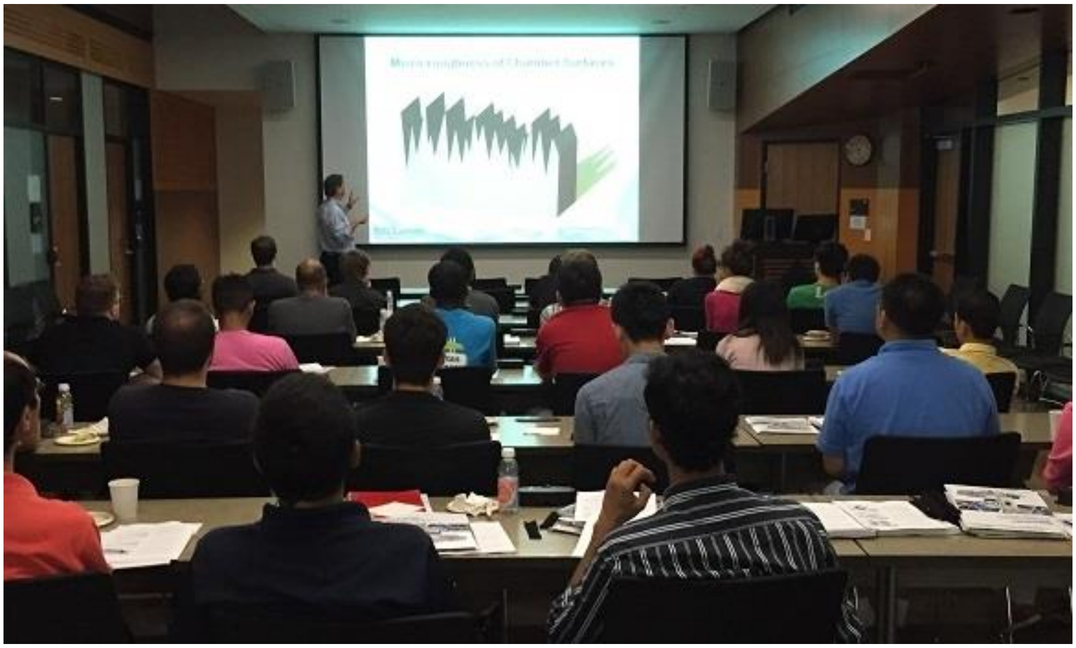
As of 3 January 2018

Lesker University Vacuum Technology Classes

About Lesker University:

The Kurt J. Lesker Company provides a family of courses on vacuum technology, vacuum-enabled processing and hardware under the banner Lesker University. The courses are designed to provide students with a basic understanding of vacuum technology and proper vacuum practices in order to improve their ability to operate and maintain vacuum systems. It is our intention that every student be a better vacuum technologist after taking the courses so that they will make fewer mistakes, create and maintain better vacuum conditions, and produce higher quality results.

The following list contains course descriptions so that our clients can select subject matter most relevant to their current level of training and build an effective training day, or portion of a day. To some extent, with prior interaction with the instructor, some customization of the course material is possible to better satisfy the unique needs of each client.



More than 150 Lesker University events have been held in the US, Europe and Asia since early 2015 and + 3,500 students have become better able to use vacuum as an enabling technology for a better world. The suite of courses offered through Lesker University includes an introduction to basic vacuum technology, physical vapor deposition and thin film growth models, atomic layer deposition, and vacuum system design.

About the Presenter:

J.R. Gaines is the Technical Director of Education for the Kurt J. Lesker Company, (Jefferson Hills, PA). The Lesker Company is a global scientific equipment manufacturer supplying materials and tools for vacuum-enabled innovation. Gaines has more than 40 years of experience in the research, development and commercialization of advanced materials technologies including superconductivity, semiconductors, cryogenics, space simulation, energy generation, energy conversion and storage. His experience includes vacuum systems, thin film deposition, inorganic chemistry, nanotechnology and advanced ceramic processing. He currently develops and delivers the Company's many educational programs through Lesker University teaching events.

