Contents

Centrifugal Compressors for Air and Process Gas 4
Compressor Components 6
Auxiliaries 9
General 10
Global Services 12
Air/CO₂ Compressors 13
Process Gas Compressors (Single Stage - Directly Driven) 14
Process Gas Compressors (Integrally Geared) 15
Steam Compressors 16
Installations 18
GE Oil & Gas started production of overhung-impeller centrifugal compressors (SRL) in 1966. The first unit with an integral gear was completed in 1979. With their simple, compact structure and excellent reliability, SRL compressors are especially suited to a wide range of heavy duty applications with air, steam and other gases such as those employed in the Petrochemical Industry. The high efficiency, reliability and operational flexibility of the SRL line of compressors is the result of the advanced centrifugal compressor design achieved through:

- extensive experience with machines in service all over the world
- continuous improvement of the aerodynamic and mechanical design
- use of sophisticated computer design codes
- advanced manufacturing processes
- innovative R&D programs.

Customers benefit from GE Oil & Gas’s advanced technology through improvement in plant productivity.

The custom-built compressors in this line are individually engineered to meet each customer’s specific needs using proven standardized components. SRL compressors combine the advantages of custom-built machines (maximum efficiency, layout flexibility, materials selection etc.) and standardization (proven, reliable components; availability of spare parts).

The SRL compressor series comes in a range of sizes. For each size the baseplate, gearbox, stage volutes, cooler shells, oil and gas piping, and auxiliaries are standardized. Machines can be produced to meet the individual requirements of each application through the appropriate selection of key design factors including:

- Number of stages
- Shaft rotational speed
- Diameter of impellers
- Exchange surface of coolers
Advantages of SRL Compressors

Simplicity of Installation
- Unit prepackaged and tested at factory
- No special foundations required

Superior Operation
- High efficiency and reliability
- High compression ratio
- Wide range of flow rate
- Optimum rotor balance for low vibration level

Advanced seal system options available
- Absence of lube oil in process gas

Ease of Maintenance
- Designed for maintainability
- Accessibility of components

SRL design options
- Single or multi-shaft models
- Direct or gear (integral or separate) driven
- Fixed or variable speed drivers (electric motor, steam or gas turbine, gas or diesel engine)
- Oil-free gas delivery system
- Automatic capacity control and safety system to reliably match any operating condition
- Auxiliary systems to meet international standards and customer specifications

Package concept

SRL compressors are usually mounted on a single base together with all auxiliaries such as oil pumps, oil reservoir and control instruments, and are delivered fully assembled and tested. Outstanding reliability, ruggedness, low installation and operating cost, plus ease of maintenance are the key features of these packages, which are especially designed for heavy-duty continuous service. The packages are usually installed outdoors and can be fully automated for remote control.

Compressor sizes

Casing sizes and number of impellers are indicated in the compressor designation by the digits following the compressor model. For example, SRL 808 is the designation for an eight-stage compressor, size 800. The letter D before the compressor designation indicates a double-flow configuration (DSRL).
Casings

Welded casings
Welded casings consist of the following parts:
- a scroll with the delivery nozzle in a tangential position
- an end cover that can be bolted either to a gearbox casing or to a shaft support (the end cover contains the seal area and all the vent / supply channels to the seal are drilled in the cover)
- a suction duct to guide the flow through the impeller’s leading edge
- a diaphragm that shrouds the impeller
- a discharge diffuser (vaneless or vaned).
The scroll is generally fixed to the end cover with a simple split locking ring that allows easy disassembly.

Forged casings
Forged casings are used for small diameter impellers and for high design pressures, and consist primarily of two pieces:
- a scroll (produced from a single forging)
- a diaphragm (with the dual function of suction duct and discharge diffuser).
The scroll can be bolted either to a gearbox casing or to a shaft support; it contains the seal area, and all the vent / supply channels to the seal are drilled in the casing.
The diaphragm shrouds the impeller, and the discharge diffuser (vaneless or vaneless type) is machined into it. The diaphragm is fixed to the scroll by means of bolts or for very high pressures with shear rings.

