



DILO Armaturen und Anlagen GmbH - Germany

The future of SF₆ gas: advantages of the SF₆ gas reconditioning and outlook into the future with alternative insulating gases



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Agenda

- Introduction of DILO Germany
- General Information about SF₆
- DILO product portfolio
- New F-gas regulation
- SF₆-reconditioning
- Outlook on the alternative insulating gases



DILO at a glance

- 75 years of experience
- >450 skilled employees
- World market- and technology leader in gas handling
- > 81% export rate
- Full service supplier in gas handling- and measuring devices as well as gas reconditioning
- Headquarter and production in Babenhausen/Germany (small production and calibration at DILO Asia-Pacific (Singapore))



→ DILO's partner in Hungary: MaxiCont Kft.



DILO. 75-Years of success

1951

Foundation of DILO-Gesellschaft Drexler & Co. KG in Augsburg



1967

Entry into SF₆ technology; delivery of the first piping system for SF₆ gas insulated switchgear

1972

Manufacture of the first DILO service cart



1984

Production of SF₆ measuring instruments



2009

Authorization as certified training company acc. to EU regulation on fluorinated gases



1961

Relocation to Babenhausen; manufacture of high-pressure tube unions for pressures up to 1,000 bar

1970

Market launch of the new product group "DILO valves and accessories for SF₆"



1982

Development of dry-running compressors

1998/99

Development of service carts B120 Economy Series and B2000 Mega Series



DILO. 75-Years of success

2014

The newly established service center DILO Asia-Pacific Pte. Ltd. starts operation in Singapore



2017

DILO training center offers a perfect ambience for efficient knowledge transfer



2019

Launch of the new product and service lines and roll out of the new company corporate design



ONE VISION. ZERO EMISSIONS.



2012

Market launch of SF₆ leak testing units

2016

Development of service and measuring devices for the handling of Alternative Gases (SF₆ gas substitutes)



2018

Development of the complete product line for Alternative Gases (e.g. C4 and C5)



DILO. 75-Years of success

2019

Laboratory for gas chromatographic and FT-IR spectroscopic analyses



2021

New generation of G057 with intuitive HMI and new design



MultiAnalyser V2 with intuitive HMI for Alternative Gases



2022

New generation of G170 with intuitive HMI and new design



2022

Launch of the MirrorAnalyser^{CA}



ONE VISION. ZERO EMISSIONS.

2019

Mixing & Separation of alternative gases (C4-FN, C5-FK, ...)



2020

MultiAnalyser V2 with intuitive HMI



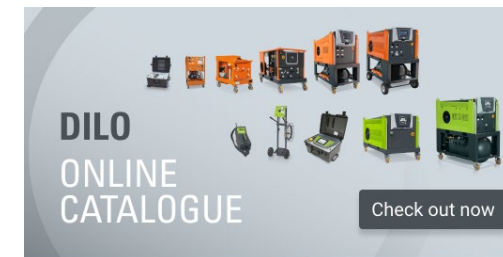
2022

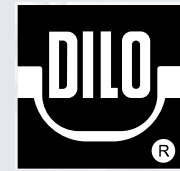
Launch of:



2022

Launch of the DILO Online catalogue



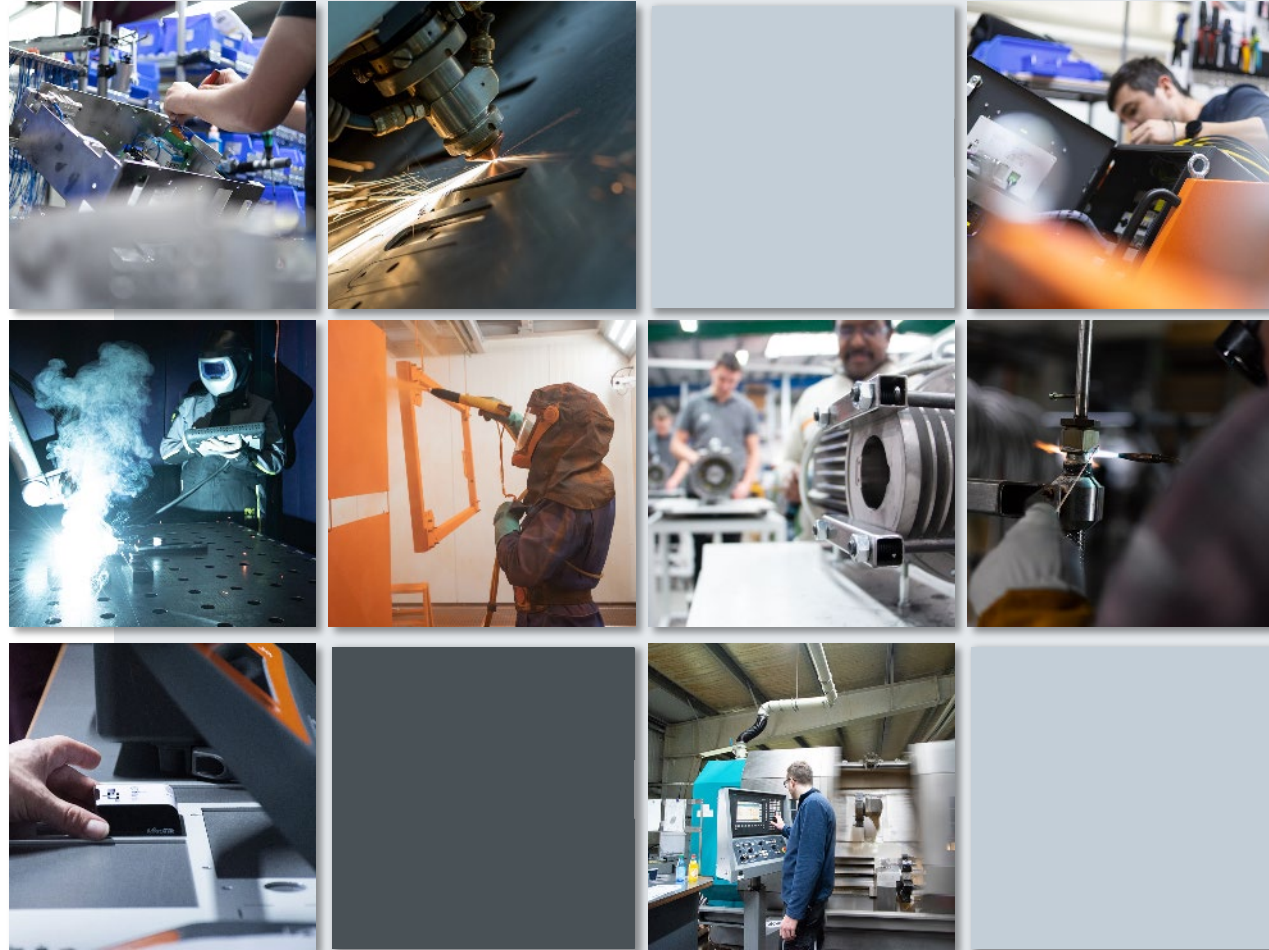


75%

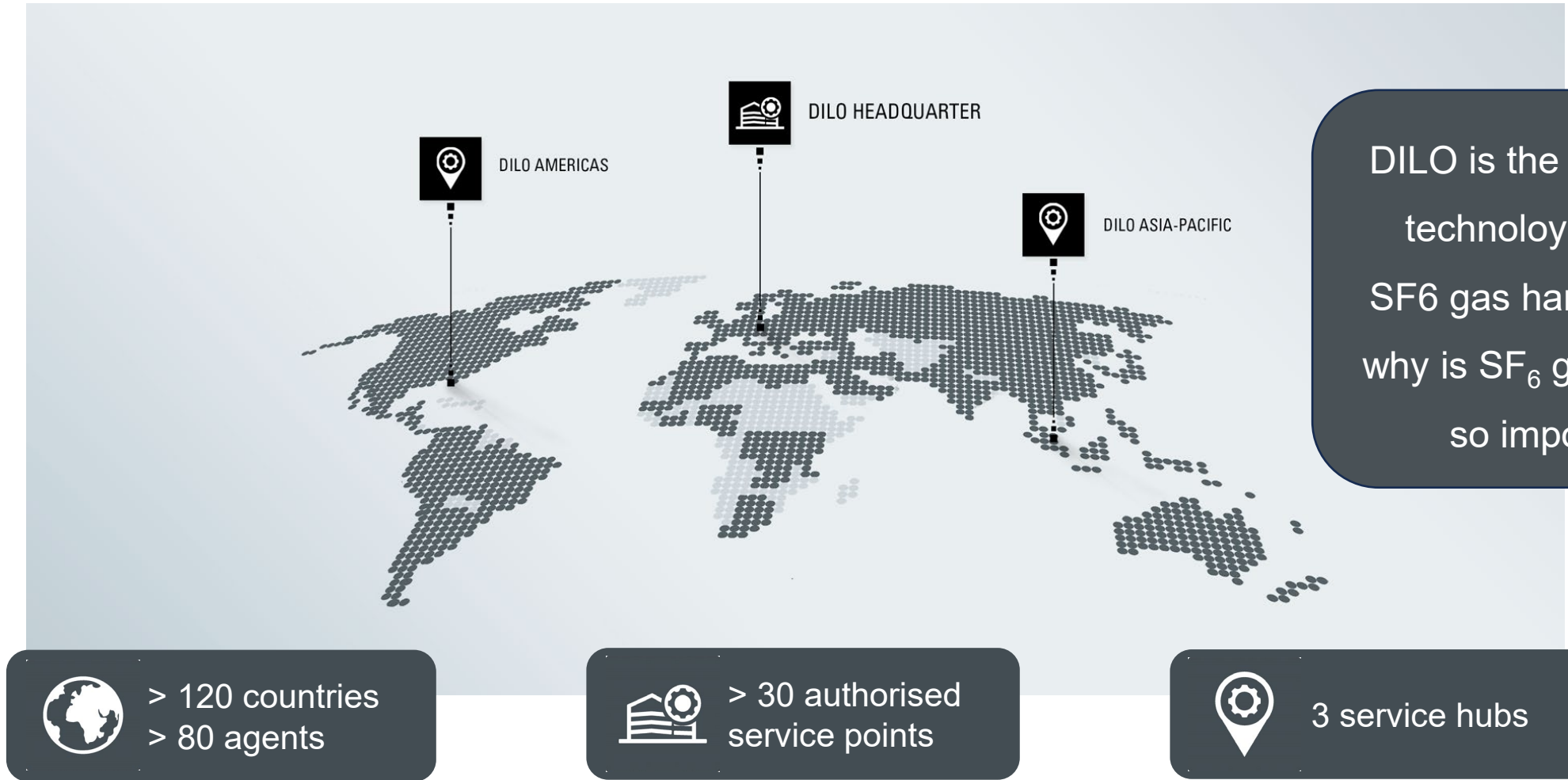
IN-HOUSE PRODUCTION

allow us to remain flexible and to constantly redefine quality standards ourselves.

**The best brains.
All from a single source.**



DILO. How we support our customers



DILO is the market and technology leader in SF₆ gas handling – but why is SF₆ gas handling so important?

Characteristics of SF₆ gas

Positive characteristics of SF₆ gas

- Enables closed and compact design of electrical equipment
- Insensitive to environmental influences (moisture, sand, salt...)
- High personal safety
- Low maintenance efforts
- High reliability
- Space saving (conventional versus SF₆ technology = 5:1)
- Three to four times higher switching performance compared to oil or air insulated switchgear



By using SF₆ gas it is possible to build electrical switchgear in a more compact way and featuring a higher switching performance than oil or air insulated modules.

Due to its outstanding properties SF₆ gas is globally used in electric power engineering.