Prior to joining the Lesker Company, J.R. worked for Lake Shore Cryotronics manufacturing temperature sensors, Superconductive Components, Inc. where he developed a line of ceramic superconductors and superconductive devices, Oak Ridge Micro-Energy where he helped commercialize solid-state thin film batteries, and the Sputtering Target Manufacturing Company where he developed a unique approach for advanced ceramic sputtering targets which was subsequently acquired by the Kurt J. Lesker Company.

What our hosts are saying about Lesker U:

Thomas S. Ferraguto
Nanofabrication Laboratory Director
Saab Emerging Technology and Innovation Center
University of Massachusetts Lowell

"UMass Lowell Core Research Facility Nanofabrication Laboratory has partnered with Kurt J. Lesker Company for 3 consecutive years to run an educational outreach seminar. We open the seminar to under graduates, graduate students, from UMass and other local Universities in addition to our Industrial User Base. The event(s) have been extremely popular and mutually beneficial.

The Lesker Training staff (particularly JR Gaines) are both knowledgeable and can provide information in a way that cuts across knowledge levels and discipline. I was in industry for nearly 30 years before coming to higher education and I know that the Lesker team understands the importance of being able to reach and bridge both industry and educational audiences.

As an example we partnered on a leak detection seminar that included hands on training (in the clean room on the Lesker Labline Sputter Tool) for anyone that wanted to learn not only the theory, but how understand some of the "art" in leak detection from the Lesker Technician. The trainees not only had find the leak, but deal with 90 feet per minute air velocity while working in clean suits. The industry users shared stories and presented unique perspectives and the students got to experience a real world scenario.

I truly appreciate Lesker being open to new training topics and ideas as well as providing great class room content. I am pleased to call Lesker a partner not just a vendor and hope to continue and improve on our annual training events."

Noah Clay
Director, Quattrone Nanofabrication Facility
School of Engineering & Applied Science
University of Pennsylvania

"The Lesker University event was a tremendous educational tool for students and staff members. We were able to review many items related to the basics of vacuum science, i.e. how to safely and correctly handle vacuum equipment, calculating pump-down speeds and time, conductance, and other technical aspect of vacuum science. A swift reminder on the importance of cleanliness and to some degree, preventative maintenance.

The Lesker team was able to offer their expertise on more specific subjects related to various physical vapor deposition techniques and how to achieve better film qualities (ramping and soaking, throw distance, temperature uniformity, etc.) and answered questions that pertain to the vacuum market in general. The University of Pennsylvania Quattrone Nanofabrication Facility is better for having spent the time with JR Gaines and the Lesker Team to review and learn more about vacuum science! I will do it again in the near future and strongly encourage my friends and colleagues to do the same."

Jacob Trevino, PhD
NanoFabrication Facility Director |Research Associate Professor
CUNY Advanced Science Research Center

"The Lesker U workshop that was held at the CUNY ASRC Nanofabrication facility in September was a huge success, and a great help to the faculty, staff, students and industry partners in attendance. Social media (Facebook) was utilized to cast a wide net of potential attendees and we ended up with more than 50 people that wanted to learn more about thin film deposition. JR Gaines' content included a mountain of technical detail that was professionally presented and in a way that made the course educational, fun, and practical.

The capital equipment in our general use facility demands that every user is educated in all areas of thin film deposition. They must understand the science behind the various deposition technologies and the differences between things such as film morphology, density, uniformity and how specific deposition system conditions effect all of that, and more. Academia and Industry benefited from the materials presented by JR and KJLC. The CUNY ASRC Nanofabrication Facility is truly grateful and looks forward to hosting another Lesker U Workshop!"

For more information please contact Mr. J.R. Gaines, Technical Director of Education, by phone at 01-614-446-2202 or by email at JRG@Lesker.com .

