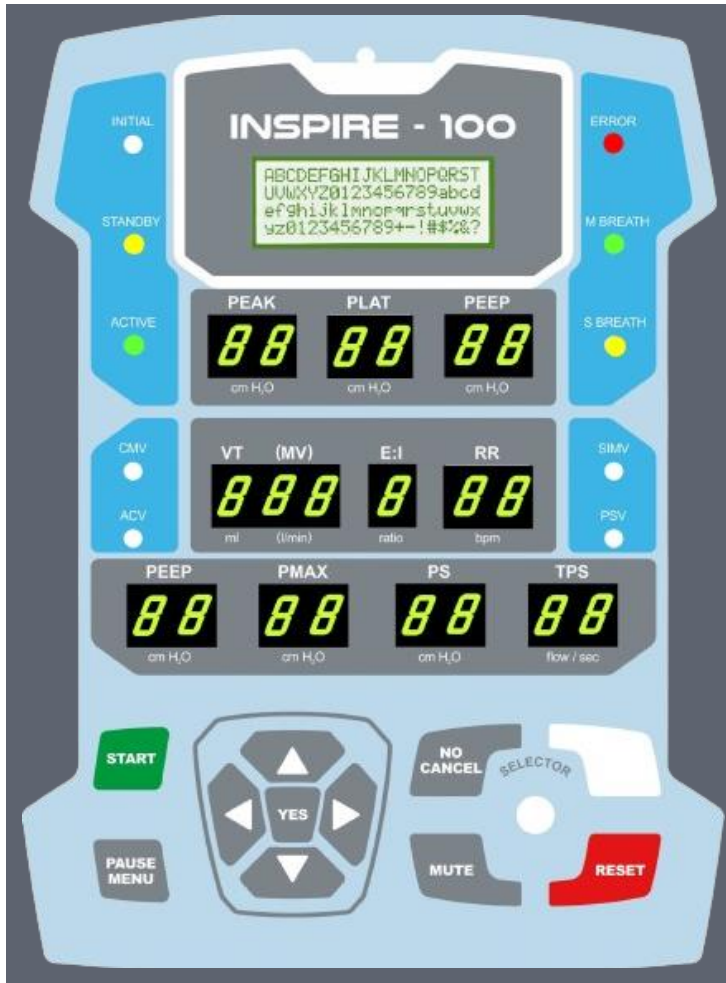
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System Components

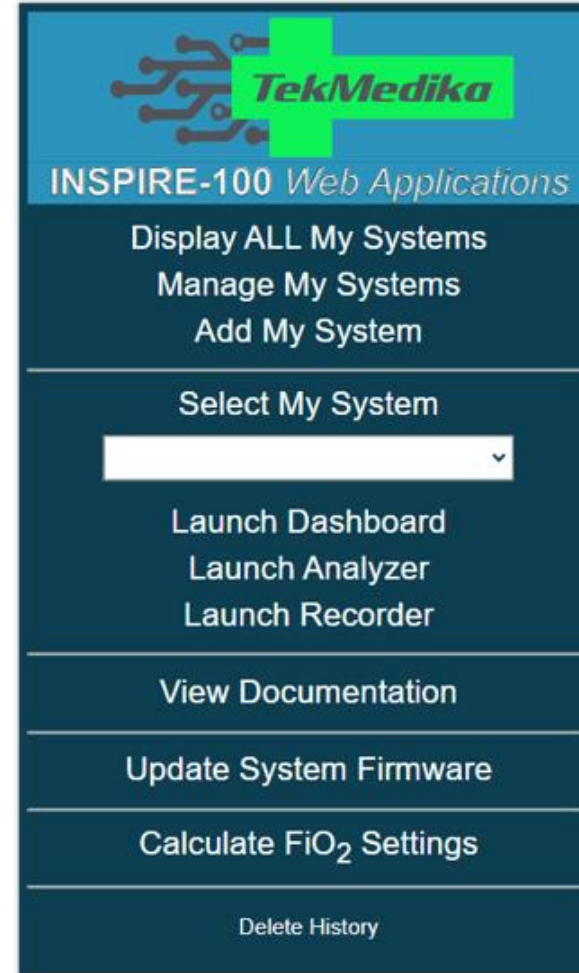
Technical Details



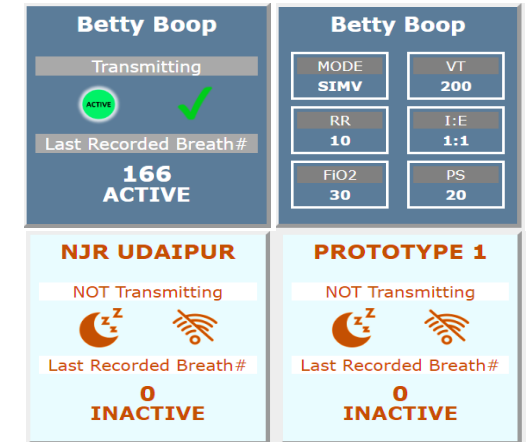
### Menu-driven, Tactile, Intuitive and Easy-to-read Control Panel



