

# HAMILTON-C1

## Technical specification for SW version 3.0.x

### Ventilation modes

Standard: ✓ Option: ○ Not applicable: --

Mode form	Mode name	Mode	Adult/Ped	Neonatal
Volume-targeted modes, adaptive pressure controlled	APVcmv / (S)CMV+	Breaths are volume targeted and mandatory.	✓	✓
	APVsimv / SIMV+	Volume-targeted mandatory breaths can be alternated with pressure-supported spontaneous breaths.	✓	✓
	VS	Breaths are flow cycled and deliver a set tidal volume to support patient-initiated breaths.	✓	✓
Pressure-controlled modes	PCV+	All breaths, whether triggered by the patient or the ventilator, are pressure-controlled and mandatory.	✓	✓
	PSIMV+	Mandatory breaths are pressure controlled. Mandatory breaths can be alternated with pressure-supported spontaneous breaths.	✓	✓
	DuoPAP	Mandatory breaths are pressure controlled. Spontaneous breaths can be triggered at both pressure levels.	○	○
	APRV	Spontaneous breaths can be continuously triggered. The pressure release between the levels contributes to ventilation.	○	○
	SPONT	Every breath is spontaneous, with or without pressure-supported spontaneous breaths.	✓	✓
Intelligent ventilation	ASV	Operator sets %MinVol, PEEP, and Oxygen. Frequency, tidal volume, pressure, and I:E ratio are based on physiological input from the patient.	✓	--
	INTELLIVENT-ASV	Ventilator management of CO2 elimination and oxygenation is based on clinician-defined target ranges and parameter limits, and physiological input from the patient. The underlying mode is ASV.	○	--
Noninvasive modes	NIV	Every breath is spontaneous.	○	○
	NIV-ST	Every breath is spontaneous as long as the patient is breathing above the set Rate. A backup Rate can be set for mandatory breaths.	○	○
	nCPAP	Demand flow nasal continuous positive airway pressure.	--	○
	nCPAP-PC	Breaths are pressure controlled and mandatory.	--	○
	HiFlowO2	High flow oxygen therapy. No supported breaths.	○	○

## Standard configuration and options (in alphabetical order)

Standard: ✓ Option: ○ Not applicable: --

Functions	Adult/Ped	Neonatal
Capnography, mainstream (volumetric) and sidestream	○	○
Communication board:	○	○
CO2/Nurse Call/COM1, CO2/SpO2/COM1 <sup>1</sup> , CO2/SpO2/Humidifier & COM1 <sup>1,2</sup>		
Communication protocols. For details, see the <i>Connectivity</i> brochure	○	○
CPR ventilation	✓	✓
Dynamic Lung	✓	--
Event log (up to 10,000 events with date and time stamp)	✓	✓
Flow trigger	✓	✓
Hamilton Connect Module (connectivity)	○	○
HAMILTON-H900 humidifier integration	○	○
IntelliTrig (leak compensation)	✓	✓
Languages (English, US English, Chinese, Croatian, Czech, Danish, Dutch, Finnish, French, German, Greek, Hungarian, Indonesian, Italian, Japanese, Korean, Norwegian, Polish, Portuguese, Romanian, Russian, Serbian, Slovak, Spanish, Swedish, Turkish, Ukrainian)	✓	✓
Manual breath/prolonged inspiration	✓	✓
Nebulization, pneumatic	✓	--
O2 enrichment	✓	✓
On-screen help	✓	✓
Patient group HAMILTON-C1 neo	--	✓
Patient group HAMILTON-C1	✓	○
Print screen	✓	✓
RJ-45 Ethernet port <sup>3</sup>	✓	✓
Screen lock	✓	✓
Speak valve compatibility	○	--
SpO2 monitoring	○	○
Standby with timer	✓	✓
Suctioning tool	✓	--
Trends/Loops	○	○
USB port	✓	✓
Vent Status (visual representation of patient's ventilator dependence)	✓	✓

<sup>1</sup> Applies only to devices with serial number > 6000

<sup>2</sup> Only available with the HAMILTON-H900 Y-cable

<sup>3</sup> Only available for use if the Hamilton Connect module is activated.



