Procedure to Operate the COT High Voltage

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Purpose:

This procedure lists the steps needed for experts to work on the COT after the high voltage supplies have been connected and to operate the high voltage for the COT, all in a safe manner.

Editorial Hand-Processed Changes Other Than Spelling
Require Department Head Approval

HPC Number	Date	Section Number	Initials
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Approvals

(CDF Operations Department Co-Head) (Date)

1.0 Controlled Copies of this procedure

There will be four controlled copy of this procedure. They will be located at

- CDF Department Office Library.
- COT HV control console
- The CDF web page at
  http://www-cdf.fnal.gov/cdfsafe/cdfproclist.html
- and at
  ADMIN.CDF/ES&H/PROCEDURES

All other copies will be marked, "INFORMATIONAL COPY ONLY"

2.0 The Procedure

In general the high voltage is treated on a superlayer by superlayer basis, i.e. the superlayers are treated independently. The procedure is the same whether working on a single superlayer or the whole chamber. It is assumed that the COT HV system is hooked up normally, as described in Section 8.0.

1) Prerequisites for high voltage operation by experts.
    a) A person designated as trained by one of the COT project managers must be present. Those currently approved are listed in section 7.
    b) If the drift gas is flammable, CDF-II Procedure 13 must be completed.
2) Authorization of the Operations Manager is required.
3) If the chamber is accessible to personnel, post "Warning High Voltage" signs on the face of the COT. If the drift gas is also flammable, a Job Hazard Analysis will be issued by the CDF Gas Systems Engineer.
4) Perform the checklist of section 3.1 before initially operating the high voltage after an extended shutdown or after work is performed on the high voltage system.
5) Perform the checklist of section 3.2 before working on the chamber or any other parts of the high voltage system if the chamber is connected.

3.0 Checklists

3.1 Before Turning On HV (after an extended shutdown or after working on the HV system)

a) If there is flammable gas in the chamber, the COT expert should make sure that all the checks in CDF-II Procedure 13 have been completed. After at least 3 volume exchanges of flammable gas:

- Verify that the ethane and oxygen readings in the baggie inerting volume are ok. The ethane reading should be less then 12%. That is 3% below the low alarm level of 15% LEL, and the oxygen reading should be in the range 4.0 to 7.5%.
- Verify that the exhaust oxygen level is reasonable. Since the reading was required to be less than 1000 ppm before the start of flammable gas flow, it should be well below 200 ppm after 3 volume exchanges.

b) The HV blocking capacitors on the ASD motherboards and HV daughterboards cannot be exposed to personnel due to their large stored energy. If the baggies are on, this is not a problem. Otherwise, in powered superlayers, all Faraday cages must in place over the HV daughterboards, and all microcoax connectors and/or Faraday cages must be in place over the ASD motherboards.

c) The connection between the HV ribbon cable that passes through the 30° slot and the daisy-chain ribbon cable from the chamber must be properly insulated to protect personnel. Likewise, the covers must be in place over the HV ribbon cable connections at the HV filter boxes.

d) Verify that connections are good from the Crowbar Box to the chamber face and from the BiRa power supplies to Crowbar Box. This can be done with two simple measurements in the counting room:

- With the BiRa's off and the Crowbar Box switch in the off position, open the lid on the Crowbar Box, attach the safety ground to the SCR, and measure the capacitance of all 25 channels in the superlayer. The sense wire readings should all agree within 5%, and the potential wire readings should all agree within 5%. Readings vary from about 200nf for the inner superlayers to 500nf for the outer superlayers. A disconnected quadrant will decrease the reading by about 25%. After completing the measurement, remove the safety ground and secure the lid.
- Run up the superlayer to 5% of nominal while observing the BiRa current draw. If a cable is not making good contact between the BiRa and Crowbar Box, the observed current draw during ramp will be extremely small and obviously less than neighboring channels.

e) Verify that the trip daisy chain is operable by inducing a trip on the layer at a few percent of nominal. One channel should indicate a trip condition, while the other 24 should just indicate being off (following the daisy chain).

f) Double check that the Crowbar Box lid is secure and that there are no "Do Not Operate" tags on or near the PC monitor.

3.2 Before Working on Chamber or HV System

a) The high voltage supplies should be turned off and tagged with a "Do Not Operate" sign.

b) The Crowbar Box switch should be in the off position and the key should be removed and tagged out with a "Do Not Operate" sign. Verify that the red LED is on, indicating that the box is in the tripped state.

