



Memorandum

To: Erin Daughton, ComEd; Thomas Johanson, ComEd; Nick Warnecke, Ameren Illinois; Andy Vaughn, Leidos

CC: Neil Curtis, Guidehouse; Jeff Erickson, Guidehouse; Zach Ross, Opinion Dynamics

From: Courtney Golino, Guidehouse; Michael Soda, Guidehouse; Presley Maurice, Guidehouse

Date: December 19, 2025

Re: Joint ComEd-Ameren Illinois Compressed Air Leak Repair Effective Useful Life Research Results Memo

1 Introduction

This memo presents the final outcomes of a three-year study on the effective useful life (EUL) of compressed air leak repairs conducted by Guidehouse (the team). Throughout this memo, Guidehouse shares a variety of methods for calculating EUL. However, the team recommends an average of approaches that leads to an EUL of 3.1 years overall and 5.7 years for non-filter leaks.

2 Background

Compressed air leak repairs commonly involve addressing air leaking through threaded connections, push-lock fittings, hose connections, hose punctures, and hose clamps. Between ComEd and Ameren Illinois (AIC), this measure accounted for roughly 27 verified gross GWh of electric energy savings in CY2019.^{1,2} AIC does not currently offer leak repair services through its programs; these offerings were discontinued in mid-2020, in part due to the TRM defined measure life of leak repairs. The Illinois Technical Reference Manual (TRM), Version 14 (v14) provides a range of EUL values of 1 to 5 years³. This broad range introduces

¹ The ComEd Industrial Systems Program saved 23,069,816 kWh (gross verified) from leak survey and repair in CY2019. ComEd Industrial Systems Impact Evaluation Report, Table 5-1. April 15, 2020. <https://ilsag.s3.amazonaws.com/ComEd-Industrial-Systems-CY2019-Impact-Evaluation-Report-2020-04-15-Final.pdf>

² AIC saved 3,682 MWh (verified gross) from Compressed Air Retro-Commissioning (The Opinion Dynamics evaluation team indicated that the majority of these savings are derived from leak repair) and 888 MWh (verified gross) from Standard prescriptive leak survey and repair. <https://ilsag.s3.amazonaws.com/2019-AIC-Business-Program-Annual-Impact-Evaluation-Report-FINAL-2020-04-30.pdf>

³ Attachment B: Effective Useful Life for Custom Measure Guidelines. Illinois Technical Reference Manual, Version 14. Volume 4. https://www.ilsag.info/wp-content/uploads/IL-TRM_Effective_010126_v14.0_Vol_4_X-Cutting_Measures_and_Attach_0919025_FINAL.pdf

evaluation risk for both utilities and implementers. Originally introduced in TRM v7 with the intention of refinement, a supported EUL value has yet to be established. As a result, the same language remains in TRM v14. This research study addresses that gap by estimating an EUL value that could inform future TRM updates.

3 Research Methods

In contrast to previous research conducted on compressed air leak repairs, which focused on the full compressed air system, this study followed the individual repaired leaks over time. The team sought to identify how long the leak repair held by understanding when contractors would recommend repairing the leak again.

All participants in this research were ComEd customers participating in the existing leak repair channels (Fix It Now, Industrial Systems). The primary objective was to establish a single Effective Useful Life (EUL) value for compressed air leak repairs based on empirical evidence. Additionally, ComEd's programs collect data on the type of leak or equipment involved—such as threaded connections, push-lock fittings, hose connections, punctures, and clamps. This allowed the team to explore whether certain leak types failed more frequently. However, due to limited sample sizes, the study did not recommend separate EUL values for each leak type.

3.1 EUL Definition

Within this research study, the team defined EUL as the time it takes for 50% of the leak repairs to fail (i.e., for the leak to re-occur). For the purposes of this research, the presence of a leak was the only consideration: it either exists, or it does not. Implementation Contractors (ICs) were asked to indicate if they would repair the identified leak again, if they were to encounter it outside of this study. If they would have repaired the leak again, the leak repair was considered to have failed at that revisit. The magnitude of leak failure (i.e., how many CFM or dB) was captured in the data collection but it was not considered in detail within the analysis.

