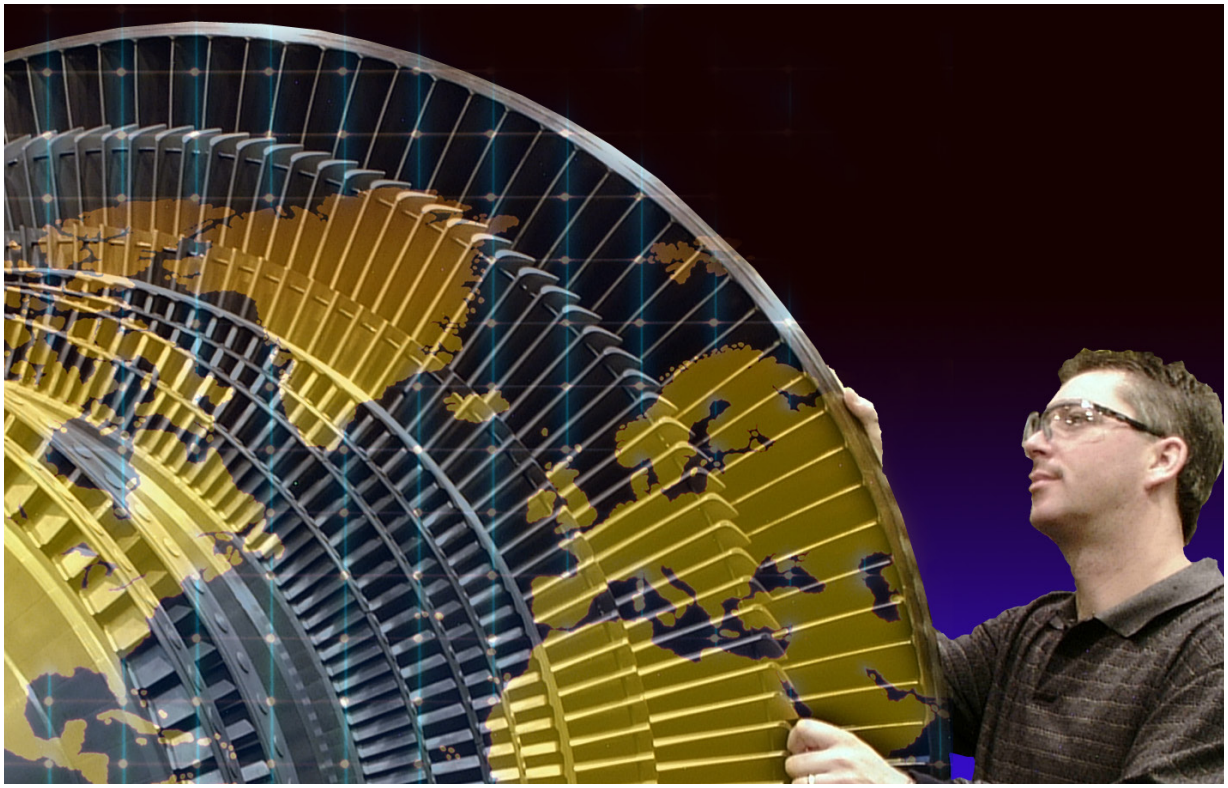


Steam Turbines and Gas Expanders

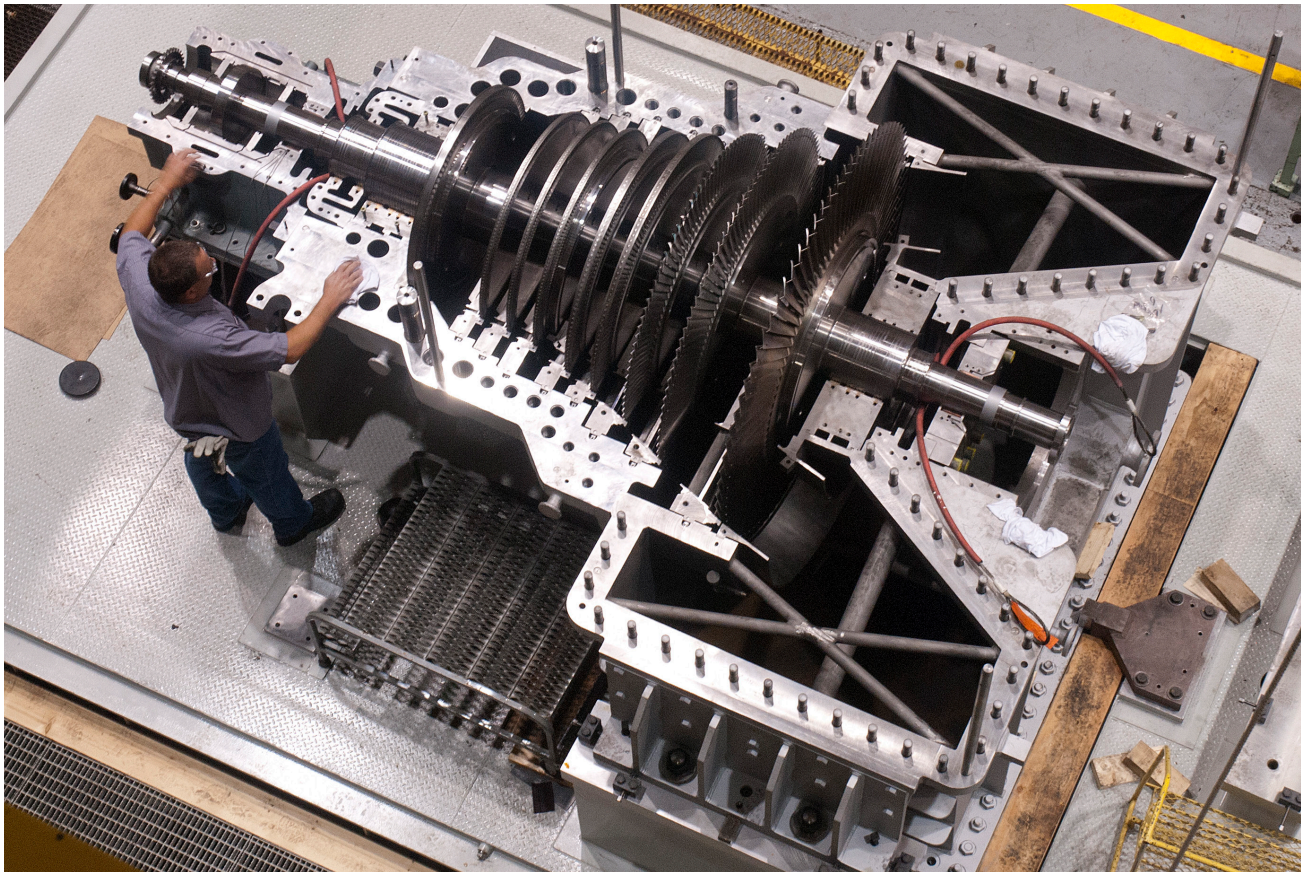
Introduction

Proven Reliability and Efficiency

Dependable, versatile turbomachinery is essential for today's refinery, chemical process, and industrial applications. Due to the high cost of energy conversion and high feedstock prices, efficiency and dependability are primary considerations for equipment operators and plant owners. Elliott steam turbines and gas expanders provide proven reliability and high efficiencies which make them a key element of successful mechanical drive or power generation services. Elliott offers a complete line of steam turbines ranging up to 135,000 HP (100,000 kW) and gas expanders up to 60,000 HP (45,000 kW).

Single stage and multistage designs

- Designed and manufactured per API 612 (special purpose steam turbine) or API 611 (general purpose steam turbine) specifications.
- Suitable for the steam pressure, temperature and steam consumption required for various industrial plants.
- Designed to drive industrial machinery such as compressors, blowers, fans, pumps, and power generators, and allowing operation under high speeds and/or wide speed ranges.
