Air Liquide

Turbo

Turboexpanders

A range of robust, reliable and efficient turboexpanders tailored to your requirements

Air Liquide Group

A world leader in gases, technologies and services for industry and healthcare

Air Liquide is present in 60 countries with 66,500 employees and serves more than 4 million customers and patients. Oxygen, nitrogen and hydrogen are essential small molecules for life, matter and energy.
They embody Air Liquide's scientific territory and have been at the core of the Group's activities since its creation in 1902.

Taking action today while preparing the future is at the heart of Air Liquide's strategy. With ADVANCE, its strategic plan for 2025, Air Liquide is targeting a global performance, combining financial and extra-financial dimensions. Positioned on new markets, the Group benefits from major assets such as its business model combining resilience and strength, its ability to innovate and its technological expertise.

The Group develops solutions contributing to climate and the energy transition—particularly with hydrogen—and takes action to progress in areas of healthcare, digital and high technologies.

Air Liquide Engineering & Construction

A technology partner of choice

Air Liquide Engineering & Construction builds the Group's production units (mainly air gas separation and renewable and low-carbon hydrogen production units) and provides external customers with efficient, sustainable, customized technology and process solutions.

Our core expertise in industrial gas, energy conversion and gas purification, enables customers to optimize the use of natural resources. We cover the entire project life cycle: license engineering services and proprietary equipment, high-end engineering and design capabilities, project management and execution services. In addition, our worldwide capability enables us to offer efficient customer services internationally.

As a technology partner, customers benefit from our research and development activities to achieve energy transition goals.

Powered by our suite of Technologies

With extensive experience, the core technology of Air Liquide Turbo has been well proven for over 60 years.

During that time, with an installed base of well over a thousand turboexpanders, our technology has steadily grown and improved to become the leading technology in terms of both overall efficiency and reliability.

Our turboexpander range:

- **Compressor TC Series:**
  TC2000, TC3000, TC4000, TC6000, TC9000, TC12000
- **Hydrobrake Cryogenic Compressor (THC) Series:**
  THC-3000, THC-4000, THC-6000
- **Turboexpander - Hydrobrake (TH) Series:**
  TH-3000, TH-4000, TH-6000

5
Manufacturing Centers incl. one JV Gigafactory

13
Countries with Technology & Execution Centers & front-end offices

174
Patent applications filed in 2024

Advancing for a sustainable future

Air Liquide is deeply committed to creating a positive impact on both the environment and society. Our strategy and actions are designed to address crucial challenges the world faces today, where we can make an impact and thus invent a sustainable future.

Climate, health, energy, mobility, sovereignty, the digital revolution... There are many global societal challenges that call for immediate – and collective – responses.

At Air Liquide, we are ready.
Ready to deploy our solutions wherever they are needed, and ready to accelerate whenever the situation requires it. Whether it is supporting our customers on their decarbonization journey, deploying hydrogen to make mobility more sustainable, or contributing to the growth of digital technologies, we offer concrete solutions to help society move forward.

To reduce our own CO_2 emissions, we have set key milestones to reach carbon neutrality:

- by 2025, -30% reduction in Carbon Intensity
- by 2035, a -33% reduction in absolute Scopes 1 & 2 emissions
- by 2050, reach carbon neutrality across the entire value chain.

The core technology of Air Liquide's Turboexpanders has been well proven for over 60 years

A value proposition for our customers

At Air Liquide Turbo, we deliver innovative turboexpander solutions tailored to meet customers' needs

Leveraging our extensive portfolio and deep industry expertise, we guide customers through every decision-making process, ensuring optimal outcomes. Our commitment to safety, reliability, and environmental performance underpins our operations and drives our mutual success.

Our turboexpander range caters to diverse requirements in the cryogenic industrial gas sector, offering flexibility in scale, operating modes, and process integration. This encompasses traditional applications like Air Separation Units and other cryogenic applications such as Liquefied Natural Gas or liquefaction cycles.

With our own internal operational experience, we understand the challenges of process safety, reliability, and maintenance. This insight shapes our design and construction processes, ensuring our plants and equipment are built for operational excellence.

We stand by the quality, reliability, and efficiency of our products, guaranteeing to fulfill and cater our customers' needs.


