Turn-to-Turn Short in Collared Coil DC0305 During Inital Keying Attempt*

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During the initial keying attempt of DC0305, a turn-to-turn short occurred. The circumstances are described in detail in this memo. The recommended dis-assembly procedure will be described in a further memo.

Installation in Keying Press: DC0305 was installed in the keying press on January 28, 1991. There were initially seven malfunctioning strain gages (see Table 1.) As shown in the table, four of these gages had been disfunctional on January 25, 1991. The other three gages had problems only after the coil was inserted in the tooling and rolled into the press.

Two of the newly disfunctional gages were found to have disconnected wires at the 24-pin connectors on the outside of the press. These connectors were resoldered and the gages functioned properly subsequently. The third gage was examined, and it was decided that its problem was more serious. Since it was a compensating gage, it was decided to continue with the keying procedure.

Initial Keying Attempt: At 0838 on January 29, 1991, the pump pressure was raised to 1000 psi. Data from strain gages, press LVDT's[1], and upper and lower coil resistance measurements[2] were recorded at this pressure value. Feeler gage information was recorded only at odd multiples of 1000 psi throughout the keying procedure. Data were taken at 2000, 3000, 4000, 5000, 6000, and 6800 pump psi as shown in Table 2.

At 0921, as the pressure was being raised from 6000 to 7000 psi, an alarm sounded which indicated that the upper and lower coil resistances were different by more than 1%. In particular, the upper and lower coil resistances were 3.212 Ω and 3.157 Ω respectively (1.77% different.) The initial resistance values were 3.215 W and 3.208 Ω, indicating that the lower coil had dropped in resistance by 51 mΩ, while the upper coil had only changed by 3 mΩ, a change within the systematic errors of the measurement.

The pump pressure was halted at 6800 psi when the alarm sounded, and was not changed until after all of the measurements had been made to localize the short as described below. However, over a period of several hours, the pump pressure did decay slightly, as shown in Figure 1.

By 0939, the resistance of the lower coil had decreased further to 3.120 Ω. It remained at this value or within several mΩ of this value until the pump pressure was taken down as described below.

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Diagnosis of the Problem: Since there are 36 turns in each coil, and since the initial lower coil resistance was 3.208 Ω, the loss of a single turn of resistance would cause a decrease of about 89 mΩ. Therefore, a turn-to-turn short was suspected immediately.

It was recommended that the lower coil ramp splice pre-forms be separated and the inner and outer lower coils measured individually. When this was done, it was found that the lower inner coil resistance had dropped by 87 mΩ from its most recently measured value. (See Table 3.)

Since the short appeared to be in the lower inner coil, it was recommended that the voltage taps be used to further localize the short. Table 4 shows the resistances measured[3] between the preform end of the coil and a set of taps on the lower inner coil. The first set of measurements was taken at 1015, the second at 1040. Other than the slightly larger than expected value of the 10A - 9A resistance, these numbers looked normal.

Also shown in Table 4 for interest are the fractional differences between resistance measurements made with and without the "temperature correction" invoked on the Valhalla meter. In general, the measured resistance without temperature correction was a little more than .5% higher.

A measurement was then made of the resistance between the lead end of the lower inner coil and the 9A voltage tap. The value of 687 mΩ was less than the expected value of 774 mΩ[4] by 87 mΩ. It was therefore concluded that the most likely location of the turn-to-turn short was in the uninstrumented portion of the lower inner coil, that is, somewhere between the 9A tap and the lead end of the coil.

Release of Pump Pressure: Once the above data had been taken, it was decided to release the pump pressure in 1000 psi steps, to see whether the short would go away or would remain. Table 5 shows the coil resistance data taken as the pump pressure was decreased.

Somewhere between 1000 psi and 0 psi, the short dissapeared. The pump pressure was then raised to 350 psi, the minimum pressure needed for any contact between the upper tooling and the collared coil. The pressure was then taken to 500 psi, and raised in increments of 50 psi, as shown in Table 5. A 550 psi, a slow decrease in the resistance of the lower coil was detected. At 650 psi, the alarm sounded indicating that the short had reappeared. The press was then dumped again, and the short went away.

Removal of DC0305 from Keying Press: On the afternoon of January 29, 1991, DC0305 was removed from the keying press and laid in an upside-down position on a table in ICB to prepare for removal of the collar packs and the lower coils.

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Notes

[1]Three LVDT's had been mounted on either side of the keying press since DC0304 was keyed. These were zeroed with the press completely closed before the attempt to key DC0305 was made. All six LVDT's are read out by the Hewlett-Packard computer and readings in inches are automatically printed to the screen.

[2]During keying, the upper inner and upper outer coils have their ramp splice preforms c-clamped together, allowing a measurement of the total upper coil resistance to be made. The lower inner and outer coils are treated the same. The resistances are monitored with Valhalla meters (.100 A current, 4-wire measurement). The data from the Valhallas is read out by the Hewlett-Packard computer, and the upper and lower coil resistances are periodically printed to the screen.

[3]These measurements were made with a separate Valhalla meter (100 mA, 4-wire measurement.)

[4]The expected value was obtained by finding the difference between the most recent (1-23-91) measurements of the 9A - 16B tap resistance and the full lower inner coil resistance: 1375 mΩ - 601 mΩ = 774 mΩ.

