What we know and what we've done about water being pumped into superconducting devices in the tunnel

TD-01-054

The purpose of this report is to document what we (Technical Division) have done to try and fix these devices. It makes no attempt at explaining how this event took place. It is assumed that BD will create and issue their own report on this incident, which will explain how this event took place and what should be done to prevent it from happening again.

Technical Division is responsible for assessing the damage to the magnets, and attempting to revive them for further use in the Tevatron. The Beams Division is responsible for handling all the other devices.

What we know:

On the morning of 1-Fed-2001 a BD person took a LCW lead and connected it to a liquid helium fitting on a high-temperature lead "H" spool in house F4. The water was turned on and left on for about 40-45 minutes at around 150-175 psi. The estimated loss of LCW is about 10 gallons. The problem was discovered when someone saw water leaking out of a kautzky valve. Figure 1 below shows where the water was connected to the spool (picture complements of the BD MCR electronic logbook from 1-Feb-2001).

The scope of damage is thought to be the following devices (at least for devices that are installed in the ring - cooling system devices are not included in this list):

Long by-pass	F48-?
TC0604	F48-3
TB0701	F48-4
TB0834	F48-5
H9002D	F49-1
5' by-pass	F49-?
TSHH373	F49-1 (this is the device that the water lines were connected to)
N9917F	F49-1C
End box	???

The scope is thought to be this limited because a "finger" test showed that the devices on either side of this list did not appear to be wet (i.e. when someone stuck their finger in the devices they did not feel any water).

What we've done:

The magnets have been brought back to TD (received on XX-Feb-2001). They still had a bit of water in them, and so we first tried to get the majority of the water out by either tipping the magnet or pumping/siphoning. The dipoles and the quad were able to be tipped slightly so that we could poor the majority of the water out. The spool had to be syringed out. The water that came out of all the devices had a yellow tinge. We have saved samples for later examination to try to determine what material is making it yellow.

Upon tipping TB0701 by BD personnel, a small G10 piece fell out. This part was delivered to TD by Mike Petkus (2/8/01). It has been identified as a lead clamp P/N 97680. Figure 2 shows the part and its associated drawing (compliments of Denny Gaw).

After pouring/pulling as much water out as possible, the magnets were put under a *dry nitrogen purge* in MSB on 2/6/01 (by Material Control). The following table was provided by Gregg Kobliska:

> The numbers are relative humidity measured in either the single-phase (I/O) or two-phase (II/O) lines. After the readings on 12-Feb the purge was turned down to a trickle. After the 20-Feb readings the purge rate was increased.

	7-Feb		8-Feb		9-Feb	10-Feb	12-Feb		13-Feb	20-Feb	21-Feb	26-Feb	5-Mar
	I/O	II/O	I/O	II/O	I/O	I/O	I/O	II/O	I/O	I/O	I/O	I/O	I/O
TB0701	38	11	27	20	13	0.9	0.9	6	1.5	6.1	2.2	1.2	0.5
TB0834	54	10	48	19	15	4.8	0.3	7	1.3	6.3	0.9	0.7	0.2
TC0604	26	9	17	9	8	5.5	0	8	2.0	4.7	0.4	1.2	0.5
H9002D	47	13	33	16	7	0.9	0	-	2.5	4.8	0.5	0.9	0.4
N9917F	55	13	49	15	20	0.8	0.3	-	1.6	5.2	2.0	1.5	0.9
TSHH373	-	-	-	-	11	2.3	0	-	-	-	-	-	-

More regarding the nitrogen purge in MSB (information take from an e-mail from Gregg Kobliska to Ted Beale on 22-Feb-2001):

> Figures 3 through 9 show the dry nitrogen purge setup. This configuration is different than was originally set up. The original setup had one purge line feeding into the I/O and one purge line feeding into the II/O. After the readings taken on 8-Feb (see chart above) both lines were fed into the I/O.
>
> Figure 8 is a picture of the upstream end from which we fed the purge. There are two lines that were force fed into the single phase. One additional line (not shown in this photo) was fed into the large white plastic end cap which covers the whole end of the magnet. This would result in some purge going down the two phase or vacuum portions of the magnet.
>
> Another picture which was not shown is the downstream end of the magnet which in this case would be the exit end of the purge. A large white plastic end cap was placed over the 12-inch vacuum flange. This end cap had a hole in it for the gas to escape.

