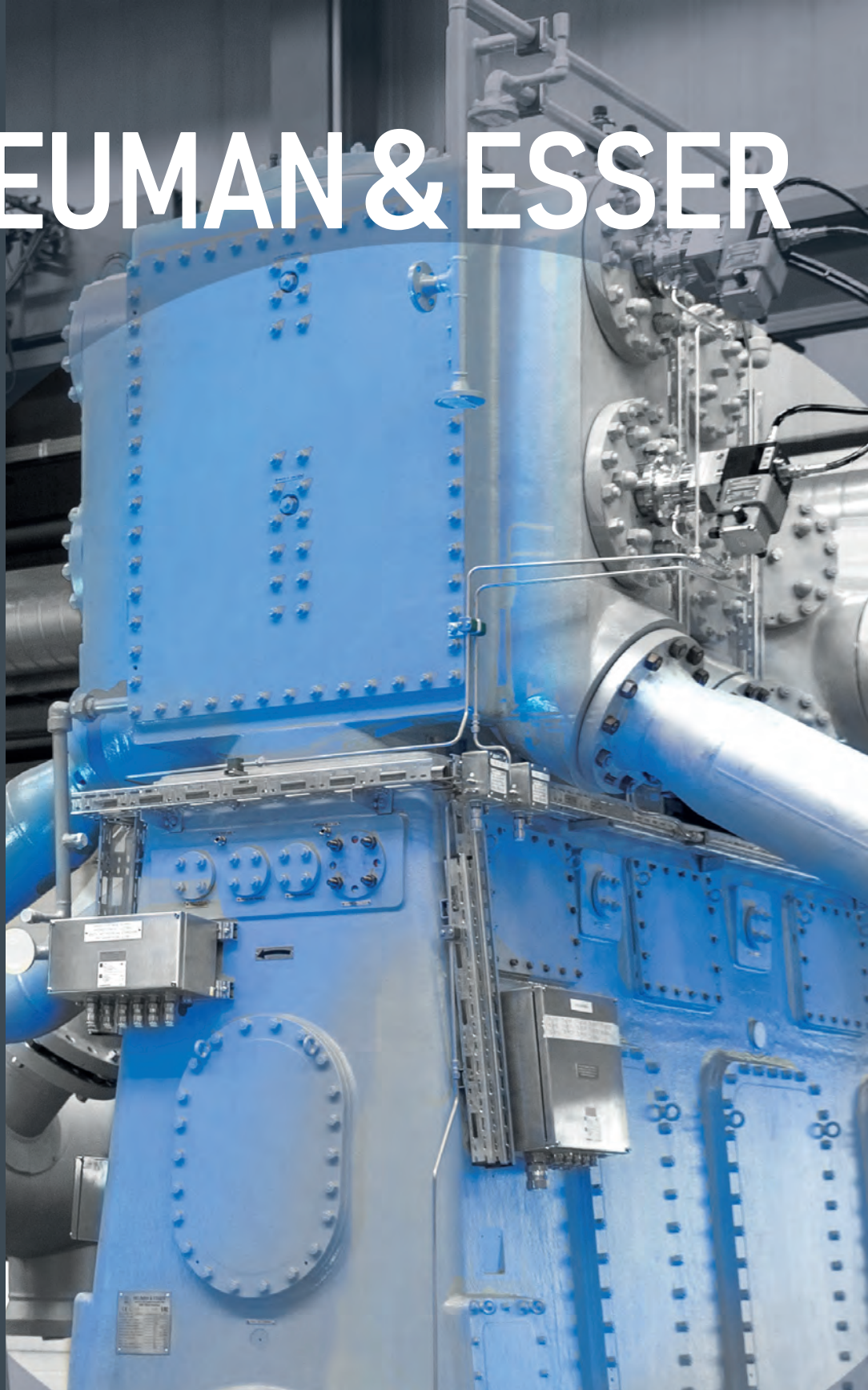




NEUMAN & ESSER



Compressor Solutions



PROFOUND AND GLOBAL

The Value Chain of a Compressor Solution

The experience of NEUMAN & ESSER in designing and constructing reciprocating compressors is just as profound, far-reaching and extensive as the years of operation of the enterprise itself since its foundation in the year 1830.

The whole life cycle of a process gas compressor is supervised by NEUMAN & ESSER, from the first "stroke of the pen" to the start-up commissioning and through its whole operating period.

A typical life time of a NEA compressor comprises the following stages:

- analysis
- solution proposal
- design and engineering
- manufacturing
- testing
- installation
- commissioning and start-up
- maintenance, and upon request, retrofit to modified process parameters.

