TC loss estimates from the G14 cell data

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1 Introduction

In this note, we summarize the analysis of HD polarization losses occuring in the transfer cryostat (TC). Losses can happen due to:

- Temperature spikes during the screwing or unscrewing of the cell in the TC, in which case the losses are independent of the particular polarization relaxation times T_1^H and T_1^D of the cell.
- Polarization decay due to spin-lattice interaction at the relatively high temperature (2K) and low magnetic field (0.1T) of the TC. These exponential decays are characterized by the particular relaxation times T_1^H and T_1^D of the given cell, at the 2K and 0.1 T.

2 Available data

We have 5 sets of data but only 2 are truly useful:

1) **Test done in August 2011 in the IceLab** with a newly condensed (unnamed) cell [1]. However, since T_1 is short, the test is inappropriate to get TC loss estimate. (We did this test to check HD gas loss).

2) **Comparison of TE calibrations in and out the IBC**: We can compare the IBC NMR calibration done using TE measured in the IBC (unaffected TC losses) and the IBC NMR calibration done using TE measured in the PD before cell transfer (affected by TC losses). The two *online* calibrations agree within 3.8%. However, since these online numbers are accurate to the 10% level, this only gives a 10-15% upper limit for the TC losses for cells having lifetimes similar to the ones of cell 21a (unmeasured but *very roughly* estimated to be 45 days for H and 400 days for D [2]) and of cell 19b (for its T_1, see data set 5 below).

3) **Data from cell 22b**. The target was lifted with the TC for 50 min and put back. Comparison between signals before and after gives a H loss of 8.8% and a D loss of 1.6%. However, the "before" and "after" measurements were not done in the same conditions (TC was attached before but was not attached after). *Therefore these numbers are unreliable for TC loss estimates.*

For information, T_1^H was measured to be 8h to 15h [3] during a 11 days measurement (the increase is due to the aging during the measurement). T_1^D went from 8.5h to 12.5h [3]. The conditions were 4.3K & 2T or 2.15K and 0.1T but the T_1 turned out to be similar in the two conditions.

These T_1 measurements were done about 26.5h (May 25th 2012, 11:34am) after the TC lift test (May 24th 2012, 2pm). This is close enough so that we do not have to worry about a systematic increase of T_1 from aging.

4) **Data from cell 19a**. The target was lifted with the TC for about 45 min and put back. Comparison between signals before and after the lift gives a H loss of 2.0±1.1%(stat) and a D loss (gain actually) of -0.2±1.4%(stat).

T_1^H was measured to be 16 days [4] at 2K and 2T or 2.5T, 10 days at 3K, 1T and 40 days at 2K, 1T. T_1^D was too long to be precisely measured but is estimated to about a year [4]. These T_1 measurements were done around the same time (Sept. 9-15 2011) as the TC lift test (Sept. 10 2011, 4-8pm). So, we do not have to worry about aging.

5) **Data from cell 19b**. The target was lifted with the TC for about 50 min and put back. Comparison between signals before and after gives a H loss of 2.0±1%(stat) and a D loss of 13.4±1%. T_1^H was measured to be about 6 days [3] at 4K, 2T and about 14 days at 2K, 1T. T_1 measurements in other field and temperature conditions exist, see [3]). T_1^D is about 3 days at 4K and 2T and about 18 days at 2K, 1T.

These T_1 measurements were done between 1 to 14 days (April 24th 2012, 3:18pm to May 7th 2012, 10:40 AM) after the TC lift test (April 23rd 2012, 1pm). This is close enough so that we do not have to worry about aging.

3 Conclusion.

Tests 4 and 5 indicate a ~2% loss for H when T_1 is in order of week(s). For D, when T_1 is very long (a year or more), there is no sign of loss within the 1.4% statistical uncertainty, while we have large (13.4%) losses when T_1 is of the order of week(s) at 2K,

1T. This qualitatively makes sense. The H loss from (unreliable) test 3 makes sense (smaller lifetime) but the D losses seems to be too small. The rough upper limit given by test 1 is compatible with these conclusions.

References

[1] HDice_TN18: A. Deur, study of NMR in the Production Dewar without Exchange Gas

[2] HDice_TN26: A. Deur, Analysis of the 2012 electron test data.

[3] HDice_TN *TBD*: A. Deur, HD target PD polarimetry for 2011 (Second batch of HD cells)

[4] HDice_TN *TBD*: A. Deur, HD target PD polarimetry for 2011 (First batch of HD cells)