FLUKE®
Reliability

10 Years After:

A Snapshot of How Reliability and Maintenance Have Changed Over the Last Decade

Bio

Thomas Wilk

Editor in Chief, Plant Services

- Plant Services Editor in Chief, 2014 – now
- Chair, SMRP Editorial Committee, 2018 – 2021
- Content Strategist / Social Media Manager / Mobility Manager, Panduit, 2006 – 2014
- Lead Technical Editor, Battelle Environmental Restoration Dept., 1998 – 2006
- English Professor, Ohio State U. (focus on business / science / engineering writing), 1992 – 2002
- Completed four marathons (2010, 2011, 2014, 2016)

Ch-ch-ch-ch-changes

Thomas Wilk
Editor in Chief, Plant Services

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More changes

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Reliability

Work then

Work now

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Plant Services covers

2014-2024

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Plant Services 2014-2019

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Reliability

Plant Services 2020

Plant Services 2021-2024

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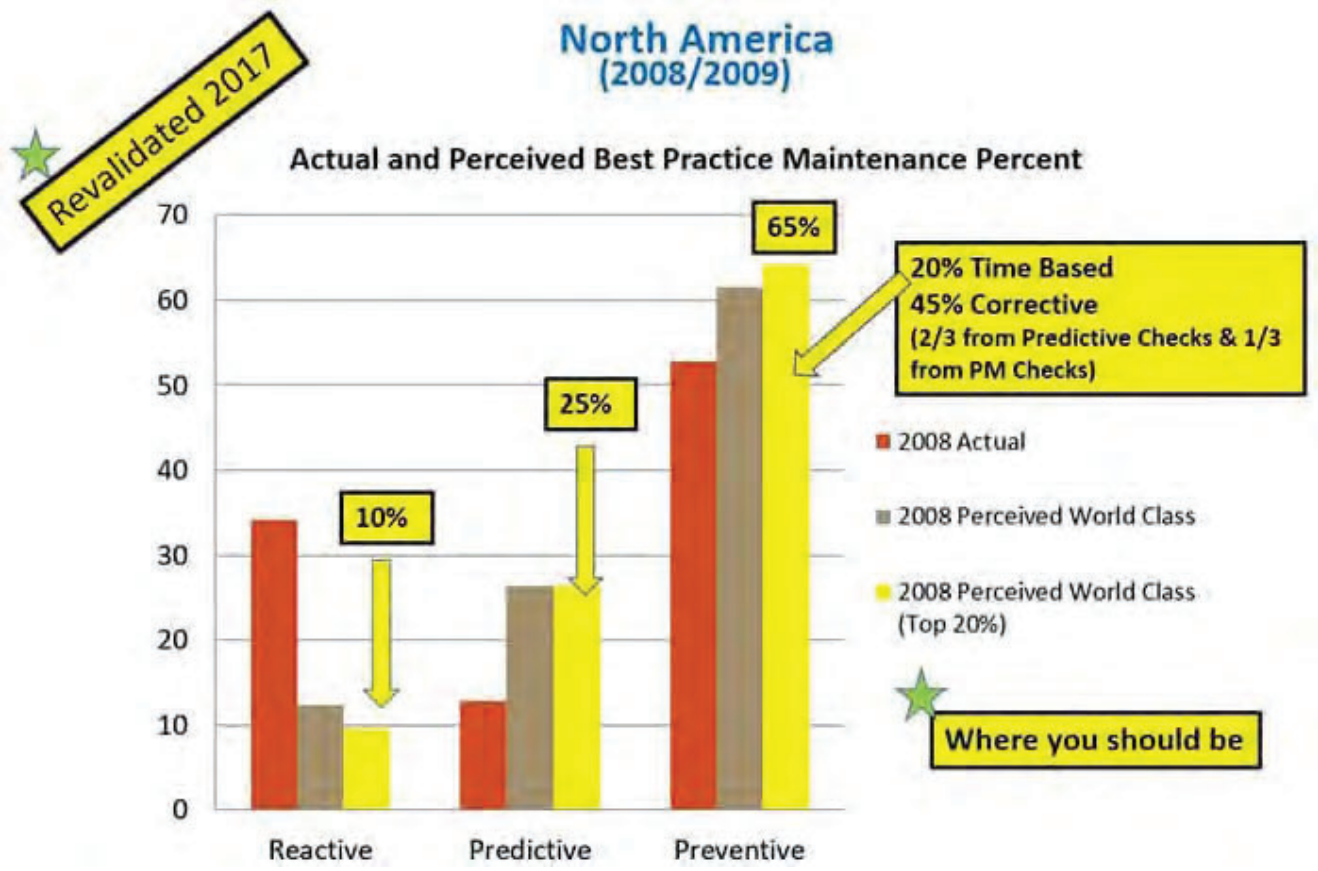
What *hasn't* changed in 10 years



Mix of maintenance work types

Source: Dr. Klaus Blache, RMC-UTK

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What *hasn't* changed in 10 years...

- Machines still rotate
- Motors still fail
- Compressed air still consumes energy
- Technicians still do PM routes
- Tools still collect machine health data
- Teams still create job plans and schedule work
- People still work overtime

...or has it?

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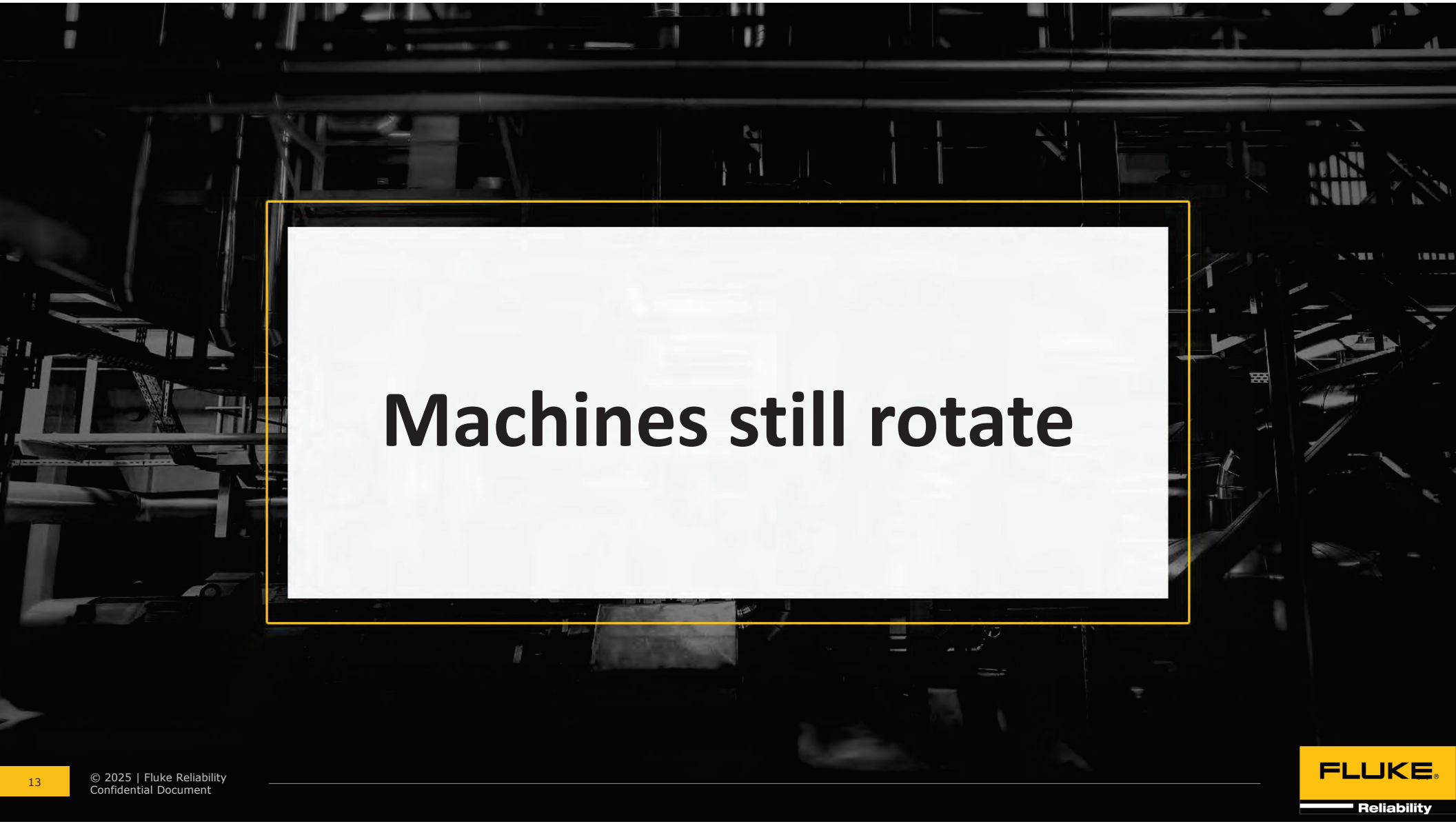


