Dust Mitigation

Test Bed Interface Control Document

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1 SUMMARY

This document identifies Dust Mitigation Test Bed interfaces and is intended to be used by test article developers to enable physical, electrical, and control interfacing with the Test Bed.

2 Recommended Test Article Quick Reference

The following recommendations/estimates are appropriate for most testing in the Test Bed. Exceeding these recommendations may be possible after consulting the detailed interface descriptions in subsequent sections or pre-arranging for modificaitons to the test bed. These values are limited by the Test Equipment (brakes, power supplies, etc) currently on hand. Hardware that outperforms these values can be procured if necessary at additional expense. The Test Bed was initially designed for a test article with an integrated motor, hence a motor is not included with the Test Bed. However, a motor can be added with modifications.

Criteria	Quick Reference Value	Relevant Document Section
Test Article Diameter Limit (cold testing)	17.2 cm	3.1
Test Article Diameter Limit (room temperature testing)	37.5 cm	3.1
Test Article Length Limit	87.6 cm	3.1
Achievable Vacuum	10^{-4} torr standard (10^{-6} torr optional)	3.4
Achievable Cold Environment	140 W @ 30 K	3.5
Output Braking Capability	960 Nm @ 500 rpm (upper range) 1.5 Nm @ 2500 rpm (lower range)	3.6.2
Feedthrough Limiting Speed	1640 rpm	3.7
Test Article Power Draw Limit	480 W (24 VDC @ 20 Amps)	3.9
Available Temperature Probes	23	3.10
Maximum Test Duration	100 days (continuous operation)	

3 DM Test Bed Description

The DM Test Bed is a system for testing actuators and components in a simulated dusty thermally relevant environment. The various sub systems are described below.