3.2 Sample

Due to the nature of a manufacturing environment, the team assumed that there may be significant attrition of leaks. To account for this attrition, the team oversampled based on initial estimates to achieve 90/10, 2-tailed precision. The team was able to reach the target sample of 400 leaks at 14 sites overall; however, the team quickly saw attrition and could not track all 400 leaks at the same time. Some sites shut down or changed management over the course of the study, which required them to end participation.

3.3 Data Collection

The team collaborated with three ICs supporting ComEd's Fix It Now and Industrial Systems programs (excluding small businesses) to recruit customers for the study. As part of program implementation, ICs identified customers willing to allow the research team to revisit their sites every six months.

Each IC conducted an initial facility review to identify and mark leaks for repair. After completing the repairs, they provided the team with a list of tracked leaks scheduled for follow-up visits throughout the study period.

To ensure alignment on research objectives, the team maintained frequent communication with the ICs during the early stages of the study and continued periodic check-ins over the 2.5-year timeline to coordinate upcoming site visits.

At participating sites, ICs attached leak tags to the affected equipment, photographed the repaired components, and recorded detailed location descriptions to support future identification during follow-up visits. Despite these efforts, the study encountered frequent loss of tracked leaks due to factors such as equipment removal, degradation of tags in oily environments, and repairs made by internal maintenance teams between scheduled visits.

3.3.1 Site Visits

In January of 2025, the team's lead researcher accompanied two ICs to five site visits for their 24-month revisits. The team attended revisits at three food-grade plastic manufacturing facilities and two metal stamping facilities. While in the field, the team had the opportunity to better understand the challenges associated with tracking air leak repairs over time, the benefits of the program, and ICs' approaches to addressing air leak repairs. The team primarily observed the work of the field technicians but also used the site visits as an opportunity to gain further context for the research study.

3.3.2 Site Visit Findings

The team identified the following findings while on-site with the ICs.

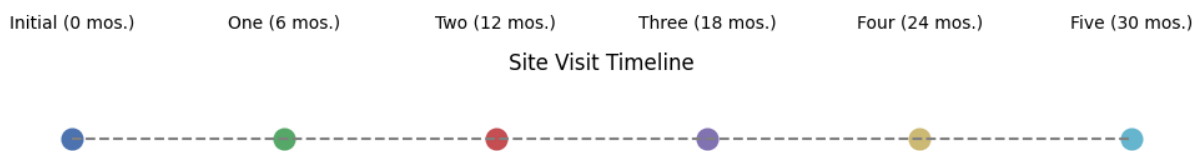
1. Tracking air leak repairs over time can be very challenging due to several factors.
 - a. Equipment is removed, repurposed, or replaced.
2. Equipment may be repaired or modified by on-site staff.
3. Air leak tags may be lost or removed.
 - a. Type of manufacturing environment (i.e., oily environments) can erode leak tags.
 - b. Staff changes at sites affected willingness to participate in leak studies.
4. Air leak repair visits serve as a gateway to further savings.
 - a. ICs reported meeting new clients through leak repair visits.
 - b. Most visited sites had participated in further offerings beyond the initial air leak repair.
5. Often, there are many factors that contribute to the decision if a compressed air leak is repaired by the facility.
 - a. Impacts to production
 - b. Size of leak
 - c. Frequency of machine use
6. ICs encourage maintenance staff to service some of the "easier-to-repair" leaks.
 - a. Many facilities have dedicated maintenance staff that can fix smaller leaks on frequently used equipment.

7. One IC suggested that there are likely different EULs for different types of leaks, with hand-held hoses and quick-disconnects being the first to fail.
8. ICs used the same equipment for checking leaks, however, approaches to tracking differed.
 - a. Differences in facility type personal protective equipment (PPE)/safety requirements impacted tracking.
9. One IC utilized the workbooks provided to the team, while the others relied on the original paper copy of identified leaks.
 - a. All ICs took pictures of the decibel readings, where possible.

4 Compressed Air Leak Failure Findings

4.1 Dataset Considerations

Although the team met the sample target of 400 leaks across 14 sites, reporting was limited to sites that completed a final 30-month revisit. This approach was taken to ensure the integrity and reliability of the dataset.



