**Compressor** – Meets the demands for high efficiency and maximum regulating range. Electric linear actuators precisely move the inlet guide vanes and variable diffuser vanes to automatically and continuously optimize efficiency and vary flow.

**Gearbox** – Speed increasing gearbox is integral with the compressor.

**Driver** – Compressors can be driven by electric motors, internal combustion engines, or steam turbines.

**Coupling and OSHA Guard** – Torsional analysis dictates the type of coupling to provide the longest life with lowest maintenance.

**Base/Oil Reservoir** – The compressor/gearbox, driver, and oil lube system are mounted on a common, rigid base. Lube oil reservoir is integral within the base.

**Lube Oil System** – Electric and mechanical oil pumps, oil/water cooler, oil filters, and piping are skid mounted.

**Inlet Filter/Silencer** – Two-stage filter provides maximum filtration to protect downstream underwater air diffusers.

**Valves** – A variety of isolation and performance-enhancing valves can be provided with any Turblex system.

**Local Control Panel** – Designed for monitoring and controlling Turblex compressors. The panel can be skid or remote mounted.

**Instrumentation** – Tailored to customer requirements and comes factory pre-wired to the control panel.

**Isolation Mounts** – Isolates the compressor from the floor.
THE TURBLEX ADVANTAGE

The Turblex single-stage, integrally-geared compressor is the world’s most efficient. With thousands of units operating worldwide, it has developed an unparalleled record of long-term reliability and maintenance-free performance. In fact, the Turblex single-stage compressor is so efficient that most older compressor installations can be replaced by Turblex units with the cost of replacement recovered in a few short years by power savings.

- Variable flow with turndown to 45% (or less) at constant speed.
- Highest efficiency is automatically and continuously maintained over the entire turndown range, including off-design ambient temperatures and pressures where units most often operate.
- High-quality bearing construction results in exceptionally long life with minimal maintenance.
- Guaranteed oil-free air delivery.
- Compact design saves floor space and facilitates the replacement of older, less efficient compressors.

ADVANTAGES AND CAPACITY

fig. 2: Air capacity vs. differential pressure

HIGH CAPACITY COMPRESSORS

Compressor air requirements that exceed 60,000 scfm per unit employ “large unit construction” with enhanced support structure for the larger volute casing. Depending on capacity and size, the unit may be fitted with an integral or separate gearbox.

fig. 3: Capacity of this integrally geared unit is 140,000 scfm, 10.4 psig, 7,000 Hp motor.

fig. 4: Operating in a sulfur recovery process, this separate gearbox unit produces 200,000 scfm, 7.7 psig, 7,500 Hp.
AERODYNAMIC DESIGN

All components in the air stream are aerodynamically designed to minimize turbulence, thus streamlining flow through the compressor.

fig. 5 (below): The aerodynamically designed concentric (annular) air inlet cavity decreases in cross-sectional area as air approaches the impeller. In concert with the variable inlet guide vanes (IGV), this geometry creates a "whirlwind" effect, pre-rotating and uniformly accelerating the air approaching the impeller.

fig. 6: Inlet air is continuously and automatically pre-rotated by 13 to 24 non-symmetrical airfoils, arranged radially around the concentric inlet, thus maximizing efficiency throughout the operational range. The vanes are supported at both ends, an unusually strong and long-lasting configuration.

Variable Inlet Guide Vanes

fig. 7: Turblex impellers are milled from solid, forged billets of the highest grade aircraft alloy, using five axis, numerically-controlled milling machines. The exact impeller shape is determined from a computerized database of thousands of previously tested compressors and ongoing aerodynamic design improvements. Thus, each new impeller incorporates all previous test data, ever-increasing the overall efficiency.

Variable Diffusers

fig. 9: Flow control is achieved by adjusting 17 to 21 non-symmetrical airfoil shaped diffuser vanes (VD), arranged radially around the periphery (discharge side) of the impeller.
PERFORMANCE SUPERIORITY

Figure 10 illustrates the unusually efficient output of the Turblex compressor. A unique “dual-point control” operational model combines the efficiency optimizing inlet guide vanes (IGV) with a set of variable diffuser vanes (VD). These dual vanes simultaneously and continuously modulate. An algorithm, contained in the programmable logic controller (PLC) of the local control panel (LCP), is responsible for directing modulation of these variable vanes, based on changes in inlet temperature, differential pressure, and discharge capacity. These are the three variables that affect machine efficiency.