Vacuum Technology Courses, with *approximate* class times

1. **Introduction to Vacuum Science and System Design** (class time 3 - 4 hours)

   This class is designed to introduce the student to basic concepts in vacuum technology. Subjects covered include molecular density in vacuum, the ideal gas law, molecular flow in various vacuum regimes, characteristics of gas composition at various molecular densities, general principles of gas-solid interactions, vacuum pump technology and the impact of fundamental design decisions and operating practices on vacuum system performance. It is intended for people who are new to vacuum or may not have any formal training. It also provides a general review for those who have had some formal training in vacuum technology. The student should achieve a general understanding of vacuum technology as a foundation for further training in vacuum system design and thin film deposition. This course also includes several short quizzes to better enable the learning process. Students who attend the class can receive a personalized certificate of attendance signed by the course instructor.

   Specific topics include:

   a. Technical resources for vacuum technology
   b. Pressure and molecular density

c. Adsorption, Desorption, Diffusion and Permeation
d. Gas–Solid Interactions
e. Flow Regimes
f. Conductance
g. Vacuum Pump Technologies, Pumping Speed and Pump Throughput
h. Detecting leaks in vacuum systems
i. Valves and Seals for high and ultra-high vacuum
j. Gas Load
k. Effects of humidity on vacuum system performance
l. Outgassing
m. Surface finishes for vacuum applications
n. Calculations of ultimate base pressure of a vacuum system

2. **Physical Vapor Deposition and Thin Film Growth Models** (class time 3 - 4 hours)

This class is designed to introduce the student to fundamental concepts and operating principles for the deposition of thin films by thermal and e-beam evaporation as well as sputtering by DC and RF techniques. It includes a recap of basic vacuum technology, followed by fundamental design and operational aspects of each thin film deposition technique as it impacts thin film properties. Issues such as deposition rate, film uniformity, morphology and density are discussed. Several growth models are presented with reference to how specific materials properties and deposition conditions may affect thin film morphology. The student should achieve a general understanding of thin film deposition by physical vapor techniques and be familiarized with available resources for further training. This course also includes several short quizzes to better enable the learning process. Students who attend the class can receive a personalized certificate of attendance signed by the course instructor.

Institutions like Harvard and The University of Massachusetts Lowell host Lesker U events every year

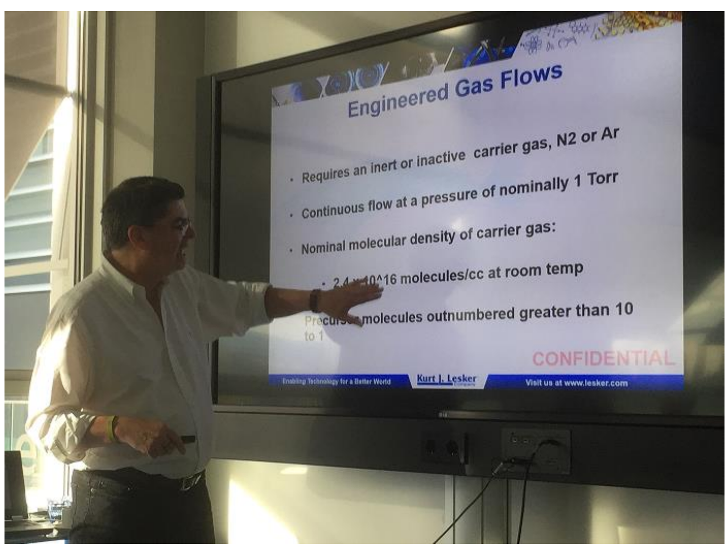
Specific topics covered include:

a. Introduction
b. References on thin film deposition technologies
c. Introduction to basic vacuum
d. Depositing thin films by:

    a. Thermal evaporation
    b. E-beam evaporation
    c. Sputtering by Direct Current (DC) Magnetron
    d. Sputtering by Radio Frequency (RF) Magnetron
    e. Sputtering using pulsed processes
    f. Cathodic Arc Deposition (if there is interest)
e. Thin Film Growth Models
    a. Layer Growth
    b. Island Growth
    c. Combined Layer and Island Growth
    d. The Structure Zone model(s)
f. Effects of Deposition Conditions on Film Characteristics, including:
    a. Stress in thin films
    b. Thickness effects
    c. Effect of Chamber Pressure on film properties
    d. Deposition rate and film characteristics
g. Enhanced Deposition Techniques