### Live Dashboard Recording and Analyzer



### Multi-system Dashboard for Nurses' Station

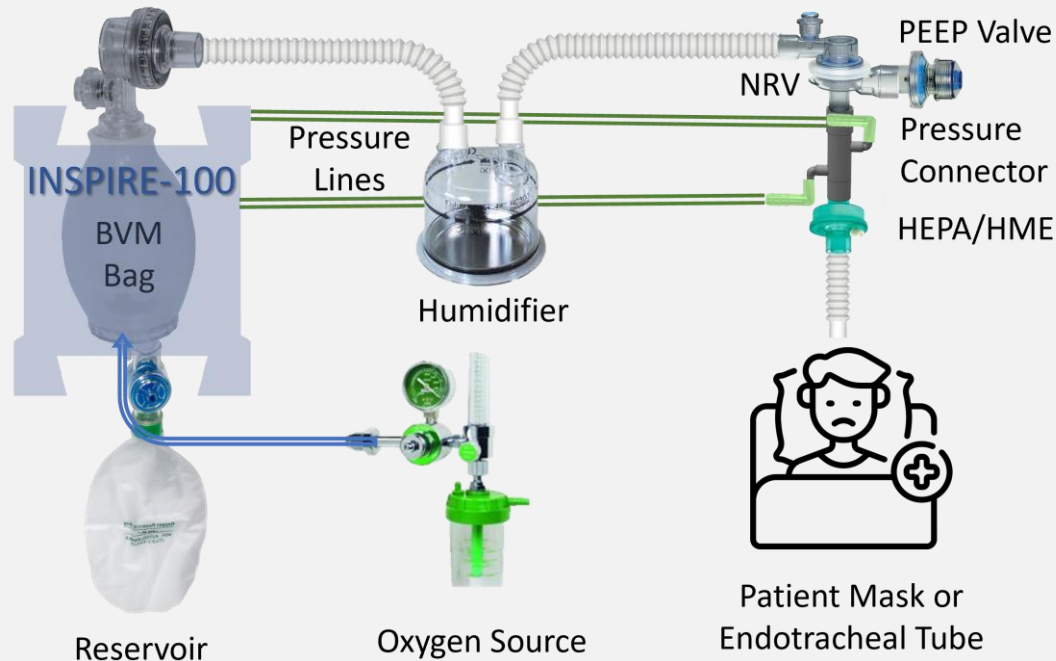


### Field Upgradeable



# Product Overview

## Breathing Circuit



## Salient Features

*Exceptionally Budget Friendly*

*Elaborate Remote Monitoring Capabilities*

*Easy-to-use  
Easy-to-train  
Rugged & Robust*

*No Need for Compressed air or Piped O<sub>2</sub>*

*Complete Set of Most-used Respiration Parameters*

*Power Consumption 100W*

## Patient Comfort

*Mandatory Breaths synchronized with Patient-initiated Breaths*

*No breath stacking*

$$Q \propto \sqrt{\frac{(P_{G1} - P_{G2})}{(P_{G1} + P_{G2}) + 2 \cdot P_{atmosphere}}}$$

An important and necessary simplification is that  $P_{G1}$  and  $P_{G2}$  encountered in our system are of the order of tens of cmH<sub>2</sub>O while  $P_{atmosphere}$  is of the order of a thousand cmH<sub>2</sub>O of pressure. At sea level,  $P_{atmosphere}$  is approximately 1000 cmH<sub>2</sub>O. Even at an altitude of 15,000 feet,  $P_{atmosphere}$  is approximately 600 cmH<sub>2</sub>O. On the other hand, the  $P_{G1}$  and  $P_{G2}$  in the system range from 1 cmH<sub>2</sub>O to 60 cmH<sub>2</sub>O.

Thus the  $(P_{G1} + P_{G2})$  term is negligible compared to  $(2 \cdot P_{atmosphere})$ , even more so since it is preceded by a square root. The flow equation can be simplified to the one below.

$$Q \propto \sqrt{\frac{(P_{G1} - P_{G2})}{P_{atmosphere}}}$$

**Patent Pending**

Recalling Equation 2 from the theory section above, this equation can be recast as below given that the orifice characteristics and pressure tap location are the same for every system.

