

How to Meet SWEL1 and SWEL2 Compliance with 99.999%+ DRE

PICARRO

LESNI
The Air Purification People

Figure 1: LESNI EO Catalytic Abatement Plant (EO CAP), with Picarro Continuous Emissions Monitoring System (CEMS) inset.

THE CHALLENGE:

US-based sterilization facilities using ethylene oxide (EtO, EO) must comply with the 2024 update to the “Commercial Sterilizer NESHAP” (40 CFR 63, Subpart-O) in 2026-2027. Many facilities worry that it is not possible to achieve the up to 99.99% EtO destruction removal efficiency (DRE) needed to meet the rule’s site-wide emissions limitations (SWEL). This case study, which summarizes a more detailed white paper found [here](#), demonstrates how two facilities comfortably met DRE compliance requirements using a combination of LESNI’s highly effective EO Catalytic Abatement Plants (CAPs) and Picarro’s ultra-sensitive Continuous Emissions Monitoring Systems (CEMS).

Subpart-O provides two SWEL pathways to prove compliance:

SWEL1 - EtO Usage-Based Compliance

Facilities must demonstrate compliance by comparing total EtO used (measured by drum scales) against total stack emissions (measured by CEMS), ensuring the strictest SCV emissions reductions are met.

SWEL2 - Process-Stream-Based Compliance

An alternative for facilities that may not meet SWEL1 due to site configurations. It allows facilities to meet a lower DRE for certain process streams if they monitor both in and out concentrations with a CEMS, leading to higher total site-wide emissions allowances.

For SWEL2, process-stream-specific DREs are as follows:

Process Stream	DRE
Sterilizer Chamber Vents (SCV)	99-99.99%
Aeration Room Vents (ARV)	99-99.9%
Chamber Exhaust Vents (CEV)	99-99.94%
Group 1 Pre-Aeration Fugitives	80-98%
Group 2 Post-Aeration Fugitives	80-98%

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The combination of the LESNI abatement and Picarro monitoring technology allows us to guarantee that our EO CAPs deliver well beyond the 99.99% DRE required for Subpart-O, saving our customers money and hassle in the long term.



Jan S. Hjort
CEO of Lesni

THE ABATEMENT TECHNOLOGY: LESNI EO CAP

LESNI manufactures industry-leading Catalytic Abatement Plants (CAPs) to abate ethylene oxide process streams at commercial sterilizer sites. Their near-complete removal of EtO from process gas is possible due to a carefully-crafted workflow that slows the movement of high-EtO gas from chambers via a balancer tank, using a stripper column and low-concentration process gas from other areas (aeration, CEV, Group 1, Group 2) to reduce the EtO concentration to a level where it can be abated by a highly-efficient low-temperature catalyst. A well-maintained LESNI EO CAP has no harmful byproducts to dispose of, and uses significantly less fuel than its competition due to its low operating temperature and recuperative heat cells, leading to lower cost of ownership.

