GE
Oil & Gas

Turboexpander-Generators

For natural gas applications

GE has achieved a leadership position in the international oil and gas industry through constant improvements in the technology and effectiveness of its solutions. GE Global Research facilities in North America and in Europe develop breakthrough technology innovations, while GE Centers of Excellence, worldwide, put these advances to work on behalf of customers.

GE's Oil & Gas business is nearly unique in its ability to provide integrated solutions to every sector of the industry, from wellhead to consumer. This network of talented, dedicated people and resourceful innovators has been responsible for many of the most significant industry achievements over the past hundred years. The development of the turboexpander in the 1960s is just one example of the GE contribution to technological advancement in the oil and gas and related industries.

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Turboexpander-generators and the natural gas industry

The first turboexpander application for natural gas processing was accomplished using Rotoflow technology in Texas in the early 1960s. It dramatically demonstrated how efficiently the expansion turbine could condense heavier components of the gas stream, while at the same time providing power to re-compress the leaner gas.

Our current range of turboexpander-generators grew from that original application. Forty years later, close to 4,000 units are in operation around the world, and GE has proven, many times over, its ability to engineer machinery that delivers higher power levels, functions at extreme operating temperatures and achieves greater pressure ratios. Our turboexpander experience and technology have become invaluable resources for every segment of the natural gas and hydrocarbon industries.

The rapid growth of GE turboexpander technology has been a story of continuous improvement in expander design, rotor and bearing design, efficiency optimization and control systems. This growth has been driven by the needs of the industry to increase capacity, reduce costs and maximize reliability.

GE's Oil & Gas business is actively involved in the application of turboexpander-generator solutions for natural gas and related processes across a wide range of applications, including:

- Natural gas liquids letdown and liquefied petroleum gas recovery; ethane recovery
- Merging of pipelines with different pressures
- Hydrogen purification; recovery of heavier components from tail gas; power recovery from gas streams; geothermal power generation; ethylene production; gas-to-liquids production
- Integration of turboexpander-generators into industrial plant designs

A GE turboexpander test facility.

GE Center of Excellence for design and testing of turboexpanders

Global Services

Global Services provides expert installation, pre-commissioning and start-up services for new turboexpander installations. It also provides maintenance and repair services on a scheduled or on-call basis, and will convert, modify and upgrade machinery to meet changing production targets.

The Center of Excellence concept enables GE to deliver innovative solutions to its oil and gas customers worldwide, and to support them in their efforts to achieve the highest productivity and efficiency throughout the life of their GE equipment.

The GE Turboexpander Center of Excellence brings together specialists in design, manufacturing and testing to ensure continuing improvement in technology and to develop unique, application specific solutions to our customers' special needs. Close co-operation between customer contact teams familiar with the challenges and objectives of the industry segment they serve and design engineers who have an unmatched understanding of every aspect of turboexpander technology and operation, ensures our equipment will provide exceptional quality, reliability and long-term value to the user.

Advanced manufacturing resources

In order to achieve synergies of size and specialization, GE's Oil & Gas business has brought together manufacturing of a wide range of precision machinery at a new facility in Oshkosh, Wisconsin. Among products which benefit from this integrated approach are a broad range of compressors of many types as well as the full range of Rotoflow turboexpanders.

Advantages to users include faster turnaround, economies in costs through strategic sourcing, and a steady increase in quality and performance as Six Sigma, the quality control methodology used throughout the GE organization, is focused on eliminating defects and adding value to every product and service we offer.

Advanced testing procedures

Our modern test facilities provide us with the capabilities required to evaluate new concepts under development, validate new computer-aided design tools, and test products before they are shipped to customers. Our facilities enable us to perform full load tests and include feed gas preparation systems which allow us to test using virtually any gas mixture of interest to a customer.

Our test facilities are completely instrumented and furnished with real time data acquisition systems, integrated with analysis tools, to provide a complete map of the equipment's performance.

