

## System 1\* Extender Dry Gas Seal RulePak

### Introduction

The System 1\* Dry Gas Seal RulePak models two of the most common dry gas seal design types—tandem, and tandem with intermediate labyrinth seal—along with their gas supply system. Data from instruments within the seals and seal gas control systems can be passed to the System 1 platform via standard OPC, MODBUS™ or custom system integration options.

The Dry Gas Seal RulePak receives the on-line data and converts it to Actionable Information\* with automatic early warning advisories to operators and maintenance planners.

### Dry Gas Sealing Systems

Dry Gas Seals are being applied to a growing number of new centrifugal compressors and to older designs as retrofits. This is due to their improved reliability, operating availability and lower life cycle maintenance cost benefits.

Higher discharge pressure capabilities continue to be developed, making them applicable to higher criticality compression processes from upstream oil and gas production to all midstream and downstream hydrocarbon processes.

Today's most common dry gas seal designs incorporate a tandem (redundant) design to improve reliability and prevent a single point seal failure (see *Figures 2 and 3*). However, associated with the growing number of installations, the number of unexpected outages reported exceeded 50 in 2006 alone, prompting end users to search for an on-line condition monitoring solution for the seal components and gas supply systems.

With the System 1 Dry Gas Seal RulePak solution (see *Figure 1*), the on-line condition of the sealing system can continuously identify early warning symptoms associated with the most common failure modes (refer to *Tables 1 and 2*). The majority of the problems can be fixed with maintenance planning to avoid an unexpected outage.

### System 1 Dry Gas Seal RulePak solution

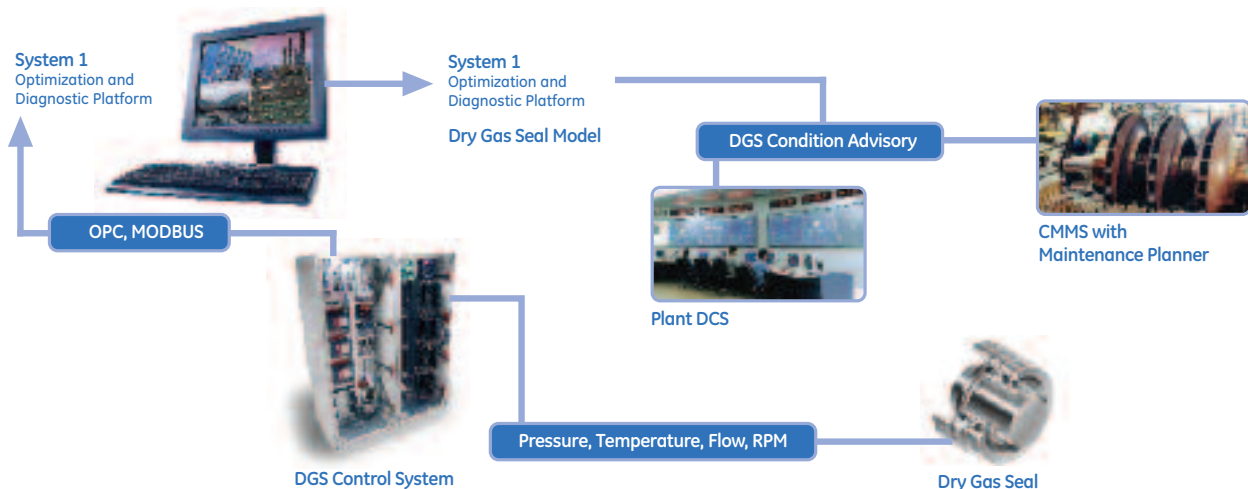


Figure 1. System Architecture



# System 1 Extender Dry Gas Seal RulePak

## Failure Modes and Consequences

Tables 1 and 2 show the failure modes detectable with the Dry Gas Seal RulePak. These apply to the tandem design seals and the associated seal gas supply system.

While redundant designs in the seals improve reliability and lower the likelihood of total failure, compressor availability can be impacted when a primary failure has taken place and the decision is made not to continue normal operations. Without time to plan, an unexpected outage for reactive maintenance can easily exceed USD \$100K per day of lost production and significant costs in expediting parts and skilled labor to repair.

## Dry Gas Seal RulePak Benefits

- Augmented Site Safety Plan.** Dry Gas Seals are being applied on processes beyond 15,000 PSI today. Higher discharge pressures typically result in a higher consequence of failure and shortened detection to failure time. The RulePak can identify potential asset issues by providing on-line condition change advisories.

