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SR03 Test Summary Report

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1. Introduction

SR03 first was cooled down November 27th, 2005. At 10:00 am on 28th of November 2005 VMTF was filled with LHe. After a successful HiPot the leads were connected to the 30kA PS system. 1000A manual trip test revealed that the Half Coil and Whole Coil voltages (L*Idot) are inconsistent with expectations. The WC voltage was the same as one of the HC voltage (expected WC = 2 * HC) and the other HC voltage was practically zero. Carefully checking the warm electrical measurements we concluded that this result is consistent with a HC short which is likely to be somewhere in the V-tap wiring. After the power leads were removed from the Top hat the inductance of the magnet was measured. The inductance value obtained cold is almost exactly the half of that measured warm. This also pointed to the direction that a HC were shorted. We also took measurements during warm up the coil (see Table I). The gradual increase of the inductance was quite puzzling.

Table I. Inductance and voltage measurements during warm up.

	20 K	**30 K**	**40 K**
INDUCTANCE @			
20 Hz	**.01938 mH**	**.02111 mH**	**.02361 mH**
1 KHz	**.01007 mH**	**.01034 mH**	**.01090 mH**
VOLTAGE @ 10A/-10A			
ACROSS LEADS	**1.081 mV**	**1.925/-1.925 mV**	**4.017/-4.026 mV**
FVT WC	**.7163 mV**	**1.5135/-1.4859 mV**	**3.4035/3.4889 mV**
FVT 1/2C	**.5042 mV**	**.9073/-.6167 mV**	**1.8668/-1.6353 mV**
FVT 1/2C	**.3562 mV**	**.7580/-.7230 mV**	**1.7005/-1.7235 mV**

At room temperature the inductance unfortunately was the same as it was measured right before cool down. So we were not able to find the hypothetical short. In any case the wiring was replaced since that was the primary suspect for the short and SR03 was re-installed into VMTF by December 11th, 2006. The symptoms were the same as they were at the previous test, the half coil signals were not equal. This time we also included a 3000A manual trip and we observed that the half coil voltages tend to equalize at this current level. This was confirmed with VSDS measurements. In principle we were ready to continue the test however we were not able to completely exclude the possibility of a temporary short. The decision was to remove again the magnet and try to localize or at least to understand the problem before we continue with the test. We were not able to find the smoking gun by opening the magnet. Again we improved the internal wiring and put back together SR03. The explanation for the effect we have seen might be related to the way SR03 was designed. Two relatively large inductive coils are wound opposite direction which reduces the overall inductance of the coil ending up with a small about 30μH inductance. The V-tap wiring itself can contribute some fraction of the inductance which might have been the case why we have been seeing the reduced value.

The next cool down occurred on February 5th , 2006. The magnet still behaved the same way as it was behaving at the previous two Test Cycles however this time we continued with the test. We had few PS issues but the test was a success and we were able to finish it by February 15th, 2006. SR02 was removed from the VMTF pit on February 27th, 2006.

2. Quench History

The first quench was at 18683*A* with the nominal ramp rate of 20*A/sec* and a temperature of 4.5*K*. The magnet exhibited relatively fast training if we subtract the malfunctioning of the QD system. The next step was to study ramp rate dependence. We took five quenches. No significant ramp rate dependence was observed. As shown in fig. 3. the magnet reached its critical current value.

In order to investigate the magnet behavior at lower temperature the magnet was cooled down to 2.2*K* and 6 quenches were performed at 20*A/sec*. At this temperature the average quench current was slightly higher than that of at 4.5*T*.

We also performed ramp rate dependence studies at 2.2K, then during warm up we quenched the magnet at several different temperatures. Taken 2 more quenches at 4.5 K then completed the quench test.

The quench history plot is presented in fig 1. while in tab. 1 are shown the quench locations and the quench starting times. The voltage tap positions on the coil are illustrated in fig. 2.

Since the quench started about the same time in both half coils it was not possible to pinpoint which coil was responsible for the quench. It is also hard to claim that the quench has started at the layer jump. In order to make such a distinction more voltage taps are needed.