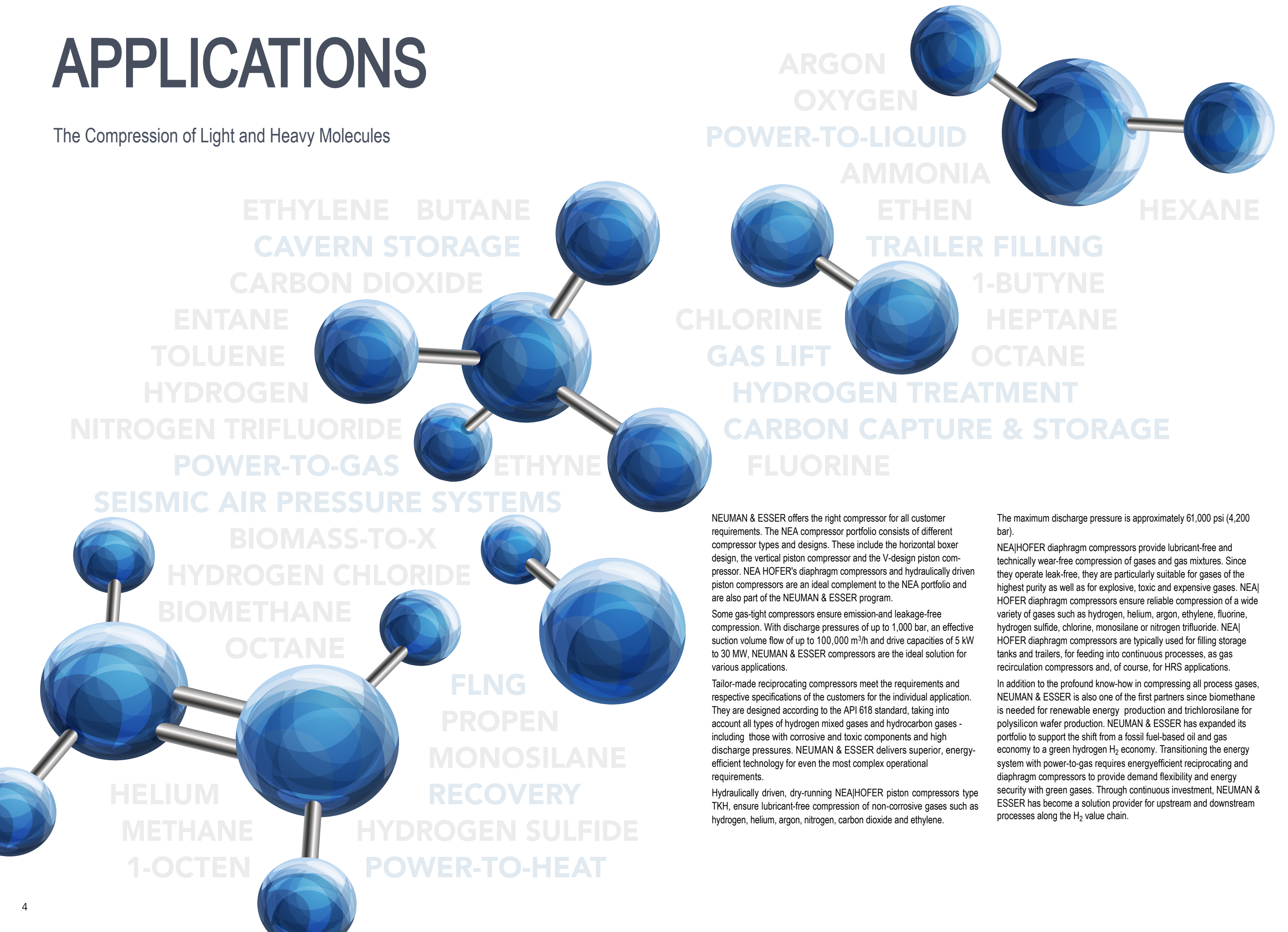
The individual steps of the process are supported by digital simulations and are put into effect by means of adjusted IT solutions. Diagnostic and monitoring systems record and analyze the technical data during the operating period. Notwithstanding the number of techniques used, great importance is attached to the personal experience of the NEA engineers, which often is based on decades of practice and is decisive for the longevity of a compressor.

Clients of the chemical and petrochemical industry confirm that longevity is the key feature of a NEA compressor, built to API 618, API 11P and ISO 13631 standards. This not only applies to the lubricated design, but also to the dry-running one. For over 90 years, the NEA compressor has had a leading role as a highly developed dry-running unit. The technology and strategy of the enterprise were adjusted to market demands requiring absolutely oil-free compression.

When leaving the workshop, the uniquely constructed NEA compressor is provided with a quality certificate. If requested by the client, the bare compressor can be completed as a packaged unit by one of the international NEA sales and engineering companies. This global engineering net, having special knowledge and experience in flexible order handling, guarantees the operating admission of the compressor plant, taking into consideration the legal and regulatory standards of each country. The world-wide presence of service centers warrants a high reliability and economic efficiency of each unit with its tailor-made service packages.

APPLICATIONS

The Compression of Light and Heavy Molecules



NEUMAN & ESSER offers the right compressor for all customer requirements. The NEA compressor portfolio consists of different compressor types and designs. These include the horizontal boxer design, the vertical piston compressor and the V-design piston compressor. NEA HOFER's diaphragm compressors and hydraulically driven piston compressors are an ideal complement to the NEA portfolio and are also part of the NEUMAN & ESSER program.

Some gas-tight compressors ensure emission- and leakage-free compression. With discharge pressures of up to 1,000 bar, an effective suction volume flow of up to 100,000 m³/h and drive capacities of 5 kW to 30 MW, NEUMAN & ESSER compressors are the ideal solution for various applications.

Tailor-made reciprocating compressors meet the requirements and respective specifications of the customers for the individual application. They are designed according to the API 618 standard, taking into account all types of hydrogen mixed gases and hydrocarbon gases - including those with corrosive and toxic components and high discharge pressures. NEUMAN & ESSER delivers superior, energy-efficient technology for even the most complex operational requirements.

Hydraulically driven, dry-running NEA/HOFER piston compressors type TKH, ensure lubricant-free compression of non-corrosive gases such as hydrogen, helium, argon, nitrogen, carbon dioxide and ethylene.

The maximum discharge pressure is approximately 61,000 psi (4,200 bar).