The team received 30-month data for eight of the fourteen sites, referred to as the “full 30-month dataset” in this memo). Of these, seven sites provided nearly complete data—defined as three or more visits—and are identified as the “screened 30-month dataset”. For one site however, there were no touchpoints between the initial visit and the 30-month revisit, as required by the study design. This site also did not report any failed leak repairs, which raised concerns about the quality and completeness of the data collected by the contractor responsible for these visits.⁴ As a result, the team opted to present additional results based on the screened 30-month dataset.

Full 30-Month Dataset

- 8 out of 14 sites had 30-month revisit data.
 - 1 of these 8 sites had no visits between the initial and 30-month revisits.
 - This site did not report any failed leak repairs and is excluded in the screened 30-month dataset outlined below.

⁴ Many factors could have influenced the lack of failed leak repairs including quality of equipment, thoroughness of leak repair, internal facility leak repair programs, and facility conditions. The study design did not account for the investigation of these variables.

Screened 30-Month Dataset

- 7 out of 14 sites had 30-month revisit data and at least three or more revisits. The 1 site with no visits between the initial and 30-month revisit was excluded from this group.

4.2 Total Tracked Leaks

This section summarizes the number of leaks that were tracked at each revisit phase for the sites with 30-month data. The table column headers in this section are defined as follows:

- **Phase** – the number of the revisit and approximate timing from initial leak repair
- **Sites** – the total number of sites revisited during the phase
- **Leaks** – the total number of leaks that were located and reviewed across all sites during the phase
- **Total Failed Repairs** – the cumulative total of leak repairs that had failed across all sites revisited in the phase
- **Cumulative Failure Rate** – the cumulative leak repair failure rate across all sites revisited in the phase (Total Failed Repairs/Leaks)

4.2.1 Full 30-Month Dataset

The number of leaks tracked by site and their associated failure rate, as tracked by ICs, in the full 30-month dataset is shown in Table 1.

Table 1. Total Failed Compressed Air Leak Repairs by Revisit Phase – Full 30-Mo. Dataset

Phase	Sites	Leaks	Total Failed Repairs	Cumulative Failure Rate (%)
Initial (0 mos.)	8	213	0	0%
One (6 mos.)	6	142	2	1%
Two (12 mos.)	6	145	25	17%
Three (18 mos.)	4	109	26	24%
Four (24 mos.)	5	96	37	39%
Five (30 mos.)	8	163	51	31%

Source: Guidehouse Analysis

4.2.2 Screened 30-Month Dataset

The number of leaks tracked by site and their associated failure rate in the screened 30-month dataset is shown in Table 2. When the one site without consistent revisits is removed, the failure rate increases at each revisit.

Table 2. Total Failed Compressed Air Leak Repairs by Revisit Phase – Screened 30-Mo. Dataset

Phase	Sites	Leaks	Total Failed Repairs	Cumulative Failure Rate (%)
Initial (0 mos.)	7	187	-	0%
One (6 mos.)	6	141	2	1%
Two (12 mos.)	6	145	25	17%
Three (18 mos.)	4	109	26	24%
Four (24 mos.)	5	96	37	39%
Five (30 mos.)	7	146	51	35%

