Release Lanyard Design

By:
Andrew Baker, Tim Haynes, Styson Koide,
David Lofgreen, Carly Siewerth and Chris Temme
Team05

Concept Selection and Engineering Analysis/Research

Document

Submitted towards partial fulfillment of the requirements for
Mechanical Engineering Design – Fall 2012

Department of Mechanical Engineering
Northern Arizona University
Flagstaff, AZ 86011

Table of Contents

Introduction

Raytheon Missile Division located in Tucson, Arizona is a well-known company that specializes in defense electronics. They have discovered that their current lanyard system design is highly susceptible to extreme temperature changes and contaminants. These environmental conditions have triggered multiple failures. As a result, Raytheon has presented our team with this engineering problem. Our previous reports have revealed a steady progress and we've been able to stay on schedule as shown in our Gantt charts. However, in this last segment of time, we've run into a few obstacles that put us back a step or two. In this report, we will reveal the research our team performed, some of the analysis that has been carried out, future analysis to be executed, and the design our team plans to proceed with.

Problem Statement and Goal

The current release lanyard design does not address issues relating to extreme temperatures and environmental effects, which leads to system malfunction. Our goal is to design a reliable, low cost system that can withstand extreme temperatures and environmental effects. This system will also be constrained due to size and specific material requirements.

After a recent meeting with our client, the emphasis of our design analysis has changed to focus primarily on the activation area instead of the entire lanyard system. This changed the original design problem from redesigning an entire lanyard system to redesigning the activation area, which disregards the cable and cable guide components.

Concept Research/Analysis

Previously, our team identified the potential areas of redesign. The categories of redesign pertained to the:

1. Cable Options
2. Cable Guide Components
3. Activation System

- **Lubrication Concept**

One concept that was researched pertained to lubrication. The concept of lubrication seems rudimental, but was an idea that could possibly be the key to a reliable mechanism. Lubrication not only reduces friction, but reduces the amount of wear, minimizes corrosion, and assists in keeping contaminants out of the system.

This concept required a lubricant that would maintain its lubricity and viscosity despite being exposed to extreme temperatures. After research, it was discovered that lubricants developed by DuPont™ Krytox® could meet these requirements. These lubricants were developed precisely for lubrication needs in the aerospace industry. Research revealed that their current products met the safety, reliability, and were in compliance with the specifications of the military.

The DuPont™ Krytox® perfluoropolyether- (PFPE-) based oils and greases feature properties ideal for aerospace applications. These properties include:

- Wide Temperature Range (in which lubricity and viscosity aren't affected): -70 °C to 399 °C (-100°F to 750 °F)
- Stable Physical Properties Over Time
- Unaffected by Harsh Environments (vibration, heat, pressure, corrosive chemicals and radiation resistant)
- No Vapor Loss in a Vacuum (high altitude)
- High Compatibility for Most Materials (metals, plastics, finishes, etc.)
- Non-flammable, Nontoxic, Inert, and Non-evaporative