## Technical performance

Description	Specification
Automatic expiratory base flow	<i>Adult/Ped:</i> Fixed at 3 l/min <i>Neonatal:</i> Fixed at 4 l/min
Inspiratory pressure	0 to 60 cmH <sub>2</sub> O
Maximum limited pressure	60 cmH <sub>2</sub> O
Maximum working pressure	<i>Adult/Ped:</i> 60 cmH <sub>2</sub> O (total inspiratory pressure); ensured through pressure limiting <i>Neonatal:</i> 45 cmH <sub>2</sub> O (limitation depending on frequency)
Maximum inspiratory flow	260 l/min (120 l/min with 100% O <sub>2</sub> )
Means of inspiratory triggering	Flow trigger control
Minimum expiratory time	20% of cycle time; 0.2 to 0.8 seconds
Minute volume capability	Up to 60 l/min
Oxygen mixer accuracy	± (volume fraction of 2.5% + 2.5% of actual reading)
Tidal volume	<i>Adult/Ped:</i> 20 to 2000 ml <i>Neonatal:</i> 2 to 300 ml
Preoperational checks	Leak test, flow sensor/circuit/O <sub>2</sub> sensor calibration, CO <sub>2</sub> sensor zero calibration <sup>4</sup>
Display device	Display of settings, alarms, and monitored data <i>Type:</i> Color TFT <i>Size:</i> 640 x 480 pixels, 8.4 in (214 mm) diagonal
Brightness setting for display	The range is 10% to 100% brightness. By default, Day = 80%; Night = 40%.
Alarm volume (loudness) <sup>5</sup>	The range is 1 to 10. The default setting is 5.
Sound power level <sup>6</sup>	51 dB(A) ± 3dB(A)
Sound pressure level <sup>6</sup>	43 dB(A) ± 3dB(A)

<sup>4</sup> CO<sub>2</sub> option required

<sup>5</sup> Volume at 1 meter distance from ventilator. A setting of 1 = 62 dB(A), 5 = 76 dB(A), and 10 = 85 dB(A), with accuracy of ±3 dB(A).

<sup>6</sup> Per ISO 80601-2-12.

## Standards and approvals

Classification	Class IIb, continuously operating according to EC directive 93/42/EEC
Valid versions	IEC 60601-1:2005/A1:2012, ANSI/AAMI ES60601-1:2005(R)2012, CAN/CSA-C22.2 No. 60601-1:14, IEC 60601-1-2:2014, ISO 80601-2-12:2011 + Cor.:2011, ISO 80601-2-55:2018, EN ISO 5356-1:2015, ISO 80601-2-61:2017, ISO 80601-2-49:2018
Declaration	The HAMILTON-C1 was developed in accordance with pertinent international standards and FDA guidelines. The ventilator is manufactured within an EN ISO 13485 and EN ISO 9001, Council Directive 93/42/EEC, Annex II, Article 3 certified quality management system. The ventilator meets the Essential Requirements of Council Directive 93/42/EEC, Annex I.
Electromagnetic compatibility	According to IEC 60601-1-2:2014
Safety class	Class II, Type B applied part (ventilator breathing system, VBS), type BF applied part CO2 sensor including CO2 module connector; SpO2 sensor including adapter, continuous operation according to IEC 60601-1

## Pneumatic performance

High-pressure oxygen inlet	Pressure:	2.8 to 6 bar / 41 to 87 psi
	Flow:	Maximum of 200 l/min
	Connector:	DISS (CGA 1240) or NIST
Low-pressure oxygen inlet	Pressure:	Maximum 6 bar / 87 psi
	Flow:	≤ 15 l/min
	Connector:	Quick-coupling system, compatible with Colder Products Company (CPC) PMC series
Air supply	Integrated blower	
Gas mixing system	Delivered flow:	<ul style="list-style-type: none"> <li>&gt; 260 l/min ±10% against ambient pressure (at sea level)</li> <li>&gt; 200 l/min with 100% oxygen</li> </ul>
	Delivered pressure:	<i>Adult/Ped:</i> 0 to 60 cmH2O <i>Neonatal:</i> 0 to 45 cmH2O
	Flow accuracy:	±10% or ±300 ml/min (whichever is greater)
	Inspiratory outlet ( <i>To patient</i> port)	Connector:
Expiratory outlet ( <i>From patient</i> port)	Connector (on expiratory valve):	ISO ID15/OD22 conical

