**Contract No:**

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**Disclaimer:**

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INTER-OFFICE MEMORANDUM July 17, 2013

TO: G. A. Morgan, 999-2W

FROM: K. C. Neikirk, 723-A

**Edwards nXDS15iC Vacuum Scroll Pump Pressure Testing**

## Summary

The SRNL High Pressure Laboratory performed testing on an Edwards Model nXDS15iC Vacuum Scroll Pump on July 10th and 11th of 2013 at 723-A. This testing was done in an attempt to obtain initial compression ratio information for the nXDS15iC pump, with compression ratio defined as discharge pressure of the pump divided by suction pressure. Pressure burst testing was also done on the pump to determine its design pressure for pressure safety reasons. The Edwards nXDS15iC pump is being evaluated by SRNL for use part of the SHINE project being executed by SRNL.

Note: The ending "C" character in the Edwards pump part number stands for internal valves made from Chemraz® and stainless steel fittings for corrosive environments.

## Discussion/Conclusions

The pump was found to fail catastrophically when subjected to 208 psig of Nitrogen pressure with the four 5 mm machine screws that fasten the outboard casing/fixed scroll end of the pump to the main pump body being "stripped" out of their threaded holes in the aluminum pump casing. Based on the 208 psig failure pressure of the pump, a design pressure of 65 psig (208/3, approximately 65 psig) can be claimed for the Edwards nXDS15iC pump in accordance with ASME B31.3 requirements.

Compression ratio testing was also performed on the Edwards nXDS15iC pump prior to pressure testing the pump. This compression ratio testing was done several different ways in order to get the best data in the allotted time. These ways included controlling discharge pressure using a Metal Bellows MB-601 pump with the inlet of the pump blocked (similar to what was done by Charlie Sharp in 1984 for the Normetex pump evaluation work), pumping from a 100 liter volume with the discharge of the Edwards pump blocked, and pumping with both the inlet and outlet of the Edwards pump blocked. Observations from this testing established that the maximum discharge pressure of the Edwards nXDS15iC pump is on the order of 38.5 psia (as measured by a calibrated Paroscientific 0-45 psia pressure transducer) when pumping from atmospheric pressure (760 Torr) or below, and that the Edwards nXCS15iC pump's inlet is well sealed from the outlet by the inlet scroll tip sealing material.

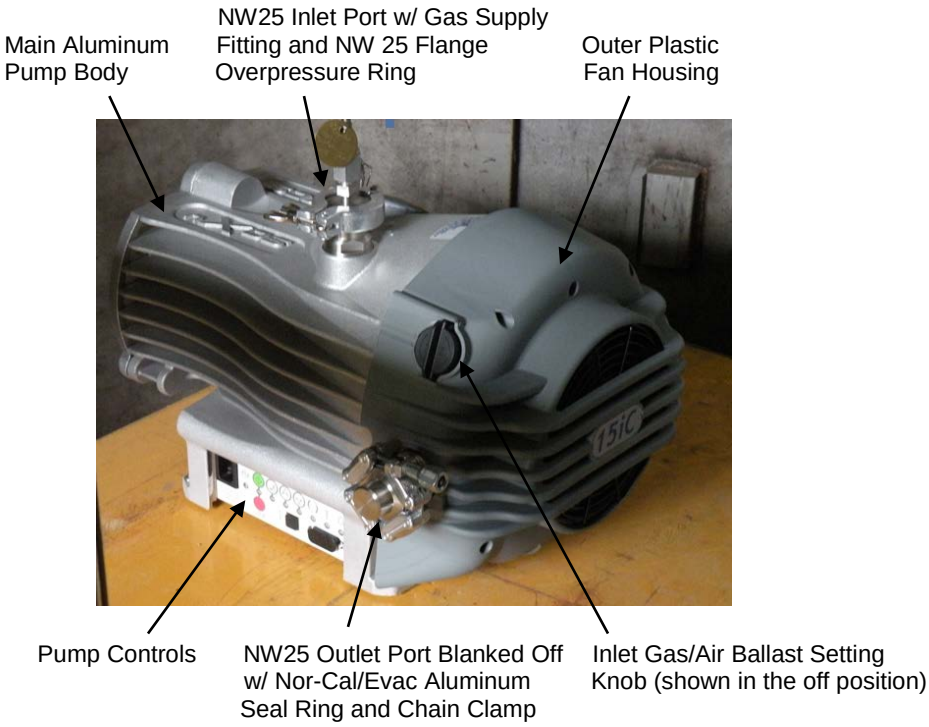
The following is a description of the Edwards nXDS15iC vacuum scroll pump pressure testing and compression ratio testing done on July 10th and 11th.

