

MRI Phantom

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Function:

The goal of this project is to develop an MRI phantom for the quantification of fat. This phantom will be used to test MRI techniques developed by the client for the imaging of fat *in vivo*. The phantom must contain samples of known physiologically relevant quantities of fat. The eventual purpose is quality control of MRI scanners that use fat-water contrast imaging.

Client Requirements:

- **Accuracy:** The concentrations of fat within the phantom must be accurate to within $\pm 0.1\%$. The concentrations must also be reproducible.
- **MRI Constraints:**
 - No magnetic materials must be used for the construction of this device.
 - The phantom must be of appropriate size to fit easily within a standard MRI head coil.

- The materials and chemicals, such as preservatives or emulsifiers must not interfere with the fat/water signal.
- **Range of Fat Concentrations:** The phantom must simulate physiological fat concentrations for different organs in the body. Ranges of samples will need to exist surrounding 5%, 40%, and 90% fat. Concentrations between these target values only need to be sparsely sampled.

Design Requirements:

1. Physical and Operational Characteristics

- a. *Performance requirements:* The concentrations of fat within the phantom must be accurate to within $\pm 0.1\%$ and be reproducible. These values should not change due to degradation for the specified lifetime of the phantom.
- b. *Safety:* Materials used in the phantom should be non-toxic, non-caustic, non-allergenic, chemically stable, and non-magnetic.
- c. *Life in Service:* The phantom should yield consistent measurements for 3 years. It must withstand standard hospital cleaning procedures such as washing with isopropyl alcohol or similar agents.
- d. *Shelf Life:* The conditions of use are not damaging to the phantom so shelf life should be equivalent to life in service.
- e. *Operating Environment:* Strong magnetic fields of, potentially, over 3 T will be used. These should not be damaging to the phantom or negatively affect its performance.
- f. *Ergonomics:* Phantom should be able to be easily handled and transported by one person.
- g. *Size:* Phantom must fit within a standard MRI head coil (20 cm X 20 cm).
- h. *Weight:* It should weigh less than 20 lbs so that one person can easily handle/transport it.
- i. *Materials:* Must consist of non-magnetic materials. No component material should interfere with fat quantification. Materials should also be transparent or translucent to allow for the user to easily detect damage to internal phantom components.

2. Production Characteristics

- a. *Quantity:* Currently, the client only requires one phantom. There may be a market on the order of 1,000 units.

b. *Target Product Cost*: The phantom should cost less than \$100 to produce.

3. Miscellaneous

a. *Standards and Specifications*: Fat/water solutions must be accurately reproducible in large quantities. Dimensions for the phantom also must be standardized for potential mass production.

b. *Customer*: Many potential customers will be familiar with phantom designs that are currently on the market. This phantom should not be too dissimilar as it may discourage its use.

c. *Patient-related concerns*: Phantom will be placed into the same scanner as a patient. Therefore, the phantom materials must be non-toxic, non-caustic, non-allergenic, and chemically stable. The phantom must not leave residues upon surfaces it comes into contact with.

d. *Competition*: Other quality control and research phantoms exist but few deal with fat quantification.