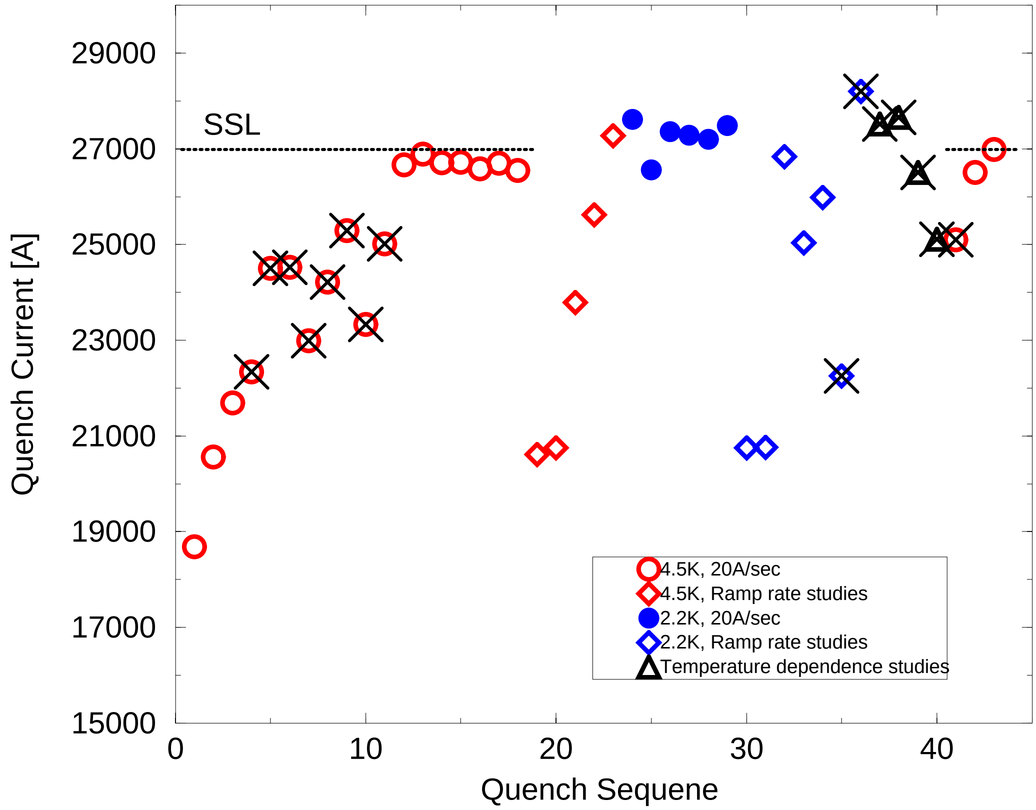

Figure 1. Quench history. Symbols which are crossed were not quenches.

