

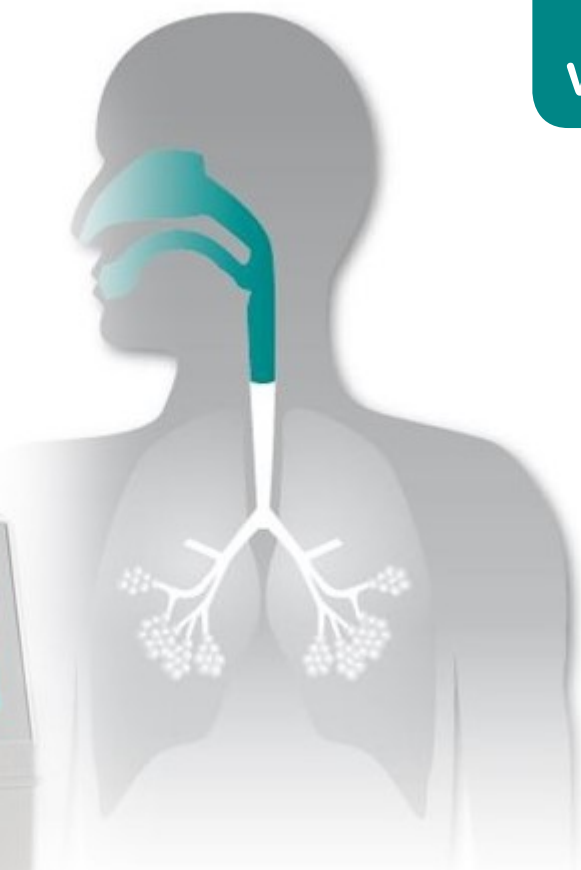
# WILAméd

*Equipment for Professionals*



## Respiratory Humidification: Basics

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# What is respiratory humidification?

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Respiratory humidification is a method of artificial warming and humidifying of respiratory gas for mechanically ventilated patients. The term respiratory gas conditioning stands for warming and humidification as well as purification of respiratory gas.

These three essential functions of respiratory gas conditioning serve the preparation of inspired respiratory gas for the sensitive lungs. If natural respiratory humidification fails, pulmonic infections and damage to lung tissue may be the consequence.

# How does natural respiratory humidification work?

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In a healthy person, 75% of respiratory gas conditioning takes place in the upper respiratory tract (nasopharynx) (Figure 1). The remaining 25% are taken over by the trachea.<sup>1</sup>

The upper respiratory tract warms, humidifies and cleanses 1,000 to 21,000 liters of respiratory gas daily, depending on body size and physical capability.<sup>2</sup>

## 1. Warming

Warming of breathing air is effected by many small blood vessels, netlike coating the nasal and oral mucous membrane (mucosa). Nerve impulses regulate the amount of blood flow like a body's-own heating system. Thus vessels are supplied with more blood when breathing cold air (warming of respiratory gas), and less when breathing warm air.<sup>3</sup>

