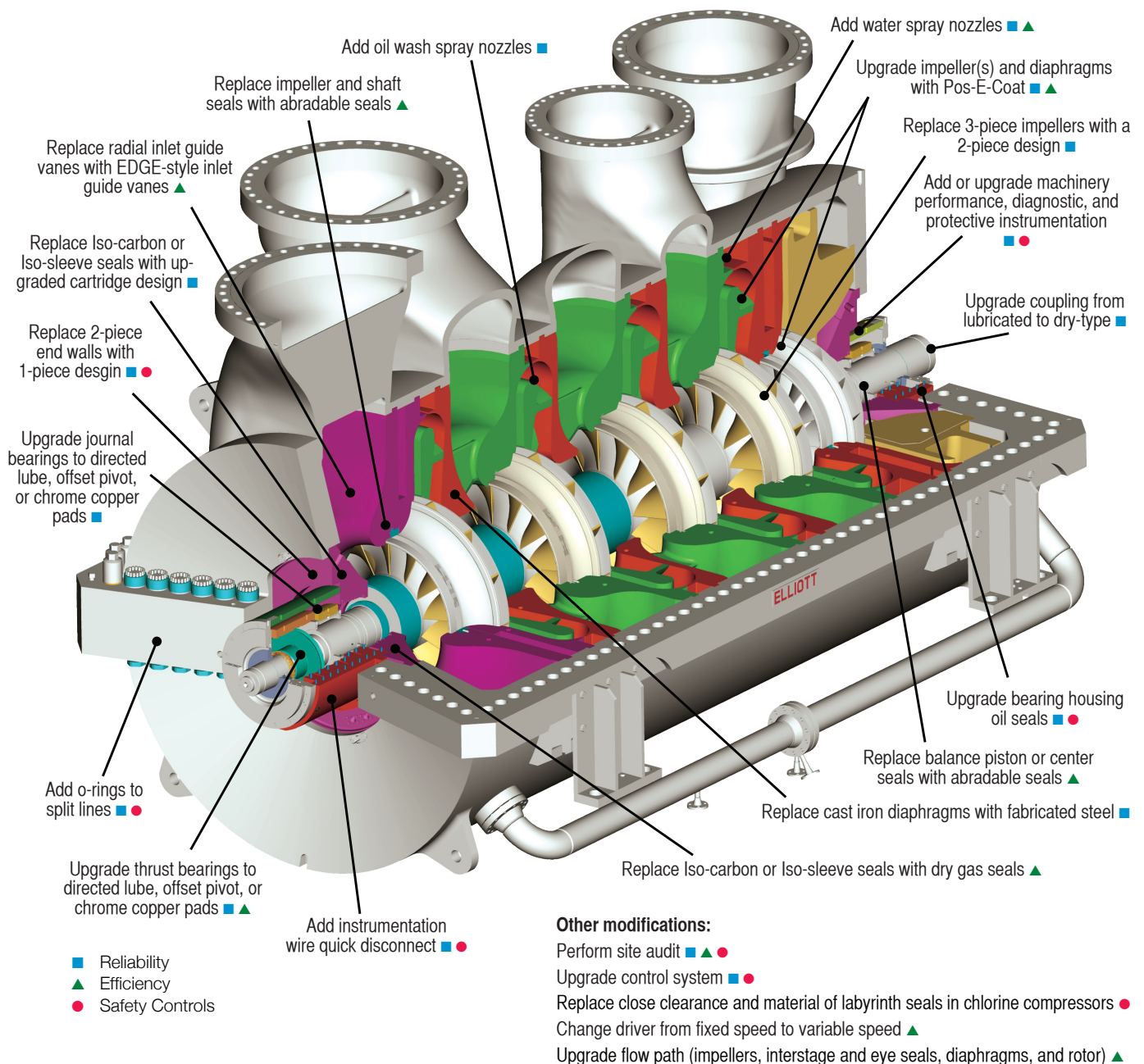


Multi-stage Centrifugal Compressor Modifications and Rerates

Changing market conditions can result in operation changes in process plants that directly affect the performance of centrifugal compressors and other critical rotating equipment. Elliott Engineered Solutions modifies and rerates compressors and other turbomachinery to cost effectively meet changing production requirements. We regularly redesign aerodynamic flow paths to meet capacity or process changes within an existing casing, avoiding drastic modification of foundations and piping.

Efficiency and reliability can also decline as process plants and turbomachinery mature. Elliott Engineered Solutions is uniquely qualified to modify installed process equipment to improve efficiency, reliability and safety, lower operating costs, simplify maintenance, and reduce cycle time regardless of the original equipment manufacturer. An upgrade to abrasion-resistant seals can improve efficiency. Advanced vibration and temperature-monitoring instrumentation improve reliability. Iso-carbon or Iso-sleeve cartridge seals simplify maintenance. Elliott Engineered Solutions' expertise and experience keep your turbomachinery performance high and your maintenance costs low.



