Determining the Effectiveness of Oleophobic Gaskets

Operations Manual

Team Number: 1

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Submitted To: Dr. Gupta, Dr. Shih

Faculty Advisor: Dr. Oates

Authors: Heather Davidson (hld12), David Dawson (dpd13), Aruoture Egoh (aje15f), Daniel Elliott (dse13), Norris McMahon (nfm11b), Erik Spilling (eds11b)

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ABSTRACT

The goal of this Cummins Inc. sponsored project was to determine the effectiveness of oleophobic gaskets compared to standard nonoleophobic gaskets. This objective was completed by utilizing on market oleophobic solutions with current gasket materials, as well as non-traditional gasket materials and then testing these products in an experimental test rig, which was designed and constructed by the team. The effectiveness of the oleophobic gaskets was assessed by comparing the respective leak rates of each gasket type under several conditions, including two variable temperatures and variable clamping pressures, to that of baseline nonoleophobic gasket leak rates. The test rig has been designed and built by the team so that it can test gaskets with oil at room temperature and at an elevated engine-like temperature while under a constant low internal pressure of 2.5 psi with variable gasket clamping pressure. A functional diagram was created to show the interactions between components, as well as a CAD model to show how the test rig components are assembled. An operations manual was created, which walks the user through all the steps for the use of the test rig in an experiment. Also, the team documented some common troubleshooting techniques and regular maintenance requirements for the test rig.

1 Introduction

Cummins Inc. has proposed a project to determine the effectiveness of oleophobic gaskets to reduce the measured leak rate at low pressure, large joints on engines compared to the current gaskets used on engines. Oleophobic items are items which repel oil by having a lower surface energy than the oil. A gasket is an item which is placed between two flanges to form a seal, which is meant to prevent oils from leaking to the opposite side of the flange. The theory behind the project is that if the gasket can repel the oil, it is less likely that oil will be capable of leaking past the gasket.

In order to determine the effectiveness of oleophobic gaskets, the design team determined what products on the market could be used to give a gasket oleophobic properties, created oleophobic gaskets using these products and nontraditional gasket materials, as well as designed and built a test rig which measures the leak rate of a gasket at various temperatures and pressures. The test rig must be capable of testing oils that range from 22 to 120° C and inducing a pressure on the oil ranging from 0 to 2.5 psi. Once the design and construction of the project was completed, tests were performed on oleophobic and standard gaskets using the test rig and results will be compared to determine the effectiveness.

2 Functional Analysis/Diagram

The test rig was designed to determine the effectiveness of various oleophobic gasket materials (both conventional and non-conventional). The various components that make up the experimental set-up include: strain gauged bolts, nuts, washers, spacers, flanges, a RTD sensor, a pressure transducer, an air inlet valve, an oil valve, and a pressure relief valve. The tests were carried out for both room temperature and an elevated temperature (120°C).

Figure 1 shows the functional diagram of the test set up. The gasket material to be tested was placed in between the flanges of the test rig, and then the strain gauged bolts were torqued down to the desired clamping load. The desired clamping load for the experimental set-up was obtained through the use of the strain gauges that were connected to the DAQ system.

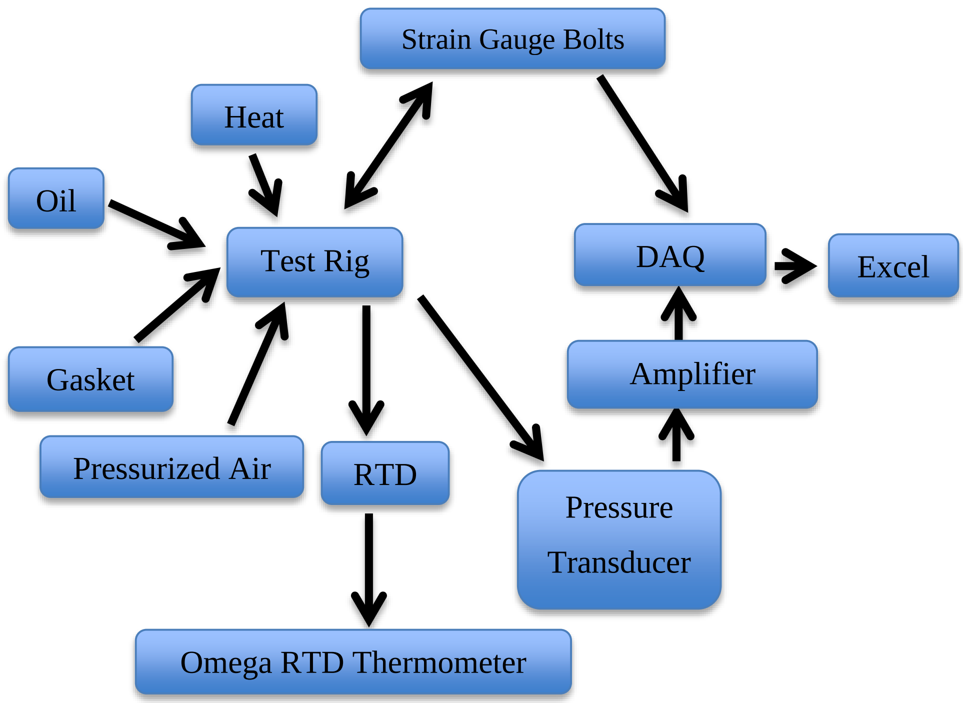


Figure 1. Functional Diagram of Project

Oil was poured into the test rig through the oil valve and pressurized air (2.5 psig) was induced into system. For elevated temperature testing, the test rig was heated to a desired temperature, which was monitored by the RTD sensor which was connected to the omega RTD thermometer.

