

The Brookhaven Tandem Van de Graaff Facility

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April 14, 2011

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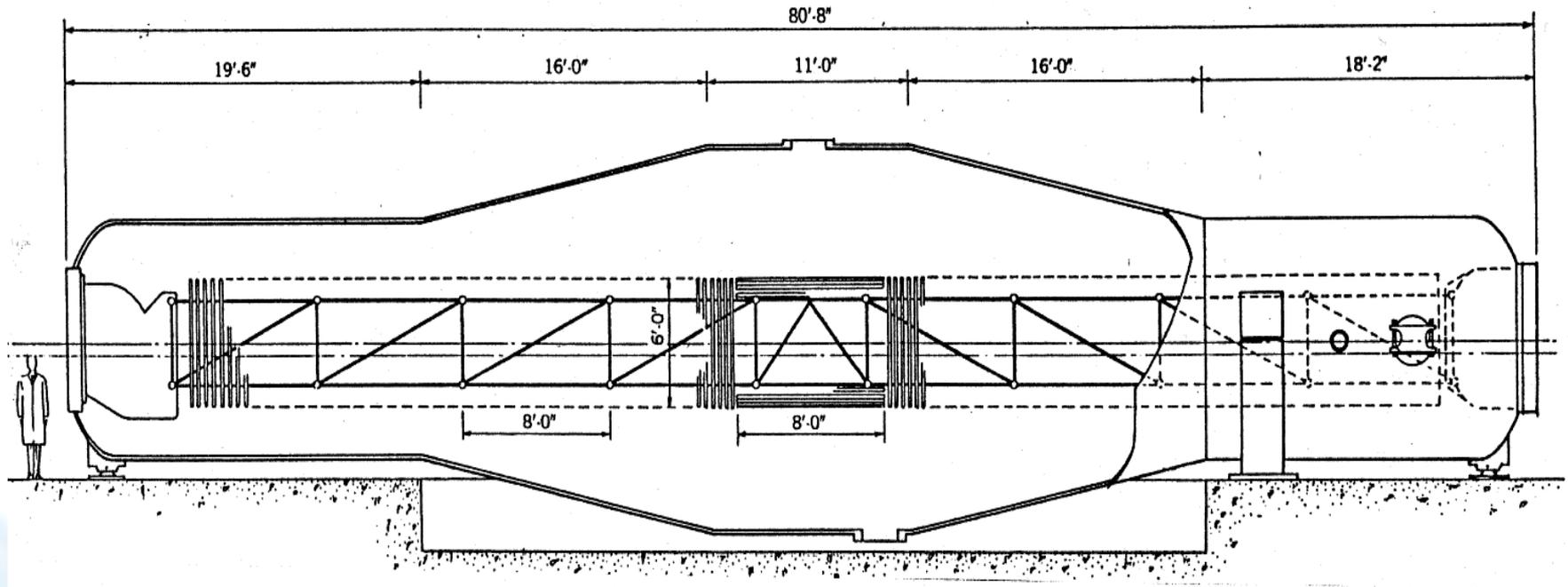
Ions for Science and Technology

- Two large electrostatic Tandem Van de Graaff accelerators are part of the Relativistic Heavy Ion Collider and NASA Space Radiation Laboratory complex, injecting beams of ions into other accelerators for studies of the fundamental components of matter and their interactions and the effects of simulated space radiation. They also provide a large variety of ion beams to a community of high tech industrial and space application users on a cost-recovery basis. Thus valuable services are provided while maintaining good operational continuity and adequate staffing levels.
- The ion species available range from protons to gold, and the energies and intensities can be accurately controlled and continuously varied over many orders of magnitude. This unusual versatility results in applications that would otherwise be impossible or inconvenient.
- Two main user applications of beams produced in the Tandems are the testing of critical space related hardware and the fabrication of ultra small-pore filter materials.