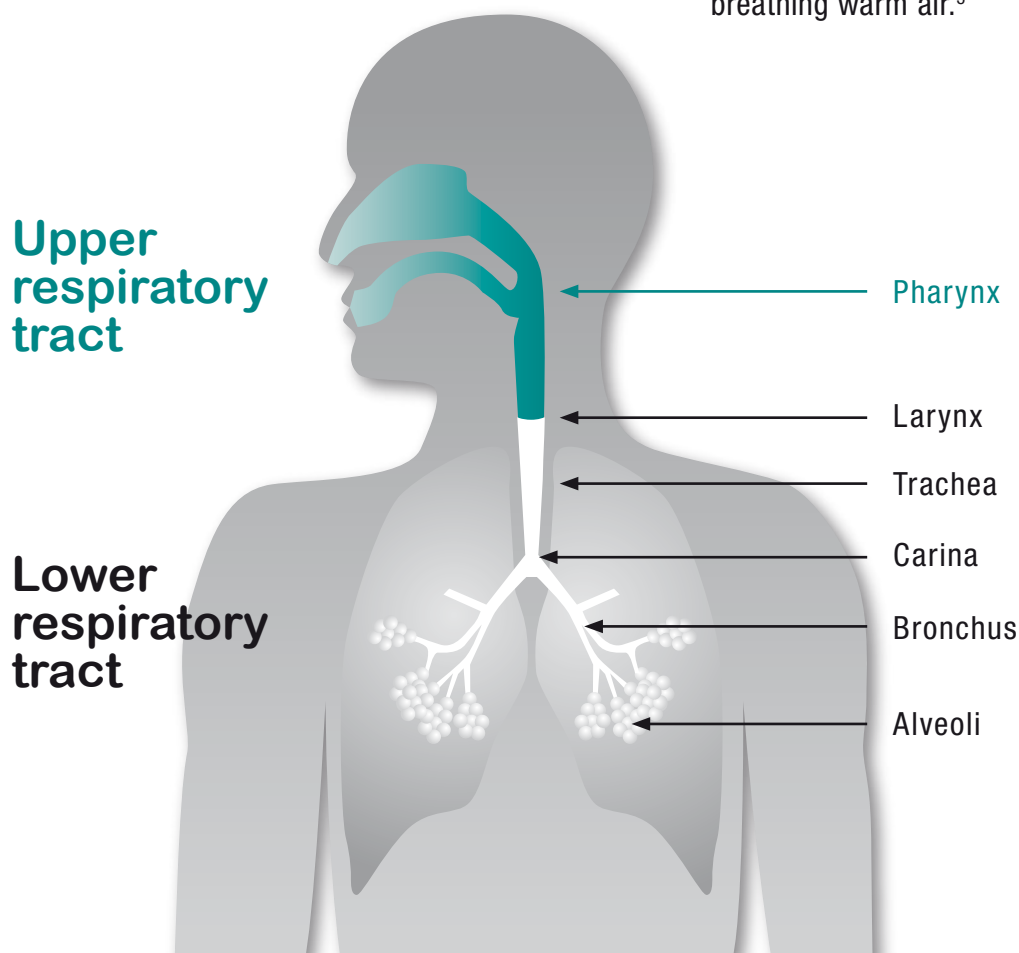


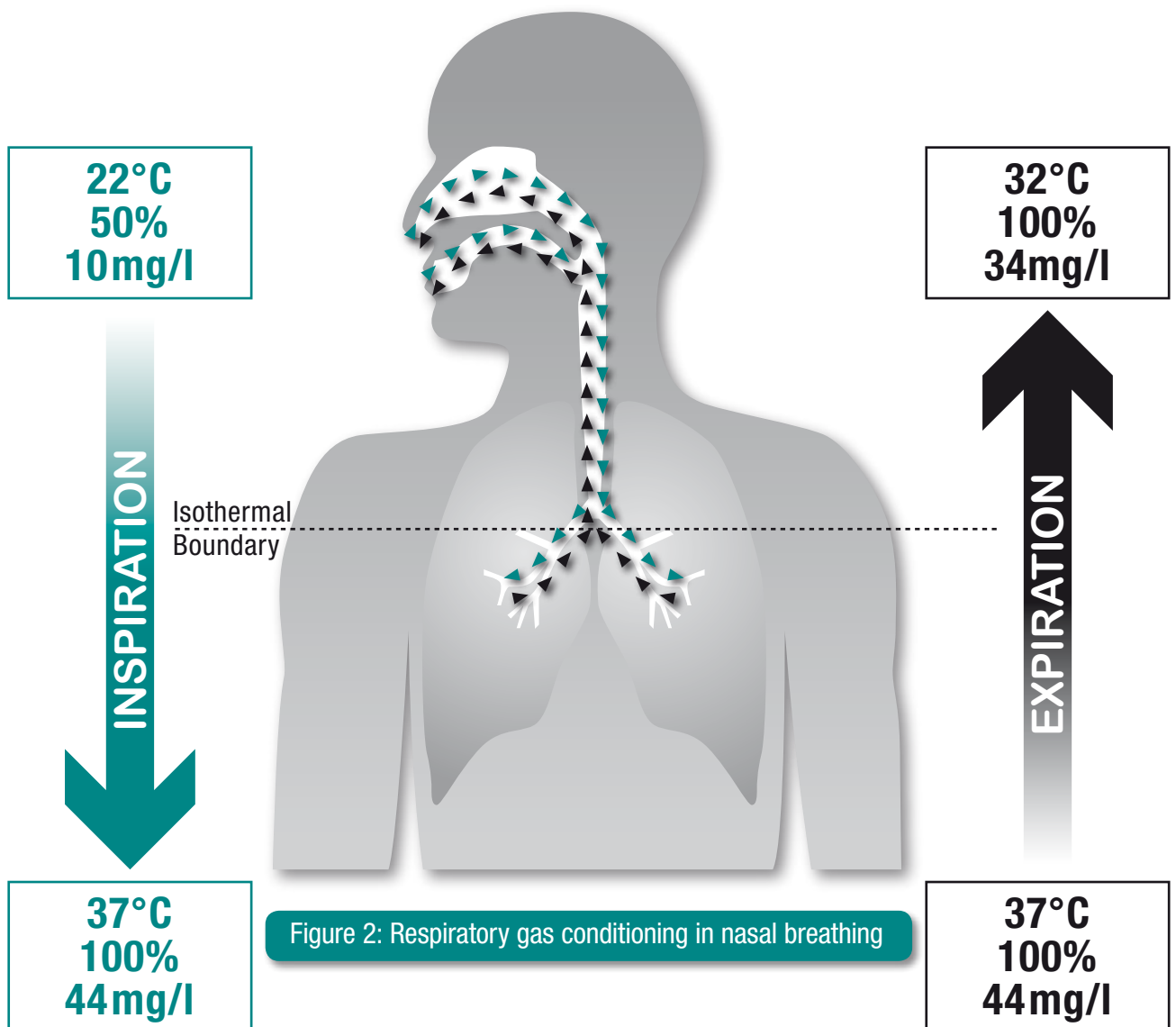
Figure 1: Respiratory tract – scheme

## 2. Humidification

During inspiration, well-vascularized mucous membranes inside the nose and mouth release moisture to the passing respiratory gas. As a result, a healthy adult person evaporates 200 to 300 ml of water per day. While inspiring through nose or mouth the mucous membranes cool down.

During exhalation this cooling effect causes a portion of moisture in the air coming from the lungs (100% relative humidity at 37°C) to condensate on the mucous membranes, whereby the mucous membranes are moisturized again.

On the way to the lower respiratory tract, the respiratory gas already humidified in the nasopharynx is conditioned further until the isothermal saturation limit is reached. Isothermal saturation limit means the maximum possible humidity at a given temperature, which amounts to 100% relative humidity and 44 mg absolute humidity at 37°C. A healthy breathing person reaches that equilibrium during nasal breathing at the bifurcation of the trachea. Hence, only water vapor-saturated and body-warm air reaches the alveoli (Figure 2).<sup>4,5</sup>

