FUGITIVE EMISSIONS SUMMIT AMERICAS

2022

Strategies for Realizing and Declaring Significantly Lower Fugitive Emissions at US Facilities

TEADIT®

Sealing for a Safer and Greener Tomorrow

Robbie Riggs
Teadit North America
Vice President

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History

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- 1943: Rising Concerns Over Smog in LA
- 1953: Smog Linked to VOCs
- 1967: Clean Air Act established (CAA)
- 1977: Survey of 14 US Refineries
- 1980: Research of Chemical Plants
- 1981: Method 21 promulgated by EPA
- 1990: Research outside of USA
- 1990: CAA amended to include LDAR
- 1998: Enhanced LDAR Programs
- 2015: The Paris Agreement: Net Zero 2050
- 2019: The Climate Pledge: Net Zero 2040

Investments in Environmental

2022

- Westlake Chemical will invest $45 million in a new flare-gas recovery system in Lake Charles
- $25 million flare-gas recovery system in Calvert City, Kentucky plant.

- Valero's Port Arthur - large-scale carbon capture project back in 2013, and it continues to capture more than 1 million tons a year.
- Working to develop a large-scale carbon capture and sequestration project, with anticipated start up in late 2024.

- Marathon Petroleum signed an agreement to install five 2.3-megawatt wind turbines at MPC's renewable diesel facility in Dickinson, North Dakota.

- ExxonMobil has invested in CCUS for over 30 years, and currently has an equity share in roughly one-fifth of global carbon capture capacity and has captured approximately 40 percent of all the captured CO2 in the world.
- Low Carbon Solutions business was formed, with the business looking to advance more than 20 CCUS projects internationally.

Investments in Environmental

- In September 2021, nearly a dozen companies — including Chevron, Dow, ExxonMobil, INEOS, LyondellBasell, Marathon Petroleum, Phillips 66 and Valero — announced their interest in supporting the large-scale deployment of carbon capture and storage technology in Houston.

- Chevron invested more than $1 billion in CCUS R&D to reduce carbon emissions.
- Plans to build a bioenergy with carbon capture and sequestration (BECCS) project in Mendota, California. The plant will use agricultural biomass to produce electricity while capturing and storing the CO2 produced into the geologic formation below the facility.

- Phillips 66 introduced Emerging Energy to help build a lower-carbon sustainable business platform focusing on renewable fuels, battery value chain, carbon capture and hydrogen opportunities.