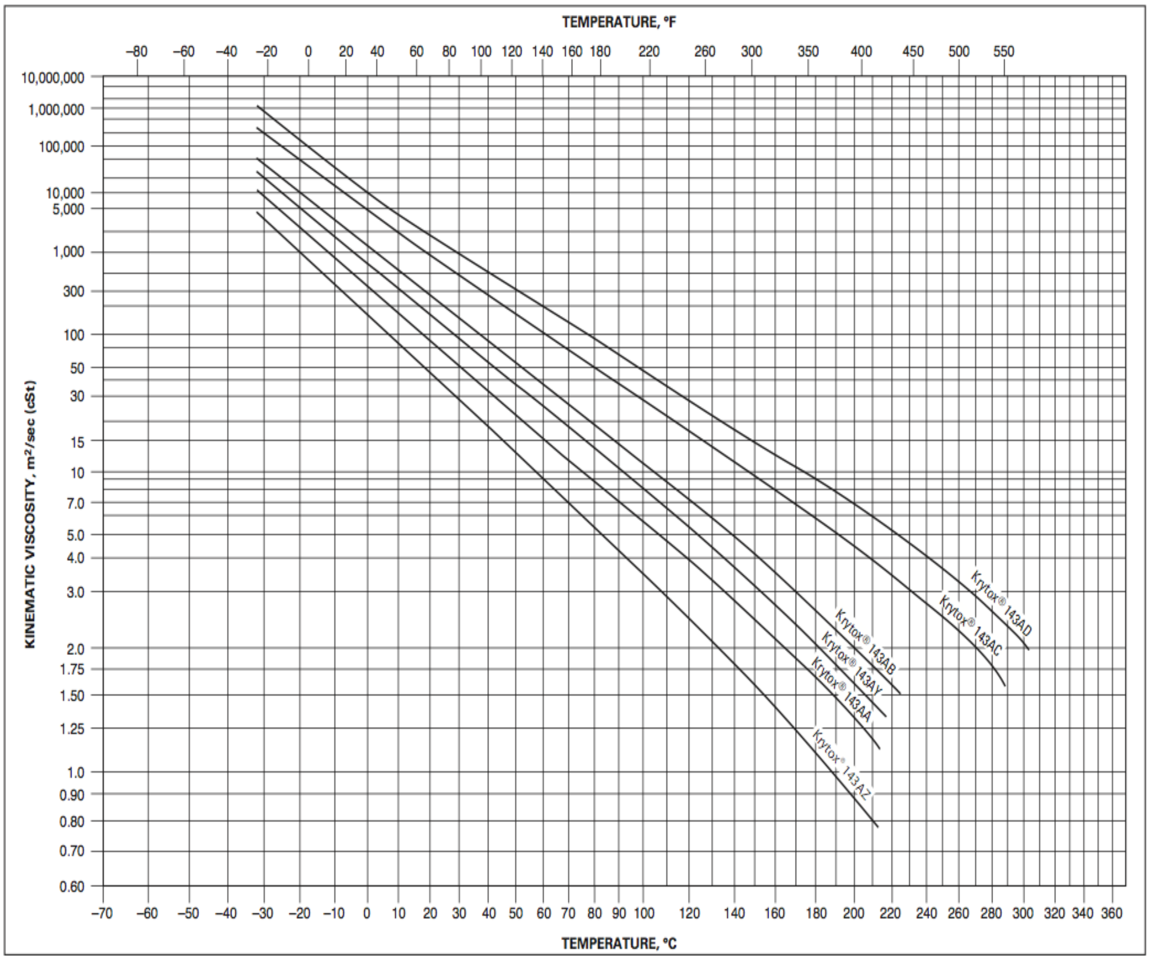

Figure 1: Lubricant Kinematic Viscosity vs. Temperature [2]

The figure above shows how the kinematic viscosity of the lubricants varies in relation to the temperature it operates in. Viscosity is defined as the resistance of a fluid to deformation. As can be seen, the kinematic viscosity has a negative correlation with respect to temperature. When the temperature is at the lower end of the spectrum, viscosity is rather high, but as temperature increases, the viscosity decreases.

Some of the current applications of this aerospace lubricant included the usual bearing applications, O-ring applications, but also utilized in wing flap actuators, lunar rover, rocket engine assemblies, and Oxygen breathing systems. The team was about to request a sample from the company to perform additional analysis, however after speaking with our client it was discovered that lubrication had recently been applied. Unfortunately, the lubrication concept was merely a temporary fix. There were concerns with how the lubrication would be affected if contaminants were encountered, how it might affect the mechanisms scheduled maintenance and maintenance costs.

- **End Cap Design**

The primary purpose of the end cap design is to prevent the accumulation of ice and other debris from forming within the cable guides. To achieve this, lightweight deformable caps will be located at one or both ends of the guide tubes. This will essentially block most moisture and other material from entering the guide tubing. A SolidWorks image of this design is displayed in Figure 2.

