Air Leakage Detection and Characterization in Facility Assessments

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POLLUTION PREVENTION SERVICES

IOWA DNR
IOWA DEPARTMENT OF NATURAL RESOURCES

Industrial Training and Assessment Centers
U.S. DEPARTMENT OF ENERGY

Optimizing Compressed Air and Asset Reliability with Ultrasound

A roundtable webinar for the Industrial Food and Beverage Sector

February 26, 2025

University of Nebraska Lincoln

Outline

1. About NITAC
   - Self introduction
   - NITAC team
   - Department of Energy's ITAC program
   - Assessments, recommendations, tools, capabilities
2. Compressed air leakage detection
   - Technology
   - Quantification

1. About us - leadership

David Yuill

Director of NITAC

Ph.D. and P.E. in mechanical engineering

Associate Professor of Architectural Engineering

Research & teaching: thermodynamics, HVAC, energy efficiency, buildings

Bruce Dvorak

Assistant Director of NITAC

Ph.D. and P.E. in civil engineering

Professor of Civil and Environmental Engineering

Research & teaching: environmental eng., pollution prevention, sustainability

About us: Our Team

Industrial Training and Assessment Centers

Created by US Department of Commerce in 1976

Goals: help small & medium-sized manufacturers to…

Reduce energy costs; operating costs; waste

Energy usage *and* demand

Workforce development

"*Train students and help the little guy*"

Provide no-cost assessments to eligible facilities

Fully-developed protocol

Confidential

Industrial Training and Assessment Centers

37 ITACs nationally

21,650+

Manufacturers assessed

161,200+

Recommendations

141,400+

Saved on Average

Manufacturer eligibility*

- Site utility costs between $100k and $3.5M annually
- SIC code between 2000 and 3999
- Annual gross sales less than $250M
- Less than 500 employees at the plant site

* Some exceptions possible

On-site Assessment Day

- Team of 6 students & staff
- Interact with plant staff
- Bring UNL PPE and follow plant safety protocols
- Make measurements (sometimes leave dataloggers)
- Preliminary calculations

On-site Assessment Day – Tools

- Thermal Imaging Camera
- Flue Gas Combustion Analyzer
- Laser Tachometer
- Illuminance Meter
- Anemometer
- Ultrasonic Air Leak Detector
- Air Leak Acoustic Imager
- Vibration Logger
- Temperature/Humidity Loggers
- Power Logger
- Dissolved Oxygen Meter

Analysis and Report

- Assessment Recommendations
  - Have short payback periods & good certainty
  - Estimates or vendor quotes for capital upgrades
  - Calculation details included
- Other Measures
  - Savings, but not sufficient payback
  - Too uncertain/more data needed
  - Non-monetary benefits
- Multiple levels of review
  - Lead student
  - Energy engineer
  - Lead faculty
  - ITAC headquarters
- Delivered to client in about 60 days

$$P_i = Load * hp * \frac{0.746\ kW}{\eta_{pf}}$$

$$P_i = 0.75 * 40 * \frac{0.746\ kW}{0.942} = 23.8\ kW$$

Now that the input power of the replacement motor has been calculated for a partial load of 75%, the annual cost to operate the motor is calculated as follows:

$$E_{Motor} = 23.8\ kW * \frac{6{,}000\ hours}{year} = \frac{142{,}548\ kWh}{year}$$

$$C_{Motor} = 142{,}548\ kWh * \frac{\$0.027}{kWh} + 23.8\ kW * \frac{\$21.478}{kW * month} * 12\ months = \frac{\$9{,}983}{year}$$

These equations are applicable to all motors in your facility. To avoid redundancy, Table 5.4-5 shows the resulting cost for all the motors being analyzed. Table 5.4-6 shows the estimated savings of downsizing these motors.

Table 5.4-5: Summary of Replacement Motors

Replacement Motor	Hours in Operation (hours/year)	Input Power/Demand (kW)	Energy Usage (kWh/year)	Annual Cost ($/year)
40-hp Banbury Motor	6,000	23.8	142,548	$9,983
25-hp Calender motor	6,000	14.9	89,282	$6,251
30-hp Vacuum motor	6,000	18.3	109,706	$7,679
Totals	-	**57.0**	**341,536**	**$23,913**

Table 5.4-6: Estimated Savings of Downsizing Motors

Current Motor	Replacement Motor	Monthly Demand Savings (kW/month)	Energy Savings (kWh/year)	Annual Cost Savings
250-hp	40-hp	- -	22,964	$1,599
			18,773	$1,306
			6,302	$428
			48,040	**$3,333**

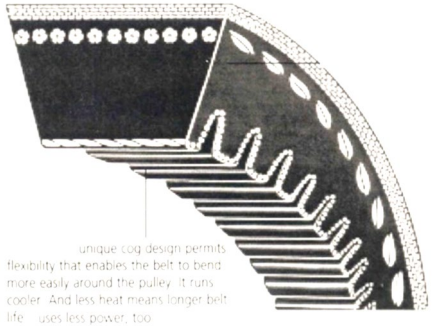
Table 1-1: Overall Summary of Assessment Recommendations

