# Differential Pumping With SC and SM Cathodes

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CONSTRUCTION OF THE SCI VACUUM SEAL CARTRIDGE

Both the Side Mount (SM) and Standard SCI Cathode (SC) models are designed to allow for differential pumping. SM models require the end-user to modify the vacuum seal cartridge to create the port necessary for differential pumping. SC models use cartridges with a built-in differential pumping port. No additional modification to the vacuum seal cartridge is required to differentially pump SC models. The basic construction of the SC and SM vacuum seal cartridge is shown in figure 1.

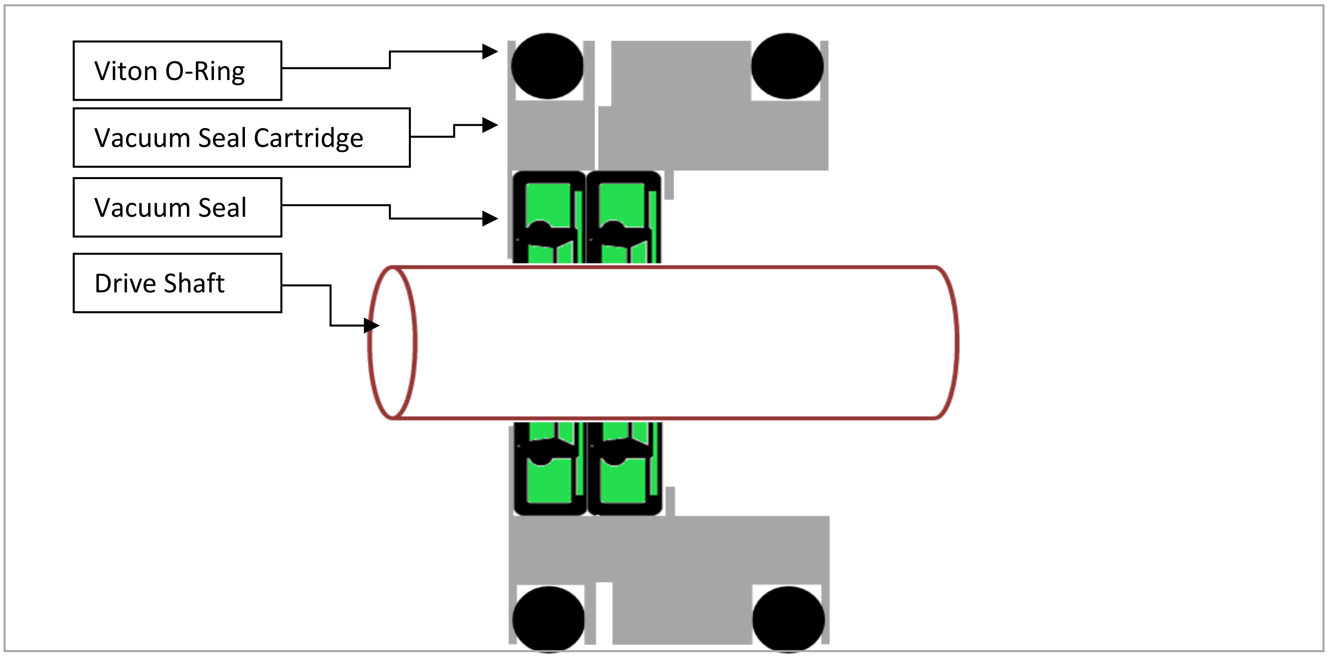
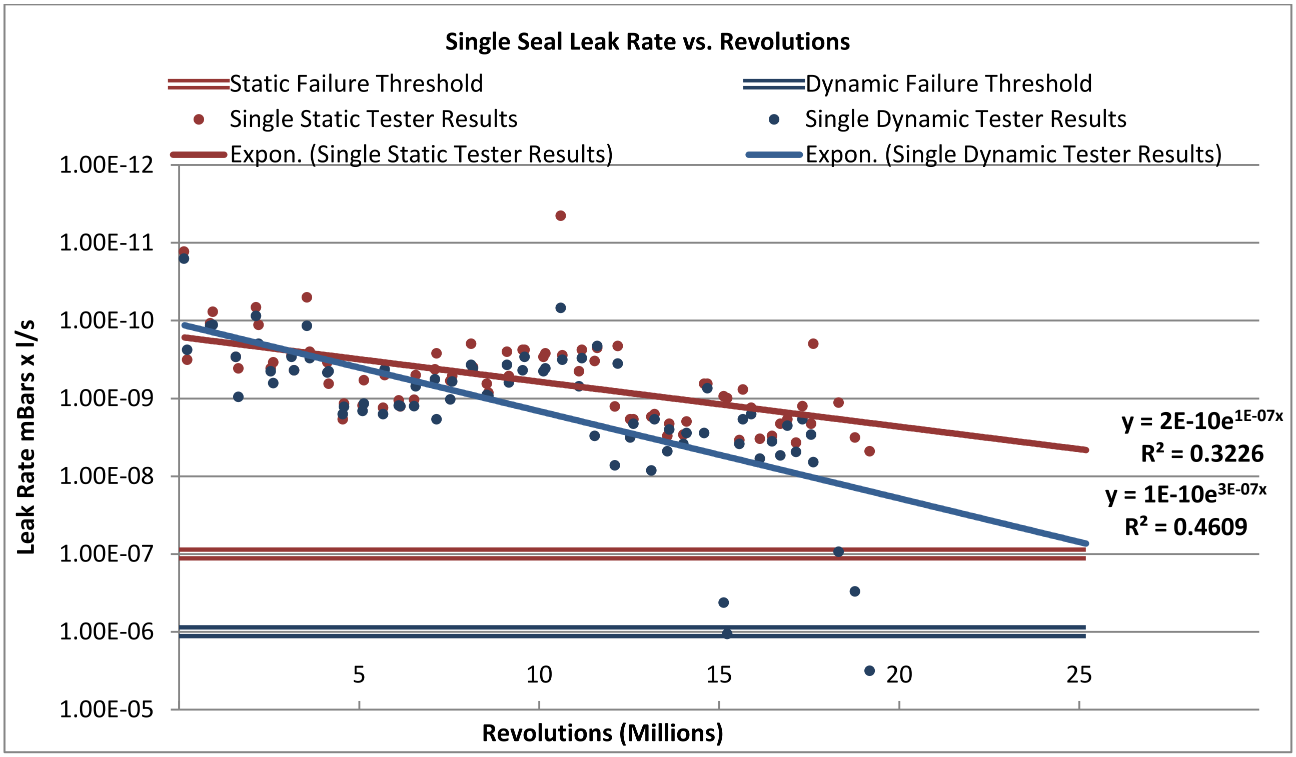