Investments in Environmental

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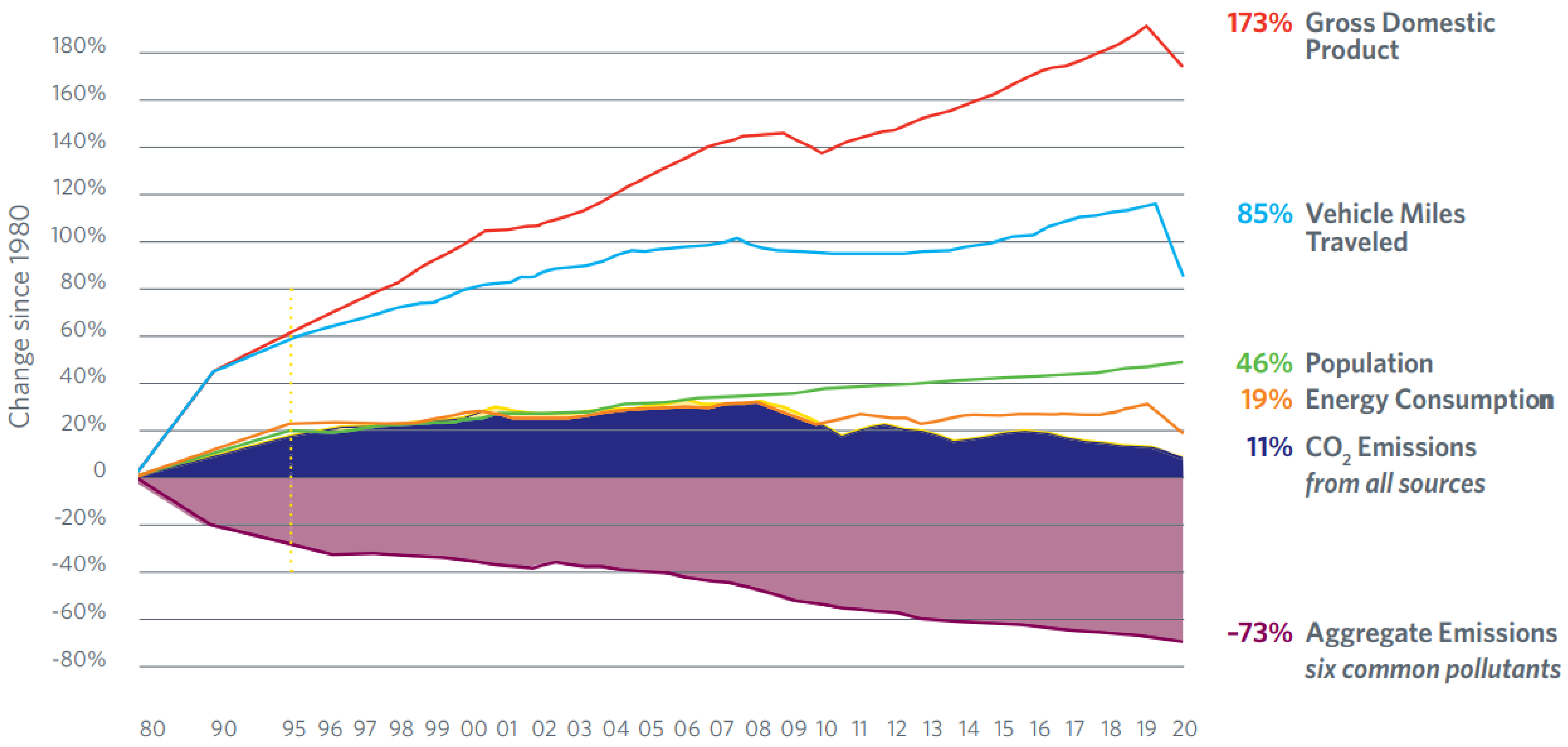
Comparing Growth and Emissions: 1980-2020