## Pressure/Burst Test

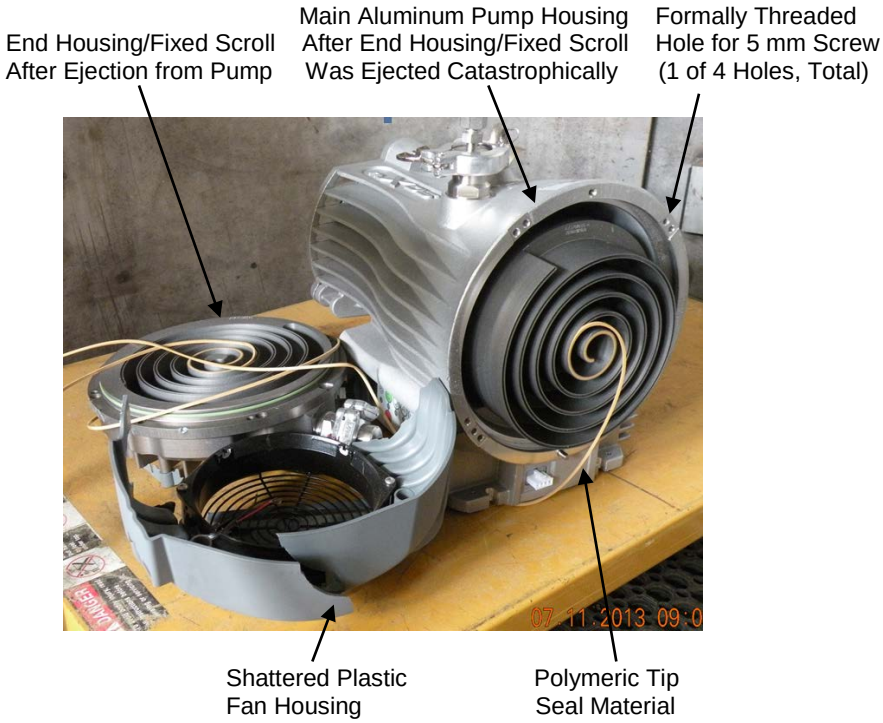
The pressure burst test was conducted at 723-A using the standard SRNL High Pressure Lab pressure testing equipment in accordance with procedure L9.4-10100. The Edwards pump was placed in the 723-A pressure test chamber (known as the walk-in gun barrel) and 25 psig of Nitrogen was initially applied to the pump. Pressure to the pump was increased in 25 psig increments, stopping at each increment to verify the absence of pump or system leakage. This

procedure was repeated until the pump was found to leak or until failure. During pressure testing, the pump was found not to leak until failure was realized at 208 psig. The following are pictures of the pump pressure test setup and pressure test results.

**Edwards nXDS15iC Scroll Pump in 723-A Walk-in Gun Barrel**
(ready for pressure testing)



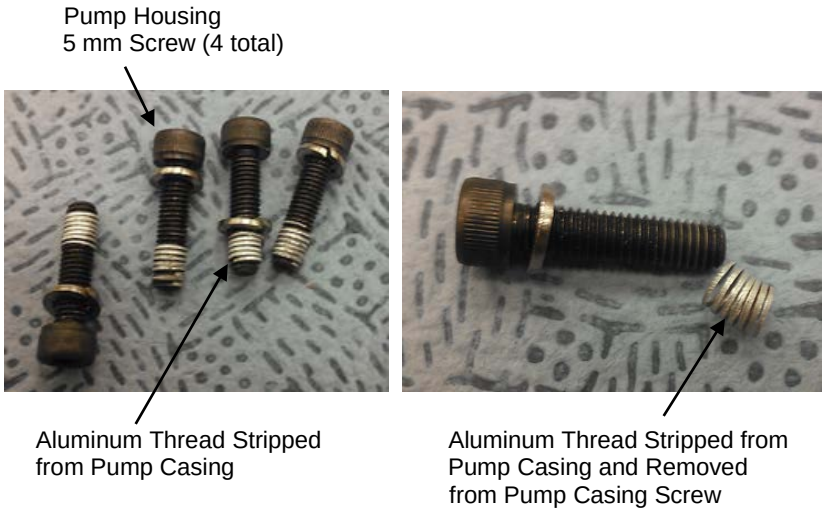

**Edwards nXDS15iC Scroll Pump after Pressure/Burst Testing**



The pump was found to fail at 208 psig. ASME B31.3 requirement dictate a factor of safety of 3 for process piping components. Although pumps are not considered part of the scope of ASME B31.3, DOE order prescribes that all process components adhere to the intent of ASME B31.3. Therefore, the design pressure of the Edwards nXDS15iC is specified to be 65 psig since 208 psig divided by 3 is 69.3 psig, or approximately 65 psig.