On 23-Mar-01, Denny Gaw and Jan Szal performed electrical tests on the devices under purge at MSB. Here are the results they provided:

Serial Number	D.C.R.		Ls@100 Hz		Q@100 Hz	Ls@1K Hz		Q@1 KHz	Coil/Buss to Grnd		Coil to Buss	
TB0701	4.6505	Ω	42.36	mH	2.5	22.4	mH	2.2	>20	MΩ	>20	MΩ
TB0834	4.622	Ω	42.83	mH	2.6	22.39	mH	2.2	>20	MΩ	>20	MΩ
TC0604	4.6107	Ω	42.42	mH	2.6	22.43	mH	2.2	>20	MΩ	>20	MΩ
H9002D	2.153	Ω	10.13	mH	2.5	4.798	mH	3.6	>20	MΩ	>20	MΩ
N9917F	2.359	Ω	11.18	mH	2.5	8.65	mH	3.2	>20	MΩ	>20	MΩ

On 26-Mar-2001 there was a short "meeting" out at MSB to review the methods of purging the devices. In attendance were Gregg Kobliska, John Zweibohmer, John Carson, Ray Hanft, Doug Kelley and Jamie Blowers. The concern was that there is a long, spiral instrumentation tube (downstream end) on the dipoles which could collect water, and it could not be cleaned out with the current configuration of the purge (issues raised by Tom Peterson). The quads do not have this issue because they do not have the instrumentation wires. The instrumentation wire covers were removed, and water leaked out from all three dipoles. After the covers were removed the nitrogen purge was turned up, and we covered up all the holes except for the instrumentation holes. This configuration should allow for the proper drying of the instrumentation tubes.

On 02-April-2001, Denny Gaw and Jan Szal performed another set if electrical tests on the devices under purge at MSB. The results are provided on the next page.

On 29-Aug-2002, Sergio Sanchez cut open the end of TB0701. It was discovered that the G-10 part found by BD when they tipped the magnet was indeed from TB0701. There are other parts missing as well (another G-10 part and screws), and they may be in the magnet that was connected to that end (TB0834?).

