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Volumetric RIP: What it is and why it matters



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What it is and why it matters

A clinician reviewing a home sleep study sees events flagged in the report — but how confident can they be in what those events actually represent? Were they obstructive or central? Did ventilation drop gradually or abruptly? Did treatment change anything meaningful overnight?

The answers often depend on what the breathing signal actually measures. **Airflow is fundamental to confident OSA diagnosis**, and different measurement methods can lead to very different levels of insight.

Respiratory inductance plethysmography (RIP) uses belts placed around the chest and abdomen to capture thoracoabdominal movement during breathing. When designed and calibrated correctly, RIP can go beyond detecting effort — it can provide quantitative information about both respiratory effort and ventilation. It can track not just whether the patient is trying to breathe but how breathing and ventilation changes across the night,[1] and includes a ventilation signal closely aligned to the oronasal gold standard.[2]

Why airflow and effort both matter

Sleep apnea events are interpreted by looking at airflow and effort together:

- **Obstructive events:** airflow is reduced or absent, but effort continues.
- **Central events:** airflow is reduced or absent, and effort is reduced or absent.
- **Mixed events:** features of both patterns are present.

This distinction is clinically important because different event types can reflect different underlying mechanisms and may require different treatment strategies.

Distinguishing event types depends on accurate airflow and respiratory effort signals.[2]





" Over the last 20 years,

Nox has invested significant energy into improving RIP signal quality, bandwidth, calibration, and analysis. What we have confirmed is that when the belts, circuitry, calibration, and algorithms are tuned together as one optimized system, RIP can provide a much richer view into breathing patterns, respiratory mechanics, thoracoabdominal coordination, sleep fragmentation, and clinically meaningful differences between patients.

This is what we call Volumetric RIP."

*- **Sveinbjörn Höskuldsson**,*
CTO and Co-Founder, Nox Medical

What makes RIP “volumetric”?

Not all RIP systems measure the same thing.

Volumetric RIP refers to belt designs where changes in the RIP signal are directly related to changes in the cross-sectional area of the chest and abdomen during breathing. In practical terms, the belts fully encircle the body and conform to natural breathing movement. When the chest and abdominal signals are properly calibrated and combined, they can estimate changes in breathing volume; from that, airflow can be derived.[1]

Non-volumetric RIP may show that breathing movement is present, but the signal is influenced by other factors, such as local stretching, overlapping belt layers, stiff materials, poor contact, or belt mechanics that distort the signal. In these cases, the signal is not reliably related to respiratory volume and cannot be used to derive airflow. These systems may be limited to tracking breathing movement or basic effort patterns, rather than supporting quantitative ventilation analysis.[1]

The same applies to belts or sensors based on piezoelectric, strain-gauge, impedance, or accelerometry approaches. Even if they are worn like belts, they do not measure inductance and do not have a well-defined relationship to respiratory volume.

Volumetric RIP vs. traditional or non-volumetric RIP

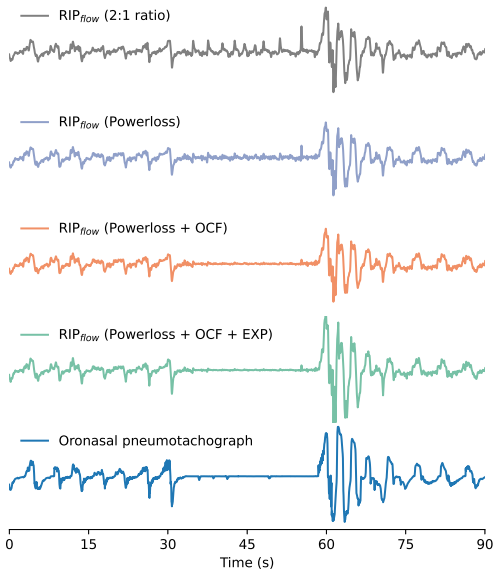
Capability	Volumetric dual-belt RIP	Traditional / non-volumetric RIP
Measures chest and abdominal motion related to volume change	✓	✗*
Can estimate airflow when properly designed and calibrated	✓	✗
Can support respiratory effort assessment	✓	✓
Can help distinguish obstructive from central event mechanisms	✓	✓
Can support advanced metrics (ventilatory burden, endotyping)	✓	✗

**Non-volumetric RIP may measure chest and abdominal motion related to breathing, but the key limitation is that the signal does not have a defined or reliable relationship to respiratory volume.*

Why calibration and correction matter

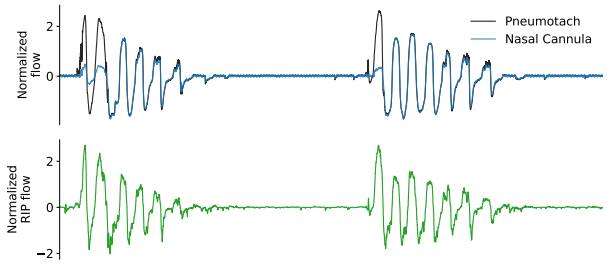
A proper belt design is necessary, but it is not enough on its own to become volumetric. RIP-derived ventilation depends on calibration: the chest and abdominal signals must be scaled and combined so they reflect tidal volume. Calibration can be affected by posture changes, belt movement, or differences in breathing pattern during the night.

During obstruction, the chest and abdomen can move out of phase. This paradoxical motion can make uncorrected RIP overestimate ventilation. Evidence shows that adaptive calibration, paradox attenuation, and nonlinear scaling can substantially improve agreement with gold-standard pneumotachography.[2]



The figure illustrates a single obstructive apnea event and how the incremental application of each of the three RIP correction steps -- power-loss calibration, paradox attenuation (OCF), and exponential scaling (EXP) -- moves the RIPflow signal closer to the oronasal pneumotachograph gold standard.[2]

This is what distinguishes Nox Flow™, Nox Medical's flow signal derived from dual volumetric RIP belts. Nox Flow applies patented continuous calibration and advanced signal processing to convert RIP signals into a volume-based respiratory signal with close agreement to gold-standard pneumotachography.



The figure above shows a flow measurement by a pneumotachograph, with the blue trace representing the flow from a nasal cannula overlaid in the black trace. The lower panel displays the Nox Flow signal derived from the thoracoabdominal Nox RIP belts.[3]

Clinical benefit

In clinical terms, volumetric RIP can support:

More confident event classification. Because obstructive and central events are distinguished by the relationship between airflow and effort, a dual-belt volumetric RIP signal provides clinically useful information for determination of the event type.[1,2]

A more complete view than AHI alone. AHI counts events, but it does not fully capture event depth, duration, cumulative ventilatory loss, arousal burden, or the mechanisms driving disease. Ventilatory burden and other physiologic measures may better represent sleep-disordered breathing than event counts alone.[1]

Scalable, physiology-based assessment. Modern volumetric RIP can extend beyond effort detection to support quantitative, physiology-based characterization of sleep-disordered breathing, with potential to bridge the gap between simplified home testing and full polysomnography.[1]

Volumetric RIP is not just another effort belt. Traditional or non-volumetric respiratory belts can show that breathing movement is present, but they do not reliably provide a calibrated measure of ventilation. **Dual, volumetric, calibrated RIP can support both respiratory effort assessment and airflow/ventilation estimation**, giving clinicians a more complete view of how breathing changes during sleep. That difference matters because airflow is critical in sleep, and volumetric RIP provides an accessible measure to capture true airflow.

References

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