GE turboexpanders are normally tested with low pressure air in an open loop set-up in accordance with ASME PTC10, Class II/III. When required, our turboexpanders can also be tested at full load and speed with mixtures of nitrogen and helium to satisfy ASME PTC10, Class I, using our state-of-the art test facilities. In 2004, we performed a full load/speed test of a turboexpander along with a Nuovo Pignone compressor for a plant in Qatar.

Design and performance features

GE turboexpander-generators are designed to run continuously, day in and day out, year after year, in extreme conditions. There is no secret to their long life cycle. The basic design is simple, manufacturing is meticulous, testing is thorough, and throughout development the customer's need for reliability and ease of operation is our primary objective.

Innovative adjustable Inlet Guide Vanes

A unique, patented Inlet Guide Vane (IGV) controls the turboexpander gas flow in order to maintain high efficiency over a wide range of process conditions. The IGV entry angle varies to accommodate a wide range of flow rates.

Key benefits of the IGV control assembly are the elimination of blow-by, which reduces efficiency losses, and prevention of excessive clamping for smoother adjustment. In addition, the mainly rotational sliding motion of the adjusting ring is exceptionally precise.

A key element of the IGV system is the adjusting mechanism. A pneumatic or electric actuator with positioner gives precise control from 0 to 130% of the design flow. The use of separate rings for clamping and for positioning reduces friction and makes possible the ultra-precise and continuous adjustment of the IGV required in plants with digital DCS.

Reduced friction eliminates wear points and enables continuous and precise computer control of nozzle geometry.

Precisely balanced expander wheels

Our turboexpander wheels are milled to computer-generated profiles using advanced technology developed within GE for the manufacture of turbine parts. All wheels are dynamically balanced and are inspected using dye penetration techniques both before and after overspeed testing, to verify mechanical integrity.

Wheels are customized to ensure the highest possible performance in each specific application. Both open and closed configurations are available to achieve maximum efficiency. Materials (typically aluminum or titanium) are selected in accordance with the process and performance conditions.

GE turboexpander wheels are guaranteed to withstand any amount of liquid formation without erosion.

Seals for every kind of service

All our turboexpanders feature a unique patented expander wheel seal – a dust free seal – which prevents dust particles from collecting behind the expander wheel, where they can cause erosion.

Buffered conical labyrinth seals permit injection of a buffer gas between the labyrinths for maximum process gas containment and minimal oil contamination of the process gas. This type of seal is adjustable: the seal clearance can be maintained by adjusting the axial position of the seal.

Dynamic dry gas seals minimize buffer gas leakage. The dry gas seal can be applied in single, double or tandem configurations. This seal is recommended when leakage can be hazardous or costly and when process gas contamination by oil is undesirable.

Drainer seals mix seal gas and a small flow of bearing oil in a cavity behind the labyrinth seals. The patented drainers have the advantage of separating the oil/gas mixture in the drainer to minimize oil dilution and eliminate the need for external oil degassing tanks. The seal gas is vented and then recovered from the top of the drainer. The oil is returned to the oil reservoir.

Test rig uses holography to balance and fine-tune each turboexpander wheel.

Automatic thrust load control keeps rotor axially centered

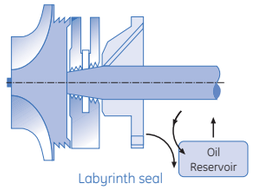
Variations in axial thrust can result in thrust overloads in turboexpanders. These axial overloads can be induced by the process, by off-design operation and by unforeseen transient process conditions. Patented thrust-load control systems in GE turboexpanders automatically compensate for these conditions and stabilize axial thrust.

Each thrust bearing is equipped with a pressure tap that senses the thrust load (see cutaway on this page). The pressure at each of the two opposing thrust bearings is monitored. If the two readings are out of balance a controller automatically adjusts the pressure behind the expander wheel and ensures that the rotor remains centered between the bearings at all times.