The pressure transducer which was connected to the DAQ system through the amplifier to record the internal pressure during each test. The initial air volume (V_1) and pressure (P_1) were obtained at the start of the test, and the instantaneous air pressure (P_2) was recorded during the tests. Using the modified ideal gas law $P_1V_1=P_2V_2$, the final air volume (V_2) was calculated and was divided by the time duration of the test to give the leak rate.

3 Project/Product Specifications

The test rig fixture is of two main parts: the top assembly (made up of the Top Cap, Top Tube, Top Flange, Oil Inlet Valve, Air Inlet Valve, Pressure Relief Valve, and the RTD Compression Fitting), and the Bottom Flange. For the body of the test rig, A36 steel was chosen because of its machinability, ability to withstand heat, good welding properties, and price.

The crucial dimensions of the test rig as shown in Table 1. The Top Flange and Bottom Flange have a diameter of 140 mm to accommodate the four M10 bolts and the gasket size. The Top Flange required an inner diameter of less than 55 mm in order to accommodate the gaskets. The thickness of the flanges were selected to be 6.35 mm in order to prevent yielding when loaded, and the surface roughness was required to be 3.2 micron RA or smoother. The bolts and their respective hardware components were M10x1.5, which was the minimum size allowed to use with the strain gauges.

Other important components used in the test rig were the sensors. The Kulite pressure transducer was chosen because it met the requirement of reading pressures between 0-5 psig and was small in overall size, which was beneficial since the test rig is a small item. Appendix A contains the data sheet for the pressure transducer selected [1].

Another sensor which was used was an Omega RTD sensor. The data sheet for the chosen RTD sensor is shown in Appendix B [2]. This RTD sensor was chosen because it was capable of reading oil temperatures of 120°C, and was only 2 inches in length. Again, the small size was beneficial because of the size of the test rig.

Table 1. Test Rig Critical Dimensions

Product Specifications	**Values**
Top Flange Dimensions	Inner Diameter (ID): 55 mm Outer Diameter (OD): 140 mm
Bottom Flange Dimensions	Outer Diameter (OD): 140 mm
Flange thickness	6.35 mm
Bolts (strain gauges)	M10x1.5 70mm
Washers and nuts	M10x1.5
Flange Surface Roughness	Maximum 3.2 microns RA.

4 Product Assembly

The test rig was assembled in two main steps: Top Assembly sub assembly and final assembly. The Top Assembly consists of the Top Flange, Top Tube, Top Cap, Oil Inlet Valve, Pressure Relief Valve, Air Inlet Valve, and the RTD Compression Fitting. The welding of the Top Flange, Top Tube, and Top Cap was done first to create the air tight chamber required for the design. Then the other components were all threaded into their respective positions in the Top Assembly. Figure 2 shows the Top Assembly CAD model.

The rest of the assembly occurs before each test, and is outlined in detail in the Operation Instructions section of this document. The main assembly tasks in this process are the placing of the test gasket and the Top Assembly on the Bottom Flange, and the tightening of the stain gauged M10 bolts. In Figure 3, the final assembly of the test rig is shown. Appendix C contains the CAD drawing of the test rig assembly.