- Condensing, non-condensing, extraction, induction and various combinations available to achieve the best process heat balance.
- Impulse type blading features operating flexibility, compact design and high reliability.
- The combination of steam chests, exhaust casings, stationary components and blades are standardized and have well proven performance under varying conditions.



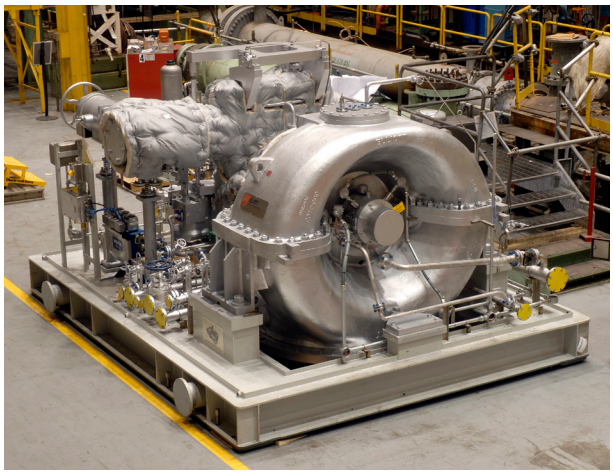
Casings

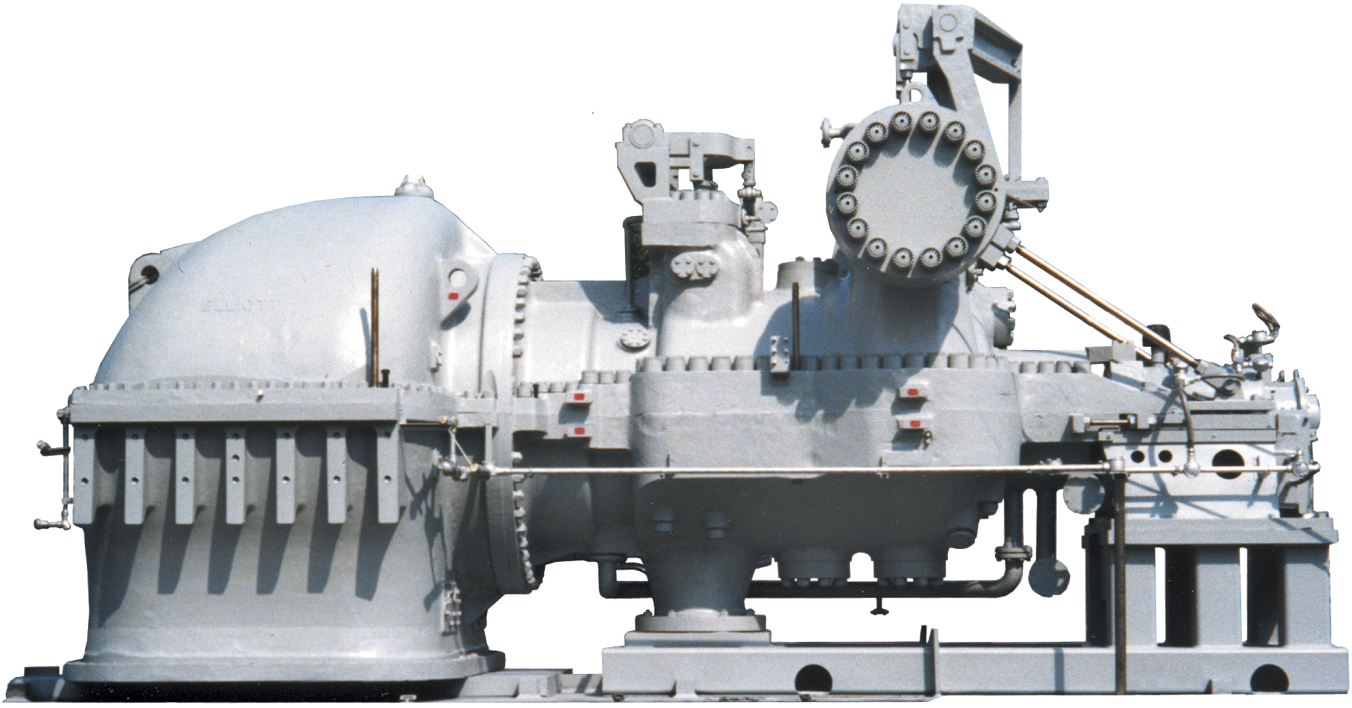
A Solid Reputation – Performing under Pressure

Elliott turbine casings are designed to perform under a wide array of operating conditions and can handle steam conditions to 2,000 psig (138 barg) and 1,005 F (541 C). The typical casing for an Elliott turbine consists of a cast high-pressure steam chest, an intermediate barrel section, and a separate exhaust casing. The barrel section is generally integral with the steam chest so that the vertical bolting joint is at one of the latter stages where internal pressures are very much reduced. The steam end, exhaust casing, nozzle ring, reversing blades and diaphragms are all split on the horizontal center line which allows for easy removal of the upper half of the turbine for internal inspection.