Air Liquide

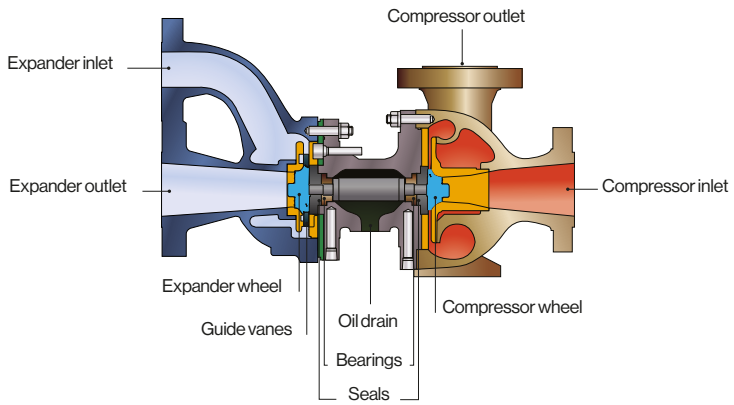
Air Liquide Turboexpanders

A range of innovative turboexpanders tailored to your requirements

Compressor TC Series:

TC2000
TC3000
TC4000
TC6000
TC9000
TC12000

CROSS SECTION: TC-4000



Description

"Zero Leakage" Inlet Guide Vanes

- Adjustable inlet guide vanes provide optimum flow patterns as well as precise and continuous control across the machine's full operational spectrum
- Self-energizing back plate maintains zero sidewall clearance for maximum expander efficiency
- Zero backlash variable guide vane configuration provides smooth turn-up capability to 125% of design flow

Rugged Rotor Design

- Stiff rotor shaft and high capacity tilt pad bearings assure maximum stability at all operating loads and speeds
- High capacity tilt pad thrust bearings provide the extra margin necessary to handle transients
- Numerous bearing designs available to accommodate specific process applications, including hydrodynamic (journal and tilt pad) bearings, ball bearings, ceramic bearings, and air/foil bearings
- Sealing design offers robust construction and reliable performance

Dual Independent Labyrinth Shaft Seal

- Reliable teeth-on-shaft design is precision machined to ultra close clearances, minimizing seal gas consumption
- Dual port, atmospheric center vent prevents process stream contamination

Self-Aligning Wheel Attachment

- Tapered bore and stretch rod design automatically compensates for thermal and mechanical changes to maintain alignment under all operating conditions
- Precision machined tapered bore/shaft attachment allows independent balancing of turbine wheel and shaft to facilitate

Application

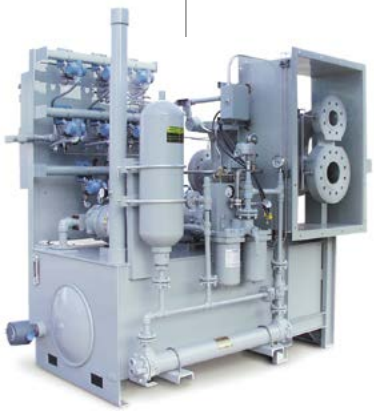
Industrial Gas Production - Air Separation & Liquefaction

Feedstock Fluids Handled

Air, Nitrogen, Waste Gas (high oxygen content)

Air Liquide | Turbo

Compressor Loaded Expanders
Dual Machines



Rugged Rotor Design

Available options

- Inlet screens
- Inlet trip valves
- Surge control system
- Low hysteresis high cycle inlet guide vanes
- Cable trays or conduit
- Safe area or hazardous area location
- International code compliance (HPGSL, PED, etc.)
- Cryogenic performance testing
- Spare cartridge with nozzle assembly

Main features

- Common lube oil system and controls support two expanders/compressors
- “Zero leakage” inlet guide vanes
- Components individually balanced for ease of field replacement
- Tapered shaft wheel attachment for field interchangeability
- Labyrinth shaft seal design minimizes seal gas consumption and prevents process stream contamination
- Shaft-driven boost compressor reduces power consumption, increasing plant efficiency
- Easily upgraded for future plant changes e.g. improved aero for higher efficiency/ capacity

Performance

- Expander Ns Range: 40 – 140
- Expander Efficiency: up to 89%
- Expander Pressure Ratio: up to 20:1
- Tip Speed: up to 1,500 ft/sec (457 m/s)
- Rotor Speed: up to 120,000 RPM
- Refrigeration Production: up to 9,500 HP (7,084 kW)