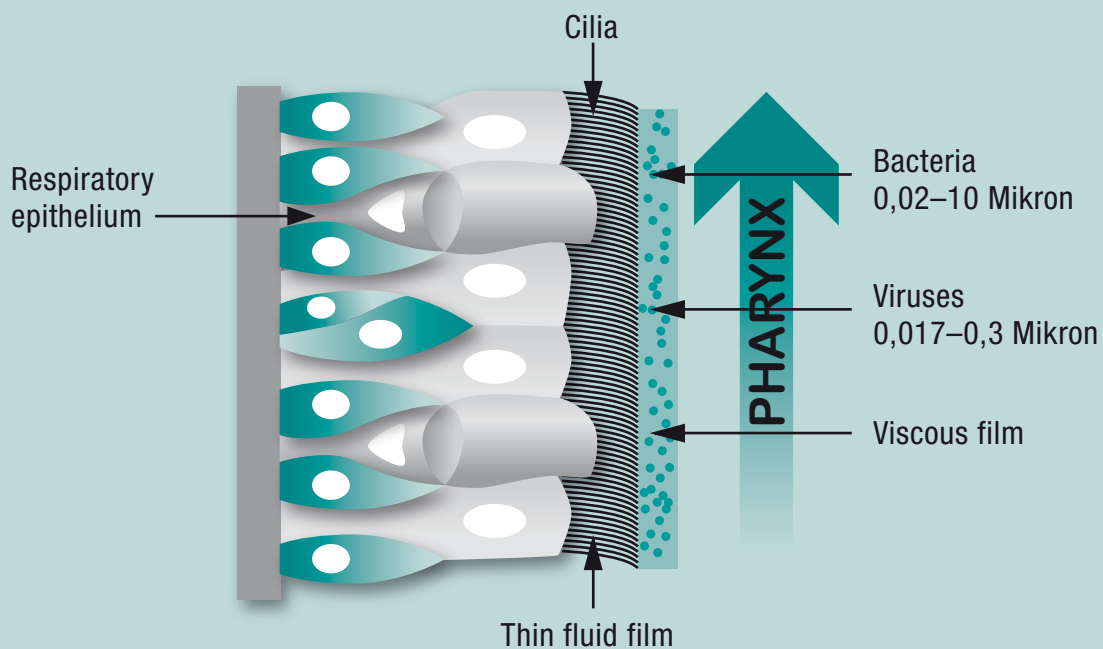


### 3. Cleaning

While the removal of inhaled particles in the upper respiratory tract primarily takes place through coughing and sneezing (tussive clearance), in the deeper respiratory tracts mucociliary clearance is paramount. It is the most important cleaning mechanism of the bronchi.

#### Mucociliary Clearance

The main bronchi down to the alveoli are lined with a respiratory epithelium. On it, cilium is existent, bearing hair-shaped structures on its surface (cilia). The cilia are surrounded by fluid mucous layer, the periciliary liquid. This ciliary layer is covered by viscous mucus which traps foreign matter and microorganisms.



The coordinated movement of the cilia in the periciliary liquid transports the mucus together with foreign matter towards the mouth, where it can be swallowed or coughed up. The efficiency of this clearance mechanism depends on the number of cilia, their structure and motility, and the quantity and consistency of the mucus. Optimum functionality of the mucociliary clearance requires a temperature of 37°C and an absolute humidity of 44 mg/dm<sup>3</sup> corresponding to a relative humidity of 100%. Insufficient heat and moisture in the lower respiratory tract causes the ciliary cells to stop transporting. Under these conditions, bacterial germinal colonization is facilitated.<sup>6, 7, 8</sup>

# When is respiratory gas conditioning affected?

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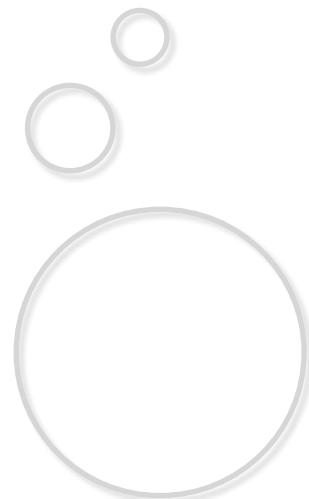
Natural respiratory gas conditioning can be affected by mechanical ventilation using cold and dry respiratory gas. In case of **non-invasive respiration** (e.g. respiratory masks), a continuous positive flow is administered (e.g. CPAP). The resulting increased oral breathing causes undesirable accompanying symptoms.

