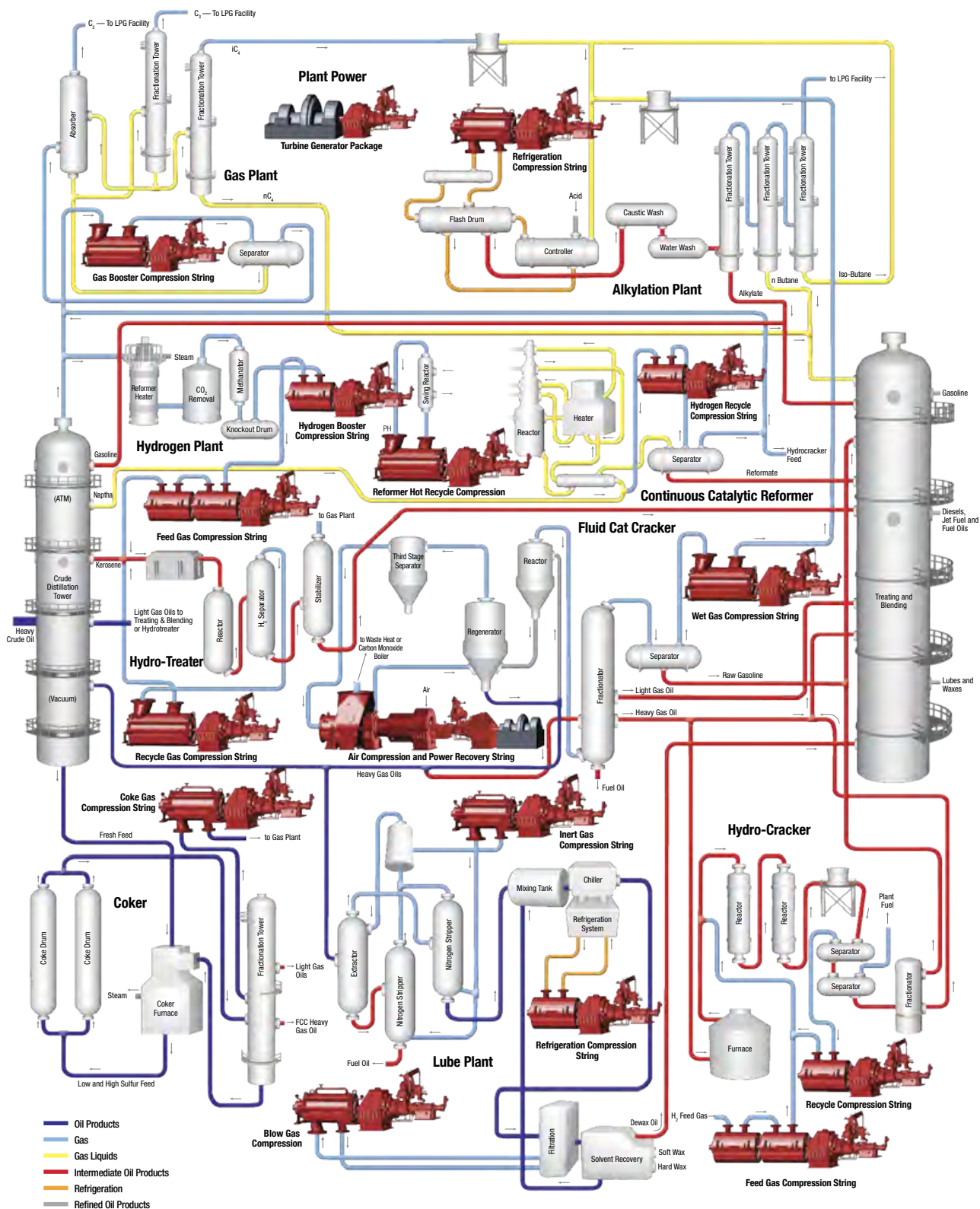


Elliott Turbomachinery for Refineries



ELLIOTT IN THE REFINERY



■ COMPRESSION SOLUTIONS FOR REFINERY APPLICATIONS

Elliott has been a leading supplier of compressors and steam turbines for refinery applications since the early 1950s. Elliott's EDGE compressor designs and large installed base – more than 700 EDGE compressors in refinery services in over 50 countries - have earned Elliott a reputation as a leader in the industry. Many of these compressors are driven by Elliott steam turbines. Elliott's experience with compressors and steam turbine drivers extends to many refinery applications including hydrotreating and hydrocracking, fluidic catalytic cracking (FCC), reforming, coking, and alkylation.