$$Q = C \cdot \sqrt{\frac{(P_{G1} - P_{G2})}{P_{atmosphere}}}$$

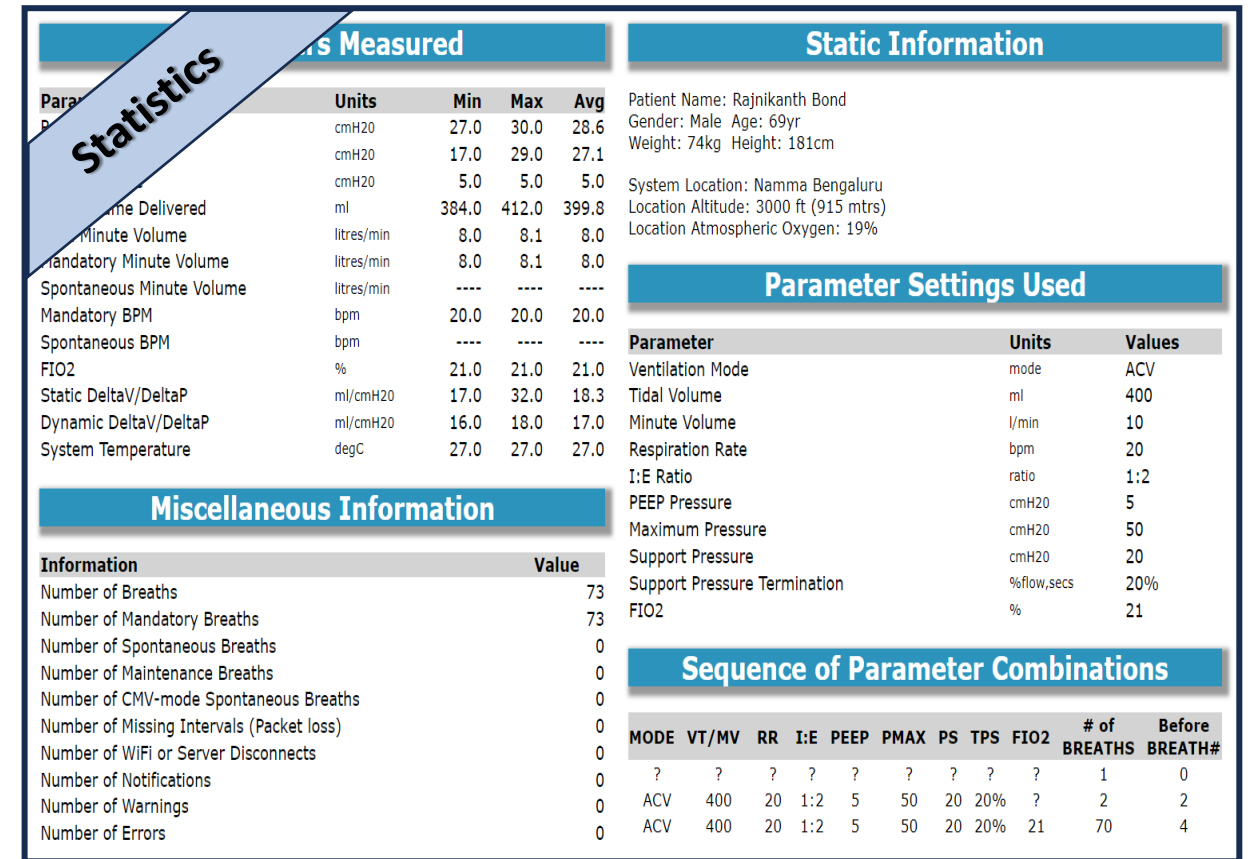
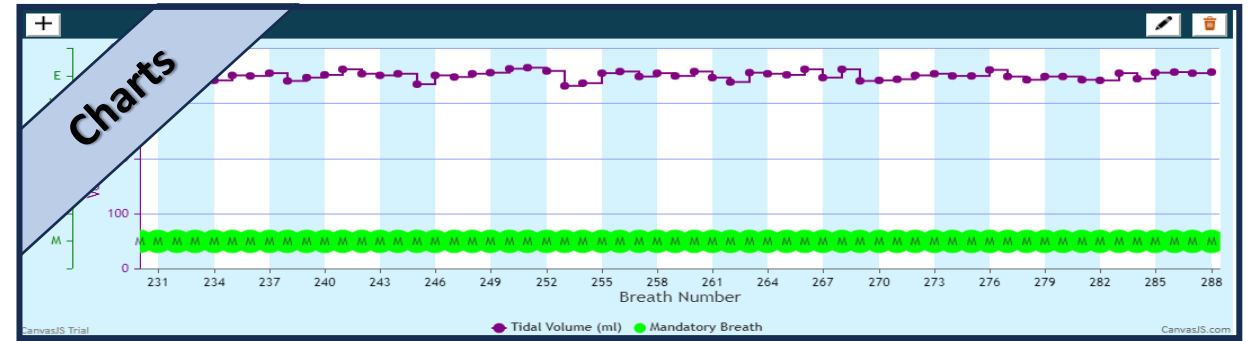
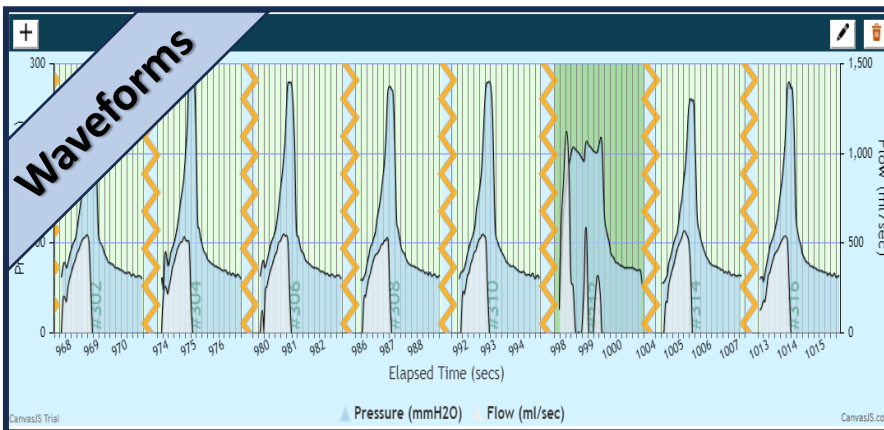
At a given geographical location,  $P_{atmosphere}$  is also a constant. So, the above equation further reduces to the one below.

$$Q = \left( \frac{C}{\sqrt{P_{atmosphere}}} \right) \cdot \sqrt{(P_{G1} - P_{G2})}$$

The equation needs further simplification to ease the computation burden of the square root computation for an inexpensive micro-controller. The constraints are as below.



