ASTM MRI TEST REPORT

Translational and Rotational Force Testing of Amerex Fire Extinguishers & Brackets In the Vicinity of a 11.7-Tesla Bruker BioSpec117/16USR Animal MRI System

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Introduction

Ferromagnetic objects pose a safety risk in the environment of a MRI scanner due to magnetic forces exerted on these objects. They become projectiles that are accelerated into the bore of the magnet, and/or may experience rotational forces causing possible loss of control of the object in the vicinity of the strong magnet. Finally some mechanical devices may not function properly in the fringe fields of the MRI magnet. Well known examples are CRT displays and motors, but also include devices with ferromagnetic moving parts such as a mechanical wrist watch.

There exist ASTM testing procedures that specify how to measure these translational and rotational forces (ASTM F2052-06 and ASTM F2213-06, respectively). The translation test consists of suspending the object in the vicinity of the mouth of the imaging magnet (where the product of magnetic field and magnetic gradient is maximized) and measuring the deflection angle towards the magnet. Torque measurement is less quantitative, laying the object on a flat surface and observing if there is a net rotation. In both cases there is a comparison of magnetic force to the force of gravity. If the magnetic force is less than the object weight it is considered MR safe (or at least MR conditional).

The purpose of the testing described in this document is to assess if the Amerex fire extinguishers and brackets (Figs. 1-5) are safe to use in the environment of a Bruker ultra high field animal MR imaging magnet. The testing consisted of making translational force and rotation measurements as well as testing the operation of the fire extinguishers while in close proximity of the magnet.

The following Amerex devices were received from Marc Stewart and were tested in the vicinity of the Bruker BioSpec 117/16USR (11.7 Tesla) animal imaging system :

Model	**Description**
Model 322NM	5.0-LB CO_2 Extinguisher
Model B270NM	1.75-Gallon Water Mist Extinguisher
Model B272NM	2.5-Gallon Water Mist Extinguisher
Model 14315	816 Stainless Steel Wall Bracket
Model 810 NM	Heavy Duty Box Type Vehicle Bracket

Table 1. Listing of items that were tested.

Figures 1-5. Photos of Amerex fire extinguishers and brackets that were examined in MRI fringe magnetic field.

Test Procedure

After a preliminary inspection of each device with a 0.5 Tesla handheld permanent magnet (Figs. 6,7) , the devices, held by hand, were carefully brought into the vicinity of the bore of the magnet. The bed of the animal transport system and the opening of the bore of the magnet were protected by sheets of polycarbonate plastic (Fig. 8). No attraction or rotational forces were noted for any of the products with the exception of the small mounting bracket (the force was minimal). Subsequently each test item was suspended from a nylon cord as close as possible to the bore of the magnet (Figs. 8-13), while the deflection angle was recorded (Fig. 14). Any preference of the rotational orientation was noted.

Figure 6. Testing extinguisher with small magnet

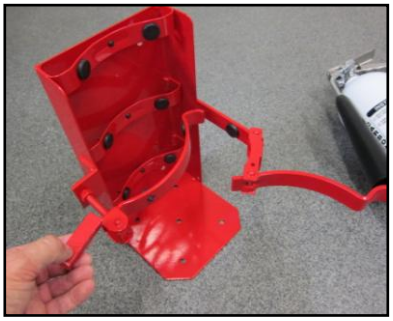


Figure 7. Testing bracket with hand-held magnet

Figure 8. 14315 Bracket.

Figure 9. 810NM Bracket.

Figure 10. 322NM CO_2 Extinguisher.

Figure 11. B270NM Ext.

Figure 12. B270NM Mist Extinguisher.

Figure 13. B272NM Mist Extinguisher

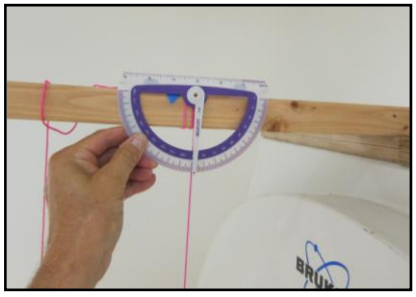


Figure 14. Deflection angle.

Bruker has documentation describing the fringe field of the magnet (Fig. 15), but the figure is not detailed enough to accurately characterize the region directly at the mouth of the scanner. A field plot was measured (Fig.16) using a Bell Model 5180 gaussmeter and the gradient computed (Fig. 17).