The diaphragms are machined on the outside diameter and assembled into grooves accurately machined in the casing. Cap screws, secured by locking, fasten the nozzle ring to the steam chest, while the diaphragm halves are locked in position by stops located at the horizontal split in the casing. Steam chest passages, nozzle block partitions and the valve opening sequence are all carefully designed to ensure even and rapid heating of the casing after steam is first admitted to the turbine.

The high-pressure end of the turbine is supported by the steam end bearing housing which is flexibly mounted to allow for axial expansion caused by temperature changes. The exhaust casing is centerline supported on pedestals that maintain perfect unit alignment while permitting lateral expansion. Covers on both the steam end and exhaust end bearing housings and seal housings may be lifted independently of the main casing to provide ready access to such items as the bearings, control components and seals.



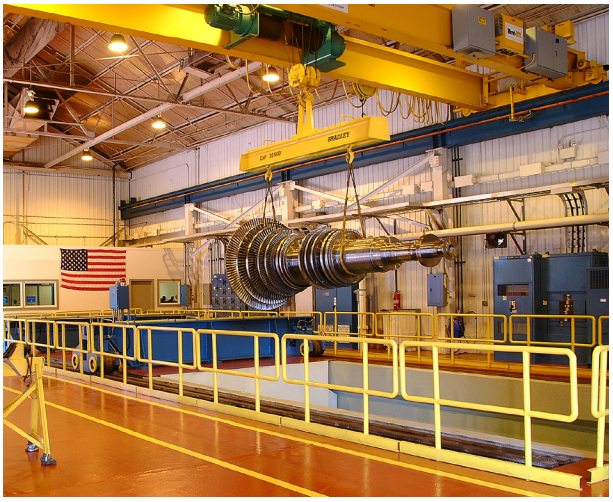


Rotors

Solid Forged Construction

All Elliott multistage steam turbines are manufactured with solid forged rotor construction. Rotors are precisely machined from solid alloy steel forgings. An integrally forged rotor provides increased reliability particularly for high speed applications.

The complete rotor assembly is dynamically balanced at operating speed and overspeed tested in a vacuum bunker to ensure safety in operation. High speed balancing can also reduce residual stresses and the effects of blade seating. Elliott also offers remote monitoring of the high speed balance testing, allowing customers to witness the testing from their offices or at any other location.

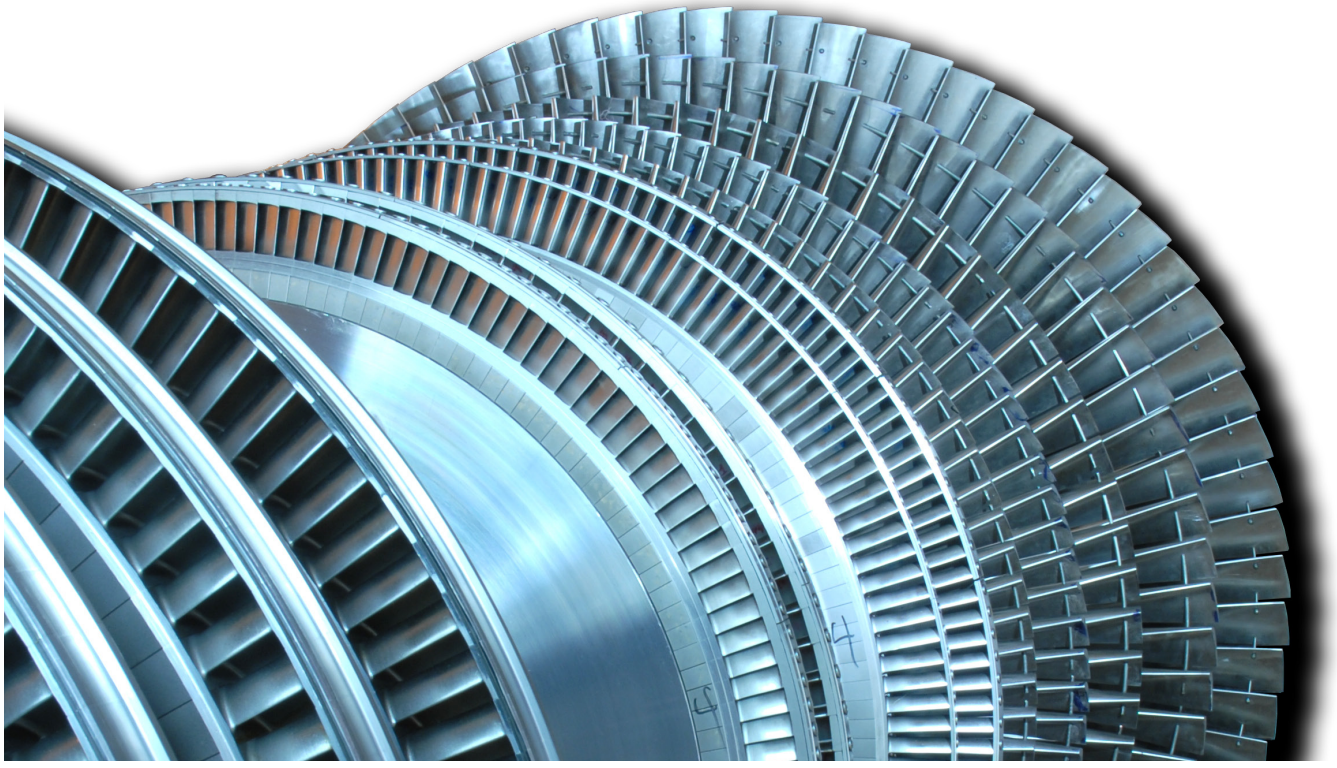


Blades

Enhanced Performance and Reliability

Blade design is extremely important in attaining high turbine reliability and efficiency. A large selection of efficient blade profiles have been developed and proven by extensive field service allowing for optimal blade selection for all conditions of service. Blades are milled from stainless steel stock purchased within strict specifications for proper strength, damping and corrosion resistant properties.

