Conductor and Cable
Summary and Comparison of MQXFB09 Witness Sample Results

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Cable and Coil Overview

Coil	Cable [1]	Cabling Report	HT	Witness Report	Cable NCRs	Strand Contract [2]	Billets		
CR152	H16OC0456A	3093914	851	3230327	-	F663/Am4 (29) F663/Am5 (11)	AO08S00469 (10) AO08S00471 (8)	AO08S00473 (11) AO08S00611 (11)	
CR153	H16OC0457A	3123166	863	3230332	-	F663/Am4 (31) F663/Am5 (9)	AO08S00462 (7) AO08S00467 (8)	AO08S00475 (8) AO08S00481 (8)	AO08S00616 (9)
CR154	H16OC0458A	3088562	866	3230333	-	F663/Am4 (25) FNAL-646116 (9) FNAL-646116/SA1 (6)	AO08S00354 (2) AO08S00355 (1) AO08S00358 (2) AO08S00371 (2)	AO08S00375 (2) AO08S00438 (9) AO08S00448 (2) AO08S00449 (3)	AO08S00451 (1) AO08S00464 (8) AO08S00472 (8)
CR155	H16OC0469A	3161492	870	3230334	-	FNAL-624035 (2) FNAL-632982 (19) FNAL-646116 (8) FNAL-646116/SA1 (3) LBNL-7428700 (8)	AO08S00076 (1) AO08S00110 (1) AO08S00147 (1) AO08S00156 (1) AO08S00157 (1) AO08S00159 (1) AO08S00162 (1) AO08S00181 (3) AO08S00182 (1) AO08S00184 (1) AO08S00189 (3)	AO08S00191 (1) AO08S00204 (1) AO08S00205 (1) AO08S00206 (1) AO08S00207 (1) AO08S00209 (1) AO08S00363 (1) AO08S00366 (2) AO08S00370 (1) AO08S00373 (1) AO08S00374 (1)	AO08S00376 (1) AO08S00377 (1) AO08S00380 (1) AO08S00382 (2) AO08S00383 (1) AO08S00409 (1) AO08S00411 (2) AO08S00415 (1) AO08S00417 (2) AO08S00503 (1)

[1] MQXF cable specification, EDMS 1863790 [2] MQXF wire specification, LHC-MQXF-CI-0001, EDMS 1419924

Nonconformities

- NCRs affecting the cable are summarised below
  - None at the level of uninsulated or insulated cables
  - Witness samples (coil heat treatments)
    - No indication of a significant performance impact from minor coil HT NCRs for CR154 and CR155

Coil	HT	Cable NCRs	NCRs Implicating Cable	Coil HT NCRs
CR152	851	-	-	-
CR153	863	-	-	-
CR154	866	-	-	2884016, 3202409
CR155	870	-	-	2884016

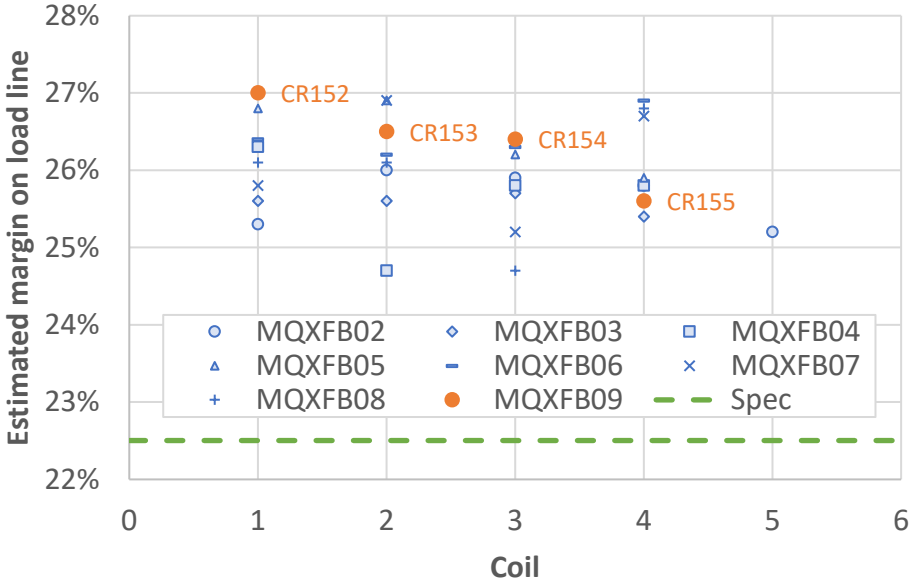
Testing Anomalies

- For CR153–CR155, the **maximum** cabling degradation evaluated from witness samples is reported as exceeding 5 %:
  - The **mean** from witness samples, and results from cable **qualification**, are in specification
  - After excluding strands with anomalous results, at the 12 T specification field, the degradation from witness samples is ~3 %, in specification, for all three coils
  - For CR153: For extracted strand 21 (WE21), I_c transitions were successfully measured only over a limited field range, with slightly elevated degradation
  - For CR154: High degradation was found for extracted strand 18 (WE18) – see below
  - For CR155: High degradation was found for extracted strands 7 and 10 (WE7 and WE10) – see below
- For CR154 and CR155, extracted strands with high degradation were excluded from further analysis
  - This degradation is **not** indicative of a heat treatment issue – adjacent virgin samples, and extracted samples of other strands, showed the expected performance at both coil extremities
  - The cause is believed to be handling damage of extracted strand samples; visible external defects were not observed, and retests were unsuccessful
  - Testing procedures are under detailed review to reduce the frequency of test piece damage
  - Little/no impact on the conclusions of the witness report, including the margin evaluated from the *average* short sample limit, which is scaled primarily from virgin witness and qualification samples