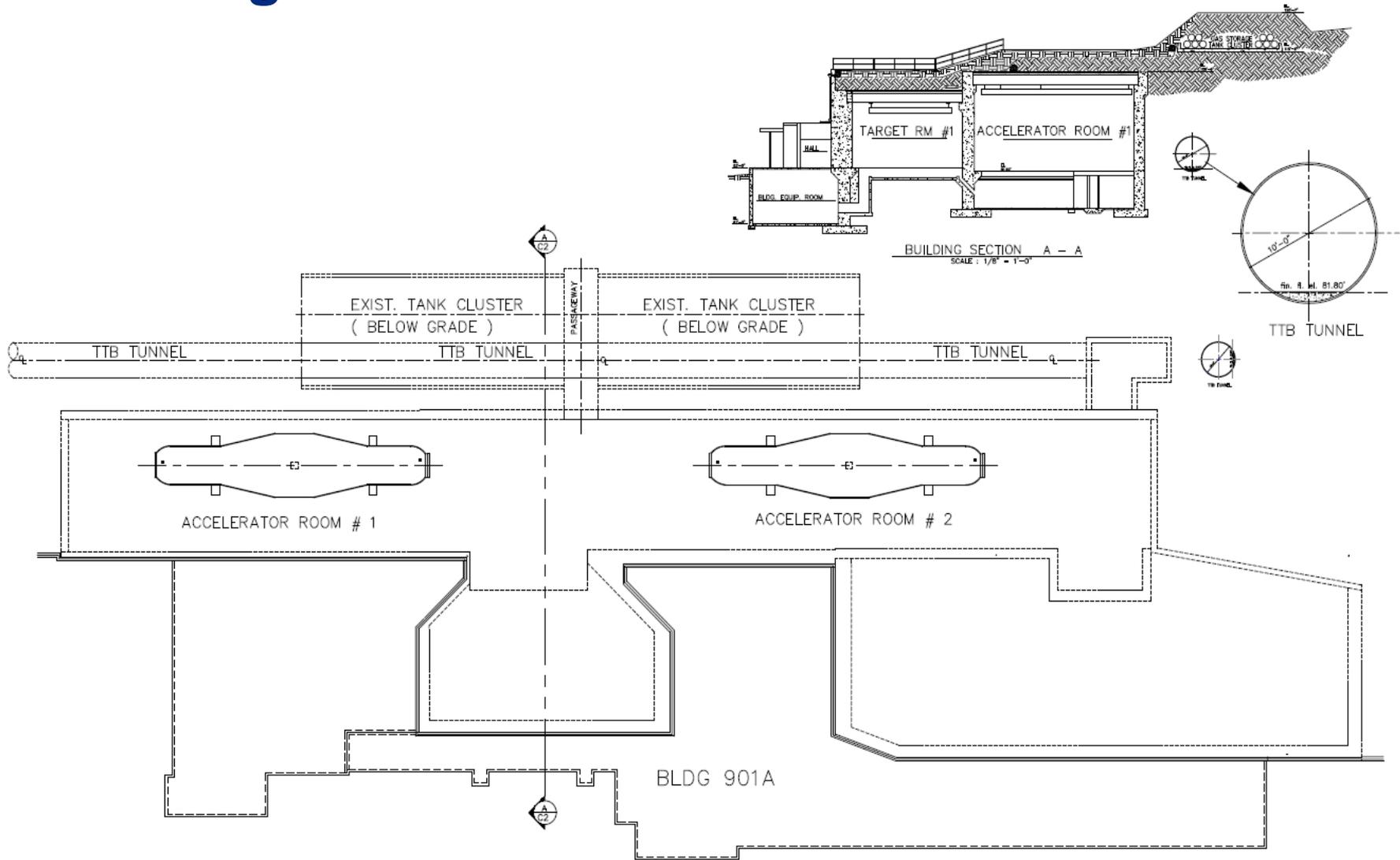
Two large electrostatic Tandem Van de Graaff accelerators



The two MP Model electrostatic accelerators, were manufactured by High Voltage Engineering Corporation (HVEC) in the 1960's. Each accelerator consists of an 80 foot long, 18 foot diameter, 11,250 cubic ft. pressure vessel which operates at about 150 psig using a gas mixture of $SF_6 \sim 46\%$ {22,170 lbs. SF_6 }, $N_2 \sim 44\%$, $CO_2 \sim 6\%$ and $O_2 \sim 4\%$. Inside the pressure vessel is a 70 foot long column structure with a Howe truss design similar to that used in steel bridges. The truss is supported at the ends only and weighs about 62,000 pounds.