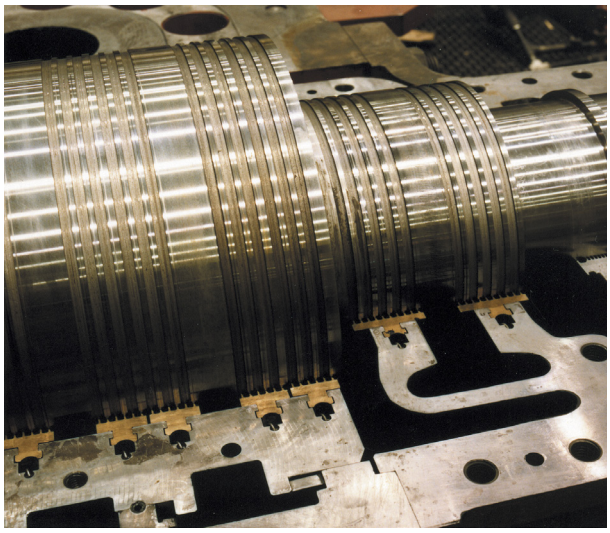
Disk profiles are designed to minimize centrifugal stresses, thermal gradient and blade loading at the disk rims. Elliott blades have various shapes to achieve maximum performance and withstand any mechanical stresses. The blade and nozzle configurations have been proven and tested over many years.



Stationary Components

Precision Design and Manufacturing

Elliott's nozzle rings and diaphragms are specifically designed and fabricated to handle the pressure, temperature and volume of the steam, the size of the turbine and the required pressure drop across the stage. The nozzles used in the first stage nozzle ring are cut from stainless steel. Steam passages are then precision milled into these nozzle blocks before they are welded together to form the nozzle ring.



The nozzles in the intermediate pressure stages are formed from profiled stainless steel nozzle sections and inner and outer bands. These are then welded to a circular center section and to an outer ring then precision machined.

The low-pressure diaphragms in condensing turbines are made by casting the stainless nozzle sections directly into high-strength cast iron. This design includes a moisture catching provision around the circumference which collects released moisture and removes it from the steam passage. Additional features such as windage shields and interstage drains are used as required by stage conditions to minimize erosion. All diaphragms are horizontally split for easy removal and alignment adjustment.

Labyrinth seals are utilized as end gland seals and also interstage seals. Stationary labyrinth seals are standard for all multistage turbines and grooves are machined on the rotating part to improve the sealing effect. The leakage steam from the outer glands is generally condensed by the gland condenser. Some leakage steam from the intermediate section of the steam end gland seals can be withdrawn and utilized by re-injecting it into the low-pressure stage or low-pressure steam line.

Replaceable journal bearings are steel-backed and babbitt-lined with five-shoe tilting pad design. Thrust bearings are double-acting and self-equalizing. Center pivots are typically used to make assembly easier and provide maximum protection if reverse rotation occurs. Chrome-copper pads are applied for both journal and thrust bearings for high oil temperature applications.

DIAPHRAGMS

All diaphragms are horizontally split and diaphragm nozzles are precision machined in stainless steel to provide

BLADES

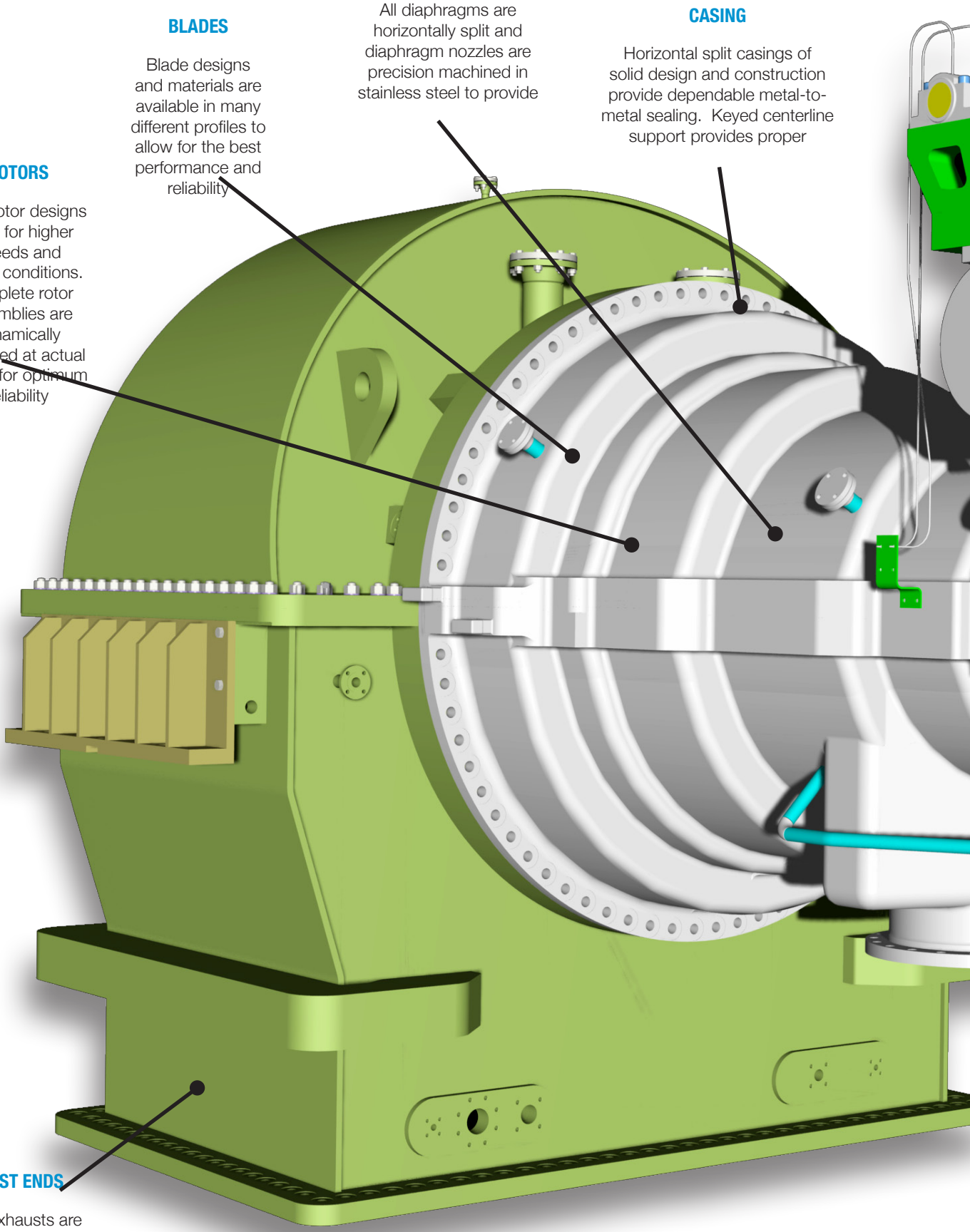
Blade designs and materials are available in many different profiles to allow for the best performance and reliability