# Elaborate Remote Monitoring



## Commonly used Ventilation Modes

<b>CMV</b>	Continuous Mandatory Ventilation
<b>ACV</b>	Synchronized Assist Control Ventilation
<b>SIMV</b>	Synchronized Intermittent Mandatory Ventilation
<b>PSV</b>	Pressure Support Ventilation

## Full Set of Alarm Alerts

Max Pressure	Pressure Leak	Pressure Loss
Airway Blockage	Coughing Hiccupping	Inconsistent Parameters
Extreme Parameter Combination	System Temperature	And many more ...

## Volume Controlled Breaths

<b>Tidal Volume</b> 200 - 600 ml	<b>Respiratory Rate</b> 10 - 30 bpm	<b>I:E Ratio</b> 1:1   1:2   1:3
<b>PEEP</b> 4 - 15 cmH <sub>2</sub> O	<b>Max Pressure</b> 15 - 60 cmH <sub>2</sub> O	<b>FiO<sub>2</sub> Support</b> System Managed Externally Controlled

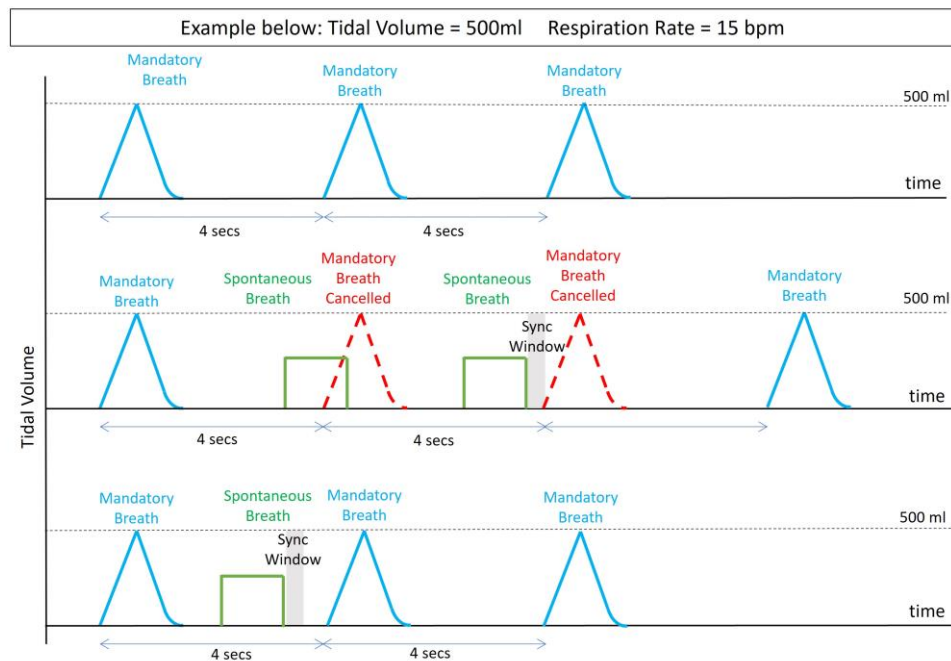
## Pressure Supported Breaths

<b>Support Pressure</b>	5 - 35 cmH <sub>2</sub> O
<b>Support Pressure Termination</b>	Flow Triggered Time Triggered