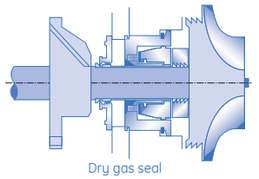
Patented oil lubricated bearings

Our patented combination journal and thrust bearings are used to support the expander shaft for expander-external gear arrangements. Compared with conventional tilting pad bearings this robust design provides increased allowance for wear and delivers nearly nine times greater oil spring strength. This exceptional stiffness ensures that there is no oil whirl (half-speed gyration) or oil film resonance over the entire operating range of speed and flow.

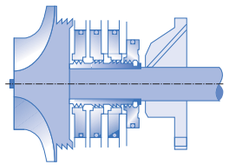
The spiral grooves on the thrust bearings produce a strong hydrodynamic effect for high load-bearing capability. The exceptional strength of the bearings reduces sensitivity to rotor imbalance caused by dust accumulation or wear, and increases the ability to withstand deposits on the wheels, such as ice or solid CO_2.



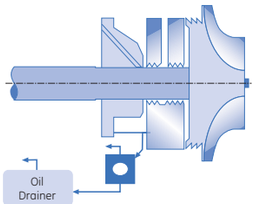
Labyrinth seal



Dry gas seal



Multiple labyrinth seal



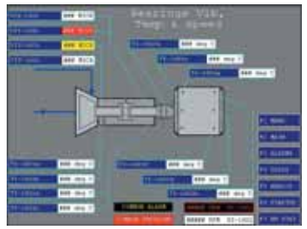
Labyrinth seal with oil drainer

Complete and user-friendly instrumentation and control

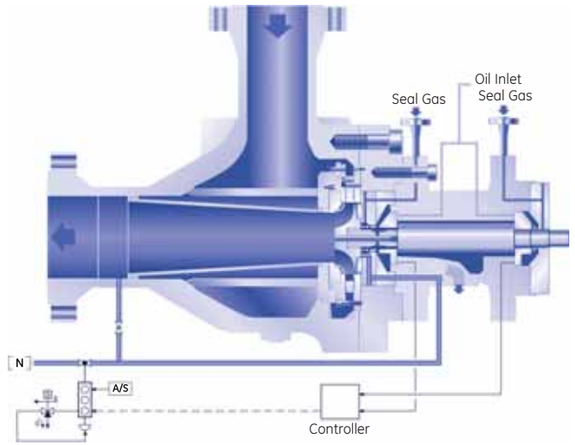
GE turboexpander-generators are equipped with integrated expander instrumentation systems and controls, in a compact package. All systems meet the highest industrial standards, and are fully compliant with the appropriate national and international statutory codes. Each system is customized according to the requirements of the application, and features protective controls.

Control packages are available with programmable logic control (PLC) systems, and with a human-machine interface (HMI) graphic display for greater ease of use. PLC control units may be mounted in free-standing cabinets or inside local gauge boards. They provide reliable indication of any fault occurring during the operation of a turboexpander and are approved for use in most electrically hazardous environments.

In addition, our control packages may be integrated with plant distributed control systems (DCS) at control levels from local to full integration. DCS ensures safe and reliable operation of the machine and allows for more intuitive operator control.



HMI Screen



Automatic thrust balancing system.

Standard configurations

Wide choice of turboexpander-generator configurations

The majority of applications for GE turboexpanders require the expander to be coupled to an electrical generator. There are two basic choices: with the generator mounted directly on the turbine shaft; or connection through speed reducing gears. An integral gearing option provides the additional benefit of multi-staging, allowing multiple expander stages to be mounted on a single gearbox. In most cases the turboexpander-generator unit can be completely skid-mounted to simplify transportation and reduce installation costs.

Direct drive

The direct drive option, when feasible, eliminates the need for speed reduction, gear boxes and associated equipment.

External gearbox

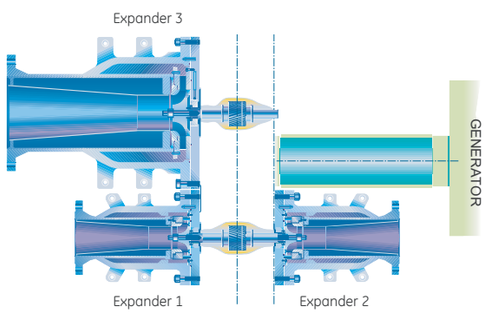
Expanders with an external gearbox feature GE patented bearings, with a common oil supply system for the complete package. The installed fleet ranges from 50 to 15,000 kW.