**Figure 1: General SCI vacuum seal cartridge design**

DIFFERENTIAL PUMPING OF THE SCI VACUUM SEAL CARTRIDGE

As shown in figure 1, SCI endblocks can be differentially pumped by evacuating the cavity between the first and second vacuum seals within the vacuum seal cartridge. Differential pumping is generally used to extend the life of vacuum seals and reduce leak rate. Differentially pumping the vacuum seals also allows the user the ability to monitor cathode leak rates. SC and SM end blocks are designed to allow the option of differential pumping although test data shows it is normally not necessary. As shown in figure 2, new lip seals are rated to achieve 8 million cycles during a 2 year campaign. Further testing is required to investigate the lifetime of new SCI seals with differential pumping.



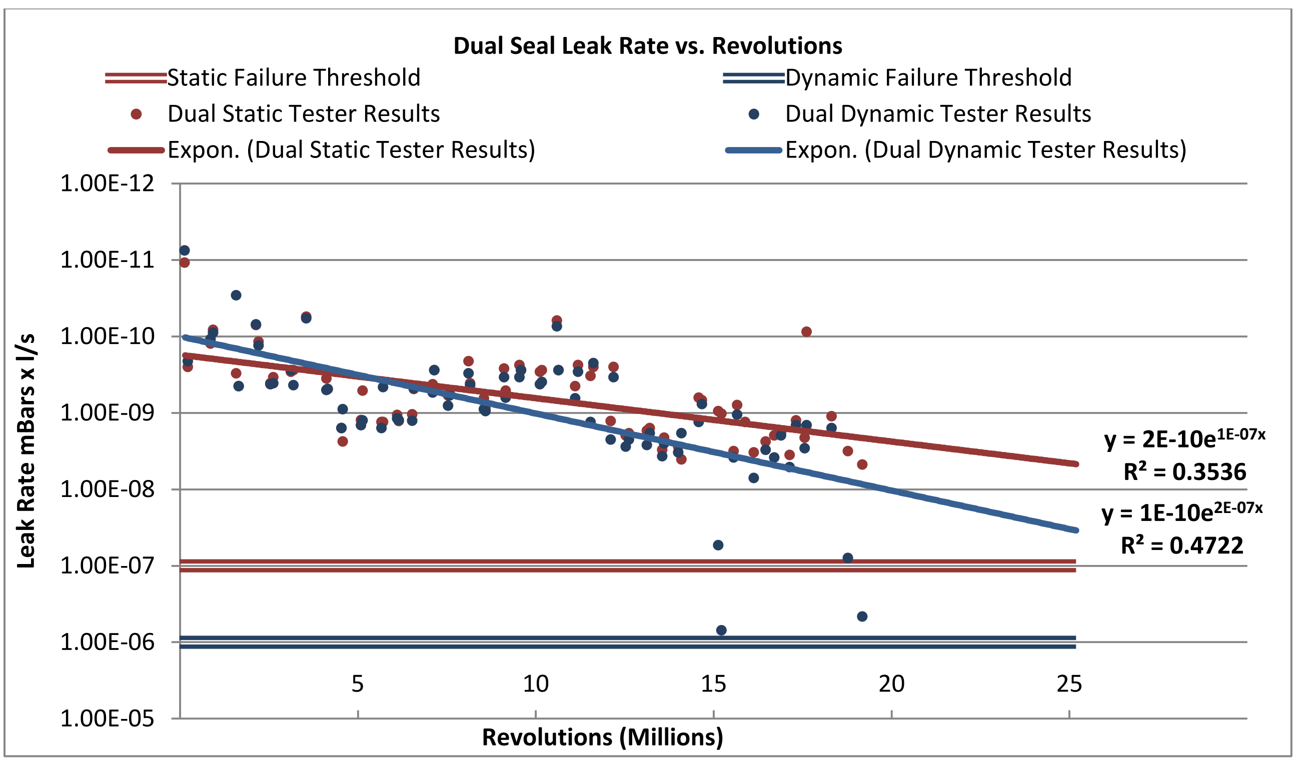




**Figure 2: Leak rate of SCI 2-year seals**

POTENTIAL DAMAGE TO THE VACUUM SEAL CARTRIDGE DURING DIFFERENTIAL PUMPING

Under some conditions, the electrical geometry of the SM cathode, shown in figure 3, may permit arcing from the drive shaft (cathode potential) to the cathode body (ground potential) through the differential pumping port (path to ground shown in red.) The SC vacuum seal cartridge, drive shaft and endblock are all at negative potential during operation and do not have a direct path to ground through the differential pumping port. As a result, breakdown voltage tests are not required for SC end blocks.