As illustrated in figure 11, the Turblex dual vane compressor has a performance curve (red lines) that is very steep (almost vertical) and backward leaning as pressure rises to surge. Only small changes in capacity occur as pressure changes. This is an important advantage, especially in process applications where the same mass flow of air is required over wide pressure changes [e.g. sequencing batch reactors (SBR)]. Secondly, the dual vane surge curve is almost flat across the entire turndown range of 100-45%. This provides very stable control at highest efficiency across the entire turndown.

![Performance Curves](image)

fig. 10: Efficiencies of various blowers/compressors. Dashed curve illustrates where turndown may be limited.

fig. 11: Performance curves for the same application using inlet guide vane or inlet butterfly valve capacity control (blue lines) are compared to a Turblex dual vane unit (red lines). In this case, the end-user required operation to 37% of maximum capacity. The inlet guide vane unit would have been required to blow-off air to avoid surging in the lower range (to the left of Point 1). The Turblex unit was not only able to turn down to this low volume, but was more efficient over the entire turn-down range.
INTEGRAL GEARBOXES

Speed increasing gearbox selection depends on the compressor capacity, horsepower, and type of driver. All Turblex gearboxes share similar heavy-duty design features for unusually long and maintenance-free operation.

- AGMA gear quality of 12 or better
- Multi-point, non-contact labyrinth seals
- Service factor of, at least, 1.8
- Cast iron housing ASTM A48 Class 30B

Turblex units have air/oil shaft seals that incorporate an aluminum alloy labyrinth with multiple slinger rings (diameter changes) on the shaft that guarantees 100% oil-free air.

fig. 13: Model GL gearboxes are vertically split. The fast shaft and overhung impeller operate between the first and second critical speeds. An inspection plate allows gearbox inspection without disassembly.

fig. 14: The heaviest duty GL500 horizontally split gearbox operates below the first critical speed and features a double helical “herringbone” gear.

fig. 15: Model GK gearboxes incorporate economical roller bearing design. The smaller KA2 unit is splash-oil lubricated and air-cooled via fins on the casing. The KA5 and KA10 units use a shaft-driven oil pump and external cooler. All GK models have a small oil reservoir internal to the gearbox.

fig. 16: Model GL gearboxes use the highest quality hydrodynamic lubricated journal bearings for longer life and minimum vibration. Bearings are constructed of bronze, which results in cooler running bearings and lower maintenance costs. Steel backed bearings are optionally available.

fig. 17: The Model GK gearbox design incorporates silicon nitride rolling element bearing construction, thus maximizing hardness and minimizing friction, deflection, and thermal growth.
SKID MOUNTED LUBRICATION SYSTEM
Pressure oil lubricated journal and thrust bearings operate with an oil film between the bearing surface and the shaft. This prevents “metal to metal” contact and produces an almost infinite bearing life. Lube oil is pumped from the integral oil reservoir in the skid base through the air or water-cooled oil cooler. The lube oil then passes through an oil filter and into the gearbox bearings. After cooling and lubricating the bearings, oil drains back into the oil reservoir through an opening in the bottom of the gearbox.

SOUND ATTENUATION PACKAGES
Turblex offers several sound attenuation options:

Option 1: 93-95 dB(A)
- Acoustically “soft” room
- Outlet pipe velocity less than 4,000 ft/min (20 m/s)
- Sound lag air piping
- Turblex inlet filter silencer
- Turblex discharge cone silencer
- Quiet duty motor

Option 2: 89-93 dB(A)
Option 1, plus a sound blanket around the compressor/gearbox and a quiet duty motor.

Option 3: 80-85 dB(A)
Option 1, plus an acoustical enclosure around the entire skid.