Failure of the pump was due to the four 5 mm screws that hold the end housing/fixed scroll to the main pump casing being "stripped" from their aluminum threaded holes in the main pump casing. The main pump casing is made from aluminum with "cut" rather than "rolled" threads, causing a high stress area and a structural weak point. It was in this location that the threads failed due to the pressure loading. The following is a picture of the screws and aluminum that was "stripped" from the pump housing.

**Edwards nXDS15iC Pump Housing 5 mm Screws after Failure**



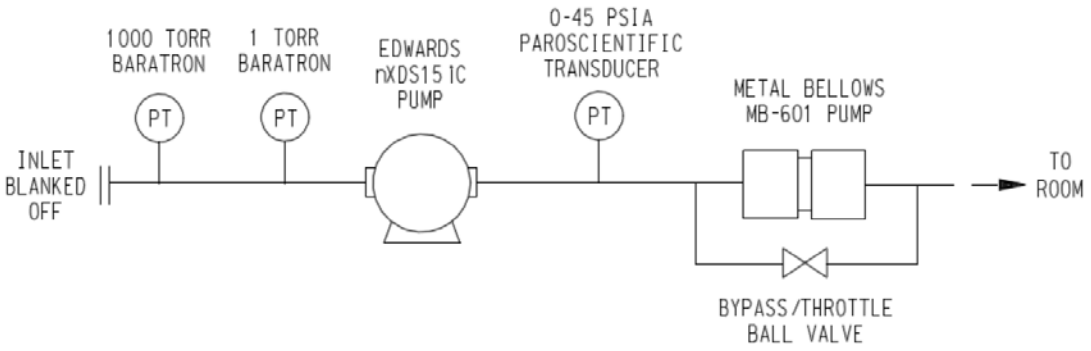

## Compression Ratio Testing

Several methods were discussed to determine compression ratio ($P_{discharge}/P_{suction}$) for the Edwards nXDS15iC vacuum scroll pump. Edwards was contacted to determine if they had information on compression ratio for the nXDS15iC pump. However, they did not nor were they able to recommend an appropriate way to measure compression ratio. The methods discussed included pumping from a volume with the discharge blocked, using a Metal Bellows MB-601 diaphragm vacuum pump with a bypass valve on the discharge of Edwards pump to vary discharge pressure with the inlet blocked, pumping with the pump inlet and outlet blocked, and pumping from a volume either using the Metal Bellows pump with bypass valve to vary discharge pressure or pumping directly to atmosphere using a valve to throttle the discharge pressure. Pumping from the volume using the Metal Bellows pump or a throttle valve to vary discharge pressure was not effective in terms of manual data collection due to the dynamic nature of the changing pressure readings. Time constraints did not allow incorporation of a computer data acquisition system that would have allowed instantaneous data collection of the discharge and suction pressures at discrete instances in time.