## Electrical specifications

Input power	100 to 240 VAC $\pm$ 10%, 50/60 Hz
Power consumption	50 VA typical, 150 VA maximum
Battery	Hamilton Medical provides a high-capacity battery <sup>7</sup> .
Electrical specifications:	6.7 Ah, 72 Wh, 50 W typical, 150 W maximum
Type:	Lithium-ion, supplied by Hamilton Medical only
Recharge time:	While the ventilator is connected to primary power, approximately 3.25 h to fully recharge one battery.
Storage:	-20°C to 60°C, $\leq$ 85% relative humidity. The storage location should be free from vibration, dust, direct sunlight, moisture, and corrosive gases, and with a recommended temperature range < 21°C.  Extended exposure to temperatures above 45°C can degrade battery performance and life.
Normal operating time:	Operating times are measured with one fully charged battery, the blower in use, without communication board, and with the following settings: Mode = PCV+, Rate = 10 b/min, $\Delta$ Pcontrol = 10 cmH <sub>2</sub> O, I:E = 1:4, PEEP = 5 cmH <sub>2</sub> O, Flow trigger = 5 l/min, FiO <sub>2</sub> = 40%.  Approximate operating times under these conditions are as follows: <ul style="list-style-type: none"> <li>• One battery, display brightness = 80%: 4 h</li> <li>• One battery, display brightness = 20%: 4.5 h</li> </ul> <p>This operating time applies to new, fully charged Li-ion batteries that have not been exposed to extreme temperatures. The actual operating time depends on battery age and on how the battery is used and recharged.</p>

## Graphical patient data

Graphic type/tab name	Options
Waveforms	Pressure, Volume, Flow, PCO <sub>2</sub> <sup>8</sup> , FCO <sub>2</sub> <sup>8</sup> , Plethysmogram <sup>9</sup> , Capnogram <sup>10</sup>
Intelligent panels	Dynamic Lung <sup>11</sup> , Vent Status, ASV Graph <sup>12</sup> , INTELLiVENT-ASV Oxygenation and CO <sub>2</sub> elimination maps and horizons <sup>10</sup>
Trends	1-, 6-, 12-, 24-, or 72-h trend data for a selected parameter or combination of parameters
Loops	Pressure/Volume, Pressure/Flow, Volume/Flow, Volume/PCO <sub>2</sub> <sup>8</sup> , Volume/FCO <sub>2</sub> <sup>8</sup>

<sup>7</sup> PN 369108, revision 4 and later.

<sup>8</sup> CO<sub>2</sub> option required

<sup>9</sup> SpO<sub>2</sub> option required

<sup>10</sup> INTELLiVENT-ASV required

<sup>11</sup> Only for adult/pediatric patients

<sup>12</sup> Only in ASV mode

## Alarms

Priority	Alarm
High priority	<p>Apnea, Apnea time, ExpMinVol high/low, Oxygen high/low, Minute volume high/low, Pressure high/low, High Pressure during Sigh, Pressure not released</p> <p>Flow sensor calibration needed (during ventilation), Check flow sensor tubing, Check flow sensor, Check patient interface, External flow sensor failed, Replace O2 sensor, Oxygen supply failed, Buzzer defective, Loudspeaker defective</p> <p>Disconnection on patient/ventilator side, Exhalation obstructed, Obstruction</p> <p>Options not found, Self test failed, Blower fault, Device temperature high, Vent outlet temperature high</p> <p>Battery low, Battery power loss, Battery totally discharged, Battery temperature high, Battery communication error, Battery defective</p> <p>SpO2:<sup>13</sup> SpO2 low</p>
Medium priority	<p>High Flow, fTotal high/low, Frequency high/low, Vt high/low, Inspiratory volume limitation, High PEEP, Loss of PEEP, Pulse high/low, Pressure limitation</p> <p>Wrong expiratory valve, Circuit calibration needed, Flow sensor calibration needed, Flip the flow sensor, Check flow sensor for water (Neonatal)</p> <p>Check for blockage, Fan failure, Function key not operational, Performance limited by high altitude, Real-time clock failure, Battery low</p> <p>CO2:<sup>14</sup> PetCO2 high/low</p> <p>INTELLiVENT-ASV: FIO2 set to 100% due to low SpO2, Oscillation %MinVol, Oscillation PEEP/CPAP, Oxygenation adjustment off, Oxygen control limit exceeded, Ventilation adjustment off</p> <p>SpO2:<sup>13</sup> SpO2: Adapter missing, SpO2: Light interference, SpO2: Low perfusion index, SpO2: Poor signal, SpO2: Probe missing, SpO2: Patient disconnected, SpO2: Sensor error, PI low/high, PVI low/high, Pulse low/high, SpO2 low</p>
Low priority	<p>Check Plimit, ASV: Cannot meet the target, Maximum leak compensation, Pressure limit has changed, CPR ON, SpeakValve ON/OFF, Suctioning maneuver, Apnea ventilation/Apnea ventilation ended</p> <p>Flow sensor calibration needed, Preventive maintenance required, Replace HEPA filter, Blower service required, Loss of external power, IRV (inverse ratio ventilation), Release valve defective, Touch not functional, Check settings</p> <p>Battery calibration required, Battery replacement required, Wrong battery, Battery low</p> <p>O2 sensor calibration needed, O2 sensor defective, O2 sensor missing, O2 sensor not system compatible</p> <p>External connections disabled<sup>15</sup>, JTAG not working, Invalid communication board</p> <p>CO2:<sup>14</sup> CO2 calibration needed, CO2 sensor defect, CO2 sensor disconnected, CO2 sensor over temperature, CO2 sensor warmup, Check CO2 sampling line, Check CO2 airway adapter, CO2: Poor signal</p> <p>INTELLiVENT-ASV:<sup>16</sup> Oxygen controller at limit, PetCO2 target range changed, Ventilation controller at limit</p> <p>SpO2:<sup>13</sup> SpO2 high</p>