Sampling and Statistics

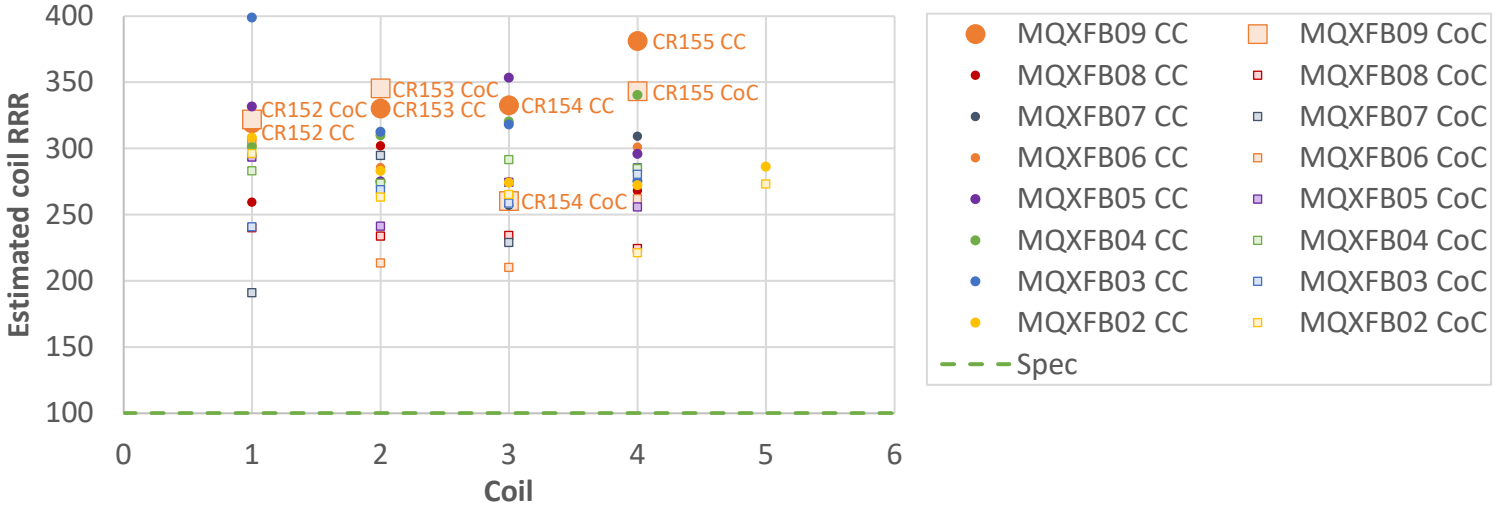
- CR154 and CR155 were produced (partly) using wire stock from CERN-US exchange, for which only 1–3 multiples of the cable unit length were received by billet
- Consequently, the cables include material from more billets than usual: 11 for CR154, 32 for CR155
- As usual, only 3 billets could be **sampled** for witness tests; and in addition:
  - For I_c – the (coincidental) higher rate of extracted strand test failures further reduced the witness I_c data available
  - For RRR – for CR155, the lack of extracted and qualification strands at the CC extremity from the same billet necessitated a different methodology for estimating coil RRR at CC
- For the primary purpose of the witness tests – validating the coil heat treatment – this has little impact; but for estimating coil performance, and especially RRR, this reduces the extent to which the witness data can be expected to be statistically representative of the overall performance

Load Line Margin



- Large margin on load line, mean 26.4 %
  - Consistent in mean and spread with recent coils
  - But note limited statistics for CR154 and CR155