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Investing in Refineries

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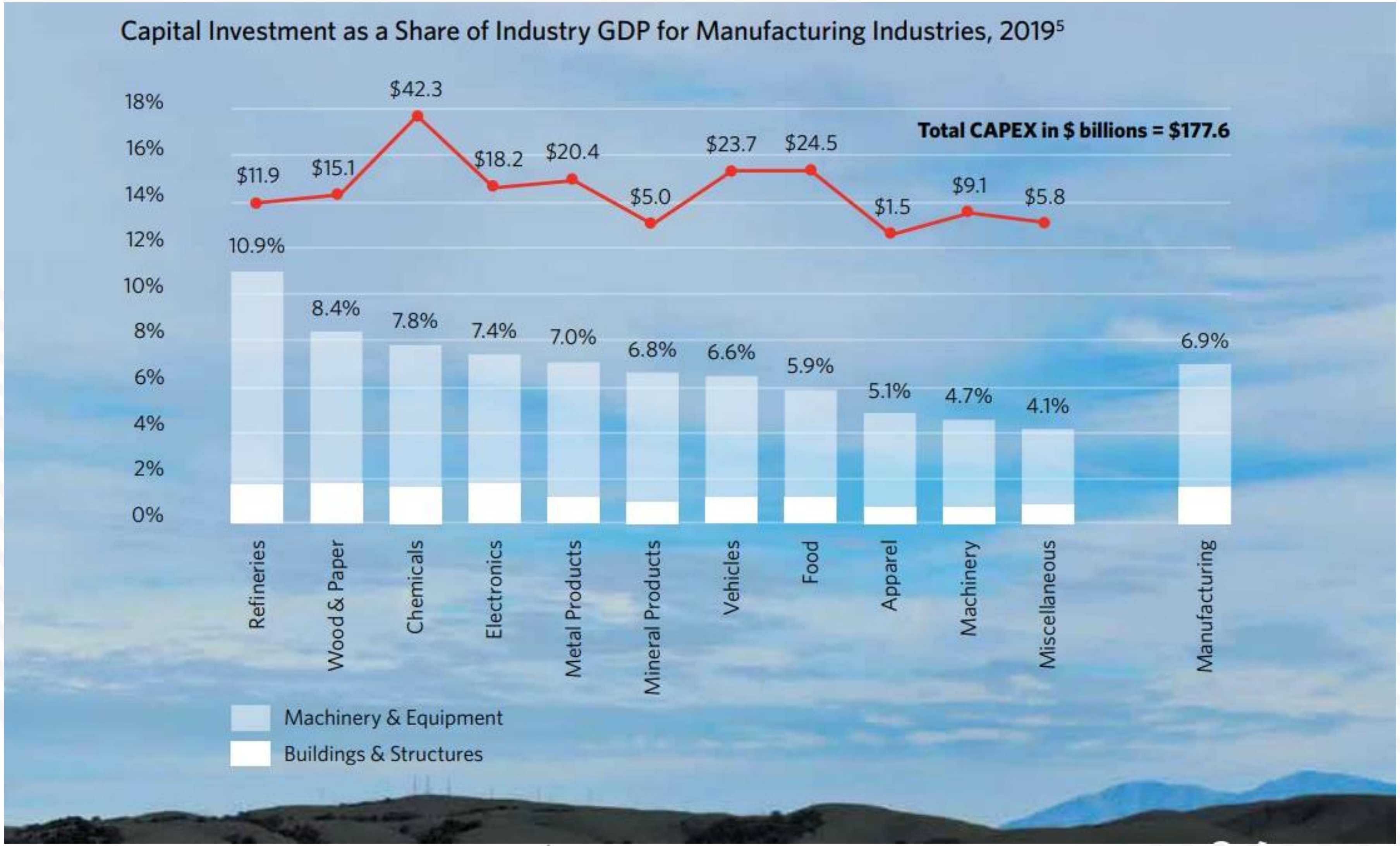

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Ethylene Demand

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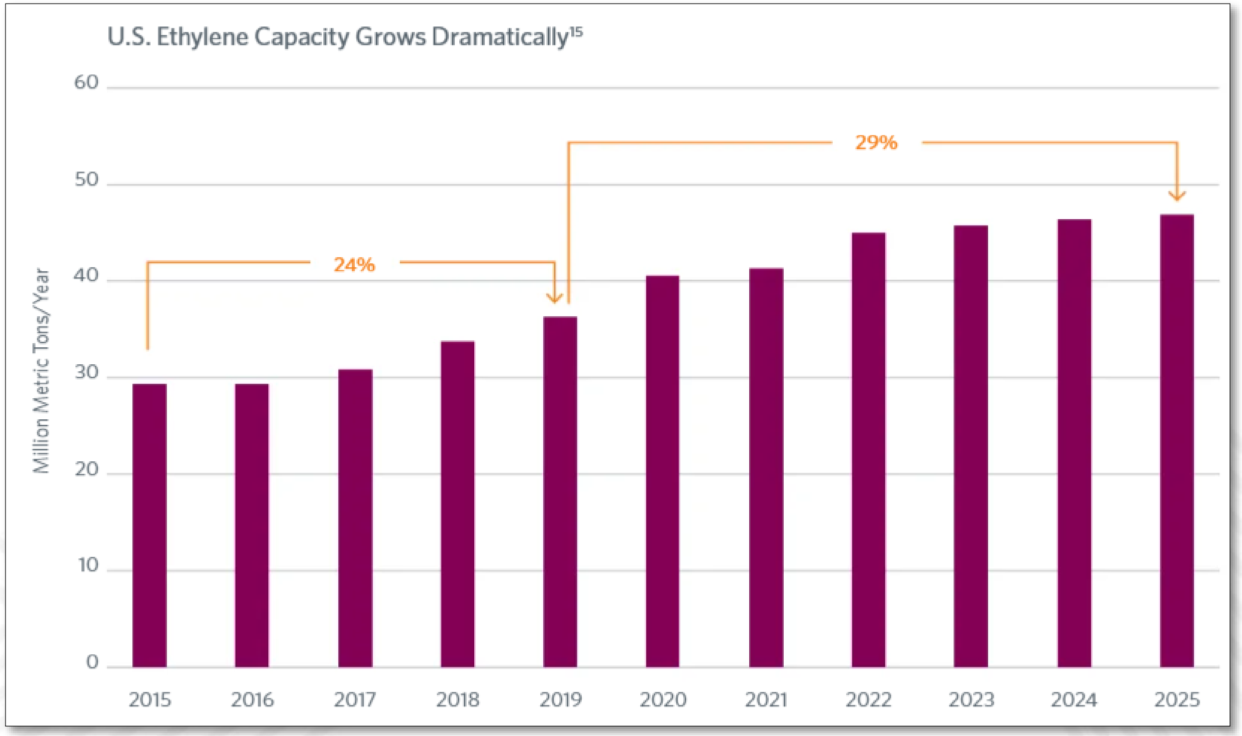

