White Paper

30 Month Follow Up:
Vapor Corrosion Inhibitors Maintain Stronger Corrosion Protection Than 98% Purity Nitrogen

April, 2026

Abstract

Dry and pre-action fire sprinkler systems are especially vulnerable to internal corrosion, which can undermine both performance and service life. Although high-purity nitrogen has been a common approach to reducing corrosion, Vapor Corrosion Inhibitors (VCIs) are now being evaluated as a next-generation option for fire protection systems. Building on earlier 12-month, 18-month, and 24-month studies, this 30-month evaluation compares compressed air, 98% nitrogen, and VCIs, showing that VCIs are 35.5× more effective than nitrogen and 207.4× more effective than compressed air at reducing corrosion, offering a proven, long-term, and highly reliable solution for the Fire Sprinkler Industry.

GENERAL AIR PRODUCTS

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1. Introduction

Dry and pre-action fire sprinkler systems face unique challenges from internal corrosion, which can compromise their performance and service life. While high-purity nitrogen has long been used to mitigate these effects, Vapor Corrosion Inhibitors (VCIs) are now being tested for application in fire protection systems.

This study compares compressed air, 98% nitrogen, and VCIs over 30 months and demonstrates that VCIs reduce corrosion dramatically, being over 35 times more effective than nitrogen and nearly 208 times more effective than air, providing a reliable solution for industrial corrosion protection.

2. Testing Overview

2.1 Objective

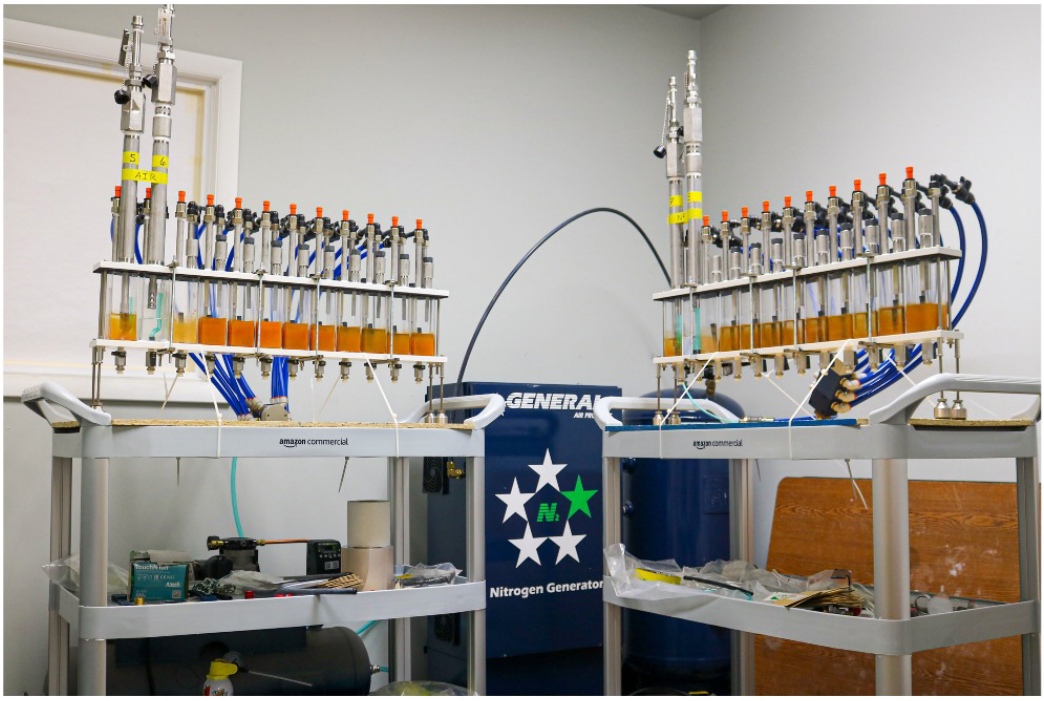
The primary objective of this five-year study is to evaluate the corrosion mitigation performance of VCIs against industry benchmarks: compressed air and 98% purity nitrogen. By analyzing corrosion rates and patterns, this study aims to demonstrate the superior efficacy of VCIs in protecting fire sprinkler systems.

2.2 Test Setup

The testing is being conducted in partnership with a third-party laboratory, Corrosion Laboratories, Inc. – MD, USA, under controlled conditions. The setup consists of three test stations representing the systems under evaluation:

- **Compressed Air:** Simulates untreated systems with atmospheric air.
- **98% Purity Nitrogen:** Reflects the current industry standard for corrosion mitigation.
- **Vapor Corrosion Inhibitor (VCI):** Uses vapor-phase corrosion inhibitors to form a protective molecular barrier.

Each test station contains 12 chambers partially filled with water to simulate real-world conditions where water accumulates in sprinkler piping. Coupons made from C1018 carbon steel are submerged and exposed to the vapor phase in each chamber. Corrosion is measured using mass loss, visual inspection, and electrical resistance (ER) probes at six-month intervals.