Elliott Engineered Solutions

Elliott Engineered Solutions has one focus – to help turbomachinery operators obtain the highest value from their critical rotating equipment. Elliott has more than 100 years of experience in engineering, manufacturing, repairing, and modifying all types of turbomachinery. Elliott Engineered Solutions specializes in the following areas:

- ♦ Modifications and rerates of turbomachinery to increase the operational life and value of your investment by optimizing performance and reducing downtime.
- ♦ Reverse engineering and comprehensive analytical studies such as lateral and torsional rotor analysis, root-cause failure analysis, mechanical evaluation analysis, finite element analysis (FEA), and aerodynamic analysis.
- ♦ Onsite audits to evaluate turbomachinery efficiency and determine potential reliability improvements to maximize your return on existing equipment.
- ♦ Reapplication of previously owned equipment for emergency installation or cost-effective replacement.
- ♦ Equipment configuration designs to precisely fit existing footprints.

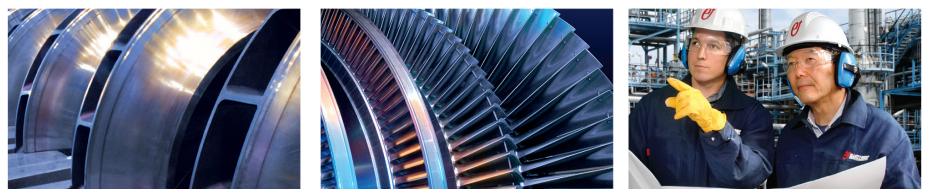
| Enhancement | Category | Benefit |
|--|---------------------------------|---|
| Add instrumentation wire quick disconnect | Reliability, Safety | Reduce chance of oil leak; reduce maintenance time |
| Add oil wash spray nozzles | Reliability | Eliminate internal fouling by mechanical cleaning |
| Add or upgrade machinery performance, diagnostic, and protective instrumentation | Reliability, Safety | Improve machinery performance, health monitoring and protective instrumentation |
| Add o-rings to split lines | Reliability, Safety | Improve sealing capability of split line |
| Add water spray nozzles | Reliability, Efficiency | Reduce/eliminate internal fouling; Decrease process gas temperature |
| Change driver from fixed speed to variable speed | Efficiency | Maintain optimal running speeds for peak efficiency; Eliminate suction throttling |
| Perform site audit | Reliability, Safety, Efficiency | Identify areas to upgrade for peak performance |
| Replace 2-piece end walls with 1-piece design | Reliability, Safety | Eliminate leak path between 2-piece end walls |
| Replace 3-piece impellers with a 2-piece design | Reliability | Greater reliability |
| Replace balance piston or center seals with abradable seals | Efficiency | Reduce seal leakage to improve efficiency |
| Replace cast iron diaphragms with fabricated steel | Reliability | Ability to weld repair; More robust design for longer life |
| Replace close clearance and material of labyrinth seals in chlorine compressors | Safety | Eliminate internal rubbing in order to prevent chance of auto ignition and fire |
| Replace impeller and shaft seals with abradable seals | Efficiency | Improve efficiency by reducing internal seal leakage |
| Replace Iso-carbon or Iso-sleeve seals with upgraded cartridge design | Reliability | Simplify seal replacement |
| Replace Iso-carbon or Iso-sleeve seals with dry gas seals | Efficiency | Save power loss by eliminating oil shear; Reduce oil consumption |
| Replace radial inlet guide vanes with EDGE-style inlet guide vanes | Efficiency | Reduce inlet losses between inlet flange and first impeller |
| Upgrade bearing housing oil seals | Reliability, Safety | Reduce oil leaks to atmosphere/Buffered design to eliminate leakage |
| Upgrade control system | Reliability, Safety | Keep compressor operating within a safe range |
| Upgrade coupling from lubricated to dry-type | Reliability | Eliminate oil requirements; Improve rotor dynamics |
| Upgrade flow path (impellers, interstage and eye seals, diaphragms, and rotor) | Efficiency | Increase performance or capacity |
| Upgrade Impeller(s) and diaphragms with Pos-E-Coat | Reliability, Efficiency | Reduce internal fouling and corrosion effects |
| Upgrade journal bearings to directed lube, offset pivot, or chrome copper pads | Reliability | Improve rotor stability at running speeds |
| Upgrade thrust bearings to directed lube, offset pivot, or chrome copper pads | Reliability, Efficiency | Reduce oil requirements, bearing temperature, and bearing heat loss |



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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



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