NEA/HOFER diaphragm compressors provide lubricant-free and technically wear-free compression of gases and gas mixtures. Since they operate leak-free, they are particularly suitable for gases of the highest purity as well as for explosive, toxic and expensive gases. NEA/HOFER diaphragm compressors ensure reliable compression of a wide variety of gases such as hydrogen, helium, argon, ethylene, fluorine, hydrogen sulfide, chlorine, monosilane or nitrogen trifluoride. NEA/HOFER diaphragm compressors are typically used for filling storage tanks and trailers, for feeding into continuous processes, as gas recirculation compressors and, of course, for HRS applications.

In addition to the profound know-how in compressing all process gases, NEUMAN & ESSER is also one of the first partners since biomethane is needed for renewable energy production and trichlorosilane for polysilicon wafer production. NEUMAN & ESSER has expanded its portfolio to support the shift from a fossil fuel-based oil and gas economy to a green hydrogen H₂ economy. Transitioning the energy system with power-to-gas requires energy-efficient reciprocating and diaphragm compressors to provide demand flexibility and energy security with green gases. Through continuous investment, NEUMAN & ESSER has become a solution provider for upstream and downstream processes along the H₂ value chain.

KO³ - THE DESIGN BENCHMARK

For the Highest Demands on Functionality

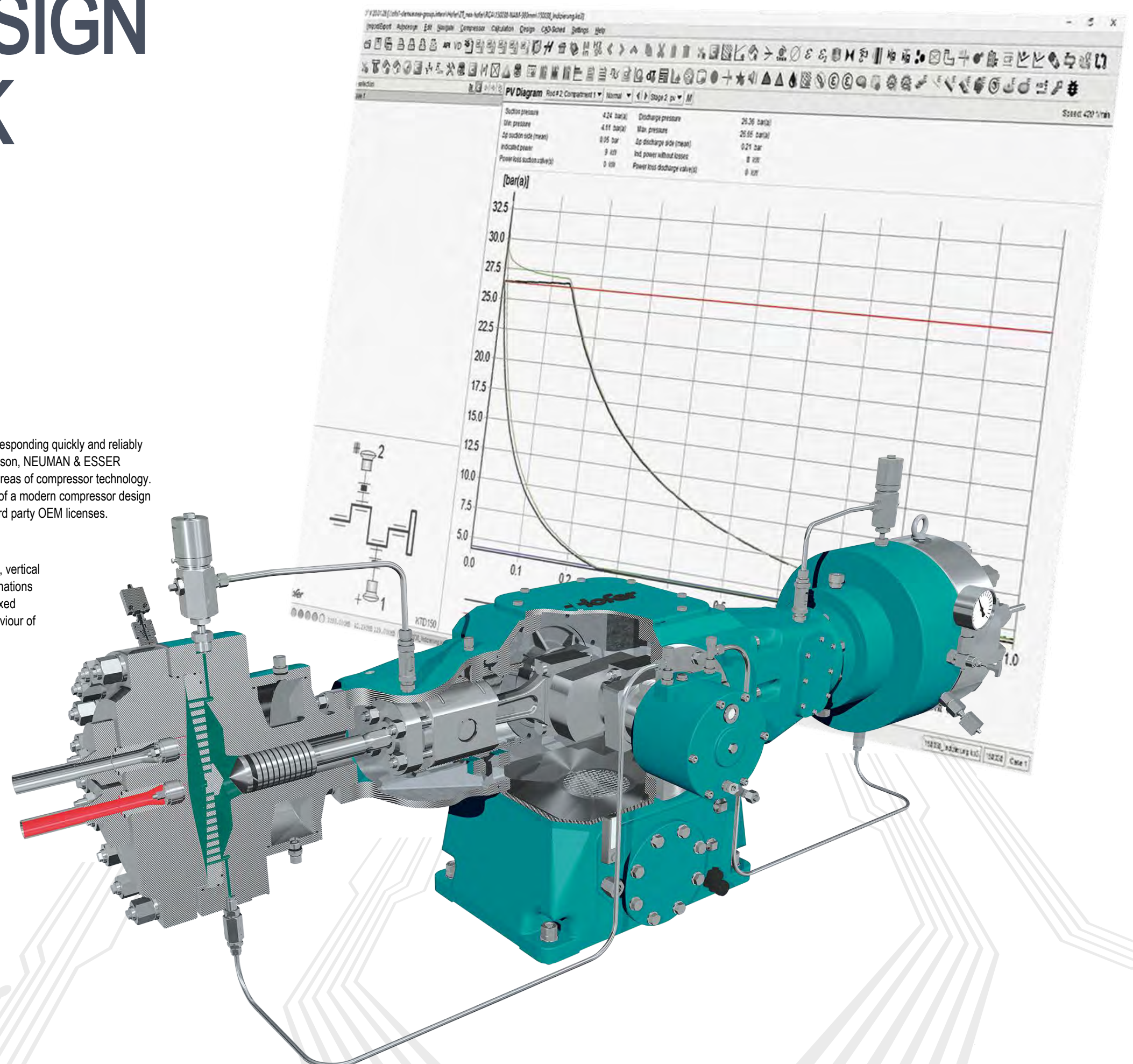
As a premium supplier to the compressor industry, NEUMAN & ESSER is committed to responding quickly and reliably to the needs of the market with tailor-made designs and new developments. For this reason, NEUMAN & ESSER operates an independent R&D/design and standardization department for all business areas of compressor technology. An important component of this is the proprietary design program KO³ - the benchmark of a modern compressor design tool for reciprocating and diaphragm compressors alike covering all NEA brands and third party OEM licenses.

This program allows for designing all compressor configurations like horizontal opposed, vertical or V-type, and scenarios such as all possible stage arrangements or even throw combinations with crossheads between cylinders as well as multi-service operations, side streams, fixed intermediate pressure levels and tail rod designs. To predict correctly the real gas behaviour of all possible gases is a system immanent feature of this program too.