Source: Guidehouse Analysis

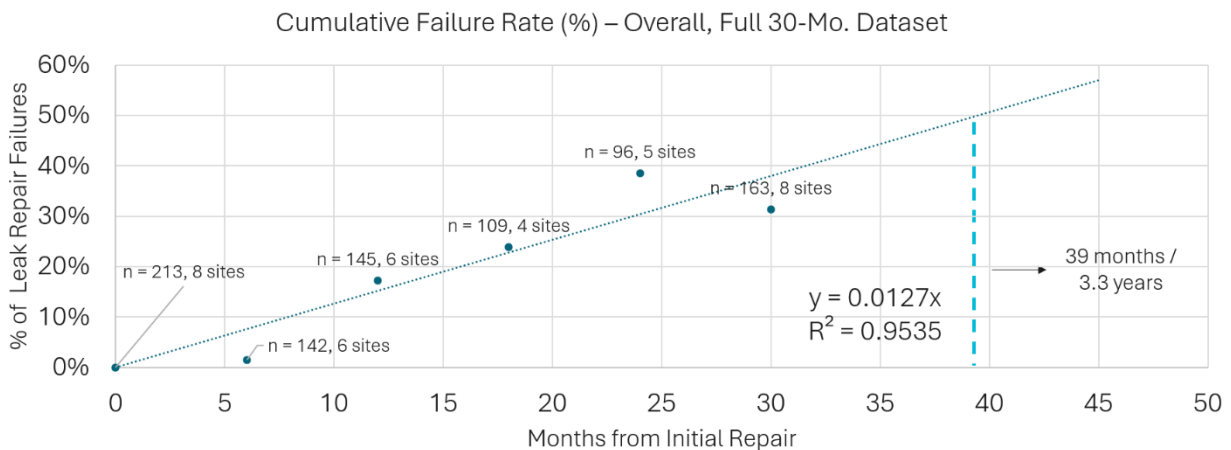
4.3 EUL Findings – Overall Leak Repair Failure

Since the team did not see a failure rate of 50% or more at any of the revisit phases, the next step was to forecast when most leaks were expected to fail.

4.3.1 Full 30-Month Dataset

After plotting all of the full 30-month dataset failed leak repairs by revisit, the team saw a linear trend ($R^2 = 0.9535$). Figure 1 shows that the trend suggests 50% of leaks will fail 39 months from their initial repair, or 3.3 years.

Figure 1. Cumulative Failure Rate (%) – Overall, Full 30-Mo. Dataset

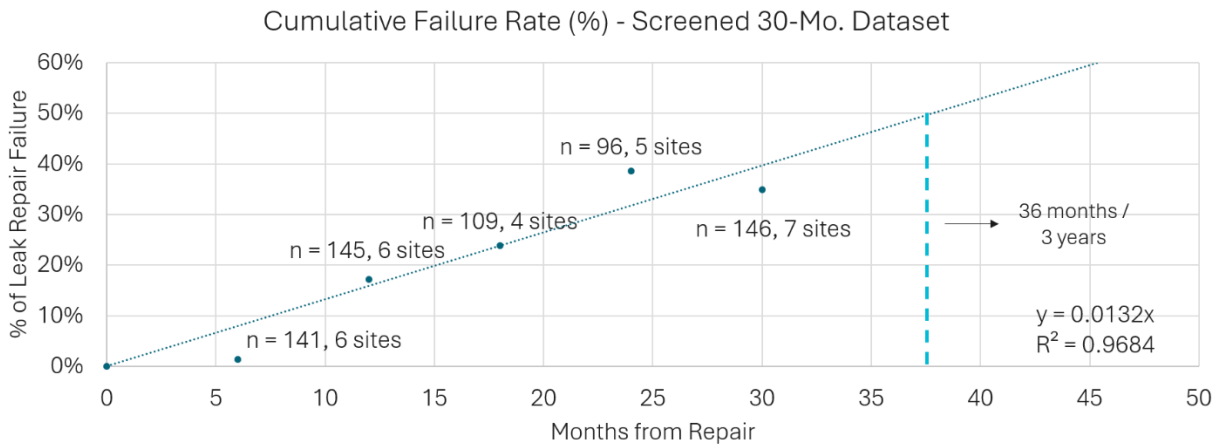


Source: Guidehouse Analysis

4.3.2 Screened 30-Month Dataset

Due to the higher failure rate at the 30-month visit within the screened 30-month dataset, the forecasted EUL decreases to 36 months or 3 years when the number of leaks included in the analysis is reduced. The team saw a stronger linear trend across the screened 30-month dataset ($R^2 = 0.9684$) repaired leaks compared to the full 30-month dataset, as shown in Figure 2.

Figure 2. Cumulative Failure Rate (%) – Overall, Screened 30-Mo. Dataset



Source: Guidehouse Analysis

4.4 Compressed Air Leak Failures by Leak Repair Type

The team also reviewed the location of leak failures, as reported by the ICs, and found that there was a large assortment of different leak types in the data. Photos submitted by the ICs did not always validate the leak repair type, so Guidehouse relied on the self-reported locations by ICs.