In the long run the upper respiratory tracts dry out caused by a permanent positive pressure supply with cool respiratory gas. The consequences are painfully inflamed nasal and oral mucous membranes as well as blockage of air passages and congestion of secretion in the respiratory apparatus. In particular, leakages at the respiratory mask may promote drying out of the nasal mucous membranes. A continuous supply of warm respiratory gas significantly reduces these clinical symptoms.<sup>9</sup>

In case of **invasive respiration** (intubation or tracheotomy), the upper respiratory tracts are bypassed, thus prevented from exercising their natural function. Respiratory gas conditioning is transferred solely to the trachea, which cannot provide the necessary humidifying, warming and clearing performance all by itself.

## The results of non-invasive and invasive respiration are:

- **Insufficient warming effect.**  
Insufficiently warmed up air arrives in the lungs.
- **Insufficient humidification effect.**  
Due to isothermal saturation limit, insufficiently warmed up air cannot carry the required amount of moisture.
- **Constrained clearance of the respiratory tract.**  
In intubated or tracheotomized patients, the tussive clearance function is significantly constrained or failing completely. With these patients, the mechanical removal of foreign particles and germs must be taken over by mucociliary clearance – which however functions only if sufficient moisture is present.



Artificial respiration with cold and dry respiratory gas causes mucus on the respiratory epithelium to become more viscous, within a short time impairing the functionality of the cilia. The stroke frequency of the cilia slows down to final suspension (at < 30% water vapor saturation after 3–5 minutes). After no more than one hour, damages are detectable in the cell smear. The consequences may be severe.<sup>1,10</sup>

- Impairment of the ciliary function through viscous mucus and swelling mucous membranes
- Increase in airway resistance and decrease of compliance through increasing secretion as well as incrustation
- Risk of atelectases formation due to reduced surfactant activity
- Aggravation of gas exchange in the lung
- Increased susceptibility to pulmonic infections

Premature infants are particularly at risk against such complications. Though they are able to survive from the 24th week of pregnancy, their lungs and mucociliary clearance are still extremely underdeveloped. They also have to adapt immediately to a cooler and dryer ambience.

Even after birth, the ontogenetic development is not completed. In order to prevent the lung from drying out or hardening, an optimum respiratory humidification is absolutely mandatory for mechanical ventilated premature infants and neonates.<sup>11</sup>



# Respiratory humidifier AIRcon – functional principle

To prevent aforesaid complications, it is imperative to take measures to compensate loss of heat and moisture, if a patient is mechanically ventilated over a longer period of time.

AIRcon compensates for this heat and moisture loss (fig. 3). Dry and cold inspiratory air is passed from the ventilator to the humidifier chamber. There it floats above the water surface and absorbs heat and humidity in form of water vapor (pass-over-procedure). Since water vapor cannot transport germs, the risk of contamination is considerably reduced.

Then, the conditioned inspiratory air is transported to the patient. An embedded heating wire in the breathing tube keeps the temperature constant and prevents condensation.

Thus, AIRcon keeps the respiratory epithelium mucous layer supple and cilia flexible. Foreign particles and microorganisms, which may lead to pulmonary infections or lung tissue damage, can be transported successfully.