3. **Introduction to Atomic Layer Deposition** (class time about 2 - 3 hours)

This class is designed to introduce the student to fundamental concepts and operating principles for the deposition of thin films by atomic layer deposition (ALD). It includes a discussion of the motivation behind ALD and some insights into the operational aspects of this thin film deposition technique as they impact thin film properties. Issues such as gas flows, chemical reactions, deposition rate, thermal window and the impact of enhanced plasma processing are discussed. The student should achieve a general understanding of thin film deposition by ALD and be familiarized with available resources for further training. This course also includes several short quizzes to better enable the learning process. Students who attend the class can receive a personalized certificate of attendance signed by the course instructor.



Lesker U events on Atomic layer Deposition have been held in the US, Asia & Europe

Specific topics include:

a. Motivation for Atomic Layer Deposition (ALD)
b. The ALD Process in ideal conditions
c. Review of basic vacuum and flow regimes critical to ALD

i. Laminar Flow
ii. Viscous or turbulent flow

d. Evolution of ALD reactor designs
e. ALD in non-ideal conditions
    i. The impact of Chaos
    ii. Thin film growth models
f. Recent Advanced in Process Design
    i. Addition of Plasmas
    ii. Enhanced Reactivity of Precursors and Carrier Gases
    iii. Alternative Pulse Regimes
g. Impact of the ALD Process on Balance-of-Plant (ie. pumping systems)
h. Recent Examples of Device Solutions achieved using ALD

4. **Introduction to Vacuum System Design** (class time 2 hours)

This class is designed to introduce the student to basic concepts in vacuum technology and their impact on vacuum system design. Subjects covered include the decision tree required for a comprehensive and compact design approach and the impact of design decisions and operating practices on vacuum system performance. It is intended for people who are new to vacuum or may not have any formal training. The student should achieve a general understanding of vacuum system design as a foundation for further training in vacuum system modeling and manufacturing. Students who attend the class can receive a certificate of attendance which is signed by the course instructor.


A vacuum chamber under construction at the Lesker Company

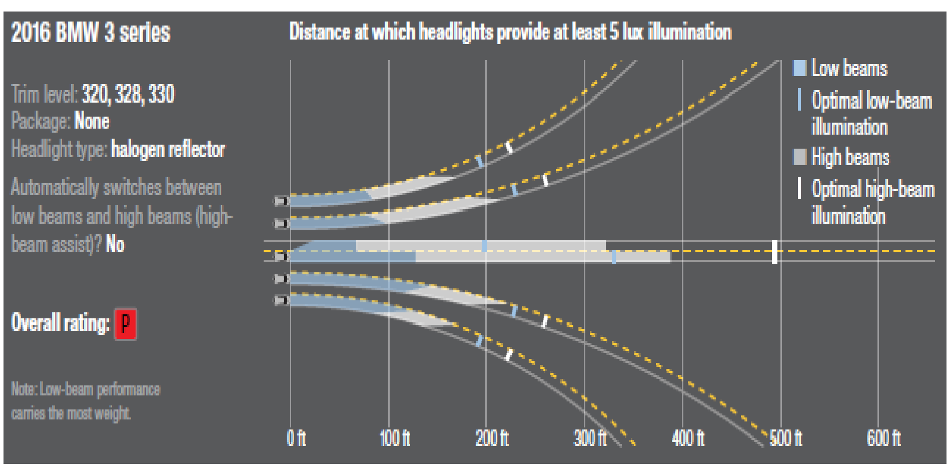
Specific topics include:

a. Vacuum Ranges Described
b. Strategies and tactics for Robust Vacuum Systems
c. Chamber Design
d. Materials for Vacuum
e. Vacuum Pumps
f. Vacuum piping, valves and fittings
g. Best Practices Vs Practicality