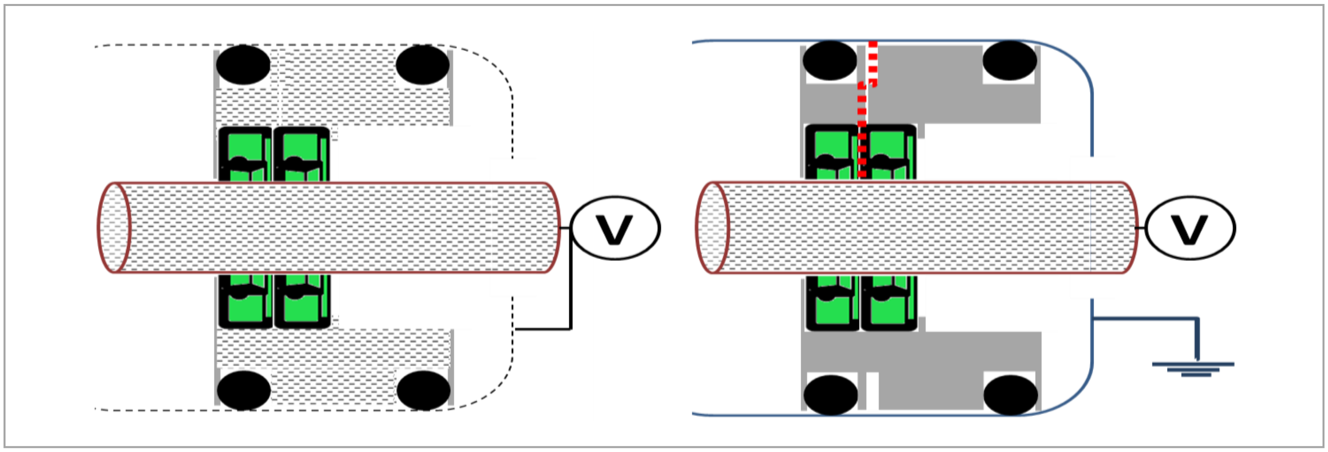



**Figure 3: Schematics of SC and SM electrical geometries, respectively.**

The ignition potential within the vacuum cartridge is dependant only on the internal cartridge pressure and gap width (Raizer, 1991). Tests were conducted with an MM cathode. Seals were installed in vacuum seal cartridges and differentially pumped. The breakdown voltage was applied and monitored with an Associated Research INC. HY-POT II 3565D AC/DC Withstand Voltage tester. Each vacuum seal cartridge has a minimum breakdown voltage, shown in figure 4.

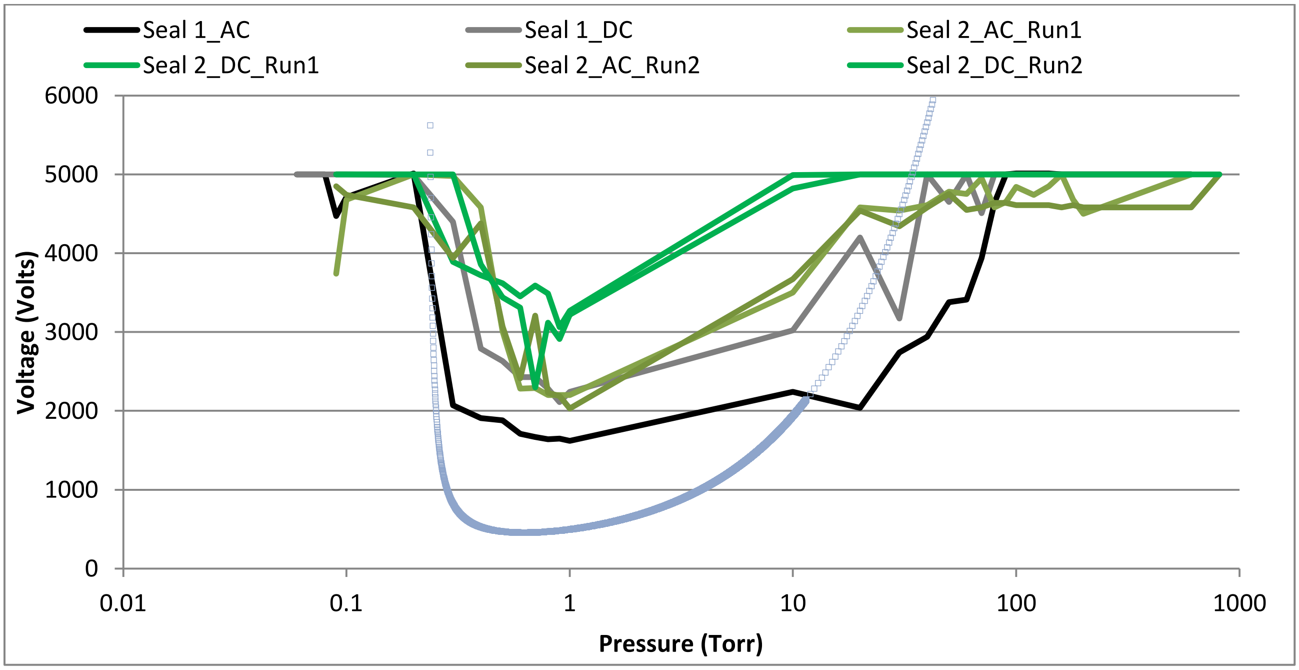


**Figure 4: Breakdown Voltages of SCI Seals**

The collected data is also in agreement with the theoretical Paschan curve (shown in blue.) It should also be noted that if the differential pumping gap is removed from the cartridge, a minimum breakdown voltage is not possible at any pressure. Differentially pumping the vacuum cartridge near the Paschen Curve minimum is not recommended since arcing within the seal cartridge may damage the vacuum seal cartridge, vacuum seals, and driveshaft. A plasma may also form within the vacuum seal cartridge in this range during the high-voltage discharge. This process was captured during testing at the SCI facility and can be observed in figure 5.