## Synchronize Mandatory breaths with Spontaneous breaths Prevent breath stacking

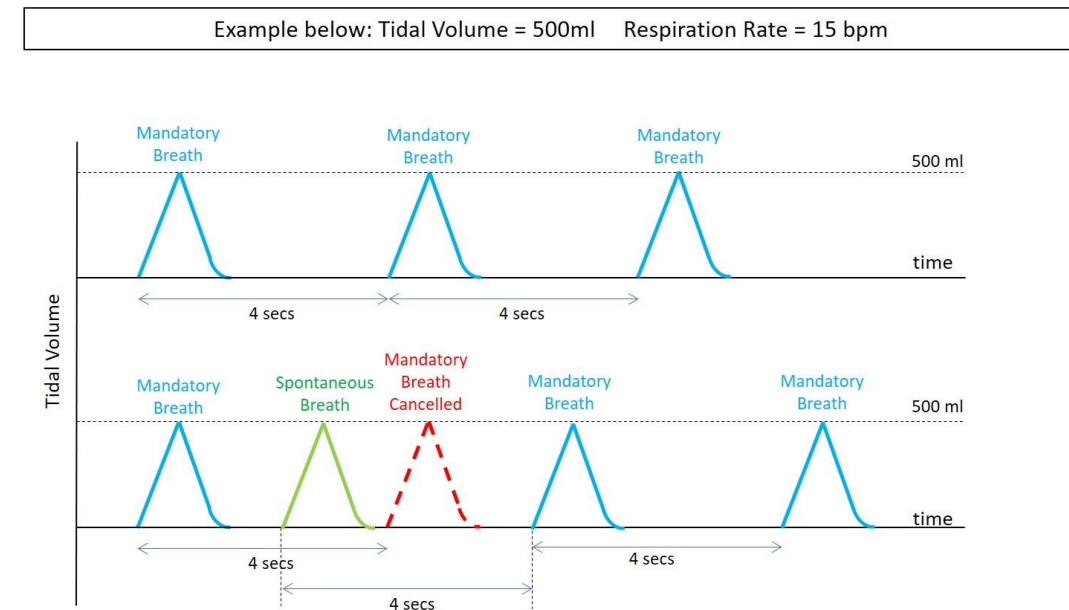
### Breath Syncing in SIMV mode

There is a sync-window – the next mandatory breath is rescheduled only if spontaneous breath within the sync-window



### Breath Syncing in Synchronized AC Mode

There is no sync-window – the next mandatory breath is always rescheduled after a spontaneous breath



# FiO<sub>2</sub> Settings

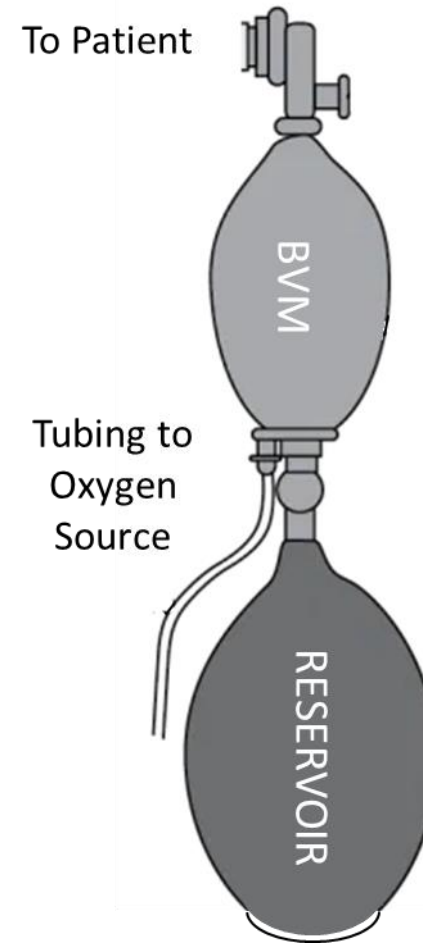
Without the Reservoir bag, FiO<sub>2</sub> delivered is the Atmospheric O<sub>2</sub> content at site

FiO<sub>2</sub> delivery with the Reservoir bag is mathematically modelled, calibrated and verified in the Lab to provide +/- 5% accuracy


Front-panel guides the user in setting the appropriate input O<sub>2</sub> flow rate from the O<sub>2</sub> source for a given FiO<sub>2</sub>

The mathematical model provides for a possible O<sub>2</sub> concentrator as an O<sub>2</sub> source (purity < 100%)

Online Web-accessible FiO<sub>2</sub> calculator is also provided for exploration purposes







**INSPIRE-100 FiO<sub>2</sub> Calculator**



**Required Incoming O<sub>2</sub> Flow**

**0.0 (litres/min)**

Altitude:  feet

Desired VT (ml)	Desired RR (bpm)
	
O <sub>2</sub> Purity (%)	Desired FiO <sub>2</sub> (%)
	