The ultimate requirement of any compressor design is reliability for decades of its operation. That's why all measures must be taken to not overload any critical component. This is especially mandatory for designs acc. to API 618, NEUMAN & ESSER can fall back on in-depth know-how and experiences gained for. Hence, integral parts of the KO³ compressor design, calculation and analysis program are:

- Thermodynamics and compressor calculations
- Verification of compressor valves
- Rod loading by inertia, gas and combined loads
- Elasto-hydrodynamic (EHD) of compressor bearings
- Crankshaft strength and torsional analysis
- Acoustical pulsation study
- Fully automated design process
- PanHandle diagram for varying pressure conditions
- Verification of measured rod loads and p-V charts

KO³ incorporates the comprehensive technical core know-how of NEUMAN & ESSER, culminating in the fully automated design process. This outstanding feature provides for three advantages: first, the overall order related engineering time is dramatically reduced, second, human errors by individual designs are excluded and third, standard design rules are definitely followed. Hence, high reliability and save operation are the predominant characteristics the NEA compressor is well-known for.



DIGITAL AND OPTIMIZED

Modern Technology in Production

The digital transformation of production and logistics is part of the digital master plan of NEUMAN & ESSER. In logistics, mobile SAP-connected scanners record and book items and storage locations. Production, with its very high vertical range of manufacture and diversity of variants, uses CAD/CAM and a tool management system, a Manufacturing

Execution System (MES), a system for controlling internal logistics, and the "FELIOS" APS system.

The optimized planning and minimized lead times increase the competitiveness of NEUMAN & ESSER and lead to an optimal and reliable fulfillment of customer requirements with this fully transparent value chain. The FELIOS software helps to identify data errors and optimization opportunities easily and reliably. Overall, this is an important step towards securing and further expanding the company's position as a leading, agile solution provider with a customer focus.

Digital Test Bench

Among the digital enhancements of NEUMAN & ESSER implemented with its subsidiary NEA X is the digital test bench. The NEA|XPLORE Test Benches at the Übach-Palenberg and Wurzen sites offer customers the opportunity to remotely observe the mechanical test run of their compressors in real time on the physical test platform. In addition to the video stream accompanied by multiple flowcharts on the screen, numerous viewing angles allow visual inspection of the machine's behavior during the five-hour test. Data from the machine that can be freely selected by the customer can be retrieved at any time or made available as XLS as well as CSV files. The chat with the test engineers serves to clarify further questions and requests.

This service thus helps customers to save travel costs, travel time and CO₂ emissions. Even in the event of unforeseen external influences on travel activities, prescribed and necessary tests can be carried out on customers' compressors, leaving delivery processes unaffected. Other test steps, such as leak tests, can also be accompanied remotely by digital connectivity.

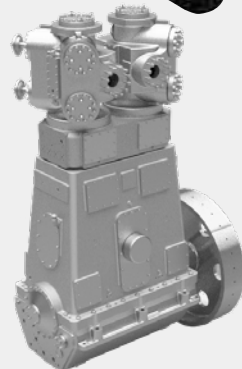
PROCESS GAS

Portfolio for Reciprocating Compressors



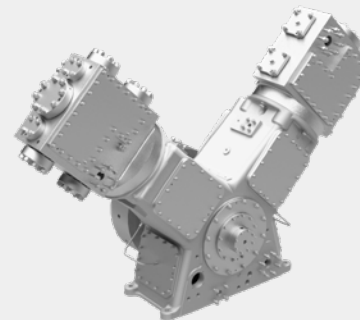
Vertical Type:

- most suitable for dry-running operation because of minor wear of the guide elements only
- appropriate for labyrinth compression for more precise guidance of piston and piston rod
- oil-free or lubricated design
 - number of cranks: 1, 2, 3, 4
 - number of stages: 1 to 8
 - discharge pressures: max. 15,000 psi
 - power range: max. 20,800 hp
 - flow rates: max. 30,000 scfm



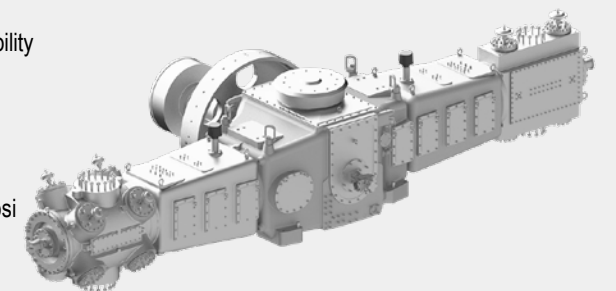
V-Type

- balanced mass forces 1st order
- horizontal mass forces only 2nd order
- less space required
- low foundation loads
- oil-free or lubricated design
 - number of cranks: 1, 2
 - number of stages: 1 to 4
 - discharge pressures: max. 6,000 psi
 - power range: max. 1,500 hp
 - flow rates: max. 2,400 scfm



Horizontal Type:

- balanced mass forces
- excellent quietness in running
- short maintenance time due to very good accessibility
- low foundation loads
- oil-free or lubricated design
 - number of cranks: 1, 2, 4, 6, 8
 - number of stages: 1 to 8
 - discharge pressures: max. 15,000 psi
 - power range: max. 41,000 hp
 - flow rates: max. 60,000 scfm
 - max. 100,000 Nm³/h



PLANT ENGINEERING

From Idea to Visualization

NEUMAN & ESSER compressors are the heart of every manufactured NEA compressor system in the world. However, the scope of supply goes far beyond this. NEUMAN & ESSER combines the entire competence that customers require and thus position themselves as a solution provider in existing and future markets. The aim is to serve customer requirements along the entire value chain with upstream and downstream processes.

