

A Comprehensive Study of Tip-Seal Life Expectancy for IDP-15

Solution Note



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I. SUMMARY

A comprehensive experiment was conducted to quantify the expected lifetime of the field replaceable Tip Seals in Agilent's new IDP-15 Dry Scroll Pump in various applications.

This Solution Note is intended to provide Customers with real world information on the expected field life of IDP-15 Tip Seals.

The study examined the influence of Temperature, Gas Flow, Venting to Atmosphere, and Duty Cycle on Tip Seals lifetime.

II. BACKGROUND

Agilent Technologies introduced the IDP-15 Dry Scroll Pump in December 2013. The Dry Scroll pump features a hermetic, isolated design. With pumping speed of 15.4 cubic meters per hour (@ 60 Hz), the IDP-15 provides rapid pump-down and is ideal for use in academic, research, analytical instrumentation and industrial applications. It is exceptionally quiet and vibration-free. In addition, the IDP-15 makes use of a Solid-tip seal, designed to provide a two-year service interval in most applications and a Single Sided Scroll design for simple, infrequent maintenance. The IDP-15 replaces the Agilent TS-300 dual-sided scroll pump. For these experiments, a population of TS-300 pumps (using foam-backed Tip Seals) was used as a control group.



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Figure 1 - Solid Tip Design (with Foam Backed Tip Seal at Left)

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Many experiments have tackled the 'Tip Seal Lifetime' question from a theoretical approach, however the Agilent QA/Reliability group in Lexington, MA tested the durability of the Solid Tip Seal design under real world conditions. Weibull statistical analysis was used to analyze the results in a meaningful way.

III. EXPERIMENT DESCRIPTION

Since most primary pumps operate at a nominal pressure well above their ultimate capacity, we designed a test that would effectively determine how long a set of tip seals could maintain a specific pressure reading (rather than looking at deviations in ultimate, or base pressure). We consulted with end-user customers in multiple applications and determined that 100 mTorr represented a suitable pressure target; a pressure far below the foreline pressure limit of virtually all commercially available Turbomolecular Pumps.

A sample of over 20 pumps was operated under a variety of gas load and duty cycle conditions (described below). Periodically, a vacuum gauge was installed at the inlet of each pump, with no external gas load present. The pump's ability to achieve 100 mTorr (within 30 minutes) was the GO/NO GO condition being measured. Data was analyzed using a one-parameter Weibull analysis technique tailored to smaller sample sizes.

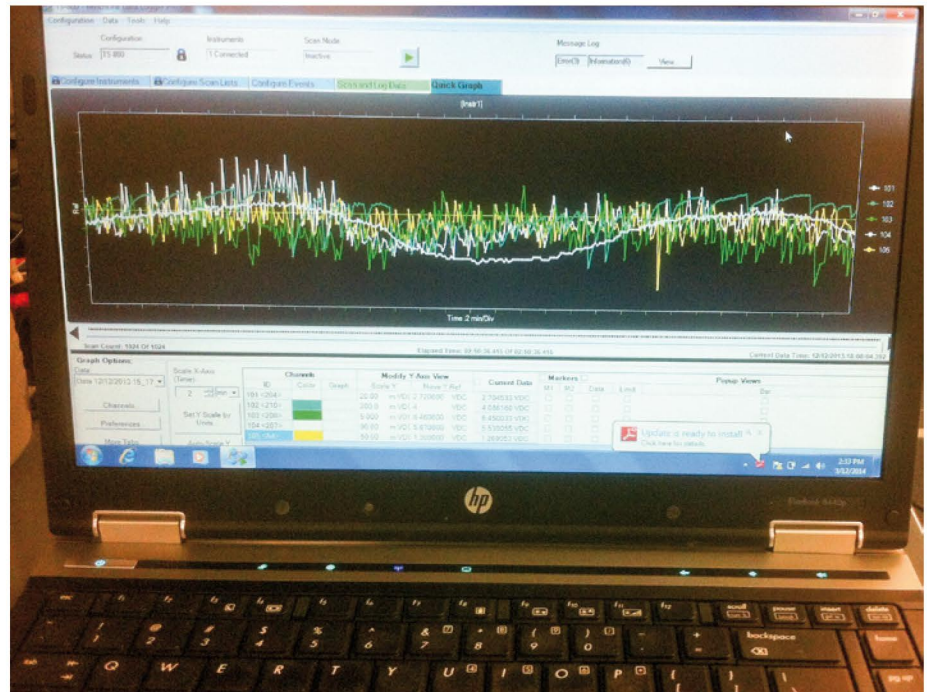


Figure 2 - Analysis of Vacuum Pressures Achieved vs Time.



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IV. STRESS FACTORS

A number of parameters were examined for their impact on the IDP-15's tip seal lifetime as described below.