Fabricated casings
Fabricated casings are selected for large single impeller, directly driven compressors, and consist of the following parts:
- one external housing (with the delivery nozzle welded in a tangential position)
- two cover flanges (suction and driver side); the seal area, is contained in the driver side cover and all the vent / supply channels to the seal are drilled in the cover while the shaft support is overhung and bolted to the driver side cover
- a diaphragm that shrouds the impeller
- a suction duct that guides flow to the impeller’s leading edge
- a discharge diffuser (vaneless or vaned)
- an aerodynamic internal volute.

Cast casings
Cast casings are normally used for standard air and steam machines, but may also be adopted for low-pressure process gas applications. They consist of the following main components:
- a cast scroll
- an end cover that can be bolted either to a gearbox casing or to a shaft support
- a discharge diffuser (vaneless or vaneless)
- a suction duct
- a diaphragm that shrouds the impeller.
The scroll is generally fixed to the end flange with a simple split locking ring that allows easy disassembly.
**Inlet guide vanes**

The Inlet Guide Vane (IGV) system allows wide capacity control of the compressor with reduced energy losses. IGVs consist of a row of aerodynamically shaped blades placed at the inlet of the stage. The blades can rotate around their aerodynamic center in order to give the suction flow a pre-swirl that guarantees an optimum incidence angle with the impeller’s leading edge even at reduced flows, minimizing inlet losses.

**The discharge diffuser**

Vaned diffusers are used for high Mach number machines, in order to reduce the thermodynamic losses in the very high speed impeller exit flow.

**Impellers**

All impellers used in GE Oil & Gas centrifugal compressors come from a number of standard families. Each family contains a set of geometrically similar impellers with different flow coefficients to match flow requirements. All geometries have been tested in the company’s Research and Development laboratory. Each impeller is dynamically balanced and overspeed tested before assembly; the shafts are then dynamically re-balanced with the impeller mounted. GE Oil & Gas has acquired vast experience in manufacturing open and closed impellers with a large variety of materials such as carbon steel or stainless steels, materials to NACE requirements or special materials (super alloy).

**Shafts**

Unless the compressor is integrally geared, the shaft is machined from a single forging of 40NiCrMo7 (AISI 4340). The impeller can be overhung mounted at the end of the shaft by means of a frontal Hirth coupling, by a flange (for high speed applications), or hydraulically fitted with a tapered coupling. Thrust collars can be either replaceable or non-replaceable.
Integral gearbox

The integral gearbox consists of a bull gear and high speed pinions, with a single-helical gear mesh.

Casing: The gearbox casing is horizontally split. The lower part is fixed to the baseplate and the compressor stages are fixed to it. The gearbox casings can be either cast or fabricated.

Gear meshing: The gear unit can be rated in accordance with AGMA or with API Codes. The toothed portion of pinions is integrally forged with the shaft. The bull gear is shrunk on the low speed shaft.

Shafts: The shafts are sized to transmit the gear rated power within the stress limits of AGMA Codes. They are made of one-piece, heat treated forged or hot-rolled alloy steel, and the entire length of the shaft is machined. GE Oil & Gas will take complete responsibility for the lateral and torsional analysis of the entire train.

Radial bearings: The radial bearings are of the hydrodynamic fluid film, tilting-pad type for the high speed shaft and fixed profile type for the low speed shaft. The bearings are split for ease of assembly, equipped with anti-rotation pins and are firmly secured in the axial direction. The bearing design suppresses hydrodynamic instabilities and provides sufficient damping to limit rotor vibrations while the compressor is operating, loaded or unloaded at the specified operating speed.

Thrust bearings: The thrust bearings are designed for equal thrust capacity in both directions, and are sized for continuous operation under all specified conditions including all external forces transmitted by the couplings or by the gear mesh. The thrust bearings of high speed shafts can be the thrust collar type (standard for multi-stage compressors) or the tilting pad type for single impeller shafts with high axial thrust. Thrust bearings of low speed shafts are generally the hydrodynamic tapered land type (a tilting pad arrangement can be supplied on request).