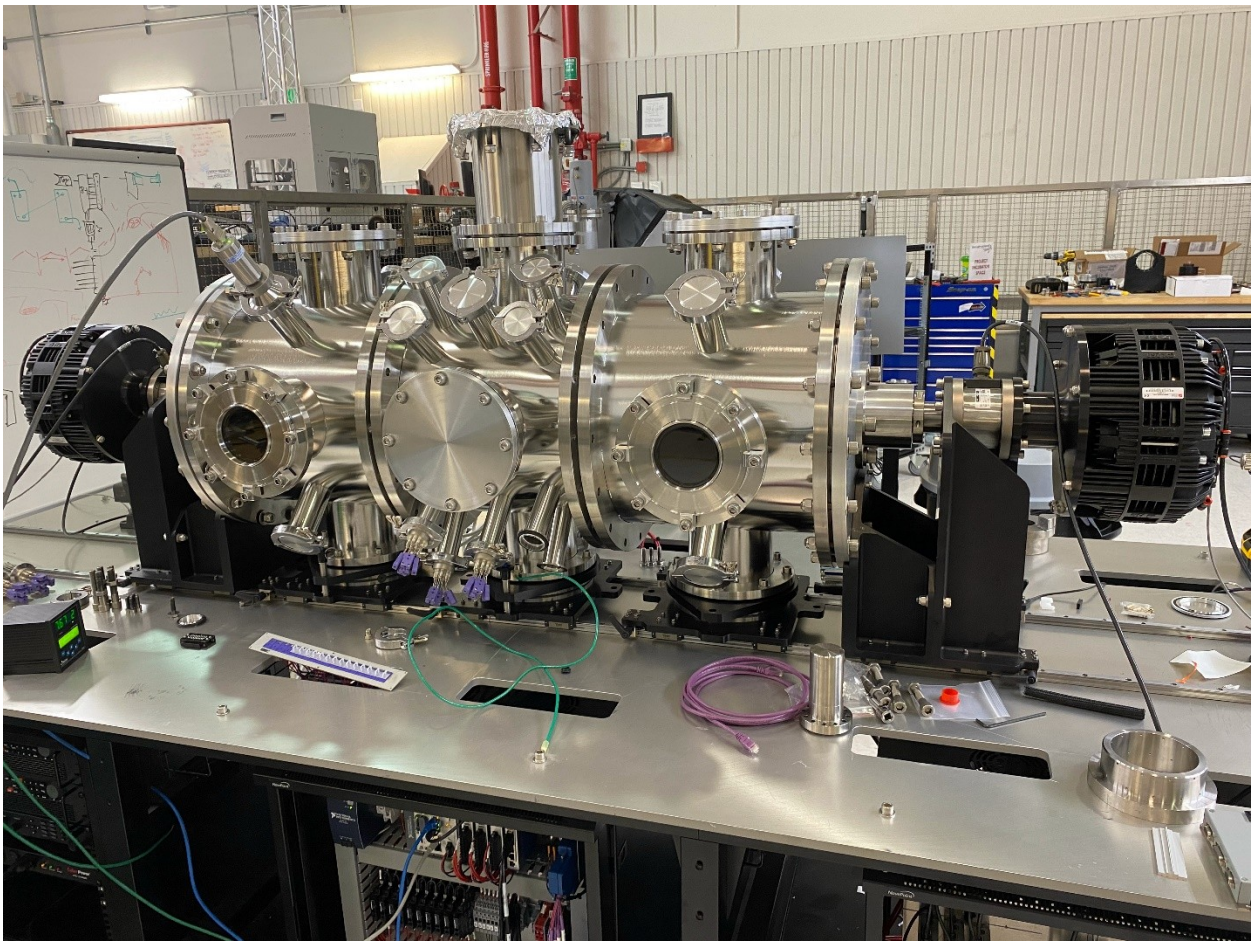


Figure 1. Test Chamber Equipment

3.1 Thermal Vacuum Chamber

The test chamber area is made of 304 stainless steel, and is 40 cm in internal diameter. The amount of space available for a test article is shown in the figure below. The modular design of the chamber allows for use of just one or two of the three available cylindrical chamber sections, or for additional sections to be installed to increase the total available internal length of 114 cm. If cold testing is required, all three sections must be used to accommodate the large Cold Finger Strap Mount Block (See Figure 2), unless a smaller Block is fabricated. Also, additional keep-out space must be maintained for braided copper thermal straps to be wrapped around the test article and clamped to the cold finger. The amount of space reserved for the thermal straps are a trade off between size and thermal conductivity and can be negotiated with the chamber operator. In general, for cold vacuum testing, a maximum test article diameter of approximately 17.2 cm is recommended to allow for appropriate thermal strap placement.

