



FERMILAB
Technical Division
Magnet Systems

Incident Report

IQB310 Failed Tie Plate Welds

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1. Incident Summary

The Main Injector quadrupole magnets, IQB169 and IQB310, were "burned" January 17-19 in the debonding oven outside IB2, with a temperature of 850 F held for 48 hours. Although the pyrolyzation of the insulating epoxy in the magnet is not meant to produce flames, flames were observed briefly at one point in the cycle. While in the oven, it could not be determined which magnet was the source of the flames.

After the magnets had cooled, they were rolled out of the oven on January 22 and transported back into IB2 utilizing a forklift. As two TD technicians prepared to move the magnets within IB2 using the custom magnet lifting fixture, one technician observed that multiple welds on IQB310 had broken. These welds attach tie plates to the top and bottom half core, holding the magnet together. The lifting fixture engages the top half core, so, during a lift, the bottom half core is suspended by the tie plates. Recognizing the broken welds, further movement of both magnets were conducted with slings rather than the lifting fixture.

2. Incident Investigation

The Technical Division, Division Safety Officer (DSO) investigated the situation and determined that the defects in the welds were so apparent and quickly identified by the technicians that there had not been a safety concern or a near miss.

The Working Foreman, Daniel Watkins, of the Fermilab Weld Shops inspected the welds and said that all the failed welds on the tie plates of IQB310 were defective cold welds (lack of fusion). He also pointed out that there were clear marks left when the original tie plates were ground off during a previous rebuild. The Weld Shop Supervisor, James O'Neill, verified Daniel Watkins findings.

There was also a seepage of an unknown white residue evident near openings, seams and tie plates of IQB310, which is an indication that there was possible contamination of the base metal and welding process.

Review of historical documentation (see appendix) indicates that only one (IQB310) out of a total of four (4) burned main injector quadrupole magnets has produced flames in the oven. The additional stress from heat may have caused expansion of unknown gasses or prompting the welds to fail.

3. Conclusions

Based on these observations, we conclude that no actions beyond the normal, prudent safety and QA precautions are necessary. The importance of correct welding technique and inspection of load-bearing welds is already well understood. In this style of quadrupole, the whole magnet is vacuum impregnated, forming a strong bond between top and bottom core even if the tie plates are compromised. IQB310 had been in circulation for a long time and only failed after the stresses of burning.



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4. Recommendations

Some good practices to include in the future:

- 1) Check everything on which a lift depends, whether the device is welded or bolted together. Until the magnet and welds can be properly inspected, all lifts shall be fully supported from the bottom surfaces with straps. Once all welds or bolting have been inspected, the designated lifting fixtures utilizing lugs and or other features may be used.
- 2) When burning magnets, the ovens should be properly equipped with instrumentation to trip off in the event of an abnormal behavior such as a pressure spike due to flames or other.
- 3) Verify no traces of coolant or liquids left in circuits. Possibly include a ramp up cycle to remove any remaining moisture prior to reaching final "burn" temperature.

5. Appendix

Figure 1, Device Service Record Form

TD/Engineering & Fabrication

Specification # 5520-FM-333428
January 9, 2001
Rev. A

Device Service Record Form for IQB 310

Date	Comments <small>(Include the following in each MSR entry: What, Where, Why)</small>	Info Provided By
7/11/05	The AD FMP database reports this device to be "INSTALLED" at 631 Main Injector	Alvie Bender
1/20/08	The MCR e-log reports that the quad at location Q631 in the Main Injector has a "known water leak that has gotten worse", and that it seems to have developed a ground fault as a result. AD folks rerouted the water and at this point expect to leave the magnet installed. http://www-bd.fnal.gov/cgi-mcr/elog.pl?nb=2008&action=view&page=53&scroll=false	Jamie Blowers
1/30/08	AD decided to replace this magnet. Bob Mau confirmed (verbally) that it was indeed replaced, and the dayshift MCR e-log says the magnet was being lifted out of the tunnel. IQB344 is the serial number of its replacement. The status of IQB310 is changed from "installed" to "needs eval: recently deinstalled " and the location from "tunnel" to "unknown".	Jamie Blowers
2/14/2008	Received IQB310 into IB2, issued incoming inspection traveler 318898.	Dennis Gaw
02/15/2008	Issued DR 4488 <u>in regards to</u> the coil to core short greater than 5mA at 170Vdc. The disposition is: This is an "old style" IQB (i.e. potted magnet), which makes a ground short very difficult to diagnose and repair. In addition, we have a "new" design for FMI quads which uses potted coils, and so if we need to replace this magnet we would likely do so with a <u>new style</u> . As such, we will not attempt to diagnose the problem with IQB310 at this time. Reflect this decision in the DSR and have the magnet sent to storage.	Dennis Gaw
9/25/09	Magnet moved from IB2 to TPL per Impeng Samayavong	JB/LZ/RE
11/20/17	Magnet Move From TPL To IB2	Darrell Frye
11/20/17	Received at IB2 prepping to burn	Nick Unold
1/22/2018	Magnet burned and ready for disassembly in IB2	Rich Motill
2/5/2018	Magnet was rebuilt in 1997 from quad 7310	Jan Szal

Figure 2, cracked welds after burning operation



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Figure 3, white residue found seeping from opening after burning