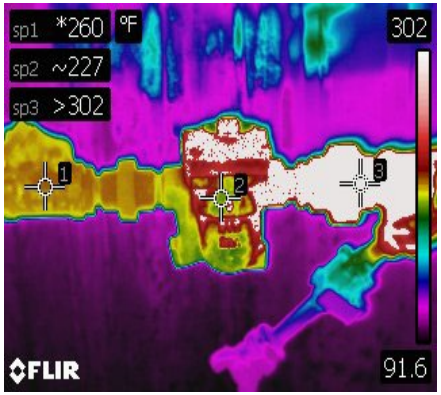
Assessment Recommendation (AR)	Annual Savings		Capital Investment	Simple Payback (Years)
	Resource (Unit/year)	Dollars ($/year)		
AR No. 1: Replace Electric Resistance Humidifier with Ultrasonic Humidifier	66,496 kWh 205.1 kW	$5,384	$20,000	3.7
AR No. 2: Upgrade Exterior Lighting	55,101 kWh 6.3 kW	$3,816	$3,372	0.9
AR No. 3: Install HVLS Fan	-	$3,717	$5,000	1.3
AR No. 4: Upgrade Main Facility Lighting	25,219 kWh 58.3 kW	$3,153	$3,266	1.0
AR No. 5: Reconfigure the Facility's Process Flow	1,001 gallons of diesel	$2,848	$9,480	3.3
AR No. 6: Install Pre-Filters in HVAC System	-	$495	$44	0.1
AR No. 7: Upgrade Facility Exit Signs	7,666 kWh 10.5 kW	$425	$2,064	4.9
AR No. 8: Reduce Air Leaks in the Distribution System	20,265 kWh	$288	$1,600	5.6
AR No. 9: Install Cool Air Intake for Compressors	6,273 kWh	$220	$525	2.4
AR No. 10: Install Occupancy Sensors to Upgraded Lighting	2,801 kWh	$98	$298	3.0
Total Sum*		**$20,545**	**$45,648**	**2.2**

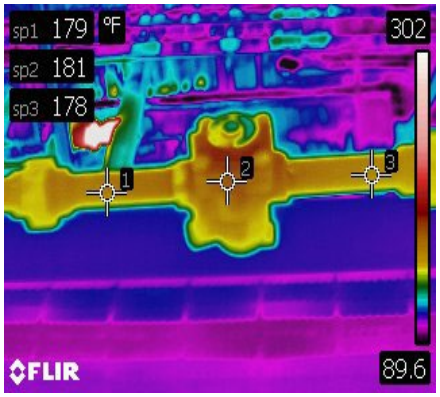
*The overall payback was calculated based on the total sum of all capital investments divided by the total sum of dollar savings from all the recommendations

Common Assessment Recommendations

- Fluorescent to LED lighting
- Compressed air management (leaks; cold air intake; etc.)
- Cogged belts
- Steam trap repairs
- Variable frequency drives
- Air economizer
- Temperature reset
- Solid waste management
- Deduct meter
- Tax, incentives, and rebates

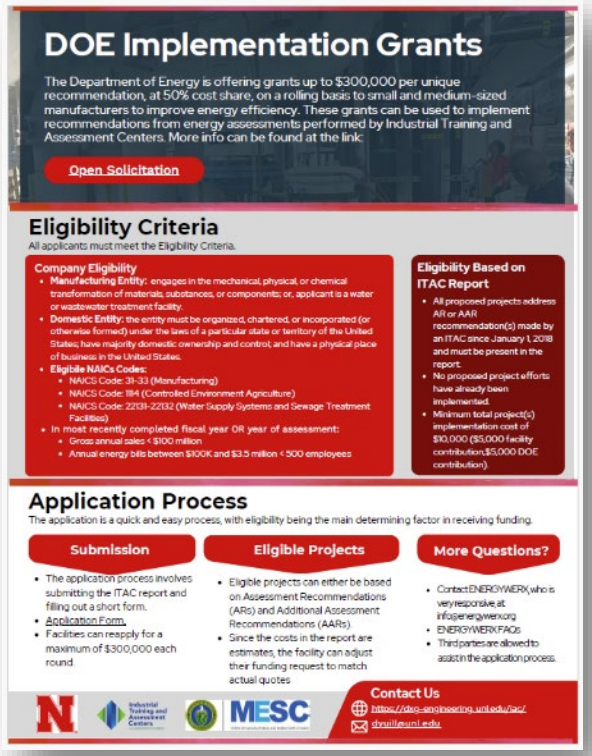






Big opportunity: Implementation Grant

- DOE program
- 1 to 1 cost match up to $300k for anything NITAC recommends
- Multiple recommendations from a single NITAC visit possible
- Very high success rate
- $350M still available
- Clients are pretty interested
- Currently on hold while they evaluate if it's "consistent with administration priorities"



2. Compressed Air Leakage

- Unavoidable
- Up to 30% of C.A. energy is lost to leaks
  - DOE: $8000/year savings
- Leakage reduction has great payback (0.4 years)
- Quarterly leak detection program (DOE)
  - Identification and tagging
  - Tracking
  - Repair
  - Verification
  - Employee involvement
- Target: 5-12% leakage, depending on facility type and size

Compressed Air Leakage - Detection

- Old-school methods
  - Listening/feeling leaks
  - Soapy water
  - Handheld directional ultrasonic detectors

- Each of these has challenges
  - Worker time!

