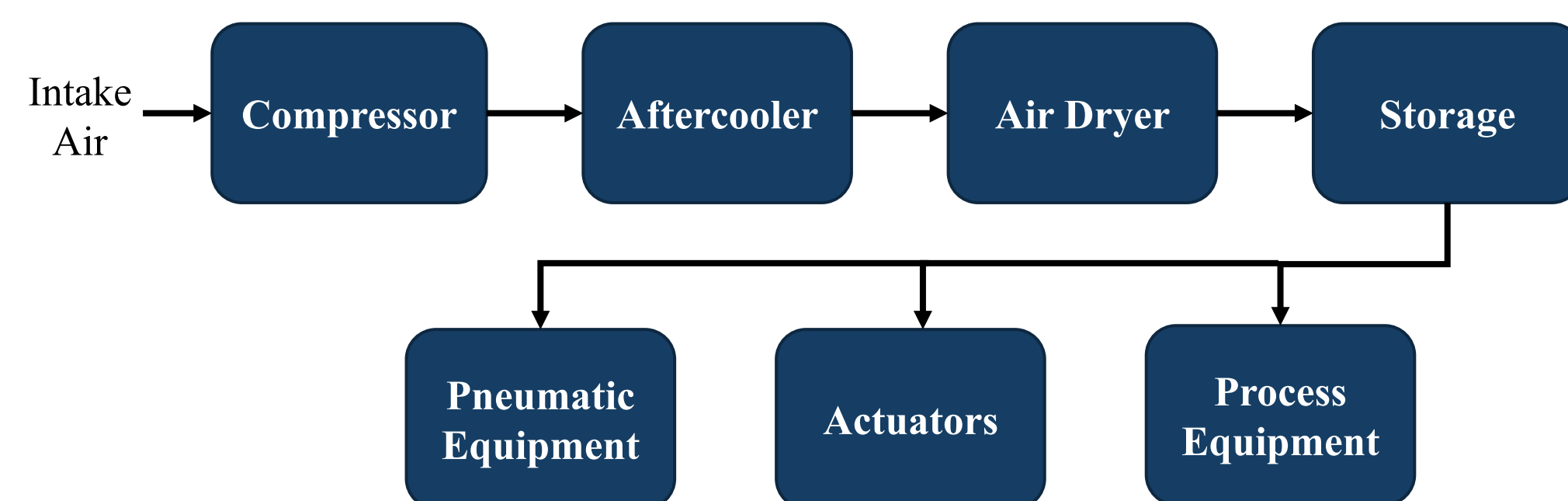


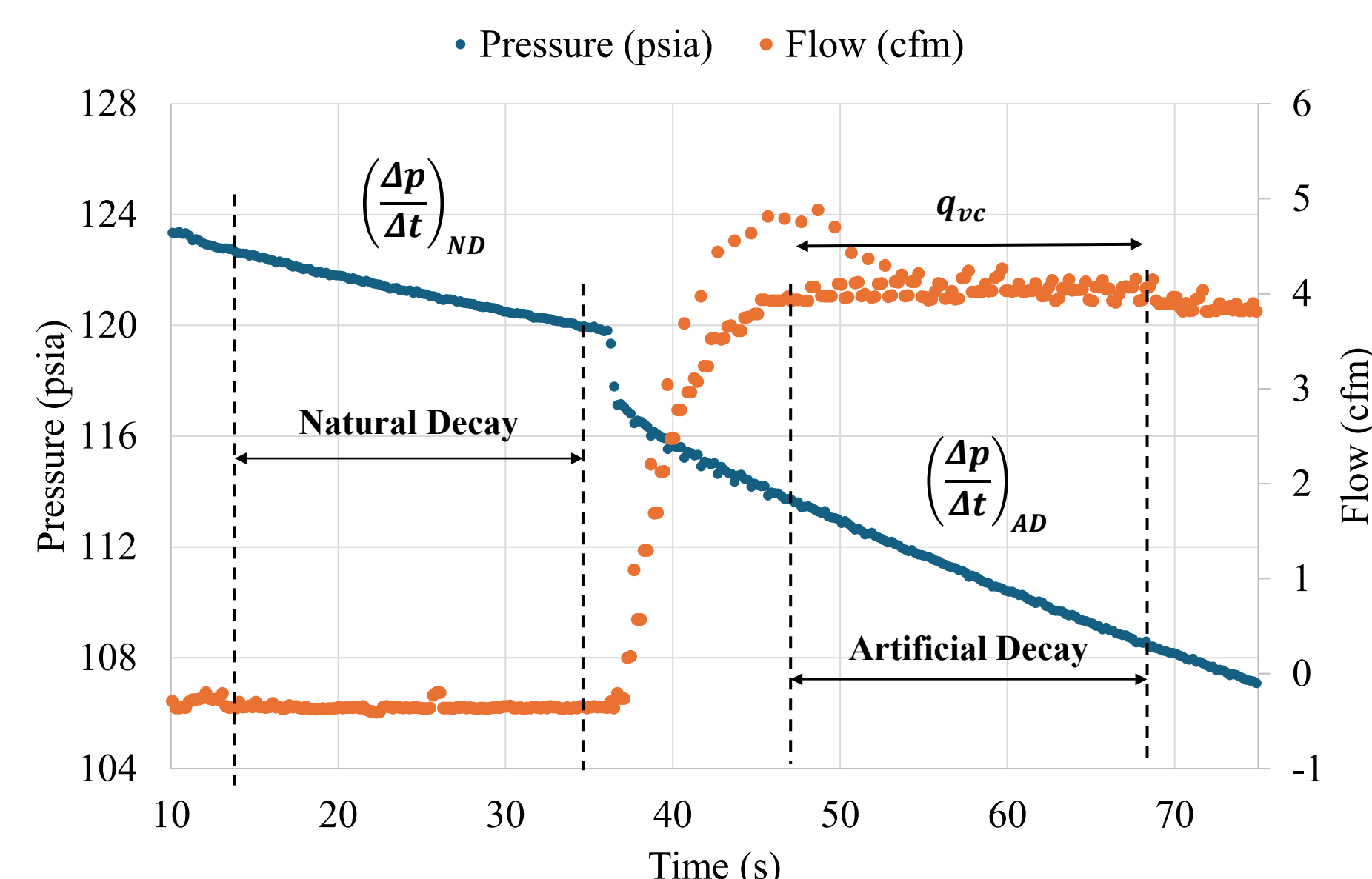
Introduction

- Compressed Air Systems (CAS) account for 10% of industrial electricity, but operate at under 15% efficiency
- Current leak detection methods are slow, error-prone, and lack real-time measurement capability



Schematic of Compressed Air Systems

Methodology



Representative Test Profile

Connection: The device was connected to the CAS via a branch line downstream of the storage, and the test began when the compressor was in the unload state.

Natural Decay (ND): The device captures pressure decay purely due to internal leaks.

Artificial Decay (AD): The device captures pressure decay while a leak is artificially induced by opening the valve.

Computation: The leak estimate is calculated using filtered and regressed pressure snapshots to be used in equation.