ISO 55000 series of standards

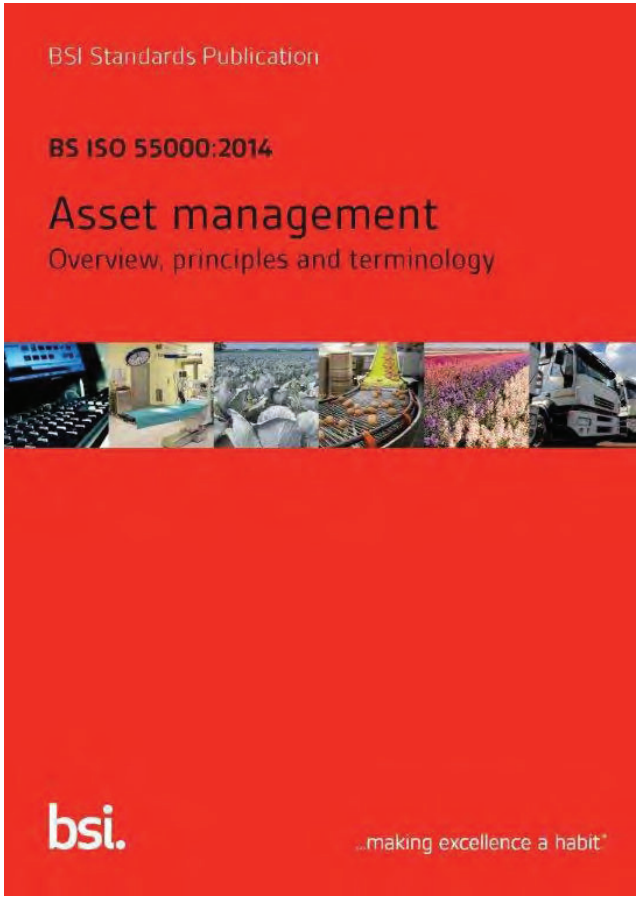
2008: PAS 55 published

2014: ISO 55000 published

ISO 55000 Asset Management - Overview, principles and terminology
Introduces the critical concepts and terminology needed to develop a long-term plan that incorporates an organization's mission, values, objectives, business policies and stakeholder requirements.

ISO 55001 Asset Management - Requirements
Specifies the requirements for the establishment, implementation, maintenance and improvement of an asset management system.

ISO 55002 Asset Management - Guidelines on the application of ISO 55001
Provides guidance for the application of an asset management system, in accordance with the requirements of ISO 55001.



https://www.plantservices.com/asset-management/software/article/11315099/what-you-need-to-know-about-iso-55000

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ICML 55 series of standards

July 2023

- **Strategically aligned to ISO 55000**
- **Supports an organization's physical asset management plans**

ICML 55.0 - Optimized Lubrication of Mechanical Physical Assets Overview

WHY do it

ICML 55.1 - Requirements for the Optimized Lubrication of Mechanical Physical Assets

WHAT to do

ICML 55.2 - Guideline for the Optimized Lubrication of Mechanical Physical Assets

HOW to do it

Ask The Experts - ICML 55:
https://www.plantservices.com/monitoring/machinery-lubrication/article/33014488/ask-the-experts-best-in-class-lubrication-practices

NFPA 70 family

NFPA 70 (NEC)

- Defines how to install listed electrical equipment properly

NFPA 70E - Standard for Electrical Safety in the Workplace

- **In 2018**, formally adopts Hierarchy of Risk Control Methods
- Defines how to reduce risk through safe work practices on equipment when it is under “abnormal” conditions
- Recognizes the risk inherent with CBM data collection
- Human error must be considered as part of the risk assessment procedure (RAP) for any work task

NFPA 70B - Standard for Electrical Equipment Maintenance

- **In 2023**, it changed from a guide to a standard
- Elevates it to same status as the NEC & NFPA 70E

https://www.plantservices.com/safety-and-security/electrical-safety/article/33007648/is-your-plant-following-the-new-nfpa-70b-standard

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Certifications

CMRP

- Certified Maintenance and Reliability Professional
- Offered through SMRP since 2001

CRE

- Certified Reliability Engineer
- Offered through American Society for Quality (ASQ)