Superconducting Magnets contaminated with LCW										
Magnet Serial Number	TB0701		TB0834		TC0604		H9002D		N9917F	
D.C. Resistance / Ls & Q Factor										
Coil/Buss D.C.R	4.6505	Ω	4.622	Ω	4.6107	Ω	2.153	Ω	2.359	Ω
Coil/Buss Ls @100Hz	42.36	mH	42.36	mH	42.42	mH	10.13	mH	11.18	mH
Coil/Buss Q @100Hz	2.5		2.6		2.6		2.5		2.5	
Coil/Buss Ls @1KHz	22.4	mH	22.39	mH	22.43	mH	4.798	mH	8.65	mH
Coil/Buss Q @1KHz	2.2		2.2		2.2		3.6		3.2	
D.C.R.Right Heater	27	Ω	27	Ω	27	Ω	No heater	Ω	No heater	Ω
D.C.R.Left Heater	27	Ω	27	Ω	27	Ω	No heater	Ω	No heater	Ω
Continuity										
Continuity Coil/Buss to Grnd	<20	MΩ	<20	MΩ	<20	MΩ	<20	MΩ	<20	MΩ
Continuity Coil to Buss	<20	MΩ	<20	MΩ	<20	MΩ	<20	MΩ	0.1	Ω
Continuity Right Heater to GRND.	<20	MΩ	<20	MΩ	<20	MΩ	No heater	MΩ	No heater	MΩ
Continuity Left Heater to GRND.	<20	MΩ	<20	MΩ	<20	MΩ	No heater	MΩ	No heater	MΩ
Continuity Right Heater to Coil/Buss	<20	MΩ	<20	MΩ	<20	MΩ	No heater	MΩ	No heater	MΩ
Continutiy Left Heater to Coil/Buss	<20	MΩ	<20	MΩ	<20	MΩ	No heater	MΩ	No heater	MΩ
Hipot										
Hipot @ 1KVDC <5uA current Leakage Coil/Buss to Grnd	<.05	uA	<.05	uA	<.05	uA	<.05	uA	<.05	uA
Hipot @ 1KVDC <5uA current Leakage Coil to Buss	<.05	uA	<.05	uA	<.05	uA	<.05	uA	Common	uA
Hipot @ 600 VDC <5uA current Leakage Right Heater to GRND.	<.05	uA	<.05	uA	<.05	uA	No heater	uA	<.05	uA
Hipot @ 600 VDC <5uA current Leakage Left Heater to GRND.	<.05	uA	<.05	uA	<.05	uA	No heater	uA	No heater	uA
Hipot @ 600 VDC <5uA current Leakage Right Heater to Coil/Buss	<.05	uA	<.05	uA	<.05	uA	No heater	uA	No heater	uA
Hipot @ 600 VDC <5uA current Leakage Left Heater to Coil/Buss	<.05	uA	<.05	uA	5uA@400VDC	uA	No heater	uA	No heater	uA
Date	4/2/01		4/2/01		4/2/01		4/2/01		4/2/01	
Tech.	D.Gaw/J.Szal		D.Gaw/J.Szal		D.Gaw/J.Szal		D.Gaw/J.Szal		D.Gaw/J.Szal	

Regarding the work on TSHH373 (information extracted from an e-mail from Sandor Feher to Ray Hanft on 21-Feb-2001):

1. Sergio Sanchez pulled out the water from the single phase through the relief valve port. He also used the borescope to inspect the bottom of the spool. (Results have not been reported).
2. The spool was hooked up to dry nitrogen purge in the magnet storage building for a few days (dates of XX-XX). We didn't purge the HTS leads since the He gas outlet was plugged in.
3. The spool was sent to IB2 last week Monday (2/12).
4. Denny Gaw performed an electrical checkout on TSHH373. Results are recorded on an "incoming inspection traveler", and is attached as Appendix I to this document. He had no experience to check the HTS leads itself, …but the worry about the 18 ohm temp. sensor.
5. Dean Kraus performed an electrical test of the HTS leads. His check out form is in the ASC logbook which is located in the MTF control room. Everything was OK with the lead.
6. Middle of last week (date XX) we started to purge the leads with dry nitrogen with the He gas outlet opened.

On 08-Mar-2001, Jan Szal began a multi-day test on TSHH373. The results of the testing are recorded in a document entitled "Recovery Testing for TSHH373", and is attached as Appendix II to this document.

