

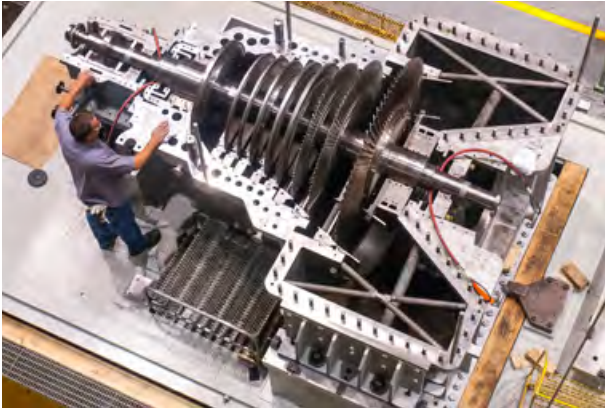


# Multi-Stage Steam Turbines

## 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 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).



### *Single-stage and multi-stage designs*

- ♦ Designed and manufactured per American Petroleum Institute (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.



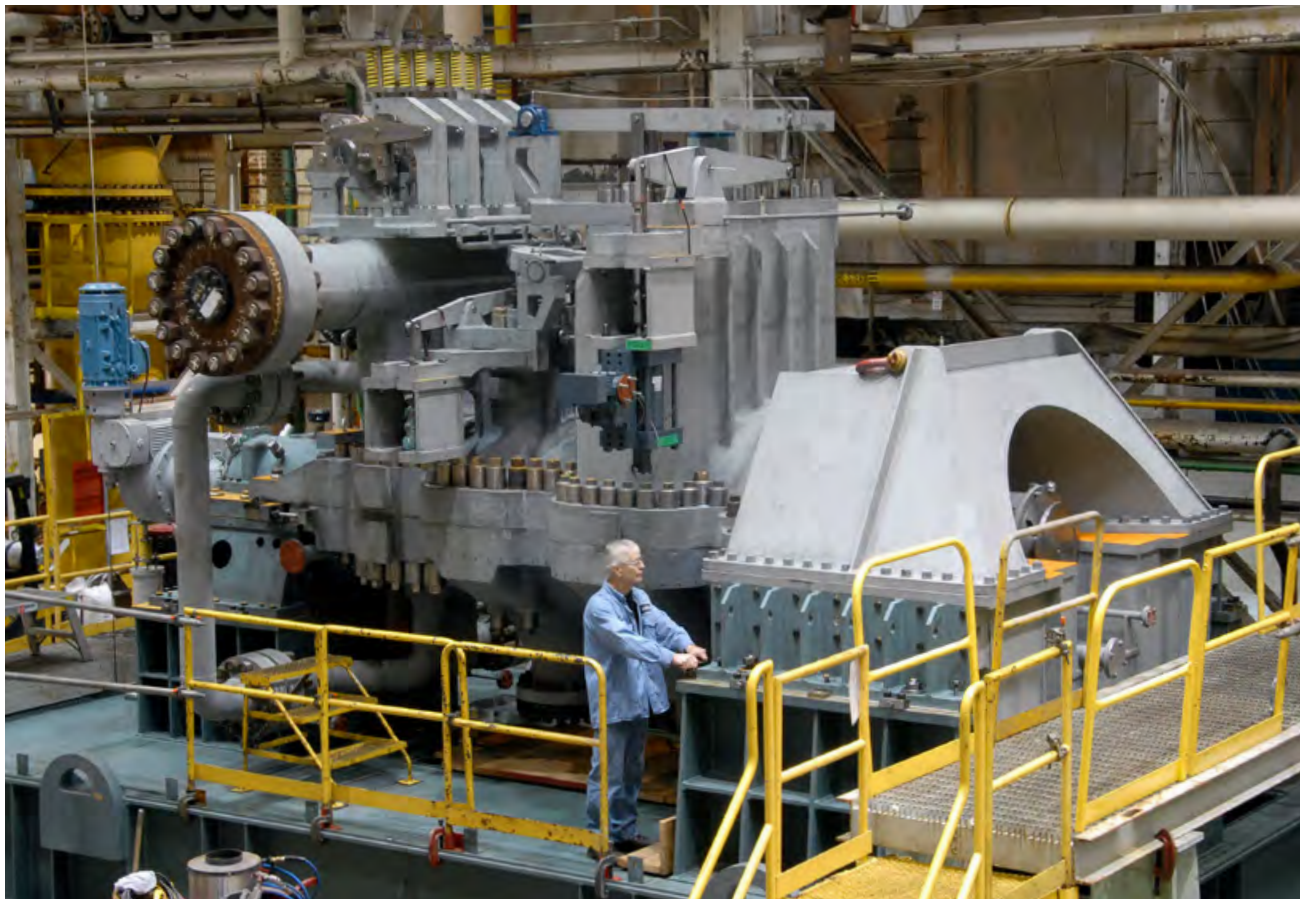
## CASINGS

### *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 2,200 psig (152 barg) and 1,019 F (548 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 centerline, 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 multi-stage 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.