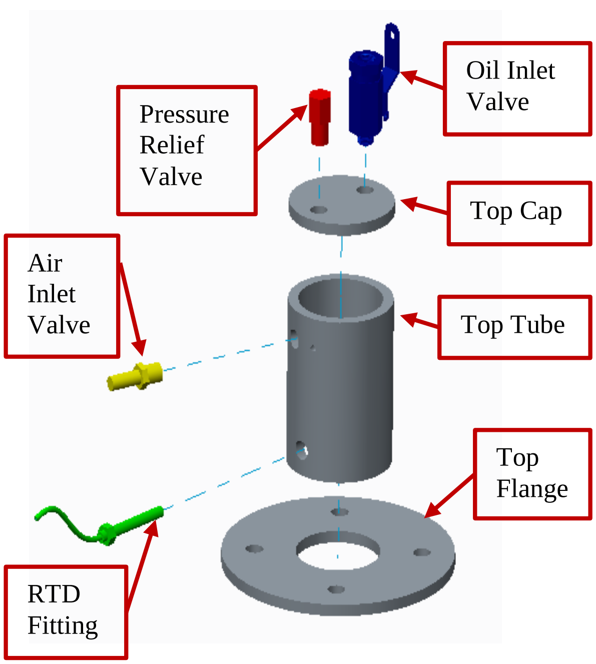


Figure 2. Exploded view of the Top Assembly

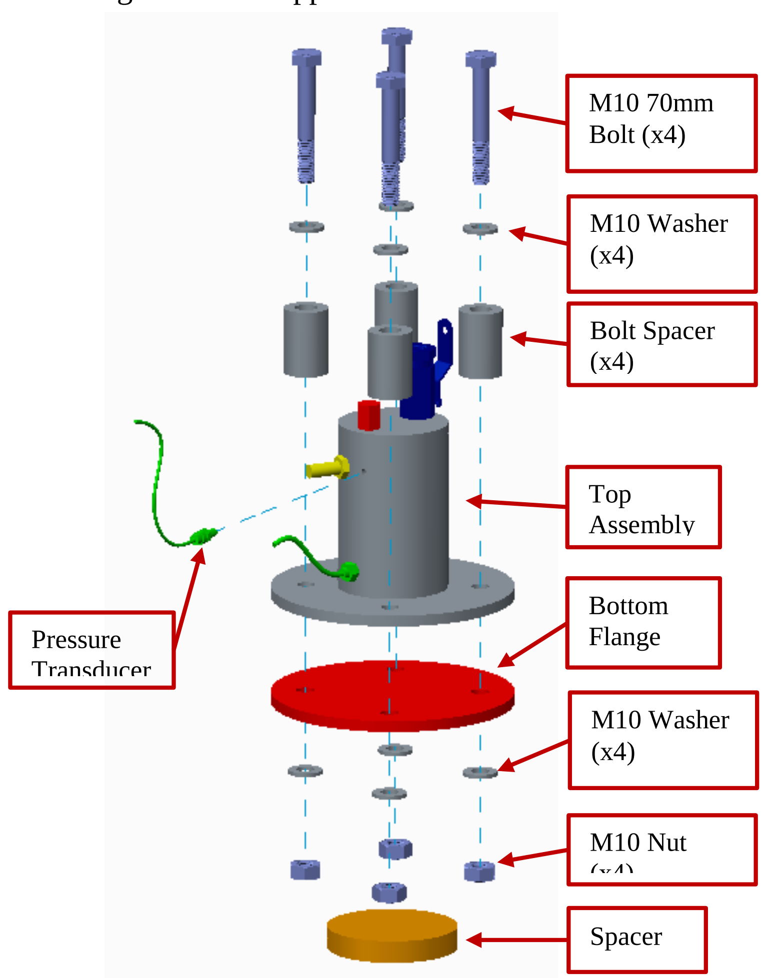


Figure 3. Exploded view of the final assembly for the test **rig.**

5 Operation Instructions

This test rig is designed to measure the leak rate of various circular gaskets with an inner diameter of 55 mm and an outer diameter of 75 mm. The internal pressure can only be set to 2.5 psi or less; however, the temperature is variable, as well as the bolt clamping loads. The following instructions refer to testing procedures:

1. Turn on power to the signal box for the pressure transducer. Let it warm up and stabilize while the test is being set up.
2. Place selected gasket in the center of the bottom flange. Four small weld marks have been placed radially out from the center of the flange. All four welds should be inside the gasket inner radius, which will ensure the gasket does not move out of place during set up.
3. Carefully set the top flange on top of the bottom flange. Make sure the four bolt holes in the top flange match with the bolt holes in the bottom flange.
4. Place a washer and spacer around each bolt and then place all of the bolts in the bolt holes. Write the number of each bolt with a permanent marker on its washer. This is important as each bolt has a different calibration curve provided by Cummins Inc.
5. Loosely tighten a washer and a nut onto the end of each bolt. Do not let the washer and nut touch the bottom flange.
6. Connect two bolts that are physically across from one another on the test rig to the DAQ system. Plug in their respective power sources. Be careful to not tangle or break any wires.
7. Open the DAQ two channel VI in Labview. Keep all inputs at their default values, except for the sampling rate which should be set to 20,000 Hz. Set the file path to the desired location and name the file accordingly.
8. Run the VI from the front panel. Locate and open the output file with Excel. There should be two columns of many data points which correspond to many samples of the unstrained voltage of each bolt.
9. For each bolt, take an average of all of its unstrained voltage data points. Record the two average unstrained voltage values in Excel. It is common for these values to differ.
10. Begin tightening down these two bolts to the specified clamping load either through two wrenches or a torque wrench, depending upon how much torque needs to be applied.
11. Run the VI from the front panel once again at the same conditions as step six. Repeat the process of accessing the file in Excel and finding one average value.
12. Using the respective Cummins Inc. calibration curves and standard formulas for strain gauges, an excel file was set up such that the only required values to calculate the bolt loads are the average unstrained and average strained voltage values from each bolt. Place the experimentally determined average values in this Excel sheet.
13. Adjust the tightness of the bolt until the desired bolt load is met.
14. Repeat steps 6-13 for the other two bolts.