From the project idea ...

Depending on the complexity of the application, project planning can take several months. Right from the initial project idea, we support the search for the right compressor solution. By entering a few operating conditions, the customer then receives a technical data sheet with temperatures, pressures and power consumption of the compressor system. In addition, a general arrangement drawing shows the rough dimensions of the overall system - for direct further use in project planning. 3D models, experts hints and a chat enable a digital customer experience and offer a direct contact with an NEUMAN & ESSER expert.

... with a customer-specific plant design

The development of the customized plant is done in close cooperation with the customer. One of the core tools for this cooperation are the database-linked 3D visualizations of the plant, which are unique in the market. NEUMAN & ESSER uses proven templates for the auxiliary systems, such as cooling water systems, lubricating oil systems, motors, pulsation dampeners or control cabinets. The innovative Product Lifecycle Management (PLM) concept and the linking of the CAD systems with the ERP (SAP) system form the basis for this. A continuous exchange of information on the project status provides the customer with the certainty that the system will be executed on time and exactly according to the specifications.

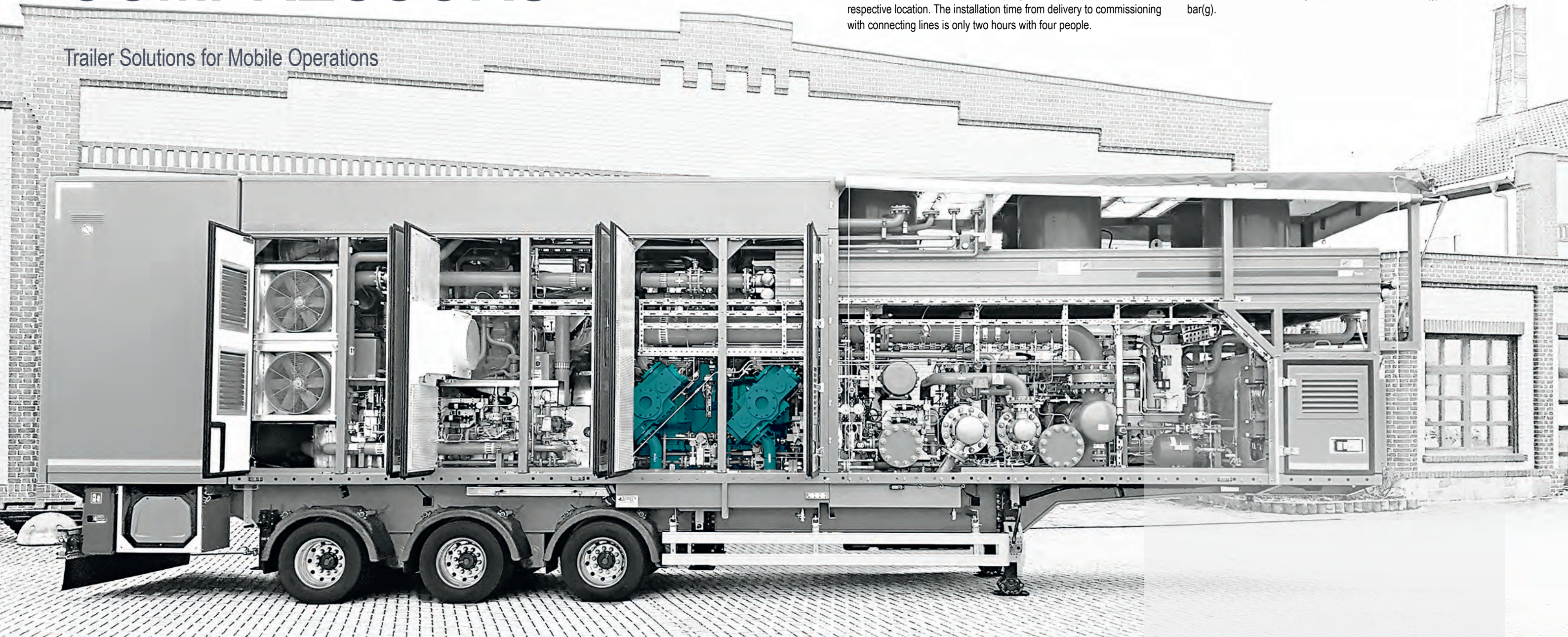
... to a 3D model experience

Another advantage is the data technology used to convert the enormous amount of information into manageable file sizes. The Autodesk A360 app offers customers and partners the possibility to visualize NEA's 3D plant design on mobile devices. A VR presentation completes the digital customer experience and enables the customer to inspect the plant virtually before delivery and to integrate additional requests at an early stage.



MOBILE COMPRESSORS

Trailer Solutions for Mobile Operations



In order to enable short-term operations and to avoid approval waiting times, the mobile unit was built according to the allowable external dimensions of the Road Traffic Licensing Regulations standard especially relevant for European market. Due to the special design with regard to weight balance, a non-route-related permanent exemption has been achieved. Various auxiliary systems and a complete control cabinet unit, enable almost self-sufficient operation, as the plant is operated via the natural gas available in pipelines at the respective location. The installation time from delivery to commissioning with connecting lines is only two hours with four people.

In addition to the Mobile Pipeline Evacuation Compressor, there is also the MoBIO 800, another mobile compressor solution in the NEA product portfolio. The MoBIO 800 consists of two dry-running, gas-tight NEA piston compressors in V-design and is driven by a 315 kW mid-mounted engine to feed the processed biomethane into the existing natural gas network even before the stationary plant is put into operation. Depending on the gas network, the NEUMAN & ESSER compressors increase the gas pressure from 0 to 9 bar(g) up to 84 bar(g).