At this time, it is not feasible to create EULs for every leak type due to the low sample sizes. However, it is noteworthy that leak repairs associated with filters tend to fail sooner than other leak types. Table 3 shows the number of leak repair failures by leak type for the screened 30-month dataset.

Based on the EUL definition above, filter related leak repairs have an EUL of 19-months or 1.6 years. This could be due to a variety of reasons, including the prevalence of filter cracks in manufacturing facilities. Since filters are often plastic, they are more susceptible to wear and tear from elevated temperatures, chemical stresses, and physical stresses compared to other metal components of a compressed air system. Filters may be more vulnerable to cracking/tearing which in turn causes leaks to occur and to re-occur after being repaired. Filters are not an integral part of all compressed air systems – in this study, they were only seen at the food-grade plastic facilities ($n = 3$ of 7 in the screened 30-month dataset). When the team removed filters from the tracked leaks, the EUL increased substantially.

The ICs did not report leaks within the compressed air piping itself. While this may indicate that these leaks are less common, the study team anticipates that repairs to this type of leak would last longer than those addressing fitting, connection, and equipment-based leaks.

Table 3. Compressed Air Leak Failure by Leak Repair Type – Screened 30-Month Dataset

Leak Repair Type	Total # of Leaks Tracked (Initial Visit)	# of Failures at 6-mos.	# of Failures at 12-mos.	# of Failures at 18-mos.	# of Failures at 24-mos.	# of Failures at 30-mos.	% Failed at 6-mos.	% Failed at 12-mos.	% Failed at 18-mos.	% Failed at 24-mos.	% Failed at 30-mos.
Total	187	2	25	26	37	51	1%	17%	24%	39%	35%
Filter	40	0	13	17	23	30	0%	33%	55%	66%	81%
Valve	6	0	1	1	2	2	0%	20%	100%	50%	67%
Regulator	7	0	0	0	1	3	0%	0%	-	20%	50%
Hose	26	0	1	2	2	4	0%	4%	15%	20%	22%
Quick Disconnect	44	2	6	3	3	6	7%	18%	14%	17%	21%
Broken Equipment	6	0	1	1	1	1	0%	20%	20%	50%	20%
Equipment Fitting	42	0	3	2	5	5	0%	14%	7%	26%	14%
Blowgun	9	0	0	0	0	0	0%	0%	0%	-	0%
Lubricator	3	0	0	0	0	0	0%	0%	-	0%	0%
Pushlock	4	0	0	0	0	0	-	0%	0%	-	0%

Source: Guidehouse Analysis

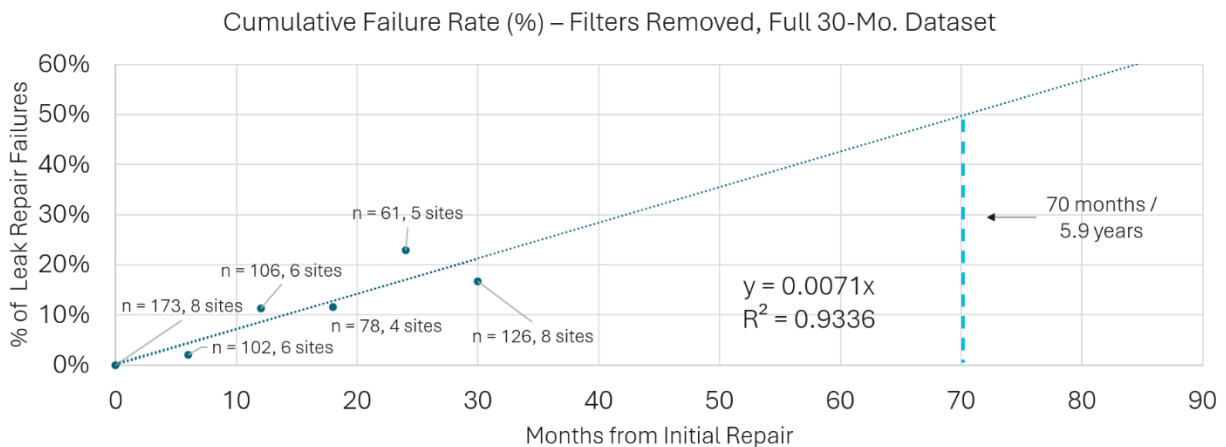
Note: The population by leak repair type changes by visit, so total number of failures at each revisit are not divisible into the total number of tracked leaks at the initial visit.