Shaft arrangement

With Integrally Geared compressors, many shaft arrangements are possible in order to suit the required duty. In particular, the bull-gear can be driven directly by an electric motor (standard solution) or by a turbine (gas or steam); the number of pinions can vary (depending on the size of the stage casings) from one to four.
Auxiliaries

Lube oil system

A force-fed lube oil system ensures that the journal and thrust bearings are properly lubricated. The system can be designed either according to API 614 or to API 672 and is suitable for continuous compressor operation. It generally consists of:
- oil reservoir
- steam turbine or electric motor driven pumps (main pump can also be driven by compressor/gearbox low speed shaft)
- full-flow oil coolers
- twin oil filter allowing cartridges to be changed during operation
- automatic by-pass valve to control oil pressure at the bearing manifold
- monitoring and safety instrumentation. The lube oil console can be either on a separate skid or integrated on the main baseplate with the machine.

Dry gas seal system

The dry gas seal control system supplies filtered gas (either process or other clean gas) and nitrogen buffer gas to the dry gas seals at the correct pressure. The system is designed based on Nuovo Pignone’s extensive experience with this type of sealing system. It generally consists of:
- twin filters allowing cartridges to be changed during operation;
- control valves for adequate buffering of the seals
- monitoring and safety instrumentation. The seal gas system can be either on a separate console or integrated on the main baseplate with the machine.

Compressor control panel

The Control Panel implements the compressor start/stop sequence logic, alarm annunciator sequence logic, capacity control logic etc. The PLC is programmed prior to shipment and includes a serial communication interface RS422, with Modbus protocol, for connection to a supervision and control system (i.e., DCS, PC, telemaintenance etc.). The Control Panel front includes a video terminal connected to the PLC, which provides the following functions, organized in pages:
- top level diagram
- unit controls to start / stop and control the compressor, auxiliary motors and heaters (with status display)
- process data monitoring (pressure, temperature, level)
- alarm display
- shutdown display
- surge controller monitoring
- hour meter
- event recorder.

If field instrumentation includes analogue signals from pressure and temperature transmitters, the operator interface can perform additional functions:
- operating parameter display
- PLC set point adjustment
- trend recording of process data.

The compressor vibration monitoring system is also located on the Control Panel.
General

Operation control

The following methods are available to control flow and suction or discharge pressures under varying process conditions:

**Compressor speed variation**: this method is utilized when a compressor is driven by a variable speed driver.

**Discharge throttling**: a valve is fitted in the discharge piping so that pressure at the compressor outlet nozzle may increase while maintaining the normal value downstream of the valve.

**Suction throttling**: a valve is fitted in the suction piping so that suction or discharge pressure can be regulated according to the process requirements.

**Adjustable inlet guide vanes**: these vanes alter the gas flow direction, as it enters the impeller, thus varying the pressure ratio and flow of the compressor. These guide vanes can be placed before each compression stage.

Anti-surge protection and process control

Anti-surge control algorithms implemented within the integrated control system are based on the knowledge acquired through our expertise as a leading compressor manufacturer and experience on thousands of applications. Different control strategies are available to meet the needs of the application. All provide both closed and open loop controls to better react to small and large process disturbances. Different process control and load bearing functions can be provided.

Dynamic simulation

Dynamic simulations ranging from a single loop to a more complete process configuration are possible to define anti-surge valves, hot by-pass requirements, piping optimization for improved compressor protection and starting conditions for electric motor drives.

Test facilities

Centrifugal compressors are carefully tested throughout the manufacturing process in order to guarantee a perfect match to their design criteria and to assure long lasting, continuous operation.