A. Venting/Duty Cycle

Four of the 20 pumps were subject to an extreme duty cycle to simulate Load Lock applications. The four pumps were vented to atmosphere EVERY 5 MINUTES. After approximately 14,000 hours operation under these conditions, one of the four 'vented' pumps was unable to achieve the 100 mTorr threshold (within 30 minutes) and a second pump was providing somewhat erratic pressure readings around the 100 mTorr threshold. Within the same time period, none of the non-vented pumps failed. From this we determined that venting the pumps at this interval would represent a 25-50% acceleration factor on the tip seal lifetime.

B. Elevated Temperature

Four of the 20 pumps were operated in a sealed enclosure, and the pumps' thermal load raised the ambient environment to 55 °C, well above the recommended operating range (5 °C to 45 °C). The results were surprising: the IDP-15's in the 'Hot Box' experienced Tip Seal lifetimes as good as those operated at normal room temperature! Several TS-300 pumps were operated under the same temperature conditions but the foam-backed Tip Seals in those pumps lasted only HALF AS LONG as their counterparts operated at Ambient Temperature.



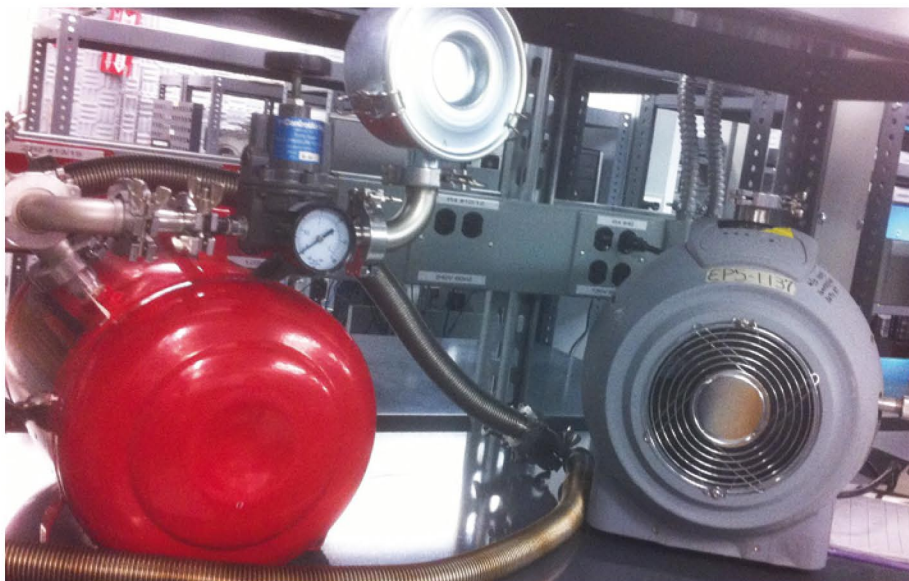
C. Elevated Back Pressure

Subjecting the pumps to an exhaust pressure above atmosphere can increase the stress on a scroll pump and accelerate the wear of the tip seals. Agilent VPD specifies a maximum back pressure of 6.5 psia for the IDP-15.



Four IDP-15 and four TS-300 pumps were run with a positive pressure of +7.5 psia at the exhaust ports. By 10,000 hours operation under these conditions 3 of the 4 TS-300 pumps were no longer able to meet the test criteria (100 mTorr within 30 minutes), however ALL the IDP-15 pumps were still meeting the specification at 20,000 hours.

Figure 3 -
Using Compressor to Provide +ve
Pressure at Exhaust



D. Constant Gas Load

In many Applications, forepumps are operated with a high constant inlet pressure. Using mechanically constructed permanent leak fixtures, IDP-15 pumps were operated at a constant inlet pressure of a few Torr.

The high inlet gas load pumps did not reduce the Tip Seal lifetime (vs pumps without inlet gas load). This indicates the IDP-15 would be an ideal choice for constant gas load applications like a Mass Spectrometer's Interface pumping region.

Figure 4 - Mechanical Leak
(4.1 Torr shown)



V. RESULTS

By analyzing the data, we can say with 80% confidence that the Tip Seals in 85% of the pumps will achieve at least 17,676 hours operating life. For these calculations, we assumed a 24/7 Duty Cycle, but excluded the Vented Pumps (average 145,000 vents/pump).

When the vented pumps are included, we can still say with 80% confidence that the Tip Seals in 70% of the pumps will achieve 2 years lifetime.

% Survive	Hrs @ 80% Confidence
99	7753
95	11785
90	15547
85	17676
80	19004
50	22346

≈ 2 years

Table 1 - Weibull Analysis
of Data Recorded as of Sept. 2014

VI. CONCLUSIONS

- The solid Tip Seal design of the IDP-15 significantly outperforms the foam-backed Tip Seals of the TS-300, particularly in applications where a high ambient temperature is present, or where the pumps will experience a positive pressure at the exhaust.
- The IDP-15 will achieve the design criteria (tip seal life > 2 years) even when pumps are exposed to working conditions beyond the limits of most applications (Venting Cycle, Ambient Temperature, Back Pressure and High Gas Flow)