HE Production Update at Jlab – Introducing an Enhanced Nitrogen Purge for Clean String Assembly

Peter Owen

Thomas Jefferson National Accelerator Facility
Newport News, VA

Contact: powen@jlab.org

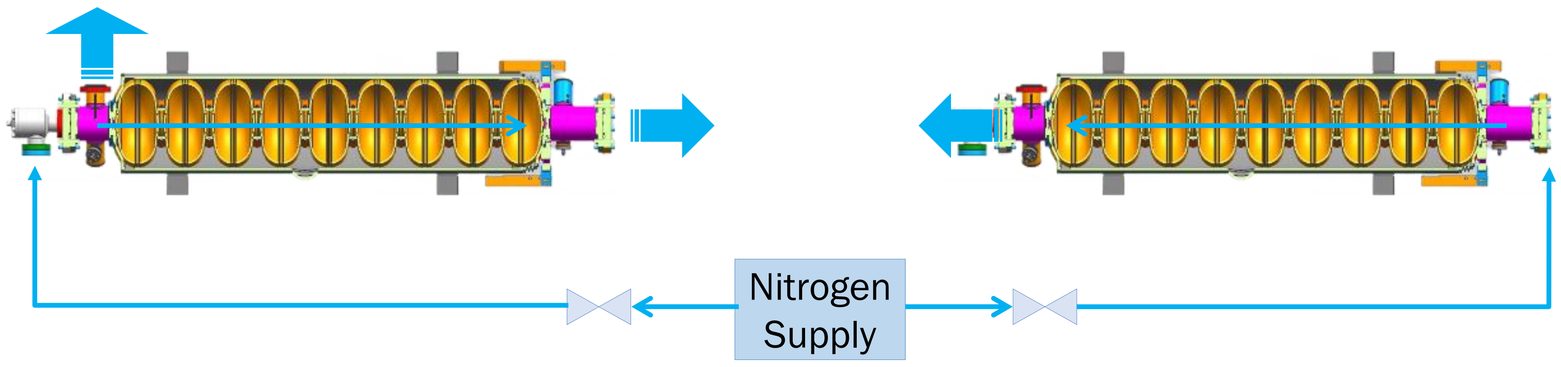
Abstract

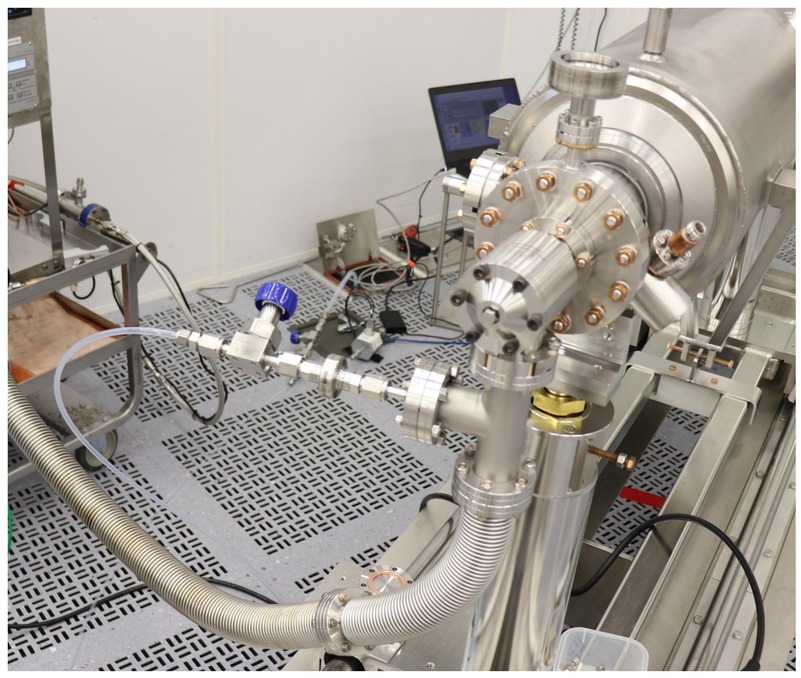
To preserve the cleanliness of the inner surface of SRF cavities and reduce field emission, a Nitrogen purge system has been developed at Jefferson Lab. The basic design comes from similar systems at Fermilab and XFEL, but was adapted for the Jefferson Lab cleanroom. Based on qualification tests, cavity performance is maintained after performing assembly with the purge system. The system has been used to assemble the first two LCLS-II HE strings at Jefferson Lab and may be adapted for other projects.