Changing markets and stricter regulations demand increasingly cleaner fuels and lower plant emissions. Conversely, the world's supply of light, sweet crude oil is declining. Refiners must meet the challenge of competing in an ever changing industry, adapting their processes to maximize product yield from lower quality, heavier and sour crude, while at the same time, meeting new environmental requirements.

As the refining industry has grown and evolved, Elliott has grown along with it, developing and advancing rotating equipment for refinery processes from distillation through production. Elliott equipment is used by refiners around the world to produce:

- ♦ Transportation fuels
- ♦ Commercial fuels
- ♦ Lubricants
- ♦ Chemical feed stocks
- ♦ Specialty products (such as coke and asphalt)



■ HYDROPROCESSING

Hydroprocessing encompasses a variety of thermal conversion processes in which hydrogen is used, along with a catalyst, to convert petroleum fractions and products to meet the refiner's objectives. These conversion processes include hydrodesulfurization (hydrotreating) and hydrocracking. In both processes, hydrogen compressors purify the product stream by removing contaminants such as sulfur, nitrogen, and aromatic hydrocarbons. The end products typically include gasoline, jet fuel, diesel fuel and kerosene. Because of the severe processing conditions and the high pressures required to convert petroleum fractions and products, these compressors are nearly always vertically split designs. Elliott pioneered high-pressure casing technology and offers a full line of compressors specifically designed for high-pressure, high-temperature applications.



■ FLUID CATALYTIC CRACKING – POWER RECOVERY

Energy represents the single largest operating expense within a refinery and in some cases, can account for nearly 50% of the total operating cost. Many refiners benefit from energy cost savings through the use of Elliott TH power recovery expanders. These units utilize the energy in high-temperature, low-pressure gas streams to drive generators and/or centrifugal or axial compressors in FCC/RFCC service. Recovered power can exceed 60,000 hp (45 MW), adding millions of dollars per year to the bottom line.

With more than a half century of experience in supplying turbo expanders for power recovery, Elliott offers the latest designs for efficient, reliable energy recovery technology. Development for this innovative and rugged product line began during the 1950's, with the first successful continuously operating Elliott power recovery expander installed in 1963. We have maintained a technology leadership in this field ever since.

High efficiency axial compressors offer substantial power savings and can be incorporated into power recovery trains. The high-flow capacity of axial compressors makes them suitable for larger, more efficient processes and they can be used to supply air to the regenerator and other plant needs. Elliott axial compressors share many of the major design features and manufacturing techniques of our centrifugal compressor product line.



■ CATALYTIC REFORMING

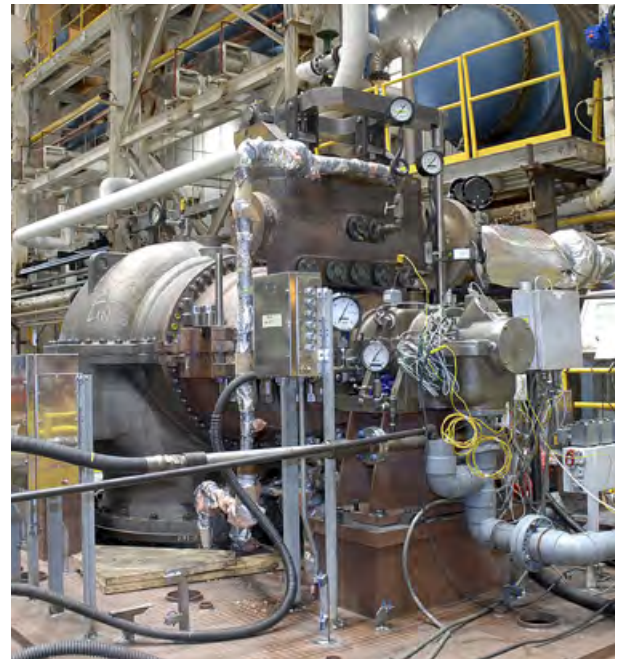
The objective of catalytic reforming is to convert low octane naptha into a high octane reformate and/or to provide aromatics (benzene, toluene, and xylene) for petrochemical plants. Reforming also produces high purity hydrogen for hydrotreating purposes. Applications include net gas and hydrogen recycle services. Hydrogen recycle compressors usually require an alternate nitrogen operating case for catalyst regeneration and must be carefully evaluated for safe operating range and for temperature limits. Elliott offers high-speed and high polytropic head designs to meet the challenging conditions associated with these applications.



■ DELAYED COKING

Delayed coking is a thermal cracking process that upgrades and converts petroleum bottoms into liquid and gas product streams and petroleum coke. Coker applications are challenging due to the wide range of operating conditions required and the fouling properties of the compressed gases. Elliott provides wet gas compressors for coker service and proprietary anti-fouling coatings to minimize foulant build-up on the aerodynamic surfaces of the compressor.