Characteristics of SF₆ gas

Essential to know

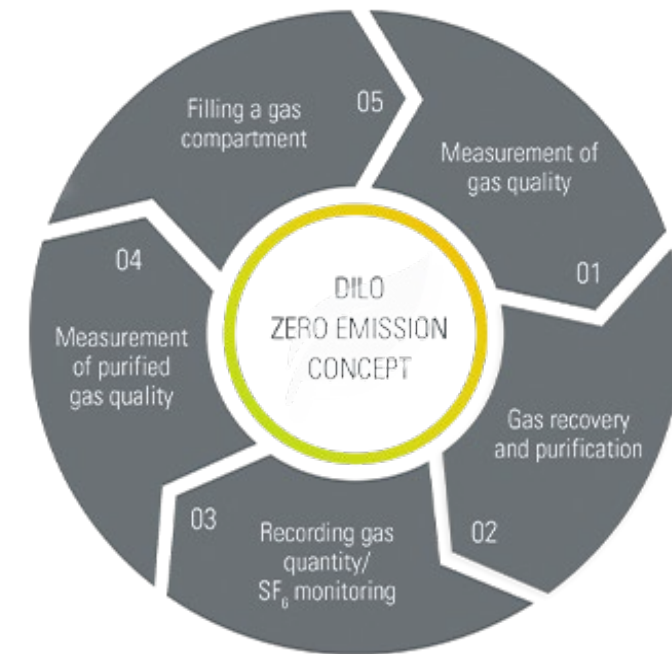
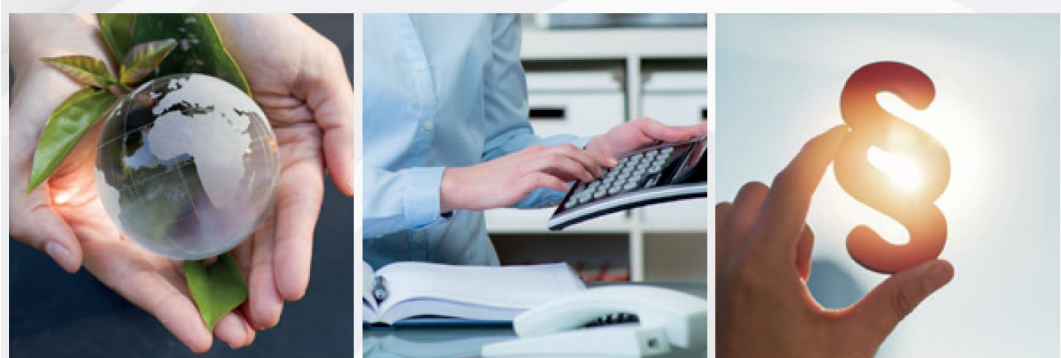
- SF₆ is a potent greenhouse gas with a Global Warming Potential (GWP₁₀₀) of 25,200* CO₂e
- The lifetime in the atmosphere is around 3,200 years.
- The gas is colourless and odourless and, therefore, goes unnoticed.
- It displaces the air and thus the oxygen required for breathing.
- Because it is heavier than air, it can accumulate on the ground and in areas below ground level, where it creates a suffocation hazard.



SF₆ re-use and Zero Emission

So, SF₆ gas handling and keeping it in a closed circle is important for

- Environmental protection
- Less expenditure for SF₆ gas
- Compliance with regulations (IEC 60480; IEC 60376; IEC 62271-4)



Product portfolio of DILO – Service carts

Product series

- Micro series
- Mini series
- Piccolo series
- Compact series
- Economy series
- EconomyReclaimer
- Mega series
- MegaReclaimer

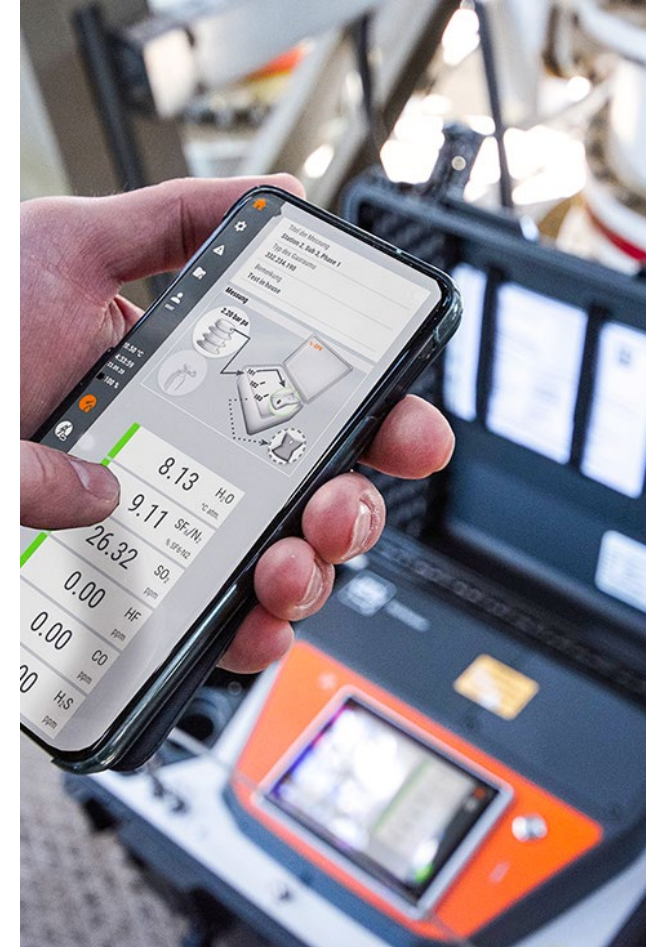
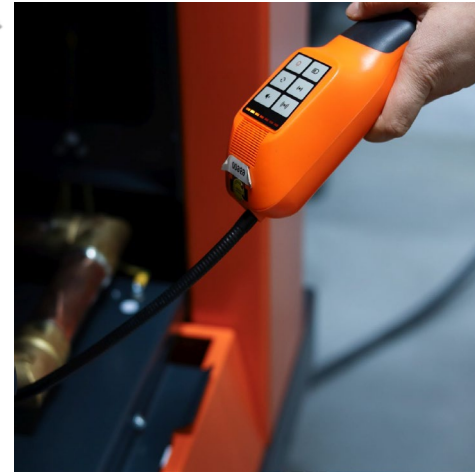


