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LQXB11 Test Report

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Quench Training

During testing, the Q2A and Q2B were trained with the pair connected in series. In the first test cycle, MQXB15 quenched at 11934 A (215 T/m[1]), then at 12551 A (226 T/m). MQXB20 quenched at 12314 (222 T/m), 12588 (227 T/m), and at 12749 (230 T/m). (Note that the series connection implies that the magnet in which the quench did not originate experienced a quench induced by the heaters.) Following the last quench at (229.5 T/m), the pair was ramped to 12800 A (230 T/m).

Quench training results are compared to previous magnets in Fig. 1. Table 1 is a list of quenches executed as part of quench training. There was one inadvertent high current (11158 A) quench when the Wcoil-Idot quench detection tripped due to noise in the system. This was after the first training quench at 11934 A, and, thus, didn't effect training.

Summary: The requirements for acceptance are satisfied.

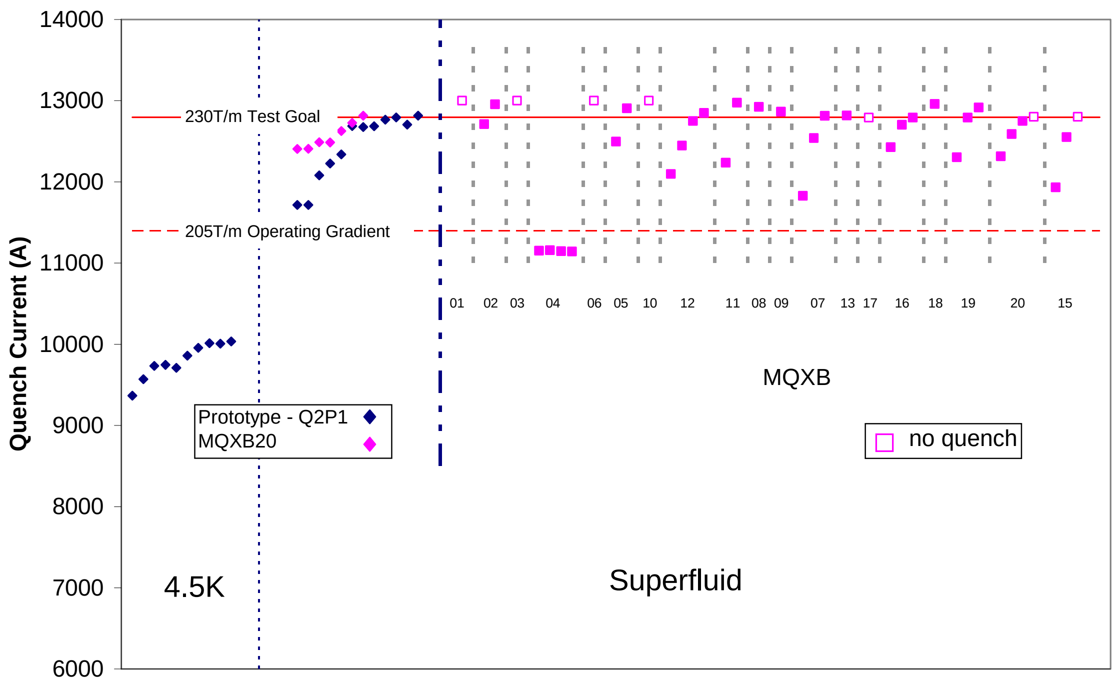

Figure 1: LQXB11 quench training. The horizontal dashed and solid lines correspond to 205 and 230 T/m field gradient respectively.

[1]Gradiant quoted is body gradiant based on HGQ09 body transfer function measurements.

Table 1: List of quenches

date	time	test cycle	current (A)	ramp rate (A/s)	location	gradient (T/m)[2]
LQXB11						
1/3/2007	2105	1	11934	20	MQXB15, Q2, BO1	215
1/9/2007	1848	1	12314	20	MQXB20, Q1, LE1,2	222
1/10/2007	1358	1	12551	20	MQXB15, Q2, RE2	226
1/10/2007	2001	1	12588	20	MQXB20, Q3, RE1,2	227
1/11/2007	1304	1	12749	20	MQXB20, Q4, BO3	230

Both MQXB20 and MQXB15 had undergone quench training prior to the testing of LQXB11. MQXB15 was part of LQXB07. MQXB20 contains the coils of the prototype magnet (MQXP01). It was tested in a signal cryostat prior to incorporation in LQXB11. A summary of quench training results for the two magnets is given in Figures 2 and 3.