CASING

Horizontal split casings of solid design and construction provide dependable metal-to-metal sealing. Keyed centerline support provides proper

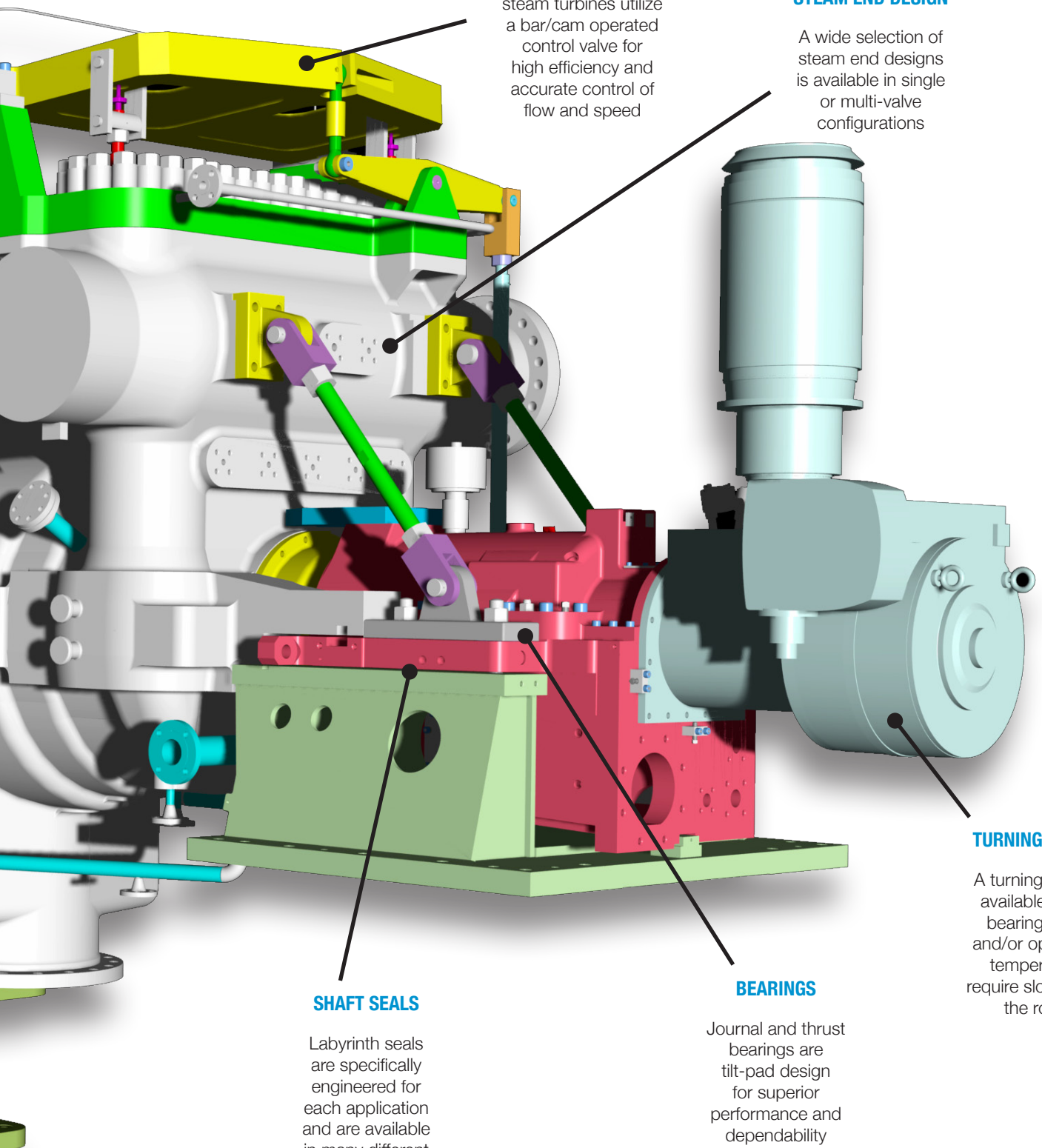
ROTORS

Solid rotor designs allow for higher speeds and steam conditions. Complete rotor assemblies are dynamically balanced at actual speed for optimum reliability



EXHAUST ENDS

Turbine exhausts are available in single flow or double flow designs



BAR/CAM LIFT VALVES

Large multi-valve steam turbines utilize a bar/cam operated control valve for high efficiency and accurate control of flow and speed

STEAM END DESIGN

A wide selection of steam end designs is available in single or multi-valve configurations

TURNING GEARS

A turning gear is available when bearing span and/or operating temperature require slow-roll of the rotor

SHAFT SEALS

Labyrinth seals are specifically engineered for each application and are available in many different

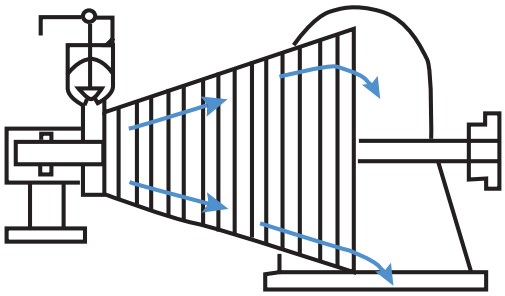
BEARINGS

Journal and thrust bearings are tilt-pad design for superior performance and dependability

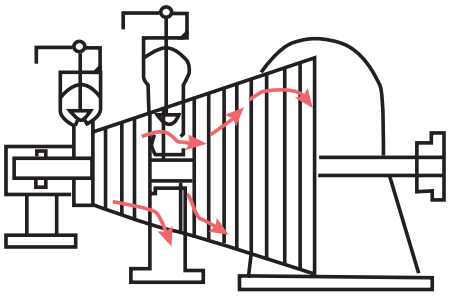
GOVERNOR / SAFETY SYSTEMS

Speed control and safety protection are available in a wide array of configurations including the patented Elliott Pos-E-Stop 203 trip block