Sound attenuation of a compressor installation is greatly impacted by the in situ environment. For example, inlet and discharge piping design can especially affect the sound level of an installed system. Turblex can offer a variety of tools to assist the design engineer including piping layout options and technical papers on construction techniques to reduce noise emission.
ACCESSORIES

ACCESSORIZE FOR A PURPOSE

Careful selection of accessories and aerodynamic piping design yields even greater energy savings of the entire package.

Inlet Filter/Silencer – A Turblex inlet filter/silencer connects directly to the compressor inlet, which eliminates the inlet piping. This reduces sound levels, inlet piping pressure loss, and greatly facilitates air filter replacement.

Discharge Cone/Silencer – The Turblex discharge cone/silencer (Evase’ stack) completes the conversion of velocity to pressure energy in the most efficient manner possible. Fitted with acoustical packing on the inside wall, it also provides sound attenuation at the direct compressor outlet.

Blow-off Valve and Silencer – Electrically operated butterfly valve and silencer is open when the compressor is off-line, and pulses closed after start-up to gently bring the compressor on-line, thus minimizing power on start-up.

Discharge Check Valve – Used for prevention of reverse air flow, this valve is important for smooth start-up, being gradually pushed open, as the compressor comes on-line and builds up pressure.

Discharge Valve – Used for isolation and prevention of reverse air flow while off-line, this electrically operated valve is closed while off-line and opens during compressor start-up.

Flex Connectors – Inlet and discharge flex connectors isolate vibration and unbalanced loads from the compressor casing.
**THINKING INSIDE THE BOX**

The Turblex containerized compressor is a modularized, self-contained unit. Set in place, connect the electrical and the discharge piping, and that’s it; no compressor building, no installation. The expense of a “brick and mortar” compressor building is eliminated. It can even be set next to the aeration cells to minimize large diameter main air header piping.

All accessory components are furnished by Turblex to minimize jobsite construction and installation labor. The compressor local control panel (LCP), conveniently positioned inside the container, is wired to all skidded instruments. The main drive motor starter may also be provided and wired inside the container.

**Container Construction** – Is similar to a standard shipping container except all walls and floors are acoustically insulated. This results in sound levels in the low 80’s, five feet from the exterior.

**Local Controls and Instruments** – The LCP is mounted inside the container. An optional ‘slave’ operator interface on the outside wall allows compressor monitoring and adjustment without entering the container. Safety monitoring instruments are conveniently mounted on the skid and located for ease of access, calibration, and observation.

Inlet Filter/Silencer – A louversed container door protects the compressor air inlet from blowing rain and snow. Inlet air then passes across the two-stage inlet filters, the inlet silencer, and into the blower inlet. Access doors on the sides of the filter box allow easy removal and replacement of the $2 \times 2$ ft. panel filters.

**Other accessories** – The electric operated blow-off and discharge butterfly valves, air discharge cone/silencer, discharge check valve, blow-off silencer, and flex connectors are shipped loose for integration into the contractor-installed discharge air piping.
INSTRUMENTATION AND CONTROLS

Turblex compressors are provided with safeguards and monitors for long-term, trouble free operation. Other instruments are available to monitor compressor operation and include vibration and bearing temperature monitors that are generally used on larger units. Maintenance status monitors are available for inlet air filters, oil filters, oil reservoir level, and reverse rotation. In fact, Turblex engineers excel at providing custom-instrumented systems to meet specific end user requirements.

CUSTOMIZED LOCAL CONTROLS PANELS

The LCP with integral programmable logic controller (PLC) is generally mounted on the skid with factory wiring of instruments. If the LCP is remote (freestanding), instruments are factory wired to skid-mounted junction boxes. All signals are available for interface with upstream plant process computer systems, and include the following functions:

Start/Stop – Local or remote (automatic) control in accordance with a specific start-up/shutdown sequence.

Monitor of Safeguards – Alarm of any safety monitor will cause shutdown either on soft stop or emergency (immediate) shutdown. A soft stop allows the blow-off valve to partially open before shutdown, minimizing surge.