- Recommendation – <u>ultrasonic imager</u>

Ultrasonic Imager

Pros

- Real-time visual representation of leaks
- Saves images and data for subsequent reporting & analysis
- Longer distance leak detection
- Quantifies leakage by frequency and amplitude
- Photos facilitate repair
- Easy to learn

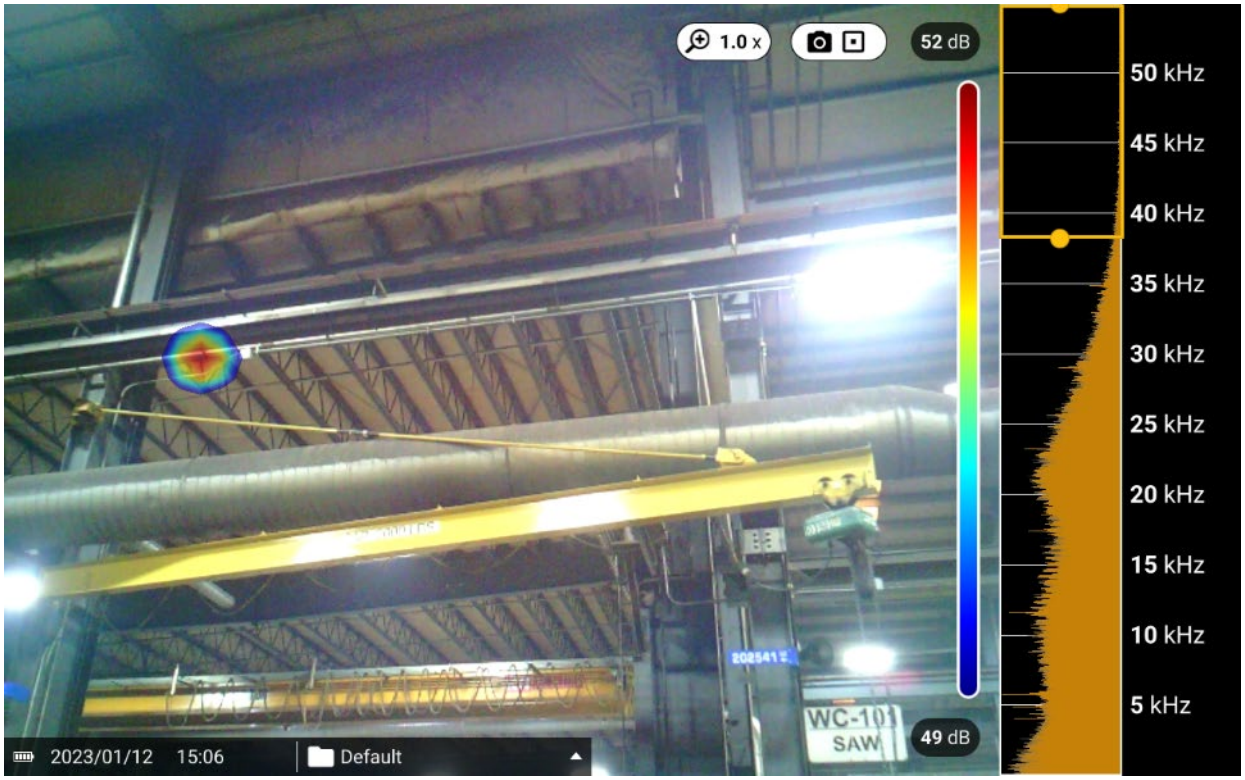
Cons

- Cost (ours was $25k)
- Rentals available
- Borrow from IA PP

Compressor Building - Air Hose Next to Valve (Start point)

Compressor Building - End point of Air Hose

Ultrasonic Imager



Leak Detection – Effort and Savings

- Case study of 11 facilities we assessed
- Usually don't scan entire facility
- Savings a function of leak rates, utility costs, operating hours, compressor specs, loading factor

Plant #	% of Facility Scanned	Plant Size (1000 ft^2)	Leak Detection Effort (hours)	# of Leaks	Cost Savings ($/yr)*
1	80%	1,700	10	240	$ 230,000
2	25%	400	2	19	$ 2,200
3	60%	134	2	42	$ 12,000
4	20%	320	2	14	$ 7,300
5	7%	500	2	8	$ 10,000
6	25%	373	1.5	20	$ 3,600
7	10%	994	1.5	24	$ 18,000
8	100%	1,400	10	119	$ 23,000
9	100%	353	10	77	$ 19,000
10	100%	294	10	32	$ 13,000
11	100%	138	10	24	$ 10,000
Average	**57%**	**601**	**6**	**56**	**$ 31,645**

***Cost savings extrapolated for plants that were not fully scanned**

Thank you!

Contact us for more information

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- (402) 554-4176
- https://engineering.unl.edu/iac/
- Or use DOE's national ITAC portal at **iac.university**