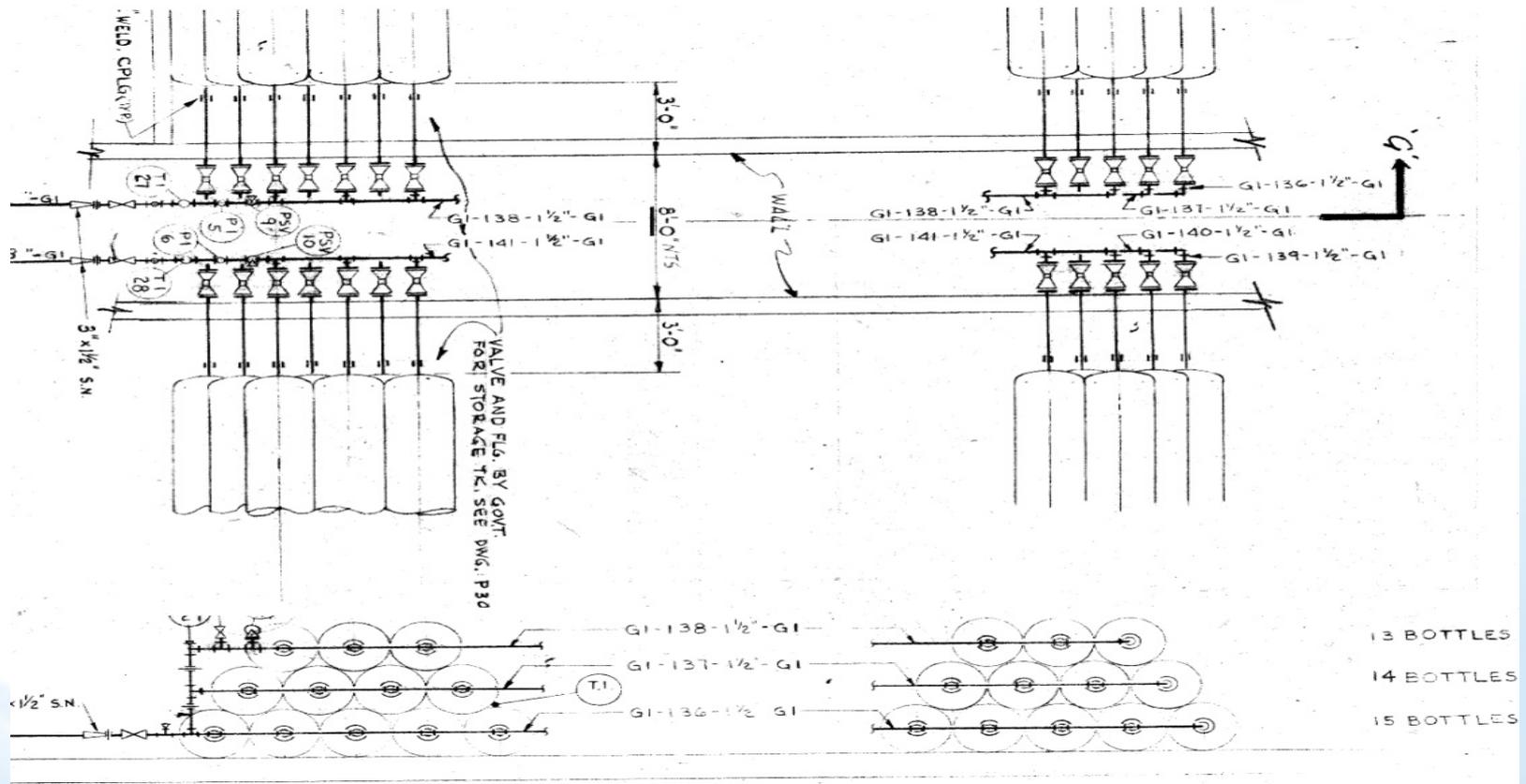
Building 901A – Plan and Elevation



Gas Storage Area

There are two banks of gas storage cylinders located below grade on the hill north of the Tandems. Each bank has 36 active, 220 cubic foot cylinders for 7,920 cu. ft. and each bank is dedicated to one of the accelerators. When an MP accelerator is fully pumped into a bank of cylinders, the storage pressure is 220-250 psig. The cylinders are 80 feet long, and were installed in 1967.