15. Carefully measure 75 milliliters of Shell Rotella T 15W-40 diesel oil and pour into the test rig via the oil inlet valve on the top of the test rig (a small funnel is recommended).
16. Connect RTD to an instrument that will read out the temperature on a digital screen. This data does not need to be recorded.
17. For room temperature tests, skip steps 18-22.
18. For elevated temperature tests, set hot plate to 500°C. Place the test rig on the hot plate on top of a metal spacer. This spacer is to ensure the bolts are not touching the hot plate.
19. Continuously monitor the temperature of the oil from the instrument digital screen. When it reaches approximately 100°C, change hot plate to about 345°C.
20. Wait for the oil temperature to stabilize around 119°C-120°C. Carefully close oil inlet valve using proper heat protectant gloves.
21. Every few minutes, pop open oil inlet valve to relieve pressure and then close again.
22. After about 15 minutes at a steady temperature, relieve pressure one last time.
23. Close oil inlet valve.
24. Tighten pressure transducer into the appropriate hole in the test rig using an 8 mm wrench. Be careful to not tangle or break any wires.
25. Open the DAQ one channel VI in Labview. Change the sampling rate to 100 Hz, the timeout to 7,200 seconds, and samples per channel to 720,000. These are the settings for a two hour run time test. All tests are run for two hours. Set the file path to the desired location and name the file accordingly.
26. Connect the pressure transducer to the DAQ system.
27. Start running the VI from the front panel.
28. Unscrew cap off of air inlet valve and begin pumping air into the test rig via a bike pump. Stop pumping when the pressure safety valve pops open, which should occur at 2.5 psi. Replace cap back onto air inlet valve.
29. Let the test run for the entire two hours. Have at least one person present in the room at all times.
30. Access the output file as previously described.
31. Input experimental data into an Excel file that is already set up to convert the change in the pressure of the air to an oil leak rate.
32. For hot tests, allow entire test rig to cool down before handling.
33. Remove pressure transducer.
34. Carefully open the oil inlet valve and tilt the test rig to slowly drain most of the oil out making sure to not allow the oil to enter the pressure relief valve. Dispose of the oil.
35. Loosen the bolts and open the test rig up.
36. Document the state of the gasket and dispose of it.
37. Wipe down the bottom and the top flange with paper towels, as well as carefully cleaning inside of the test rig.
38. Return the test rig back to its original condition and begin testing again.

6 Trouble Shooting

Rarely do experiments ever happen without some error or unexpected occurrence. Thus, there were a few problems throughout the duration of the experimentation. The first and most common problem was the breaking of strain gauge bolt wires. The wires on the strain gauges are very thin and fragile. Making too fast or strong of movements with them would cause them to break connection. This was noticed either visually or when there was a zero voltage return on Labview. The wires could be repaired using a soldering iron and shrinkwrap.

Another noticeable occurrence throughout the experiment was having oil come out of the pressure relief valve. When the pressurized air was inserted into the test rig, remaining oil from previous experiments that had gotten into the valve would shoot out. This could possibly affect the internal pressure for the next experiments. The best way to mitigate this is to remove the oil very slowly from the test rig and to be very careful when cleaning the inside of the test rig for the next experiment.

Fluctuating internal temperature was also an issue. The hot plate heats the spacers, the spacers heat the test rig, and the test rig heats the oil. So we had to gauge the internal temperature by changing the external applied temperature from the hot plate. When the temperature is fluctuating, the best way to mitigate that was to allow the temperature to equalize for a longer time. Once the temperature remained constant for 30 minutes, then experimentation should begin.

The last noticeable occurrence was when we tested a sprayed rubber coated metal gasket with high heat. After the experiment, the RCM gasket had partially melted onto the flange. To fix the partially melted gasket, place the flange back on the hot plate so the gasket will warm up and be easier to remove. The melting was a result of the oleophobic solution, not the test rig. However, in the event that tested gaskets do melt, re-heating the flange allows the gasket to be removed.

7 Regular Maintenance

There was only minimal regular maintenance to be done throughout the course of this experimentation process because the test rig was designed to be as simple as possible. One part of the maintenance was using the RTV Silicone to ensure no air leaks were present so that the test rig would remain pressurized. While the RTV Silicone is not required since NPT threading was used to prevent air leaks, the RTV Silicone can be added as an additional safe guard to prevent air leakage.

The second part of the maintenance plan, and most common, was to remove residual oil that was in the test rig between each experiment. Once a majority of the oil was poured out of the test rig and it was disassembled, the inside of the upper cavity and the bottom flange had to be cleaned every time. Depending on the amount of leakage for the test, sometimes the bolts, spacers, washers, and nuts had to be cleaned off if oil ended up reaching them.

The last part of the routine maintenance was to check the integrity of all the components of the test rig and fix any issues. The only noticeable component that had to be repaired was the o-ring on the pressure transducer. Due to the continuous high heat in addition to repeated loading, the o-ring on the pressure transducer sheared and had to be replaced with the back-up o-ring that was supplied.

8 Spare Parts/Inventory Requirements

Table 2 lists spare parts which would be useful to have on hand while using the test rig for an extended period of experiments. The first two items listed are wear parts on the test rig. After repeated use, the washers and the pressure transducer o-ring tend to show signs of wear from the repeated loading due to removing the items between tests. The other spare items are for creating additional gaskets for testing. This also lists the inventory of parts which are required for the construction of the test rig and the testing of gaskets.