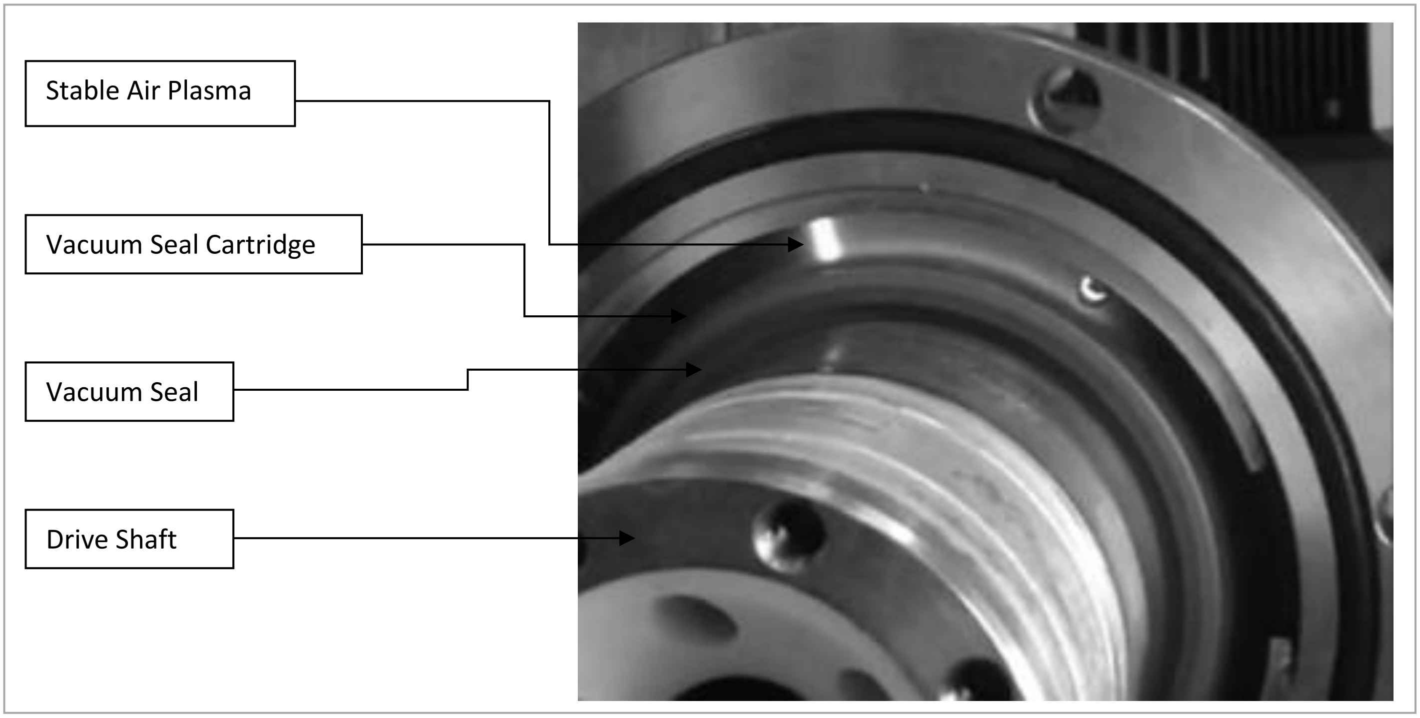



**Figure 5: Voltage discharge within the vacuum seal cartridge.**

RECOMMENDATIONS

Though generally not required, differential pumping is available for all pressure ranges for SC end blocks. If the user desires to differentially pump SM cathodes, care must be taken to stay either above 100 Torr, or below 100 mTorr within the seal cavity. Using power supplies with lower strike voltages (less than 1500 volts) can alow the user to operate within a broader range.

## ***Works Cited***

Raizer, Y. P. (1991). *Gas Discharge Physics.* New York: Springer-Verlag.