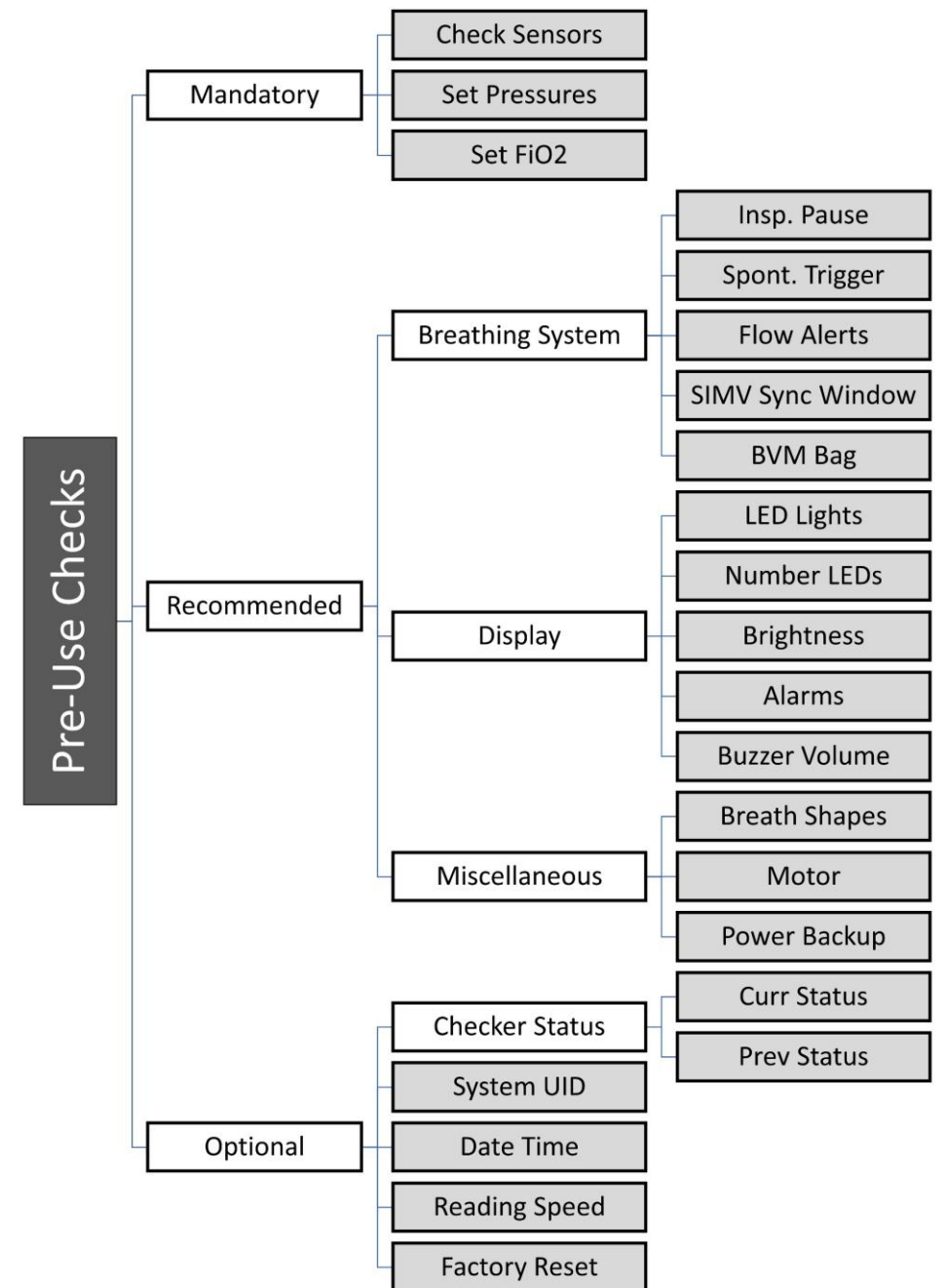
# Alarms & Safety Features

## Enforcement of Pre-use checks

## Maintenance Breaths till Alarm situation rectified

## Alarms, Warnings and Notifications

- Max Pressure Alarm
- Pressure Leak Alarm
- Pressure Loss Alarm
- Airway Blockage Alarm
- System Temperature Alarm
- Sensor Failure Alarm
- Breathing Circuit Failure Alarm
- Detect coughing/hiccupping fits
- Inconsistent input parameters
- Extreme parameter combination warnings
- And many more ...

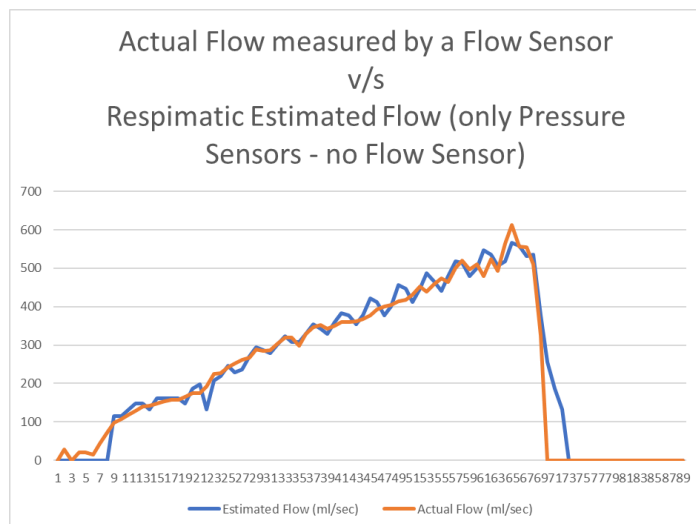


*Backup*

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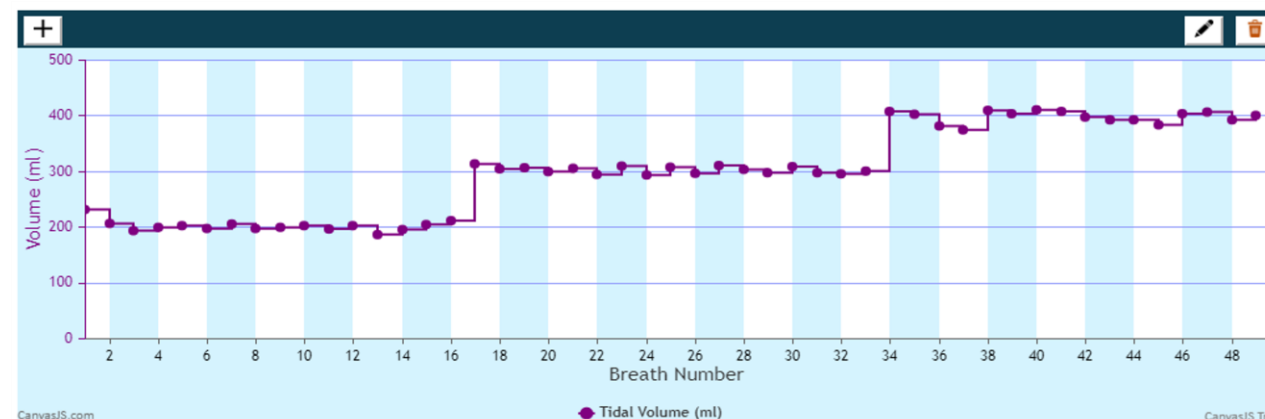