Self-Aligning Wheel Attachment

Hydrobrake Cryogenic Compressor (THC) Series:

THC-3000
THC-4000
THC-6000

Application

Industrial Gas Production - Air Separation & Liquefaction

Feedstock Fluids Handled

Air, Nitrogen, Waste Gas (high oxygen content)

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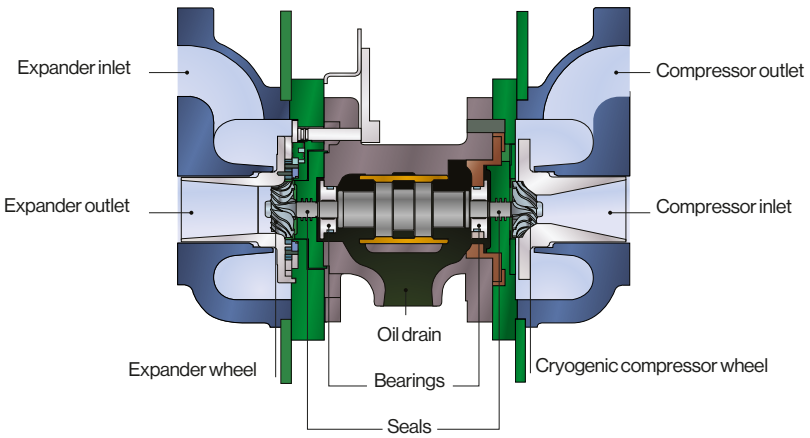
CROSS SECTION: THC-3000



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- Zero backlash variable guide vane configuration provides smooth turn-up capability to 125% of design flow

Rugged Rotor Design

- Stiff rotor shaft and high capacity tilt pad bearings assure maximum stability at all operating loads and speeds
- High capacity tilt pad thrust bearings provide the extra margin necessary to handle transients
- Numerous bearing designs available to accommodate specific process applications, including hydrodynamic (journal and tilt pad) bearings, ball bearings, ceramic bearings, and air/foil bearings
- Sealing design offers robust construction and reliable performance

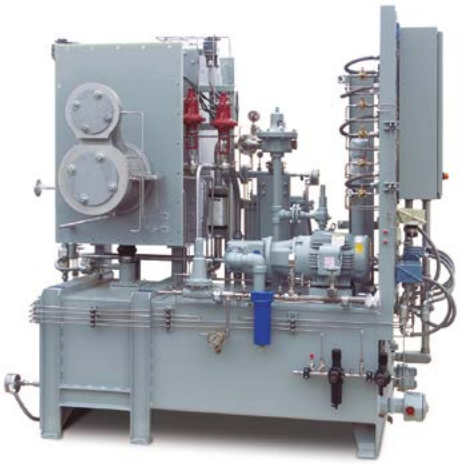
Dual Independent Labyrinth Shaft Seal

- Reliable teeth-on-shaft design is precision machined to ultra close clearances, minimizing seal gas consumption
- Dual port, atmospheric center vent prevents process stream contamination

Self-Aligning Wheel Attachment

- Tapered bore and stretch rod design automatically compensates for thermal and mechanical changes to maintain alignment under all operating conditions
- Precision machined tapered bore/shaft attachment allows independent balancing of turbine wheel and shaft to facilitate field repair

Hydrobrake Cryogenic Compressor
Loaded Expanders



Available options

- Inlet screens
- Inlet trip valves
- Surge control system
- Low hysteresis high cycle inlet guide vanes
- Cable trays or conduit
- Safe area or hazardous area location
- International code compliance (HPGSL, PED, etc.)
- Cryogenic performance testing
- Spare cartridge with nozzle assembly

Main features

- Compact footprint
- “Zero leakage” inlet guide vanes
- Rugged rotor design
- Components individually balanced for ease of field replacement
- Tapered shaft wheel attachment for field interchangeability
- Dual vibration probes
- Coalescing/fan mist eliminator
- Labyrinth shaft seal design minimizes seal gas consumption and prevents process stream contamination
- Easily upgraded for future plant changes e.g. improved aero for higher efficiency/ capacity