DILO SF₆-Gas Servicegerät



Product portfolio of DILO – measuring devices

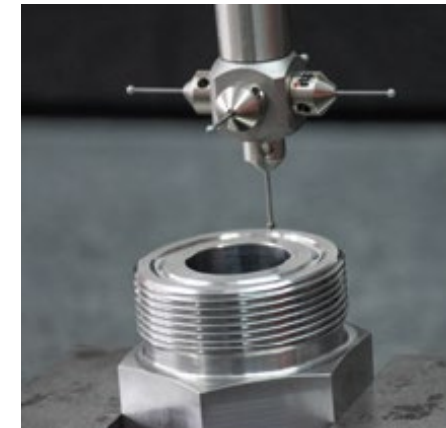
- LeakSpy
- Multi-Analyser
- Mirror-Analyser
- EcoAnalyser
- LeakPointer
- Room monitoring
 - GasSafetyMonitor
 - Sensors



Product portfolio of DILO - High Pressure products

Our High-Pressure product range:

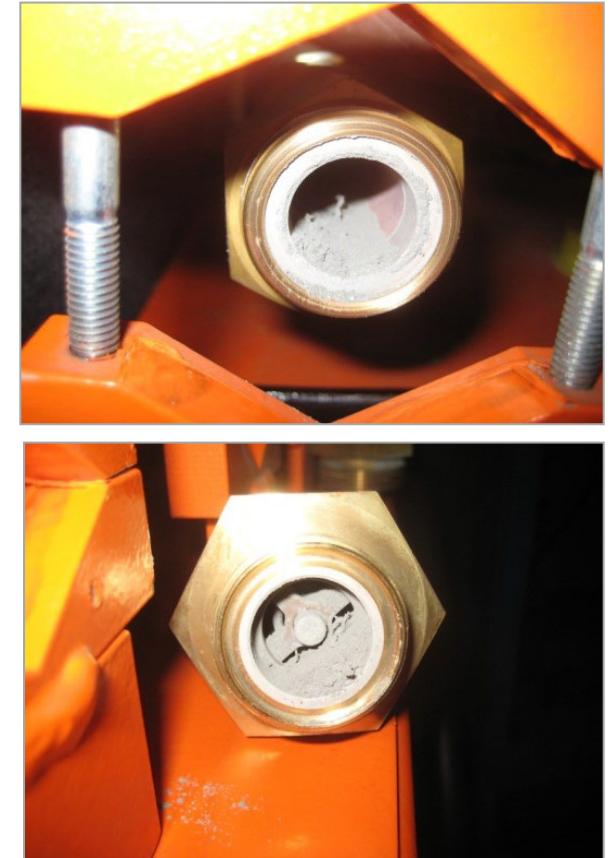
- Up to 1000 bar
- From -200°C up to 650°C
- Weld-on tube unions
- Screw-in tube unions
- Special H₂ certification for automotive application
- Throttle-free swivel screw unions
- Gauge connection unions
- Blanking discs
- Manual blocking valves
- Non-return valves
- Superheated steam unions
- High pressure hoses



- 9. The putting into operation of the following electrical switchgear using, or whose functioning relies upon, fluorinated greenhouse gases in insulating or breaking medium shall be prohibited as follows:
 - (a) from 1 January 2026, medium voltage electrical switchgear for primary and secondary distribution up to and including 24 kV;
 - (b) from 1 January 2030, medium voltage electrical switchgear for primary and secondary distribution from more than 24 kV up to and including 52 kV;
 - (c) from 1 January 2028, high voltage electrical switchgear from 52 kV up to and including 145 kV and up to and including 50 kA short circuit current, with a global warming potential of 1 or more;
 - (d) from 1 January 2032, high voltage electrical switchgear of more than 145 kV or more than 50 kA short circuit current, with a global warming potential of 1 or more.
- - (22) *In order to limit the need for the production of virgin sulphur hexafluoride (SF₆), the capacity for reclamation of SF₆ from existing equipment should be increased. Without endangering the safe functioning of the electrical grids and power plants, the use of virgin SF₆ in electrical switchgear should be avoided where it is technically feasible to use reclaimed or recycled SF₆ and it is available.*

SF₆ gas reconditioning – why is it necessary?

- Root cause for SF₆ exchange:
 - The technical quality of the gas is no longer given:
Low level of purity
 - During arc quenching and all electrical discharges, the SF₆ gas gets decomposed, and the arising decomposition products react with the electrodes or the surfaces of the inner components.
- Build-up of gaseous and solid decomposition products
- SF₆ can be contaminated with air, nitrogen and / or tetrafluoromethane (CF₄), oil, or other components
 - Maintenance must be carried out on the GIE
 - The GIE will be replaced / shut down / dismantled



SF₆ Reconditioning with a separation plant

Solution:

- Usage of a DILO Separation plant

Process steps on-site:

1. Measure the SF₆ quality
2. Recovery of the complete SF₆
3. Store the gas in transportation vessels

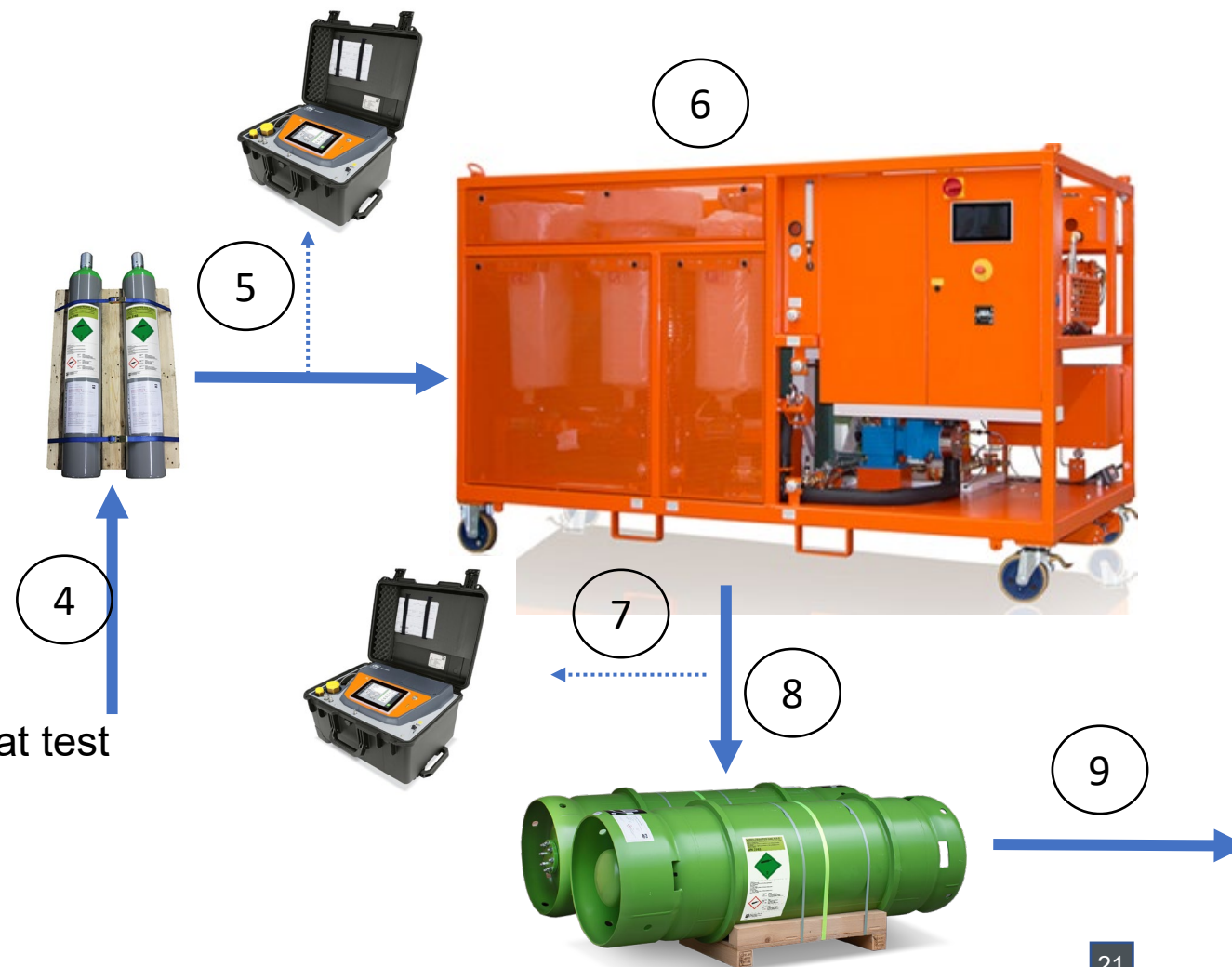


SF₆ Reconditioning with a separation plant

4. Transport the gas to the separation plant
5. Measure the gas quality before separation
6. Carry out the SF₆ treatment
7. Measure the gas quality after separation
8. Fill the processed gas into transport vessels
9. Transport back to the GIE

Advantages:

- Service instead of
 - disposal of used SF₆
 - production of new SF₆
- In accordance to the ecological (and legal) goal of waste prevention
- Improved carbon footprint through reuse
- Combination with other services, e.g. TÜV repeat test of pressure tanks is possible



SF₆ reconditioning – qualities after treatment

Thanks to the interaction between multiple DILO treatment units, even extremely poor SF₆ gas qualities can be reconditioned to 99.9% purity.

This not only exceeds reuse standards, but DILO Certified Gas even exceeds the relevant specifications for new gas when using in electrical equipment.

- Quality levels after reconditioning compared to EC standard and specifications from the manufacturer for new gas:

| Substance | DILO quality "Certified Gas" | EC 60376:2018* (New gas) |
|-------------------------------|------------------------------|--------------------------|
| SF ₆ | > 99.9 vol.-% (> 99.99 wt%) | > 98.5 vol.-% |
| H ₂ S | 8 µl/l | < 200 µl/l |
| Frost point (100 kPa) | -62 °C | -36 °C |
| Total acidity (HF equivalent) | < 0.1 µl/l | < 7 µl/l |
| Air | < 500 µl/l | < 10.000 µl/l |
| CF ₄ | < 500 µl/l | < 4,000 µl/l |
| Oil mist | < 1 mg/kg | < 10 mg/kg |
| SO ₂ | < 0.1 µl/l | – |

DILO Certified Gas - Laboratory

Analytical services: DILO LABORATORY

- The DILO laboratory offers a wide range of gas chromatographic and FT-IR spectroscopic analyses of SF₆ and by/decomposition products
- as well as alternative gas mixtures based on 3M™ Novec™ 4710 (C4-FN).
- We also offer analysis for a wide range of other gases.



Labelling and documents

- Reconditioned gas is labelled in the same way as new gas (UN1080)
- DILO is a Certified Waste Management Company



UN1080
SCHWEFELHEXAFLUORID



Product data sheet Sulphur hexafluoride 3.0

Complies with the IEC 60376 standards,
ASTM D2472-15 and GB/T 12022/2006

Version: 16.08.2018

| | | | |
|-----------------------------|-------------------------------------|-------------------------------|--|
| Purity: | 99.9 vol.-% | | |
| Gas impurities: | Air | ≤ 500 ppm _v | |
| | CF ₄ | ≤ 500 ppm _v | |
| | H ₂ O | ≤ 8 ppm _v | |
| | Oil mist | < 1 mg·m ⁻³ | |
| Physical properties: | Gas liquefied under pressure | | |
| | AGW value | 1000 ml·m ⁻³ (ppm) | |
| | Molar mass | 146.05 g·mol | |
| | Density (273.15 K) | 6.6 kg·m ⁻³ | |
| | Critical point temperature | 318.70 K | |
| | Critical point pressure | 37.6 bar | |
| | Critical point density | 736 kg·m ⁻³ | |
| | Asphyxiating in high concentrations | | |