In 2016 a Lesker U event on vacuum system design and thin film deposition was held at the Shanghai Synchrotron, the largest vacuum system in China

5. **Introduction to Vacuum and Thin Film Deposition Technology for Automotive Lighting Manufacturers** (class time about 3 hours)

This class is designed to introduce the student to basic concepts in vacuum and thin film deposition technology. Subjects covered include molecular flow at various vacuum pressures, general principles of gas-solid interactions, vacuum pump technology and the impact of fundamental operating practices on vacuum system performance and the quality of metal thin films. It is intended for people who are new to vacuum or may not have any formal training and is focused on issues critical to the manufacture of highly reflective metal coatings for automotive applications. The student should achieve a general understanding of vacuum technology as a foundation for further training in vacuum system performance and thin film deposition. This course also includes several short quizzes to better enable the learning process. Students who attend the class can receive a personalized certificate of attendance signed by the course instructor.



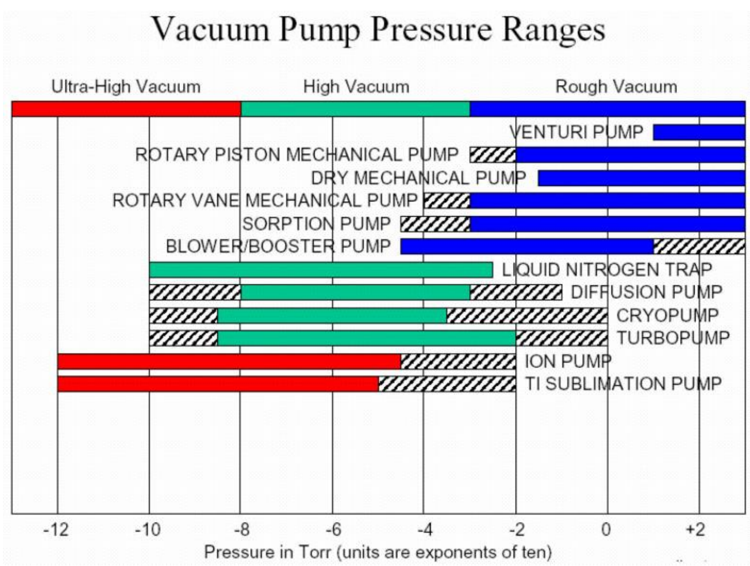
Specific topics include:

a. Technical resources for vacuum technology
b. Pressure and molecular density
c. Adsorption, Desorption, Diffusion and Permeation

d. Gas–Solid Interactions
e. Flow Regimes
f. Vacuum Pump Technologies, Pumping Speed and Pump Throughput
g. Detecting leaks in vacuum systems
h. Gas Loads, outgassing, and good vacuum practice
i. Calculations of ultimate base pressure of a vacuum system
j. Thin film deposition by Thermal, E-Beam or Sputtering
k. Impact of good vacuum practice on the reflectivity and mechanical characteristics of aluminum thin films
l. Thin Film Growth Models
m. Care and Feeding of Vacuum Pumping Systems

6. **Vacuum Pumps for High and Ultra High Vacuum Applications** (class time about 1.5 hours)

There is no one vacuum pump technology that will take a system from atmosphere down to high or ultra-high vacuum. Vast differences in molecular density from laminar flow to molecular flow require the utilization of two or more approaches. This course provides fundamental descriptions of the basic vacuum pumps and pumping mechanisms in current practice and provides insight into the various pros and cons for each approach in order to provide a basic understanding with which to guide pump selection for vacuum technologists. Students who attend the class can receive a personalized certificate of attendance signed by the course instructor.

