TRANSITIONING FROM REACTIVE TO PREVENTATIVE MAINTENANCE:

A LOOK INTO SIEMENS ENERGY'S LONG-TERM COMPRESSOR SERVICE PROGRAMS

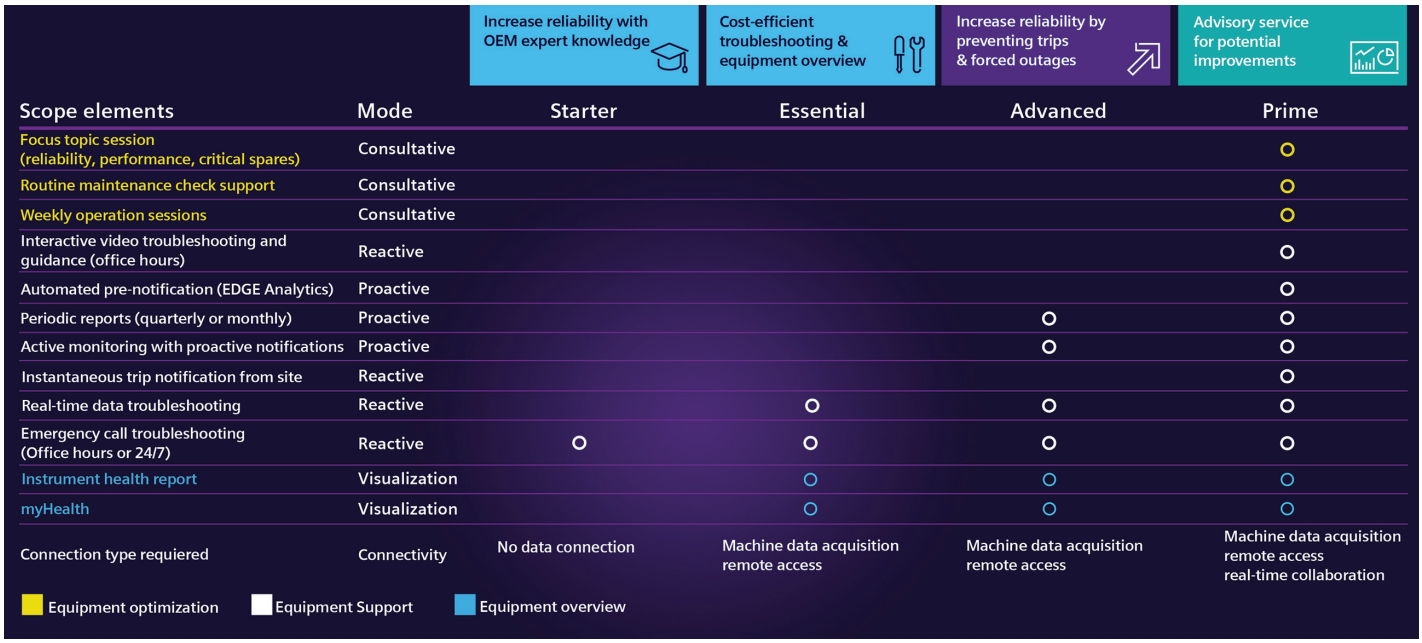


Figure 1. RDS Offering Overview

BY HUI KUANG AND ANDREW FORD

Maintenance plays an important role in a compressor's total cost of ownership. Too often, however, operators view maintenance only as an expense, without considering its return on investment (ROI). While this mindset may be appropriate for reactive maintenance, preventative maintenance strategies can generate savings (i.e., by avoiding unplanned downtime) that far outweigh the actual cost of repairs and service.

Developing and implementing a preventative maintenance approach for a compressor is a complex undertaking that requires the evaluation of many different variables. No two facilities or applications are the same. Maintenance concepts need to be tailored and optimized to ensure maximum compressor performance, efficiency, and uptime.

THE ADVANTAGES OF REMOTE DIAGNOSTIC SERVICES

Siemens Energy has a long history of developing long-term service programs designed to meet the unique needs of our customers' compression equipment, including both turbo-compressors and reciprocating compressors. Depending on the requirements, these service programs can incorporate advanced digital monitoring tools, like remote diagnostic services (RDS), that enable enhanced visibility.

Many compressor end users today are already using condition monitoring in combination with data analytics based on advanced technologies like artificial intelligence (AI) and machine learning. While the value these tools provide is not in question, it is important that they not be viewed as a direct replacement for original equipment manufacturer (OEM) expertise.

Analytics are highly effective for flagging certain anomalies in data that may indicate a potential problem. However, maximizing the predictive window and determining the best course of action ultimately requires operational context.

RDS provides this by establishing a collaborative, data-sharing model between the plant operator and compressor OEM. The OEM receives data from the unit(s). With full transparency, dedicated engineers can then act as a natural extension of the customer team by providing advanced troubleshooting and 24/7 remote support, along with recommendations for corrective maintenance — without having to be physically onsite.

The objective is to establish an early warning system that alerts plant operators to performance anomalies before a breakdown occurs. Data analytics tools can continue to be used for decision support, for example, on how best to manage degrading performance until the next planned maintenance outage. Other advantages of RDS include:

- OEM can screen false positives and forward only true-positive identifications of abnormal behavior.
- Allows for comparisons between actual as-is and as-designed performance parameters, via the equipment design software packages.
- Provides operators with access to as-build knowledge of equipment, which only the OEM has access to.
- OEM can provide recommendations to extend mid-life and full-life overhauls and improve train availability.
- In certain cases, it may be possible to eliminate the need for spare trains and their associated capital and operating expenses.