N/A = None of these specific leak types were revisited at a specific phase

4.4.1 EUL without Filter Leak Repairs – Full 30-Month Dataset

As noted above, the EUL increased when filters were removed from the dataset. Figure 3 shows that the EUL increased to 70 months or 5.9 years. The relationship between the percent of leak repair failures and time remained linear in this data view.

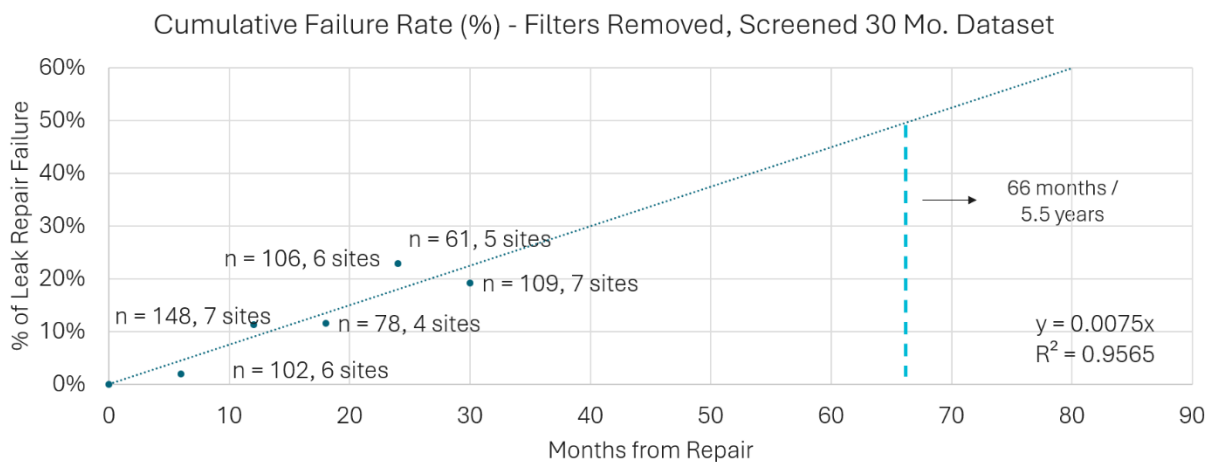
Figure 3. Cumulative Failure Rate (%) – Filters Removed, Full 30-Mo. Dataset



4.4.2 EUL without Filter Leak Repairs – Screened 30-Month Dataset

Similarly to the chart above, the EUL also increased when filters were removed from the screened 30-month dataset. Since the site without revisits did not have filters in their leak lists, the EUL for this group did not increase as much as in the full 30-month dataset. The EUL for the screened 30-month dataset without filters is 66 months or 5.5 years. As seen in the overall data set, the R^2 is higher when the site without revisit data is removed from the analysis.

Figure 4. Cumulative Failure Rate (%) – Filters Removed, Screened 30-Mo. Dataset



4.5 EUL Findings – Cumulative Failure Rate vs. Total Failure Rate

The Cumulative Failure Rate is calculated as follows.

$$\text{Cumulative Failure Rate} = \frac{\# \text{ of Failed Leak Repairs}}{\# \text{ of Tracked Leak Repairs}}$$

Where:

$$\# \text{ of Failed Leak Repairs} = \text{Count of Failed Leak Repairs Over Time}$$

(i. e., if a leak repair fails at Ph 1 it will count towards the Failed Leak Repairs through Ph 5)

$$\# \text{ of Tracked Leak Repairs} = \text{Count of Revisited Leak Repairs}$$

(i. e., if a leak repair cannot be found or the revisit was not completed, it is not counted)

This method may be excessively conservative. The number of tracked leak repairs fluctuates during each phase of revisits as some of the initially identified and repaired leaks could not be located during later visits. Conversely, once identified, a failed leak repair may not be “lost.” The consistently increasing count of failed leak repairs divided by the fluctuating number of tracked leak repairs likely results in artificially lower EULs.