CRL

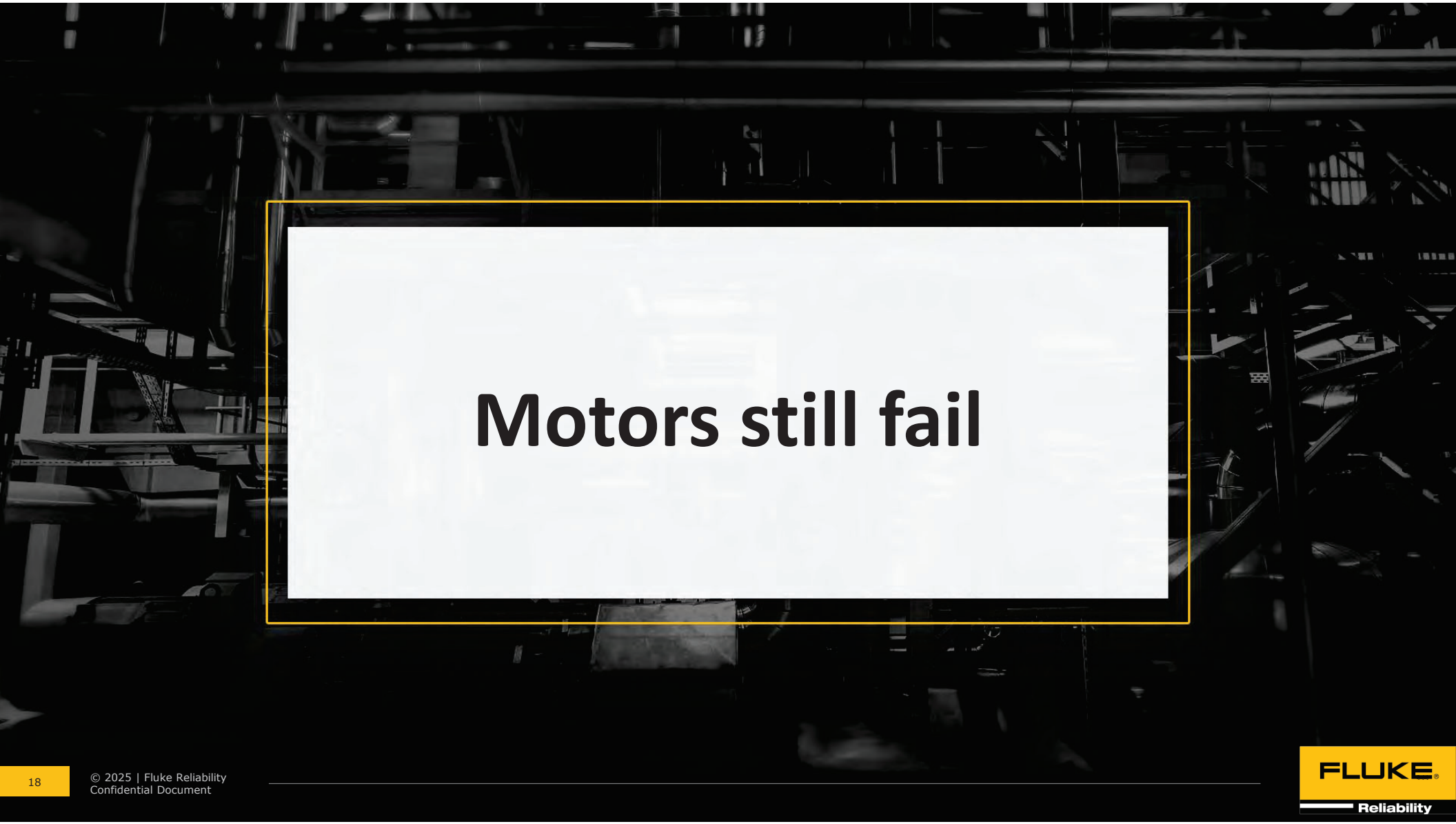
- Certified Reliability Leader
- Offered through Association of Asset Management Professionals (AMP)

RMIC

- Reliability & Maintainability Implementation Certification
- Offered through UTK-RMC

CAMA

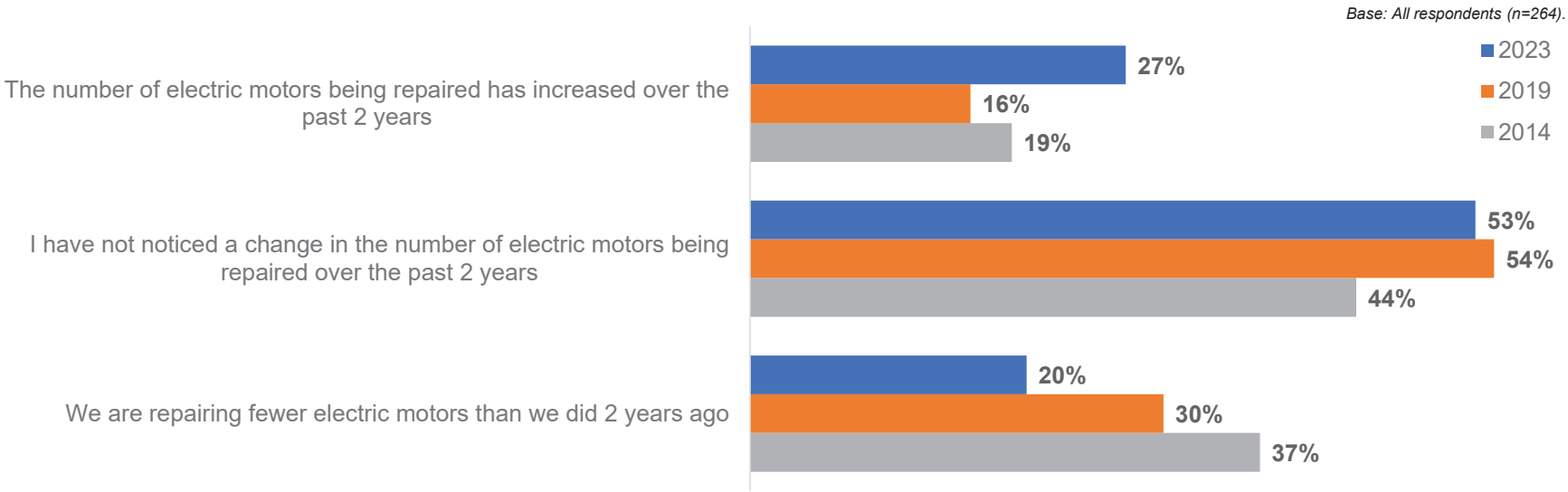
- Certified Asset Management Professional
- Offered through World Partners in Asset Management



Trend in Electric Motor Repairs

- **27% of respondents have seen an increase in the number of electric motors being repaired, up from 19% in 2014**

Which of the following statements best describes your present experiences with regard to electric motors operating in your facility?

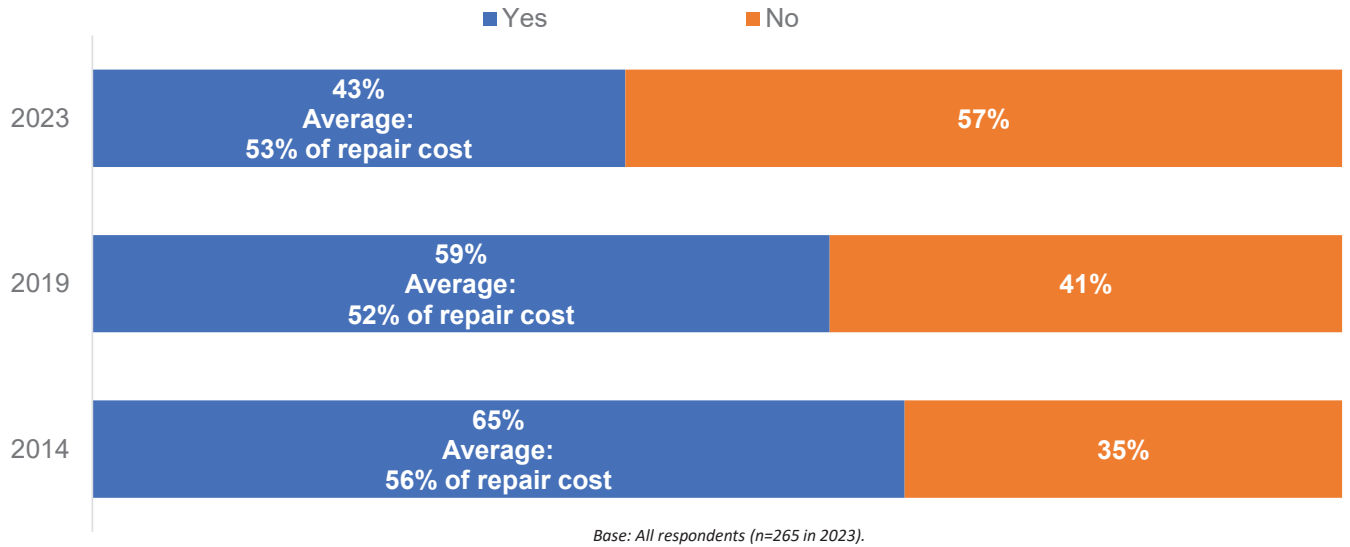


https://www.plantservices.com/equipment/industrial-motors/article/55042289/4-factors-impacting-electric-motor-maintenance-according-to-plant-professionals

Repair Cost Cut-Off

- **Forty-three percent of respondents automatically buy a replacement motor if the repair cost is an average 53% or higher of the replacement cost.**

When comparing the estimated cost to repair an electric motor to the price of a new replacement motor, do you have a repair cost % above which you will choose to buy a new motor replacement instead of repairing the existing motor? If yes, what is the cut-off?

