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MEASUREMENT OF ELECTROLYTIC VOLTAGES GENERATED BETWEEN COILS AND LAMINATIONS OF FAILED MAIN-RING MAGNETS

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Main-Ring magnets fail for a variety of reasons, one of which involves the presence of water. The source of water can be either internal from a leaky coil or external such as from a broken insulator. It was proposed that if a magnet failed because of the presence of water, one should be able to detect an electrolytically generated voltage between the copper coils and the iron laminations. This voltage would be expected to be a few tenths of a volt.

The following measurements were made on several failed magnets. The resistance between coil and lamination was measured for each coil. The self-generated voltage between coil and lamination was also measured for each coil. The manifolds had been removed from all measured magnets, allowing the measurement of all three coils (the upper outer, the lower outer and the inner) separately. All measurements were made with a fluke digital multimeter model 8000A. This instrument has an input impedance of 10 MegΩ and can measure resistances up to 20 MegΩ's. Any resistance which was measured to be greater than 20 Megohms was considered to be infinite.

These measurements were confined to 27 bending magnets constituting the total sum of failed bend magnets stored in the magnet facility. They are stored there for one of two reasons. Either they are radioactive or they have failed very recently.

After a magnet has failed in the ring it is given a static pressure test in an attempt to determine the possible existence of a leaky coil. This test is recorded on a returned magnet history form. The present measurements have been compiled into the attached table which includes information from the static pressure tests. The table identifies each magnet by number and removal number.

As can be seen from the table it appears that a large fraction of the magnets indicate water related failures. Of the 27 magnets, 6 clearly indicated leaks during the static pressure tests. A seventh gave conflicting results during the test. Four of these seven leakers also produced an electrolytic voltage. The remaining three which did not produce a voltage can be explained as follows: One was a turn-to-turn short which measured ∞ resistance between all coils and laminations. It, therefore, appears that the water did not provide a path between iron and copper but only between coils. In the other two cases the short for one of the set of coils was 0 ohms, therefore, any possible voltaic cell would be shorted out on these voltage coils. The adjacent coils of the set show infinite resistance and no voltage, indicating that they had not been made wet by the same leak.

There were also six instances where a magnet showed no leak under static pressure but did produce an electrolytic voltage. In one such case the magnet was sprayed when an insulator broke. It is presumed that in the other cases the water leak was so small that it was not detected by the static pressure test. From these combined measurements it is concluded that 13 of the 27 magnets indicate water problems. We conclude that magnets that indicate an electrolytic voltage and/or a static pressure loss should be considered to be wet magnets.

Resistance measurements typically produced the following results: ∞ (>20 MegΩ), a few megohms or 0.0 resistance. Voltage measurements also fell into three categories: 0.0 volts for a dead short, a few millivolts for ∞ resistance (typically 1-3 millivolts) or a few tenths of a volt (.1 to .6). All magnet coils which showed a significant electrolytic voltage also indicated a resistance to the laminations of a few megohms. With the exception of one case, the converse is also true. Two new magnets were tested and each coil measured ∞ resistance and a few millivolts. The voltage produced by a wet magnet seemed to depend on the resistance and this is assumed due to the high internal impedance of the cell.

The table of results can be analyzed as follows: Of the 27 magnets 13 or 48% failed due to water problems and 52% were dry or insulation puncture failures. Twenty-three or 85% of the magnets contained innter coils which show less than 20 megohms to ground, 8 (30%) of the magnets had lower coils of low insulation resistance and 4 (15%) had upper coils of low insulation resistance. One magnet (4%) had a turn-to-turn short.

Considering the wet magnets alone 92% (12) had shorted inner coils, 38% (5) had shorted lower coils, 30% (4) had shorted upper coils and 7% (1) had a turn-to-turn short. Of the dry magnets 80% (11) had shorted inners, 20% had shorted lowers. There were no turn-to-turn or upper shorts among the dry magnets. There were also no magnets with more than one coil shorted among the dry mangets.

If one considers the lowest resistance to be the primary short, the following distributions are found: For all magnets 70% (19) had primary shorted inner coils, 18% (5) had primary shorted lower coils, 8% (2) had primary shorted upper coils and 4% (1) had a turn-to-turn short. For the dry magnets the distribution of primary shorts is the same as for total shorts because the dry magnets only contained one shorted coil. For the wet magnets 61% (8) had primary shorted inners, 15% (2) had primary shorted lowers, 15% (2) had orimary shorted uppers and 8% (1) had a turn-to-turn short.

	MAGNET NUMBER	RESISTANCE MΩ			VOLTAGE			PRESSURE TEST	REMOVAL NUMBER	H_2O
		U	I	L	U	I	L			
Plaster Stick	1087	∞	0	∞	.003	0.00	.003	Leak	430	W
Plaster Stick	1572	∞	2.1	1.8	.001	.190	.125	Sprayed No Leak	498	W
Plaster Stick	1578	∞	∞	0	.004	.005	0.00	No Leak		
Plaster Stick	2019	∞	0.00	∞	.002	0.00	.001	Leak	484	W
Plaster Stick	2026	∞	∞	0.00	.003	.003	0.00	No Leak	505	
Epoxy Stick	1122	∞	5.34	1.23	.044	.123	.123	No Leak	531	W
Epoxy Stick	1626	∞	∞	∞	.004	.004	.001	Leak	Turn to Turn 449	W
Epoxy Stick	1659	1.8	.6	3.2	.050	.055	.298	No Leak	527	W
Epoxy Stick	1667	4.7	0	6.6	.023	0.00	.125	Leak	534	W
Epoxy Stick	1697	∞	∞	.8	.004	.002	0.00	No Leak	513	
Epoxy Stick	1699	∞	0	∞	.005	0.00	.001	No Leak	499	
Epoxy Stick	2649	0.00	.28	∞	0.00	.057	.005	Leak		W
Epoxy Stick	2707	∞	0.00	∞	.004	0.00	.001	No Leak		
Epoxy Stick	2709	∞	0.00	∞	.002	0.00	.001	No Leak	515	
Vac Imp.	1226	∞	0.00	∞	.001	0.00	.001	No Leak	509	
Vac Imp.	1730	∞	*	∞	.002	.004	.001	No Leak	*Hi Voltage Inner Short 456	
Vac Imp.	1743	∞	3.7	∞	.025	.347	.003	Leak	537	W
Integrally Imp.	1244	∞	8.4	∞	.005	.672	.001	No Leak	483	W
Integrally Imp.	1756	∞	0.00	4.7	.003	0.00	.248	No Leak	494	W
Integrally Imp.	1762	∞	0.00	∞	.004	0.00	.003	No Leak	489	
Integrally Imp.	1767	∞	0.00	∞	.004	0.00	.001	No Leak	526	
Integrally Imp.	1781	∞	0.00	∞	.001	0.00	.008	No Leak	533	
Integrally Imp.	2252	∞	.05	∞	.003	.004	.002	No Leak	536	
Integrally Imp.	2273	∞	.2	∞	.002	.017	.005	No Test	504	W
Integrally Imp.	2779	∞	0.00	∞	.002	0.00	.002	No Leak	497	
Integrally Imp.	2801	∞	0.00	∞	.002	0.00	.003	No Leak	535	
Super Int. Imp.	2312	0.00	2.8	3.8	0.00	.145	.324	No Leak Leak?		W