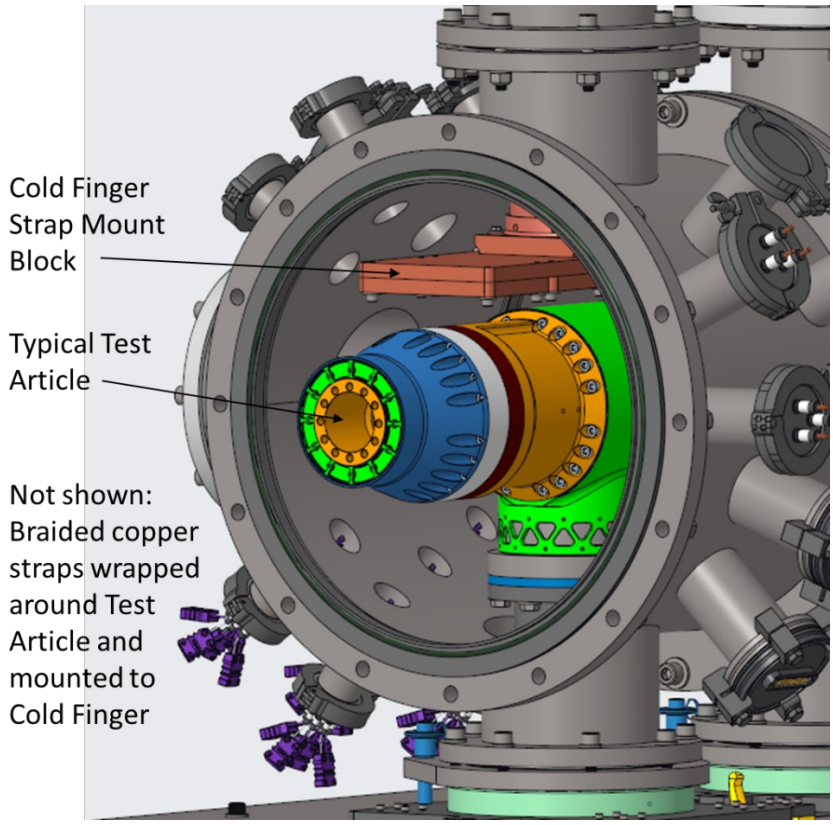


Figure 2. Isometic Section View of Internal Chamber Volume

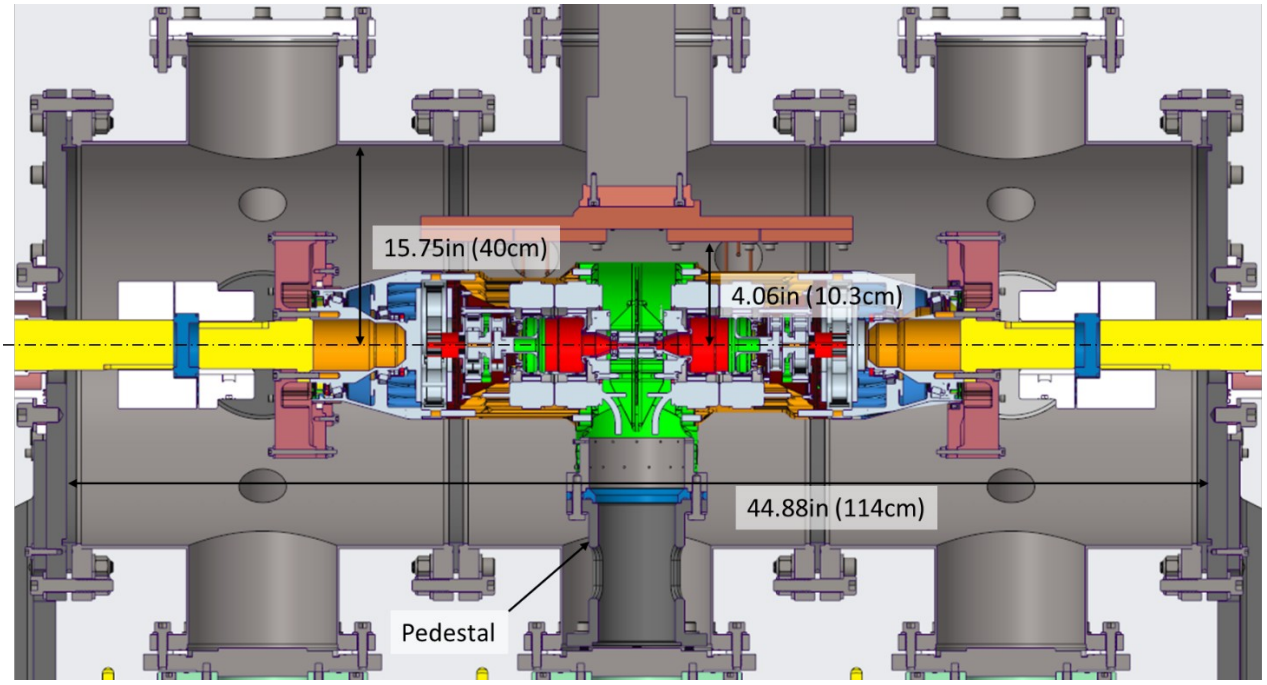


Figure 3. Side Section View of Internal Chamber Volume

3.2 Test Article Mounting Interface Plates

To limit thermal loses, it is recommended that all test articles be mounted on interface flanges with thermal standoff spacers. To mount the test article to the chamber, an adapter can be fabricated to interface with the bolt hole pattern on the pedestal mounted in the chamber interior (see Figure 3). This bolt