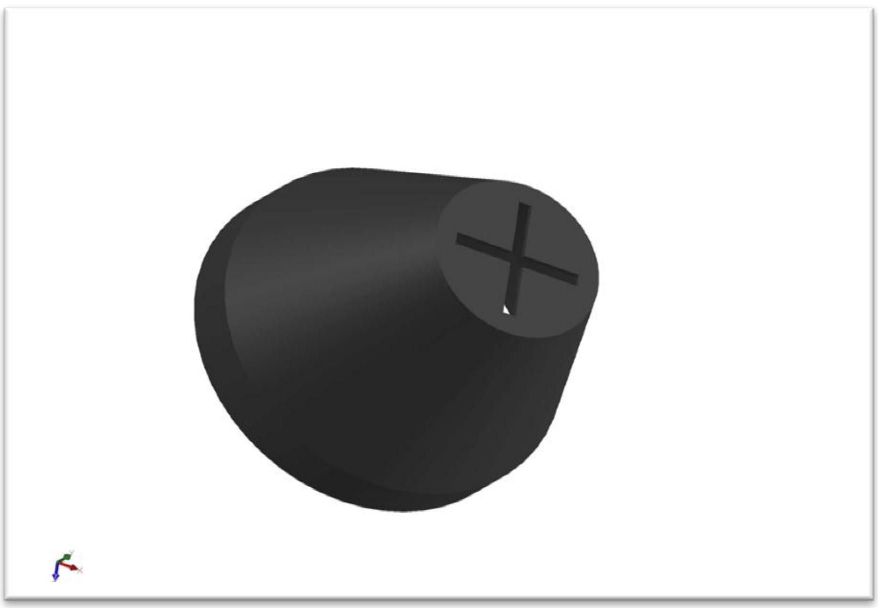

Figure 2: End Cap design

Based on the information provided by Raytheon, the release lanyard system must demonstrate a temperature range from –50°C to 150°C which means that the end cap material needs to have a working temperature that encompasses this range. Three materials considered were flurosilicone rubber, silicone and Teflon PolyTetraFluoroEthylene (PTFE). The first two materials considered, flurosilicone rubber and silicone, have working temperature ranges of -74°C to 175°C and -60°C to 200°C respectively. Both of these materials are resistant to most fuel emissions, which show that either choice would be ideal for this application. However, these materials are primarily used for static situations due to poor abrasion resistance [5]. The last material considered, Teflon PTFE, was found to have a working temperature range of-73°C to 204°C. This material is also resistant to most fuel emissions and works well under dynamic situations [1].

Based on these specifications, Teflon PTFE appears to be the most suitable choice for this application. However, more research must be done to determine if this material will perform normally when exposed to particular types of fuel emissions. This material must also be evaluated to determine if it is a suitable choice for manufacturing.

- **Cable Coating Design**

The main purpose for investigating cable coatings is to eliminate the cables exposure to the environmental elements. Possible coatings that could be used are Tyvek® and Teflon® tubing, an image of Teflon tubing can be seen below.

Figure 3: Teflon Tubing [4]

Based on the working range for the lanyard, the tubing must withstand the temperature range noted in the previous section. The Teflon tubing has a working range of -270°C to 260°C, and the Tyvek® has a working range of -73°C to 132°C [3]. Due to the working range of the lanyard, the Tyvek® is not suited for this application and consideration on the Teflon® tubing will be pursued.

Based on working temperature ranges, Teflon® tubing seemed like a viable option for consideration. However, based on the information given to us by Raytheon and a number of other studies done on similar applications this solution will most likely produce failure. In some studies the application of a stainless steel wire coated by Teflon® tubing induced corrosion [6].

- **Device Casing**

  The top two designs that we are looking into prototyping for our client, Raytheon, consist of a casing concept and a servo activation device. For any design our team pursues in it will involve a casing device, which can be viewed in Figure 3 below. By using the casing concept we can decrease the amount of condensation that will build up on the activation mechanism by providing a shielding over the entire activation area. By keeping the activation device free of ice and debris, contamination will decrease and the failure rate of the device will also decrease. Installation of the casting will only add a very small amount of time to preexisting procedures, since this component is designed to use the same mounting points as the previous design. The pieces that will change in the assembly process will be the screws, which will hold the casing and activation mechanism in place. The only reason for changing the screws is that they need to be longer in order to hold the casing and activation mechanism to the weapon. With the casing being a small item Raytheon has the ability to machine the casing in their facilities using standard tools such as a milling machine.