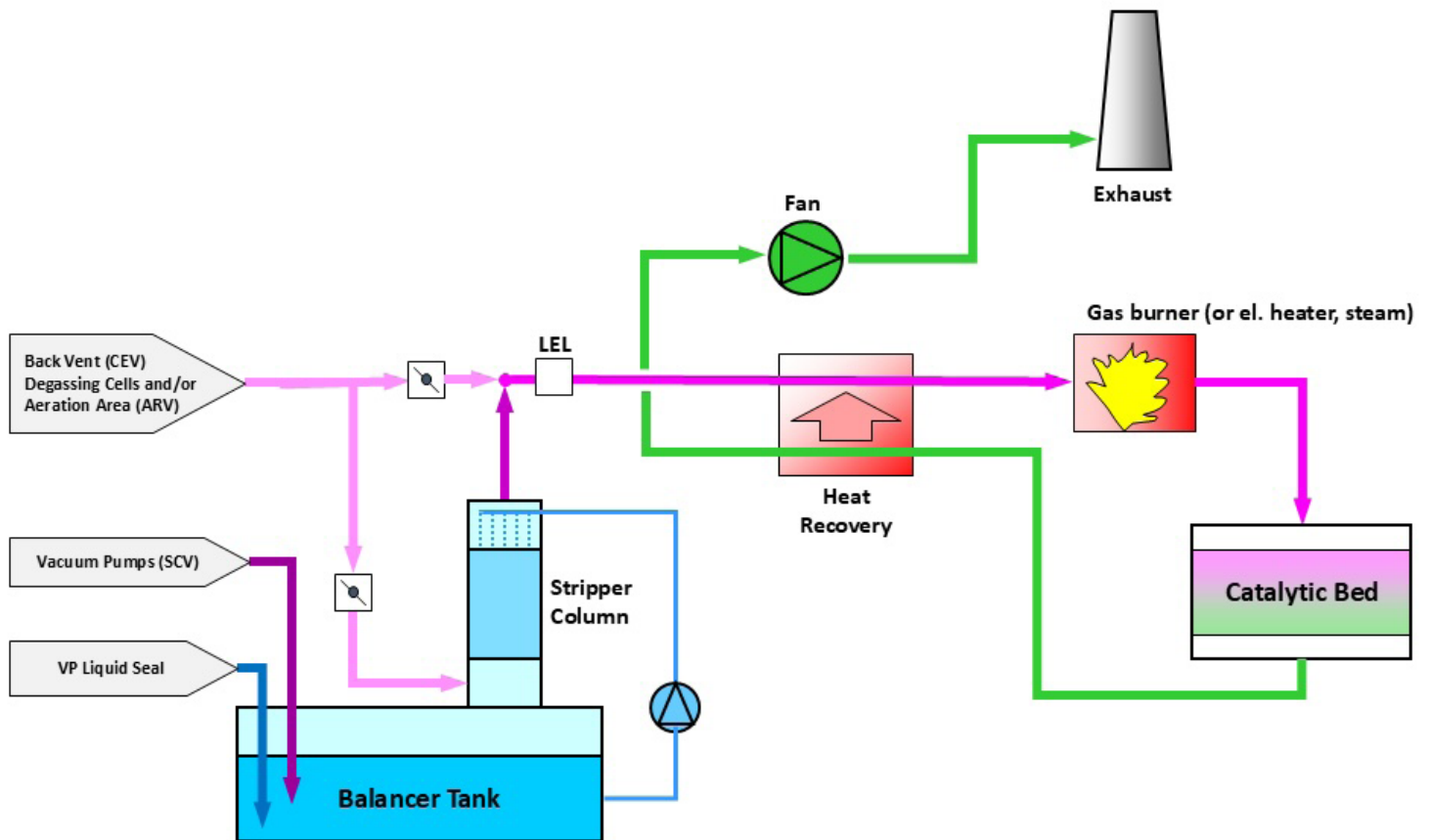


Figure 2: LESNI EO CAP process diagram.





Figure 3: The Picarro EtO CEMS, showing the cabinet itself (left middle), flow probe (left top), sample probe (right top) and heated umbilical (right middle).

THE MONITORING TECHNOLOGY: PICARRO CEMS

Picarro's CEMS for EtO is specifically designed for the commercial sterilizer setting and proactive compliance with Subpart-O. It leverages the sensitivity, selectivity, and stability of Picarro's cutting-edge technology to achieve a remarkable guaranteed lower detection limit of 0.25 ppb. This ultra-low detection limit is critical to proving the aggressive DRE required by Subpart-O, as demonstrated below.

Picarro offers a variety of CEMS configurations to match the needs of the sterilization community, and the compliance pathways offered by the Subpart-O NESHAP. It can accommodate up to four measurement points per CEMS cabinet, set up as either pure outlet measurements, or in vs out configurations for SWEL2 compliance. Its software is designed with compliance in mind, incorporating data streams from other facility components including the LESNI EO CAP, sterilizer chamber SCADAs, and Method 204 differential pressure sensors to consolidate and simplify compliance reporting. Configurable alarms allow facilities to track their SWEL DREs on an ongoing basis, and warn operators when the facility might be trending toward a non-compliant state.

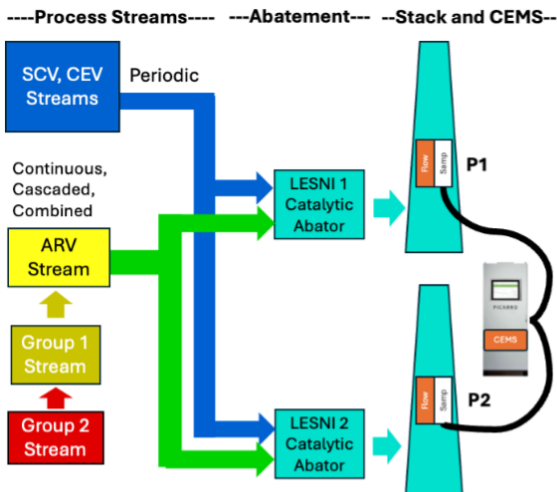


Figure 4: Simplified diagram of Facility A's abatement system, featuring a single shared Picarro CEMS-2 cabinet with sampling points designated as P1 and P2, respectively.