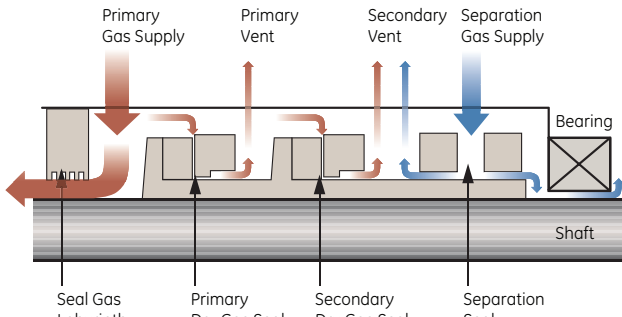


Figure 2. Tandem seal general design

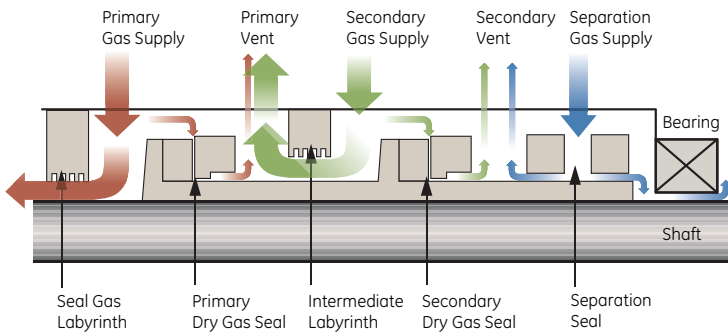


Figure 3. Tandem seal with intermediate labyrinth

	Fouled Seal Gas Filter - Warning	Fouled Seal Gas Filter - Alert	Fouled Seal Gas Filter - Danger	Low Seal Gas Supply Differential Pressure - Warning	Low Seal Gas Supply Differential Pressure - Alert	Low Seal Gas Supply Differential Pressure - Danger	Low Seal Gas Inlet Flow - Warning	Low Seal Gas Inlet Flow - Alert	Low Seal Gas Inlet Flow - Danger	Low Seal Gas Inlet Pressure - Warning	Low Seal Gas Inlet Pressure - Alert	Low Seal Gas Inlet Pressure - Danger	High Seal Gas Inlet Flow - Warning	High Seal Gas Inlet Flow - Alert	High Seal Gas Inlet Flow - Danger	Low Seal Gas Inlet Temperature - Warning	Low Seal Gas Inlet Temperature - Alert	Low Seal Gas Inlet Temperature - Danger	
Inputs																			
X - Required																			
O - Optional																			
<b>Measurements</b>																			
Machine Speed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Machine Speed Backup	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	
Seal Gas Filter DP	X	X	X																
Seal Gas DP				X	X	X													
Seal Gas DP Backup				O	O	O													
Seal Gas Inlet Flow							X	X	X				X	X	X				
Seal Gas Inlet Flow Backup							O	O	O					O	O				
Seal Gas Inlet Pressure										X	X	X							
Seal Gas Inlet Pressure Backup										O	O	O							
Seal Gas Inlet Temperature																	X	X	X
Seal Gas Inlet Temperature Backup																	O	O	O
<b>Machine Properties</b>																			
Design Speed	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Lower Auditable Speed Range	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	
Upper Auditable Speed Range	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	
<b>Configured Attributes</b>																			
Sev 1 Filter DP Setpoint	X																		
Sev 3 Filter DP Setpoint		X																	
Sev 4 Filter DP Setpoint			X																
Sev 1 Low Seal Gas DP Setpoint				X															
Sev 3 Low Seal Gas DP Setpoint					X														
Sev 4 Low Seal Gas DP Setpoint						X													
Sev 1 Low Inlet Gas Flow Setpoint							X												
Sev 3 Low Inlet Gas Flow Setpoint								X											
Sev 4 Low Inlet Gas Flow Setpoint									X										
Sev 1 Low Inlet Gas Pressure Setpoint										X									
Sev 3 Low Inlet Gas Pressure Setpoint											X								
Sev 4 Low Inlet Gas Pressure Setpoint												X							
Sev 1 High Inlet Gas Flow Setpoint													X						
Sev 3 High Inlet Gas Flow Setpoint														X					
Sev 4 High Inlet Gas Flow Setpoint															X				
Sev 1 Low Inlet Gas Temperature Setpoint																	X		
Sev 3 Low Inlet Gas Temperature Setpoint																		X	
Sev 4 Low Inlet Gas Temperature Setpoint																		X	
Control Type (Flow=TRUE, DP=FALSE)										X	X	X							

Table 1: Dry Gas Seal Supply failure modes showing optional and required inputs to the RulePak

# Application Overview

## Required measurements and setpoints for failure mode ID

**Note 1:** Flow can be measured in volumetric units, mass units or differential pressure units (as pressure measured across a restriction orifice). The corresponding setpoints must use the same unit type.