The following tests are typically carried out on components and assembled machines:

- casing: hydraulic pressure test
- impellers: ultrasonic and dye penetrant liquid tests; over speed testing
- impellers/rotors: over-speed testing
- mechanical run test

Optional tests may be performed based on the specific job requirements. For example:

- performance tests (with air or other gases in an open or closed loop)
- full load - performance tests (including flammable gases) to check rotor stability and the performance of the machine
- mechanical string test.

Numerous indoor and outdoor test beds together with a sophisticated system for data acquisition and processing of test results distinguish the Florence, Massa and Le Creusot facilities. We have the largest and most complete testing facilities.
capability in the industry to perform tests under actual load and pressure conditions (including LNG and re-injection) for trains driven by gas turbines or electric motors.

**Research and development**

Research and Development plays an important role in GE Oil & Gas’s strategies and therefore receives substantial resources. One of the main objectives is continuous updating and improvement of existing products, to extend the state-of-art in the company’s traditional markets (e.g. natural gas, fertilizers, methanol, refining and chemical industries in general). New products are developed driven by customer needs in applications that fit within GE Oil & Gas’s business strategy and expertise. Research on centrifugal compressors accounts for a substantial portion of the company’s total research activity. GE Oil & Gas’s test laboratory is equipped with a number of advanced test facilities both for developing and tuning major compressor components (stages, seals, bearings) and for performing all kinds of stress, vibration and rotor dynamic investigations. Besides testing, continuous effort is dedicated to development and improvement of analytical tools used in the fluid dynamic, structural and rotor dynamic design of components and complete compressors. Many years of analytical and experimental research work on components has led to establishing a wide selection of standardized stages, each individually tested and tuned and application engineering tools that provide maximum reliability in performance prediction in all applications. Advanced knowledge of non-stationary flow phenomena and high speed rotor dynamics has led to the unsurpassed reliability and availability of these machines.

**Quality assurance**

The GE Oil & Gas Quality Assurance group is centered in Florence and has a staff of over 60 people stationed throughout the company’s plants. One of the fundamental duties of the group is the development of quality standards and assistance in the correct application of all quality assurance processes in all product development, manufacturing and testing operations. Special laboratories certified by Sinal, are equipped for measuring mechanical properties, chemical and optical emission spectrometric analyses, fatigue tests and macro and micrographic examinations (scanning electron microscopy). A calibration room certified by SIT for checking and calibrating lengths, forces and temperatures is also available. GE Oil & Gas’s Quality Assurance System has been certified to meet ISO 9001 standards for design, manufacture, installation and after-sales service of centrifugal compressors, centrifugal pumps, reciprocating compressors, gas and steam turbines, gas expanders, heat exchangers and pressure vessels by Lloyd’s Register Quality Assurance Ltd., one of the most authoritative international certification organizations.
Global Services

Customer service

GE’s Oil & Gas business provides a complete set of services to support the entire centrifugal and axial compressor product line. We offer an extensive portfolio of proactive and interactive service products such as condition-based maintenance, Conversions, Modifications and Uprates (CM&Us) and Contractual Service Agreements (CSAs) complementing the traditional service offerings of OEM spare parts, repairs and field services. Our innovations are not limited to mechanical engineering. We have developed business solutions such as remote monitoring and diagnostics to help drive customer value by providing higher equipment reliability, availability and productivity at a predictable cost.

Other advanced information-based developments include electronic parts catalogs and ecommerce solutions. Global Services engineers are backed up by our new product design engineering groups and by the GE Global Research Center - hundreds of creative minds working to provide the high-tech products and business solutions for the 21st century.
Air/CO$_2$ Compressors

General

These compressors are used in air separation, synthetic fiber and fertilizer plants as main process gas compressors and in all industrial plants as service air compressors, and for the compression of CO$_2$ in CCS/EOR applications.

Technical data

The inlet flow for such machines can vary from 10,000 to 200,000 m$^3$/h (6,000 to 120,000 cfm), with a max. discharge pressure of up to 200 bar (2900 psi).