Delivery types:

| Volume [L] | Filling quantity [kg] | Vapour pressure at 20 °C [bar] | Product number |
|----------------|-----------------------|--------------------------------|----------------|
| Steel cylinder | | | |
| 10 | 10 | 21.1 | 05-1144-R001 |
| 20 | 20 | 21.1 | 05-1144-R002 |
| 40 | 40 | 21.1 | 05-1144-R004 |
| Steel tank | | | |
| 600 | 600 | 21.1 | 05-1144-R006 |

| | | |
|-------------------------------|-----------------------------|--------------------------------|
| Transport information: | UN number | 1080 |
| | UN shipping name | SULPHUR HEXAFLUORIDE |
| Labelling: | Colour of cylinder shoulder | Shining green (RAL 6018) |
| | Cylinder body | Grey (RAL 7037) |
| | Valve connection | DIN 477 No. 6 (W 21.80 x 1/14) |

Applications: As quenching and insulating gas in medium and high voltage switchgear
Research & development
Metallurgy

Disclaimer of liability: All information in this document corresponds to the current state of knowledge. We cannot assume any liability or guarantee for the completeness or correctness of the data. Suitable occupational health and safety measures must be taken to ensure that the appropriate measures for exposure at the workplace can be adhered to and that the negative effects on health can be avoided.

Alternative Insulating gases



Overview of Alternative Gases



Brand name of GE → g³
Brand name of HITACHI → EconIQ™



Other companies using other brand names

Overview of Alternative Gases

AirPlus™

Brand name of ABB

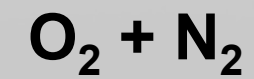
C5-FK + O₂ + N₂ for MV GIS
(C₅F₁₀O)

Other companies using other brand names

Overview of Alternative Gases

Clean Air

Brand name of SIEMENS



Other companies using other brand names

DILO product lines for Alternative Gases

| PRODUCT LINES C4 | C5 | CA |
|---------------------------------|----------------------------------|---------------------------------|
| C4-FN | C5-FK | Synthetic Air |
| 3M™ Novec™ 4710*) | 3M™ Novec™ 5110*) | Compressed Air |
| C ₄ F ₇ N | C ₅ F ₁₀ O | N ₂ , O ₂ |

Handling – differences compared to SF₆

SF₆



Alternative Gases



Different components

- Compressor for higher pressures
- Different filter material
- Sealing material resistant to the gas mixture
- Handling of 3 substances, not just one gas

SF₆ equipment cannot be used for handling of Alternative Gases!

Service carts for Alternative Gases

Mini-Series C4/C5



C4 or C5-B095R12 / C4 or C5-B093R30
for C4-FN / C5-FK

- **Recovery and filling**
- Gaseous storage (25 bar)
- Filling from cylinder with gaseous storage
- Final vacuum recovery < 5 mbar
- For small gas volumes (MV)
- Coupling DN8 (C4 = M28 / C5 = M24 thread)

Economy-Series C4/C5 Mega-Series C4/C5



C4 or C5-G057R01 for C4-FN / C5-FK
C4 or C5-G170R01 for C4-FN / C5-FK

- **Recovery, filling and evacuation**
- Gaseous and liquid storage (up to 100 bar)
- Temperature controlled filling from bottles for liquefied gas mixture
- Final vacuum recovery < 1 mbar
- For HV gas volumes
- Coupling DN20 (C4 = M48 / C5 = M43 thread / DN40 M78x2 (Mega-Series only)
- 600 or 1,000 Ltr. integrated buffer tank
- Material brass or stainless steel

EconomyReclaimer C4/C5 MegaReclaimer C4/C5



C4 or C5-G057R51 for C4-FN / C5-FK
C4 or C5-G170R51 for C4-FN / C5-FK

- **Recovery only**
- Gaseous and liquid storage (up to 100 bar)
- Final vacuum recovery < 1 mbar
- Coupling DN20 (C4 = M48 / C5 = M43 thread)
- Coupling DN40 (C4 = M78x2 MegaReclaimer only)

Accessories

- **Precision gauge with hose C4-3-558-R001**

with coupling tongue part DN8 and DN20
(M48x2, M28x1,5)



- **Digital vacuum gauge C4-Z619R01**

with coupling tongue part DN8 and DN20
(M48x2, M28x1,5)



- **Pre-filter unit (pe 50 bar) C4-B077R20**



- **Pre-filter unit (pe 50 bar) C4-B077R22**



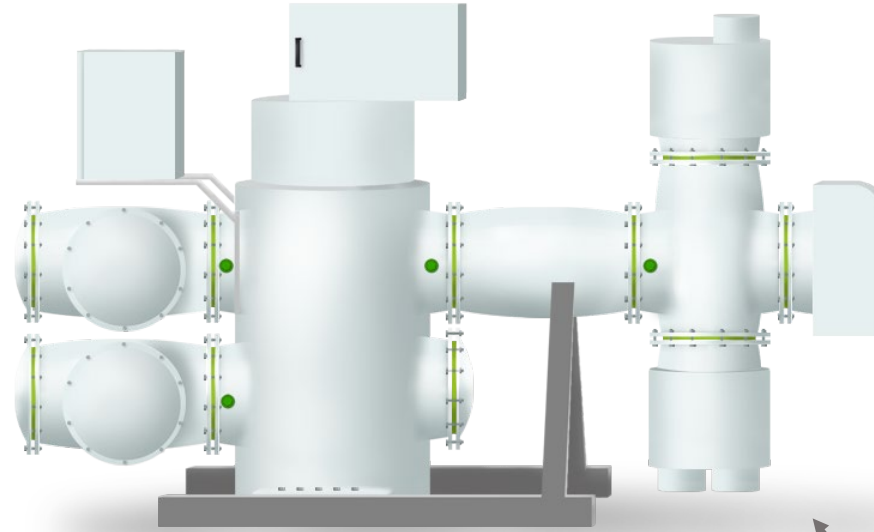
- **Gas refilling device 0-10bar C4-3-001-R001**