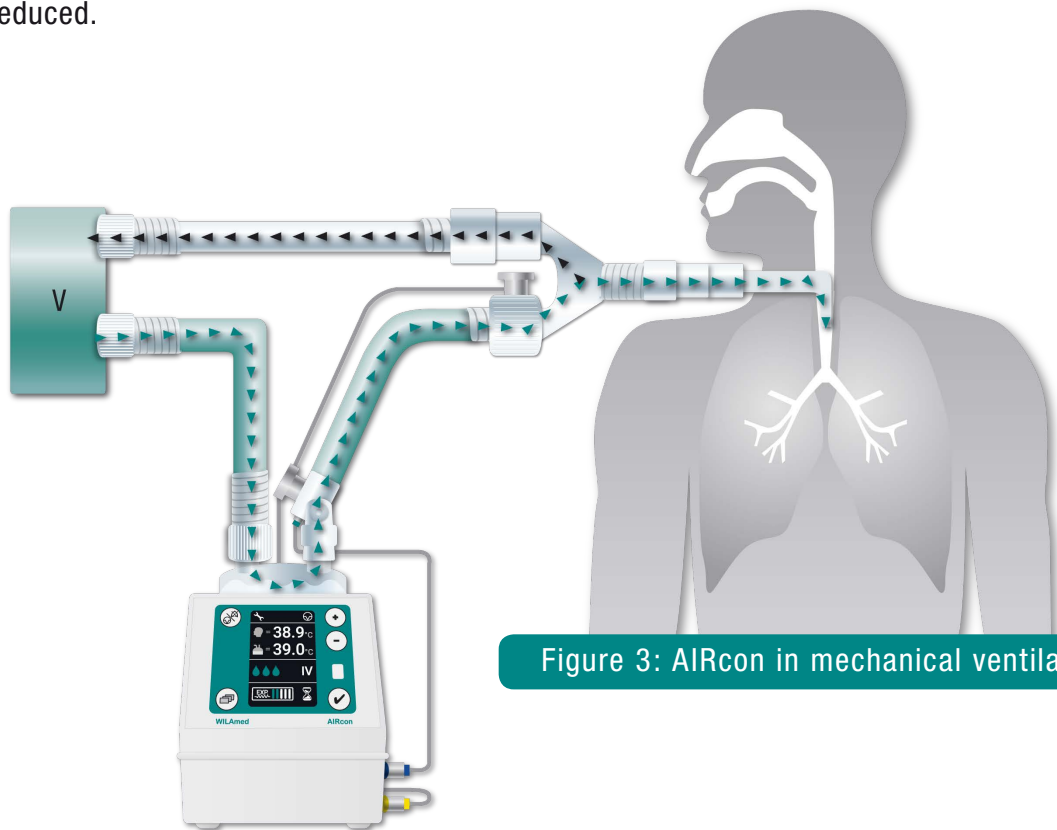


Figure 3: AIRcon in mechanical ventilation





# Advantages of the respiratory humidifier AIRcon over HMEs

- Providing the physiological temperature of 37°C with the optimum of 100% relative humidity
- Maintaining of mucociliary clearance over long periods of time
- Secretion liquefaction reduces the risk of tube or cannula occlusion
- No increase of dead space or breathing resistance
- Applicable also for neonates of less than 2500 g
- No sustainable moisture losses during extraction
- Operation with heated and unheated breathing tube systems possible
- Intelligent alarm management
- Individual adjustability to patient's needs

# Active humidification – accessories

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## Humidifier chamber



- **Practical autofill system:**  
An integrated floater ensures the correct water fill level.
- **Constant volume:**  
A regulated autofill mechanism ensures a constant volume in the humidifier chamber.
- **Economical:**  
Our range of products includes disposable humidifier chambers (usable for up to 7 days), and reusable humidifier chambers (autoclavable at 134°C).

## Mountings

- **Universal application:**  
Our mountings are applicable with conventional and common standard rails.
- **Stable support:**  
The mountings are specifically designed for the device and ensure safe and stable support.

## Breathing Tube Systems

- **Reduced condensate formation:**  
The integrated heating wire reduces condensate formation which causes increased breathing resistance, a false triggering of the respirator, or promotes the growth of germs.
- **High-quality materials:**  
Breathing tubes made of medically approved materials are used. Unless otherwise indicated, all materials are Latex, PC and DEHP free.
- **Individual adaptation:**  
Our disposable breathing tube systems (usable up to 7 days) and reusable systems (autoclavable at 134°C) can be used for neonates, children and adults. We offer configurations for clinics and for home care. In addition, we also design breathing tube systems for individual requirements.

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