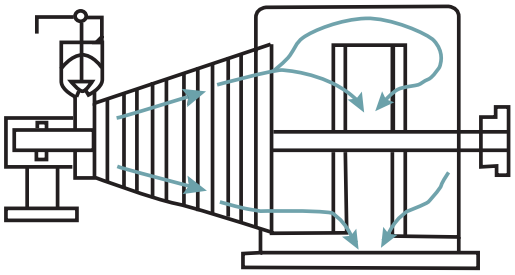
Frames and Configurations



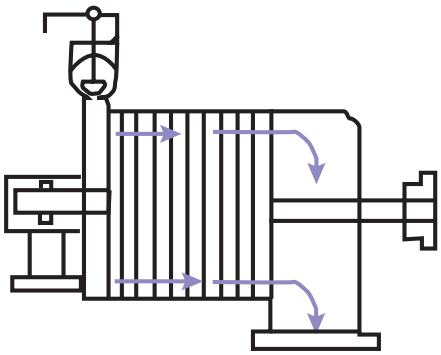
SINGLE-FLOW CONDENSING are highly economical and require the least steam for a given horsepower. Typically they are direct connected to a high speed compressor.



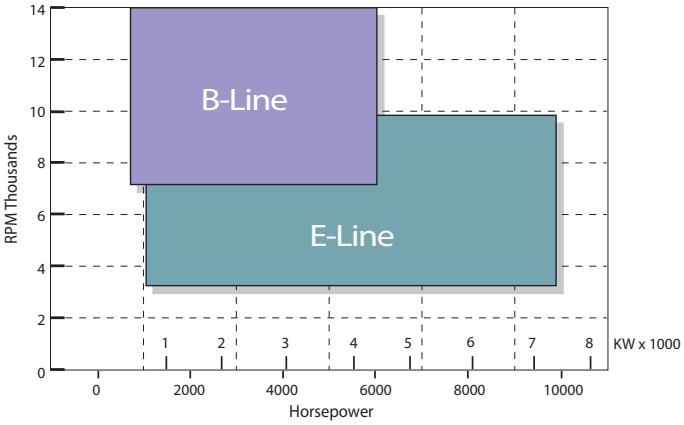
AUTOMATIC EXTRACTION and/or induction allows for controlled power and process steam pressure by automatically regulating the extraction/induction steam flows.



DOUBLE-FLOW CONDENSING accommodates high capacity steam flow for higher speed applications. The exhaust flow is split between two (2) duplicate rows of blades.

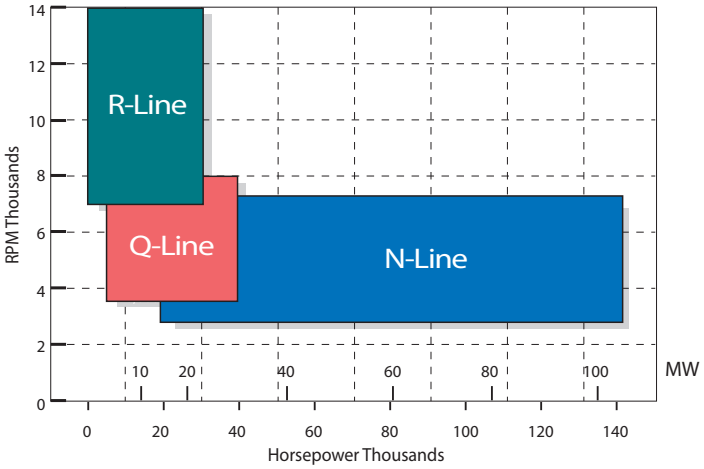


NON CONDENSING or BACK PRESSURE allow further use of the energy in the exhaust steam for process heat or other services.



Single Valve Turbines

Designed for low to moderate power applications and available in two (2) frame sizes or in the Elliott YR turbine product line. These turbines are available up to 12,000 HP and 16,000 rpm. For higher speeds, Elliott offers the V model turbine.



Multi-Valve Turbines

For higher power applications, Elliott multi-valve, multistage designs provide the highest levels of efficiency as well as accurate control of speed and steam flow. Elliott multi-valve turbines are available for a wide range of applications with horsepower ratings to 135,000 HP (100,000 kW) and speeds to 14,000 rpm.