Overview

- Flow filtered Nitrogen through the cavity interior, pushes away particles generated during assembly.
- Nitrogen flow is regulated by a controller. It shuts off when the flange is sealed to prevent damage from overpressure.
- Tested new assembly procedures on four clean 9-cell cavities followed by 2K RF test
- Most of the tested cavities maintained previous performance after assembly with Nitrogen purge.
- The first two LCLSII-HE strings at Jefferson Lab have been assembled using this method

Design Overview





Qualification Tests

Before using the system for a production string assembly, the new procedures and tooling were used in a series of mock-up assemblies. The mock-up procedures were designed to mirror all steps done during string assembly. Each mock-up was repeated on two cavities. The cavities were qualified for string use and had no field emission in the previous vertical test, the goal was to preserve this clean performance.

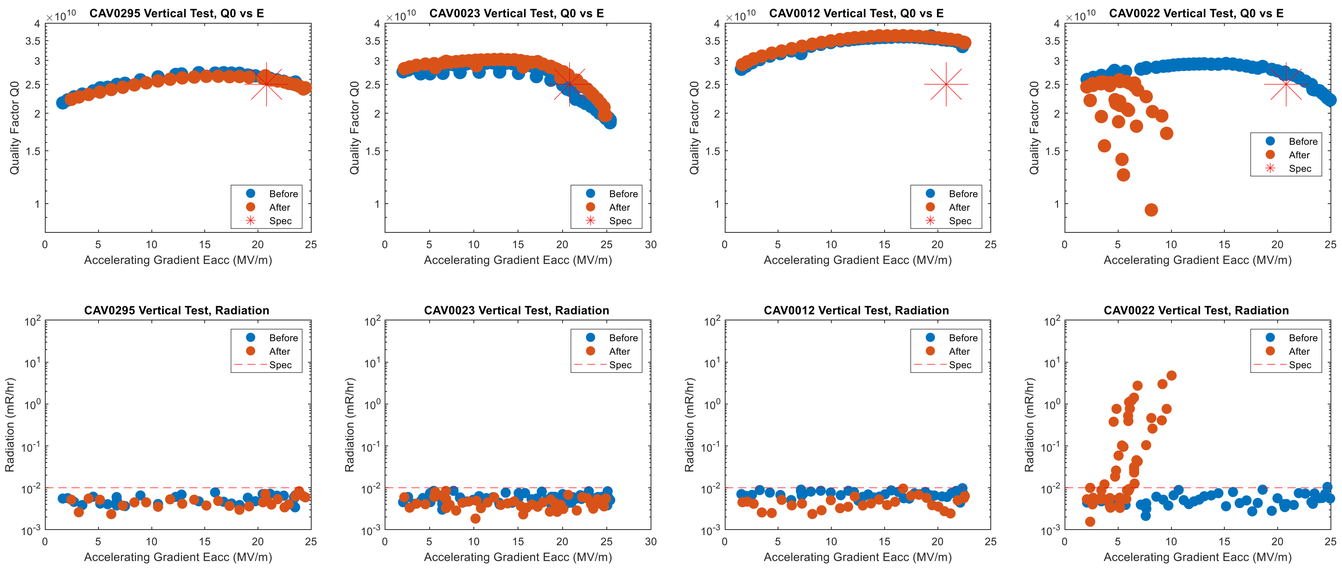
First Mock-up Procedure

1. Backfill from vacuum to atmospheric pressure using the purge's Nitrogen supply
2. Remove and reinstall temporary antenna used for Vertical Test
3. Remove and reinstall beamline flange on upstream end
4. Pump down cavity, send to vertical test

Second Mock-up Procedure

1. Repeat steps 1 and 2 from first Mock-up
2. Place valve on opposite end of CAV0022 for two-sided purge
3. Connect CAV0012 and CAV0022 with bellows
4. Disconnect cavities from each other, leaving extra hardware installed
5. Pump down cavity, send to vertical test