Foulant build-up can increase rotor vibration, constrict process gas passageways, decrease efficiency and reduce output. Elliott's Pos-E-Coat 523 is a proprietary anti-foulant coating that provides excellent foulant release properties, corrosion resistance, and the ability to withstand the harsh liquid/chemical injections that are typically used for cleaning compressors in refinery service. Field experience has demonstrated that Pos-E-Coat 523 helps to maintain rotor dynamics and compressor efficiency under severe fouling conditions significantly longer than other industry coatings.



■ ALKYLATION

Since the 1960s, Elliott has provided compressors for alkylation applications in refineries. In the alkylation process, olefin yield, commonly from a fluid catalytic cracker (FCC), is used as a feedstock and reacted with isobutane in the presence of an acid catalyst. A centrifugal compressor is needed to recirculate the isobutane. The resulting alkylate is available for market as high octane fuel, or is blended with lower grade gasoline to raise the octane level. Elliott centrifugal compressors enable reliable delivery of this high-value product at a very low operating expense.



■ INCREASED PRODUCTION THROUGH DESIGN OPTIMIZATION

Powerful design and modeling tools enable Elliott engineers to develop the highly efficient compressor and steam turbine designs required for refinery services. Computational fluid dynamic (CFD) analysis, finite element analysis (FEA), and solids modeling provide full 3-dimensional analyses of the aerodynamic flow path and the structural mechanics of compressor designs. We employ rotor dynamic analysis, compressor selection, and dynamic simulation programs to optimize multistage compressor applications. Compressor configurations we design with these tools include those with side-streams, double flow, back-to-back, and inter-cooling. Typical steam turbine configurations include multiple controlled and uncontrolled extractions, inductions and double flow exhaust.



■ THE ELLIOTT COMPRESSOR SELECTION PROGRAM

Elliott's proprietary compressor selection program is used in performance simulations for all customer applications. The program incorporates data from single-stage design verification tests and actual factory performance tests. This is a powerful tool that accurately models and predicts stage performance for any compressor design.

In refinery applications, wet gas and delayed coker processes have high molecular weights and high pressure ratios between the discharge and inlet pressures of the compressor. Multiple impeller stages are required, and consequently, iso-cooling is typically required to reduce the process temperature. It is common to have two process sections in a compressor casing for these applications.

■ WORLD-CLASS MANUFACTURING AND TESTING CAPABILITIES

Elliott's commitment to serve the growing refinery market is underscored by continued investments in our manufacturing facilities and testing capabilities. Elliott's manufacturing centers in Jeannette, Pennsylvania, USA and in Sodegaura, Chiba, Japan are fully equipped with the latest machine tools and test equipment. A recent expansion in Jeannette's assembly and test facility added four new test stands for the mid-size compressors typically specified for refinery services.

All Elliott compressors and turbines are assembled and thoroughly tested before shipment. The testing facilities in Jeannette and Sodegaura can accommodate multiple equipment test strings simultaneously. Both Jeannette and Sodegaura have state-of-the-art at-speed rotor balancing facilities equipped to handle rotors up to 284 inches (7,213 mm) in length and 96 inches (2,438 mm) in diameter, with a maximum weight of 27,000 lbs (12,246 kg) and speeds up to 30,000 rpm.

Elliott's testing capabilities include:

- ♦ Testing to American Petroleum Institute (API) requirements for:
 - API 612 (steam turbines)
 - API 614 (lube, control and seal oil systems)
 - API 617 (axial and centrifugal compressors)
- ♦ Compressor gas cooling facility over 100,000 HP (75 MW)
- ♦ Testing to ASME Power Test Code (PTC-10) requirements for compressors
- ♦ Customer specific testing requirements for process applications
- ♦ Full Variable Frequency Drive (VFD) motor drive capabilities
- ♦ Variable frequency start-up motor configurations



103M3 compressor casing (lower half) on the masterhead

■ GLOBAL SERVICES

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 has a global network of service centers that are registered to ISO 9001 or have structured quality management systems. They provide 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 accredited by the American Society of Mechanical Engineers (ASME), holding both U and R boiler and pressure vessel certifications. Nondestructive Examination (NDE) and welder qualifications are important parts of our quality control system. Elliott qualifies its NDE personnel in accordance with American Society of Nondestructive

Testing (ASNT) Recommended Practice SNT-TC-1A or country-specific equivalent based on ISO 9712. Elliott qualifies its welders in accordance with ASME Boiler and Pressure Vessel Code Section IX. Project-specific compliance with other industry standards includes: ANSI, API, CRN, CSA and CE/PED.





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.



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



COMPRESSORS ■ TURBINES ■ CRYODYNAMICS ■ GLOBAL SERVICE