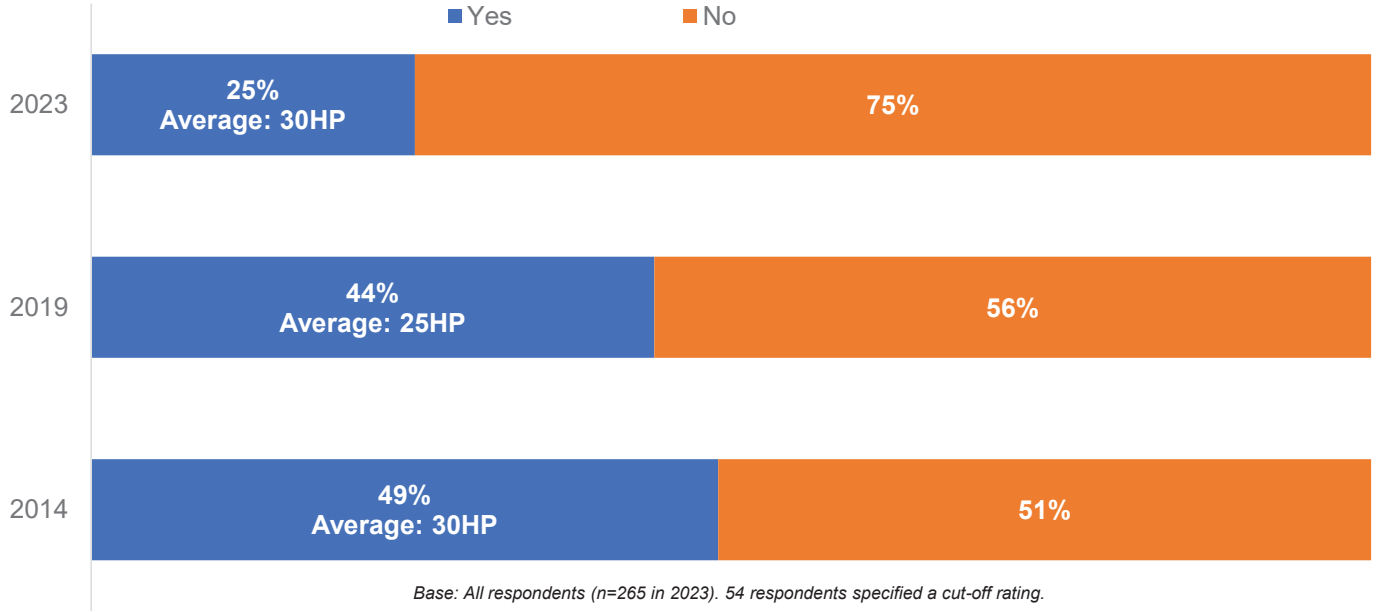


Base: All respondents (n=265 in 2023).

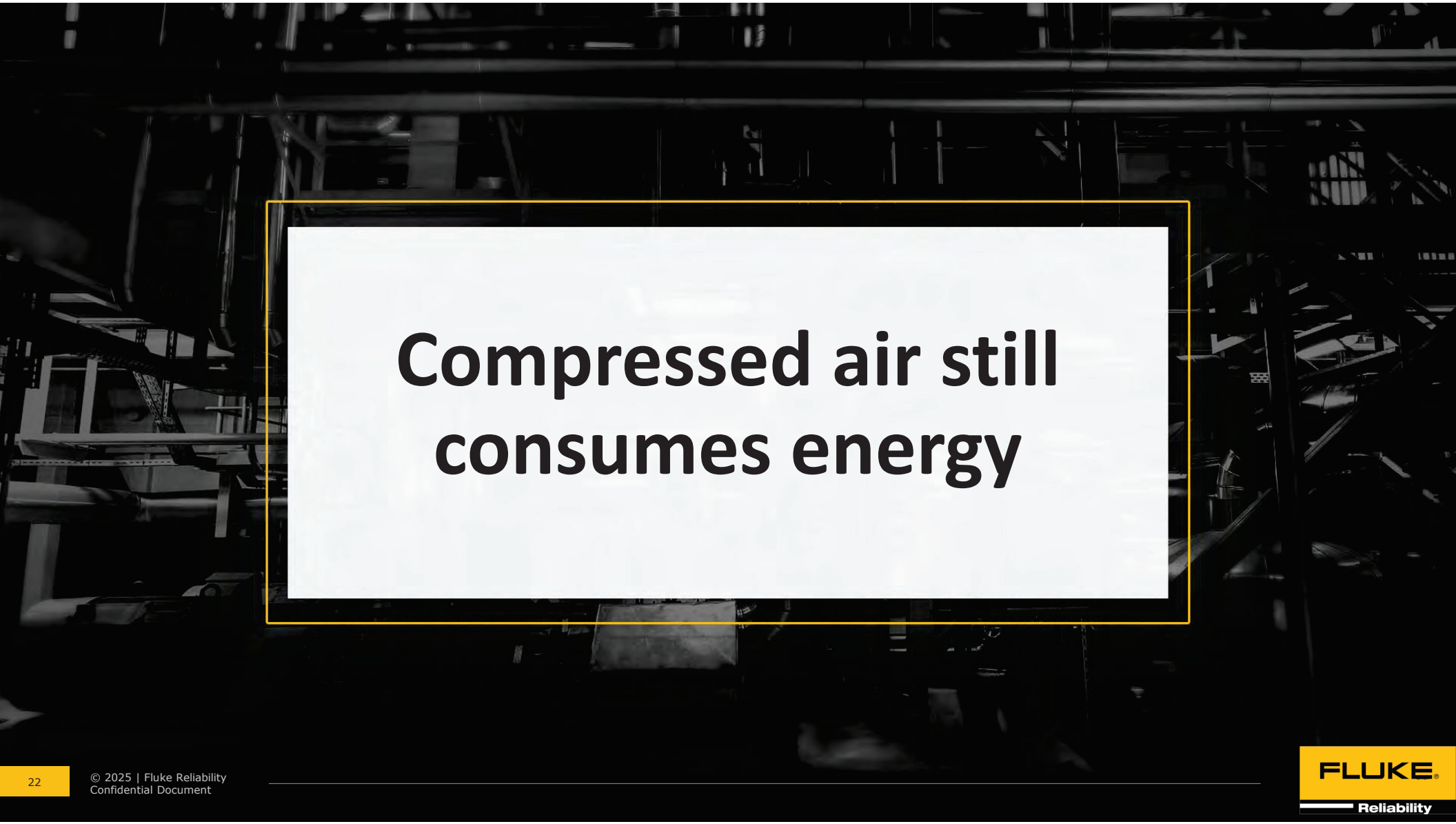
Automatic Replacement Cut-Off Rating

- **25% of respondents have a policy of automatically replacing failed electric motors that fall below a specific rating, down from 49% in 2014.**

Do you have a policy of automatically replacing failed electric motors below a specific rating? If yes, what is the rating?



Base: All respondents (n=265 in 2023). 54 respondents specified a cut-off rating.