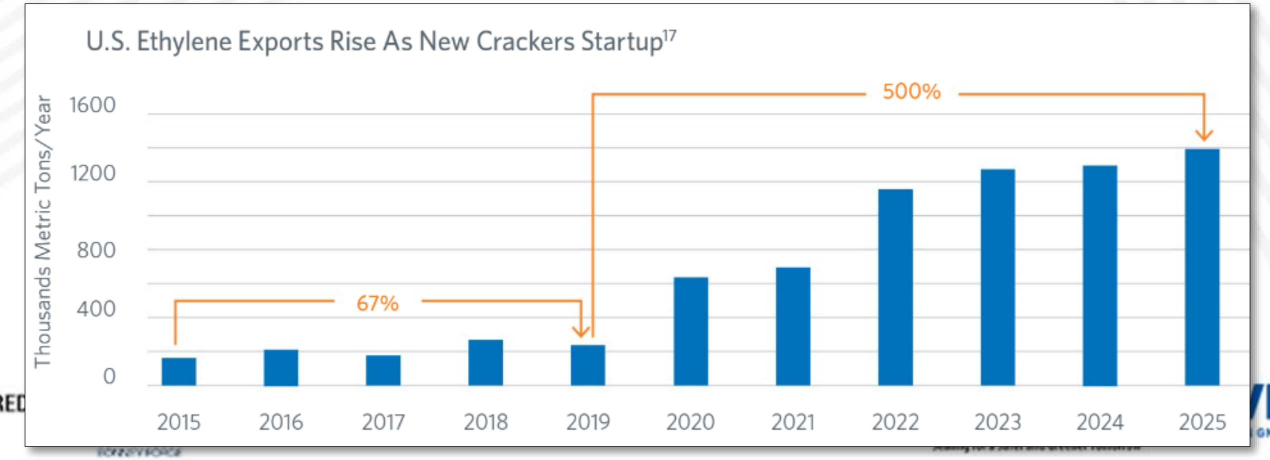

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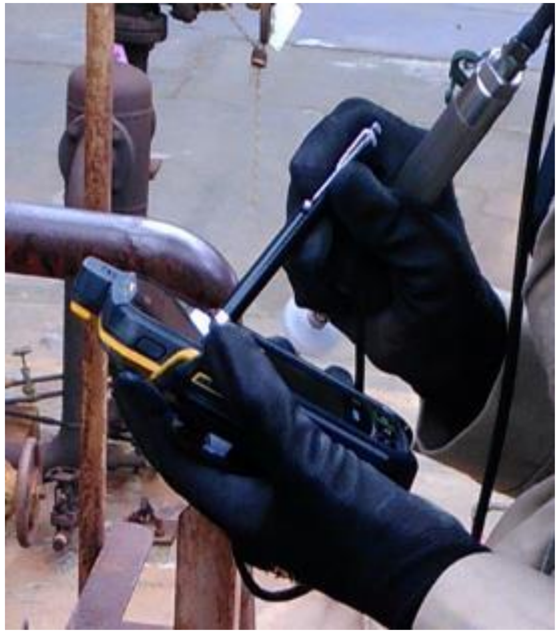
What is LDAR?