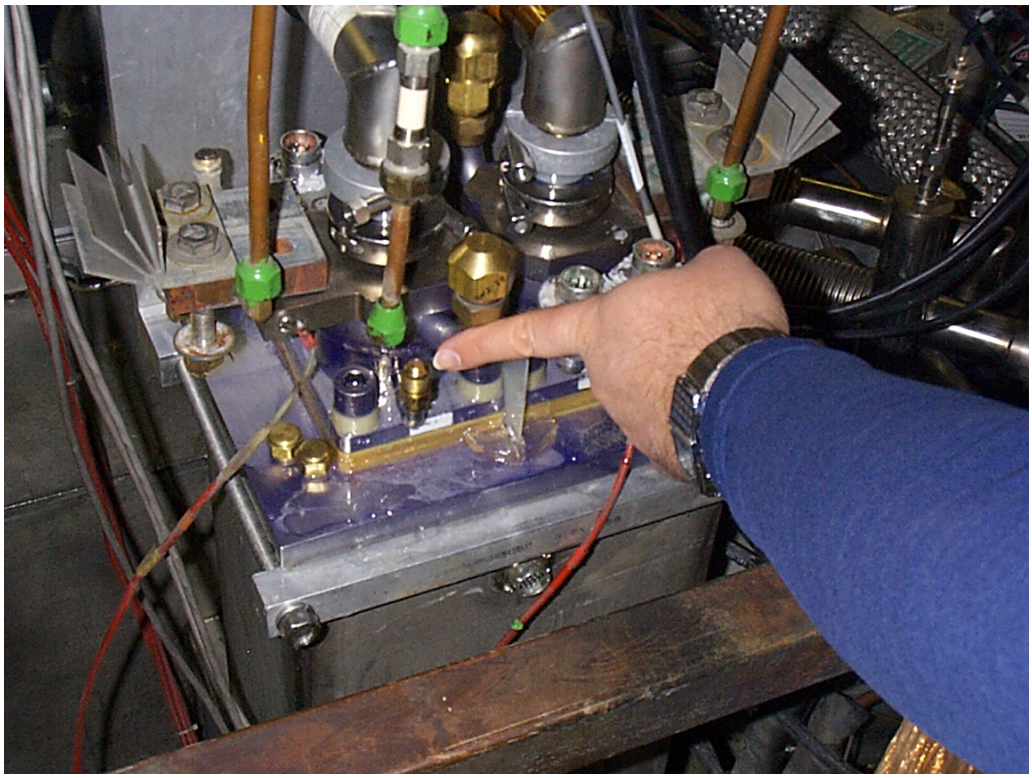

Figure 1

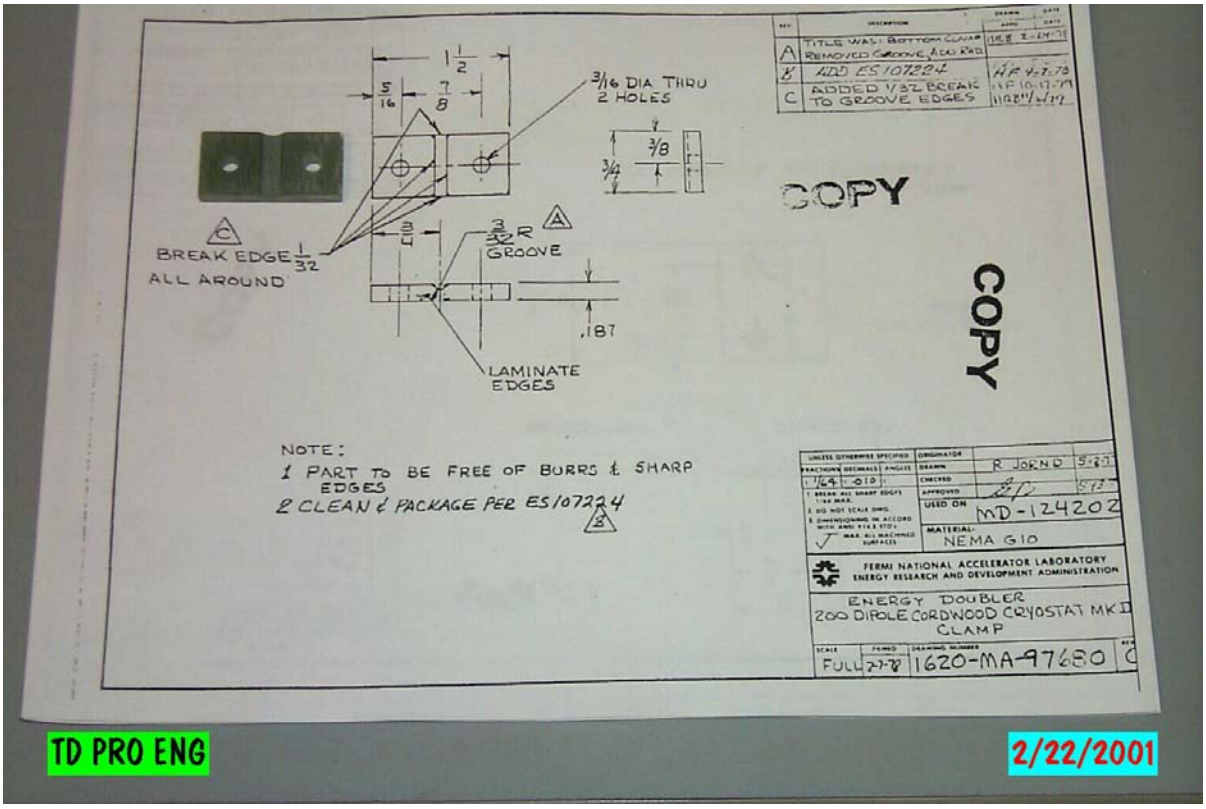

Figure 2

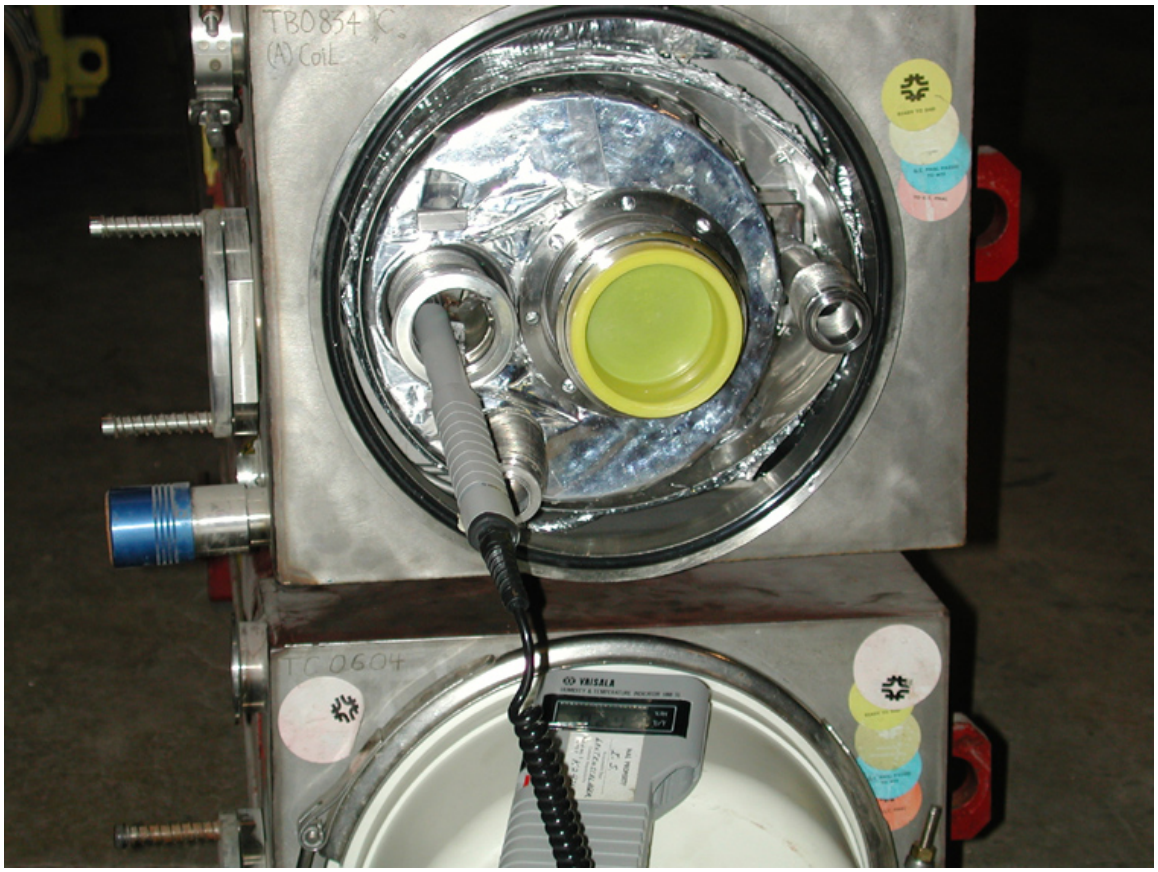

