Economic Viability of Supplemental Piping

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This **White Paper** describes the methodology CCG uses to evaluate cost while designing the chilled water piping distribution system. By combining owner requirements and industry best design practices with agile modeling software and custom cost-estimating spreadsheets, CCG is able to provide clients with a final piping design that is both operationally and financially efficient.

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Introduction

The volume of distribution piping for chilled water in data centers is typically designed to be minimized while maintaining the redundancy necessary to ensure uptime during maintenance or failure events; individual piping designs vary greatly, but they must maintain the ability to fulfill mission critical requirements. Often, it seems logical to assume that the simplest arrangement of piping may be best to meet design requirements, but from an economic standpoint, this decision is not always sound. This paper discusses 1) how capital cost may be optimized by examining various system piping configurations and 2) demonstrates how CCG investigates the economics of designing for fewer larger pipes vs a greater number of smaller pipes.

Dynamic Flow Modeling To Optimize Performance

Baseline Design

Figure 1 is a flowchart showing the process followed to design a piping distribution system. The baseline design is determined by using the owner's program requirements and industry standards to develop a piping schematic reflecting the layout of the data center and the location of the central plant. This schematic is entered into a computer model and populated with estimated pipe sizes, fittings, valves, coils, pumps, and other accessories. Once populated, the model is run through a number of simulations, including maintenance and flowrate variation scenarios, to validate the design. The resulting baseline is then the benchmark to which alternate models are compared.

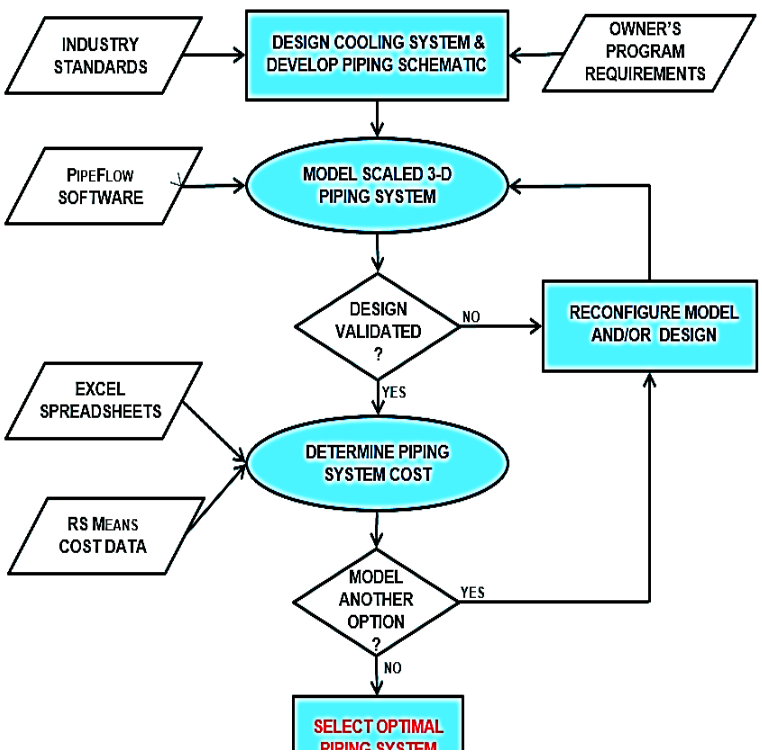

Figure 1: Piping System Design Overview

Economic Model

The software used to model the piping system can display tables containing system information, such as the length, diameter, and fittings of each individual pipe. These tables can be exported to Excel for further analysis and customized spreadsheets can then be used to compile the total length of piping, the total number of valves, and the total number of fittings. All of these are classified by pipe diameter, from which RS Means cost data is used to determine the total installation cost of the modeled system. The model and cost data are then archived and alternate piping configurations are analyzed for comparative purposes.

Alternate Designs: Case Study

The following analysis is a modified version of one performed by CCG for an actual project determining the most cost effective piping configuration for an 11 MW data center. The figures below show four alternative design configurations that satisfy the all requirements for the same facility.

Each layout consists of incoming piping from the chiller plant with distribution to UPS room CRAH units on the North end, and piping connections to other parts of the system on the South end. In each model, these two sections are connected by two long piping-runs that also serve the Computer Room CRAH units. Therefore, they must have butterfly valves between each tapped connection. As extra piping-runs are added in subsequent configurations, pipe size requirements decrease throughout the system, not just in the noted mains, but in support piping as well.