PROVING SWEL1 COMPLIANCE: FACILITY A

Facility A combines all process streams, sending them to two LESNI CAPs working in parallel for redundancy. Non-SCV streams dilute the EtO for the CatOx. Site leadership were considering an 8-figure facility enhancement to install dry beds to comply via a SWEL2 pathway. The LESNI CAP's efficiency, and the sensitivity and speed of the Picarro CEMS helped them prove they could comfortably comply using SWEL1 and their existing abatement setup — saving them many millions of dollars.

The LESNI CAP and Picarro CEMS proved Facility A complied using SWEL1 and their existing abatement setup – saving them many millions of dollars in unnecessary facility upgrades.

Facility A SWEL1 EtO Usage-Based Compliance	
Classifications	Highest EtO use class, legacy facility, area source
DRE Required	99.99% for all emissions, based on the applicable SCV standard
Abatement Configuration	Two LESNI CAPs
CEMS	Picarro CEMS sampling from both LESNI stacks
Monthly Average Stack EtO Concentrations	LESNI1: 0.83 ppb LESNI2: 0.84 ppb
30-Day Mass In	7011 lbs.
Allowed 30-day Emissions	0.6941 lbs.
Actual 30-Day Emissions	0.046369 lbs.
Results	LESNI DRE of 99.99935%, with emissions about 15x lower than the SWEL1 allowance.

PROVING SWEL2 COMPLIANCE: FACILITY B

Facility B combines SCV, ARV, Group 1, and CEV to a LESNI, and sends its Group 2 emissions to dry beds. Picarro's CEMS samples from the LESNI and dry bed stacks, and Group 1 and Group 2 inlets.

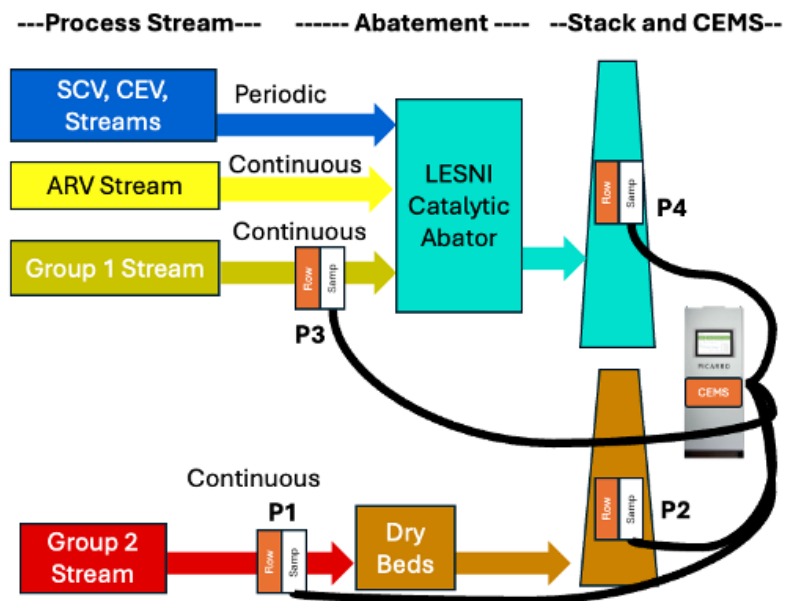


Figure 5: Simplified diagram of Facility B's abatement system using a SWEL2 pathway and a Picarro CEMS-4. Measurements are made for the dry bed stack (P2) and LESNI stack (P4), and for inlets to the Group 1 (P3) and Group 2 (P1) streams.

Facility B worked with Picarro and LESNI to answer 3 critical questions.

1. Could the facility achieve SWEL2 compliance with their current abatement configuration?
2. How much leeway would they achieve using SWEL2 over the more conservative SWEL1?
3. Could an OE-FTIR CEMS prove compliance?

With LESNI and Picarro solutions, they:

- Achieved SWEL2 compliance with a margin of about 14x, with a DRE of 99.99948%.
- Proved that SWEL2 compliance allowed them to emit about 3 lbs more EtO than they currently do, and roughly 6.4x more than the SWEL1 limit would permit.
- Learned that, lacking the appropriate level of accuracy and sensitivity, an FTIR CEMS was likely to overstate emissions by more than 20x — erroneously indicating the facility's emissions to be about 150% of the compliance limit.