hole pattern is shown below. This adapter should be of the correct length to position the test article in the center axis of the chamber for output shaft alignment. This adapter should also be designed to position the test article in the middle of the chamber, which is especially important for cold testing. When not cold testing, the pedestal can be mounted on any of the three chamber sections. The KSC test team is available to help design the adapter mount hardware.

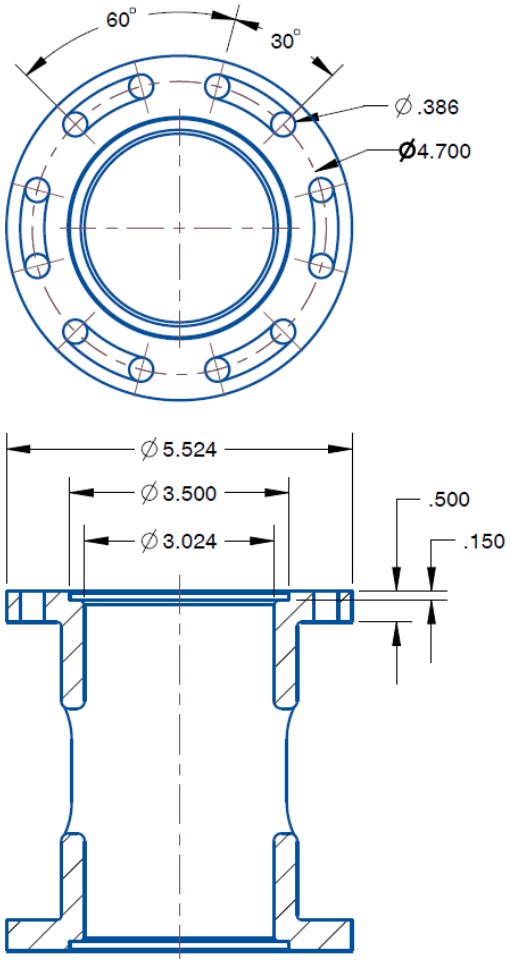
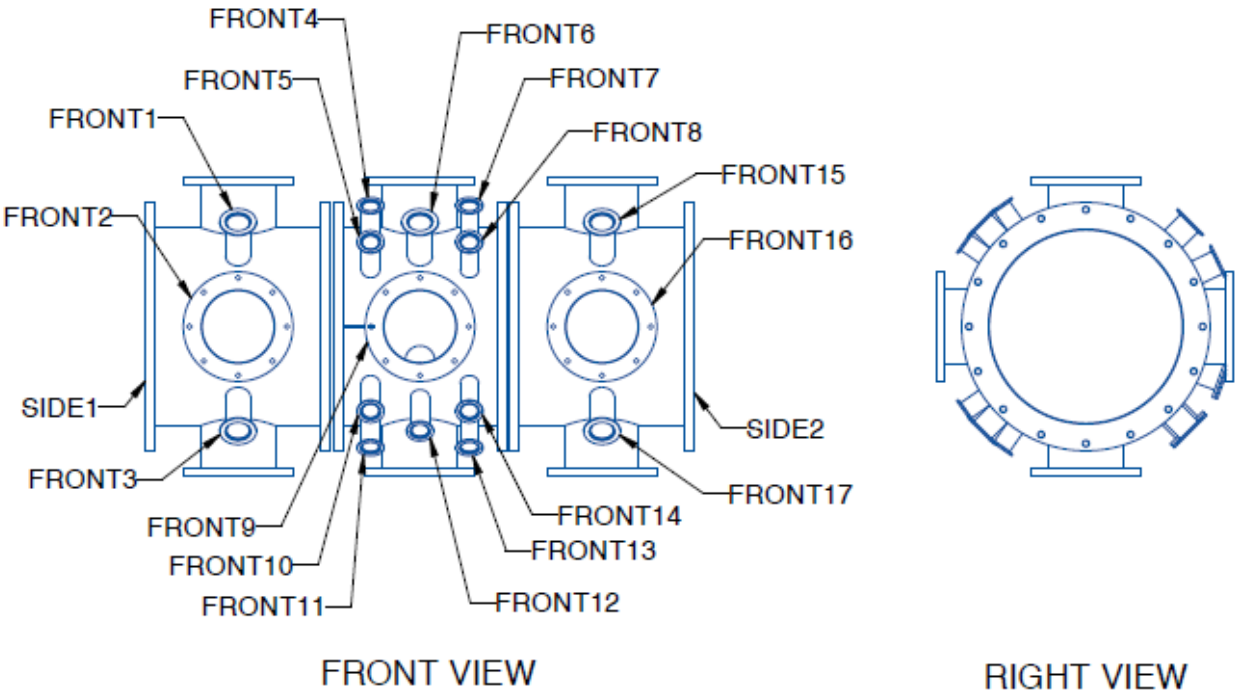