Technology design

1. Variable speed drive compressors

- Before: Bolt a variable drive onto a standard compressor
- **Now:** better quality drives + specially designed motors that are more compatible with VSD technology

2. Noise abatement

- Vibration dampening through rubber mounts, pads, and other isolators
- Smoother-operating motors and fans + quieter bearings
- Composite noise-absorbing materials for enclosures, housings, and guards

3. Heat recovery

- Integrating heat exchangers and efficient heat transfer mechanisms
- Reclaim up to 90% of waste heat
- Use it for space heating, water heating, or preheating air

https://www.plantservices.com/equipment/compressed-air-systems/article/55094268/compressed-air-innovations-in-industry-a-10-year-retrospective

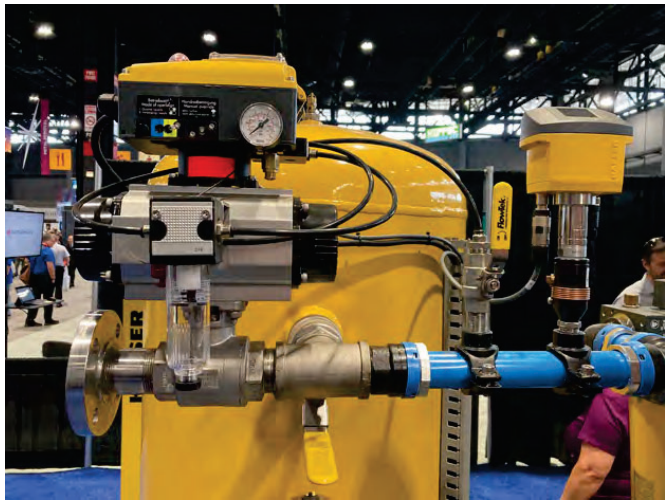
Asset management

1. System monitoring

- Intuitive, user-friendly interfaces that include **visual dashboards**, customizable reports, and simple navigation
- **Smart controllers** that optimize compressor performance by adjusting operations based on real-time demand
- IoT-enabled devices collect and analyze data continuously
- Cloud-based platforms store and provide centralized access to data

2. Air quality monitoring instruments

- More accurate & affordable
- Detect the dryness and cleanliness of produced compressed air
- Measure dew point, temperature, flow, and oil content
- Count and categorize entrained particles within compressed air



3. Ultrasonic leak detection

- Ultrasonic instruments
- Acoustical imaging leak detectors

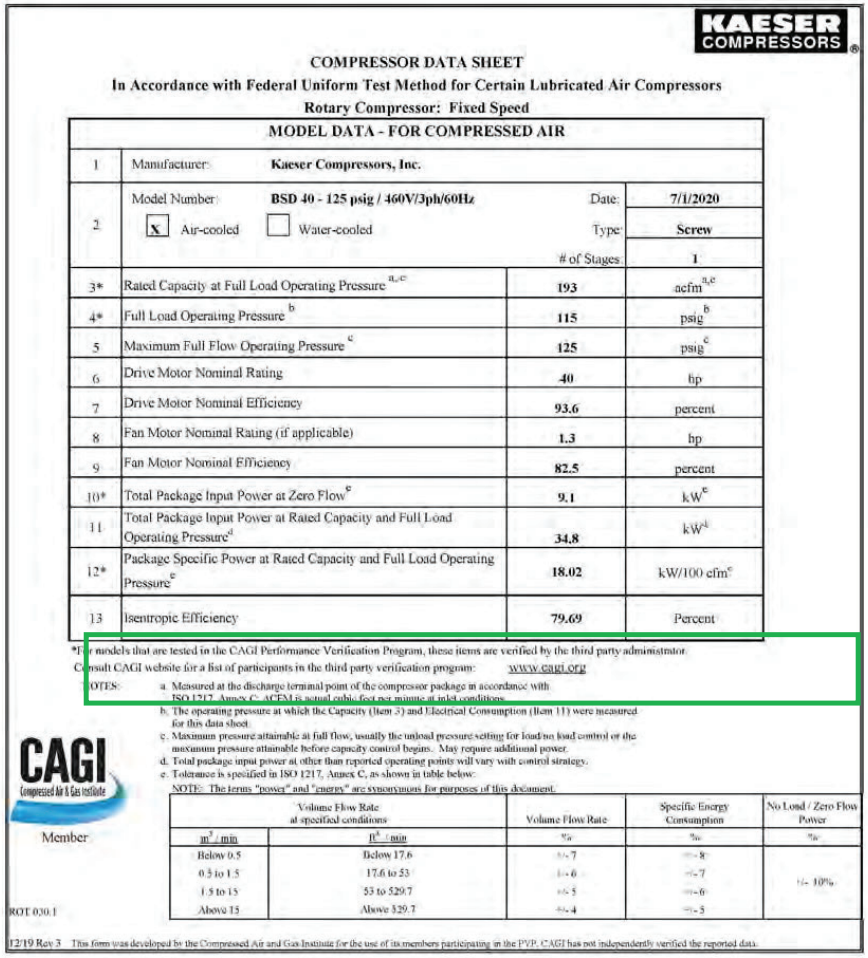
Industry initiatives

1. CAGI data sheets (~2013)

- Provides a **transparent and consistent format** to evaluate performance metrics across manufacturers
- Developed for fixed speed, variable displacement, and variable speed screw compressors (both lubricated and non-lubricated)
- New metric: **isentropic efficiency - the ratio of real work to work under ideal conditions**
- Eliminates any confusion about published Specific Power numbers, which change with compressor output pressure

2. Training & certifications

- Compressed Air Challenge (CAC) Fundamentals and Advanced training
- **New:** CAC Compressed Air Assessment and Project Development
- CAGI CCASS (Certified Compressed Air System Specialist)
- **Upcoming:** CAGI CCASA (Certified Compressed Air System Auditor)



KAESER COMPRESSORS

COMPRESSOR DATA SHEET

In Accordance with Federal Uniform Test Method for Certain Lubricated Air Compressors

Rotary Compressor: Fixed Speed

MODEL DATA - FOR COMPRESSED AIR

1	Manufacturer:	Kaeser Compressors, Inc.	
2	Model Number: BSD 40 - 125 psig / 460V/3ph/60Hz	Date:	7/1/2020
	[X] Air-cooled [ ] Water-cooled	Type:	Screw
		# of Stages	1
3*	Rated Capacity at Full Load Operating Pressure [a,e]	193	acfm [a,e]
4*	Full Load Operating Pressure [b]	115	psig [b]
5	Maximum Full Flow Operating Pressure [c]	125	psig [c]
6	Drive Motor Nominal Rating	40	hp
7	Drive Motor Nominal Efficiency	93.6	percent
8	Fan Motor Nominal Rating (if applicable)	1.3	hp
9	Fan Motor Nominal Efficiency	82.5	percent
10*	Total Package Input Power at Zero Flow [e]	9.1	kW [e]
11	Total Package Input Power at Rated Capacity and Full Load Operating Pressure [d]	34.8	kW [d]
12*	Package Specific Power at Rated Capacity and Full Load Operating Pressure [e]	18.02	kW/100 cfm [e]
13	Isentropic Efficiency	79.69	Percent

*For models that are tested in the CAGI Performance Verification Program, these items are verified by the third party administrator.
Consult CAGI website for a list of participants in the third party verification program: www.cagi.org

NOTES:
a. Measured at the discharge terminal point of the compressor package in accordance with ISO 1217, Annex C. ACFM is actual cubic feet per minute at inlet conditions.
b. The operating pressure at which the Capacity (Item 3) and Electrical Consumption (Item 11) were measured for this data sheet.
c. Maximum pressure attainable at full flow, usually the unload pressure setting for load/no load control or the maximum pressure attainable before capacity control begins. May require additional power.
d. Total package input power at other than reported operating points will vary with control strategy.
e. Tolerance is specified in ISO 1217, Annex C, as shown in table below:
NOTE: The terms "power" and "energy" are synonymous for purposes of this document.