<sup>13</sup> If the SpO2 option is installed and enabled.

<sup>14</sup> If the CO2 option is installed and enabled.

<sup>15</sup> If the Hamilton Connect module is installed and enabled.

<sup>16</sup> If INTELLiVENT-ASV is installed.

## Control settings and ranges

Parameter (units)	Range Adult/Ped <sup>17</sup>	Range Neonatal <sup>17</sup>
%MinVol (%) <sup>18</sup>	25 to 350	--
Apnea backup	On, Off	On, Off
ETS (%)	5 to 80	5 to 80
Flow (l/min) <sup>19</sup>	2 to 100 <sup>20</sup>	2 to 30
I:E <sup>21</sup>	1:9 to 4:1	1:9 to 4:1
IBW (kg) (calculated)	3 to 139	--
Oxygen (%)	21 to 100	21 to 100
P high (in APRV) (cmH <sub>2</sub> O)	0 to 60	0 to 45
P high (in DuoPAP) (cmH <sub>2</sub> O)	0 to 60	3 to 45
P low (in APRV) (cmH <sub>2</sub> O)	0 to 35	0 to 25
Pat. height		
(cm)	30 to 250	--
(in)	12 to 98	
PEEP/CPAP (cmH <sub>2</sub> O)	0 to 35	3 to 25
Plimit (cmH <sub>2</sub> O)	5 to 60	5 to 60
P-ramp (ms) <sup>22</sup>	0 to 2000 <i>ASV, NIV, NIV-ST, SPONT, VS: max = 200</i>	0 to 600 <i>NIV, NIV-ST, SPONT, nCPAP-PC, VS: max = 200</i>
Rate (b/min) <sup>23</sup>	1 to 80 <i>APVcmv, PCV+: 4 to 80</i> <i>PSIMV+, NIV-ST: 5 to 80</i>	1 to 80 <i>PSIMV+: 5 to 80</i> <i>APVcmv, PCV+, PSIMV+PSync, nCPAP-PC, NIV-ST, APVsimv + Apnea backup: 10 to 80</i>
Set temp (°C)	INV: 35 to 41 NIV: 30 to 35 HiFlowO2: 33 to 37	INV: 35 to 41 NIV: 30 to 35 HiFlowO2: 33 to 37
Sex	Male, Female	--
Sigh	On, Off	--
SpeakValve	On, Off	--
T gradient (°C)	-2 to 3	-2 to 3
T high <sup>23</sup> (in APRV and DuoPAP) (s)	0.1 to 40.0	0.1 to 40.0
T low (in APRV) (s)	0.2 to 40.0	0.2 to 40.0
TI (s) <sup>21,23</sup>	0.1 to 12.0	0.1 to 12.0
TI max (s)	0.5 to 3.0	0.25 to 3.0

<sup>17</sup> Parameter settings and ranges can vary depending on the selected mode.

<sup>18</sup> Only in ASV mode.

<sup>19</sup> Only for high flow oxygen therapy.

<sup>20</sup> In some markets, the maximum possible Flow setting may be limited.

<sup>21</sup> In PCV+, (S)CMV, and APVcmv modes, mandatory breath timing can be controlled by using a combination of inspiratory time (TI) and Rate, or by the I:E ratio; set the method in Configuration. All other modes are controlled by using a combination of inspiratory time (TI) and Rate.