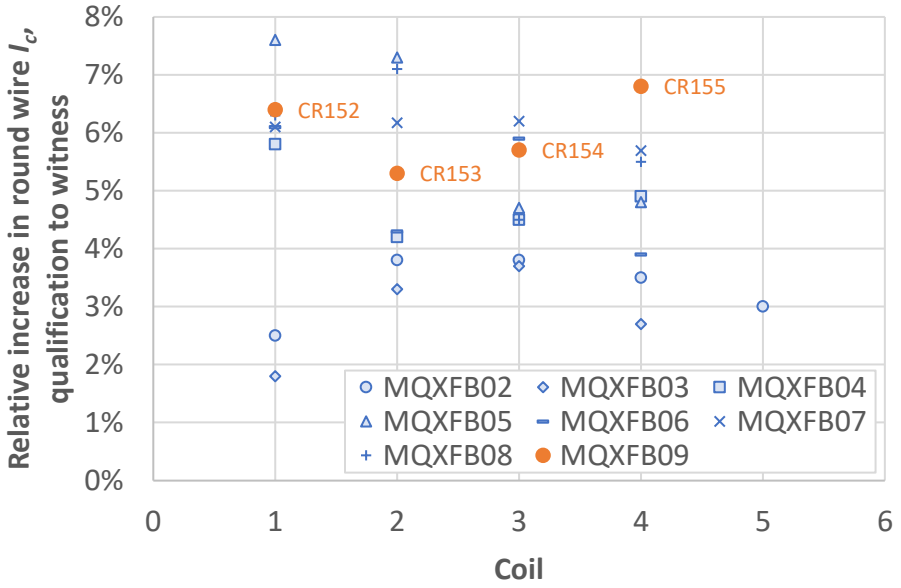
Estimated Coil RRR



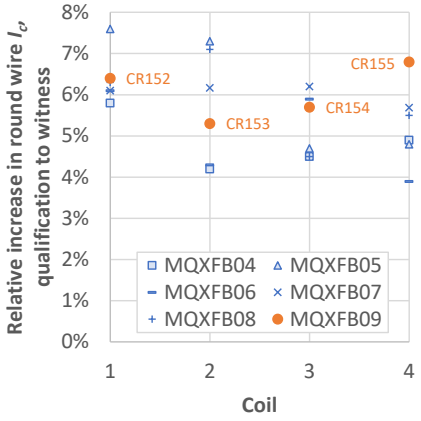
- Large RRR margin
- RRR at both extremities similar for CR152 and CR153
- Connection side (CC) has higher RRR for CR154 and CR155 (as typically found); but note limited statistics for these coils
- Values higher than average, but within the range of other recent coils

Effect of HT/Furnace on Round Wire I_c

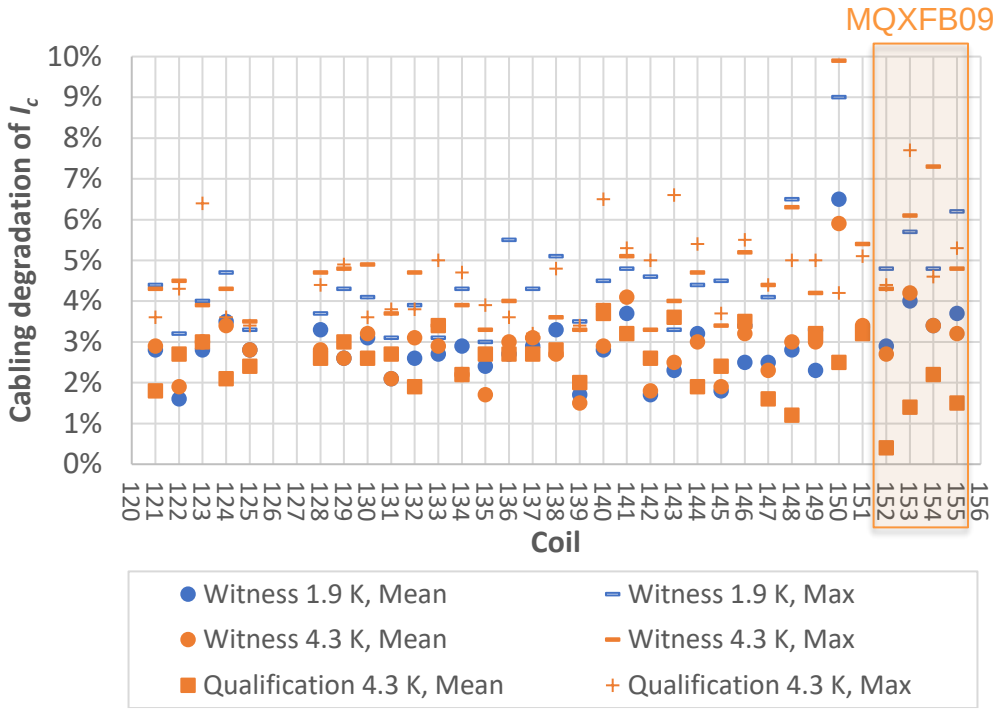
- I_c of virgin **witness** samples (building 180) – I_c of virgin **qualification** samples (building 163)



- I_c consistently slightly higher for witness samples (HT in building 180) than qualification samples (HT in building 163)
- In a consistent range for recent coils (especially MQXFB04 onwards)



Cabling Degradation of I_c



- **Mean** cabling degradation of I_c is within the 5 % specification for qualification and witness samples
- >5 % maximum degradation, *excluding* damaged extracted strands, is influenced by testing anomalies discussed earlier
- Otherwise, consistent and conforming degradation as assessed from witness samples across all recent production, both at 1.9 K and 4.3 K
- Excluding outliers: mean cabling degradation ~3.5 %

Summary

- Cable data in specification for all coils
  - Excluding anomalous cabling degradation for three damaged extracted strand samples
- Good consistency between recent coils, and data in a comparable range to MQXFB02-08
- Limited sampling of the large number of billets used for CR154 and CR155 reduces the confidence in estimates of coil performance
- Systematic differences between small (building 163) and large (building 180) HT furnaces stable

Thank you for your attention!