Figure 4. Pedestal mounting geometry

3.3 Chamber Access Ports

Several ISO-KF style ports are available for interfacing with the test article. Optionally, additional sight glass windows may be installed on an available port if desired. Additional chamber sections may also be installed. If needed, KF Flange Tee's may be used to increase the total amount of instrumentation pass through. These ports are detailed below.



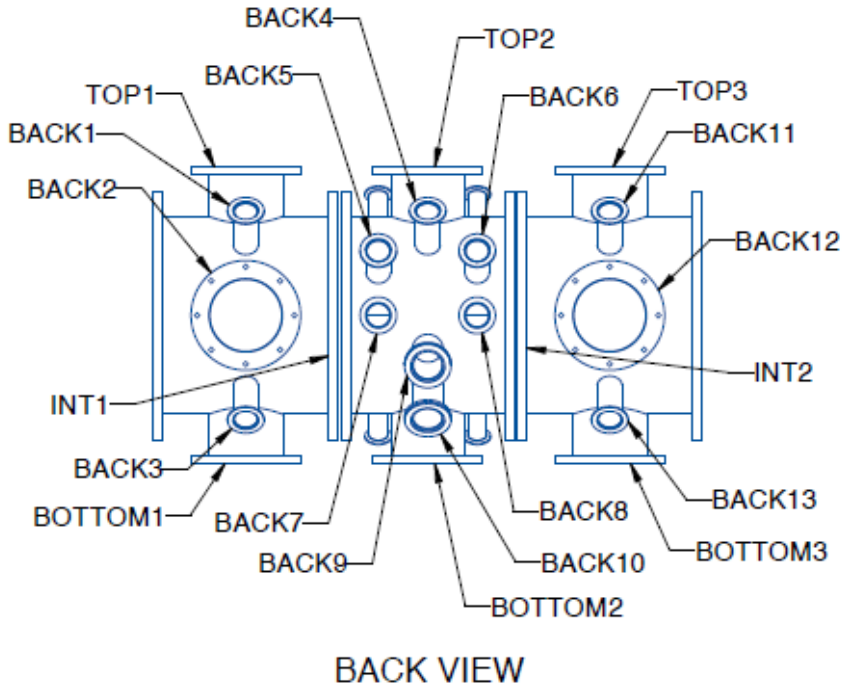


Figure 5. Interface Port Locations

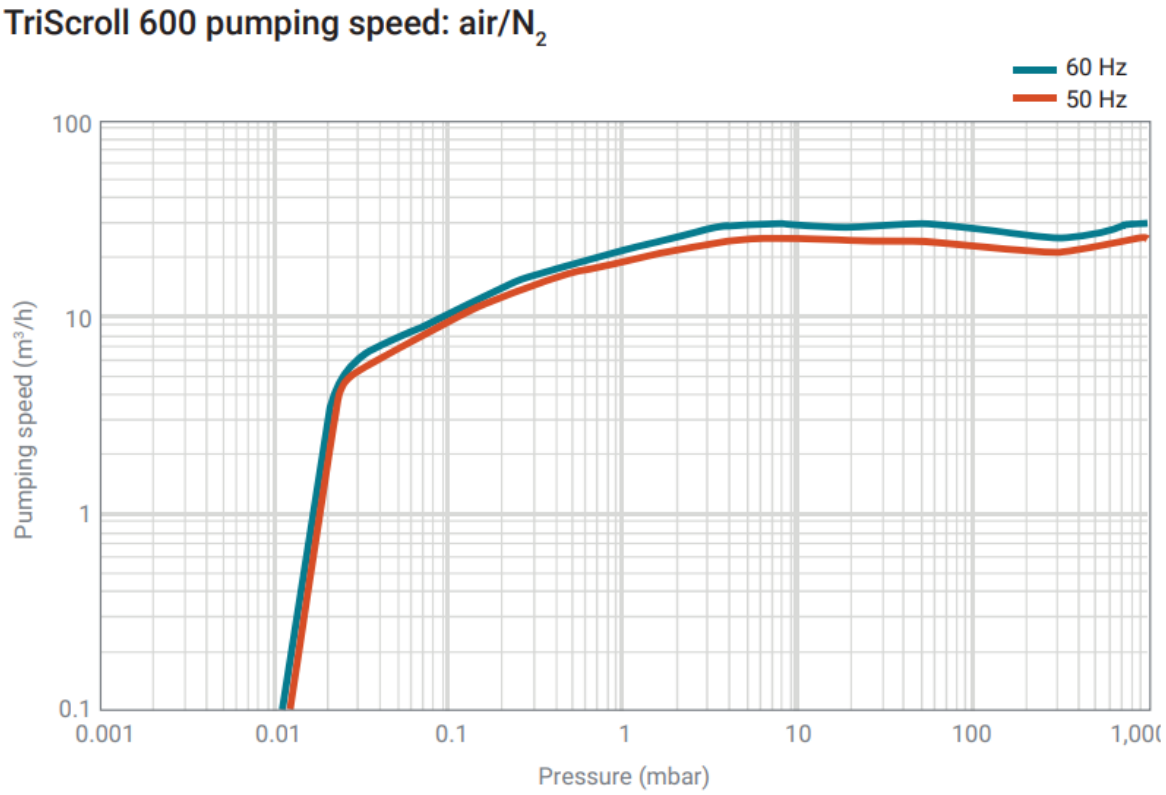
Table 1. Interface Port Sizes

Port	Type/Size	Note
FRONT 1	KF50	Available
FRONT 2	ISO160-F	Reserved for Viewport
FRONT 3	KF50	Available
FRONT 4	KF40	Reserved for Vacuum Instrumentation
FRONT 5	KF40	Available
FRONT 6	KF50	Available
FRONT 7	KF40	Available
FRONT 8	KF40	Available
FRONT 9	ISO160-F	Available
FRONT 10	KF40	Reserved for Temperature Instrumentation
FRONT 11	KF40	Reserved for Temperature Instrumentation
FRONT 12	KF40	Reserved for Temperature Instrumentation
FRONT 13	KF40	Reserved for Temperature Instrumentation
FRONT 14	KF40	Reserved for Temperature Instrumentation
FRONT 15	KF50	Available
FRONT 16	ISO160-F	Reserved for Viewport
FRONT 17	KF50	Available
BACK 1	KF50	Available
BACK 2	ISO160-F	Available
BACK 3	KF50	Available
BACK 4	KF50	Available
BACK 5	KF50	Available
BACK 6	KF50	Available
BACK 7	KF50	Available
BACK 8	KF50	Available
BACK 9	ISO63-K	Available
BACK 10	ISO63-K	Available
BACK 11	KF50	Available
BACK 12	ISO160-F	Reserved for Vacuum System
BACK 13	KF50	Available
TOP 1	ISO160-F	Available
TOP 2	ISO160-F	Reserved for Cryo Cooler
TOP 3	ISO160-F	Available
BOTTOM 1	ISO160-F	Reserved for Table Mounting
BOTTOM 2	ISO160-F	Reserved for Table Mounting
BOTTOM 3	ISO160-F	Reserved for Table Mounting
SIDE 1	ISO400-F	Available
SIDE 2	ISO400-F	Available
INT 1	ISO400-F	Reserved for Chamber Coupling
INT 2	ISO400-F	Reserved for Chamber Coupling

3.4 Vacuum System

The Test Chamber is typically evacuated by an Agilent/Varian Triscroll PTS06001UVPI 500 lpm scroll pump capable of achieving $7x10^{-3}$ torr ultimate vacuum. When needed, a turbo molecular pump can be added (depending on availability) to achieve a $5x10^{-6}$ torr ultimate vacuum. If the user has detailed information available for their test article, final vacuum levels may be estimated from the following pumping curve for the standard scroll pump only configuration.

