RF breakdown in vacuum layers for MRI noise reduction

W. Renz[1], H. Stark[2], J. Nistler[1], M. Rausch[1]

[1]Siemens Medical Solutions, Erlangen, Germany, [2]STARK CONTRAST MRI Coils Research, Erlangen, Germany

Introduction:

Noise reduction in MRI systems is one of the main issues to improve patient comfort /1/. Conventional passive noise reduction measures need enough space to be effective. Especially with high field strengths and the reduced space of head MRI systems the problem is getting more severe. A solution needing much less space is a vacuum (or low gas pressure) encapsulation /2/, /3/. A 5mm vacuum layer at 100mbar or less would yield a considerable noise reduction comparable to a much thicker conventional solution.

One of the problems associated with vacuum are gas discharges generated by the transmit RF fields. Experiments to integrate the transmit RF coil into the vacuum assembly (Fig. 1a) gave a usable pressure range, which was considerably above 100mbar. Therefore an improved approach is to keep the vacuum layer separate from the transmit coil and as thin as necessary (Fig. 1b) and to have only the RF screen in the vacuum region.

Method:

The investigation shown here is focused on the determination of limits for a safe operation of an RF coil close to a vacuum region. A test setup was built which allowed varying the relevant dimensions of cover D1 and D2, the RF coil, RF screen and vacuum layer. A glass vessel containing an RF screen was covered with an 8mm thick layer of GRP and evacuated. A head coil size birdcage tuned to 123.2 MHz was positioned on top of the GRP cover (see Fig. 2).

The RF power transmitted into the coil was pulsed with a duty cycle of 1% to avoid heating effects. During a typical test sequence the peak power was increased slowly until a discharge started ("breakdown voltage"). Then the power was decreased again until the discharge disappeared ("extinguish voltage"). As expected from gas discharge theory, repeated experiments showed a strong variance of the breakdown voltage and reduced variance of the extinguish voltage, depending on parameters like duty cycle, rise time of the RF power, humidity etc. As a criterion for safe operation the minimum extinguish voltage from repeated experiments was chosen. Some results are shown in Fig. 3 and 4.

Conclusion:

A setup for the interaction between RF coils and a vacuum layer for noise damping was investigated. Maximum voltages for an operation free of discharges were determined. Corresponding B_1 values were calculated. For this setup practical operating values up to 50µT were possible.

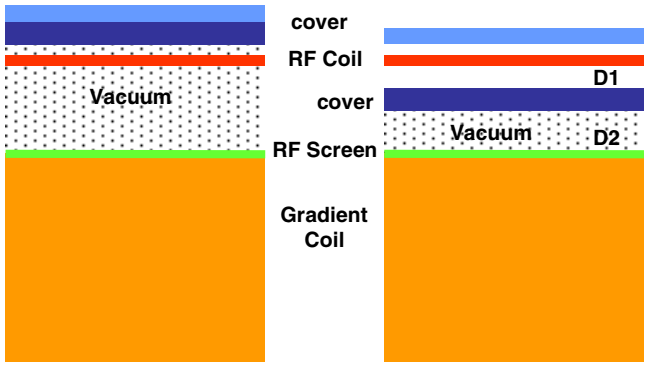

Fig. 1: Two possible configurations for noise damping by vacuum

Fig. 2: The test setup (RF-shield in vacuum, coil outside)

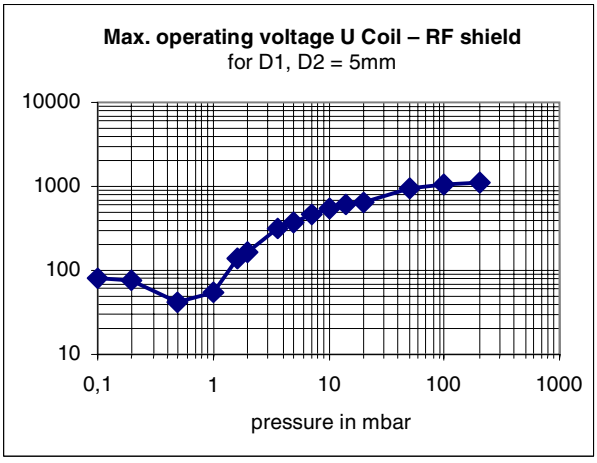

Fig. 3: Maximum operating voltage U vs. vacuum pressure (Paschen curve)

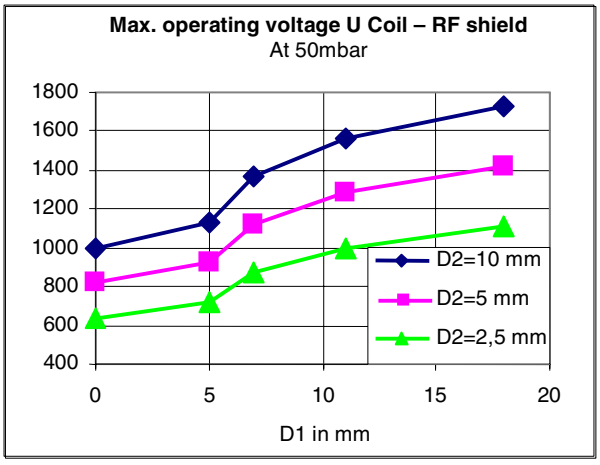

Fig. 4: Maximum operating voltage U vs. distance RF-shield to cover (D1)

References:

[1] Edelstein W.A., et al.; Magn Resonance Imaging 20:155-163 (2002) [2] Patent WO 01/22109A1 [3] Patent JP10118043-A