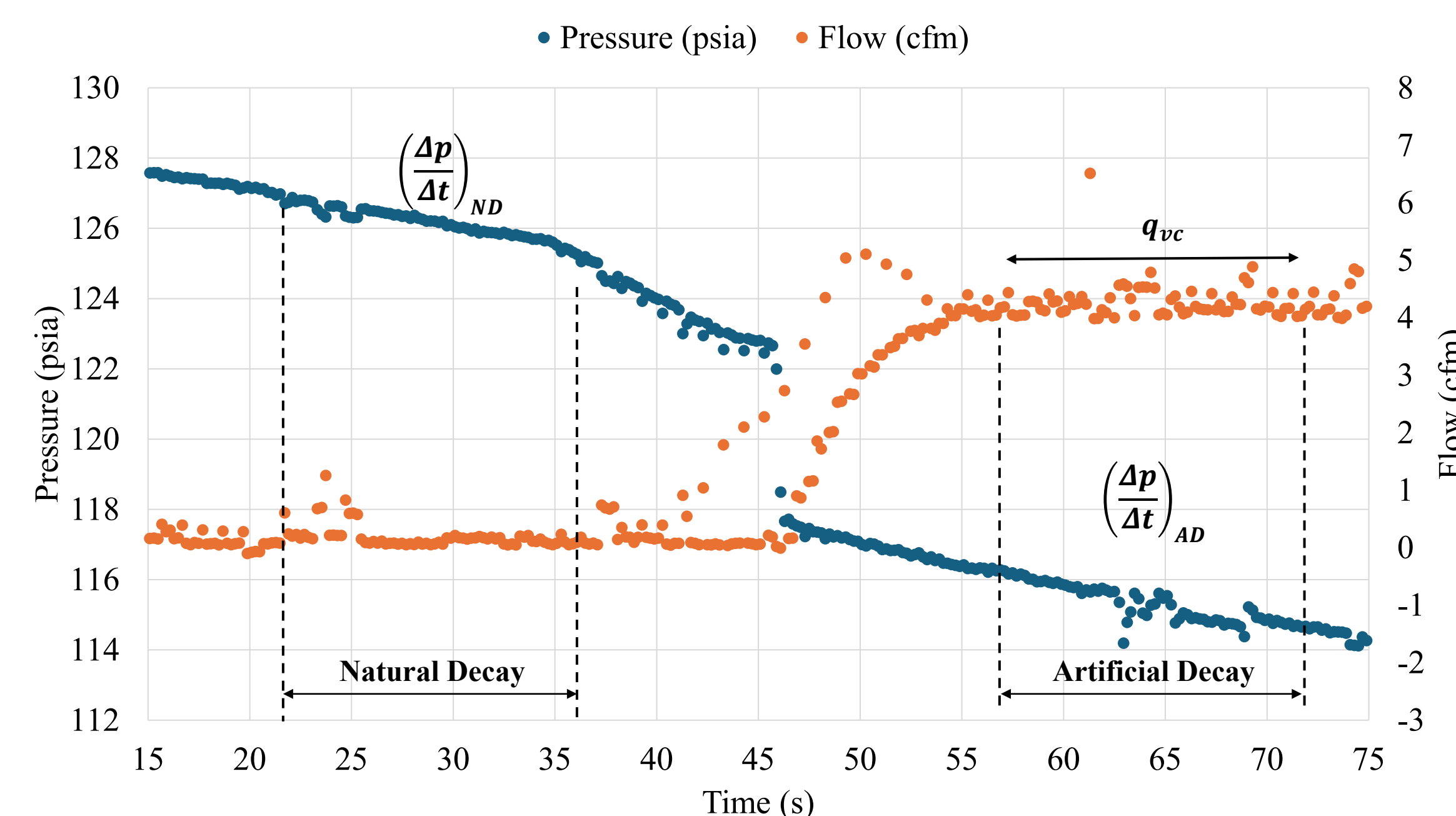
$$q_L = K_t \cdot q_{vc} \cdot \frac{\left(\frac{\Delta p}{\Delta t}\right)_{ND}}{\left(\left(\frac{\Delta p}{\Delta t}\right)_{AD} - \left(\frac{\Delta p}{\Delta t}\right)_{ND}\right)}$$

Device Layout



Labeled Image of the Device

Field Testing



Actual Test Profile from the Industrial Plant

- Systems with a larger storage capacity produced a less pronounced pressure decay, making the device susceptible to errors due to pressure fluctuations.
- Increasing decay time periods and filtering out outliers is recommended to improve the pressure decay clarity and reduce measurement errors.
- For best results, test parameters (valve % opening and time interval) must be modified to produce a proper pressure decay.