Table 2. Scroll Pump Performance Curve



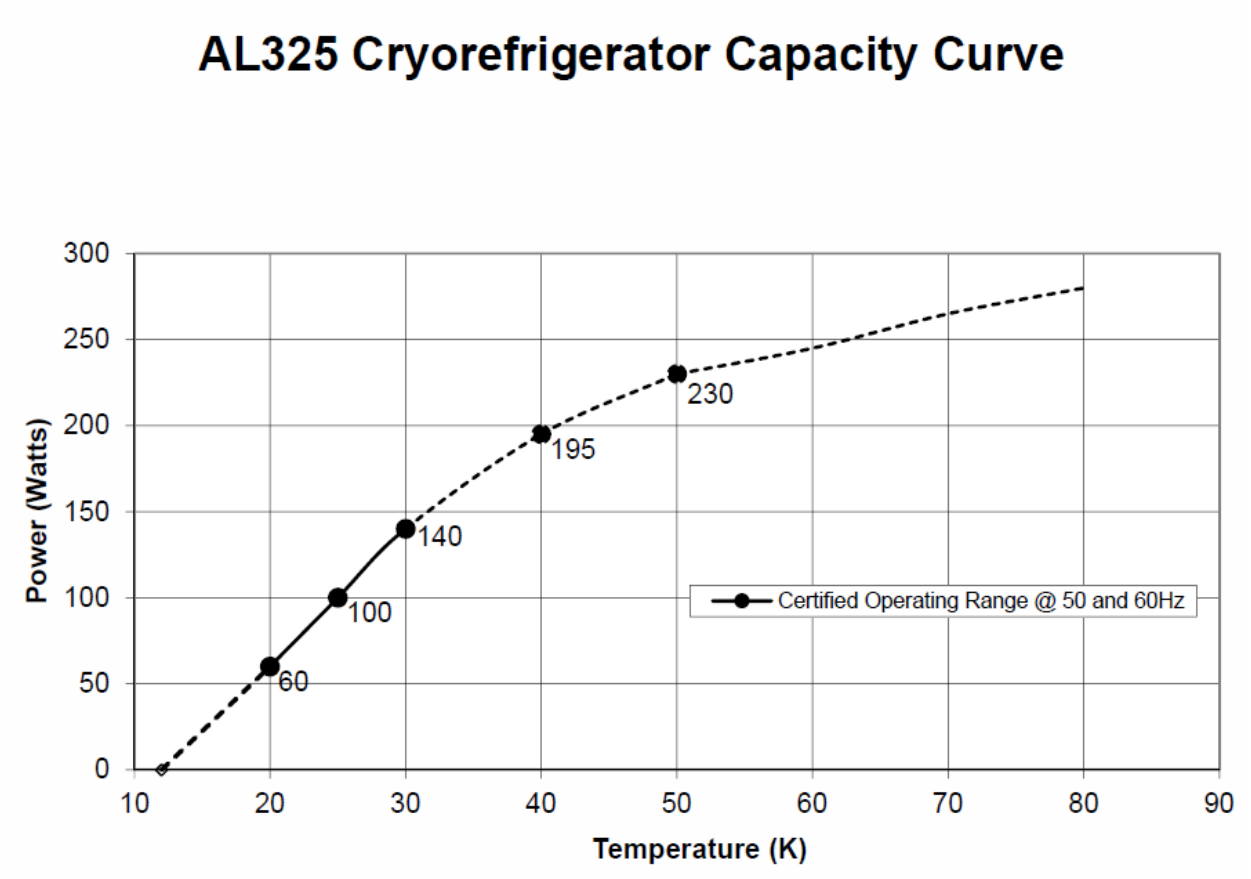
3.5 Cryo pump and chiller

Cold testing is achieved by the use of a cyrocooler. A Cryomech AL325 Gifford-Mcmahom cryocooler with a cooling capacity of 100W @ 25K is coupled to the braided copper straps to remove heat from the test article. Below is detailed information on the AL325 cryocooler.

Table 3. Cryo Pump Performance Specifications

Cooling Capacity:	100W @ 25K
Base Temperature:	12K
Cool Down Time:	<1 HOUR TO BOTTOM TEMP
Cold Head Weight:	48lb (22kg)
Compressor Package:	CPA1110
Water Cooled Weight:	420lb (190.5kg)
Water Cooled Dimensions:	24 X 24 X 31in (61 X 61 X 79cm)
Air Cooled Weight:	N/A
Air Cooled Dimensions:	N/A
Power Consumption 60Hz (Input Power):	200/230 or 440/480 VAC 3 PH / 11.2 Kw
Power Consumption 50Hz (Input Power):	200 or 380/415 VAC 3 PH / 10.4 Kw
Cooling Water Requirements:	3 GPM (11.4 LPM) @ 80°F (27°C)
Helium Pressure:	220 ± 5 PSIG (15.2 ± .34 bar) @ 60Hz 250 ± 5 PSIG (17.2 ± .34 bar) @ 50Hz
Ambient Temperature Range:	45°F to 100°F (7 to 38°C)

Table 4. Cryo Pump Performance Curve



3.6 External Test Load System

3.6.1 Input Motor Loads

Typical testing to date has only consisted of testing articles with integrated motors. However, input rotational loads from a motor external to the chamber is available for passive test articles such as gear boxes. The KSC Test Team has a wide variety of motors available for use, including open loop and close loop control schemes depending on customer requirements.