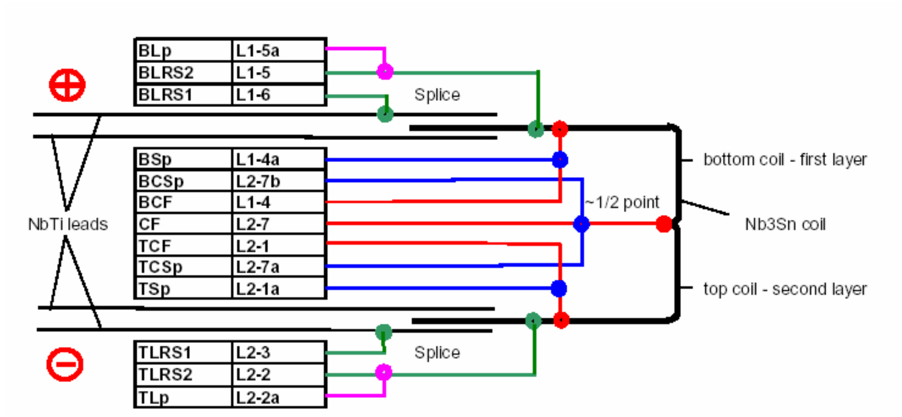

Figure 2. Voltage Tap position

File	Current	dIdt	tquench	MIITs	QDC	1st VTseg	trise	Comment
sr03.Quench.051128141724.262	0	0	0.0000	0.00		QBLRS1_QBLRS2	0.0248	first trip at turn on
sr03.Quench.051129112917.009	0	0	0.0000	0.00		QBLRS1_QBLRS2	0.0248	Ramp001-0501129-1130 for VSDS
sr03.Quench.051212141559.296	0	0	0.0000	1.21		QBC_QCC	0.0248	1000 Manual trip, VSDS file name 1000manualtrip_2005-12-12_1410
sr03.Quench.051212143359.733	0	0	0.0000	9.46		QBC_QCC	0.0248	3000A manual trip
sr03.Quench.051212150019.321	0	0	0.0000	1.12		QBC_QCC	0.0246	1000A manual trip
sr03.Quench.051212174452.252	0	0	0.0000	0.00		QBC_QCC	0.0248	1000A manual trip
sr03.Quench.051212180133.895	0	0	0.0000	9.44		QBC_QCC	0.0246	3000A manual trip
sr03.Quench.060206131312.818	0	0	0.0000	0.00		QBC_QCC	0.0248	trip for no reson
sr03.Quench.060206133831.921	0	0	0.0000	1.11		QBC_QCC	0.0031	
sr03.Quench.060206135339.559	0	0	0.0000	0.00		QBC_QCC	0.002	3000A manual trip
sr03.Quench.060206142947.990	0	0	0.0000	25.93		QBC_QCC	0.0246	5000A manual trip
sr03.Quench.060206145751.260	**18683**	20	0.0000	11.2		QBC_QCC	0.0025	1st quench, 20A/sec, Iq=18683A, 4.5K
sr03.Quench.060206163025.334	**20559**	20	0.0000	434.56		QBC_QCC	0.0024	2nd quench, Iq=20558.7A, 20A/sec, 4.5K
sr03.Quench.060206165855.275	**21687**	20	0.0000	483.44		QBC_QCC	0.0025	3rd Quench, Iq=21687.3A, 20A/s, 4.5K
sr03.Quench.060206172932.191	**22336**	20	0.0000	502.50		QCC_QTC	0.0003	4th Quench, Iq=22335.9A, 4.5K, 20A/sec
sr03.Quench.060207095510.779	**24503**	20	0.0000	604.61		QCC_QTC	0.0004	5th quench, 20A/sec, 4.5K, Iq=24142A
sr03.Quench.060207110611.309	**24525**	20	0.0000	605.75		QCC_QTC	0.0001	6th quench, 20A/sec, 4.5K, Iq=24142A
sr03.Quench.060207121905.892	**22990**	20	0.0000	530.36		QCC_QTC	0.0004	7th quench, Iq=22989.7A, 20A/s, 4.5K
sr03.Quench.060207142556.760	**24215**	20	0.0000	591.15		QCC_QTC	0.0003	tripped by dump A over temperature, after about 3 minutes at 24200A
sr03.Quench.060207154838.658	**25293**	20	0.0000	0.00		QCC_QTC	0.0003	8th quench, Iq=25000A, 20A/s, 4.5K
sr03.Quench.060210114920.316	1000	20	0.0000	1.11		QBC_QCC	0.002	1000A manual trip
sr03.Quench.060210122356.888	**23327**	20	0.0000	541.85		QCC_QTC	0.0004	Lead trip
sr03.Quench.060210134057.709	**25013**	20	0.0000	631.68		QCC_QTC	0.0004	Ramp11 Tripped AQD_LEADS at 25013A 4.5K
sr03.Quench.060210154847.729	**26665**	20	0.0000	0.00		QCC_QTC	0.0004	4.5K, 20A/sec, Iq=25900A
sr03.Quench.060210162740.145	**26665**	20	0.0000	728.57		QBC_QCC	0.0013	4th quench, 4.5K, 20a/sec
sr03.Quench.060210165948.617	**26888**	20	0.0000	739.90		QBC_QCC	0.0013	5th quench, Iq=26888A, 20A/sec, 4.5K
sr03.Quench.060210174635.296	**26714**	0	0.0000	731.20		QBLRS2_QBC	0.0011	6th Quench, 20A/s, 4.5K
sr03.Quench.060210183130.322	**26723**	20	0.0000	731.47		QBLRS2_QBC	0.0011	Iq=26723.2. 20A/sec, 4.5K
sr03.Quench.060210191027.289	**26580**	20	0.0000	685.12		QBLRS2_QBC	0.0013	8th quench, 20A/sec, Iq=26580A, 4.5K
sr03.Quench.060210194350.519	**26698**	20	0.0000	730.26		QBLRS2_QBC	-0.001	9th quench, 20A/s, 4.5K, Iq=26698.4A
sr03.Quench.060210201909.346	**26549**	20	0.0000	720.58		QBLRS2_QBC	0.0011	Iq=26548.8A, 20A/sec, 10th quench, 4.5K

