Course Outline: Comprehensive Training – Hall Effect Thrusters

Primary Instructor: Professor Mitchell L. R. Walker
http://mwalker.gatech.edu/

Location:
1. Part I: Classroom Instruction – Georgia Tech Hotel & Conference Center
   http://www.gatechcenter.com/
2. Part II: Hands-On Experience – High-Power Electric Propulsion Laboratory
   http://mwalker.gatech.edu/hpepl/visitors/

Academic Level: Requires undergraduate knowledge of Engineering, Math, Physics

Description:
The Georgia Institute of Technology "Comprehensive Training – Hall Effect Thrusters" course is an intense immersion into the physics, operation, plasma diagnostics, and vacuum facilities required to operate Hall effect thrusters (HETs). This program provides the participant with 2 days of private instruction followed by 5 days of hands-on training with a laboratory-model, 5-kW HET. All experimental work is performed in Vacuum Test Facility 2 in the High-Power Electric Propulsion Laboratory (HPEPL), which has the highest pumping speed of any University-based electric propulsion facility in the United States. The contents of the course are ITAR-free.

The course begins with an overview of the basic electromagnetics and plasma physics concepts required to understand the operation of HETs. These concepts are then related to specific impulse, thrust, and efficiency. The course slides contain the equations, diagrams, and references required to perform basic engineering exercises for HETs. The course provides a solid background of the operating principles, performance characteristics, and design features of HET systems. The course is then customized to address the specific needs of the attendees.

Attendance:
1. Classroom Instruction: Maximum of 10 people
2. Hands-on Experience: Maximum of 5 people

Group Price: Please contact us for details.

Unique Features:
- Exclusive, private access to Professor Walker and VTF-2 in the HPEPL
- Access to Dr. Walker via e-mail for 2 months after completion of the course to ask questions related to course content
- All-inclusive "hands-on" experience with HET operation and related diagnostics
- All interactions throughout the course are covered under an NDA
- Participants that successfully complete the program will receive an Official Certificate of Completion from the Georgia Institute of Technology
- Cameras are allowed in the "hands-on" portion of the course
- Participants will receive a copy of the "Best of HETs" – Contains the most substantial articles related to HET development and operation in electronic form

Part I – Classroom Instruction

A tentative course outline is listed below.

Part 1 – Why Electric Propulsion?
Part 2 – Hall Effect Thruster History
Part 3 – Electricity, Magnetism, and Charged Particles
Part 4 – Kinetic Theory, Ionization of Gases, & Plasma Physics
Part 5 – Hall Effect Thruster Physics
Part 6 – Diagnostics
Part 7 – Custom Content (see below)

Continental Breakfast and catered Lunch will be provided during Classroom Instruction.

Part II – Hands-On Training

HET system:
1) Operation of 5-kW HET for 24 hours (at least three full working days with the thruster) and measurement of thrust, efficiency, specific impulse, ion current density profiles (with a Faraday probe) to calculate the plume divergence angle, and ion energy distribution measurements (with a Retarding Potential Analyzer).

2) Operation of HET under different discharge conditions including:
Discharge Voltage: 200-500 V
Flow rate: 5- 15 mg/s
Propellant: xenon and krypton

3) Information about the standards for HET qualification from the published literature will be provided with references.

4) The following measurements (based on published literature):
Ion current density measurements - Faraday Probe
Electron temperature and electron number density - Single Langmuir probe
Ion energy distribution measurements - Retarding Potential Analyzer
Ion charge state measurements - ExB Probe

5) Thermal analysis of a HET will be discussed based on the information available in the literature.

Vacuum Chamber:
1) Regarding the usage of graphite panels in the chamber to protect the walls, analysis of the installation of panels and appropriate measurements will be provided.

2) The procedures of pumping out and venting the vacuum chamber and critical points in these procedures will be covered. In addition, the team will assist the lab team with these processes during the visit. A copy of the HPEPL VTF-2 operating procedures will be provided.

3) The methods used to measure the pressure and the leakage in the chamber will be covered. In addition, visiting team will assist the lab team with these processes during the visit. A copy of the HPEPL VTF-2 operating procedures and measurements will be provided.

Diagnostics:
1) Information on methods for life time tests will be discussed the methods for this process.

4) Observation and practice of the operation of a fast positioning system. The critical points in these measurements will be declared.

6) Procedures to measure thrust (including calibration of the thrust stand, time period and frequency of the measurements) will be discussed.

7) Possible difficulties and error mitigation methods in thrust measurements will be discussed (such as environmental vibration, noise, thermal problems?). The team will be able to experience and then correct for these issues.

Nominal Course Schedule:
2 Days: Classroom Instruction
2 Days: Experimental Setup
2 Days: Experimental Testing – Xenon propellant
1 Day: Experimental Testing – Krypton propellant
1 Day: Data Analysis and Questions (You will take home all of the data)
2 Days: Buffer