- **Gas refilling device 0-16bar C4-3-001-R002**

mobile as cylinder cart with wire-braided hose

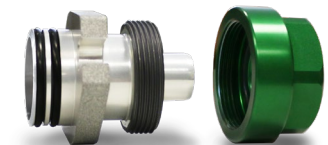


Valves and Couplings



DILO DN20 couplings. For operator safety and to avoid errors caused by the mixing of other gases.

| Thread sizes | DN20 | DN8 |
|---------------------------------|-------|---------|
| SF ₆ | M45x2 | M26x1.5 |
| C4-FN gas mixtures | M48x2 | M28x1.5 |
| C5-FK gas mixtures | M43x2 | M24x1.5 |
| Synthetic air gas mixtures (CA) | M50x2 | M24x1.5 |



Gas analysing



Measuring devices

Multi-Analyser ^{C4}



Multi-Analyser ^{C5}



Mirror-Analyser ^{CA}



LeakSpy ^{C4 / C5}



GasSafetySensor / Monitor



C4-3-039R-R
for C4-FN

- Mol-% C4-FN (in CO₂ / O₂ or N₂ / O₂)
- Moisture
- Mol-% Oxygen (O₂)
- Mol-% carbon dioxide (CO₂)
- Concentration carbon monoxide (CO)

C5-3-039R-R
for C5-FK

- Mol-% C5-FK (in CO₂ / O₂ or N₂ / O₂)
- Moisture
- Mol-% Oxygen (O₂)
- Mol-% carbon dioxide (CO₂)
- Concentration carbon monoxide (CO)

CA-3-035R-R
for CA

- Moisture (Frost- / Dewpoint)
- Mol-% Oxygen (O₂)
- Concentration nitrogen oxides (NO_x)

C4-3-033-R400 for C4-FN
C5-3-033-R500 for C5-FK

- C4-FN
- C5-FK

3-026-R200
3-026-R...

- Sensors: CO₂, O₂, C4-FN, C5-FK, CO

DILO Certified Gas – Mixing services for alternative gases

DILO Service:

**Delivery of pre-mixed gases in bottles or containers
directly to the installation site**

- DILO offers mixing of C4-FN gases with analyzing certificate
- Mixtures are available in **gaseous** or **liquid** phase
- Different bottles and tanks available
- High accuracy of the required gas mixtures

Contact: Certified-gas@dilo-gmbh.com



C4-FN reconditioning

DILO Reconditioning* service:

- Despite low GWP, gas mixtures should not be deliberately released to the atmosphere.
- C4-FN can be regained in specially designed stationary separating plants.
- Return and reclamation of used C4-FN mixtures for the subsequent reuse for new mixtures.
- Purity > 99%
- Reclamation level > 95%

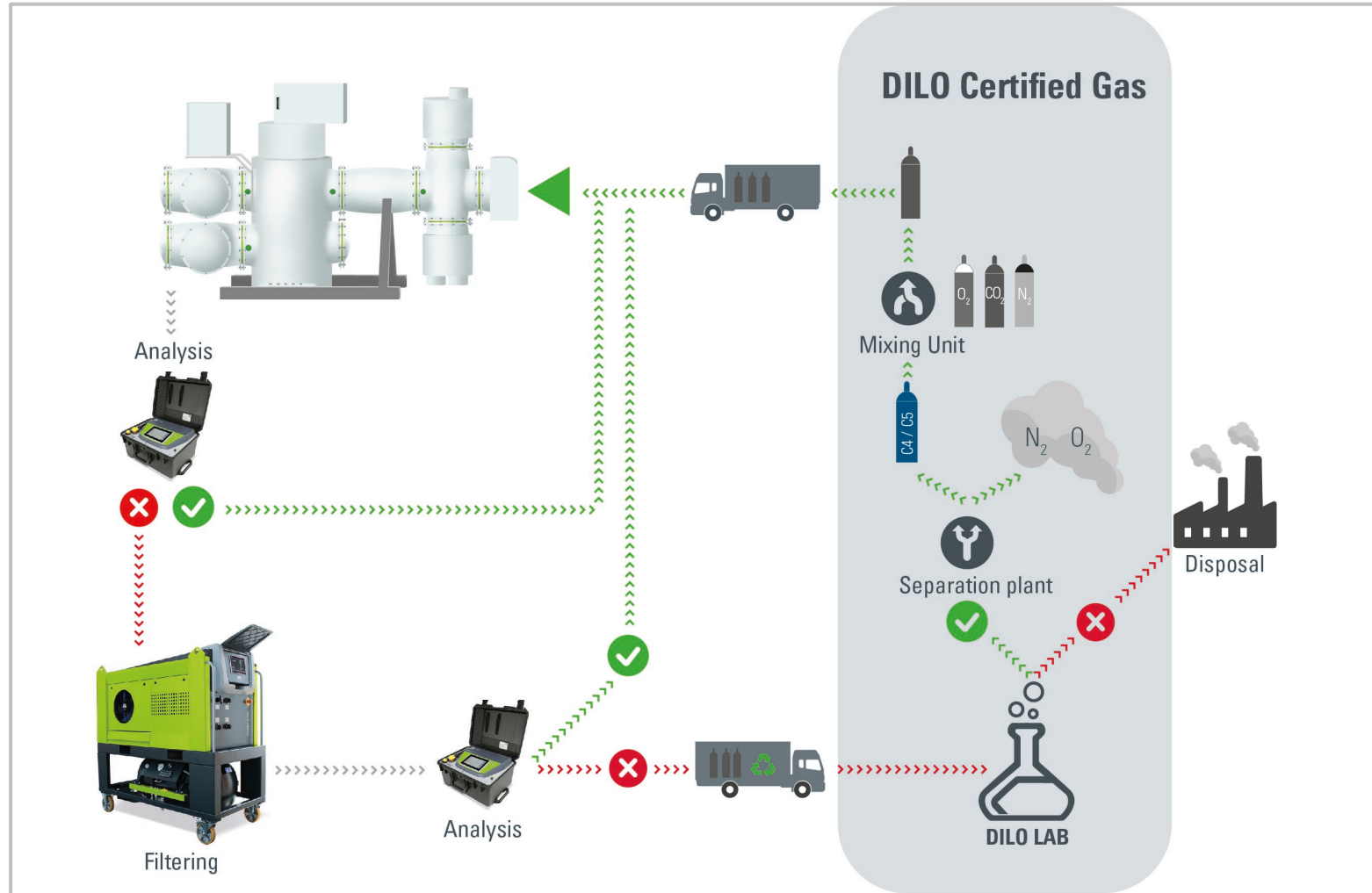
*Reconditioning means the reprocessing of a recovered fluorinated greenhouse gas in order to match the equivalent performance of a virgin substance, taking into account its intended use.