Volume Flow Rate at specified conditions		Volume Flow Rate	Specific Energy Consumption	No Load / Zero Flow Power
m^3 / min	ft^3 / min	%	%	%
Below 0.5	Below 17.6	+/- 7	+/- 8	+/- 10%
0.5 to 1.5	17.6 to 53	+/- 6	+/- 7	
1.5 to 15	53 to 529.7	+/- 5	+/- 6	
Above 15	Above 529.7	+/- 4	+/- 5	

CAGI Compressed Air & Gas Institute Member

ROT 030.1

12/19 Rev 3 This form was developed by the Compressed Air and Gas Institute for the use of its members participating in the PVP. CAGI has not independently verified the reported data.

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Mobility & the connected worker

Adoption: Field > warehouse > plant floor

State of tech: Early device convergence

"When you're able to look at the combination of thermal images and vibration on the same motor, and you're able to see the production schedule or the work orders, you can go from predictive to pretty much reliability-centered maintenance."

John Neeley, product director for SaaS and IoT, Fluke

"People want to be portable, they want to be enabled, and the specific device doesn't matter."

Kyle Reissner, industrial automation mobility platform leader, Rockwell Automation

February 2016

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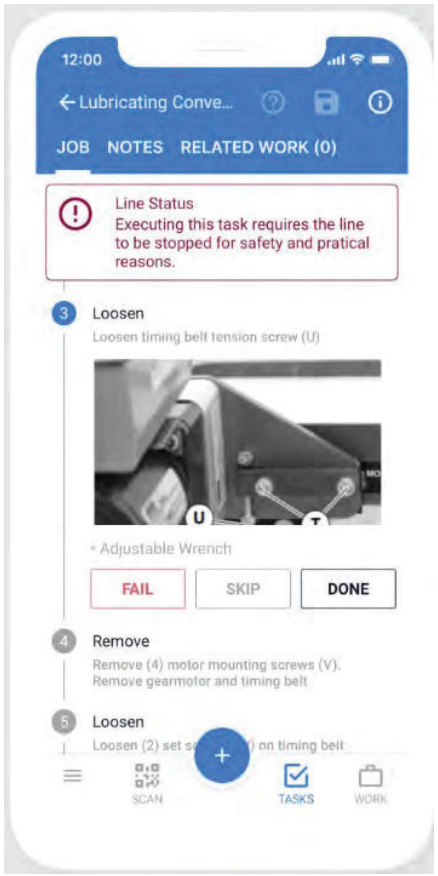
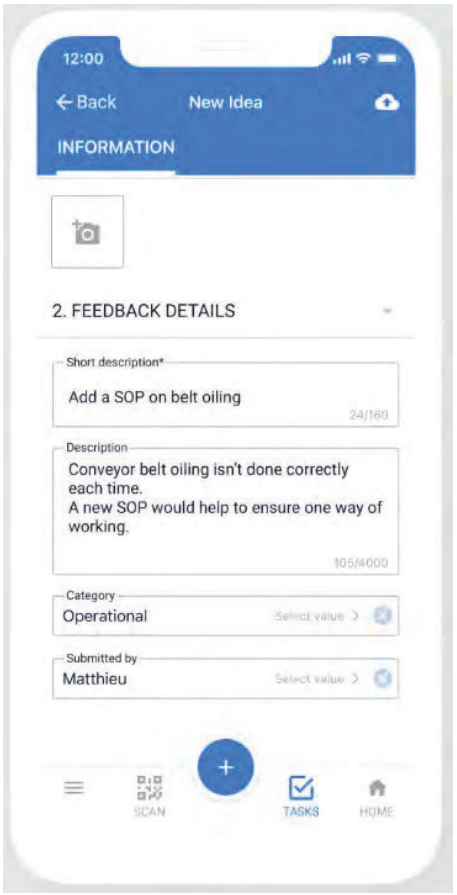
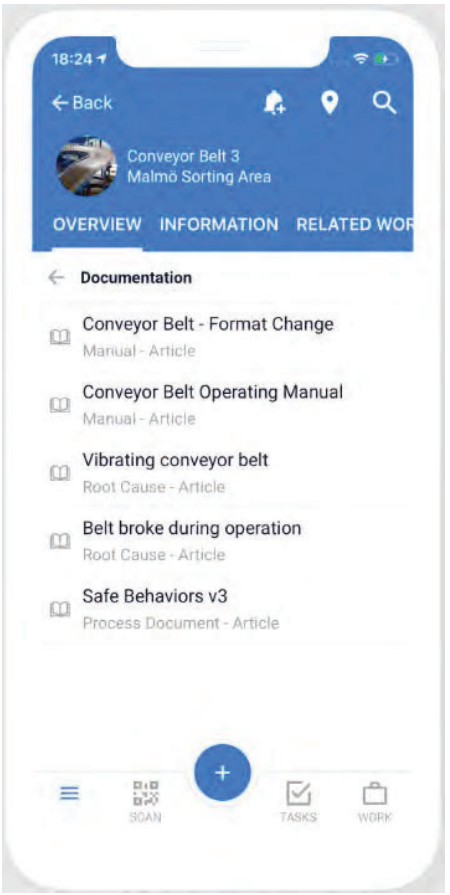
Mobility & the connected worker







Source: Industry https://4industry.com/

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Mobility & the connected worker

Mobile CMMS being used for:

- PM templates / manuals
- Work order history / search
- Safety & compliance tracking / auditing
- Centralized communication in real-time
- Improved responsiveness

Matt Olson, Director of Facilities and Reliability, Bentek (contract manufacturer in power distribution

Bryan Christiansen, CEO and Founder, Limble

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PdM technologies deployed

	Using now				In this year's budget				No plans			
	2014	2018	2020	2022	2014	2018	2020	2022	2014	2018	2020	2022
Vibration	60.0%	64.1%	70.1%	59.5%	5.8%	7.8%	5.2%	12.7%	21.3%	15.6%	14.3%	12.7%
Ultrasound	45.5%	60.9%	44.7%	41.6%	5.2%	6.3%	7.9%	9.1%	32.5%	25.0%	26.3%	28.6%
Acoustic	24.7%	21.9%	21.1%	28.2%	6.5%	4.7%	10.5%	6.4%	54.5%	57.8%	50.0%	42.3%
Corrosion	33.8%	28.6%	39.5%	28.6%	7.8%	11.1%	14.5%	10.4%	43.5%	46.0%	36.8%	44.2%
Infrared	65.8%	71.4%	56.6%	55.1%	3.9%	3.2%	19.7%	15.4%	14.8%	19.0%	15.8%	17.9%
Oil analysis	62.3%	74.6%	63.6%	59.5%	4.5%	6.3%	13.0%	11.4%	17.5%	14.3%	18.2%	17.7%
Predictive modeling software	17.5%	11.1%	15.6%	14.3%	6.5%	6.3%	13.0%	11.7%	50.6%	49.2%	49.4%	45.5%
Electric motor testing	50.0%	42.9%	44.2%	50.0%	5.8%	9.5%	15.6%	12.8%	29.2%	30.2%	27.3%	24.4%

https://www.plantservices.com/predictive-maintenance/predictive-maintenance/article/21435521/2022-pdm-survey-results-how-does-your-plant-compare