sr03.Quench.060210203117.355	**20616**	300	0.0000	390.95		QBC_QCC	0.0028	11th quench, Iq=20616.4A, 4.5K, 300A/sec
sr03.Quench.060210204355.987	**20756**	200	-0.0041	10.09	WcoilIdot	QBC_QCC	0.0027	12th quench, Iq=20756.6, 200A/s, 4.5K
sr03.Quench.060210205816.322	**23786**	100	-0.3044	183.33	GndRef	QBLRS2_QBC	-0.0034	13th quench, Iq=23786.6A, 100A/sec, 4.5K
sr03.Quench.060210211428.632	**25622**	50	-0.0073	15.70	HcoilHcoil	QBC_QCC	-0.0011	14th quench, Iq=25622.6A, 50A/sec, 4.5K
sr03.Quench.060210214222.391	**27274**	5	-0.0020	12.84	WcoilIdot	QBLRS2_QBC	-0.0011	15th quench, Iq=27274.6A, 5A/s, 4.5K
sr03.Quench.060214112110.719	**27613**	20	-0.0031	15.61	SlWcoil	QBC_QCC	-0.0022	16th quench, Iq=27613.4A, 20A/s, 2.2K
sr03.Quench.060214115104.664	**26554**	20	-0.0035	16.10	SlWcoil	QBC_QCC	-0.0022	17th Qeucnh, Iq=26554.6S, 20A/s, 2.2K
sr03.Quench.060214122105.019	**27361**	20	-0.0060	17.90	GndRef	QBC_QCC	-0.0022	one quench at 2.2K.....
sr03.Quench.060214132006.819	**27282**	20	-0.0034	15.97	SlWcoil	QBLRS2_QBC	-0.002	19th quench, 20A/s, 2.2K, Iq=27281.8A
sr03.Quench.060214135016.135	**27198**	20	-0.0039	15.99	HcoilHcoil	QBC_QCC	-0.0027	20th Quench, 20A/sec, 2.2K, Iq=27197.8A
sr03.Quench.060214144413.852	**27488**	20	-0.0074	19.43	WcoilIdot	QBC_QCC	-0.0017	21st Qeunch, Iq=27487.8A, 20A/s, 2.2K
sr03.Quench.060214145356.667	**20748**	300	-0.0035	9.81	SlWcoil	QBC_QCC	-0.0024	22nd quench, 300A/sec, 2.2K, Iq=20747.6A
sr03.Quench.060214150403.512	**20762**	200	-0.0085	12.02	HcoilHcoil	QCC_QTC	0.0029	23rd quench, Iq=20762.2A, 200A/sec, 2.2K
sr03.Quench.060214151406.207	**26840**	100	-0.0025	15.96	SlWcoil	QBLRS2_QBC	-0.0013	24th quench, 100A/sec, 2.2K, Iq=26840A
sr03.Quench.060214152503.733	**25035**	150	-0.0027	12.26	SlWcoil	QBC_QCC	-0.0015	25th Quench, 150A/sec, 2.2K, Iq=25035.8A
sr03.Quench.060214153530.130	**25981**	125	-0.0021	15.20	SlWcoil	QBC_QCC	-0.0011	26th quench, 125A/sec, 2.2K, Iq=25981A
sr03.Quench.060214155127.160	**22256**	50	0.0008	0.61	WcoilIdot	QCC_QTC	0.0003	Lead trip
sr03.Quench.060214163016.437	**28048**	50	-0.0095	8.79	WcoilIdot	QCC_QTC	0.0006	Lead trip
sr03.Quench.060214180856.426	**27524**	20	-0.0655	50.77	HcoilHcoil	QCC_QTC	0.0001	Lead trip
sr03.Quench.060214190127.717	**27659**	20	-0.0664	51.63	HcoilHcoil	QCC_QTC	0.0003	Lead trip
sr03.Quench.060214193420.121	**26507**	20	-0.0774	56.12	WcoilIdot	QCC_QTC	0.0003	Lead trip
sr03.Quench.060215075252.983	**25115**	20	-0.0926	60.10	WcoilIdot	QCC_QTC	0.0003	Lead trip
sr03.Quench.060215083114.980	**26509**	20	-0.0022	15.07	HcoilHcoil	QBLRS2_QBC	-0.0011	Iq=26509.6A, 20A/s, 4.5K
sr03.Quench.060215090144.108	**26982**	20	-0.0042	16.30	SlWcoil	QBC_QCC	-0.0013	Iq=26982.4, 20A/s, 4.5K
sr03.Quench.060215110530.625	5000	0	-0.0165	0.98	WcoilIdot	QBC_QCC	-0.0027	Manual trip 5000A
sr03.Quench.060215152828.131	15066	150	0.0008	0.30	WcoilIdot	QBC_QCC	1	Phase back by Alex

