

Small Animal Barostat Instrument Design

ECE 480 Design Team 7
Sponsor: Michigan State University
Department of Pharmacology & Toxicology

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Design Issues
April 15th, 2011

Project Overview

The Department of Pharmacology and Toxicology at Michigan State University is currently conducting research to better understand the symptoms and treatment of Irritable Bowel Syndrome (IBS). To aid in their testing, Dr. James J. Galligan of the Department of Pharmacology and Toxicology requires the use of a device known as a barostat in his laboratory. A barostat is a medical device or structure that is used to deliver a constant pressure to a region of interest. In order to maintain a constant pressure, most barostats will use a distention balloon. ECE 480 Design Team 7 has been asked to produce said barostat.

In developing this technology, a variety of design issues must be addressed by Design Team 7 when considering how this device will be used and what it is made of. Included in these issues is what the market outlook is for a device like this as well as what is known as the Voice of Customer (VOC). Additionally, Design Team 7 has to consider the product life cycle of the barostat they build. Finally since this barostat will be used exclusively on small mammals, the design issue of animal safety and animal rights will have to be considered.

Product Market

In conducting research, Dr. Galligan discovered that there is only one company currently producing a fully functioning electromechanical barostat. This barostat is produced by G and J Electronics Inc. and will meet all of the specifications needed for the purpose of applying gastrointestinal pressure on small mammals. However due to the fact that each of these barostats are assembled by hand, the cost of this device is extraordinarily high at \$26,000. It is almost not feasible to buy one of these units for use in a laboratory where funding may be limited. Also the recent G and J electronics model has not been updated much from the previous models due to the lack of competition in

the market. The high cost limits access by university research groups and small commercial laboratories.

Design Team 7 has been asked to attempt to create a product that replicates the results of the current market standard on a budget of \$500. Since G and J electronics has not had the need to update their barostat, many of the components used are out of date and much cheaper than they were when the first one was sold around 1992. Given this fact, it may be feasible to think that Design Team 7 can produce a marketable device on a limited budget. If this new product can be created on a budget of \$500, it could be replicated and sold for a much cheaper cost. In drastically reducing the selling price of the barostat, there will be strong appeal for several groups that need to make use of such a device such as university research groups and small commercial laboratories.

Voice of Customer

Since the current market standard appears to meet all of the needs required by the Department of Pharmacology and Toxicology, Design Team 7 will have to consider the VOC of Dr. Galligan and his laboratory. For the design of the barostat, Dr. Galligan had specific constraints that the device must follow, the first of which is that since we are working with a small mammal, the barostat should never exceed a pressure of 80mmHg. To accomplish this, a pressure sensor will be used in feedback with a micro-controller to communicate if the pressure limit has been exceeded and correct the issue.

Another issue that needs to be addressed is that with the current laboratory set up used by Dr. Galligan's research team, is that the desired pressure is administered by a lab assistant via a syringe. The problem with this is that the pressure must be increased slowly by the assistant as not to exceed the desired pressure. The result is a delayed rise time as well as a significant overshoot that can be equated to human error. The hopeful goal is to have the pressure to increase from 0mmHg to the desired pressure as instantaneously as possible and retain that pressure for a duration of ten seconds. To

achieve this, a motor controlled stepper motor with a lead screw will be used to push a syringe to increase the pressure at a high rate of speed. To maintain the desired pressure, the use of the pressure sensor in feedback will be utilized to communicate with the micro-controller what the pressure is and if it should be increased or decreased. In meeting all these demands, hopefully, a marketable and user friendly product can be generated.

Product Lifecycle

When creating a product, the whole life cycle must be taken into account. The initial stage of product life is the part selection. In this process, the design team has direct control on the amount of circuitry the device may need and therefore, can control the amount of hazardous materials present in the lead solder and the polyvinyl chloride wiring. The circuit boards all contain lead soldering. The lead in the solder can pollute the environment as well as possible issues to the human body. While the solder is now a mixture of tin and lead in a few different ratios (60/40 and 63/37), it still contains a large enough amount to still cause health issues. The use of non-lead solders has become a viable option, but the results from this solder does not allow for a great conductive joint in the circuit board and because of this, the non-lead solder is not widely used in practice. To dispose of the lead solder, it must be melted off of the circuit boards and put into a certified transport container (with appropriate hazard indication) and delivered to a certified disposal plant, where the solder may or may not be recycled. The device in question will have a usable life span where it will be able to operate with no problems (usually until a new model comes out) and run without any problems or issues. To create the device, you must decide what types of materials you will be using. In the case of electronic devices, lead solder and use of polyvinyl chloride in the wiring is almost mandatory for any streamlined product.

Every product must be disposed of at some point, usually at the end of the life cycle. In the case of the barostat device, there is an issue with the amount of electronic components that are used to perform the desired tasks. The circuit boards contain lead

and wiring contains polyvinyl chloride. These two hazardous materials are only dangerous in large amounts or prolonged exposure to the materials. The lead in the solder joints can have serious impacts on the life of an individual; if the exposure to the lead is extreme (water, ingestion) and it can cause birth defects to newborn children if the parents are over exposed to it as well.

Animal Safety / Animal Rights

Another design issue to be addressed by the ECE 480 Design Team 7 is animal rights. To perform any type of laboratory testing on an animal requires that strict regulations be followed so that the animal is not put through any form of harm [1]. For the purpose of the Barostat device, there are strict regulations to the pressure that can be used during the IBS testing. As mentioned previously, it is the preference of Dr. Galligan and his research group, to limit the maximum pressure allotted for inflation to be 80mmHg.

Animals used in any lab experiment must be treated with a form of scientific respect. The animals must be used in a manner as to not injure the creature while the experiment is being conducted and the animal must also be kept in an environment that will keep the creature safe and with a minimal amount of stress. If there is a medical issue with the animal, the facility is also required to treat the animal for the medical issue or, if appropriate, euthanize the animal.

The main issue Design Team 7 is tasked with is maintaining the pressure in the distention balloon under the maximum of 80mmHg. If this pressure maximum is exceeded, the animal may be put in some physical distress, which will cause physical harm. For this reason, the device design must include a emergency release that will cause the pressure in the balloon to be released immediately.

Summary

Developing a barostat can be a delicate and painstaking process considering all of the design issues that accompany creating this type of product. It is this reasoning that may be why there is only one brand of barostat currently sold on the market. It must be noted that not only should such a device be user friendly and adequate, but safe and as pain free as possible for the animals and assistants involved in the testing process. In addressing and overcoming these design issues, it is the aspiration of Design Team 7 to create such a product in the hopes of opening the market to more university research groups and small commercial laboratories who otherwise could not afford such a technology.

Works Cited

- [1] Office of Laboratory Animal Welfare, *Public Health Service Policy on Humane Care and Use of Laboratory Animals*, Aug. 1st, 2002. Available at:
<http://grants.nih.gov/grants/olaw/references/phspol.htm#AnimalWelfareAssurance>