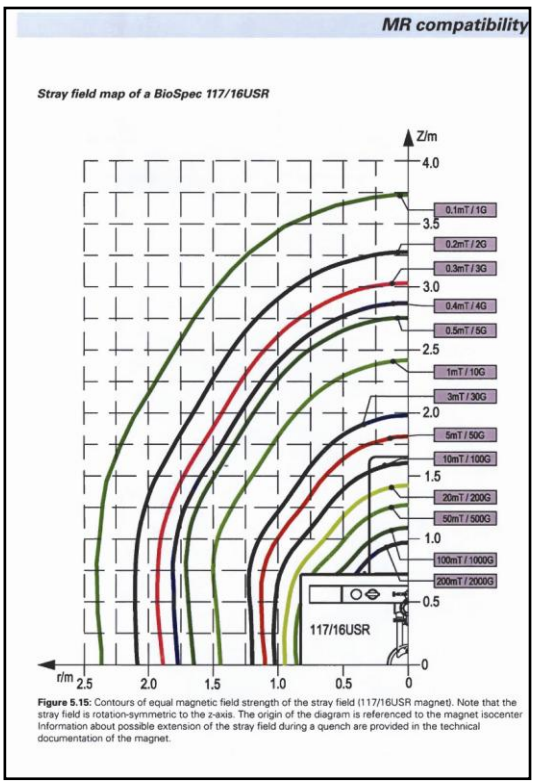
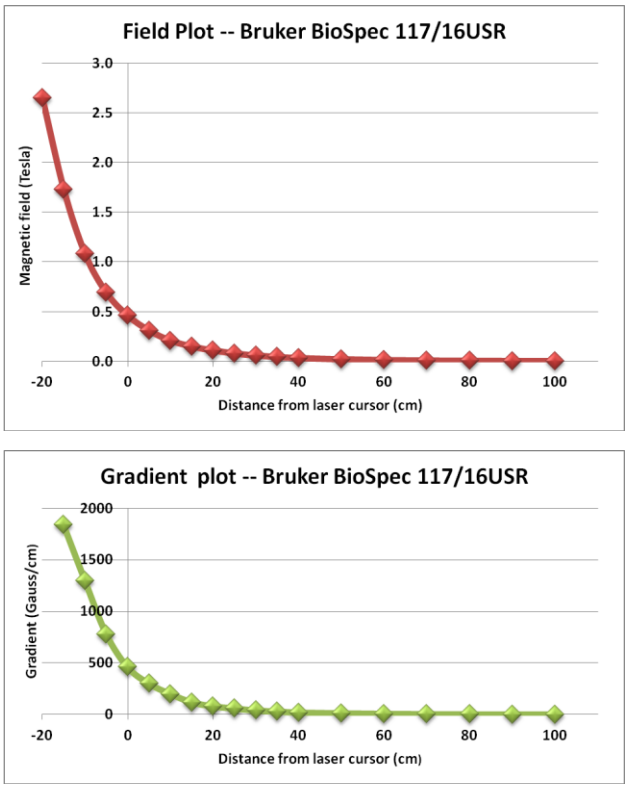


Figure 15. Plot of fringe field.



Figures 16, 17. Field and gradient plot along magnet axis.

Test Results

The magnetic fringe field surrounding this 11.7 Tesla Bruker 117/16USR self-shield superconducting magnet is quite weak. Examining the plotted field parallel to the cylindrical axis of the magnet (Fig. 16) one notes an external maximum 0.5 Tesla reading with only a 500 gauss/cm gradient (Fig. 17). Although this is an 11.7 Tesla magnet, the self shielding is very effective, limiting the external fringe field to very low values. The distances are referenced to the laser cursor which is at the mouth of the magnet. Negative distances refer to points inside the front surface of the magnet. The environment around this magnet system is much safer than around most clinical sized systems. The situation becomes very different once an object enters the bore. Here the field and gradients become extreme, posing very serious dangers to any ferromagnetic object. With the exception of the small SS bracket, all test objects were larger than the 16 cm opening of the magnet.