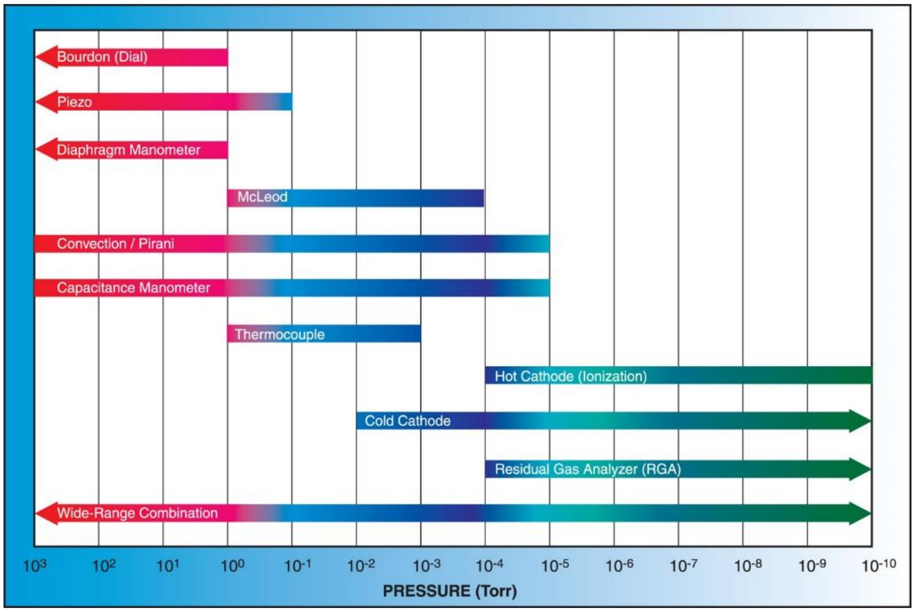


a. Technical references for Vacuum Pumps
b. Pressure regimes
c. Types of vacuum pumps and pumping technologies
d. Wet Vs Dry pumps
e. Pumping speed
a. Pump throughput
b. Rotary Vane Pumps
c. Dry scroll pumps
d. Diaphragm pumps
e. Cryo Pumps
f. Turbomolecular pumps and hybrids
g. Diffusion pumps
h. Ion Pumps

i. Titanium sublimation pumps
j. Non Evaporable Getter (NEG) Pumps

7. **Vacuum Gauging** (class time about 45 minutes)

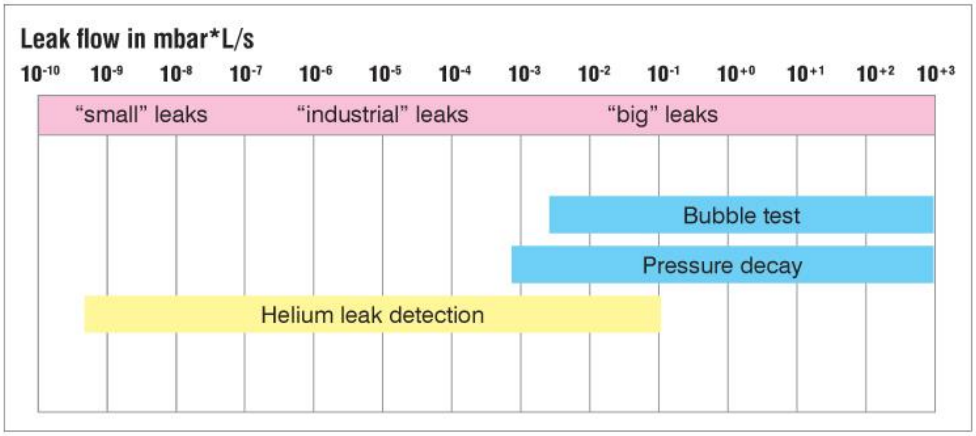
Like vacuum pump technology, the vast differences in molecular density at atmosphere and high or ultra-high vacuum require a multitude of pressure measurement techniques. This course describes a wide range of pressure measurement approaches as well as the pros and cons of each device. Certain process-specific characteristics are identified that might guide the user on the selection of the suite of instruments required to cover large pressure ranges. We encourage coupling this course with our Introduction to Vacuum Technology. Students who attend the class can receive a personalized certificate of attendance signed by the course instructor.