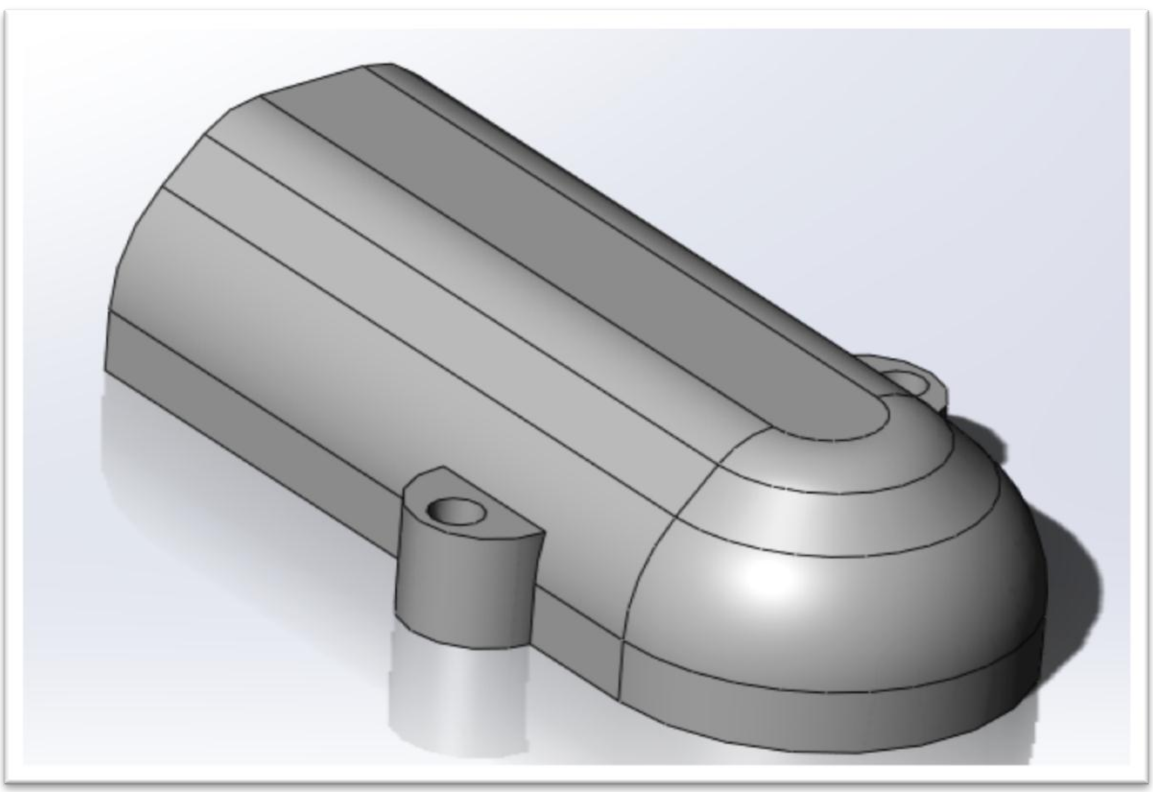

Figure 4: Casing

- **Servo Mechanism**

  The servo activation device was thought of to eliminate as many mechanical parts as possible. This would help prevent ice and debris from building up on the device with the changing environments Raytheon has asked us to consider into our design. A servo is made up of three main parts the first being a computer processor that communicates a signal back and forth from the motor and a secondary computer. Second key component of a servo is the motor that turns a set of gears a certain degree clockwise or counter clockwise, and lastly is the only mechanical aspect to the activation device which is a set of gears. The computer processor and motor components can be view in Figures 4 and the set of gears can be viewed in Figure 5 below. To protect these key components, the servo has its own housing to protect it from the environment. Having the gears already in a case will keep ice and debris off the gears improving the mechanical aspect and allow us to place a safety pin in the activation design, which Raytheon as required us to do. The servo will only be replacing the mechanical activation mechanism that is currently being used, and all the existing cable, cable housing, and attachment points will still be in used. To have the weapon activate, the servo will be hooked up to a small battery pack that will send the current to the weapon's battery once activated. To activate the servo a cable will be pulled and turn the gears of the servo an arbitrary amount before the cable breaks. Once the servo has turn an arbitrary amount the servo will allow the current in the extra battery package to follow freely down to the weapon's battery. With this the weapon will now be activated and ready to be used. When consiering these two designs we needed to look at materials that will not corrode under the extreme environmental conditions and materials that can withstand these conditions for long periods of time.