3. Ramp Rate Dependence

The default current ramp rate was 20 A/sec. Ramp rate dependence study at 4.5*K* and 2.2 *K* is summarized in Figure 4. Quench current as a function of the ramp rate for 4.5K operation was a smooth curve. At 1.8K the magnet didn't reach its short sample limit and the ramp rate dependence clearly reveals this fact.

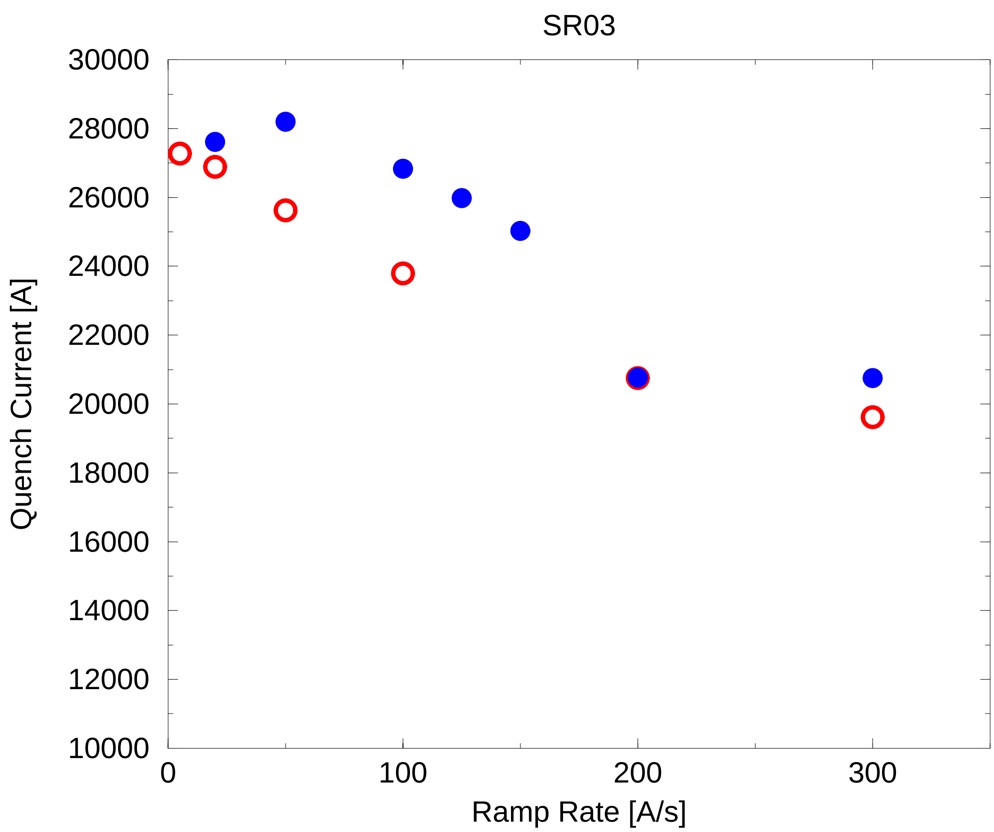

Figure 4. Current ramp rate dependence.

4. RRR measurement

The RRR measurement was performed between 12/13/2005 and 12/19/2005. The magnet was gradually warming up and meanwhile we recorded the whole coil voltage value generated by ±10 A across the magnet.. The measured RRR value is 173±10.