None of the extinguishers showed a measurable attraction at the mouth of the magnet, but the mist extinguishers had a very weak rotation that slightly favored the hose assembly being closer to the magnet when suspended from the nylon cord. This can be seen in the photos (Fig. 12 & 13). The large red CO_2 extinguisher mounting bracket, Model 810NM, had one pin that was quite ferromagnetic. This was already detected with the small hand-held magnet (the pin shown being examined in Fig. 7), and caused the 5 deg attraction and noticeable rotation documented in Table 2. The small bracket Model 816NM was uniformly weakly ferromagnetic producing an 11 deg deflection at the mouth of the magnet as well as a rotational alignment that favored the long axis parallel to the field direction. There is not a safety issue unless this bracket finds its way into the bore of the magnet, e.g. dropped onto the animal bed close to the magnet bore. The Model 322NM CO_2 extinguisher showed some magnetic damping as one moved the device in front of the mouth of the magnet. The other extinguishers were considerably heavier and larger (see wt column in Table 2) and the effect was not as noticeable.

Model	**Wt (kg)**	**Deflection angle**	**Rotation**	**Fig. #**
Model 322NM extinguisher	5.77	< 1 deg	No rotation.	10
Model B270NM extinguisher	9.53	< 1 deg	Very slight rotation with hose side of extinguisher favored to be closer to magnet.	11,12
Model B272NM extinguisher	12.83	< 1 deg	Very slight rotation with hose side of extinguisher favored to be closer to magnet.	13
Model 816NM bracket	0.057	11 deg	Strong alignment with long axis parallel to field.	8
Model 810NM bracket	1.49	5 deg	Weak rotation to bring ferromagnetic pin close to magnet.	9

Table 2. Results of magnetic force testing.

Each extinguisher was discharged in a vertical position as close as possible to the mouth of the magnet. This was done five times with about a 2 second discharge each time. The extinguisher was rotated approximately 30 deg between each discharge test to sample the effect of possible orientations with respect to the magnetic field. All tests were successful – the magnetic field had no effect on the operation of any of the extinguishers.

Conclusions

Each of the tested extinguishers (322NM, 270NM, 272NM) and bracket Model 810NM are MRI conditional and safe to store and use in the vicinity of the Bruker 11.7 Tesla BioSpec 117/16USR MRI magnet system. There was negligible attraction to the MRI magnet, negligible torque, and only weak eddy current forces when moving the extinguisher in the vicinity external to the magnet. The extinguishers all functioned properly during repeated tests in the highest magnetic field available external to the magnet. The Model 14315 bracket is MRI conditional as long as it is fastened in a manner to prohibit its introduction into the bore of the magnet. Since none of these devices was actually introduced into or tested in the 11.7 Tesla field, labeling must not be worded in such a way to suggest that these devices have been tested at 11.7 T. Rather, they have been tested, found safe and operate properly in the fringe field of this specific animal imaging system. One way to word this might be, "The extinguisher has been tested to operate properly and to pose no safety hazard in the immediate environment of an 11.7 Tesla 16 cm bore MRI magnet." And use the MRI conditional symbol.

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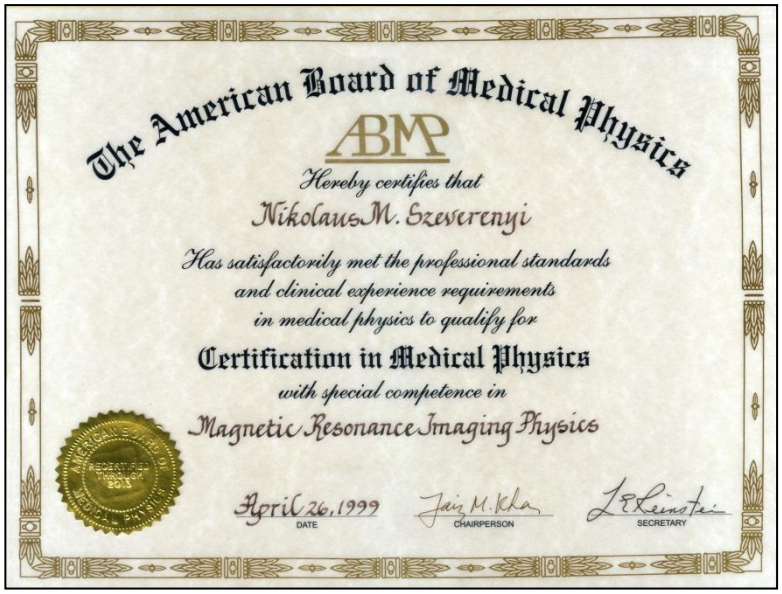
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Figure 18.