With the maximum possible delivery volume as the top criterion and the customer-specific requirement always in mind, the new Mobile Pipeline Evacuation Compressor System was developed. This solution from NEUMAN & ESSER is mounted on only one trailer and driven up to a 1000 kW gas engine. All auxiliary systems, such as the water cooling, air conditioning, control, regulation and the accessories for the set-up are installed on the trailer. An innovative design for maximum flow rate requiring minimum space.

The aim of this mobile system is to avoid the controlled release of gas into the atmosphere during maintenance work on the gas network pipeline.

In order to keep the time expenditure, downtime costs and emissions of the customers as low as possible, a particularly high capacity is necessary. Due to the special design, geared to the maximum flow rate, NEUMAN & ESSER makes a significant contribution to environmental protection and supports the green visions of the customers. Here, a 2TVL63 gastight compressor pumps up to 100,000 Nm³/h of natural gas from up to 60 bar(g) discharge pressure into another gas pipeline. The 2TVL63 was designed with a particularly short crank case to make maximum use of the space available on the trailer.

Features of the mobile compressor

- Increased Volume: up to 100,000 Nm³/h
- Suction pressure (min.): 1 bar(g)
- Discharge pressure (max.): 60 bar(g)
- Gas engine power: up to 1,000 kW
- Total drive power: up to 1,100 kW
- Gas-tight engine
- Total weight: approx. 40 t
- Dimensions: 13.00 m x 2.55 m x 2.70 m
- Ready for operation: in a few hours
- Operating conditions: all year round

WITH HIGH PRESSURE INTO NEW MARKETS

The Diaphragm Compressor

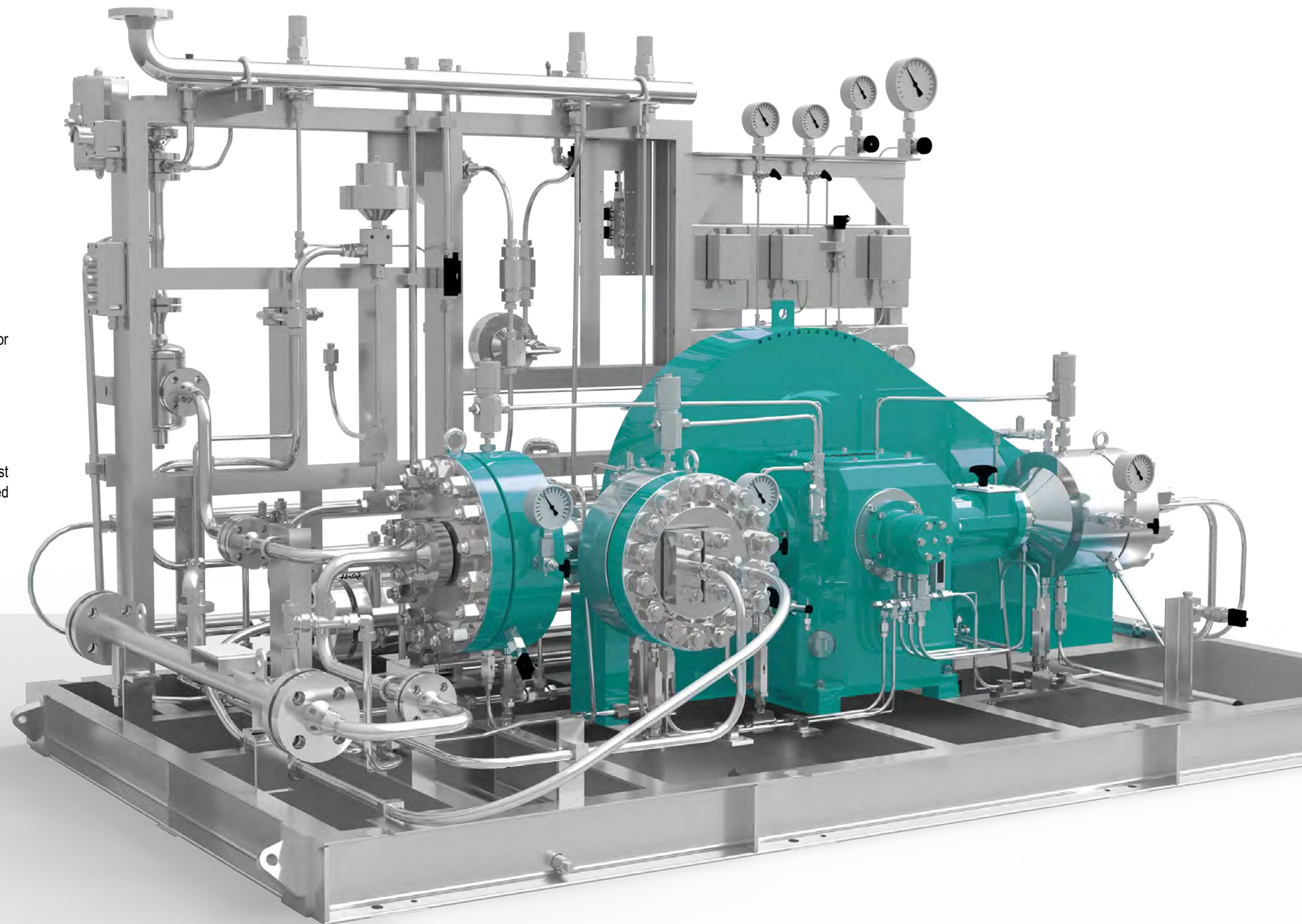
The diaphragm compressor is the central product from NEA|HOFER. Above-all, the mastery of the working life of the diaphragms and high quality standards are the outstanding features of the compressors from Mülheim. The continuous further development of this complex technology offers new, significant application options, primarily for the future.