Gas Storage Cylinders and Piping



Gas Storage Area



Accelerator Maintenance

- BNL has two Tandem accelerators, MP6 and MP7. The volume of the pressure vessels for each is 11,250 ft³.
- When entering the accelerator vessels for maintenance the gas is transferred to storage.
- Each accelerator was pumped a total of 17 times during the last 5 years, or ~3.5/year.
- During a pumping cycle from pressure the vessel is evacuated to 300 microns (millitorr).
- The vessel is then vented with room air and connected the HVAC system for at least 20 minutes
- The vessel is checked for SF₆ and O₂ using our SenTech system and a RKI atmosphere monitor prior to entering

Calculating insulating gas transfer losses at the Tandem facility

- Gas mixture is SF₆~ 46%, N₂~ 44%, CO₂~ 6% and O₂~ 4%
- The specific volume of SF6 at 70 degrees F and 1 atm. = 2.62 ft³/lb.
- 1 atmosphere = 760,000 microns (millitorr)
- evacuated to 300 microns (millitorr)
- $(11,250 \text{ ft}^3) \times (300/760000) = 4.44 \text{ ft}^3$
- $4.44 \text{ ft}^3/2$ (46% mix) = 2.04 ft³
- $2.04 \text{ ft}^3/2.62 \text{ lbs/ft}^3) = 0.780 \text{ lbs SF6/pumping cycle}$
- $0.780 \text{ lbs} \times (3.5 \times 2) = 5.46$ or **5.5 lbs SF6/year fugitive loss**

Calculating insulating gas loss at the Tandem facility

- BNL has two Tandem Gas storage banks comprised of 39 cylinders each. The volume of each is 222.9 ft³.
- BNL uses 36 cylinders of each storage bank for gas storage.
- Gas losses are based on the change in storage pressure from 5/04 to 9/10.
- Total storage volume - 16050 ft³
- 5/04 total storage pressure - 514 psig
- 9/10 total storage pressure - 512 psig
- Total pressure loss for 6 yr period – 2 psig

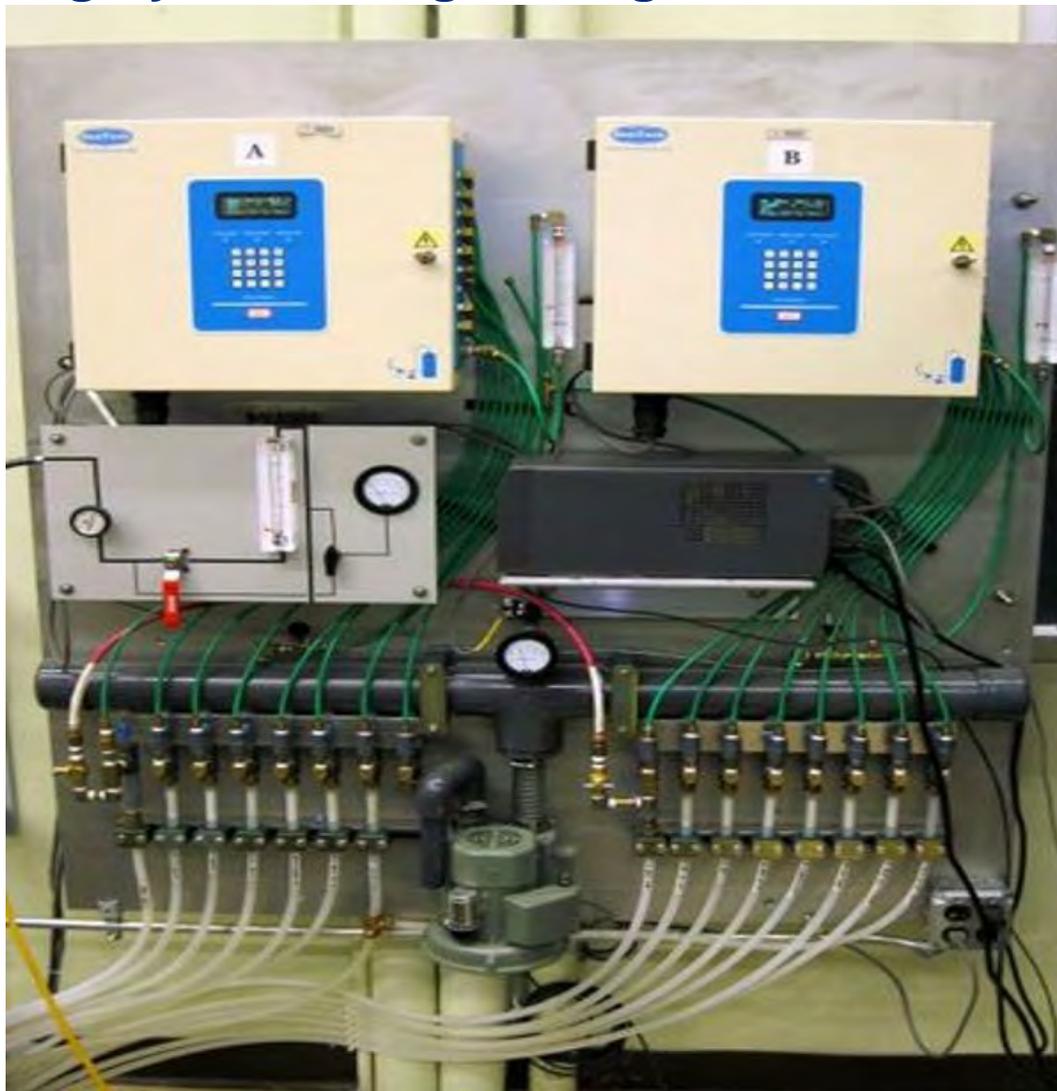
Calculating insulating gas losses at the Tandem facility