3.6.2 Braking Loads

Braking Loads for powered test articles are provided by Re pneumatic brakes. The load from the brake is closed loop controlled from the output torque sensor to provide a much smaller variance in load input. The brake consists of 6 calipers, each capable of providing minimum of 1.5 N-m at 0.3 bar and maximum of 160 N-m at 6 bar, a total of 960 N-m maximum when all calipers are used. Other loads outside of this may be accommodated.

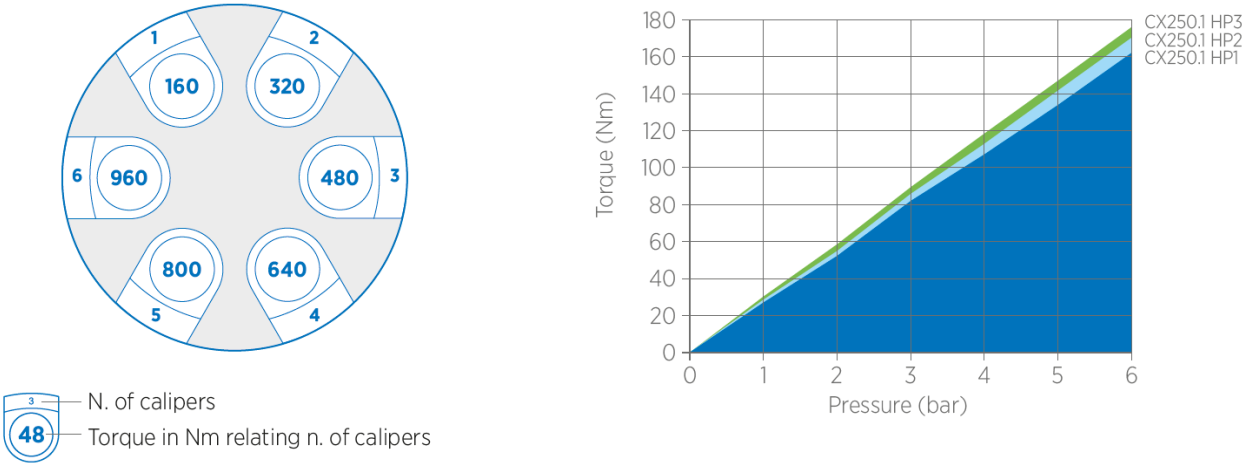


Figure 6. Brake Caliper Configuration and Pressure-Torque Graph of Single Caliper

Table 5. Pneumatic Brake Specifications

Torque max 1 caliper	160 Nm
Torque min 1 caliper	1,5 Nm
Pressure min / max	0,3/6 bar
Max disc rpm	2500 rpm
Total weight	20 kg
Disc inertia	0,04 Kgm²
Heat dissipation without fan	1,3 kW
Heat dissipation with 24V fan	HP1 3,5 kW HP2 4 kW HP3 4,5 kW