Leak Estimate by Device

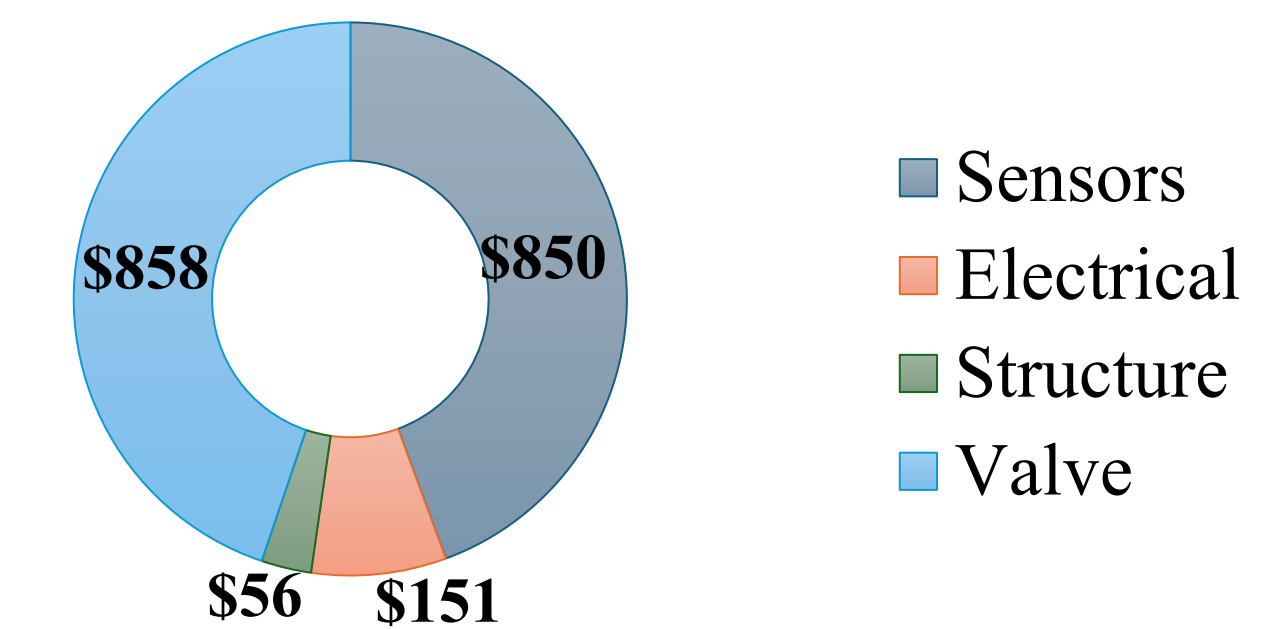
Trial 1	31.99 cfm
Trial 2	36.95 cfm
Trial 3	32.64 cfm

Leak Estimate by Other Methods

Bleed Down Test	15 cfm
Duty Cycle Approach (based on current consumption)	36-18 cfm

Cost Breakdown and Comparison

- Total material cost of the device was approximately **\$1,915**.
- When compared to other leak quantification methods, this device remains competitive in time and cost



Method	Time	Cost	Remarks
This Device	5 minutes	~ \$ 1,500-2,000	Provide an overall estimate
Bleed Down Test	15-30 minutes	~ \$100-200	Need to know storage volume
Duty Cycle	7-14 days	~ \$ 400-700	Requires data analytics expertise
Acoustic Imaging	1-2 days	~ \$ 5,000 -15,000	Provide detail breakdown

Conclusions

- The results confirm that this device is a simple and useful tool for companies to conduct a preliminary audit of their CAS
- Further development is required to improve measurements, including replacing fixed time-period snapshots with a pressure drop for better snapshot periods, and integrating a power clamp to automatically detect compressor usage and ensure valid no-load test conditions



Testing at the Texas A&M TurboLab

Acknowledgments & References

- This work was supported by U.S. Department of Energy's Office of Manufacturing and Energy Supply Chains ((DE-EE0009705)
- The views expressed herein do not necessarily represent the views of the U.S. Department of Energy or the United States Government

U.S. Department of Energy, "Compressed Air Tip Sheet #3: Minimize Compressed Air Leaks," Industrial Technologies Program, Washington, D.C., Aug. 2004. [Online].

R. Dindorf and P. Wo's, "Automatic measurement system for determination of leakage flowrate in compressed air pipeline system," Metrology and Measurement Systems, Vol. 25, no. 1, pp. 159-170, 2017, Index 330930, ISSN: 0860-8229.