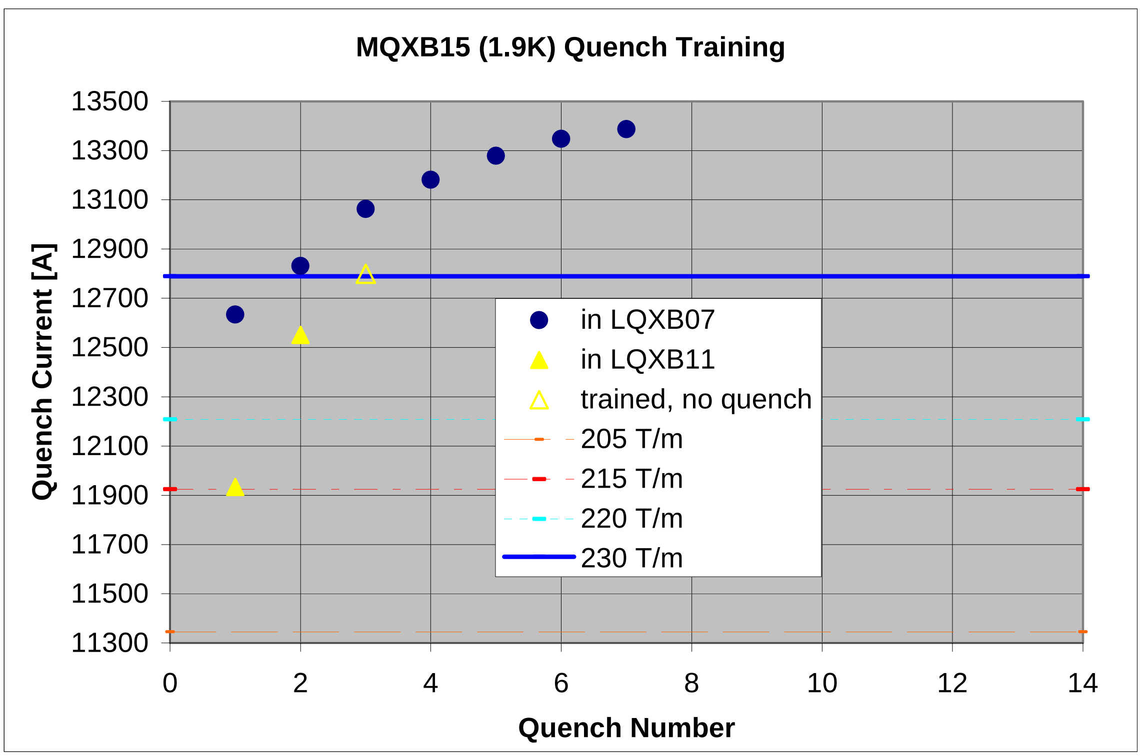

Figure 2: MQXB15 quench training.

[2] This is the equivalent body gradient based on HGQ09 measurements. The linear fit parameters to the high current transfer function are slope 0.0174 and intercept 7.34.