# Some Results

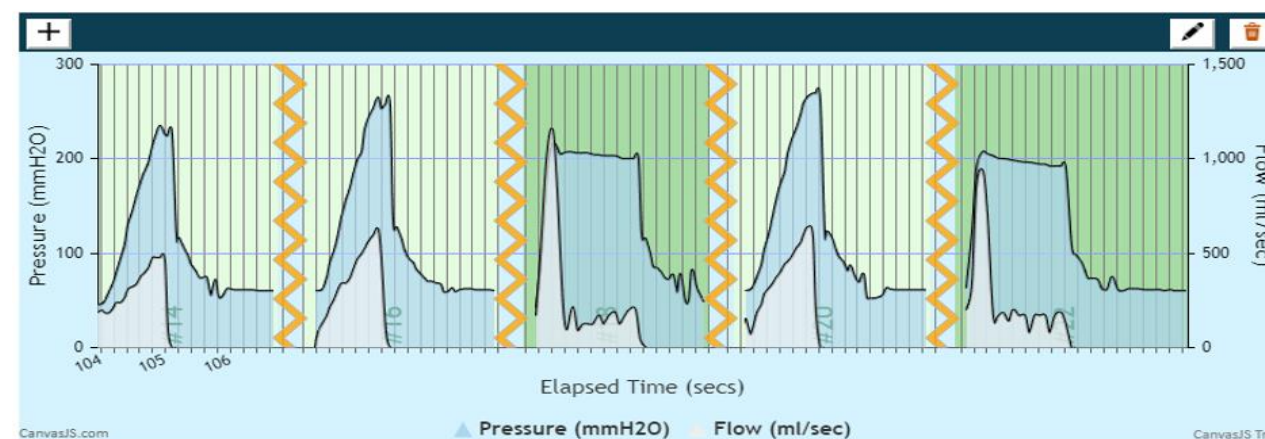


Sample FiO2 Data					
PEEP=6, EI=2			Measured	Calculated	ERROR
VT	RR	O2 (l/min)	FiO2(%)	FiO2(%)	%
400	20	2	40.5	39	4%
400	20	2.5	45.5	43.5	4%
400	20	3	49	48	2%
400	20	3.5	54	53.5	1%
400	20	4	59.8	57	5%
400	20	4.5	63.5	61.5	3%
400	20	5	67.5	66	2%
400	30	2	33	33	0%
400	30	2.5	36.5	36	1%
400	30	3	38.5	39	1%
400	30	3.5	41.5	42	1%
400	30	4	44.5	45	1%
400	30	4.5	47.1	48	2%
400	30	5	49.8	51	2%