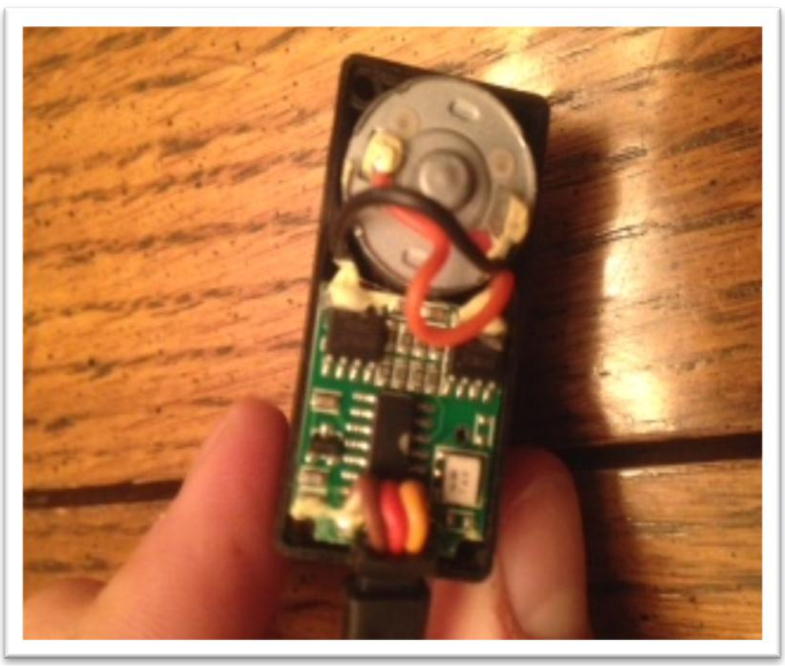

Figure 3: Computer and Motor Components of a Servo

Figure 4: Gears of a Servo

A method of analysis of our design will include testing. First we will test the servo at room temperature to verify that it will be able to perform the tasks that we would like it to. Then we will test the servo at varying temperatures between -50° Celsius to 150° Celsius to see how the servo responds at the extreme temperatures. We will also test the material of the housing and the casing of the servo to understand how they react to the exhaust fumes of the vehicle. To test this we will first weight the raw material and then soak the material in fuel used by the vehicle. After soaking it we will allow the material to air dry and then we will reweigh the material and calculate any change in the weight.

- **Conclusion**

Due to the project alterations from our client, and basic analysis seen above, the designs mentioned above will be neglected for further analyses. The remainder of this project will primarily focus on the activation area, which will be discussed in the above section. The desired features that were still considered in this concept analysis, research and selection process include:

1. Easy to Correctly Assemble and Install External Cable, Guides, and Activation System while in the Field
2. Cost Less than the Current Design

Gantt Chart

Looking at our Gantt Chart below in Figure 6 you can see that as a team we have kept close to our original dates set at the begin of project, which are viewed by the solid green bars. The dark solid gray bars are there to designate the different sections of our project phase and the time aloud for each section. The light gray bars that go across the entire Gantt Chart represent the sections that have been completed. We have also had to change the time spend on sections of our project and this can be viewed by the solid yellow bars on the Gantt Chart.