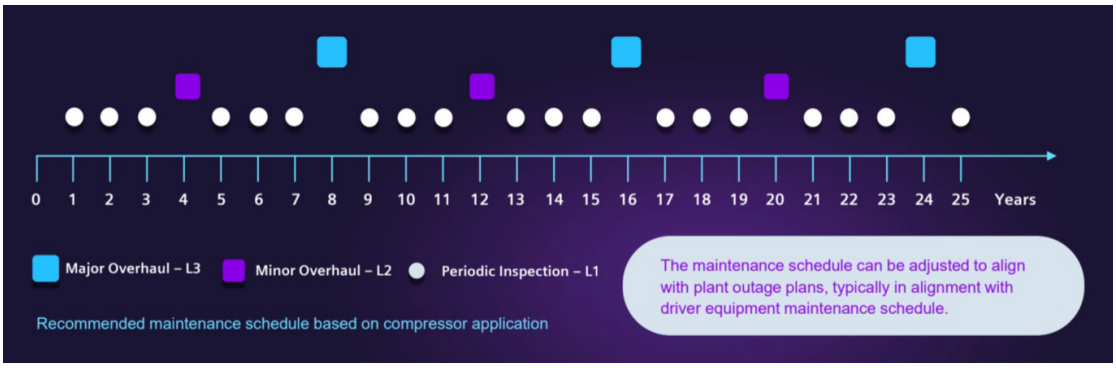


Figure 2. Exemplary Maintenance Schedule For A Compressor

SINGLE SHAFT TURBO-COMPRESSORS

With the largest compressor installed fleet worldwide, Siemens Energy's turbo-compressors are found in a wide range of industries and process applications. Our long-term service programs for single-shaft units include the following:

Level 1: Periodic Site Inspection With RDS — Visual inspection of the compressor, auxiliary systems, special tools, and spare parts, along with a check of operational records, alarms, and event logs.

Level 2: Minor Overhaul — Minor overhaul includes inspection of bearings, barrier and dry gas seals, and couplings. Instrumentation function and alignment checks are also performed. Components are replaced based on their condition.

Level 3: Onsite Overhaul — Complete disassembly of compressor bundle, including bearings and seals. Inspection, cleaning, and replacement of components based on condition, along with open/close wearables. Includes a coupling inspection and alignment check.

Level 3: Bundle Exchange — Complete swap of the bundle and disassemble, clean, inspection, and assemble (DCIA) of the old bundle (performed in the service shop). By swapping the bundle onsite, Siemens Energy can reduce downtime by as much as six days.

INTEGRALLY GEARED (I.E., MULTI-SHAFT) TURBO-COMPRESSORS

Siemens Energy built the world's first integrally geared compressor (IGC) in 1948. Today, we have more than 2200 units installed in a wide range of industries and process applications, including carbon dioxide service.

Our customized line of IGCs can accommodate up to four pinion shafts with up to eight impellers. Compressors can be designed according to API 617 or API 672 and customer specifications. Driver options depend on process and energy resources and can be electric motor, steam turbine, or gas turbine and are suitable for direct turbine-drive or even integrated expansion turbine configurations.

Level 1 and Level 2 maintenance activities for IGCs are very similar to those for single-shaft units. The major differences for Level 3 activities are outlined below:

Level 3: Onsite Overhaul — Complete disassembly of the compressor gear set, including bearings, carbon seals, and oil seals/labyrinth seals. Components are cleaned, inspected, and replaced if needed. Couplings are inspected and alignment is checked.

Level 3: Gear Set Exchange — Change of pinion shafts, bull gear, bearings, and all seals, along with refurbishment of replaced components.

RECIPROCATING COMPRESSORS

Siemens Energy reciprocating units range from medium- to high-speed separable units driven by engines or electric motors, to large, slow-speed, motor-driven machines. Like turbo-compressors, maintenance activities on our reciprocating units are typically separated into three different levels.

Level 1: Periodic Inspection — Components visually inspected for the compressor, auxiliary systems, special tools, and spare parts, along with a check of operational records, alarms, and event logs.

Level 2: Minor Overhaul — Check web defection, con rod, main bearings, thrust bearings, clearance, piston, and piston rods. Compressor valves are changed out as needed. Oil filters and open/closed wearables are replaced. Inspection of frame for debris and oil condition, as well as inspection of cylinder gas packages.

Level 3: Major Overhaul — Perform minor scope. Remove pistons and piston rods, inspect cylinders, replace rings, riders, and packing. Change out compressor valves and bearings. Flush lube oil system.

"DIGITAL READY" COMPRESSION TRAINS

Virtually all OEMs today equip new compressor units with the requisite hardware and software to enable digital condition monitoring. However, in most cases, monitoring services are offered as an "add on" feature, and thus come at a cost to the end user.

OEMs can do their part to accelerate digital adoption by making "digital readiness" part of the standard offering on new compressor packages. This is an approach Siemens Energy has adopted for most of its turbo-compressors and drivers.

At no additional cost through the warranty period, operators can access the health of their compression train remotely via our myHealth mobile app. myHealth aims to provide operators with a transparent and easy way to manage performance logs and planned outages, and to browse all the notifications issued for their compression trains. The data connection is included with the compressor train. However, it can easily be disabled depending on the operator's preferences. Depending on customer needs, more advanced capabilities, like RDS, can be added to the service package.