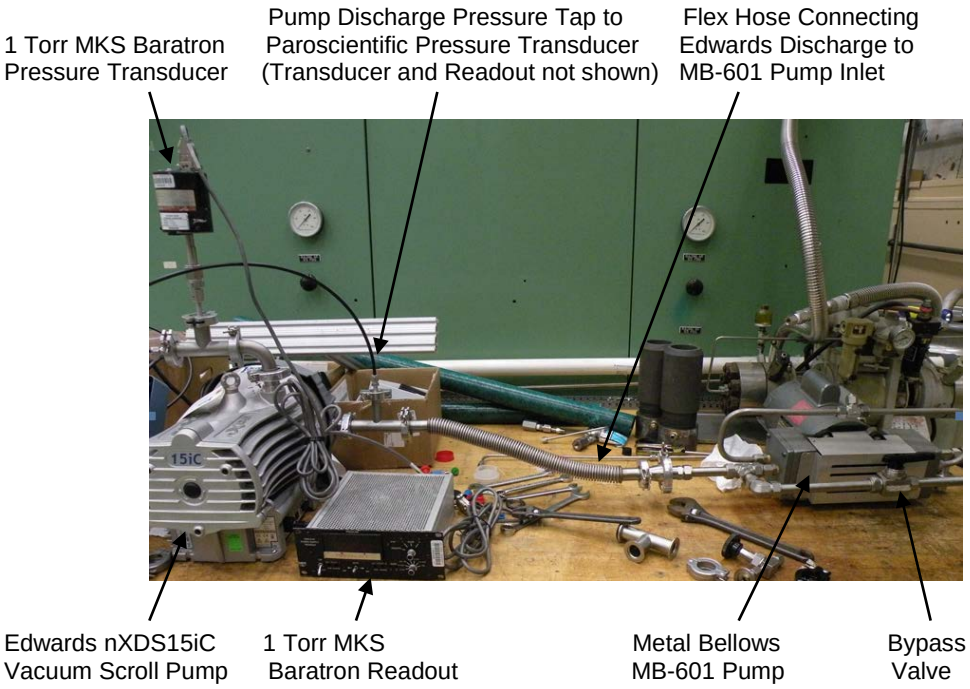
**Pumping Using the MB-601 Pump to Vary Discharge Pressure (w/ inlet blocked)**

The following is a schematic and picture of the compression pump test setup in the above testing configuration.

**Edwards nXDS15iC Pump Test Setup Schematic with MB-601 Pump**
(inlet blocked)




**Picture of Edwards nXDS15iC Pump Test Setup with MB-601 Pump**
(inlet blocked)




Results from this testing are shown on the following page. The protocol was to turn on the Metal Bellows MB-601 pump to create a vacuum on the discharge side of the Edwards pump with the bypass valve closed then turn on the Edwards nXDS15iC pump. In this condition, the discharge pressure of the Edwards pump was 7.2 psia (or 372 Torr). This discharge pressure was achieved just before the Edwards pump was turned on as well as after the Edwards nXDS15iC pump was turned on. Then, the Metal Bellows pump bypass valve was throttled to achieve different discharge pressures and the suction and discharge pressures were measured. The following is the data as a result of this testing.

**Edwards Pump Suction Blanked Off with Metal Bellows Backing Pump:**

| Measured Suction Pressure (mTorr) | Measured Discharge Pressure (psia) | Discharge Pressure (Torr) | Compression Ratio ($P_{discharge}/P_{suction}$) |
|---|---|---|---|
| 43.0 | 7.20 | 372 | 8651 |
| 43.3 | 9.70 | 501 | 11570 |
| 43.8 | 10.22 | 528 | 12055 |
| 46.0 | 11.83 | 612 | 13304 |
| 47.5 | 12.94 | 669 | 14084 |
| 48.5 | 13.40 | 693 | 14288 |
| 49.9 | 14.01 | 724 | 14509 |
| 50.5 | 14.24 | 736 | 14574 |
| 50.8 | 14.42 | 746 | 14685 |

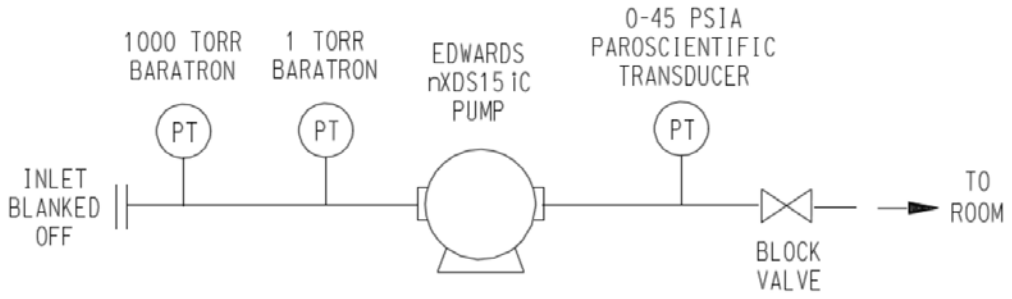
Note: A 1 Torr MKS Baratron capacitance manometer (M&TE # EA-463) was used to measured suction pressure and a 0-45 psia Paroscientific quartz crystal pressure transducer (M&TE # 3-4455) was used to measure discharge pressure.