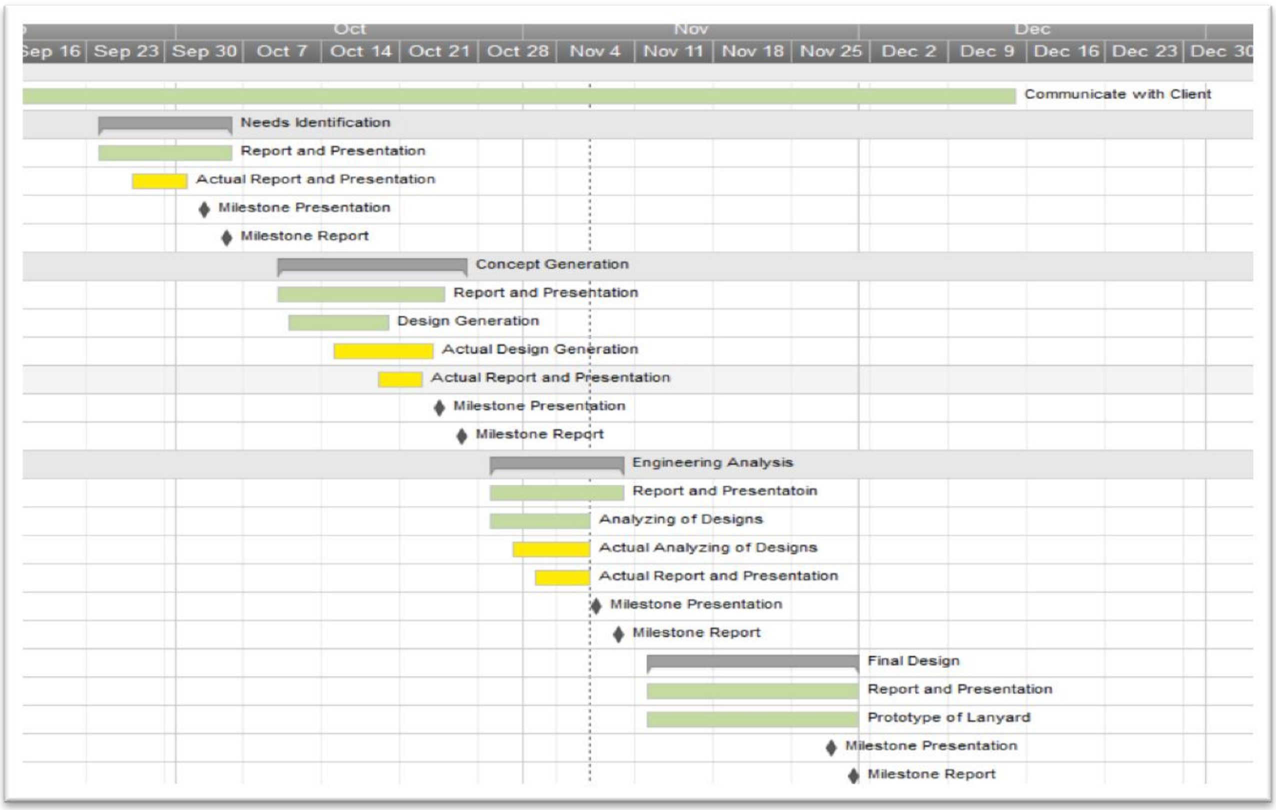

Figure 5: Updated Gantt Chart

References

1. "Boedecker.com." *DuPont™ Teflon® PTFE Specifications*. N.p. Web. 15 Nov 2012. <http://www.boedeker.com/teflon_p.htm>.

2. "Dupont.com." *DuPont™ Krytox® Aerospace Grade Oils and Greases.* N.p. Web. 15 Nov 2012 http://www2.dupont.com/Lubricants/en_US/assets/downloads/H-58519-7_Krytox_Aero_Grade_Oils_and_Greases.pdf

3. "Dupont.com." *DuPont™ Tyvek*®. N.p. Web. 15 Nov 2012 <http://www2.dupont.com/Tyvek/en_US/products/product_properties.html#range >

4. "Environmental Equipment & Supply" Tubing. N.p. Web 16 Nov 2012 <http://www.rotaloc.com/PTFE-Tube-Rod.html>

5. "Materials." *American High Performance Steels*. N.p. Web. 15 Nov 2012. <http://www.ahpseals.com/tech/materials.php>.

6. "Mcnallyinstitute.com" Corrosion Problems Associated with Stainless Steel. N.p. Web. 16 Nov 2012 <http://www.mcnallyinstitute.com/04-html/4-1.html>