Table 2. Spare and Initial Inventory Items

Spare Items List	**Initial Inventory Items List**	
Item	**Item**	**Quantity**
M10 General Purpose steel washer	M10 General Purpose steel washer	4
Pressure Transducer O-Ring	M10 Class 8 Zinc Plated Steel Hex Nut	4
Teflon Gaskets	Zinc-Plated Steel Unthreaded Spacer	4
Rubber Coated Metal Gaskets	M10x1.5 70mm long class 8.8 cap screw	4
Paper Gaskets	Pressure Relief Valve	1
Ultra Everdry	Compact High-Pressure Brass Ball Valve	1
StainGuard-WB	Brass Air Fill Valve Straight	1
	1ft x 1ft x ¼ in Thick A36 Steel Plate	1
	1ftLong2-1/2 OD x 2 ID Round Steel Tube	1
	Short RTD Probe	1
	Compression Fitting	1
	Pressure Transducer	1
	Teflon Gaskets	6
	Rubber Coated Metal Gaskets	12
	Paper Gaskets	12
	Felt Gaskets	6
	Ultra Everdry	2 canisters
	StainGuard-WB	1 quart
	T Triple Protection CJ-4 15W-40 Motor Oil	1 gallon
	Hot Plate	1

9 Conclusion

A functional analysis was completed to demonstrate the relationship between the inputs and the outputs of the test rig. The inputs include a gasket, oil, heat, pressurized air, and strain gauged bolts. All of these interface with the test rig and produce useful outputs. The outputs of the test rig include raw data which was converted to bolt load, pressure, and temperature through the use of components such as an amplifier, DAQ system, RTD Omega Thermometer, and Excel.

The project and product specifications were outlined by the team. This includes the dimensions of critical components such as the diameter of the flanges, the thickness of the test rig, and the size of the bolts, nuts, washers, and bolt spacers. Additionally, the data sheets for both the pressure transducer and the RTD sensor were included.

A brief explanation was provided for assembling the test rig; however, due to the nature of the test rig, much of the assembly is repeated before every single test. Therefore, a much more in depth description of how to set it up is provided in the actual operation instructions. The operation instructions include a step by step process of how to properly perform a test by installing a gasket, sensors, oil, pressurized air, tightening the bolts to a desired value, and then extracting the raw data from the DAQ system.

In addition to these previous items, troubleshooting help and regular maintenance was reported in hopes of shedding lights on common issues that may occur if the test was performed according to our procedure. Finally, a list of spare parts and an initial inventory was created to summarize what is required in order to accomplish this test.

References

[1] " Pressure Transducers XTL-123B-190." Kulite. Web. 30 Mar. 2016.

[2] "Short RTD Probe." Short RTD Probe. Web. 30 Mar. 2016.

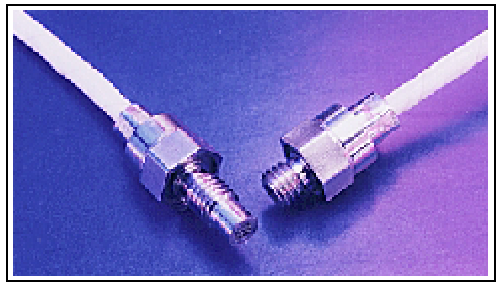
Appendix A

kulite

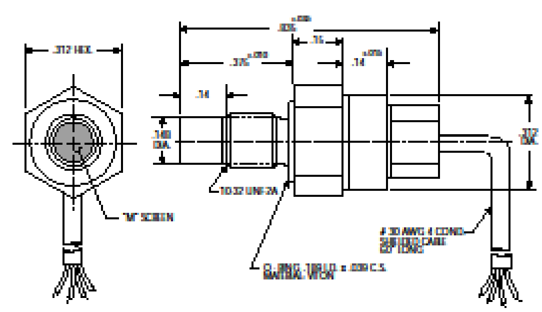
RUGGEDIZED AUTOMOTIVE PRESSURE TRANSDUCERS

XT-123B-190 XT-123C-190

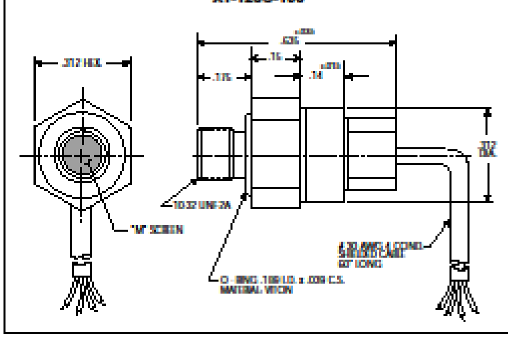
- Easy Installation
- High Natural Frequency
- 10-32 UNF x 0.375" Long Thread (XT-123B)
- 10-32 UNF x 0.175" Long Thread (XT-123C)
- Wide Temperature Range
- Compatible With Most Automotive Fluids