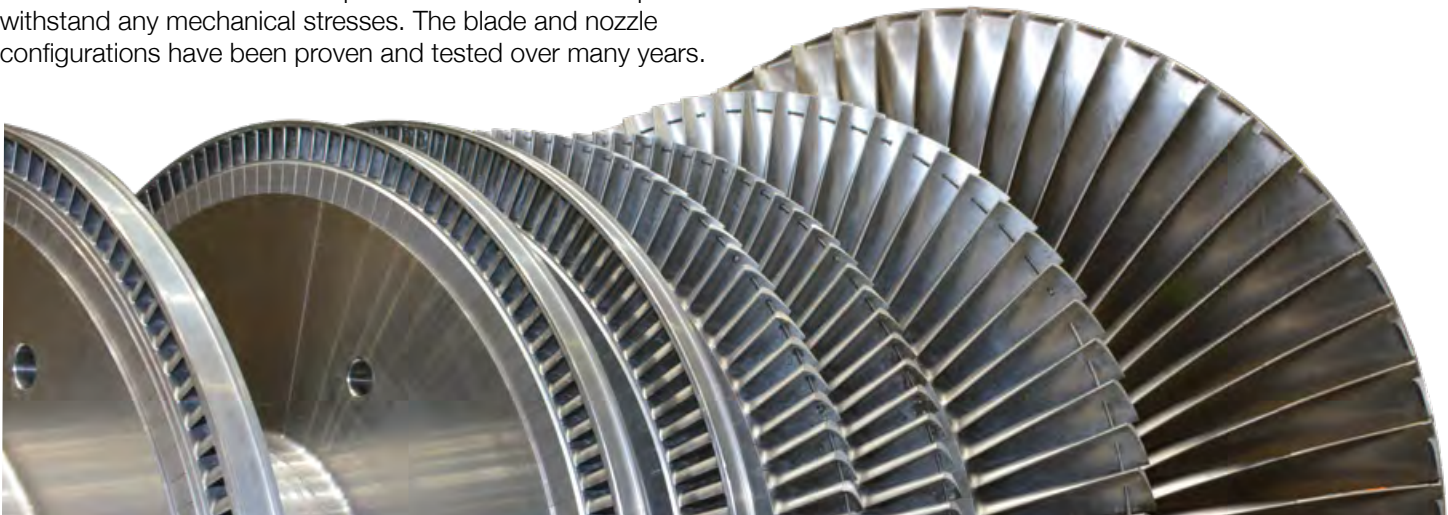


## ■ BLADES

### *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. These can also be made by 5-axis milling and electron discharge machining.

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

The low-pressure diaphragms in condensing turbines are made using cast modified chromium steel nozzle blades welded directly into high-strength carbon steel plate. 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. Replaceable stainless inlay can be provided on both the casing and the diaphragms for additional erosion protection. All diaphragms are horizontally split for easy removal and alignment adjustment.

Labyrinth seals are used as end gland seals as well as interstage seals. Stationary labyrinth seals are standard for all multi-stage turbines, which includes grooves that are machined on the rotating part to improve the sealing efficiency. 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, regaining lost energy.

Replaceable journal bearings are steel-backed and babbitt-lined with a 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.



# ■ STEAM TURBINE DESIGN FEATURES

## BLADES

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

## DIAPHRAGMS

All diaphragms are horizontally split and diaphragm nozzles are precision machined in stainless steel to provide superior strength and erosion protection.