Leak Detection And Repair:
A set of requirements designed to systematically raise the quality and effectiveness of a facility’s program.



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Elements of an LDAR Program

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- Identifying Components
- ↓ Leak Definition
- ↓ Monitoring Components
- ↓ Repairing Components
- ↓ Recordkeeping

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Financial Benefits of LDAR

A good LDAR program saves money

1. Leaks mean you're **losing products** you could be selling. It might be the feedstock or the finished product, but either way your facility is leaking profits.
2. LDAR programs help prevent unintended venting of toxins, **keeping workers safe**, healthy, and on the job.
3. Long lasting leaks can start to affect the health of the **surrounding community**, leading to long-lasting reputational loss and costly litigation.
4. A carefully scheduled, executed, and documented LDAR program helps you **avoid EPA fines** for noncompliance.

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2011 Protocol: Table 2-6

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Leak Rates for Equipment Components

Equipment Type (All Services)	Default Zero Emission Rate (kg/hr/source)	Pegged Emission Rates (kg/hr/source)		Correlation Equation[b] (kg/hr/source)
		10,000 ppmv	100,000 ppmv	
Leak Rates for Petroleum Industry (Refinery, Marketing Terminals, and Oil and Gas Production)				
Valve	7.8E-06	0.064	0.14	$2.29E\text{-}06 \times SV^{0.746}$
Pump	2.4E-05	0.074	0.16	$5.03E\text{-}05 \times SV^{0.610}$
Other[c]	4.0E-06	0.073	0.11	$1.36E\text{-}05 \times SV^{0.589}$
Connector	7.5E-06	0.028	0.030	$1.53E\text{-}06 \times SV^{0.735}$
Flange	3.1E-07	0.085	0.084	$4.61E\text{-}06 \times SV^{0.703}$
Open-ended line	2.0E-06	0.030	0.079	$2.20E\text{-}06 \times SV^{0.704}$
Leak Rates for Synthetic Organic Chemical Manufacturing Industry (SOCMI)				
Gas valve	6.6E-07	0.024	0.11	$1.87E\text{-}06 \times SV^{0.873}$
Light liquid valve	4.9E-07	0.036	0.15	$6.41E\text{-}06 \times SV^{0.797}$
Light liquid pump[d]	7.5E-06	0.14	0.62	$1.90E\text{-}05 \times SV^{0.824}$
Connector	6.1E-07	0.044	0.22	$3.05E\text{-}06 \times SV^{0.885}$

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2011 Protocol: Table 2-6

Refinery and SOCMI Average Component Emission Factors

Equipment Type	Service	Refinery Emission Factor (kg/hr/source)[b]	SOCMI Emission Factor (kg/hr/source)[c]
Valves	Gas	0.0268	0.00597
	Light liquid	0.0109	0.00403
	Heavy liquid	0.00023	0.00023
Pump seals[d]	Light liquid	0.114	0.0199
	Heavy liquid	0.021	0.00862
Compressor seals	Gas	0.636	0.228
Pressure relief valves	Gas	0.16	0.104
Connectors	All	0.00025	0.00183
Open-ended lines	All	0.0023	0.0017
Sampling connections	All	0.0150	0.0150

Note: kg/hr/source = kilograms per hour per source

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Mid-Large Size Refinery

Valves
20,000

Connectors
70,000

Example: Valves

Emission Reduction Efforts	Leak Rate Method	Leak Rate per Valve (kg/year)	Total Site Valve Emissions (tons/year)
Pre-LDAR	Historical Data	22.00	**440**

Example: Connectors

Emission Reduction Efforts	Leak Rate Method	Leak Rate per Source (kg/year)	Total Site Emissions (tons/year)
Pre-LDAR	Historical Data	8.00	**560**

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Emission Reduction Summary

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Emission Reduction Efforts	Total of Valve Emissions (tons/year)	Total of Connector Emissions (tons/year)	Sum (tons/year)
Pre-LDAR	440	560	1,000
LDAR	41	153	194
ELDAR/B16.20	12	14	26
Premium Technology	1	5	6

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Savings

Emission Reduction Efforts	Total Emissions of Valves & Connectors (tons/year)	Cost of Emissions / year
Pre-LDAR	1,000	$694,000
LDAR	194	$134,636
ELDAR/B16.20	26	$18,044
Premium Technology	6	$4,164