Integral gearbox

This arrangement, in use since the early 1970s, mounts the expander wheel directly on the high-speed pinion, eliminating the need for a high-speed coupling. Standard designs are available, up to 15,000 kW.

Multi-stage

High pressure ratios or high flow rates require the multi-stage arrangement. Standard expander-gear designs can accommodate up to four expanders on a common integral gearbox.



Multi-stage expander mounted on a single integral gear.

Expander-generator direct drive.

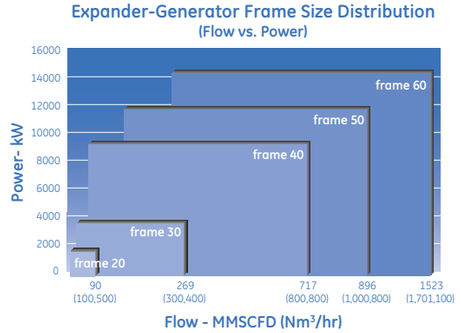
External gear configuration.

Integral gear configuration.

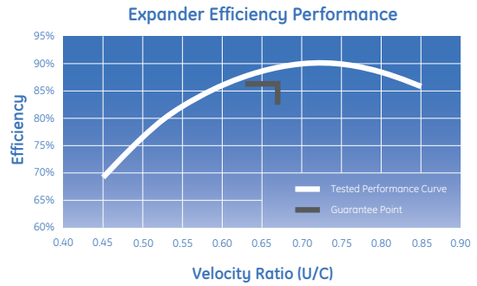
Multi-stage configuration.

Wide choice of turboexpander-generator configurations

A broad range of expander sizes is available to meet your process requirements for any turboexpander application. Wheels are designed to handle the entire flow range.



Frame sizes vary to give the best efficiency to cost ratio.



No negative tolerance on expander efficiency.

GE recently modified an axial turbine at a geothermal facility in the western US to a radial turboexpander.

Product range

GE's Turboexpander-generater product range	
Pressure	up to 3,000 psia (200 BarA)
Temperature	-450°F to 925°F (-270 °C to 500 °C)
Power	up to 20,000 hp (15,000 kW) per stage
Expansion ratio	up to 14
Process fluid	All pure or mixed fluids including natural gas, petrochemical products, hydrogen, air, steam, etc.

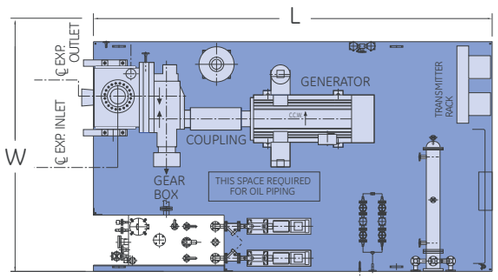
Machinery layout

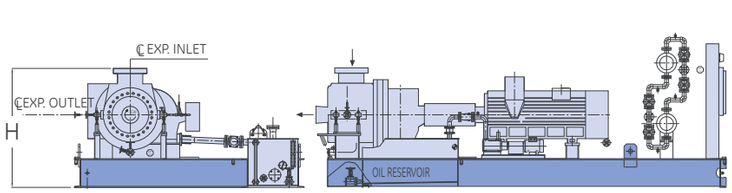
Standard turboexpander-generator skid dimensions and weights for our product range are presented here. Custom skid designs are also available.