Power Recovery Expanders

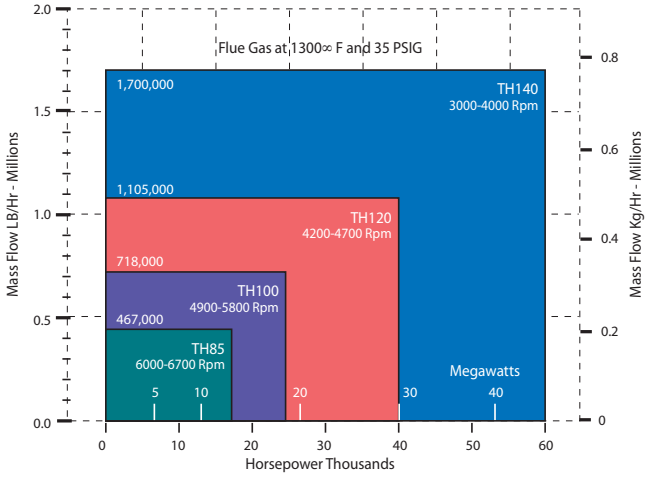
The Leader in Reliability

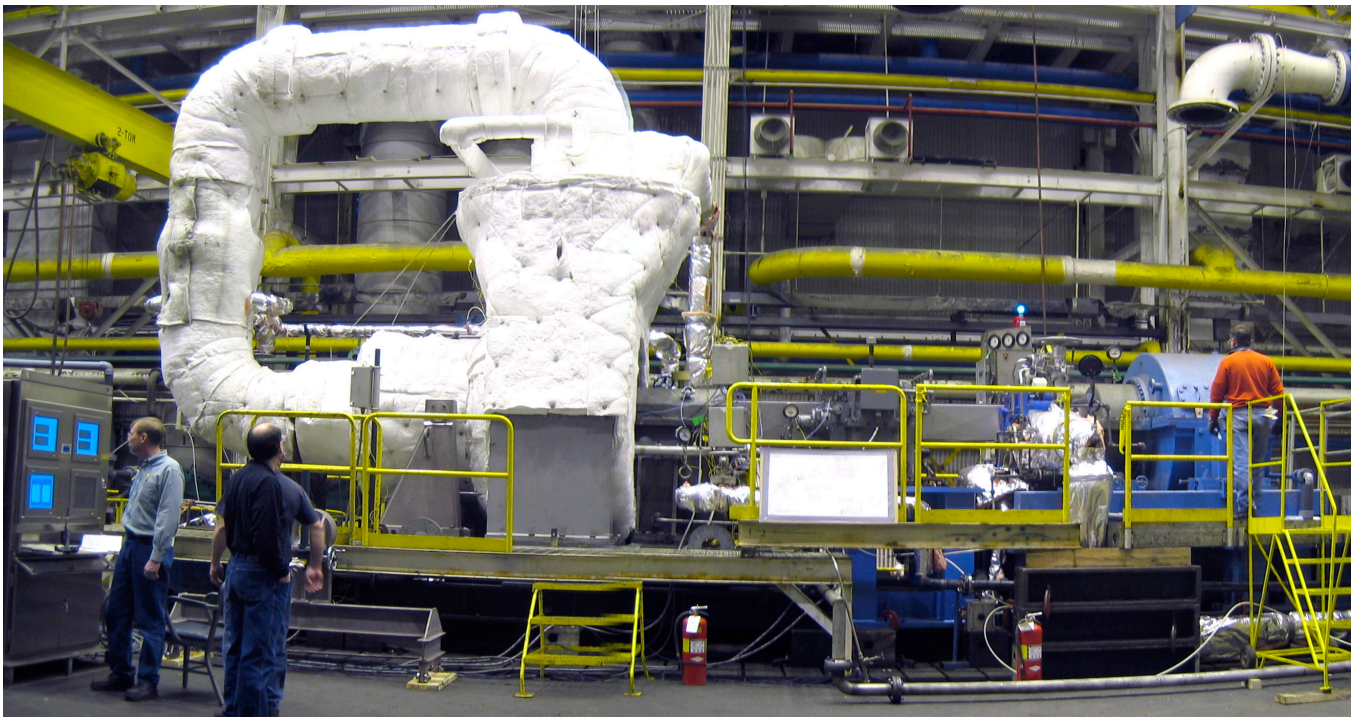
Over the years, Elliott has brought many advances to refining processes including pioneering the Fluidized Catalytic Cracker (FCC) power recovery expander. Due to catalyst particulates in the flue gas, equipment design and reliability play a key role in successful installations. The exceptional engineering that has gone into this product line has produced the most dependable and durable unit of its type in the industry. Elliott boasts the longest blade life of any manufacturer and has recently overhauled a unit that has had an incredible ten (10) year operating history with the same blades.

Elliott supplies casings that are constructed of high temperature base materials and alloyed metals to provide long term reliable service without age embrittlement issues, and allow for flow rates up to 1.7 million pounds per hour. Our cases are designed using computational flow dynamics (CFD) analysis, which allows us to design inlet casings that provide smooth acceleration of flue gases, assuring an even catalyst particle velocity distribution.

Elliott's unique rotor design uses multiple thru-bolts, a technique that eliminates the high stress concentrations associated with a single thru-bolt design. Power and torque are transmitted to the rotor by a high capacity axial face spline, allowing for thermal growth without the use of unreliable shear pins.

All of our stator vanes are individually replaceable for simple maintenance, and their placement is optimized to prevent "secondary erosion", the cutting of the rotor blade platform and airfoils by the catalyst. Elliott's superior aerodynamic design allows our TH expanders to maintain power recovery with proven reliability with minimal maintenance costs.





Standard Designs

Elliott YR Steam Turbines

Elliott's product portfolio also includes several standardized turbine models for industrial and mechanical drive applications. Elliott YR steam turbine models are standardized and components are inventoried resulting in shorter lead times and quick turnarounds. Because of their flexibility, thousands of YR turbines are driving pumps, compressors, fans, blowers, generators, sugar mill tandems, cane shredders, paper machine line shafts and many other industrial plant applications.

Single-valve, single-stage designs

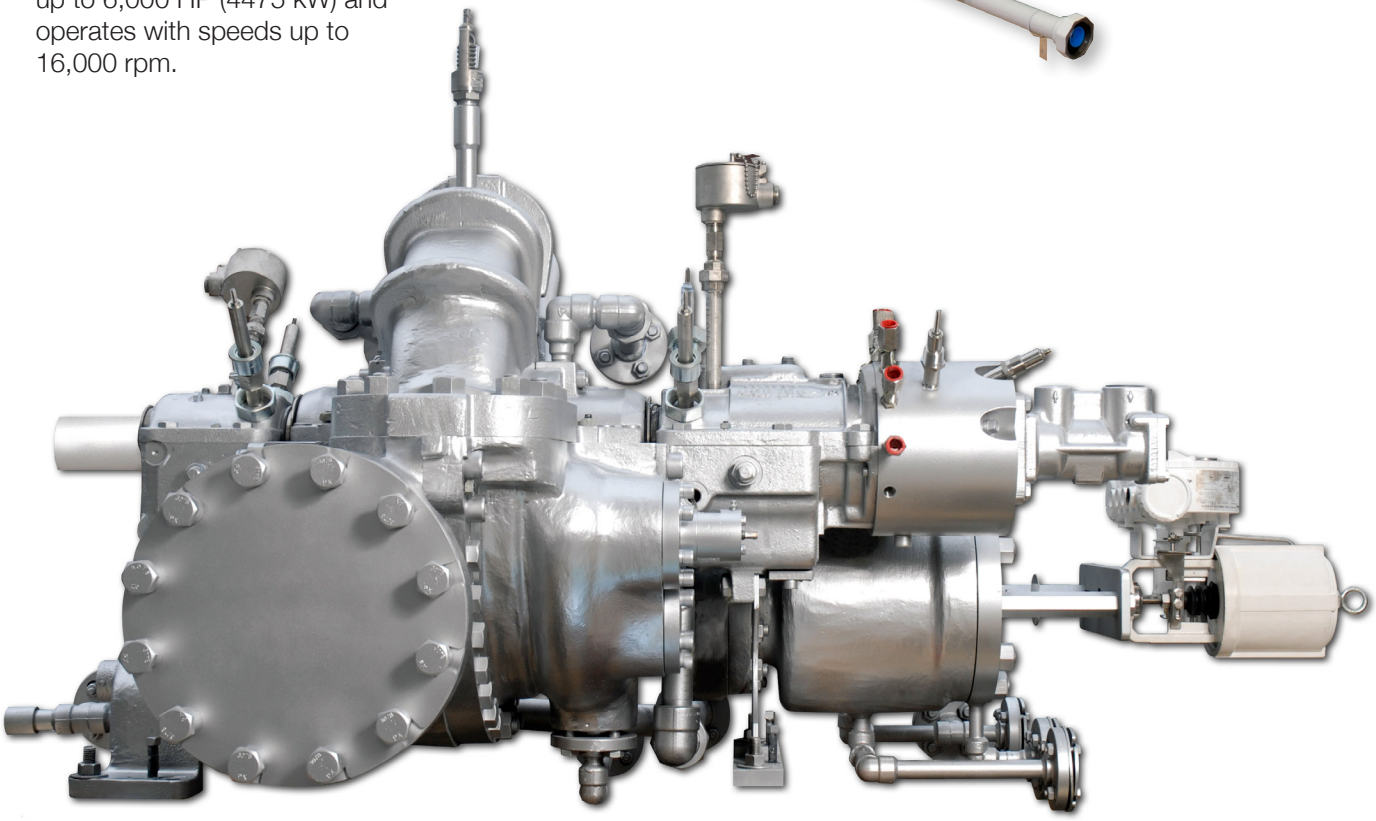
Single-valve, single-stage, multi-purpose YR turbines have a world-wide reputation for the highest quality, reliability and adaptability to serve many needs. Available in ratings up to 2500 hp (2611 kW), the YR turbine is a cost-effective answer for a wide range of requirements.