12 chambers partially filled with water where coupons made from C1018 carbon steel are submerged.

3. Methodology

The study follows ASTM G1 standards for preparing, cleaning, and evaluating corrosion specimens. These specimens are evaluated by an Independent 3rd Party laboratory (Corrosion Laboratories, Inc. – MD, USA).

- **Coupons:** The test involves metal coupons in submerged (low) and vapor (high) positions.
- **ER Probes:** Collect data from vapor and liquid phases to correlate with mass loss observations.
- **Corrosion Rate Calculation:** Rates are calculated in mils per year (mpy) and adjusted based on surface area exposed to water.

During the test, the original ER probe in the compressed air line completely corroded through. On March 3, 2025, it was replaced with a new probe and the test was continued.

4. Key Results

4.1 Six Month Findings

- VCIs demonstrated exceptional performance with minimal corrosion compared to nitrogen and air systems.
- Metal loss for VCIs was 1/5 of that observed in the nitrogen system and approximately 1/30 of the air system.

4.2 Twelve Month Findings

Twelve-month results align with the six-month findings, confirming consistent performance across test conditions. Notable outcomes include:

- **Compressed Air:** Continued to drive the most aggressive corrosion. Significant pitting was observed on low-position coupons, with 5.53 mils of adjusted metal loss.
- **98% Purity Nitrogen:** Offered moderate protection, though corrosion remained evident. Coupons recorded an adjusted metal loss of 1.10 mils.
- **VCIs:** Delivered superior performance, limiting metal degradation to just 0.16 mils. Only light surface corrosion appeared, with no signs of pitting or localized attack.

4.3 Eighteen Month Findings

Extended testing further validates the long-term effectiveness of VCIs. Key insights include:

- **Compressed Air:** Remained the most corrosive environment. After 18 months, low-position coupons exhibited deep pitting and an adjusted metal loss of 19.95 mils.
- **98% Purity Nitrogen:** Continued to reduce corrosion relative to air, though still led to measurable loss, totaling 2.5 mils.

» **VCIs:** Maintained top performance, with minimal degradation - just 0.17 mils lost.

4.4 Twenty-Four Month Findings

Testing continues to highlight how effective VCIs are over long durations. The latest results show:

» **Compressed Air:** This remained the harshest environment, with low-position coupons developing significant pitting and an adjusted metal loss of 21.83 mils after 24 months.
» **98% Purity Nitrogen:** While noticeably less corrosive than air, nitrogen still allowed measurable deterioration, resulting in 4.48 mils of metal loss.
» **VCIs:** VCI-treated samples showed exceptional stability, experiencing only 0.19 mils of metal loss, indicating minimal corrosion throughout the test period.

4.5 Thirty Month Findings

Testing continues to show the effectiveness of VCIs compared to nitrogen. The latest results show:

» **Compressed Air:** This continues to be the harshest environment, with low-position coupons showing significant pitting and an adjusted metal loss of 29.04 mils after 30 months.
» **98% Purity Nitrogen:** While still noticeably less corrosive than compressed air, nitrogen continues to allow measurable deterioration, with updated results showing 4.98 mils of metal loss.
» **VCIs:** VCI-treated samples continue to demonstrate exceptional stability, with updated results showing only 0.14 mils of metal loss, indicating minimal corrosion throughout the test period.

4.6 Thirty Month Findings Data

Compressed Air	
Date of Test	Estimated Total Mils Lost
10/20/2023	0.24
11/20/2023	0.87
1/10/2024	2.3
2/23/2024	2.7
3/11/2024	2.85
4/22/2024	3.15
5/15/2024	3.33
6/20/2024	3.56
7/18/2024	3.99
8/22/2024	4.7
9/19/2024	5.14
10/9/2024	5.53
11/12/2024	6.65
12/10/2024	8.22
2/4/2025	13.16
3/19/2025	19.01*
4/11/2025	19.95
5/13/25	20.25
6/17/2025	20.4
7/7/25	20.67
8/7/2025	21.13
9/11/25	21.51
10/9/2025	21.83
11/14/2025	22.22
12/11/2025	23.38
1/14/2026	25.42
2/12/2026	26.73
4/6/2026	29.04

98% Purity Nitrogen	
Date of Test	Estimated Total Mils Lost
10/20/2023	0.01
11/20/2023	0.09
1/10/2024	0.18
2/23/2024	0.22
3/11/2024	0.26
4/22/2024	0.4
5/15/2024	0.49
6/20/2024	0.6
7/18/2024	0.74
8/22/2024	0.81
9/19/2024	0.96
10/9/2024	1.1
11/12/2024	1.39
12/10/2024	1.63
2/4/2025	1.89
3/19/2025	2.28
4/11/2025	2.5
5/13/25	2.84
6/17/2025	3.06
7/7/25	3.38
8/7/2025	3.71
9/11/25	4.1
10/9/2025	4.48
11/14/2025	4.53
12/11/2025	4.62
1/14/2026	4.94
2/12/2026	4.97
4/6/2026	4.98