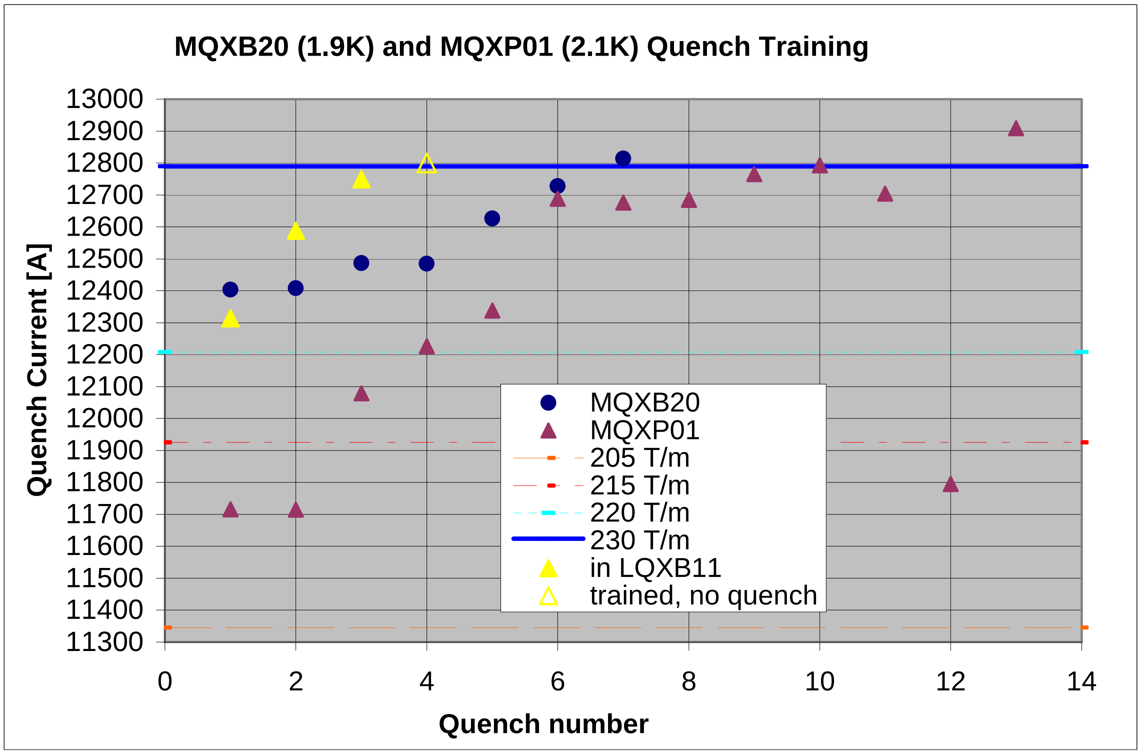

Figure 3: MQXB20 quench training.

Magnetic Field Quality Measurements

Field quality measurements were made with rotating coils. Integral field measurements were made with a multi-sectioned probe of 3 sections matched to the pitch length of the inner coil with one pitch length between sections. Complete longitudinal scans were made with a probe of length 0.82 m. The program consisted of the following measurement types.

- A “DC loop” in which the magnet was ramped in a series of steps with the field characterized at DC field at each level on the up and down ramp which we use to establish both the upramp and the geometric component of the harmonic. This is done with the integral probe. No such measurement was made as they are redundant with the longitudinal scans with the short probe.
- A prototypical accelerator cycle in which the field was measured during a conditioning pre-cycle to full field followed by a ramp down, a stop at an extended injection porch with a ramp to full field afterwards. This serves to characterize the field at injection including decay and snapback effects. These are typical done with the integral probe; however in these 2 magnets we did cycles with the short probe in the magnet body and in the magnet ends.
- Continuous measurements during a series of ramps to full field and back at different ramp rates to check for eddy current effects. These are done with the

integral probe. (Note that the aforementioned accelerator cycle is a 10 A/s loop; 40 and 80 A/s loops were also done.)

- A DC loop with a longitudinal scan at each stopping point. This allows body-end field separation. These scans may be integrated to provide a characterization of the entire magnet.
- A cleansing quench preceded the accelerator cycle measurement with the integral probe.

A list of the measurements made is given in Appendix A. Data is posted at the following URL.

http://wwwtsmtf.fnal.gov/~dimarco/usrAnalysisLQX/web_summaries/LQXB11/magneticMeasurements/LQXB11_mag_meas.html

Tables 2-4 summarize the field quality measurements with respect to the harmonics acceptance criteria[3] for the magnet.

Table 2: Integral Field Harmonics for LQXB11

	LQXB11		
	669 A (12.3 T/m)	11345 A (205 T/m)	Unit
TF	0.20219	0.19831	T/A
ML	10.963	10.971	m
FD	0	0	mrad
b3	-0.34	-0.25	units
b4	0.03	0.00	units
b5	0.05	0.05	units
b6	-1.88	-0.22	units
b7	0.05	0.01	units
b8	-0.02	-0.01	units
b9	-0.01	-0.01	units
b10	0.06	0.02	units
a3	0.60	0.68	units
a4	-0.34	-0.22	units
a5	0.09	0.13	units
a6	0.00	-0.05	units
a7	-0.04	-0.03	units
a8	-0.03	-0.01	units
a9	-0.01	0.00	units
a10	0.02	0.02	units

[3] Acceptance criteria for harmonics are from v7 of the acceptance document. Acceptance bands are from v3.2 of the reference harmonics table. The method for calculation of integral harmonics is given in Appendix D.