Efficiency Optimization – Aerodynamic flow through the compressor is optimized to obtain the lowest possible power consumption with changing compressor capacity, ambient temperature, or differential pressure. The PLC contains efficiency optimization software that simultaneously and continuously modulates the diffuser vanes and the inlet guide vanes as these three variables change.

Operator Interface Screen Monitor – Advanced visual graphics are displayed on a touch sensitive, full-color screen.

fig. 25: Typical skid-mounted local control panel with touch-sensitive operator interface (OI). All Turblex control panels incorporate customer specified PLCs and OIs.

fig. 26: Operating screens are customized for each project.

MASTER CONTROL PANEL (MCP)

The MCP is the heart of the entire aeration system and houses the job specific and custom designed operating software. The MCP performs many functions, including the three major control loops that optimize performance.

- Air Header Pressure Control – Regulates the on-line air compressor volume based on an air header set-point.

- Process Variable Control – This loop within a loop, fine tunes each air flow set point, thus feeding the proper volume of air to each aeration cell.

- Most Open Valve Control – Maintains the air flow control valves in their most open position, ensuring the lowest overall system pressure.

Other functions performed by the MCP include:

- Lead-lag compressor selection
- Air header blow-off valve algorithm
- System time delays
- Setpoint intervals
- System data acquisition and monitoring
- Data transmission to plant computer
THE COMPLETE SYSTEM

A Turblex supplied air delivery system offers the design engineer an opportunity to maximize efficiency of the overall system by operating at the lowest air header pressure and the minimum air volume to meet process oxygen demand.

The air delivery system, designed to operate as an integrated cost savings system, consists of:

Air Flow Control Valves – Modulating air flow control valves must be properly sized to operate between about 20% and 80% open.

Air Flow Meters – Used to control air flow to each aerated zone.

Dissolved Oxygen (DO) Probes – The process monitor is generally dissolved oxygen and must be reliable and long lasting.

Main Air Header Blow-off Valve – Start-up (evacuation of water in aeration piping) and optimization are facilitated by use of this valve. With an appropriate algorithm in the MCP, overall system surge can be virtually eliminated.

Piping – Using conservative piping air velocities and low pressure drop piping components minimizes air header noise and pressure drop. Turblex facilitates overall aeration piping layout by saving space and materials with optimum aerodynamic piping design.

Single point responsibility by Turblex will ensure that the entire aeration system is supplied with the properly sized components. The system is then placed on line by Turblex, and optimized to maximize efficiency with minimal operator attention.

fig. 27: Complete Aeration System Diagram
W O U L D  Y O U  C A R E  F O R  A N  U P G R A D E ?

The upgrade of aging aeration systems is a Turblex specialty. No other company matches our expertise when it comes to taking on this difficult task. Several alternatives are available and the proper choice rests with the end-user’s desires, the cost of upgrade, and operating cost savings.

Retrofit Instrumentation and Controls – Aging centrifugal compressors may be mechanically functional, but valves, instrumentation, controls, and oil lube systems need upgrade/replacement. Turblex will visit the jobsite, inventory the compressors, and make recommendations for the upgrade/replacement of the LCP, instruments and ancillary equipment.

Reuse or Replacement of Existing Compressors – A new Turblex single-stage is provided, then one or two existing units are upgraded for use as standby compressors as well as for peak demand periods.

Retrofit Existing Compressor Buildings – Because the Turblex units have a smaller footprint than comparable equipment, our engineering staff is experienced in custom designing single-stage compressors to retrofit existing compressor buildings with minimal piping modifications.

H Y B R I D  C O M P R E S S O R  S O L U T I O N S

In some cases, a combination of different types of compressor technologies may be most economical. A multi-stage, with a lower first cost, albeit less efficient, is “base loaded” or used as the standby (spare) compressor. That is, the multi-stage, when needed, is run at 100% capacity, where it is most efficient and the Turblex single-stage compressor then varies capacity to meet demand.
Quality Control and Testing

Turblex ISO 9001-2000 quality assurance procedures and the customer’s own requirements, combine to form the basis of a rigorous inspection/test program. With efficiency being a key advantage of the Turblex single-stage compressor, only the most complete and detailed test program will suffice to prove performance on the test stand. Likewise, the aeration system, as a whole, will only accomplish peak power savings if it is designed, tested, and operated as one combined system. Major milestones of quality assurance and testing the entire aeration system include:

- Torsional and Lateral Critical Speed Analysis.
- Compressor Performance Tests – Per ASME PTC-10.
- Completed Assembly Tests – Functional testing of all components including blow-off and air valves, connected to the LCP.