Inspection of the data suggests that the inlet of the Edwards nXDS15iC vacuum scroll pump is well sealed from the discharge of the pump. This is most likely due to the polymeric tip seal material between the scroll impellers which creates a good seal between the inlet and outlet of the pump. It was also thought that a check valve on the discharge side of the pump could be the reason for the low suction pressure verses discharge pressure. Additional inspection of the failed pump did in fact reveal a check valve on the discharge side of the pump, which explains results from this testing.

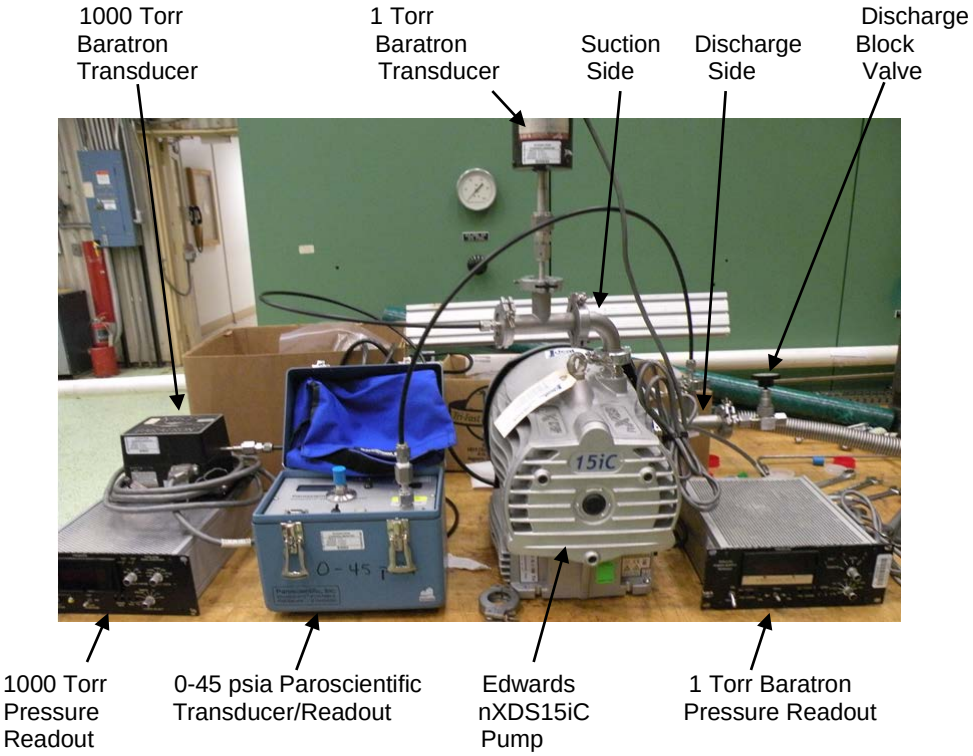
**Pumping w/ a Blocked Inlet and Discharge Side of the Pump**

The Edwards nXDS15iC pump was also operated with the suction and discharge ports blocked on the pump. A valve was used on the discharge of the pump in the closed position and the inlet side was blocked with the required pressure transducer connections. A schematic of this pump test setup is shown below and a picture of the test setup is shown on the following page.

**Edwards nXDS15iC Pump Test Setup Schematic w/ Inlet and Discharge Blocked**



**Picture of Edwards nXDS15iC Pump Test Setup w/ Inlet and Discharge Blocked**




The following are the results from this testing. It should be noted that during testing it was observed that suction pressure tended to be a function of how much volume of air was available on the suction side of the pump. In the case described later in the report, when pumping from a large (100 liter) volume against a blocked discharge valve, suction pressure dropped very little. However, based on the testing done, it can be said with high certainty that the Edwards nXDS15iC pump will not generate more than a 38.5 psig discharge pressure with a suction pressure of atmospheric pressure (760 Torr) and below.

