Nitrogen Supply and Distribution

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Project Formulation and Project Plan

Document

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Introduction

The U.S. Naval Observatory (USNO) does research for the Naval Research Laboratory in providing astrometric positioning which is used for navigation and timing for the U.S. Department of Defense. Most military and GPS navigation is still based on the position of the stars and the process of orienteering. Because the stars are ever shifting, the U.S Navy is required to continuously map the location of stars. The Navy accomplishes this by the use of the Navy Precision Optical Interferometer (NPOI). Our sponsor, the operators of the NPOI, works under the USNO. The NPOI located south east of Flagstaff, AZ on Anderson Mesa. The research done in this facility involves precise observations of the astronomy needed for navigation use.

The NPOI is considered an array telescope. It consists of three 300meter arms that have observatory like mirrors along each arm. By utilizing an array, the optical surface being studied is effectively the diameter of the whole facility. Using the mirrors at the ends of the array has an equivalent effect of employing the use of a 600meter diameter solid mirror. These mirrors are used to direct optical light, the visible light spectrum, into a lab facility that further studies the image.

To operate and manage this system of mirrors, each station is equipped with a gaseous nitrogen supply. This consists of a 150lb rented nitrogen tank at each of the 11 stations on each of the three arms. The gaseous nitrogen is used to accomplish mainly two tasks. The first is the purge the mirrors of any moisture buildup that may ruin the mirrors. Nitrogen is pumped directly onto the mirror surface whenever the array is not in use, which keeps water from accumulating on the very delicate reflective surface. Aside from this, the nitrogen is also employed for a series of pneumatic actuators. Surrounding the very expensive mirrors are housings and flaps for protection. In order to open these flaps to let light through for observation, nitrogen is sent to a pneumatic system that opens the coverings with no vibration due to water in the line or any debris.

On behalf of NPOI, our clients Jim Clark and Steve Winchester have requested an improved Nitrogen Supply system.

Needs Identification

Navy Precision Optical Interferometer has approached us with this project in pursuit of improving their Nitrogen supply system. It is currently a cumbersome system that involves more work than intended for our client. In order to provide an improvement, our client gave us some specific requirements to meet their needs. These requests include:

- One single supply station
- Flow time to stay within time constraint to prevent a waste in Nitrogen
- Continuous flow at a lower psi level
- Nitrogen tubing to withstand corrosion
- Tubing that handles potential temperature drops within cable trays where thermal expansion can occur

- Tubing strong enough to prevent failure from vibrations within cable tray

Based on these needs, we have concluded that our client needs an easily operable Nitrogen supply system that is not labor intensive with little cost effectiveness.

Project Goal

The goal of this project is to design the Nitrogen distribution with one supply station to replace the several that are currently in use and to have a system that prevents a waste in Nitrogen gas. In order to prevent any further waste, the improved design must have the supply shut off when required. There are currently 11 supply stations along each of the three 300 meter length arrays. Within each station there are supply tanks that are routinely refilled to maintain Nitrogen levels.

Our client has emphasized that the waste in nitrogen affects the cost of supply and renting of the supply tanks itself. Site operators themselves refill each station with nitrogen tanks manually, which is labor intensive.

Objectives

When creating this system, three runs of nitrogen compatible tubing are connected to a large supply tank. This tubing must be of a diameter that is large enough to handle the necessary flow rate, but small enough to fit inside the cable tray. Since the system will undergo a large change in temperature, the tubing must have a small enough thermal expansion coefficient that it does not induce a large amount of stress on the tubing or brackets. Any vibrations that affect the tubing must be of a low enough amplitude that an infinite amount of cycles will not reduce the life of the system. Although there is no budget for the finalized system, it is also important that cost be kept as low as possible.

Table 1: Table of Quantifiable Objectives

Objective	**Measurement Basis**	**Units**
Inexpensive	Cost	$
Tubing size	Diameter	m
No significant change in size	Length	m
Vibration resistant	Cycle life	# of cycles

Operating Environment

The NOPI site is located in a high elevation environment. It is located in this area for the advancement of their research. However, the effects of the environment place constraints of what material and how it can be supplied efficiently throughout the site. The location of the facility must take into account the exposed system to rain, snow, ice, UV light and potential wildlife interfering with its operating environment. There is a temperature gradient that creates a concerning factor for moisture and thermal expansion. The supply system must be able to operate between the temperatures of -20^{O}F to 120^{O}F.

The supply of nitrogen is dispersed to each station by means of nitrogen tubing along cable trays. The cable trays are run along the stations and are exposed to the atmosphere as well as with other machine operating cables. These cable trays vibrate and therefore require that the nitrogen lines have a life cycle high enough to prevent fatigue and damage in their line.

Constraints

To meet the needs of the clients, each of the three runs must be 300m long with 11 manifolds on each. These manifolds will have 5 ports each, and a regulator attached to each port. Each of the ports should be able to provide 0.5 [ft^3/hr] with a maximum combined flow rate of 10 [ft^3/hr]. The regulators will be used to ensure that the mirror cover purge receives 9psi, the lizard head actuator receives 30psi, and the gate valve (only on one manifold per run) receives 40psi. Rather than allowing the nitrogen to flow all night when the mirror cover is removed, a solenoid will be put in place to stop flow if the cover is not in place. The client also requested that a valve be put in place before each manifold to allow the flow to be manually shutoff. Since the instrumentation at NPOI is extremely delicate, the employees do not want to add another fragile item to the workplace. Therefore, the nitrogen system should be tough enough that the employees do not have to go out of their way to ensure that they are extremely careful with all of the lines, fittings, regulators, etc.

Conclusion

The Navy Precision Optical Interferometer provides important data that is used for navigation by military personnel as well as civilians. Nitrogen is used by this facility for several different tasks, and it is important that the supply system does not interfere with the data collection at the location. If a system can be built that works as well as the client visions it, the NPOI employees can spend less time moving and setting up nitrogen tanks, and more time collecting data and improving the technical aspects of the instruments. The supply system must be able to accurately provide the flow rate and pressures required by the different objects, and withstand all of the harsh weather conditions that are found in Flagstaff.

References

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[3] "USNO Flagstaff Station." *USNO Flagstaff Station.* N.p., n.d. Web. 06 Oct. 2013.