Our commitment to quality assurance, with testing of the entire system, ensures the most efficient and trouble-free installation.

Service and Spare Parts

Turblex compressors, using only the highest quality components, operate for unusually long periods before maintenance is required. If needed, however, service technicians and mechanical/electrical engineers can be dispatched to a job site within 24 hours. Spare parts and materials are shipped via overnight air freight from Turblex warehouses in Springfield, Missouri, centrally located in the population and geographic center of North America. Preventative maintenance, service, and operator training contracts are available. Contact your local representative or Turblex for details.

fig. 32: Operator training is an integral part of the Turblex service program.

fig. 33: All servicemen are extensively trained and experienced to handle all facets of both electrical and mechanical servicing of Turblex equipment, as well as training end-user personnel in operational and maintenance strategies.
THE FLEXIBILITY OF TURBLEX

Turblex can provide a custom engineered aeration system to meet a variety of requirements. Some design considerations include:

- Automated control of compressors and downstream air distribution system
- Reduction of contractor-installed air piping
- Variety of sound attenuation options
- Custom operator interface stations
- Minimization of footprint
- Maximum turndown
- Precise control of flow and pressure

Turblex compressor packages are tailored to the end-user’s specifications. Lube oil piping is generally Schedule 40 carbon steel with welded fittings, and is available in stainless steel. Electrical conduit, electrical wiring, and instruments are provided “per specifications.” Turblex units also meet most elements of API 672. Your Turblex Regional Sales Manager and local Manufacturer’s Representative will be pleased to work with you on special applications.

fig. 34: Turblex Model KA2 units, 2,316 scfm, 8.0 psig, 100 Hp, containerized compressors mounted on the fixed surface aerator concrete pedestal. Replacement of the surface aerators with Turblex compressors and fine bubble diffusers saved 56 percent power costs of the entire plant.

fig. 35: Installation of smaller Model KA2 units at a western wastewater facility, 1,550 scfm, 8.1 psig, 100 Hp.

fig. 36: Model KA10 units providing oxidation air to a flue gas desulphurization process at a coal-fired power plant. 5,500 scfm, 16.8 psig, 500 Hp.

fig. 37: Model KA22 units, 12,300 scfm, 8.2 psig, 600 Hp.

fig. 38: Installation of compressors at a southern wastewater treatment plant, KA66, 22,500 scfm, 8.0 psig, 1,000 Hp.
As a Siemens Company, Turblex is part of an organization with presence in more than 190 countries. The experience, support and stability of the Siemens organization filters down to every Turblex customer, delivering a world class experience.

A GLOBAL ADVANTAGE

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fig. 39: Installation featuring five KA10 units, each rated for 6,000 scfm, 11.2 psig and 400 Hp.

fig. 40: Three 1,000 Hp model KA22 units, each rated for 10,000 scfm, 21.0 psig, and featuring local mounted Turblex inlet filter/silencers.

fig. 42: Highly skilled electricians, pipe fitters, mechanical and electrical engineers apply their craft to the production and testing operations at the Turblex manufacturing shop in Springfield, Missouri.

fig. 43: Siemens Turbomachinery A/S manufactures and tests the compressor and gearbox at the factory complex (lower right), located in Helsingor, Denmark, 60 minutes north of Copenhagen. The famous Kronberg Castle of Shakespeare’s Hamlet is located just north of the factory, a focal point of this historic city.
Turblex is committed to partnering with our customers to produce the most intelligent aeration solution available in the industry today. Our goal is quite simple: exceed customer expectations by producing single-stage compressor technology unparalleled in efficiency, flexibility, and reliability.