**Edwards Pump Inlet and Discharge Ports Blanked Off:**

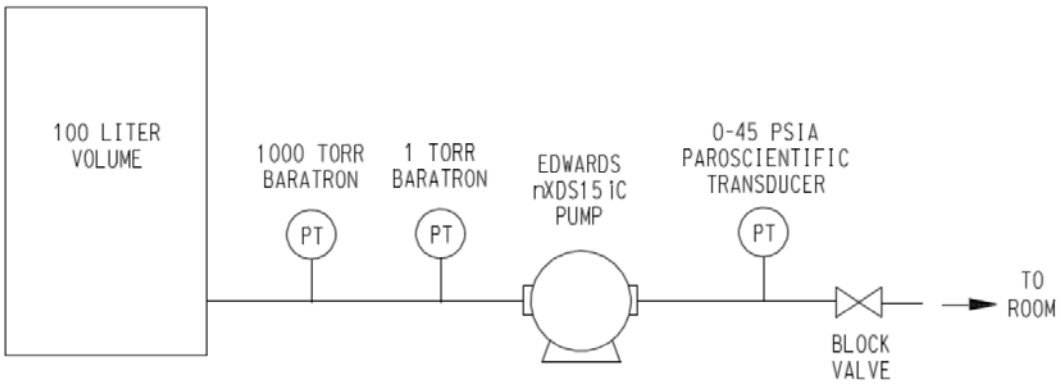
| Measured Suction Pressure (Torr) | Measured Discharge Pressure (psia) | Discharge Pressure (Torr) | Compression Ratio ($P_{discharge}/P_{suction}$) |
|---|---|---|---|
| 476 | 38.5 | 1991 | 4.2 |

Note: A 1000 Torr MKS Baratron capacitance manometer (M&TE # EA-317) was used to measured suction pressure and a 0-45 psia Paroscientific quartz crystal pressure transducer (M&TE # 3-4455) was used to measure discharge pressure.

**Pumping From a 100 Liter Volume w/ Discharge Side of the Pump Blocked**

The Edwards nXDS15iC pump was also operated with the suction of the pump connected to a 100 liter volume and the discharge port blocked. A valve was used on the discharge of the pump in the closed position and the inlet side had the required pressure transducer connections. A schematic of this pump test setup is shown on the following page.

**Edwards nXDS15iC Pump Test Setup Schematic When Pumping from Volume w/ Pump Discharge Blocked**




The 100 liter volume pressure before the pump was turned on was approximately 760 Torr (atmospheric pressure). After the Edwards pump was turned on, pressure in the tank (i.e., the pump suction pressure) was 731 Torr. Again, discharge pressure against a blocked discharge valve was found to be 38.5 psig as measured by the calibrated Paroscientific pressure transducer.

**Pumping from 100 Liter Volume w/ Discharge Port Blanked Off:**

| Measured Suction Pressure (Torr) | Measured Discharge Pressure (psia) | Discharge Pressure (Torr) | Compression Ratio ($P_{discharge}/P_{suction}$) |
|---|---|---|---|
| 731 | 38.5 | 1991 | 2.7 |

## Other Pump Testing

Compression ratio data ($P_{discharge}/P_{suction}$) collection was also attempted using the test setup above but throttling the discharge valve as well as using the Metal Bellows pump on the discharge side of the Edwards pump. However, manual data collection utilizing this test configuration was not possible since it was not possible to manually record suction and discharge pressures accurately at discrete instances in time. Accurately collecting data utilizing this test setup requires a computer data acquisition system which was not available at the time of testing.

A test that may realize useful data in the future is to throttle the suction side of the Edwards nXDS15iC pump with a manual throttle valve and to vary discharge pressures using the Metal Bellows pump with bypass valve. Although this wasn't done during this test evolution, it could possibly be done in the future to obtain additional compression ratio data for the Edwards nXDS15iC pump.

## Acknowledgements

Chris Allen – SRNL High Pressure Lab (pump pressure/burst testing)
Doug Holiday – SRNL High Pressure Lab (pump test setup and testing support)
John McIntosh – SRNL R&D Engineering (pressure transducer technical support)

Attachment 1 – Pump Pressure Test Data Sheet

**INFO ONLY**

Job Number: SRNL - HPL - 2013 - 4887
Building No: 999-2W
Record No 17221

# HPL Pressure/Leak Test Data Sheet

Test Item: Edwards Scroll Pump, Model nXDS15Ic
Test Item S/N: 139482311
Customer: Brent Peters, 999-2W, Room C1, Phone 646-9426, Pager 21878, SRNL
Test Date: 7/11/2013 Test Specialist: Chris Allen, 55704, Certified Level II
RDE Test Engineer: Don Trapp, 723-A, Phone 5-8307 , Pager 14570

| Pressures: | |
|---|---|
| Test Type | Measured |
| Proof: psig | 208 |

Reviewed By: Signed electronically by Donald J. Trapp, Level III, on 7/11/2013

Certified L.T. Signed electronically by Chris L. Allen, Level II, on 7/11/2013

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