Size and weights of integral gear equipment

Integral gear footprint of machinary layout for frame sizes 20, 30 and 40

Frame Size	Length		Width		Height		Weight	
	in	mm	in	mm	in	mm	lb	kg
20	250	6,350	144	3,658	120	3,048	36,000	16,364
30	250	6,350	144	3,658	120	3,048	41,000	18,637
40	250	6,350	144	3,658	120	3,048	46,000	20,910

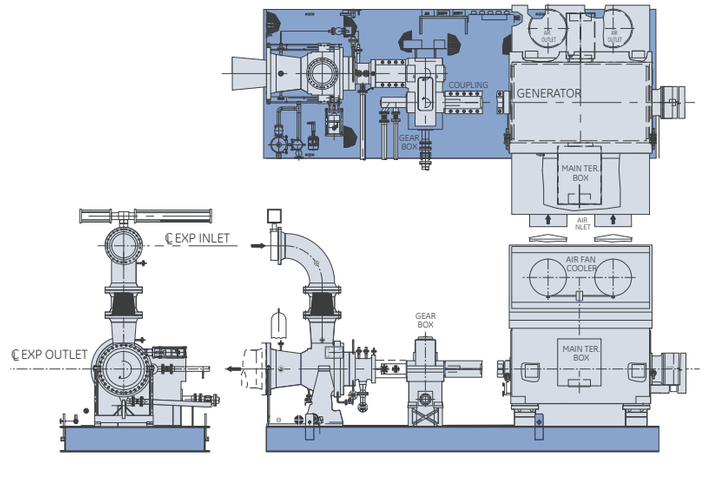




Size and weights of external gear for machinary skid

External gear footprint of machinary layout for frame sizes 50 and 60

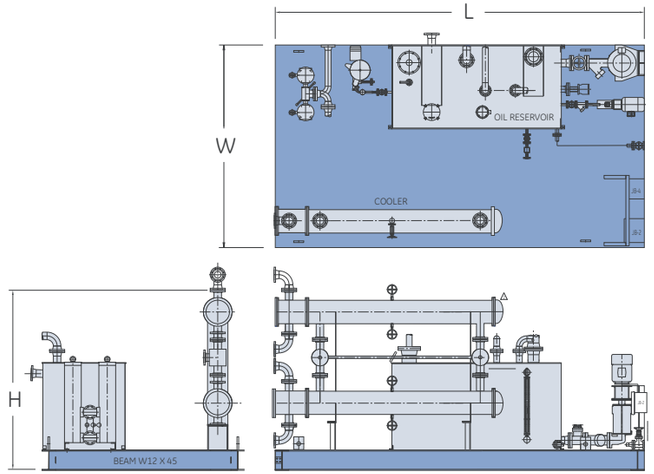
Frame Size	Length		Width		Height		Weight	
	in	mm	in	mm	in	mm	lb	kg
50	400	10,160	144	3,658	230	5,842	126,000	57,276
60	400	10,160	144	3,658	230	5,842	140,000	63,640



Size and weights of lube console for external gear

Lube console footprint for frame sizes 50 and 60

Frame Size	Length		Width		Height		Weight	
	in	mm	in	mm	in	mm	lb	kg
50	250	6,350	144	3,658	120	3,050	31,500	14,319
60	250	6,350	144	3,658	120	3,050	35,000	15,910



Energy recovery applications for turboexpander-generators

Wherever gas flows, a GE turboexpander-generator can carry out processing tasks while helping to recover energy.

Virtually any high-temperature or high-pressure gas is a potential resource for energy recovery. Generator-loaded expanders can be custom engineered to recover the maximum amount of useful energy available in the process.

In typical investment scenarios, the cost of the installation can be recovered within the first two years. Our expanders can make a significant contribution to the profitability of your operation by converting energy for use in the process, or for sale.

Waste heat

Waste heat can be converted to useful energy with a turboexpander-generator, alone or as a component in an Organic Rankine Cycle system. Potential heat sources include: tail gas from industrial furnaces or combustion engines, waste vapor from industrial furnaces or combustion engines, waste vapor from chemical and petrochemical processes, and solar heat from flat or parabolic reflectors. Exhaust gases are hot and may contain solvents or catalysts. An expander can not only recover energy and cool down exhaust gases which vent to the atmosphere, it can also separate solvents or catalysts.