XT-123B-190



XT-123C-190



	XT-123B	XT-123C
INPUT Standard Pressure Range	15 to 3000 PSIA, PSIG, PSISG	15 to 1000 PSIA, PSIG, PSISG
Proof Pressure	2 Times Full Rated Pressure or 4500 PSI Whichever Is Less Will Not Cause Change In Performance Beyond The Specified Tolerances	2 Times Full Rated Pressure or 1500 PSI Whichever Is Less Will Not Cause Change In Performance Beyond The Specified Tolerances
Burst Pressure	3 Times Full Rated Pressure or 4500 PSI Whichever Is Less Will Not Cause Rupture	3 Times Full Rated Pressure or 2000 PSI Whichever Is Less Will Not Cause Rupture
Construction Materials	316 SS, 17-4 PH SS SiO2, Si, Parylene Media Isolation	
Rated Electrical Excitation	10 VDC	
Input Impedance	1000 Ohms (Min.), 2500 Ohms (Max.)	
OUTPUT Zero Balance	0 mV ±5% FSO	
Full Scale Output	100 ± 10 Millivolts, Open Circuit, @ 10 VDC Excitation	
Combined Non-Linearity & Hysteresis	± 0.1% FSO BFSL (Typ.)	
Non-Repeatability	± 0.1% FSO (Typ.)	
Resolution	Infinite	
Insulation Resistance	1000 Megohms (Min.) @ 50 VDC Between All Terminals In Parallel and Case	
Output Impedance	1000 ± 500 Ohms	
ENVIRONMENTAL Operating Temperature Range	-65°F to +400°F (-55°C to +204°C)	
Compensated Temperature Range	-40°F to +350°F (-40°C to +177°C)	
Thermal Sensitivity Shift	± 1% FSO/100°F Over The Entire Compensated Temperature Range (Typ.)	
Thermal Zero Shift	± 1% FSO/100°F Over The Entire Compensated Temperature Range (Typ.)	
Natural Frequency	Greater Than 210 KHz @ 10 PSI, 500 KHz @ 100 PSI, 1030 KHz @ 1000 PSI	
PHYSICAL Electrical Connection	4 Conductor 30 AWG, Silver Plated, Teflon Coated Cable 60" Long	
Weight	5 Grams (Nom.) Excluding Cable	
Sensing Principle	Fully Active Four Arm Wheatstone Bridge Using Silicon on Silicon Sensor Technology With Parylene Media Isolation Barrier And Mesh Protective Screen	
Mounting Torque	15 Inch Pounds (Max.)	

Continuous development and refinement of our products may result in specification changes without notice.

KULITE SEMICONDUCTOR PRODUCTS, INC. • One Willow Tree Road • Leonia, New Jersey 07605 • Tel: 201 461-0900 • Fax: 201 461-0990 • http://www.kulite.com

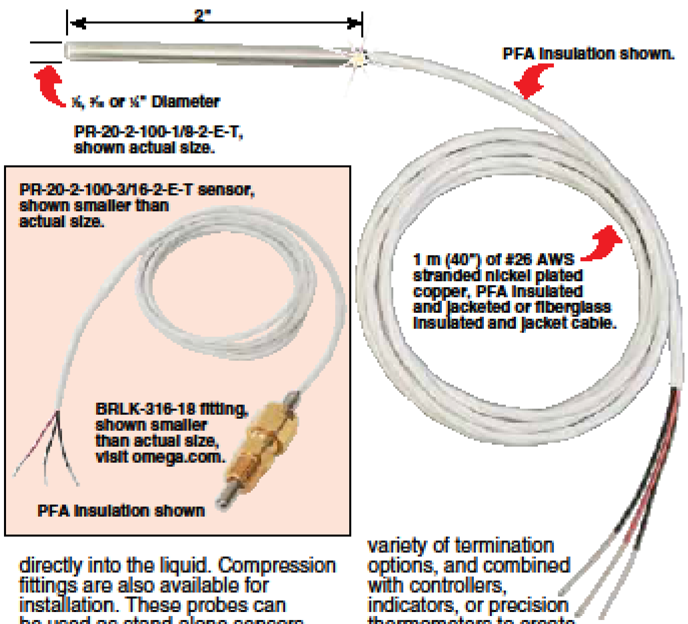
Appendix B

Short RTD Probe

PR-20 Series

ACCURACY IEC CLASS A

- 2" Compact Design for Applications with Space Restrictions
- Transitions Directly to Lead Wires (No Transition Fitting)
- Temperature Range: PFA: -50 to 260°C (-58 to 500°F) Fiberglass: -50 to 450°C (-58 to 842°F) Depending on Cable Selection
- High-Accuracy, 100 Ω, Class "A" DIN Platinum Elements per IEC751 (alpha = 0.00385 Ω/Ω/°C)
- 2-, 3-, 4-Wire Constructions Available



These general purpose 2" long sensors can be used in most liquid and air applications. When used in liquid environments, the epoxy-sealed end should not be immersed directly into the liquid. Compression fittings are also available for installation. These probes can be used as stand-alone sensors, or they can be configured with a variety of termination options, and combined with controllers, indicators, or precision thermometers to create complete measurement systems.

