

# Project Design Specifications—Phantom for Microwave Ablation Testing

September 13, 2010

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## Problem Statement:

Microwave ablation is a medical treatment for many abdominal cancers *in vivo*. Thin antennas positioned in the tumor cells deliver microwave energy to destroy the tumor cells. This method has achieved some clinical success; however, improvements for devices and ablation techniques are in demand. The current tissue models are heterogeneous and inconsistent and impede device development. Dr. Brace is currently developing new ablation devices and desires a reliable medium to test his innovations. Our collective goal is to create a phantom for microwave ablation that is nearly transparent, mirrors the dielectric and thermal properties of a liver, and provides visual identification of ablation zones.

## Client Requirements:

- Reproducible
- Homogenous
- Ideally transparent
- Cost effective
- Similar conductivity and permittivity to the liver
- Clearly marks ablation area

## Design Requirements:

### 1) Physical and Operational Characteristics

- a) *Performance requirements:* The phantom must be able to withstand high temperatures without melting or deforming (160-180 degrees Celsius). It must mimic the liver when subjected to a 2.45 GHz microwave frequency. Ideal permittivity of the phantom should be  $45 \pm 5$  F/m and conductivity  $1.7 \pm 0.2$  S/m. It must distinguish ablation areas when the temperature exceeds the threshold of 50° C.
- b) *Safety:* The phantom must not produce harmful gases or liquids when heated. No hazardous materials can be used.
- c) *Accuracy and Reliability:* The phantom must perform consistently for repeated tests. The results need to be within a range specified by the client.
- d) *Life in Service:* The phantom may be utilized for one time use only if readily producible.

If reusable, it must remain stable and accurate while providing desired amounts of testing for cost.

- e) *Shelf Life*: For one time use, the phantom must be able to sit refrigerated or at room temperature for one week. If reusable, it must thrive under a longer shelf life to provide a larger time frame for use that is satisfactory to the client.
- f) *Operating Environment*: The phantom must be able to perform in standard laboratory conditions. During ablation, it must withstand very high temperatures exceeding 160° C.
- g) *Ergonomics*: The phantom solution must be easily produced and portable.
- h) *Size*: The phantom must be approximately the size of a human liver.
- i) *Weight*: Weight restrictions are not specified but should be easily handled by one person.
- j) *Materials*: Materials must mimic the organic qualities of the liver. It must be cost effective. Ideally the phantom would be transparent until subjected to microwave heat.
- k) *Aesthetics, Appearance, and Finish*: The phantom does not need to model after the appearance of the liver.

## 2) Product Characteristics

- a) *Quantity*: Enough phantoms must be produced for tests and demonstrations.
- b) *Target Product Cost*: Total cost must be within \$20-\$30 for several ablations. The client will pay more for reusable prototype and greater precision.

## 3) Miscellaneous

- a) *Standards and Specifications*: The phantom recipe must be reproducible and accurate to properties of liver.
- b) *Customer*: Dr. Brace would like a phantom he could use to reliably determine differences in microwave ablation devices.
- c) *Patient Related Concerns*: N/A
- d) *Competition*: Microwave ablation devices are currently tested on animal livers and excised human liver tissue.