An alternative approach for calculating the failure rate is as follows.

$$\text{Total Failure Rate} = \frac{\# \text{ of Failed Leak Repairs}}{\# \text{ of Original Leak Repairs}}$$

Where:

$$\# \text{ of Failed Leak Repairs} = \text{Count of Failed Leak Repairs Over Time}$$

(i. e., if a leak repair fails at Ph 1 it will count towards the Failed Leak Repairs through Ph 5)

$$\# \text{ of Original Leak Repairs} = \text{Count of Original Leak Repairs}$$

(i. e., consistent denominator despite not all leaks being revisited)

This method maintains a consistent denominator of the originally tracked leaks (by site). As a counterpoint to the above method, this approach likely overstates the appropriate EUL, particularly for sites with significant missing data, by inherently assuming that leak repairs that could not be relocated on follow-up site visits never fail.

Each of these methods has the potential to either understate or overstate the calculated EUL, respectively. Because the best estimate of the actual EUL likely lies between these two estimates, the evaluation team recommends averaging the results.

4.6 EUL Findings – Summary

Table 4 below summarizes the forecasted EUL for compressed air leak repairs, comparing the full and screened 30-month datasets and showing the impact of including or excluding filter-related leaks.

Table 4. Forecasted EUL for Compressed Air Leak Repairs

Dataset	Cumulative Failure Rate		Total Failure Rate		Average Failure Rate	
	All Leak Types	Without Filters	All Leak Types	Without Filters	All Leak Types	Without Filters
Full 30-Month Dataset	39 months / 3.3 years	70 months / 5.9 years	44 months / 3.7 years	81 months / 6.7 years	42 months / 3.5 years	76 months / 6.3 years
Screened 30-Month Dataset	36 months / 3 years	66 months / 5.5 years	39 months / 3.3 years	71 months / 6 years	38 months / 3.1 years	67 months / 5.7 years

5 Considerations

The study found that EULs vary by leak type. The average EUL for the full 30-month dataset and screened 30-month dataset falls within the 1 to 5 year range currently in the IL TRM. However, recording leak type at the time of repair could increase the EUL above that range for non-filter leak types. While the calculated EULs are higher than one year, it is important to distinguish the expected lifespan of repaired leaks from the rate of formation of new and different leaks. The team recommends that ICs revisit sites on an annual basis to address new leaks that have formed over that year. Regular leak repair is a vital component in compressed air systems to ensure equipment performance and to prevent significant energy waste.

Currently, the team does not recommend disaggregating EULs by leak type beyond filters versus non-filters. However, this could be a future research opportunity, as there is some indication that there may be some differences in compressed air leak failure rate by leak type.

For future studies, the team recommends incorporating additional site visits throughout the research period. This would allow the team to accompany ICs during their revisits, helping to observe and better understand the challenges ICs face during data collection. These insights can then be used to suggest targeted improvements that reduce recurring issues and enhance the overall quality and consistency of the data collection process.

6 Appendix

During the review of the study findings, stakeholders raised that the linear forecast may be more conservative due to the interim datapoints where higher proportions of leak repair failures were found. Guidehouse acknowledged that the interim datapoints are likely lower than the forecasted EUL. However, the evaluation team chose to include the datapoints in the recommended EUL. The team’s opinion is that the interim data is necessary to support the linear interpretation. Without the interim data, the EUL increases slightly, as shown in Table 5. Additional datapoints allow the creation of some statistical interpretation of "goodness of fit" and/or relative precision. Including only one real sample point at the end of the time period removes any ability to estimate statistical error.

Including all data aligns with the original evaluation plan that was agreed upon by all stakeholders.

Table 5. Forecasted EUL with Interim Datapoints Removed

Dataset	All Leak Types	Without Filters
Full 30-Month Dataset	48 months / 4 years	90 months / 7.5 years
Screened 30-Month Dataset	43 months / 3.6 years	78 months / 6.5 years