Main characteristics

These compressors are generally multi-shaft, integrally geared type, single or multi-stage (up to 8 stages). Compressors are modularized in order to meet varying customer needs. High compression efficiencies are achieved by using 3-D impellers especially designed for this service. Inlet Guide Vanes are available for each compression stage, permitting extremely large compressor turndown with high efficiencies throughout the range. Seals are generally labyrinth type (single, dry gas type for last stages of high pressure applications). Multi-stage compressors are equipped with inter-coolers with an integral condensed water separator.

Drivers

Drivers for this type of compressor are generally electric motors, but it is also possible to use steam and gas turbines (either as a direct driver or through an intermediate gearbox).

Package arrangement

In multi-stage compressors, coolers are located below the compressor in order to obtain a very compact arrangement of the unit. The lube oil system is supplied separately; the main lube oil pump can be either shaft driven or electric motor driven.

Applicable codes and standards

Compressors may be designed either according to API 617 or API 672, or customized to the customer’s specific requirements.
Process Gas Compressors
(Single Stage - Directly Driven)

General
This type of compressor is mainly used as a booster in petrochemical applications, or a recycle compressor in polypropylene and polyethylene plants. Axial inlet flow guarantees an optimum aerodynamic design, and therefore very high efficiency. Due to their rugged mechanical design, this type of machine guarantees very high reliability. Almost all gases can be handled by this type of compressor with appropriate construction materials and seal systems.

Technical data
Flows can vary from 5,000 to 120,000 m³/h (3,000 to 70,000 cfm), with discharge pressure up to 50 bar (730 psi).

Main characteristics
Several configurations are available to cover all applications of this type of machine. Impellers are 3-D, backswep, semi-open or closed type, overhung mounted on the shaft. The thrust bearing is located between the two journal bearings and is of the tilting-pad type. A special design, with internal spiral volutes (to avoid any dead-point in the flow), is available for process gas that may polymerize during operation (for example in polypropylene and polyethylene plants). Inlet Guide Vanes are available for fixed-speed units, in order to increase the operating range of the compressor while maintaining high efficiency. Seals can be dry gas, mechanical oil or labyrinth type, depending on the service requirements.

Drivers
This type of unit can be driven either by an electric motor (directly coupled or via an external gearbox to increase speed), or by a steam or a gas turbine (directly coupled or via an external gearbox to increase or decrease speed).

Package arrangement
The baseplate generally accommodates both the compressor and its driver. The lube oil system can be either integrated with the main machine baseplate or manufactured as a separate console.

Applicable codes and standards
Generally designed according to API 617, or customized to customer’s specific needs.
Process Gas Compressors
(Integrally Geared)

General
This type of compressor is used in several petrochemical applications, either for low-flow/high pressure applications, or for high-flow/low pressure applications. The multi-shaft configuration allows frequent intercooling, and therefore a better compression efficiency compared to traditional in-line centrifugal compressors. Axial inlet flow guarantees an optimum aerodynamic design, and therefore very high stage efficiency. Due to its rugged mechanical design, this type of machine guarantees very high reliability. Almost all types of gases can be handled by this compressor design with appropriate construction materials and seal systems.

Technical data
Flows can vary from 500 to 50,000 m³/h (300 to 30,000 cfm), with discharge pressure up to 100 bar (1,500 psi).

Main characteristics
Several configurations are available to cover all applications for this type of machine. Impellers are 3-D or 2-D, backsweped semi-open or closed type, overhung mounted on the shaft. The thrust bearing is located on the pinion shaft and is of the thrust collar type. The journal bearings of the pinions are the tilting-pad type. Inlet Guide Vanes are available to increase the operating range of the compressor with a low decrease in efficiency. Seals can be of the dry gas, mechanical oil or labyrinth type, depending on the service requirements.

Drivers
This type of unit can be driven either by an electric motor (directly coupled or via an external gearbox to increase speed), or by a steam or a gas turbine (directly coupled or via an external gearbox to increase or decrease speed).

Package arrangement
The baseplate generally accommodates both the compressor and its driver. The lube oil system can be either integrated with the main machine baseplate or manufactured as a separate console.