**Note 2:** The seal failure events require at least one vent flow or pressure measurement and the setpoints configured for the available measurement.

**Note 3:** For the Bearing Oil Migration event, the Lube Oil Header Pressure is required when the Bearing Lube Oil Operation State is unavailable.

Inputs  
X - Required  
O - Optional

	Primary Seal Failure - Warning	Primary Seal Failure - Alert	Primary Seal Failure - Danger	Secondary Seal Failure - Warning	Secondary Seal Failure - Alert	Secondary Seal Failure - Danger	Secondary or Separation Seal Failure - Warning	Secondary or Separation Seal Failure - Alert	Secondary or Separation Seal Failure - Danger	Predicted Primary Seal Failure - Warning	Predicted Primary Seal Failure - Alert	Predicted Secondary Seal Failure - Warning	Predicted Secondary Seal Failure - Alert	Bearing Oil Migration
<b>Measurements</b>														
Machine Speed	X	X	X	X	X	X	X	X	X	X	X	X	X	
Machine Speed Backup	O	O	O	O	O	O	O	O	O	O	O	O	O	
Primary Vent Flow	X	X	X	X	X	X				X	X	X	X	
Primary Vent Flow Backup	O	O	O	O	O	O				O	O	O	O	
Primary Vent Pressure	O	O	O	O	O	O				O	O	O	O	
Primary Vent Pressure Backup	O	O	O	O	O	O				O	O	O	O	
Secondary Vent Flow							X	X	X					
Secondary Vent Flow Backup							O	O	O					
Secondary Vent Pressure							O	O	O					
Secondary Vent Pressure Backup							O	O	O					
Separation Seal Gas Inlet Pressure														X
Separation Seal Gas Inlet Pressure Backup														O
Lube Oil Header Pressure														X
Bearing Lube Oil Operation State														O
<b>Machine Properties</b>														
Design Speed	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lower Auditable Speed Range	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Upper Auditable Speed Range	O	O	O	O	O	O	O	O	O	O	O	O	O	O
<b>Configured Attributes</b>														
Sev 1 High Primary Vent Flow Setpoint	X													
Sev 3 High Primary Vent Flow Setpoint		X												
Sev 4 High Primary Vent Flow Setpoint			X							X	X			
Sev 1 High Primary Vent Pressure Setpoint	O													
Sev 3 High Primary Vent Pressure Setpoint		O												
Sev 4 High Primary Vent Pressure Setpoint			O							O	O			
Sev 1 Low Primary Vent Flow Setpoint				X										
Sev 3 Low Primary Vent Flow Setpoint					X									
Sev 4 Low Primary Vent Flow Setpoint						X						X	X	
Sev 1 Low Primary Vent Pressure Setpoint				O										
Sev 3 Low Primary Vent Pressure Setpoint					O									
Sev 4 Low Primary Vent Pressure Setpoint						O						O	O	
Sev 1 High Secondary Vent Flow Setpoint							X							
Sev 3 High Secondary Vent Flow Setpoint								X						
Sev 4 High Secondary Vent Flow Setpoint									X					
Sev 1 High Secondary Vent Pressure Setpoint							O							
Sev 3 High Secondary Vent Pressure Setpoint								O						
Sev 4 High Secondary Vent Pressure Setpoint									O					
Sev 4 Low Separation Gas Inlet Pressure Setpoint														X
Lube Oil Header Pressure Operating Threshold														O

Table 2: Dry Gas Seal failure modes showing optional and required inputs to the RulePak