## VT Titration for VT = 200, 300 and 400ml



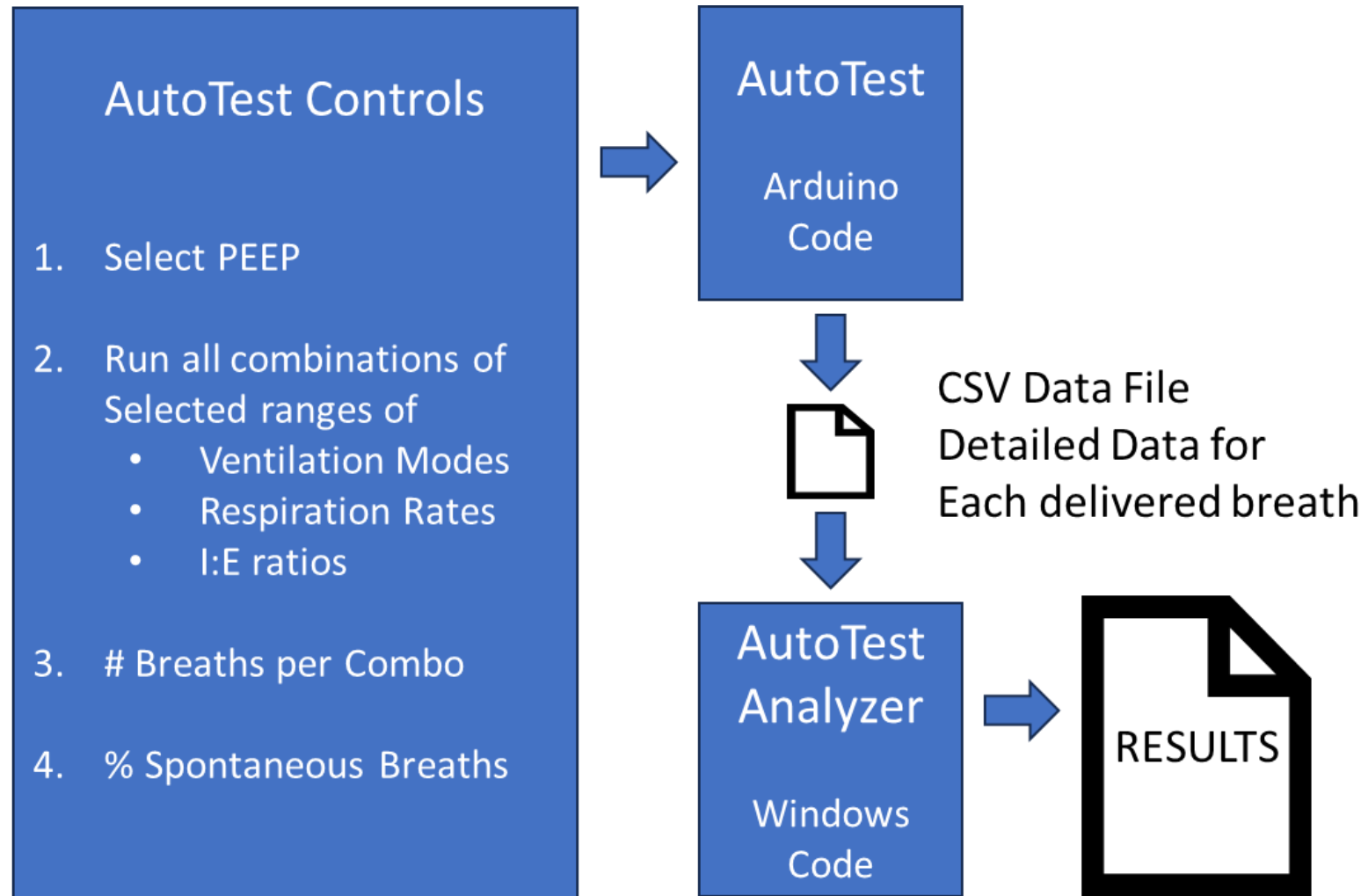
## A Mix of VC and PS Breaths



# CPAP v/s BiPAP v/s INSPIRE-100 v/s ICU-VENTILATOR

CPAP	BiPAP	Respimatic 100	ICU Ventilator
Continuous Positive Airway Pressure	Continuous Bi-Level Airway Positive Pressure	Mechanical Ventilation with 4 most-used ventilation modes and controls	Mechanical Ventilation with very sophisticated modes and controls
Non-invasive	Non-invasive	Non-invasive + Invasive	Non-invasive + Invasive
High Flow + PEEP	Inspiratory Pressure + PEEP	Tidal Volume + Support Pressure + PEEP	Tidal Volume + Support Pressure + PEEP
Useful for Type 1 respiratory Failure (Hypoxemic)	Useful for Type 2 respiratory Failure (Hypercapnic)	Useful for Hypoxemic and Hypercapnic respiratory failure	Useful for Hypoxemic and Hypercapnic respiratory failure
Continuous flow of air at a constant pressure. Increases mean airway pressure to recruit collapsed alveoli	Continuous flow of air at different constant pressures during inspiration and expiration breathing phase	Independent control over the volume, the respiration rate and pressure	Independent control over the volume, the respiration rate and pressure
Useful only when patient can breathe on his own	Useful only when patient can breathe on his own	Useful when patient can or CANNOT breathe on his own	Useful when patient can or CANNOT breathe on his own
Only Spontaneous breaths that are patient triggered.	Only Spontaneous breaths that are patient triggered.	Spontaneous breaths + Mandatory breaths controlled by RR and I:E	Spontaneous breaths + Mandatory breaths controlled by RR and I:E
External FiO2 control	External FiO2 control	System assisted FiO2 control	Direct FiO2 control
Breath Synchronization N/A	Breath Synchronization N/A	Full Breath Synchronization	Full Breath Synchronization
No Tidal Volume control	Indirect Tidal Volume control (IPAP-EPAP)	Direct Tidal Volume control	Direct Tidal Volume control
No Respiration Rate control	No Respiration Rate control	Direct Respiration Rate control	Direct Respiration Rate control
No Inspiration:Expiration ratio control	No Inspiration:Expiration ratio control	Direct Inspiration:Expiration control	Direct Inspiration:Expiration control
External Humidity control	External Humidity control	External Humidity control	Direct Humidity control
No display of Peak, Plateau or PEEP	No display of Peak, Plateau or PEEP	Full display of Peak, Plateau and PEEP	Full display of Peak, Plateau and PEEP
Minimal alarm signals	Minimal alarm signals	Full set of Alarm signals	Full set of Alarm signals
No remote monitoring	No remote monitoring	Sophisticated Remote WEB Dashboard	Minimal Remote monitoring (if any)

# Automated Testing



*Thank you*

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