Performance

- Expander Ns Range: 40 – 140
- Expander Efficiency: up to 86%
- Expander Pressure Ratio: up to 20:1
- Tip Speed: up to 1,200 ft/sec (366 m/s)
- Rotor Speed: up to 55,000 RPM
- Refrigeration Production: up to 200 HP (150 kW)

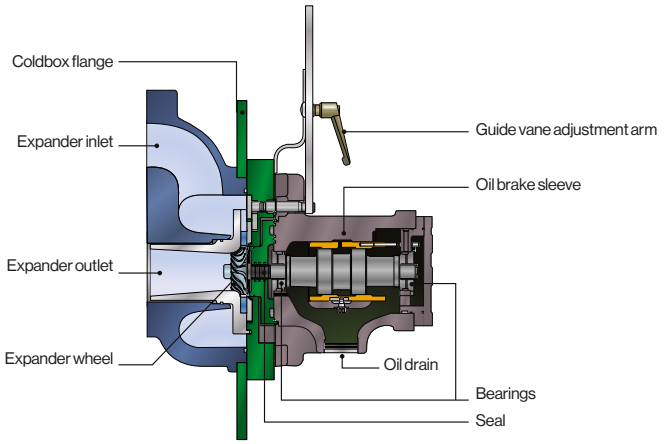
Self Aligning Wheel Attachment

Air Liquide Turboexpanders

Turboexpander Hydrobrake (TH) Series:

TH-3000
TH-4000
TH-6000

CROSS SECTION: TH-3000



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Rugged Rotor Design

- Stiff rotor shaft and high capacity tilt pad bearings assure maximum stability at all operating loads and speeds
- Sealing design offers robust construction and reliable performance
- Uniformly loaded drive tangs provide the high torque capacity necessary to handle upset conditions

Self-Aligning Wheel Attachment

- Tapered bore and stretch rod design automatically compensates for thermal and mechanical changes to maintain alignment under all operating conditions
- Precision machined tapered bore/shaft attachment allows independent balancing of turbine wheel and shaft to facilitate field repair

Self Aligning Wheel Attachment

Application

Industrial Gas Production -
Air Separation & Liquefaction

Feedstock Fluids Handled

Air, Nitrogen, Waste Gas
(high oxygen content)

Oil Brake Loaded Expanders

Main features

- Compact footprint
- “Zero leakage” inlet guide vanes
- Rugged rotor design
- Tapered shaft wheel attachment for field interchangeability
- Components individually balanced for ease offield replacement
- Externally adjustable power absorption control
- Labyrinth shaft seals with oil-free design
- Manual or automatic oil brake flow control valve for adjustment
- Easily upgraded for future plant changes e.g. improved aero for higher efficiency/ capacity

Available options

- Inlet screens
- Inlet trip valves
- Surge control system
- Low hysteresis high cycle inlet guide vanes
- Cable trays or conduit
- Safe area or hazardous area location
- International code compliance (HPGSL, PED, etc.)
- Cryogenic performance testing
- Spare cartridge with nozzle assembly

Performance

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Rugged Rotor Design

Global Service Network: Expert Technicians for Commissioning and Support

Our aftermarket services extend beyond spare parts, offering comprehensive support for upgrades, retrofits, repairs, training, field services, warranty, and commissioning

Our factory-trained field representatives work alongside the engineers and technicians who originally designed, built, and tested your equipment.

Turboexpander Repair: At our Santa Ana, California factory, each unit is meticulously evaluated and restored to factory specifications, ensuring the lowest Total Cost of Ownership (TCO). Utilizing the same criteria, equipment, processes, and suppliers as new builds, we assemble & test all repaired units to make sure they meet original product specifications. Decades of experience guide our commitment to operational reliability.

Field Services & Commissioning: We ensure smooth installation and operation of your equipment. Our technicians offer remote support, pre-commissioning checklists, on-site support, and training to minimize start-up issues and ensure efficient commissioning activities.

Upgrades and Retrofits: Our engineering resources assess and implement necessary aero, process flow, and hardware adjustments for plant relocations or operational changes, maintaining peak performance and efficiency.

- Headquarters
- Authorized service centers

Air Liquide

Contact us

turboexpanders@airliquide.com

www.engineering.airliquide.com