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Video condition monitoring revolution

RDI Iris M

Fluke ii905

RDI Iris MX

- **Digital video and image processing**
- **Visual CM data**
- **Non-invasive**

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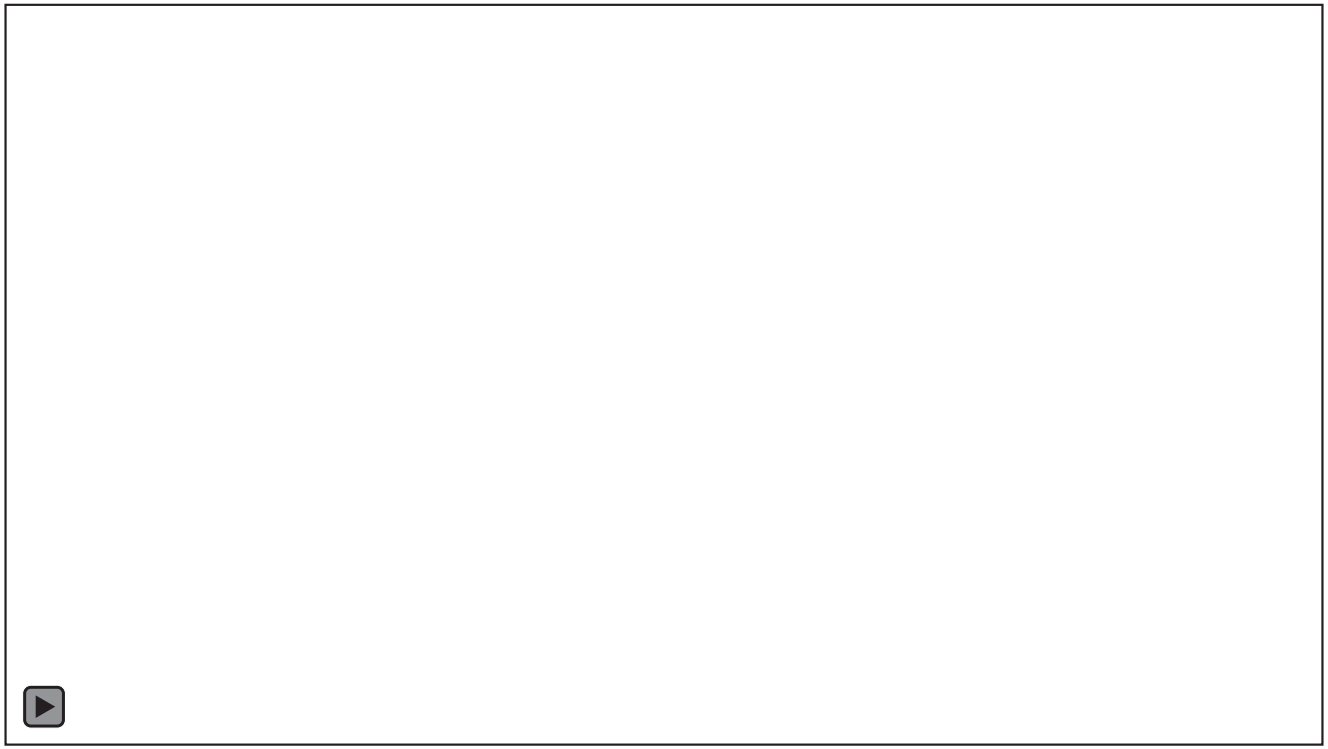
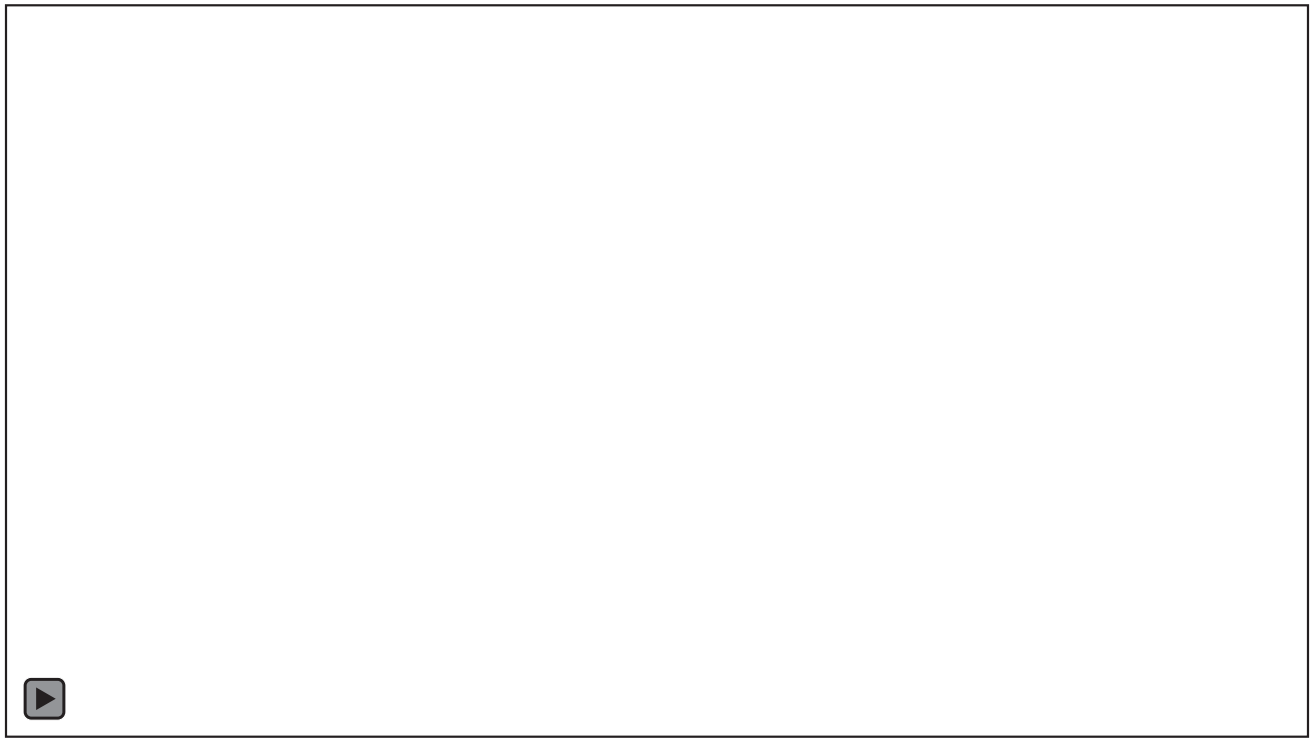
Video CM revolution - Motion amplification
Motor rocking



https://www.youtube.com/watch?v=8bB9aWWZ39c

Video CM revolution - Motion amplification
Motor pump



https://www.youtube.com/watch?v=FVkUN3_YsWc

Video CM revolution - Acoustic leak detection

https://www.fluke.com/en-us/product/industrial-imaging/fluke-ii905

Flavors of AI (i.e., machines acting in a way that seems intelligent)