To Order *Visit omega.com/pr-20 for Pricing and Details*

Model Number	Probe Diameter (inch)	Lead Wire Style*	Max Temp Range °C (°F)
PR-20-2-100-1/8-2-E-T	⅛	3-wire/PFA insulation	260 (500)
PR-20-2-100-3/16-2-E-T	3/16	3-wire/PFA insulation*	260 (500)
PR-20-2-100-1/4-2-E-T	¼	3-wire/PFA insulation*	260 (500)
PR-20-2-100-1/8-2-E-G	⅛	3-wire/fiberglass insulation	450 (842)
PR-20-2-100-3/16-2-E-G	3/16	3-wire/fiberglass insulation*	450 (842)
PR-20-2-100-1/4-2-E-G	¼	3-wire/fiberglass insulation*	450 (842)

Note: For leads longer than 40", add "(-desired length in inches)" to the model number for additional price.
** For 4 wire configurations change the "2" to a "3" in the model number for additional price.*
4-wire constructions are not available in ⅛" diameters.
Terminations Available: for "-LUG", for "-OTP" and "-MTP" connectors. Visit omega.com for additional price.
Ordering Example: PR-20-2-100-3/16-2-E-T, 2", 3/16" diameter, 3-wire 100 Ω RTD probe with 40" PFA insulated lead wire.

Accessories

Model Number	Description
MTP-U-M	Miniature male 3-prong flat pin connector
OTP-U-M	Heavy-duty male 3-prong round pin connector
DPi32	1/32 DIN panel meter
SSLK-18-18	Compression fitting for ⅛" probe with ⅛ male NPT
SSLK-14-14	Compression fitting for ¼" probe with ¼ male NPT
SSLK-316-14	Compression fitting for 3/16" probe with ¼ male NPT
SSLK-316-18	Compression fitting for 3/16" probe with ⅛ male NPT

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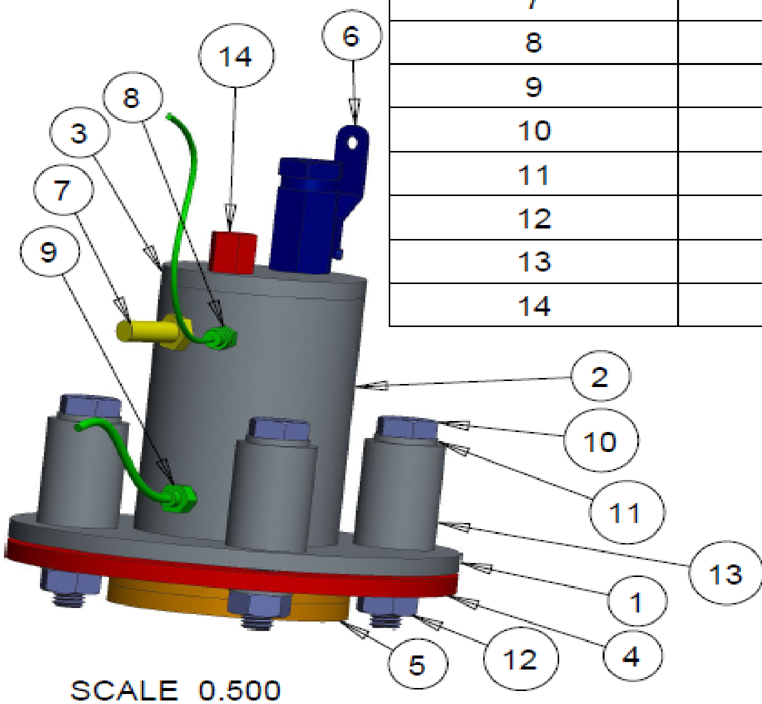
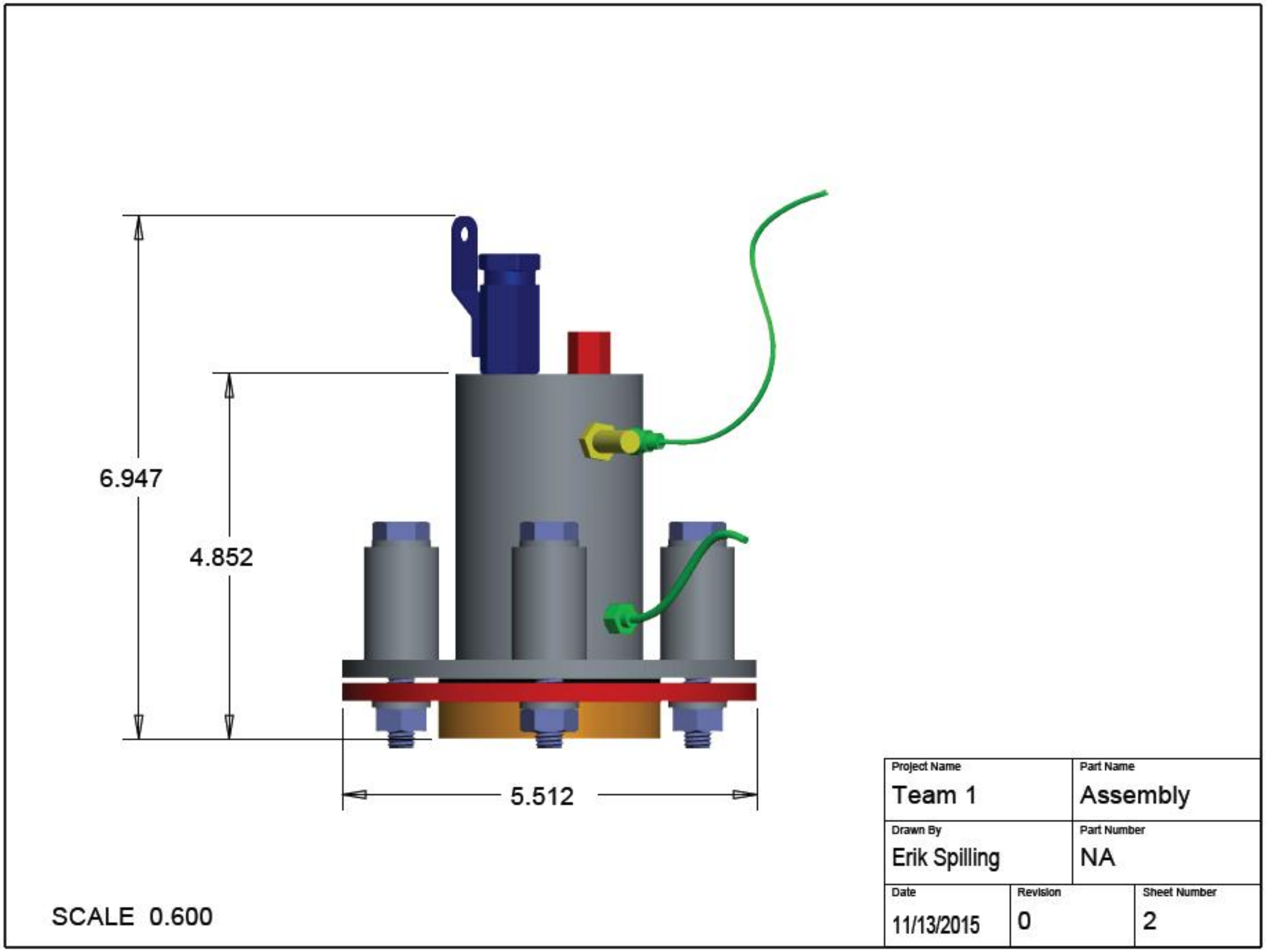
C