a. Gas pressure
b. What makes vacuum pressure difficult to measure?
c. The Ideal Gas Law and gas law variables
d. Gas Dependent Vs Gas Independent gauges
e. Examples of gauging systems

8. **Detection of Leaks in Vacuum Systems** (class time about 1 hour)

The identification of gas sources that prevent to achievement of high or ultra-high vacuum is critical to the performance of any vacuum system. This course provides an overview of potential gas sources, such as leaks, permeation, outgassing and poor vacuum cleanliness. The definition and detection of leaks is discussed in detail and various approaches, specific to leak size and system pressure are described. We encourage coupling this course with our Introduction to Vacuum Technology. Students who attend the class can receive a personalized certificate of attendance signed by the course instructor.



a. Technical references for helium leak detection
b. Types of leaks
c. Detection methods
d. Basics of helium leak detectors
e. Practical guidelines

9. **Seals, Flanges and Valves** (class time 1 hour)

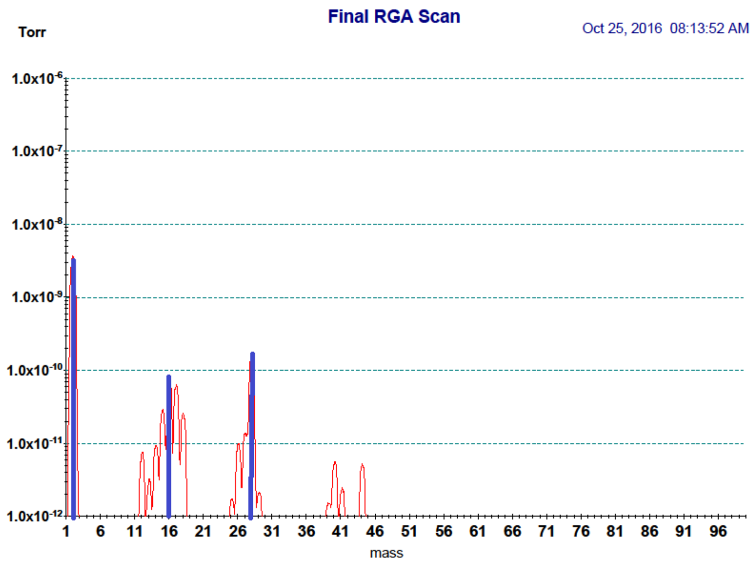
Seals, flanges and valves are critical to the performance of any vacuum system. The specific choice of gasket or O-ring material and the appropriate flange are highly process dependent. In this course the various options for making great seals are reviewed some approaches to the proper care and feeding of sealing systems are discussed.

a. High vacuum flanges
b. Ultra-high vacuum flanges
c. Seals and O-rings
d. Assembly tips
e. Vacuum valves
f. Operating principles

g. Valve selection

10. **A Beginners Guide to Residual Gas Analyzers and Partial Pressure Analyzers** (class time 45 minutes)

The residual gas analyzer (RGA) is in many ways the most precise tool for the practical measurement of very low pressures. Not only will the RGA give you total pressure (by summing the partial pressures of the various detected masses) it will also help identify the specific gases that make up the atmosphere within a vacuum chamber or component. This course provides the student with a fundamental understanding of how the system works and provides examples of the ‘usual suspects’ present in high or ultra-high vacuum environments, including water, CO_2 , methane, popular solvents and system components like Viton.



a. Review of pressure gauges for vacuum applications
b. Technical resources for RGA operation and analysis
c. Flow regimes in vacuum
d. Likely gas species present in a vacuum environment
e. How an RGA works
f. Cracking patterns of common gases, oils and solvents
g. Evolution of cracking patterns and partial pressures before and after bake-out
h. Approach to identify individual RGA peaks
i. Additional support for RGA users