** Replacement of the original air-line ER probe after it corroded through.*

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Vapor Corrosion Inhibitor	
Date of Test	Estimated Total Mils Lost
10/20/2023	0.05
11/20/2023	0.13
1/10/2024	0.09
2/23/2024	0.03
3/11/2024	0.08
4/22/2024	0.08
5/15/2024	0.14
6/20/2024	0.12
7/18/2024	0.13
8/22/2024	0.12
9/19/2024	0.14
10/9/2024	0.16
11/12/2024	0.1
12/10/2024	0.18
2/4/2025	0.13
3/19/2025	0.16
4/11/2025	0.17
5/13/25	0.13
6/17/2025	0.16
7/7/25	0.15
8/7/2025	0.16
9/11/25	0.21
10/9/2025	0.19
11/14/2025	0.13
12/11/2025	0.18
1/14/2026	0.17
2/12/2026	0.15
4/6/2026	0.14

5. Visual and Analytical Insights

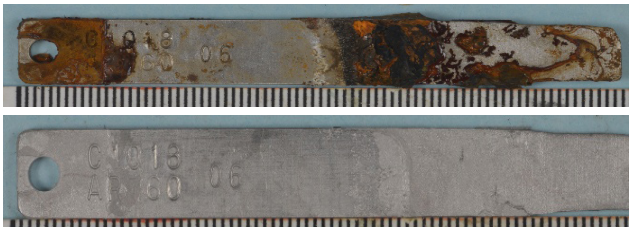
Photographic documentation reveals stark contrasts between the systems:

- Compressed air coupons displayed extensive corrosion and material degradation
- Nitrogen coupons showed some improvement but still exhibited localized corrosion.
- VCI coupons maintained their integrity, with only superficial pitting observed in some cases.

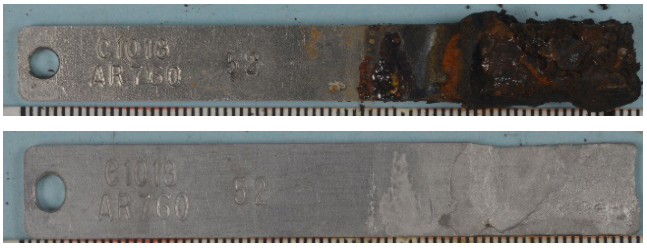
ER probe data corroborate these findings, showing the least material loss in VCI-treated chambers.

Depicted images were taken before and after cleansing.

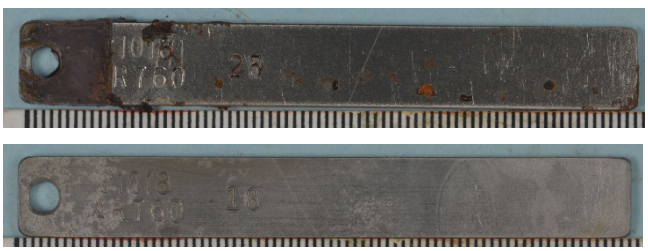
Compressed Air



98% Purity Nitrogen



Vapor Corrosion Inhibitor



6. Discussion

These findings underscore the transformative potential of VCI technology in mitigating corrosion. While nitrogen systems reduce oxygen levels, they cannot address other corrosive factors, such as microbial activity or deposit corrosion. VCIs form a molecular barrier, offering comprehensive protection that extends to hard-to-reach areas within the system.

The study also highlights the limitations of traditional methods. Despite the widespread adoption of nitrogen generators, the higher corrosion compared to VCIs indicates that industry standards may need reevaluation.

This testing follows similar parameters to a those conducted when nitrogen was first introduced to the fire protection industry nearly two decades ago, comparing of 95% purity nitrogen to 98% purity. It was determined then that 95% purity was not sufficient in its corrosion mitigation effects, and 98% was deemed the only acceptable standard.

7. Conclusion and Future Implications

The 30-month results affirm VCI's position as a superior solution for corrosion mitigation in dry and pre-action fire sprinkler systems. As the study progresses, additional data will provide further insights, reinforcing the long-term benefits of vapor-phase corrosion inhibitors.

This research holds implications beyond fire safety, suggesting broader applications for VCIs in industries where corrosion control is critical. By demonstrating the limitations of current methods and the efficacy of innovative solutions, this study aims to drive change in industry practices, enhancing system longevity and reliability.

This study is slated to run for 5 consecutive years, and subsequent results will be published by General Air Products going forward.

8. About General Air Products

General Air Products is the trusted leader in fire protection air supply solutions. With over 80 years in the industry, we specialize in high-quality air compressors, dry air generators, nitrogen generators, and vapor corrosion inhibitor technologies designed to prevent corrosion and supervise dry and pre-action fire sprinkler systems.