Appendix C

Part Number	Part Name	Quantity	Material
1	Top Flange	1	A36 Steel
2	Top Tube	1	A36 Steel
3	Top Cap	1	A36 Steel
4	Bottom Flange	1	A36 Steel
5	Spacer	2	A36 Steel
6	Oil Valve	1	Bronze
7	Air Valve	1	Bronze
8	Pressure Transducer	1	Steel
9	RTD Sensor	1	Steel
10	M10x1.5 70mm Bolt	4	Steel
11	M10 Washer	8	Steel
12	M10x1.5 Nut	4	Steel
13	Bolt Spacer	4	Steel
14	Pressure Relief Valve	1	Brass



Project Name	Part Name	
Team 1	BOM	
Drawn By: Erik Spilling	Part Number: NA	
Date: 11/13/2015	Revision: 0	Sheet Number: 1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4.852
5.512
SCALE 0.600
Project Name
Team 1
Part Name
Assembly
Drawn By
Erik Spilling
Part Number
NA
Date
11/13/2015
Revision
0
Sheet Number
2

Biography

Erik Spilling: Project Leader

Erik is a Florida State University Mechanical Engineering student from Saint Augustine, Florida. Erik has completed three internships at Cummins Inc., with two of those internships having been spent in High Horse Power Design Engineering. After graduation, Erik will join Cummins Inc. full time as a High Horse Power Design Engineer.

Heather Davidson: Lead ME and Web Designer

Heather is a Florida State University Mechanical Engineering student graduating in May of 2016. Heather was born in Deland, Florida. She has completed two summer internships with ExxonMobil at an oil refinery in Torrance, California. After graduation, she will be working at Southern Company in Birmingham, Alabama.

David Dawson: Financial Advisor

David is a Florida State University mechanical engineering student with a focus on Thermal Fluids and Energy. David was born in South Africa and raised in Jacksonville, Florida. Following graduation, David plans to pursue a job in either energy satiability or work for the armed forces as a mechanical engineering officer.

Aruoture Egoh: Lead Materials Engineer

Aruoture is an exchange student of Florida Agricultural and Mechanical University from Federal University of Technology, Akure, Ondo state, Nigeria. He plans to complete his bachelor's degree in Materials Engineering, attend graduate school to pursue a master's degree and PhD in materials engineering focusing on Polymeric Materials.

Daniel Elliott: Research Coordinator

Daniel is a Senior Mechanical Engineering student with a minor in Psychology and a mixed focus in Materials and Energy Systems. After graduation, he plans to move to Austin, Texas as his first step in his professional career and in order to be closer to his family.

Norris McMahon: Chronicler

Norris is a student at Florida State University originally from Pensacola, Florida. His area of focus is Mechanics and Materials. He has experienced an internship with Blattner Energy Inc. Following graduation, Norris plans to pursue a Masters in Sports Engineering and would like to end up in the Research and Development of sports products field.