*S. Glomb, P. Pilzecker, M. Göppel, J. Owens, R. Kurz; End-of-life procedures and gas reclamation of SF6 alternative gas mixtures, CIGRE 2022.



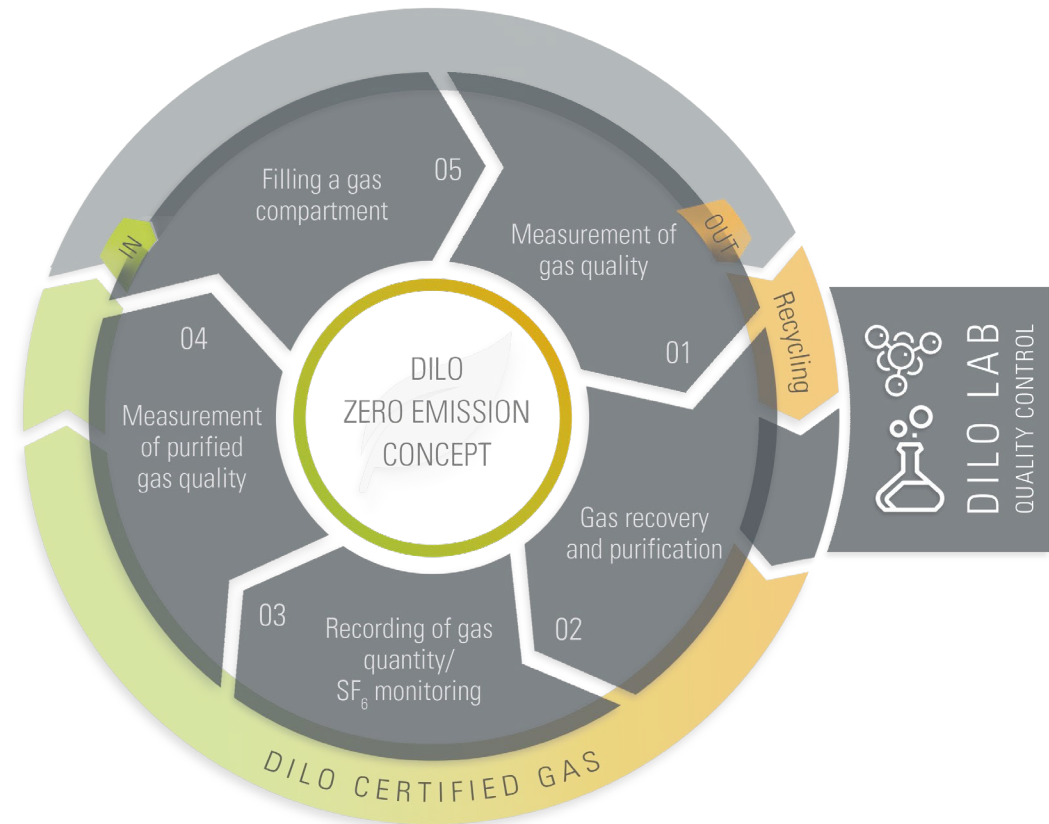
DILO gas separation plant for reclamation of used C4-FN mixtures

ReUse cycle for alternative gases



DILO. Certified Gas

- Reconditioning of used SF₆ gas to a purity of > 99.9%
- Recycled “DILO Certified Gas” thus exceeds even the specifications for new gas
- Customer-specific mixture of Alternative Gases, e.g. on the basis of Novec™ 4710 or Novec™ 5110 as well as other insulation gas mixtures
- DILO is certified by TÜV SÜD as a waste management company in accordance with the German Waste Management Facility Ordinance (EfbV)
- Recycling of Alternative Gases using Novec™ 4710 or Novec™ 5110



Summary: What is offered by DILO?

Devices, components and solutions for professional gas handling

SF₆ GAS

ALTERNATIVE
GASES

INDUSTRIAL GAS
EQUIPMENT

HIGH PRESSURE
PRODUCTS

Gas reconditioning, services, trainings & certification

DILO
CERTIFIED GAS

AFTER SALES
SERVICES

TRAINING &
CERTIFICATION

Customers around the world have valued DILO as an important partner for professional and emission-free gas handling.

Our range of services includes the reconditioning of used SF₆ gas and the mixing of “Alternative Gases” to DILO CERTIFIED GAS, technical support and after sales services as well as training and certification.

Outlook...

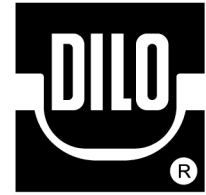
- Germany is still in the early stages of the energy transition, and the energy demand (e.g., for data centers, e-mobility, and digitalization) is set to rise dramatically in the coming years.
 - Some estimate that demand will double by 2045.
 - Presumably, there will be several solutions in the future, both using reconditioned SF₆ gas and gas mixtures.
- No matter which solution is chosen, DILLO can supply the equipment, true to our motto:



Thank you very much for your attention!



ONE VISION. ZERO EMISSIONS.



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