Figure 3


Figure 4

Figure 5

Figure 6

Figure 7

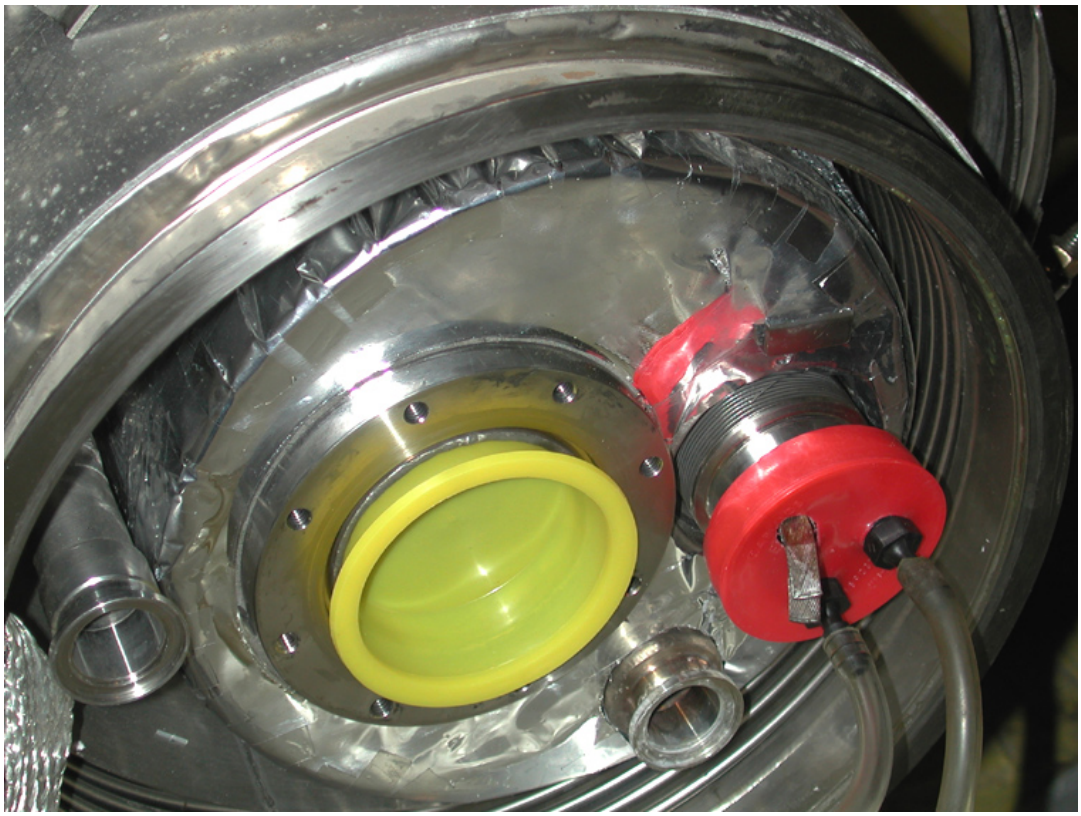

Figure 8


VAISALA
HUMIDITY & TEMPERATURE INDICATOR HMI 31
08.6
%RH
NAL PROPERTY
ON
OFF
PENN ALUMIN
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Figure 9