VMOP - Valve Performance Pressure Relief Valve Reporting Overview

Executive Summary of Curtiss-Wright VMOP SWE Methodology testing

This summary outlines testing strategies utilized for Curtiss-Wright's Valve Maintenance Optimization Program (VMOP). VMOP testing involves using SWE (StressWave) ultrasonic monitoring equipment during valve lift certification testing to monitor for valve leakage to ensure excellent seat-tightness. Test results are analyzed and compared with historical data from similar valve designs, including well over one thousand tests performed on Constellation Generation valves for more than a decade. SWE monitoring technology is a proven method to detect leakage within Steam Pressure Relief Valves.

Using the SWE Methodology of monitoring to measure seat-tightness of every valve allows tracking and trending of consistently superb valve refurbishment techniques and creates future opportunities for increased in-service cycle time reliability due to SRV maintenance performance improvements and is a useful tool in eliminating unscheduled outages due to SRV seat leakage. A StressWave (SWE) data collector, ultrasonic sensors and SWANLX database software are used to collect and analyze the SWE data. Between two and five sensors are mounted to the valve on the valve body externally near the seats. Heat dissipating mounts are used to protect the sensor from the radiant heat of the valve during testing. The sensor mounts are attached to the valve using flange or clamp attachments – no valve modifications are required. The only requirement is that the sensor have a solid mount to facilitate the frequency path to the valve seat through the valve body. Once the SWE data is collected, it is extracted from the server and imported into our proprietary software so detailed calculations can be performed. The critical period for the data extraction is the 'quiet period' after each lift and during the final seat tightness check.

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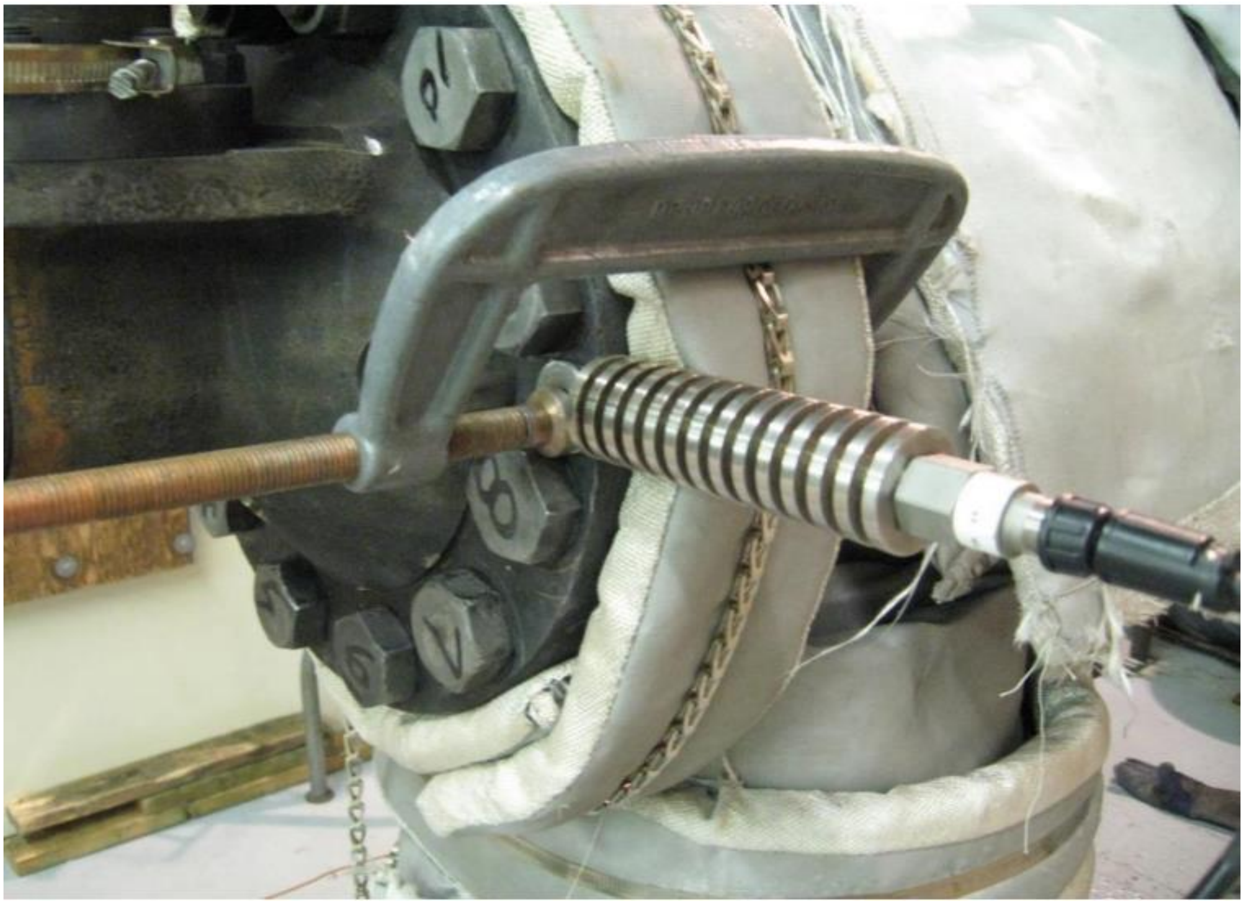
Test Set Up