$509 per ton in fines
$185 per ton in social cost

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Test Methods - Valve Sealing

- API 622 – valve stem packing
- API 624 – rising stem valves
- API 641 – quarter-turn valves
- ISO 15848-1
- Chevron Texaco GR-500 App. V
- Shell MESC SPE 77/312
- TA Luft / VDI 2440
- ANSI/ISA SP93.00.01
- FCI 91-1-1997

Valve Sealing: API 622

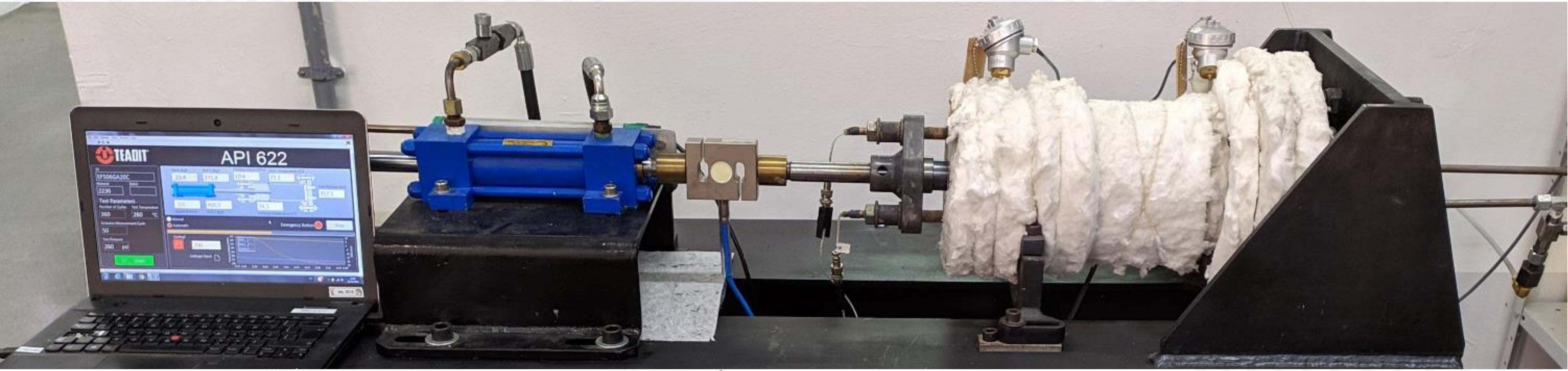
2022

Standardized Test Fixture

- Eliminates variables from valve designs
- Comparable results between packings

Test Conditions

- 1,510 mechanical cycles at 600 psig
- 5 thermal cycles at 500°F
- Methane gas
- 100 ppmv max allowable leakage
- Zero adjustments allowed



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Valve Sealing: ISO 15848-1

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Test Methods

- Global: Bagging and pulling a vacuum
- Sniffing: Local leakage measurement

Test Conditions

- Options for mechanical and thermal cycles
- Temperature: 200C (392F) and 400C (752F)
- Helium gas
- Tightness Classes:

  AH: 1.78 x 10^{-7} mbar-L/s per mm stem diameter: AM: 50 ppm

  BH: 1.78 x 10^{-6} mbar-L/s per mm stem diameter: AM: 100 ppm

  CH: 1.78 x 10^{-4} mbar-L/s per mm stem diameter: AM: 500 ppm

- On/Off Valves:

  CO1: 205 cycles, 2 thermal cycles

  CO2: 1,500 cycles, 3 thermal cycles

  CO3: 2,500 cycles, 4 thermal cycles

- Control Valves:

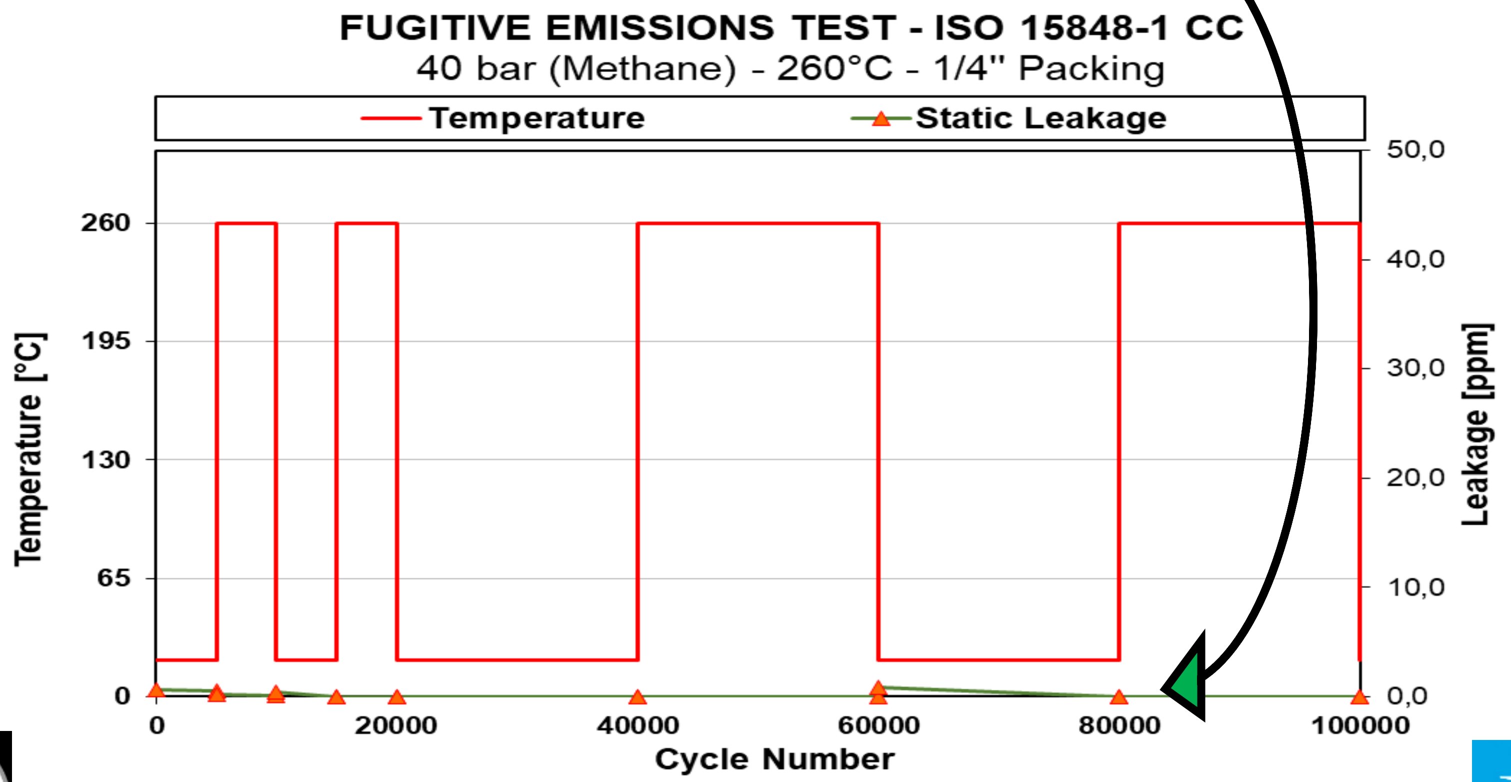
  CC1: 20,000 cycles, 2 thermal cycles

  CC2: 60,000 cycles, 3 thermal cycles

  CC3: 100,000 cycles, 4 thermal cycles

Valve Sealing: ELDAR & CLLT

Conventional LDAR	500 ppm max
Enhanced LDAR	100 ppm max
Certified Low-Leak Technology Packing	10-20 ppm
Premium CLLT Packing	< 2 ppm



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Connector Sealing:
ASME B16.20 Performance Test

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Standardized Test Fixture

- Defined max leak rate of 0.0137 mg/s.m
- Leak rate measured in ppmV

Test Conditions

- 4-hour compression test at room temp
- Methane gas
- Gasket Stress:
  - 5,000 psi for Class 150
  - 8,000 psi for Class 300
  - 10,000 psi for Class 600 & above
- Internal Pressure:
  - 290 psi for Class 150
  - 580 psi for Class 300 & above

