The Operation of the Tevatron Vacuum system

Authors
David Augustine
Alex Chen
Scott McCormick
Outline

• Tevatron overview and some history
• Vacuum upgrades
• Cryogenic upgrades
• Maintenance and records
• Vacuum diagnostics
• Failures
• Lessons Learned
The Tevatron contains

- 24 Cryogenic loops.
- 48 Insulating vacuum systems
- 24 Cryogenic beam vacuum systems
- 29 Major and minor warm straights
- A cornucopia of gauges, valves, mechanical pumps, ion pumps, titanium sublimation pumps, and NEG
The Tevatron is installed under the original Main Ring Accelerator
Some history

- Originally Tevatron operated in fixed target mode
- Vacuum in warm insertion points was $10^{-8}$ Torr
- Insulating vacuum was $10^{-4}$ to $10^{-8}$ Torr
- Cryogenic temperature was 4 to 4.5 K
Cryogenic and vacuum upgrades

• Cryogenic system was upgraded
  – Magnets now operate colder which allows higher current on buss without quenching

• Warm vacuum insertion points were upgraded
  – Better choice of materials
  – Improved cleaning technique
  – Vacuum baking

• Reduced beam scattering due to poor vacuum
Tevatron Superconducting Dipole

Beam Vacuum

Pop-Up

LHe, SC WIRE

He Return

CVI

Insulation Vacuum Seal

Nitrogen
Cryogenic Beam Vacuum System

- No elastomers between the beam vacuum and atmosphere
- Ion pumps various types, area dependent
- Seals are all metal
- Gauges are thermocouple, cold cathode, and ion
- Vacuum pump out valves are all metal
- Isolation valves are metal sealed on the outside but o-ring sealed on the gate
Warm Beam Vacuum

• No elastomers between beam vacuum and atmosphere
• System mostly electro-polished stainless steel or ceramic
• Non metal objects are measured for out gas rate prior to installation
• Many objects vacuum baked *in situ*
• Electrostatic separator areas have all metal gate valves
Cryogenic Insulating Vacuum system

• One turbo molecular and roughing pump every 450 feet
• Vacuum breaks every 100 feet with isolation valves
• EPDM (Ethylene Propylene) o-rings specified
• Almost everything on the insulating vacuum system is sealed with o-rings
Maintenance records

• Then
  – Originally all installations and repairs entered into paper log books
  – Information difficult to find

• Now
  – All log books are web driven databases
  – Most accessible and editable outside of the Main Control Room
  – Electronic work list for work on operational equipment
Tevatron E-Log Maintenance entry

Tevatron E-Log 2011 17:27:17 Tue May 31 2011
-- Shot setup for store 8784 --

Start of Studies Notes:

Wed Jun 1 10:52:21:

- xz_bk

Wed Jun 1 10:53:04 comment by...xz_bk -- Tables showing the change to proton horizontal tune of +0.01 at collisions

Wed Jun 1 10:54:44: We lowered the Tev injection energy from 150.11 to 150.10 in order to reduce synchrotron oscillations at injection. - xz_bk


Wed Jun 1 16:53:10: Access to A-B and Transfer Hall: In addition to above entry techs Sal Slezak and James Williams installed turbo cart JP-1 on TEL-2. Techs Bob Steinberg and Bill Dymond changed out turbo stations at B-37 and A-47 locations. B37 Rougher out #32385, Turbo out #34972, Rougher in #41622, Turbo in #34932. A47: Rougher out #099403476 Edwards18, Turbo out #39752, Rougher in #35940, Turbo in #34952. Also did small solenoid work in ED to help re-open valves after compressor fan loss. Supervisor Scott McCormick.
Electronic Work List

Work Request

* - indicates required field

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<th>Field</th>
<th>Example</th>
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<td>Submitted by</td>
<td>@fnal.gov</td>
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<tr>
<td>Task Type</td>
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<td>Duration</td>
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<td>Manpower</td>
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<td>Does this job require keys?</td>
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<tr>
<td>Work Crew</td>
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<tr>
<td>LOTO coordinator</td>
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Options:
- Alignment
- ES&E
- Instrumentation
- NuMI
- Proton
- Trivation
- Controls
- Electricians
- Cryo
- Beams
- FESS
- Mech Support
- Projects
- Telecom
- Carpenters
- Electrical Task Manager
- Ironworkers
- Operators
- Piping Task Manager
- Technicians
- Construction Task Manager
- Electricians
- Janitorial
- Scientists
- Rigging Task Manager
- Welders
- Contractors Other
- Engineers
- Machinists
- Pipefitters
- Surveyors

Yes  No

@fnal.gov / This job does not require a LOTO coordinator
Vacuum remote readouts

• Then
  – Limited remote control of vacuum hardware
  – Limited ability to data log past history of an individual device

• Now
  – Lots of computing power to data log thousands of devices
  – Vacuum read out and control pages readily accessible
An example of a Tevatron Vacuum page, house A-2 ACNET driven

<table>
<thead>
<tr>
<th>Loc</th>
<th>Pirani</th>
<th>Cold Cats</th>
<th>Valves</th>
<th>Ion Pmp/Gage</th>
<th>Misc/Pumps</th>
<th>Memo</th>
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<td>A21</td>
<td>TC1 &lt;1.E-3</td>
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<tr>
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<td>CC9U 9.54-8</td>
<td>BVD</td>
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Bubble help is disabled - it can be enabled via Pgm_Tools.
An Example: Vacuum and Cryo @E4
An Example of Diagnosis
Failures
Tevatron repair

• Normal cryoloop
  – Seven days cold to cold with around the clock shifts

• Low Beta cryoloop
  – 12 days cold to cold with around the clock shifts
Typical Repair Routine

• During Warmup
  – Crews assigned
  – Insulating vacuum spoiled to assist warmup
  – Spares selected and tested
  – Equipment stationed in tunnel

• When Warm
  – Insulating vacuum pumped out
  – Insulating vacuum leak checked first
  – Cryogenic circuits leak checked next
  – Sometimes damage obvious ie a 4000 amp ground fault
Ground Faulted magnet
View of beam tube
Equipment

• Diffusion pump based leak detectors with upgraded electronics
• Electronic signal from all leak detectors fed to one custom computer (1 to 16 channel chart recorder lab view based)
• All signals can be analyzed at one time and compared to one another
Leak Detector
Chart Recorder
Chart of test
Lessons Learned
O-rings

Problem: original EPDM o-rings cleaned with acetone, causing o-ring to melt over time

Solution: switched to EPDM colorized series o-rings for easy identification to choose correct cleaning solvents
The O-ring fix continued

It takes many hours to disconnect, replace and o-ring.

We decided to vulcanize a new o-ring around the interface saving ~4 hours per interface.
The end of a great run

• Collider run to end FY 2011
• Performance of collider chain was stellar
• The Tevatron will be warmed to room temp
• Much of the vacuum infrastructure will be used in future neutrino projects
Acknowledgements

• This presentation was made possible by the gracious assistance of:
  • Lucy Nobrega, Cryomodule Test Facility Vacuum Engineer
  • Linda Valerio, Accelerator NuMI Upgrade Installation Engineer