4.0 Deviations from the Procedure

1) If fewer than 10 cells in a superlayer are being powered (5 ASDQ boards), the maximum stored energy is only about 1 Joule; therefore procedure section 2-5 is not necessary.
2) If less than 500 volts is being applied to the system, the maximum stored energy for a superlayer is less than 1.5 Joules; therefore procedure section 2-5 is not necessary.
3) Authorized personnel may remove small sections of Faraday cage (covering 3 or 4 ASDQ boards) to look at the output signal with approval of the COT project leader.

5.0 Required Training and Authorized Training Personnel.

LOTO Level II training is required for all people listed as qualified for this procedure.

6.0 Training Materials.

1) This procedure.
2) CDF-II Proc-13 "Sign-Off Procedure Required before Flowing Flammable Gas to or Turning High Voltage on the CDF Detector Subsystems"
3) COT Operations Reference (available 5/01)
4) LOTO Level II - Course # FN000212/CR

7.0 List of Trained People for this procedure.

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8.0 References and Supporting Documentation.

1. CDF-II Proc-13 "Sign-Off Procedure Required before Flowing Flammable Gas TO or Turning High Voltage on the CDF Detector Subsystems"
2. COT Operations Reference (available 5/01)
3. Description of the COT HV System:

The COT HV is divided into 8 superlayers each with 25 HV supplies (channels) corresponding to the 12 sense wires and 13 potential wires.

Each BiRa supply is capable of 3.5 kV at 3.5 ma. They are computer controlled and reside in racks at the west end of the first floor electronics room. The output is via SHV connectors and RG58 cables that go to the crowbar boxes. These cables have been modified to include a resistive load that returns this current to the high voltage pod in a manner that bypasses the current monitor. This load is 20 MΩ for sense wires and 10 MΩ for potential wires and it is installed to stabilize the BiRa power supply.

The HV Crowbar boxes also reside in the racks at the west end of the first floor electronics room. Their purpose is preventing multiple discharges on a single wire due to the energy stored in other wires in the COT. There is one high voltage crowbar box for each superlayer that discharges all the wires in a given superlayer simultaneously. The rear panel has 125 SHV connectors in 25 columns of 5 connectors each. Each column of 5 connectors is bused together and corresponds to a specific sense or potential wire in the superlayer. One of the five connectors is for input from the power supply and the other four are for fanout to the four quadrants of the COT. Inside the crowbar box the 25 channels are connected together through high voltage diodes and current limiting resistors. The diodes prevent one channel from supplying or taking current from another channel. The current limiting resistors are chosen to limit the peak discharge current to about 100 amps. The RC of the discharge ranges from 200-400 μsec depending on the superlayer.

The one hundred output RG58 cables go from each of the 8 crowbar boxes to the four corners at the appropriate end of the detector. There they connect to a high voltage filter box. Each high voltage filter box services two superlayers; there are two high voltage filter boxes on each of the 8 corners of the detector. Input to the high voltage filter boxes is via insulated SHV connectors; filtering is done with 1000 Ω in both the supply and return (ground) lines followed by a 1 nF capacitor between the two. After the filter, the grounds of all the sense and potential wires in the superlayer are tied together. The value of the filter resistors was chosen to limit the maximum voltage drop across them under normal operation to less than one volt. In parallel with these resistors are high current diodes that limit the voltage in the reverse direction during fast discharge (maximum of about 1 amp) to about one volt. The high voltage filter box delivers all the voltages for the sense wires in a given superlayer to a header for the flat ribbon cable that carries the power through the 30° slot. All the voltages for the potential wire are delivered to a similar header. In addition the filter box has varistors (2500 amp maximum peak current) between adjacent sense wires and another set of varistors between adjacent potential wires to limit the maximum voltage differences to about 1000 volts. The varistors are specified to draw less than 1ma at 940 volts. The currents were measured to increase from 10 μA to 500 μA when the voltage is raised from 940 to 1040 volts.

The voltages are carried through the 30° slot on flat 14 conductor, 50 mil pitch silicon ribbon cable. This cable is suitable for mass termination. These cables are individually wrapped with 1 mil Kapton® and through the 30° region the bundle is wrapped in 2 mil Kapton®. At the chamber face they connect to daisy-chains constructed of the same ribbon cable. The daisy-chain distributes high voltage to the individual cells in a superlayer. There is one daisy-chain for the sense wires and one for the potential wires.