Curtiss-Wright has permanent test units at NWS Technologies, as well as mobile units for onsite testing, that are used to collect continuous SWE readings on an sites' valves that are participating in VMOP SWE testing. The SWANguard unit can support up to eight SWE sensors simultaneously. A sensor is placed near all or on a combination of the following locations: inlet or main seat, pilot seat, second stage seat, exhaust, and pilot filter. StressWave Energy (SWE) data is collected during the certification testing that is performed on each valve. Unlike traditional sensors, which require special mounting methods, the StressWave sensors are designed for easy mounting and installation and only require a suitable sound path through the structure. In this case an elongated flange mount equipped with heat dissipating fins is used to lower the temperature at the sensor. No valve modifications are required.

Example SWE sensor location



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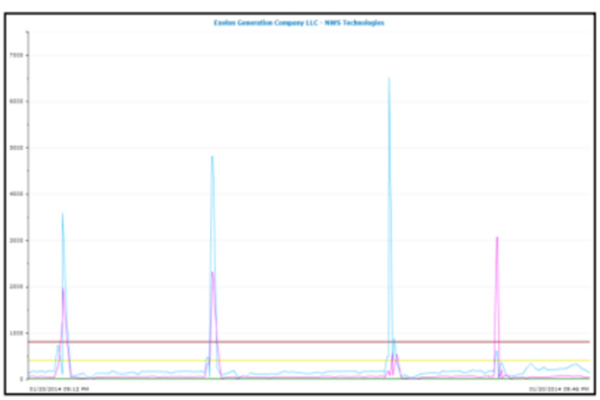
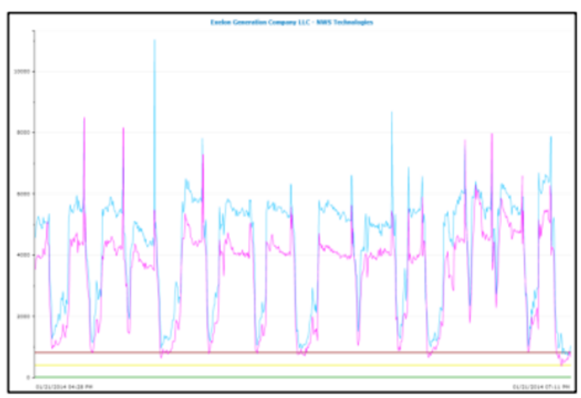
Analysis Performed

The SWE Methodology of testing and analysis uses a proprietary and patented ultrasonic sensor to gather data and advanced pattern recognition software coupled with machine learning A.I. to analyze data and detect anomalies. The data collected can provide leak identification, source of valve leak, and in some cases – the severity of the leak; if baseline data is taken on a newly rebuilt valve – our software can calculate a degradation curve for said valve. This technology is now being integrated into Curtiss-Wright SmartPlatform as a means of continuous online monitoring. The basic property being recorded by the equipment is the SWE signature plotted on a graph. These readings are derived by the frequency generated by a leaking valve and are a measurement of seating surface condition, spring integrity, and seat load. The StressWave Energy (SWE) created by the leaking valve is transferred though the metal body of the valve to the sensor strategically, and in a non-intrusive fashion, located on the outside of the valve body.

Examples of SWE Data Signatures - Good vs Bad



Example of a Tightly Seated Valve (Pre / Post Lifts)



Example of Loosely Seated or Simmering Condition

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Analysis performed (contd)

The SWE data is compiled and analyzed resulting in specific metrics that are used to determine the valve performance. Here is an explanation of those metrics: SWE Average = The calculated average of the Stress Wave Energy during a specific period in between the pressure lifts. 1σ = The one sigma standard deviation in the SWE data. UCL (Upper Control Limit) = The SWE Average plus 3 times the 1σ. This calculation helps to determine the presence of excessive variation in the data that could be concealed by only looking at the overall average of the data. UCL Acceptance Criteria = A threshold level that was determined from the statistical analysis of the StressWave data that was collected during the past 12 years of valve testing experience representing the transition between normal results and abnormal results The critical time period for extracting the SWE data is during a quiet period in between the lifts and just before the final seat tightness check. The quiet period between the lifts is important because at this time the pressure has been restored to a nominal level and the valve seat should be sealed. If there is leakage during this time, there may be a maintenance issue with the valve. Tightly seated valves typically have SWE readings which are less than the defined upper control limit (UCL) criteria, and leaky valves have UCLs greater than the defined criteria. Since the UCL is a continuous measurement of valve performance, a comparison trend can be developed between this data and performance data once the valve is installed back at the station. Invariably, valves with SWE test results greater than the UCL are those candidates that have less margin and could develop major leaks which could warrant unscheduled maintenance outages to complete the needed maintenance.

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