Table 3: Integral Field Harmonics for MQXB20

	MQX20		
	669 A (12.3 T/m)	11345 A (205 T/m)	Unit
TF	n.a.	n.a.	T/A
ML	5.480	5.486	m
FD	0	0	mrad
b03	0.35	0.45	units
b04	0.05	-0.06	units
b05	-0.01	-0.02	units
b06	-2.52	-0.86	units
b07	0.03	-0.01	units
b08	-0.01	0.00	units
b09	0.00	-0.01	units
b10	0.06	0.03	units
a03	0.00	-0.06	units
a04	1.12	1.04	units
a05	-0.02	-0.07	units
a06	-0.04	0.04	units
a07	0.08	0.04	units
a08	0.04	0.06	units
a09	0.01	0.01	units
a10	-0.02	-0.02	units

Table 4: Integral Field Harmonics for MQXB15

	MQXB15		
	669 A (12.3 T/m)	11345 A (205 T/m)	Unit
TF	n.a.	n.a.	T/A
ML	5.483	5.486	m
FD	0	0	mrad
b03	-1.03	-0.94	units
b04	0.01	0.05	units
b05	0.11	0.11	units
b06	-1.25	0.43	units
b07	0.07	0.03	units
b08	-0.03	-0.01	units
b09	-0.02	-0.01	units
b10	0.06	0.02	units
a03	1.21	1.29	units
a04	0.44	0.60	units
a05	0.16	0.20	units
a06	-0.04	-0.06	units
a07	-0.01	-0.01	units
a08	-0.02	0.03	units
a09	-0.01	0.00	units
a10	0.02	0.01	units

MQXB20 has a more negative b_6 than we'd like. Note that we tuned this after the first several full size magnets we built. MQXB20 is the prototype.

Summary: Field quality is still decent in the combined magnet. Most harmonics are within one sigma of the target.

Magnetic Field Strength Measurements

SSW measured integral field strength with magnets powered in series is given in Table 7. The first 4 entries are taken on the up ramp and the last on the down ramp.

Summary: The strength at 11345 A is within the acceptance band of 2254.8±5.7 [2249.1:2260.5].

Table 5: Field strength vs. current.

	integral gradient transfer function (T/kA)	integral field strength(T)	strength TF @ Rref (T.m/A)	B_2 (T.m)
Current (A)	Q2a+Q2b	Q2a+Q2b	Q2a+Q2b	Q2a+Q2b
668.5	202.19	135.2	0.00343723	2.298
5460	200.93	1097.1	0.00341581	18.650
11345.4	198.31	2249.9	0.00337127	38.248
11923.3	197.92	2359.9	0.00336464	40.118
5460	200.89	1096.9	0.00341513	18.647

Alignment

LQXB11 had alignment measurements at each stage of testing at MTF

Relative alignment of the magnet assemblies compared to AP requirements is given in Table 7. The relative alignment is similar to the last couple of magnets.

Table 7: Relative alignment of magnet assemblies (cold).

relative alignment of MQX magnets in composite Q2			relative alignment	
			x	y
Q2a/Q2b transverse alignment	500	μm	-138	-1453
Q2a/Q2b relative roll	1	mrad (rms)	0.00	
Q2a/Q2b relative pitch	0.1	mrad	0.27	
Q2a/Q2b relative yaw	0.1	mrad	-0.50	
relative alignment of MCBX to Q2				
corrector displace-ment	500	μm	n.a.	
corrector roll	5	mrad		
B1 (hor.)			-3.04	
A1 (vertical)			-0.60	

Other tests performed

Other items of interest

Appendix A: Q2A/Q2B->MQXB20/MQXB15

Inside LQXB11, Q2A, closest to the MTF return can, the CDF side of the building, is MQXB20 Q2B, closest to the MTF feed can, away from CDF, is MQXB15

Appendix B: Calculation of Integral Field Harmonics

Integral field harmonics are computed from the data taken during the longitudinal scan of the magnets as described in earlier reports.

Appendix C: Calculation of Magnetic Length

Magnetic lengths were calculated from rotating coil data as described in earlier reports.