## ROTORS

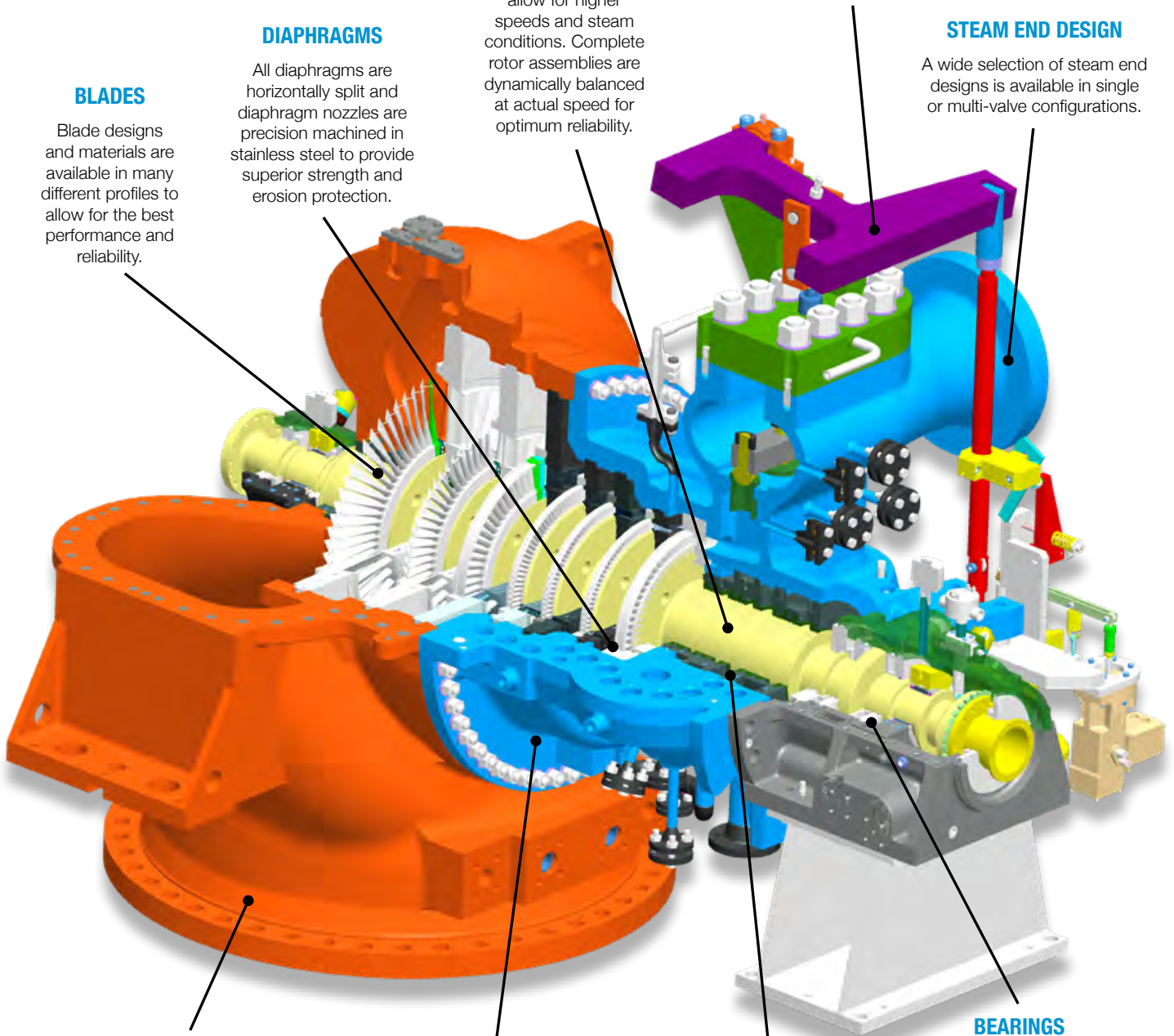
Solid rotor designs allow for higher speeds and steam conditions. Complete rotor assemblies are dynamically balanced at actual speed for optimum reliability.

## BAR/CAM LIFT VALVES

Large multi-valve steam turbines utilize a bar/cam-operated control valve for highly efficient 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.



## EXHAUST ENDS

Turbine exhausts are available in single-flow or double-flow designs.

## CASING

Horizontal split casings of solid design and construction provide dependable metal-to-metal sealing. Keyed centerline support provides proper alignment and allows for thermal growth of the casing.