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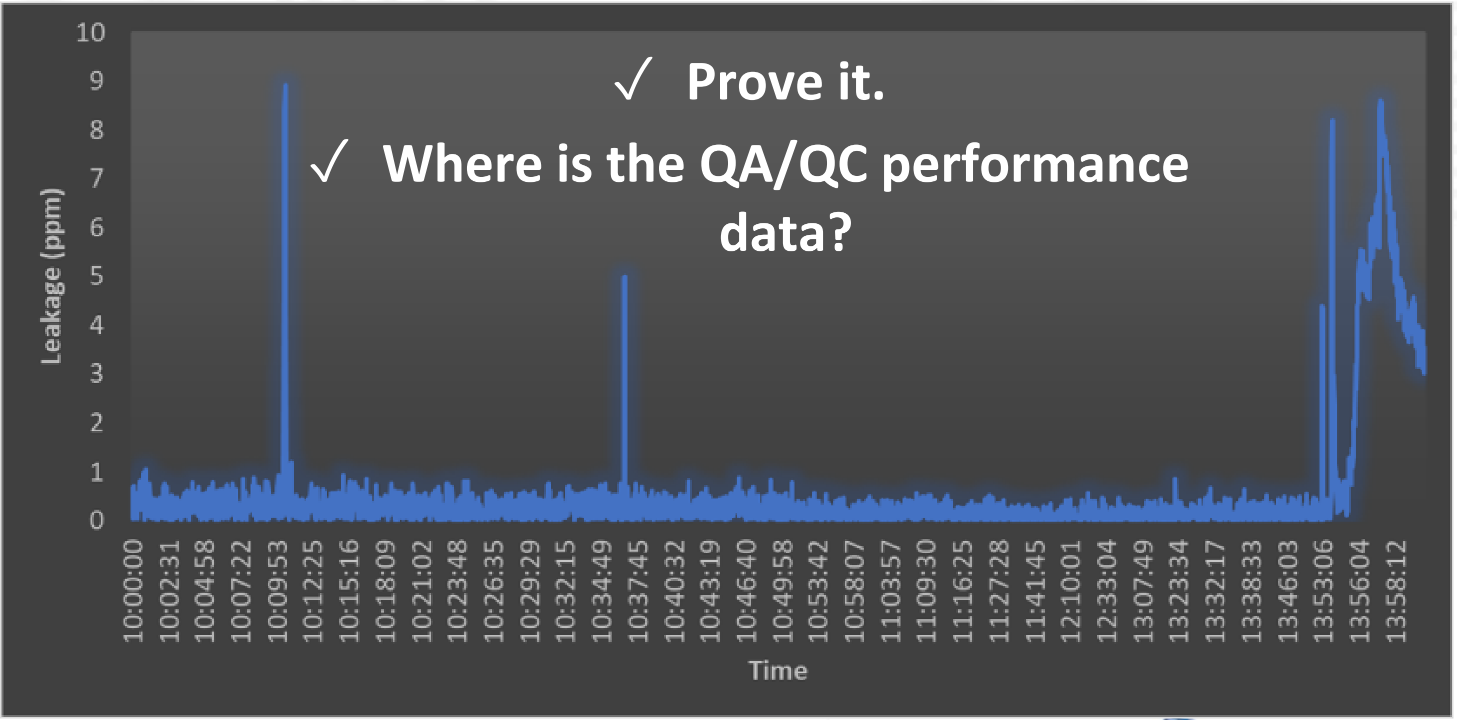
Connector Sealing:
ASME B16.20 Performance Test

2022

- ASME B16.20 = 100 ppmV
- Un-Controlled = 3X of B16.20: 300 ppmV
- Controlled & Tested = 1/3X of B16.20: 33 ppmV



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Emission Reduction Summary

The reduction of fugitive emissions can be realized and declared by implementing an LDAR Program with the best available sealing technology. Premium sealing products have been proven to significantly outperform EPA's leakage requirements and provide the site with a favorable return on investment.

Questions?