Construction-Driven Execution Design Challenge: PUMP IT UP (Template)

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## Introduction

The AquaDucks team is composed of three mechanical engineers who wanted to push the limits of their problem-solving abilities. Joseph Amar, the team lead, works for NASA as a co-op student at Johnson Space Center. Zach McBurney works as an engineering intern at a construction firm in League City, and Saul Pizano has significant experience with CAD modeling and building concepts, but seeks to hone his other engineering skills.

This task was extremely difficult to complete from a time perspective. Even spending nearly every free minute on the project was not enough; the challenge was almost two weeks underway when we learned of it, making every second count that much more. This was the greatest difficulty of the whole project: gaining a firm grasp of the challenge and its interconnected variables, developing techniques for optimizing these variables with respect to cost, and doing it all in about two weeks while balancing school and personal obligations.

The three most important/useful lessons gained through this process were:

1. We are always capable of accomplishing more than we initially think is possible.
2. Your solution can only take advantage of combinatorics if you know what that word means.
3. Heroic efforts are all well and good, but much more valuable is consistency: do a little bit at a time, regularly, until you cross the finish line.

## Hydraulic Calculations Explanation

The hydraulics portion of the design consists of the pipe thicknesses along with the pump choice and location. Using the AFT Fathom software, it was quickly established that with all else held equal, the maximum static pressure in the system would be minimized by placing the pump location further toward the outlet. However, this minimization technique has a built-in limiter: the pump cannot be placed so far down the line that the pressure at its inlet is negative. In fact, each pump has a criterion known as Net Positive Suction Head (NPSH), which is required at its inlet in order to avoid cavitation. The NPSH Available (NPSHA) scales linearly with the pressure in the line; so, place the pump too far down the line, and it will cavitate. Place it too close to the source, and it drives up the maximum pressure in the system, increasing the required wall thickness for the pipes, and therefore, their mass and cost.

Two major assumptions were made throughout this process:

1. Only the (5) different schedules of 30” pipe wall thickness available in AFT Fathom could be used in the various mill runs.
2. An increase in wall thickness (at the scales available in the aforementioned schedules) produces a negligible decrease in the static pressure of that line (Bernoulli’s equation).

As directed, only the “STD” schedule wall thickness was used in the AFT Fathom simulation.

Code was written in Python

1. Show the design basis
2. Assumptions (if any)
3. And calculations.

## Excavation Calculations

1 Show the design basis

2. Assumptions (if any)

3. And calculations.

## Foundation Calculations

1 Show the design basis

2. Assumptions (if any)

3. And calculations

## Modularization (Pros and Cons)

This is the process in which we utilize a compact design of process equipment and condense the pipe, steel, and instruments so that it can be fabricated safely and with high quality control. The entire module is then moved to site and set in place with minimal efforts in the field. Show in your narrative what aspects of the design have the scope for modularization and list the pro-cons of modularizing the design.

## Zero Based Execution (show calculations)

This is your team’s primary opportunity to provide design innovation to the overall concept. This is Fluor’s term for revisiting the early decisions that were made on a project that may have inadvertently driven cost and schedule high. For example, in this case if the pipeline is operating 24 hours, thereby reducing the flow rate condition.

It was also decided that the pump cannot be placed within the first 30,000 feet of the start of the pipeline; if that decision was revisited, how it could positively impact the overall cost of the project. Show calculations for how it impacts the design (wall thickness, pipe diameter, pump size, etc) and how it leads to lower costs.

## Risk Assessment

Your team will be tasked with determining the risks of the project and quantifying them in terms of costs. Several sets of criteria will be given to the teams so that they can brainstorm the issues and provide mitigations against those risks. Now that you are familiar with aspects that entail design, costs of procuring and installing them, identify five risk areas and your plan to mitigate them. List your assumptions

## Innovation Idea

Any idea you have come up during design development that you think would improve safety, ease of construction, or cost/schedule.