Diaphragm compressors are particularly suitable for processes with relatively low gas quantities, but very high pressure. They are needed in particular if no soiling is allowed to flow into downstream applications. NEA|HOFER diaphragm compressors excel specially with their hermetic imperviousness and constructional details when working with toxic or explosive gases, making the machines particularly safe, reliable and service-friendly.

These high quality requirements are guaranteed by NEA|HOFER due to many years' experience and their own test bed on which all compressors are put to the acid test under load. The diaphragm compressors are either delivered individually or as a complete system with a base frame, drive, pulsation dampers, coolers, fittings, instruments and a controller.

Features at a glance:

- oil-free compression due to hermetic separation between gas and oil chamber
 - abrasion-free compression due to static seals in the gas stream
 - leakage rates of 10^{-4} mbar l/sec (on request up to 10^{-6} mbar l/sec)
 - purge or buffer gas is not required
 - long service life because of a hydraulically actuated diaphragm, no mechanical linkage
 - good cooling due to the large surface of the diaphragm head
 - cooling coil in the oil chamber of the diaphragm head, no weakening of the cover caused by cooling channels
 - automatic shutdown in case of diaphragm failure prevents consequential damage
 - discharge pressure up to 72,518 psi (5,000 bar)
 - stage pressure ratios up to 7
 - up to 4 stages on a crank drive
 - mass compensation for foundation-free installation
 - wear resistant and smooth operation due to low piston speeds
 - water cooling provides the best cooling effect and a low sound pressure level
 - manufactured in compliance with EC Machinery Directive 2006/42/EC.
- Standards applied: DIN EN 1012 part 1, DIN EN 12100 part 1, DIN EN 60204 part 1 et al.
- if necessary, explosion proof according to ATEX Directive 2014/34/EU



FOR HIGHER MOBILITY

The Hydraulical Driven Compressor

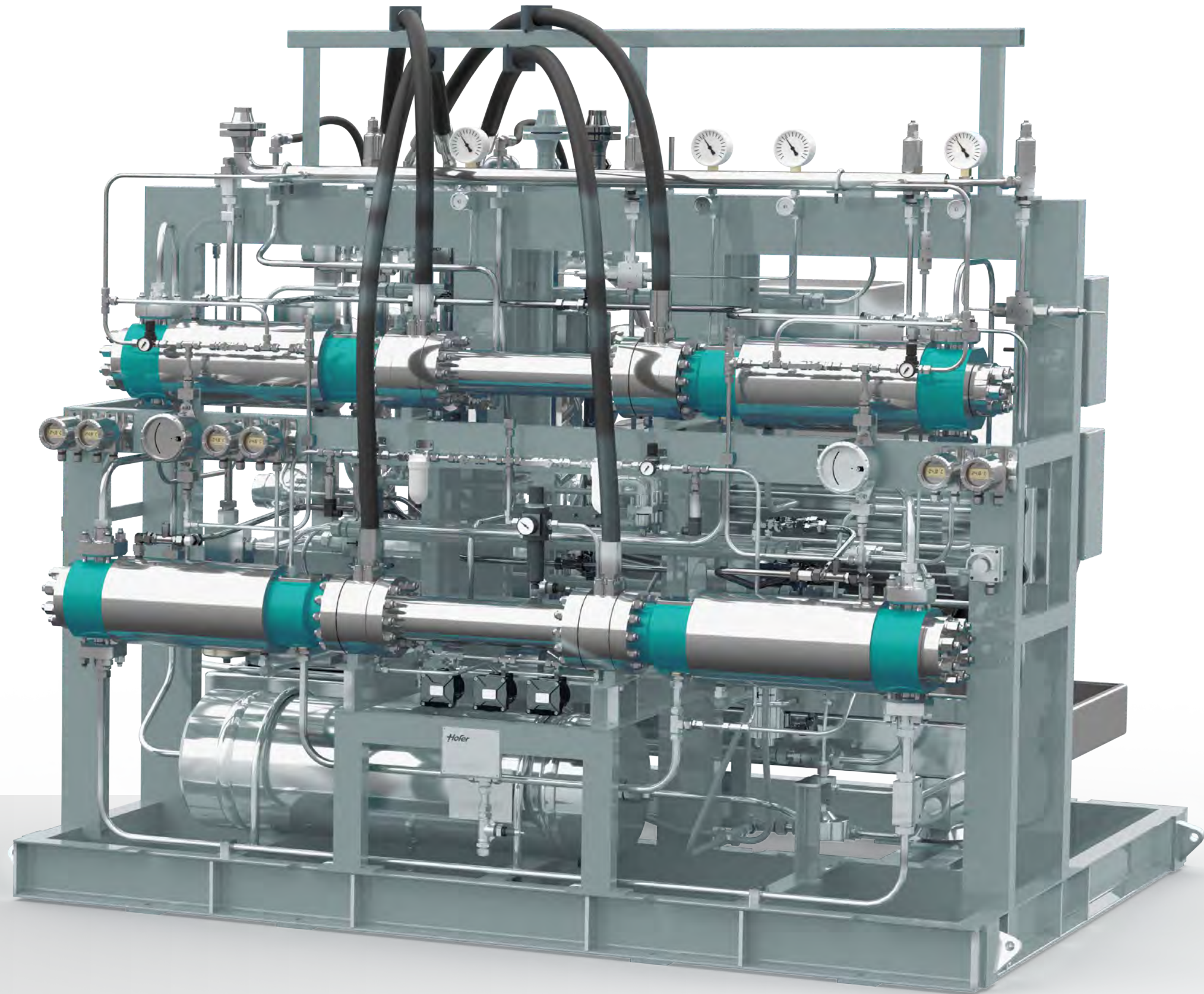
Reciprocating compressors enjoy a long tradition at NEA|HOFER. The first compressors were already developed by the founder Andreas Hofer. Since then, this technology has been continuously developed further. Today, NEA|HOFER also manufactures hydraulically driven reciprocating compressors (TKH).