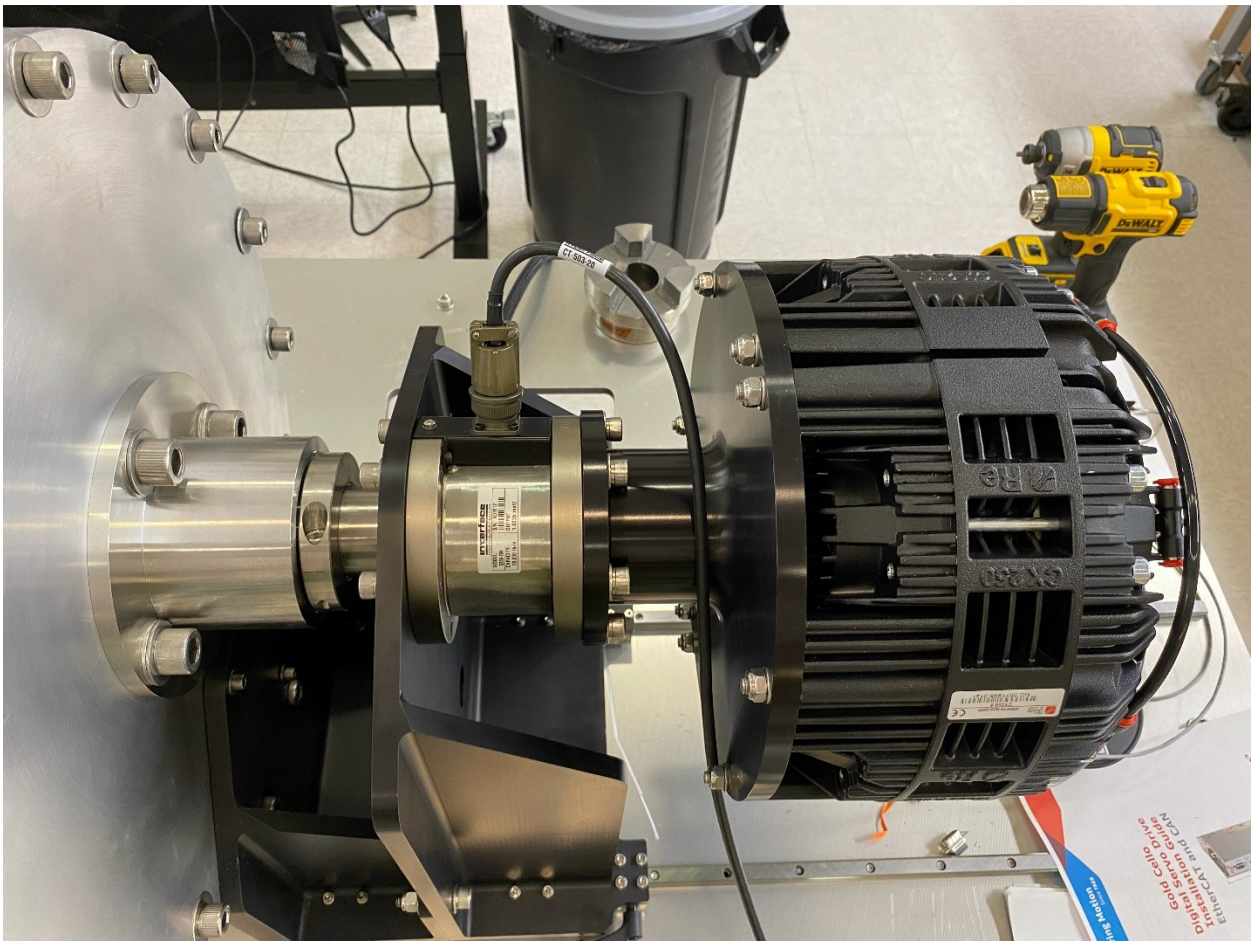


Figure 7. Output Feedthrough, Pneumatic Brake and Torque Sensor

3.6.3 Torque Measurement

Loads are measured from reactionary (static) torque sensors from Interface Force Measurement Solutions. Reactionary torque sensors can be used on the input and the output when possible to measure efficiency of the test article. The available torque sensor has the following specifications. Other configurations may be accommodated from requirements from the customer.

Table 6. Available Torque Sensor Hardware

Torque Sensors	Capacity	Nonlinearity %FS	Hysteresis %FS	Output mV/V	Excitation Voltage VDC	Safe Overload %RO
5330-20K	20,000 in-lb	±0.1	±0.25	1.5	10	200

3.6.4 Speed Measurement

Typical testing to date has only consisted of testing articles with integrated resolvers. RPM telemetry had been captured by use of those resolvers. However, an incremental encoder on an input drive motor (if used) may be used.

A Renishaw absolute encoder with 26-bit resolution can also be attached to the input and/or the output of the test article to record position and velocity. These can be located inside the vacuum chamber.

3.7 Vacuum Rotary Feedthrough

Feedthroughs for rotary motion out of the chamber use FerroTec vacuum rotary feedthroughs. Ferrotec's standard hydrocarbon-based ferrofluid, specifically optimized for introducing rotary motion with a magnetic liquid hermetic seal in most environments. The table below is list of the current feedthroughs. Other options may be available upon request.

Table 7. Available Vacuum Rotary Feedthrough Hardware

Feed Throughs Part Number	Vacuum Connection	shaft/thru hole	shaft diameter	Max Torque	Max Speed (rpm)	Drag Torque	Drag speed
103361	oring flange	thru	2.0025in	-	1640	96.7 in*ozf	100
						149 in*ozf	1000

3.8 Linear Rail Alignment System

The chamber and all attachments are located on linear profile rails. These rails provide an easy method to assemble the test articles and other items while maintaining critical axial alignment between all rotary components.

3.9 Power

A variety of power service is available to test articles including:

- Multi-range 1200 W, 80 VDC at 60 amps
- Multi-range 5000 W, 250 VDC at 80 amps

Customers may also provide their own power equipment as needed. If customer provided power is provided, procurement of the proper vacuum rated electrical feedthrough may also be required.

3.10 Data Acquisition and Control Components

Experimental command, data acquisition, and control is achieved via a National Instruments (NI) cRIO based real time industrial controller. 25 temperature measurements are available and are recorded to the data log along with pressure, torque, and speed. The power draw of various components can also be recorded to calculate efficiencies. The NI cRIO is a flexible system with reasonably priced input cards, thus the Test Bed control system can be readily expanded to meet customer needs for additional Input and Output types. This is beneficial when synchronization of the control and response data streams is desired as all system parameters can be recorded into a single timestamped data file. The KSC test team is available to discuss software and control hardware modifications needed to accommodate different test articles.

3.10.1 Data Package Format

Data from the test will be made available in TDMS format. This is a compact binary data storage format native to the National Instruments Data Acquisition system. A free TDMS to Excel converter is available from National Instruments if needed.

4 Customization

The Test Bed is a highly customizable system supporting many types of tests. Modifications may be feasible if they align with the system characteristics described in this document.