<sup>22</sup> P-ramp is limited to one-third (1/3) of TI time. Adjustment of TI time can override the P-ramp setting.

<sup>23</sup> Startup setting derived from IBW (adult/pediatric), body weight setting (neonatal). Does not apply in ASV mode.

Parameter (units)	Range Adult/Ped <sup>17</sup>	Range Neonatal <sup>17</sup>
Trigger, flow (l/min) <sup>24</sup>	0.5 to 20.0 <i>APVcmv, PCV+</i> : 0.5 to 20.0 / Off	0.1 to 5.0 <i>APVcmv, PCV+</i> : 0.1 to 5.0 / Off
Vt (ml)	20 to 2000	2 to 300
Vt/IBW	5 to 12	5 to 12
Vt/Weight (ml/kg) <sup>25</sup>		
Weight (kg)	--	0.2 to 30.0
$\Delta P_{control}$ (cmH <sub>2</sub> O) <sup>26</sup>	5 to 60	3 to 45 <i>nCPAP-PC</i> : 0 to 45
$\Delta P_{insp}$ (cmH <sub>2</sub> O) <sup>26</sup>	3 to 60	3 to 45
$\Delta P_{support}$ (cmH <sub>2</sub> O) <sup>26</sup>	0 to 60	0 to 45

<sup>24</sup> Flow trigger is leak compensated.

<sup>25</sup> IBW is calculated using height and sex, for adult and pediatric patients. Actual body weight is used for neonates.

<sup>26</sup>  $\Delta P_{control}$ : Control pressure, added to PEEP/CPAP.  $\Delta P_{insp}$ : Inspiratory pressure, added to PEEP/CPAP.  $\Delta P_{support}$ : Pressure support, added to PEEP/CPAP.





## Monitoring parameters

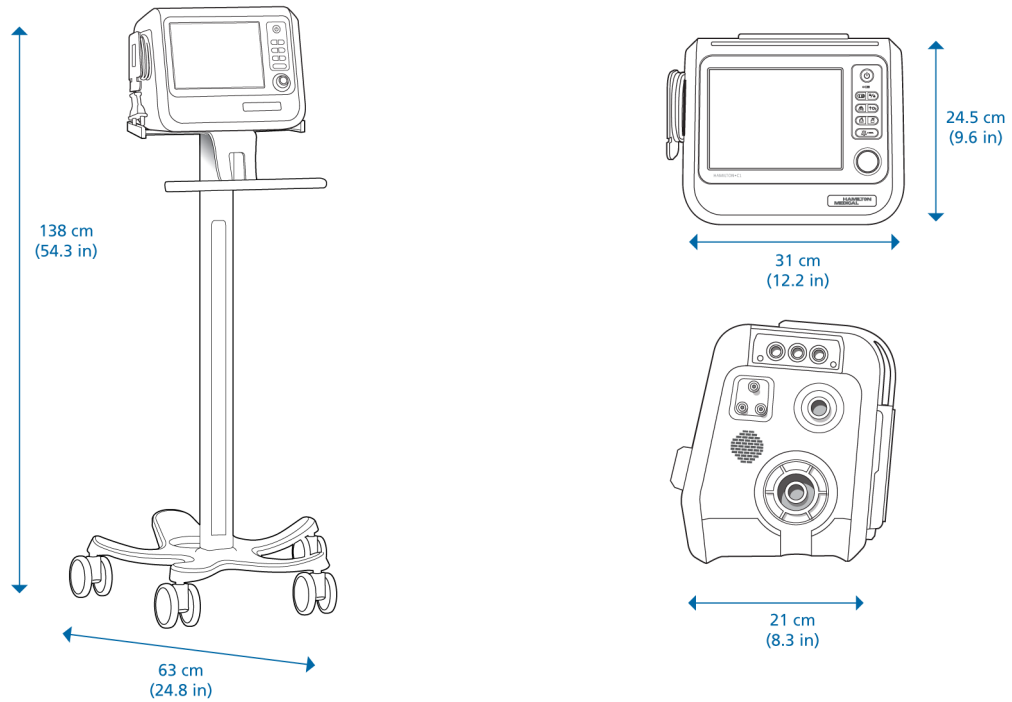
Parameter (units)	Description	
Pressure	AutoPEEP (cmH2O)	Unintended positive end-expiratory pressure
	PEEP/CPAP (cmH2O)	PEEP (positive end-expiratory pressure) and CPAP (continuous positive airway pressure)
	Driving pressure, $\Delta P$ (cmH2O)	Driving pressure, calculated value reflecting the difference between Pplateau and PEEP
	$\Delta P_{\text{Insp}}$ (cmH2O)	Inspiratory pressure
	Pmean (cmH2O)	Mean airway pressure
	Ppeak (cmH2O)	Peak airway pressure
	Pplateau (cmH2O)	Plateau or end-inspiratory pressure
	Pprox (cmH2O)	Airway pressure at proximal patient interface
Flow	Flow (l/min)	HiFlowO2: The set flow of gas to the patient nCPAP: The average flow updated every second nCPAP-PC: The average flow during expiration, updated every breath
	Insp Flow (peak) (l/min)	Peak inspiratory flow, spontaneous or mandatory
	Exp Flow (peak) (l/min)	Peak expiratory flow
	Volume	ExpMinVol or MinVol NIV (l/min)
MVSpont or MVSpont NIV (l/min)		Spontaneous expiratory minute volume
VTE or VTE NIV (ml)		Expiratory tidal volume
VTEspont (ml)		Spontaneous expiratory tidal volume
VTI (ml)		Inspiratory tidal volume
VLeak (%)		Leakage percent or total minute volume leakage
MVLeak (l/min)		Leakage percent or total minute volume leakage
Vt/BW or Vt/Weight (ml/kg)		Tidal volume is calculated by ideal body weight (adult/pediatric patients) or actual body weight (neonatal patients)
Oxygen	Oxygen (%)	Oxygen concentration of the delivered gas
	O2 consumption (l/min)	The current oxygen consumption rate
Time	CPR timer	MMP during CPR ventilation showing duration of CPR ventilation
	I:E	Ratio of the patient's inspiratory time to expiratory time for every breath cycle
	fControl (b/min)	Mandatory breath frequency
	fSpont (b/min)	Spontaneous breathing frequency
	fTotal (b/min)	Total breathing frequency
	TI (s)	Inspiratory time
	TE (s)	Expiratory time
Lung mechanics	Cstat (ml/cmH2O)	Static compliance
	P0.1 (cmH2O)	Airway occlusion pressure
	PTP (cmH2O*s)	Pressure time product
	RCexp (s)	Expiratory time constant
	Rinsp (cmH2O / (l/s))	Inspiratory flow resistance
	RSB (1 / (l*min))	Rapid shallow breathing index