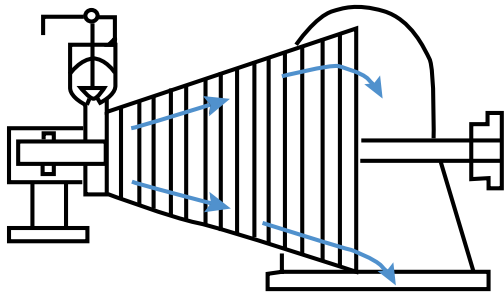
## SHAFT SEALS

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

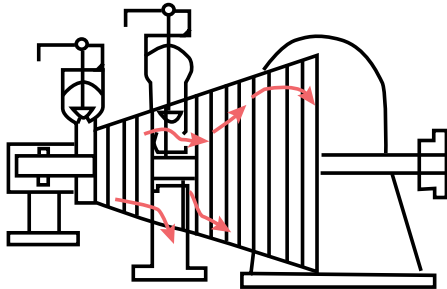
## BEARINGS

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

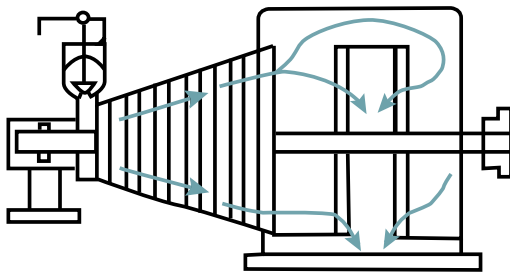
## FRAMES AND CONFIGURATIONS



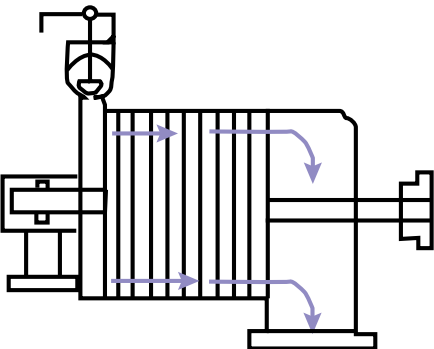
**SINGLE-FLOW CONDENSING** are highly economical and require the least steam for a given horsepower. Typically they are direct connected to a high-speed compressor.



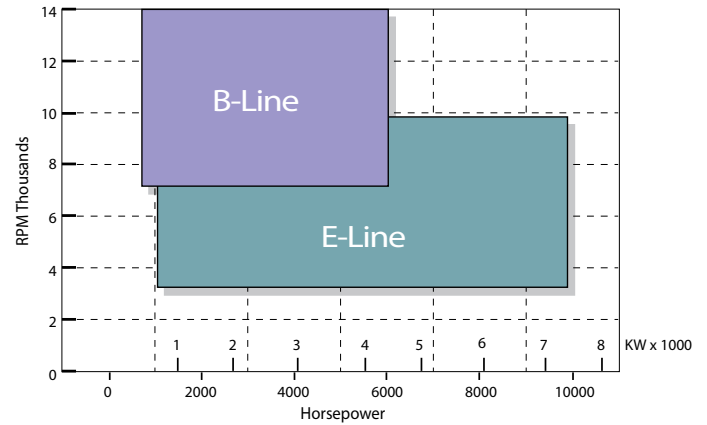
**AUTOMATIC EXTRACTION and/or induction** allows for controlled power and process steam pressure by automatically regulating the extraction/induction steam flows.



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

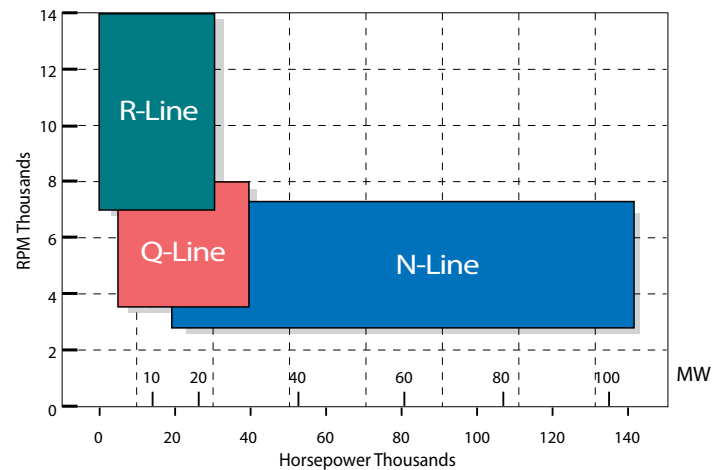


**NON CONDENSING or BACK PRESSURE** allow further use of the energy in the exhaust steam for process heat or other services.



### Single Valve Turbines

Designed for low to moderate power applications and available in two frame sizes or in the Elliott YR turbine product line. These turbines are available up to 12,000 HP (8,948 kW) and 16,000 rpm. For higher speeds, Elliott offers the V model turbine.



### Multi-Valve Turbines

For higher power applications, Elliott multi-valve, multi-stage 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.



Elliott Group is a global leader in the design, manufacture, and service of technically advanced centrifugal compressors, steam turbines, power recovery expanders, cryogenic pumps and expanders, and axial compressors used in the petrochemical, refining, oil & gas, liquefied 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.



901 North Fourth Street  
Jeannette, PA 15644-1473  
Telephone: 724-527-2811  
Fax: 724-600-8442

Email: [info@elliott-turbo.com](mailto:info@elliott-turbo.com)  
[www.elliott-turbo.com](http://www.elliott-turbo.com)

T H E W O R L D T U R N S T O E L L I O T T



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