Facility B Process-Stream-Based Compliance	
Classifications	Highest EtO use class, legacy facility, area source
DRE Required	98% for Group 1 and 2 streams, 99.99% for all remaining streams (SCV, CEV, ARV)
Abatement Configuration	Combines SCV, ARV, Group 1 and CEV to a LESNI, and sends its Group 2 emissions to dry beds.
CEMS	Picarro CEMS sampling from the LESNI and dry bed stacks, and Group 1 and Group 2 inlets.
Monthly Average Stack EtO Concentrations	Group 2 dry bed: 0.54 ppb LESNI: 1.03 ppb
30-Day Masses In	Group 1 In: 58 lbs. Group 2 In: 95 lbs. SCV/ARV/CEV In: 5698 lbs.
Allowed 30-day Emissions	Group 1: 1.16 lbs. Group 2: 1.90 lbs. Combined Streams: 0.57 lbs Total allowed Emissions: 3.63 lbs.*
Actual 30-Day Emissions	LESNI w/ Picarro CEMS: 0.029 LESNI w/ Picarro Group 2: 0.232 Total per Picarro: 0.261 lbs. LESNI w/ OE-FTIR: 0.422 lbs LESNI w/ OE-FTIR Group 2: 5.25 lbs Total per OE-FTIR: 5.675 lbs.**
Results	LESNI DRE: 99.99948% Dry bed DRE: 99.6% Total emissions about 14x lower than the SWEL2 allowance. OE-FTIR CEMS would likely overstate emissions by more than 20x

* See full study for explanation of why three inlet masses, but only two outlet masses are needed for the SWEL2 calculations.

** Calculated using historical OE-FTIR data. Shows that an OE-FTIR CEMS would likely overstate emissions by roughly 20x, erroneously indicating non-compliance.

The LESNI CAP and Picarro CEMS proved Facility B comfortably complied with SWEL2 – and saved them from massively overstating EtO emissions, and possibly paying high fines or shutting down operations.

THE RESULTS

Using their existing LESNI CAPs and data from Picarro's CEMS, two facilities in the United States proved they could satisfy SWEL1 and SWEL2 compliance pathways by very comfortable margins. Data from Picarro's CEMS showed remarkably low EtO concentrations on the order of 1 ppb at the outlet of the LESNI CAPs, corresponding to destruction removal efficiencies of 99.99934% and 99.99948%, respectively, roughly 15 times better than the most stringent Subpart-O NESHAP requirements. The low outlet concentrations observed on the LESNI EO CAPs by Picarro's CEMS are a reminder that sensitivity is key in proving the aggressive compliance DREs required by Subpart-O.

The benefits to the facilities were significant:

- Facility A achieved SWEL1 compliance comfortably with LESNI CAPs and Picarro CEMS, eliminating the need for an 8-figure dry bed investment.
- Facility B achieved SWEL2 compliance easily, and found that it gave them a roughly 6x larger emissions margin than SWEL1 would.
- Legacy OE-FTIR systems could have overestimated emissions by 20x, falsely suggesting non-compliance.

CONCLUSION

Compliance deadlines for the Subpart-O NESHAP are looming, and designing and installing appropriate abatement systems takes time. Commercial sterilizers should move aggressively and immediately to shore up their abatement performance and monitoring. Having been proven to meeting stringent regulatory demands, the combination of LESNI's EO CAP and Picarro's CEMS is the ideal solution. Together, these companies provide key tools and expertise necessary for reliable, scalable, compliant EtO emissions management.

LEARN MORE

For more information on these case studies, download the detailed white paper, "Guaranteeing Subpart-O EtO SWEL1 and SWEL2 Compliance with LESNI EO CAPS and Picarro CEMS" from www.picarro.com/LesniPicarroWP2.

CONTACT US

Learn how Picarro and LESNI can support your compliance goals. Contact Picarro for a consultation and explore tailored technology and service solutions for your facility at eto@picarro.com. Contact LESNI for more information on their advanced CAPs systems at sales@lesni.com.

COMPANY PROFILES

LESNI A/S

LESNI provides innovative solutions for waste air purification, targeting removal and depletion of irritating odor emissions, toxic gases, solvents, dust and aggressive gases. For nearly 40 years LESNI has designed, supplied and installed more than 1,000 air purification plants throughout Europe, America, Asia and Australia. LESNI systems are designed to customer specifications and engineered to meet local and international standards.

PICARRO

Picarro specializes in regulatory expertise, world-class service and support, and advanced EtO monitoring systems that deliver trusted data. This unique suite of EtO emissions management services and solutions allows sterilization facility operators to focus on their business while Picarro focuses on comfortably meeting and maintaining EtO emissions compliance.