Parameter (units)		Description
CO2	FetCO2 (%)	Fractional end-tidal CO2 concentration
	PetCO2 (mmHg)	End-tidal CO2 pressure
	slopeCO2 (%CO2/l)	Slope of the alveolar plateau in the PetCO2 curve, indicating the volume/flow status of the lungs
	V'alv (l/min)	Alveolar minute ventilation
	Vtalv (ml)	Alveolar tidal ventilation
	V'CO2 (ml/min)	CO2 elimination
	VDaw (ml)	Airway dead space
	VDaw/VTE (%)	Airway dead space fraction at the airway opening
	VeCO2 (ml)	Exhaled CO2 volume
	ViCO2 (ml)	Inspired CO2 volume
SpO2	SpO2 (%)	Oxygen saturation
	Pulse (1/min)	Pulse
	SpO2/FiO2 (%)	The SpO2/FiO2 ratio (%) is an approximation of the PaO2/FiO2 ratio, which, in contrast to PaO2/FiO2, can be calculated noninvasively and continuously
	OSI	Oxygen saturation index
	PI (%)	Perfusion index
	PVI (%)	Pleth variability index
Humidifier <sup>27</sup>	T Y-piece (°C)	Measured temperature at the Y-piece
	T humidifier (°C)	Measured temperature at water chamber exit

<sup>27</sup> If HAMILTON-H900 humidifier integration is enabled, and a humidifier is connected and turned on.



## Physical characteristics



Weight	4.9 kg (10.8 lb)
	16.9 kg (37.3 lb) with trolley
	The trolley can accommodate a maximum safe working load <sup>28</sup> of 44 kg (97 lb).
Dimensions	See graphic above
Trolley accessories	HAMILTON-H900 mounting kit, optional O2 bottle holding system, optional tubing support arm, water bottle holder, basket

<sup>28</sup> The maximum safe working load applies to a stationary, properly load-balanced trolley.

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