High-speed designs

While retaining the reliability and economy of the standard YR turbines, Elliott specialists created the V turbine line in response to customer demand for a simpler and more economical means of operating high speed equipment. The V model is available up to 6,000 HP (4475 kW) and operates with speeds up to 16,000 rpm.

Single-valve, multi-stage designs

For improved steam consumption, Elliott engineers designed the Multi-YR turbine product line. This design combines the reliability and interchangeability of our popular single-stage YR turbine with the power and efficiency of our traditional multistage turbines. Multi-YR turbines are available up to 10,000 HP (7500 kW)



Tri-Sen TSx Control System

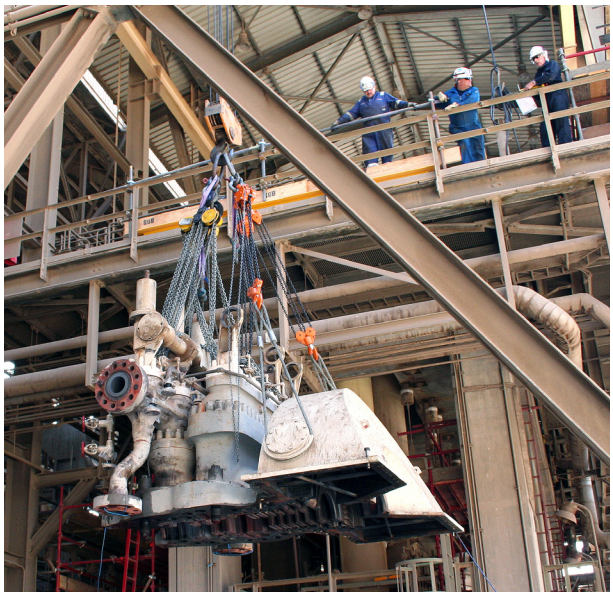
Elliott has partnered with Tri-Sen to offer the TSx programmable turbomachinery control system for Elliott equipment. The TSx is uniquely suited to meet the needs of critical turbomachinery control applications in oil & gas, power, refining, chemicals, or any other industry where unmatched performance and flexibility is demanded. The TSx architecture is completely scalable from the simplest single chassis systems to the most complex systems with up to sixteen chassis per note without any degradation in performance. The TSx controller boasts SIL3 reliability, 99.9999% availability and an unheard of millisecond scan rate (12 milliseconds screw-to-screw). The TSx also features:

- Configurable redundancy up to quad-redundant
- Advanced diagnostics
- Built-in HMI with operator graphics
- Real time and historical trending,
- Alarm management
- 1 ms sequence of events recording

For many of the same reasons that the TSx is perfect for critical turbomachinery control applications, it is also the most versatile turbine protection system available. The TSx architecture is completely scalable, from a simplex SIL2 certified configuration up to dual and TMR SIL3 configurations. With its purpose built frequency input module that updates every millisecond, it is also the fastest.

Global Service

Elliott offers comprehensive service and support for all types of turbomachinery regardless of the original manufacturer. Our experienced engineers, metallurgists, technicians, welders and mechanics have the expertise and experience to keep equipment performance high and maintenance costs low.



Elliott's global service network is ISO 9001:2008 certified and provides installation, maintenance, repair, overhauls, parts, rerates, modifications and training, 24 hours a day, 7 days a week. Supported by our service centers throughout the world, Elliott's field service teams are recognized for their hands-on experience with comprehensive overhauls; project management; resource planning; subcontractor control; installation and commissioning and on-site repair. Elliott Technical Services provides practical, timely and cost-effective solutions for complex turbomachinery problems. Rerates and modifications by Elliott Engineered Solutions enhance operating efficiency and extend the life of rotating equipment from any manufacturer.

Elliott is fully compliant with all relevant industry standards including API, ANSI, APO, CRN, CSA, and CE/PED. We are accredited by the American Society of Mechanical Engineers (ASME), holding both the U and the R Boiler and Pressure Vessel (BPV) certifications, and we adhere to the principals of the American Society of Nondestructive Testing (ASNT) and are SNT-TC 1A complaint.

Elliott Group is a global leader in the design, manufacture and service of technically advanced centrifugal compressors, steam turbines, power recover expanders and axial compressors used in the petrochemical, refining, oil & gas and process industries, as well as in power applications. Elliott Group is a wholly owned subsidiary of Ebara Corporation, a major industrial conglomerate headquartered in Tokyo, Japan.

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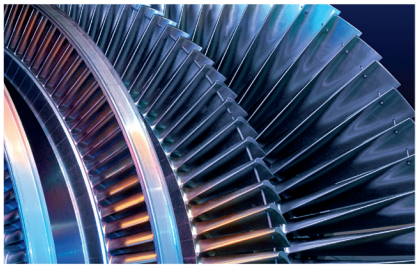
THE WORLD TURNS TO ELLIOTT


COMPRESSORS ■ TURBINES ■ GLOBAL SERVICE