Applicable codes and standards
Generally designed according to API 617, or customized to Customer’s specific requirements.
Steam Compressors

General
Rising energy costs have led to a demand for high efficiency machines for energy recovery. Steam compressors are employed in various sectors, such as the agriculture-food industry, chemical industry, paper industry and desalination plants. Another application of SRL compressors is in geothermal power stations to extract non-condensable gases from the steam turbine condensator.

Technical data
Flows can vary from 5,000 to 250,000 m³/h (3,000 to 150,000 cfm), with discharge pressure up to 10 bar (150 psi).

Main characteristics
Steam compressors are of the integrally geared type, single or multi-stage (up to 6 stages) machines. The compressors are modularized, for flexibility in meeting customer requirements. High pressure ratios together with high compression efficiencies are reached by using 3-D open impellers specially designed for this service. Inlet Guide Vanes are available for each compression stage to provide a large turndown for the compressor with high efficiencies throughout the range. Labyrinth type seals are always used.

Drivers
Drivers for this type of compressor can be either electric motors, or steam turbines (as a direct driver).

Package arrangement
The baseplate generally accommodates both the compressor and its driver. The lube oil system can be either integrated with the main machine baseplate or manufactured as a separate console.
Installations

**SRL 601**
- PROJECT: EO/EG PLANT
- CUSTOMER: PRALCA
- COUNTRY: VENEZUELA
- SERVICE: RECYCLE FOR EO/EG PLANT

**SRL 454**
- PROJECT: H-OIL
- CUSTOMER: PEMEX
- COUNTRY: MEXICO
- SERVICE: PSA TAIL GAS

**SRL 601**
- PROJECT: COPOLIMEROS
- CUSTOMER: REPSOL QUIMICA S.A.
- COUNTRY: SPAIN
- SERVICE: POLYPROPYLENE PLANT RECYCLE

**SRL 603**
- PROJECT: GEEL NO.3 PTA
- CUSTOMER: AMOCO
- COUNTRY: BELGIUM
- SERVICE: OFF-GAS COMPRESSOR

**SRL 801**
- PROJECT: ACIDE NITRIQUE
- CUSTOMER: ENG. D’AMBES
- COUNTRY: FRANCE
- SERVICE: NITRIC ACID PLANT

**SRL 903**
- PROJECT: MONTEVERDI 2 GEOTHERMAL POWER STATION
- CUSTOMER: ENEL
- COUNTRY: ITALY
- SERVICE: GEOTHERMAL POWER STATION
SRL 454
- PROJECT: CAPROLACTAM
- CUSTOMER: SINOPEC
- COUNTRY: CHINA
- SERVICE: PROCESS AIR

SRL 603 AND SRL 453
- PROJECT: STEEL PLANT – AIR SERVICE
- CUSTOMER: ITALIMPIANTI
- COUNTRY: IRAN
- SERVICE: AIR FRACTION

44 EM + SRL (FROM SRL 251 TO SRL 254)
- PROJECT: ZUBAIR GAS PROJECT - PHASE II
- CUSTOMER: STATE COMPANY FOR OIL PROJECTS (SCOP)
- COUNTRY: IRAQ
- SERVICE: GAS GATHERING

2 SRL 801
- PROJECT: TIANJIN ETHYLENE
- CUSTOMER: SINOPEC TIANJIN PETROCHEMICAL CORPORATION
- COUNTRY: CHINA
- SERVICE: RECYCLE - ETHYLENE OXIDE

6 SRL251
- PROJECT: JBEL ALI
- CUSTOMER: ENEL POWER FOR DUBAI ELECTRICITY & WATER AUTHORITY
- COUNTRY: DUBAI
- SERVICE: FUEL GAS COMPRESSOR

SRL 806
- PROJECT: GT DEVELOPMENT LAB. AIR
- CUSTOMER: GENERAL ELECTRIC
- COUNTRY: CINCINNATI (OHIO)
- SERVICE: AIR