Note – *CAV0022 had a leak during pump down after mock-up



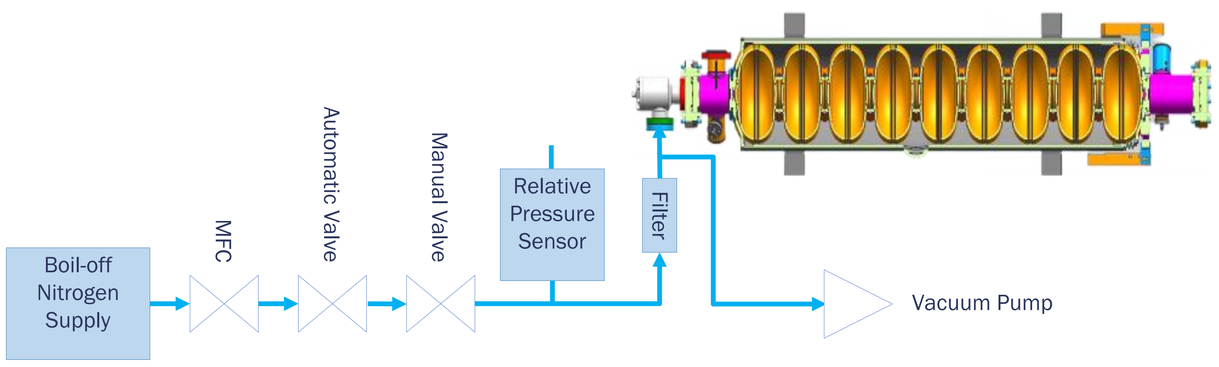
Test Criterion	Before	After
	CAV0295	
E_{max} (MV/m)	23.5	24.45
Q_0 at 20.8 MV/m	2.6e10	2.6e10
Field Emission Onset Gradient (MV/m)	N / A	N / A
	CAV0023	
E_{max} (MV/m)	25.3	24.9
Q_0 at 20.8 MV/m	2.5e10	2.7e10
Field Emission Onset Gradient (MV/m)	N / A	N / A
	CAV0012	
E_{max} (MV/m)	22.3	22.5
Q_0 at 20.8 MV/m	3.5e10	3.5e10
Field Emission Onset Gradient (MV/m)	N / A	N / A
	CAV0022*	
E_{max} (MV/m)	24.9	10
Q_0 at 20.8 MV/m	2.7e10	N / A
Field Emission Onset Gradient (MV/m)	N / A	6.8

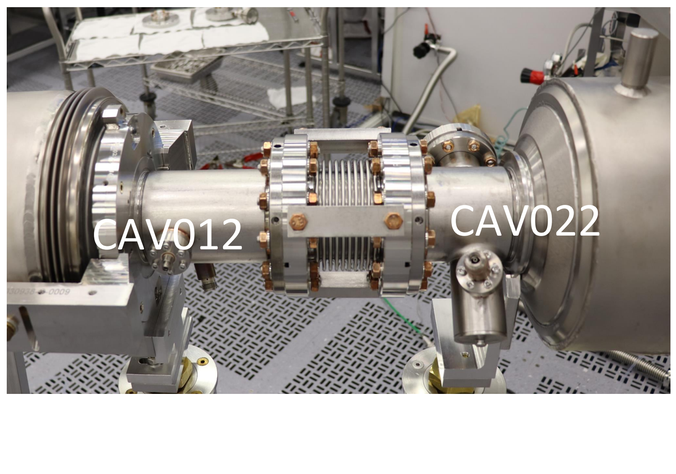
HE String Assembly Process

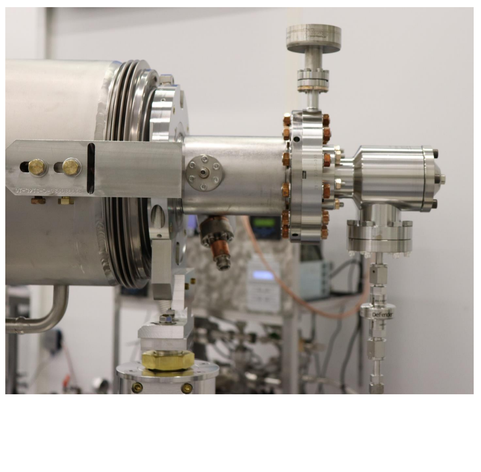
- Vertical RF test with no field emission
- Move to cleanroom, external cleaning
- Connect purge system to valve evacuate hose
- Open valve, begin backfill
- Remove test antenna, install FPC
- Remove upstream flange, install bellows
- Connect bellows to previous cavity
- Disconnect purge hose, prepare for next cavity

System Design

The purge system has three parallel supply lines to allow for a two-sided purge and parallel assemblies. Each line contains a Mass Flow Controller, pneumatic isolation valve, and a relative pressure sensor. If the pressure in the cavity is 50 mbar above the pressure of the room, the isolation valve shuts off flow. When pressure falls below the threshold, the isolation valve opens and the MFC resumes the purge rate of 1 L/min. This logic is handled by a cRio controller with a LabVIEW interface.







Acknowledgements

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