Table 1. Malfunctioning Strain Gages in DC0305

gage #	position	symptom
1020	Lead End Inner Active Q2	red open; black & white shorted to collars
162	Lead End Outer Active Q2	all wires shorted to collars
280	Lead End Outer Compensating Q3	white, black shorted to collars
153	Return End Outer Active Q2	open green wire
95	Return End Outer Active Q4	all wires shorted together, but not to collars

Table 2. DC0305 Keying Data; Initial Attempt

time	pressure (psi)	data taken	Upper coil (Ω)	Lower Coil (Ω)
initial			3.215	3.208
0838	1000	SG, LVDT, F, R		
0850	2000	SG, LVDT, R		
0856	3000	SG, LVDT, F, R		
0905	4000	SG, LVDT, R		
0907	5000	SG, LVDT, F, R		
0917	6000	SG, LVDT, R		
0921	6800	SG, LVDT, R	3.212	3.157
0929			3.211	3.124
0931			3.211	3.121
1031			3.208	3.129
1057	6386		3.210	3.121

*** SG = strain gage, F = "feeler gage", R = coil resistance**

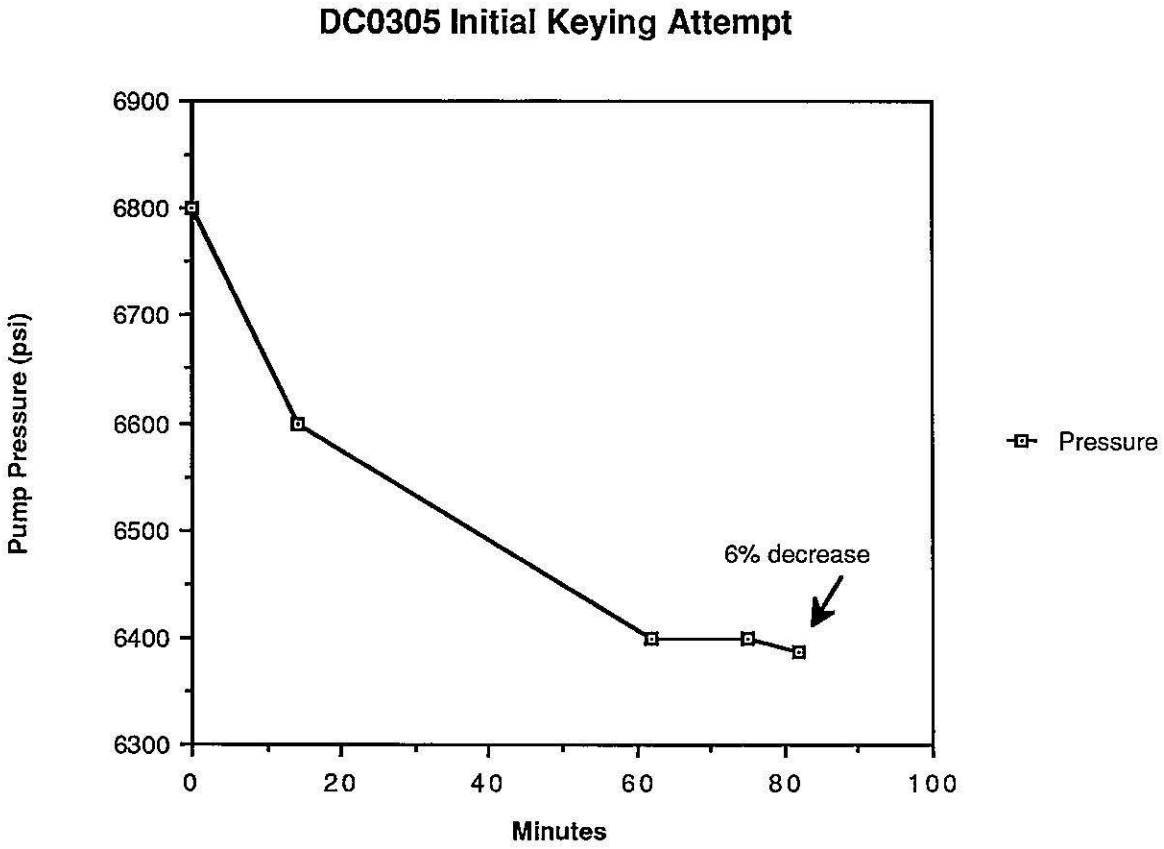

Figure 1. Pump Pressure Decay Over Time

Table 3. DC0305 Keying Data; Quarter Coil Resistances

	1-23-91 (mΩ)	During Keying Attempt (mΩ)
Upper Inner	1379	1384
Lower Inner	1375	1288
Upper Outer	1829	1834
Lower Outer	1833	1837

Table 4. DC0305 Keying Data;
Lower Inner Coil Voltage Tap Resistances
(16B to indicated tap position)

position	1-23-91 (mΩ)	1-29-91 (10:14) (mΩ)	1-29-91 (10:40) (mΩ)	ΔTC/R (%)
16A	1.8	1.7	1.9	0
15A	87.3	87.2	87.4	.57
14A	172.6	172.5	172.7	.57
13A	258.0	257.7	257.8	.62
12A	343.7	343.1	343.1	.64
10B	512.1	-------	511.8	.66
10A	515.3	513.1	513.3	.64
9B	598.0	-------	596.5	.67
9A	601.0	599.7	596.5	.65
9A - 0A	--------	-------	687.2	.65

Table 5. DC0305 Keying Data;
Final Measurements in Keying Press

time	pressure (psi)	Upper coil (Ω)	Lower Coil (Ω)
1100	6000	3.209	3.121
1102	5000	3.209	3.122
1105	4000	3.209	3.122
1108	3000	3.209	3.122
1110	2000	3.209	3.122
1112	1000	3.210	3.124
1113	1000	3.210	3.125
1119	0	3.211	3.207
1121	350	3.212	3.205
1122	500	3.212	3.202
1122	550	———	3.193
1123	600	———	3.185
1124	650	3.211	3.175 (alarm)
1125	0	3.211	3.208 (final reading)