## Dry Gas Seal RulePak Benefits (continued)

- Increased Availability.** Example: a process upset, recycle control failure or misconfiguration may result in the compressor experiencing a surge event. At higher discharge pressures surge events will produce higher impacts and damage on dry gas seals and other components. Understanding the extent of dry gas seal condition change can enable continued operation decision-making, extending availability.
- Increased Reliability.** The Dry Gas Seal RulePak was developed using Failure Mode Effect Analysis (FMEA) tables, as typically produced for critical equipment identified in a Reliability Centered Maintenance (RCM) program. By addressing the most common failure modes and bringing on-line data into the RulePak, the opportunity to catch a failure mode early and take proactive decisions can extend the overall reliability and availability of the seals. Example: a production upset that enables process gas or bearing oil ingestion to the seals. The impact on the seals' condition, and therefore reliability, can be detected by the RulePak, which will produce advisories with an associated severity.
- Decreased Maintenance Cost and Lost Production Revenue.** Dry Gas Seal maintenance intervals can typically extend to desired run time goals. However, an upstream or downstream process problem may shorten the life considerably. The cost to reactively repair or replace a seal or its gas supply system with skilled labor and parts can typically eradicate a day's production revenue. When the condition of the seal has not been monitored, the process of troubleshooting to root cause can be days to weeks in some cases. The System 1 platform's troubleshooting capabilities have repeatedly proven to reduce the impact of these incidents by identifying root cause faster.
- System 1 Added Value.** The Dry Gas Seal RulePak complements the other Rule Paks for centrifugal compressors available for the System 1 platform.
- Better Environment.** In highly toxic compression processes, such as upstream production gas re-injection with H<sub>2</sub>S, the risk to personnel and the environment can be reduced with proactive condition advisories. These are available directly to local operations and/or remotely to machinery experts and maintenance planners to mitigate a process to atmosphere leakage event.

## Solution Package or Configuration

The Dry Gas Seal RulePak is available for System 1 software installations of version 6.1 and above. For more information on ordering Rulepaks in general, please consult Specification and Ordering Information document 175487. The part number convention for ordering the Dry Gas Seal RulePak is as follows:

### 3061/22 - AXX

#### A Type

01 Tandem

02 Tandem w/Intermediate Labyrinth

## Installation Services

Upon request, GE can install and configure any of our RulePaks for an additional fee. Provided your System 1 installation has been enabled for remote access, this installation and configuration can often be performed remotely, eliminating travel-related costs. The time required to install and configure a Dry Gas Seal RulePak is approximately one hour per seal. This estimate assumes that all seal-related process variables are already present in the System 1 database. It also assumes that you have documented each seal's design and operating properties, and that you have provided this data to us, allowing it to be readily entered during configuration of the RulePak.

## Additional Services

GE Energy's Bently Nevada team provides additional services to support your System 1 installation. These can be quoted upon request and include:

### System Integration Services

We provide complete integration services to seamlessly link your System 1 software with process control measurements and platforms.

### IT Coordination Services

Our IT support engineers will work directly with your IT department to understand your particular IT policies, constraints, and technologies, ensuring that your System 1 installation is configured and deployed with full compliance to your IT environment. This is an especially valuable service when you need to enable remote connectivity by your own employees, GE technical support personnel, and others, as remote access typically entails special security concerns and technologies.

## Supporting Services Agreements (SSAs)

Individually tailored Supporting Services Agreements are available to address the health of your condition monitoring system and the assets it monitors. The most basic component of an SSA is to continuously maintain the health of your System 1 software and associated Bently Nevada instrumentation, ensuring the integrity and availability of your condition monitoring system. An additional SSA component that many of our customers elect to purchase is our ability to augment your own machinery diagnostics and reliability capabilities with remote condition monitoring services. These services focus on the health of your machinery assets (rather than your condition monitoring assets) and are delivered remotely by our machinery experts that connect to your system and assess mechanical health of monitored assets. The level of support is tailored to your needs and can range from on-demand consultation when you need assistance diagnosing a particularly difficult machinery problem, to continuous 24/7 coverage that monitors the status of all machinery in your system for anomalies and alarms, to scheduled machinery health audits conducted at quarterly or other intervals.

## Technical Support Agreements (TSAs)

Technical Support Agreements are available in three different levels (Platinum, Gold, and Silver), allowing you to select the appropriate degree of phone, web, and e-mail support for your System 1 software and associated Bently Nevada instrumentation. In addition to as-needed access to our technical support specialists and online resources, Gold- and Platinum-level TSAs entitle you to free software updates. One year of complimentary Platinum-level support is provided with your software purchase and is renewable in multi-year increments at the level of your choosing. To learn more, visit [www.ge-energy.com/bentlyTSA](http://www.ge-energy.com/bentlyTSA).

GE Energy welcomes all questions and comments from our customers. For more information, please contact us at:

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