They are currently primarily used in special areas and compress solids-free gases such as hydrogen, helium, argon, nitrogen, carbon dioxide and ethylene lubricant-free. If small volume flows are required, e.g. for hydrogen refueling stations (HRS), the NEA|HOFER TKH is the ideal solution. For hot isostatic presses (HIP), metallic components are improved for high mechanical stability by sintering them under high argon inert gas pressure of up to 4,200 bar.

The great advantage of these compressors is their simple structure and uncomplicated, fast replacement of the piston packing in 10 to 30 minutes. Moreover, they excel with low space requirements as their stages are easy to arrange on top of each other. They can also be equipped with explosion-protected hydraulic drives. Here, too, NEA|HOFER offers the option of individual supply or the installation of complete compressor systems.

Features at a glance: :

- discharge pressure up to 145,037 psi (10,000 bar)
- dry running piston for oil-free compression
- easy and quick maintenance
- easy flow control by changing the number of strokes from 5 to 100%
- constant monitoring of leakage rates
- stage pressure ratios up to 5
- arbitrary number of stages
- mass compensation for foundation-free installation
- wear resistant and smooth operation due to low piston speeds
- water cooling provides the best cooling effect and a low sound pressure level
- manufactured in compliance with EC Machinery Directive 2006/42/EC.
- standards applied: DIN EN 1012 part 1, DIN EN 12100 part 1, DIN EN 60204 part 1 et al.
- explosion proof according to the ATEX Directive 2014/34/EU



SERVICE

Passion for Details and Procedures

"Passion for Details and Procedures", this is the guiding principle of the NEUMAN & ESSER Service - one of the world's largest OEM service providers for reciprocating and diaphragm compressors.

The range of services includes:

- Installation and commissioning
- Maintenance
- Service
- Repairs of the compressor system including foundations
- Spare parts supply
- Wear parts rings and packings
- Consulting services
- Remote condition and asset management

What makes NEUMAN & ESSER's service special? After the takeover of the first license more than 40 years ago, numerous renowned licenses were included in the portfolio. This means we use original documents, drawings and standards. Thus, NEUMAN & ESSER has one of the broadest knowledge on the market about the different piston compressor designs. In addition, further competent OEM cooperation partners work with us as an exclusive service provider.

The majority of our experts worldwide were trained in-house. After all, they know the products best. This ensures that experience and expertise are shared internally. Comprehensive expert know-how makes NEUMAN & ESSER a reliable partner when it comes to servicing existing systems and supporting installations and commissioning. It does not matter how large or complex the task is.

NEUMAN & ESSER not only offers classic services. Thanks to a global network of specialists and backed up by the support of the internal Central Division of Technology, we can draw on the latest technical know-how. The added value for compressor plant operators lies in our numerous diagnostic and technical capabilities. This starts with engineering studies, continues with state-of-the-art cloud-based platforms for intelligent remote Condition Management (NEA|XPLORE compressors) and ends with the completely digitalized machine history of EVERY of the 7,500 compressors NEUMAN & ESSER services worldwide.

With the themes "We Want Safety", "Goal ZERO" and a "Stop the Job" philosophy for unsafe onsite works NEUMAN & ESSER proactively faces hazard detection and accident prevention.

Authorized OEM supplier for reciprocating compressor lines:



HALBERG
Linde Demag

Borsig
(Recips built in Berlin
up to the end of 1995)

PPC
PENN
Process
Compressors

Norwalk



NEA|XPLORE Compressors

Digital OEM Service
for Maximum Customer Proximity

With the progress of digitalization, plant operators are increasingly facing the challenge how to deal with the vast amounts of data gathered from their machine assets. The potential that lies in the data often remains unused. At the same time, digitalization initiatives are expanded even further. The experience and competence to generate insights from large amounts of data and to draw the right conclusions is the key to ensuring availability and performance of vital machine assets. That is why digitization experts from the digital Operation Team of NEUMAN & ESSER have joined with the Compressor Service Team to develop practice-oriented, digitally supported service solutions.

Hardware for data acquisition, cloud-based analysis software, integration in superior systems - we provide tailored solutions for connecting machine and system networks that can be adapted and expanded flexibly to meet individual customer requirements.

With the help of the NEA|XPLORE compressors platform, our engineers apply a permanent health assessment of connected equipment and according wear conditions. The machine performance is monitored remotely via measured KPIs, analyzed data trends and personalized notification rules.

And just recently, the high-frequency data solution NEA|XPLORE compressorsHD has been launched for temporary remote-measurement projects by our diagnostics experts. A portable, ATEX-certified plug'n'play solution supplied in a pressure-resistant housing (Ex d) delivers pV-monitoring in the cloud for even more reliable results from specific analyzes. Combined with individual service levels from our Condition Management program, NEUMAN & ESSER customers have access to expertise in machine data analysis, even up to a 360° OEM service solution including supply chain management for spare parts.

The fusion of a stringent maintenance strategy with digital platform services is real added value: we ensure system availability and efficient maintenance - system operators have more time to focus on the core of their added value.





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