Pressure letdown

In pressure letdown applications, such as the merging of two transmission pipelines at different pressures, or at the city gate of a gas distribution system, GE turboexpander-generators can safely reduce the pressure of large volume gas streams while at the same time recovering energy in the form of electric power. An expander can therefore be a profitable replacement for other pressure regulating equipment such as control valves and regulators.

Reliability and maintenance

GE turboexpanders are designed for long life and easy maintenance. Continuous operation with minimal maintenance and downtime is essential to an efficient and profitable process. Our dynamically balanced center section can be easily replaced or disassembled for inspection by operating personnel. This allows our customers to purchase a spare mechanical center section instead of an entire spare machine.

Conversions, Modifications and Uprates

In the process industry, it is undeniable that process conditions change over time. GE's Oil & Gas business can redesign expanders to perform optimally for current, projected and/or proposed operating conditions. Our Global Services personnel provide a wide range of Conversion, Modification and Uprate (CM&U) products and options including:

- Performance Upgrade
- Programmable Logic Control (PLC) Upgrade
- Automatic Thrust Balance of Turboexpander
- Conversion of Axial Flow Turbine to Radial Expander
- Dry Gas Seal Conversion

GE is rare among suppliers to the oil and gas industry in that we are a single-source supplier capable of providing integrated solutions to every segment of the industry.

When you choose GE turboexpanders for your processes, you initiate a continuing partnership that extends well beyond design, delivery and installation. Total life cycle quality management is fundamental to every project we undertake.

Located in Sicily, Italy, an Integrated Gasification Combined Cycle facility uses a GE Turbo-expander-Generator to reduce the fuel gas pressure into its gas turbines. At the same time it produces 10-MW of electricity by expanding 313 MMSCFD (350,000 Nm 3/hr).

A three stage expander mounted on a single integral gear. This natural gas pressure letdown application handles 68 MMSCFD (76,000 Nm 3/hr) and produces 5-MW of elecrical power.

A pressure letdown installation recovers 1,000,000 kWh/yr from a southern California, US municipal natural gas pipeline.

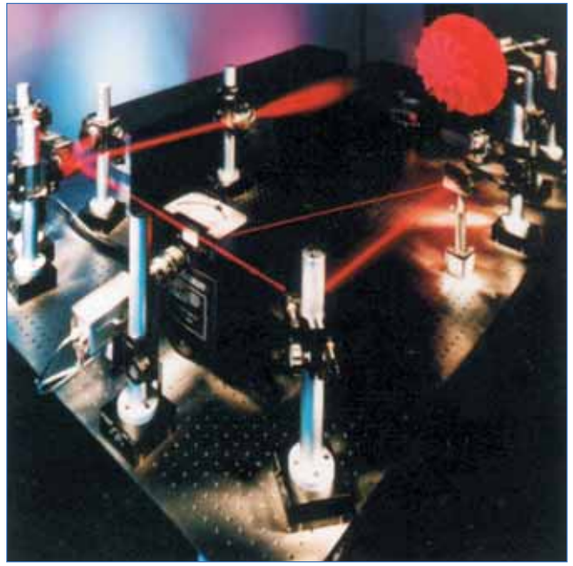
Integrated solutions for every segment of the industry

A project team will work with you through every stage of the engineering and manufacturing process. A Project Manager leads this team and becomes your advocate and your principal contact during engineering, manufacturing, delivery and commissioning.

The partnership does not end at startup. Through our Global Services team, your installation can be maintained in peak operating condition throughout its life cycle – and its operating life can often be extended through the installation of new technology designed to meet future processing and business challenges.

Global Services for turboexpander-generator owners:

- Service is available 24 hours a day, every day of the year, from local facilities.
- Experienced service personnel are continually updated on new products and techniques.
- Service Centers are always ready to analyze, evaluate and provide recommendations regarding your plant operation.
- Turboexpander Remote Monitoring and Diagnostics is available over the internet.
- Contractual Service Agreements allow you to ensure future performance at a fixed cost.



Laser holography machine.

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GE imagination at work