- Gas mixture is SF₆~ 46%, N₂~ 44%, CO₂~ 6% and O₂~ 4%
- The specific volume of SF₆ at 70 degrees F and 1 atm. = 2.62 ft³/lb.
- 2 psi/14.7 psi X 16050 ft³ = 2184 ft³
- 2184 ft³ X 46% = 1004 ft³ SF₆
- 1004 ft³ / 2.62 = 383 lbs SF₆ total
- 383 lbs / 6 yrs = 63.8 lbs/yr or **64 lbs/year SF₆ loss**
(includes 5.5 lbs fugitive loss)

SF6 Inventory Monitoring

To accomplish BNL's need of monitoring for SF₆ at many distant locations we utilize SenTech's multi-point refrigerant detection systems. These infrared monitors are designed for highly reliable performance with the flexibility to satisfy a wide range of continuous monitoring applications. BNL has selected the 8 zone detection system within a single field-programmable self-contained metal enclosure. The monitors utilize non-dispersive infrared. BNL has two monitors built in to our locally designed sampling system with each monitor cycling through 8 channels every 15 minutes.

Area Monitoring System using two eight channel SenTech monitors



Calibration gas is available to each system

Control Room Alarm Panel



Alarms, levels and locations are displayed

Preventive and Predictive Maintenance Program

- Requires semi-annual calibration of SenTech system.
- Requires an annual leak check of all normally pressurized joints of the SF₆ gas handling system.
- 592 locations between both machines and pumping systems.
- Relief valves are recycled every 5 years for pressure safety and become a concern as some recalibrated valves leaked up to 50 psi below valve design pressure.

Local SF₆ Sniffing used in our Preventive and Predictive Maintenance Program

TIF5750A Super Scanner TM Refrigerant Leak Detector

- LED Leak Size Indicators
- Two Sensitivity positions, including our unique Scan Mode
- Reset Button for instant re-calibration
- Detachable probe
- High efficiency pump
- Detects ALL Halogenated Refrigerants, including R-410A
- Constant Power Indication
- Carrying case and spare sensing tip included
- Detachable, flexible probe with micro-pump.
- Leak intensity indicators.
- Includes SCAN mode.



Additional precautions

- **TIF5750A Leak Detector** is used during pumping to monitor doors and relief valves during the pumping procedure.
- BNL designed and fabricated fast acting insulation gas containment ball valves have been installed at each end of the accelerator tubes to protect the external vacuum systems and contain the SF₆ within the pressure vessel for transfer to storage in case of the failure of an accelerator tube.

Summary

Through engineering, design, predictive and preventive maintenance and monitoring, BNL has minimized SF₆ emissions from the Tandem Facility