Type of AI	Definition	Data Requirements	Examples
Rules Engine	Set of rules (if/then statements) that must apply for an outcome to be true. Assesses operations based on prior system performance and design intent.	Relatively small data and defined by the rules.	Equipment OEM Maintenance models, root cause detection, Symptom 1+ Symptom 2 = Failure
Machine Learning	Searching many possibilities to find the ones that work best; mathematical techniques such as linear regression, optimization, probabilistic reasoning, etc. Assess empirically, the operations based on prior system performance.	The more data the better	Component Life Prediction, Association Models, unsupervised anomaly detection, remaining useful life, association models,
Physics Model	First principles and engineering models to characterize behaviors. Assesses operations based on design intent and underlying physical principles.	Relatively small data and defined by engineering equations	Dynasty, MatLab, Finite Element Analysis, Computation fluid dynamics, solid mechanics
Natural Language Processes	Processing natural language data. Unstructured data mining.	The more data the better	Email, Folder Mgmt. (spam), ChatGPT, Bing, Google, inspection data, fluid sample, machine operator logs
Robotics	Automation of physical tasks; sensing, computing and actuation.	Must acquire all necessary data at the source.	SCADA, Autonomous vehicles, Factory Robots
Robotic Process Automation	Reproduction of steps in the process through software – a.k.a. Software Robotics	None	Data extraction, optical character recognition, eCommerce merchandising, Chatbots

Source: MIT Artificial Intelligence: Implications for Business Strategy, Professor Tom Malone, via Terri Lewis, Planet Connected

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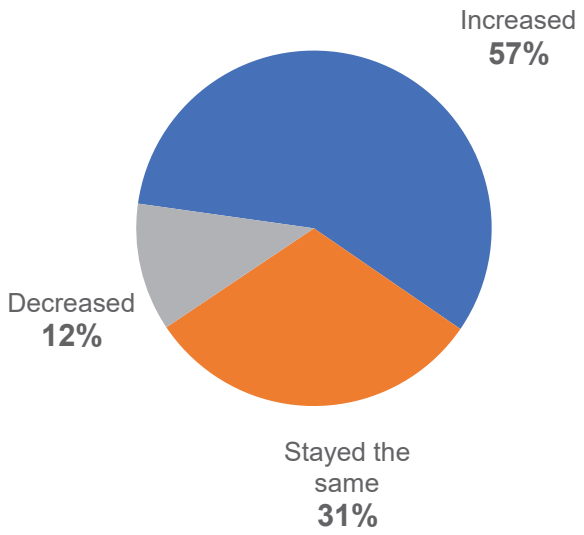
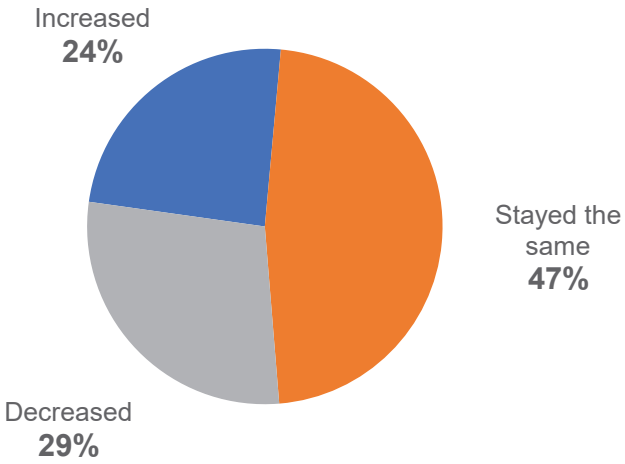
Where are the workers?

Over the past three years, how has your overall maintenance budget changed?



Base: All respondents (n=258).

Over the past three years, how has your size of maintenance staff changed?



Base: All respondents (n=256).

Who are the workers?

Jake Hall, The Manufacturing Millennial

Manufacturing is 8.5% of the workforce:

- 11% of US GDP ($2.5T)
- 12.9M people
- **Up 11% since 2010**

There are 4.6M jobs to fill:

- **Only 2.2M will be filled** (GenZ/Millennial)
- 2.4M (53 out of 100) will lie vacant due to the skills shortage

2020 study: Where do GenZ's want to work?

- 36.6% STEM
- **3.5% Manufacturing**

https://tallo.com/data-insights/tallo-data-insights-where-does-gen-z-want-to-work/

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What do they want?

- 77% of Millennials will leave entry level MFG jobs in the first 30 days
- 34% of new hires would leave within the first 48 hours, often times without telling anyone

Pennington's keys to success

Attract

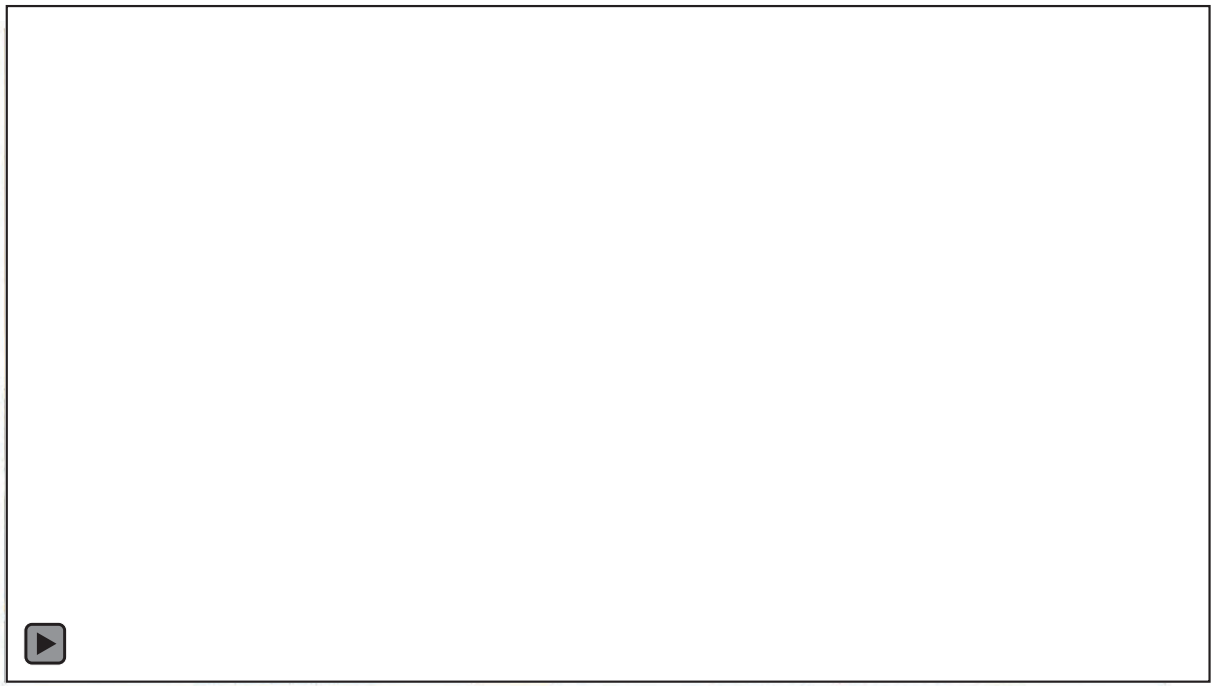
- Skills training / benefits / advancement

Retain

- Mentoring & personal development – young leaders need extra leadership training
- Create an inclusive culture – zero tolerance for harassment / eliminate negative social perceptions

Abby Pennington, Maintenance Manager, TAMKO Building Products

Where we are on the skills gap



Jack Schron Jr., President & CEO of Jergens Inc.

Blair Haas, CEO of Bud Industries

Full video available at: https://www.industryweek.com/the-economy/video/55141148/production-pulse-smaller-manufacturers-talk-about-the-economy

In Conclusion

Questions / contact info

Thomas Wilk
Editor in Chief, *Plant Services*
twilk@endeavorb2b.com