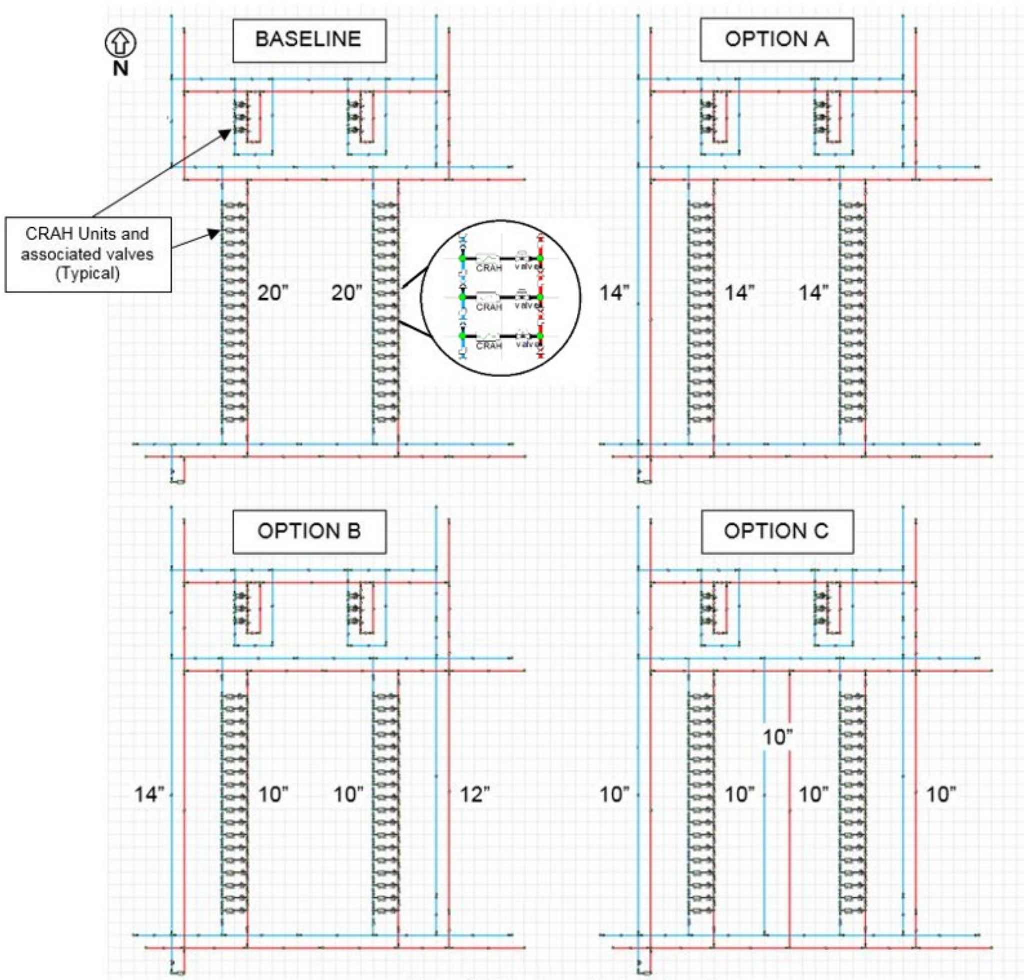

Figure 2: Piping Layout Option Schematics

Using the modeling software to calculate system flowrate and head, the chilled water piping sizes are optimized under each configuration. Each option represents an effective piping scheme, and is acceptable based on project requirements. Adding the extra piping runs decreases the necessary size of other pipes within the system, representing a tradeoff between size and quantity of piping and the overall capital cost.

The table below shows the total cost of materials and installation estimated from the RS Means Construction Cost Data for each system. Options B and C are very similar in cost, and both are significantly less than the Baseline system or Option A.

Chilled Water Distribution Piping Cost

	Baseline		Option A		Option B		Option C	
Piping	3270 ft.	$874,435	3730 ft.	$871,330	4190 ft.	$857,760	4650 ft.	$861,900
Valves	126	$802,600	130	$622,650	134	$405,650	140	$419,700
Total	**$1,677,035**		**$1,493,980**		**$1,263,410**		**$1,281,600**	

Table 1: System Cost Totals

It is important to note that the pump head is similar for each of these system options, indicating that their operating costs from an energy standpoint will not be significantly different.
From the Baseline cost estimate, Option A provides a 10.9% cost reduction while Options B and C represent 24.7% and 23.6% reductions, respectively. Option B is the least expensive configuration, but Option C would likely be the preferable solution because having more piping and valves of the same size improves spare parts storage and ease of maintenance.

Conclusion

In order to provide the best possible solution for a client, quantitative data on the tradeoffs between piping arrangement and cost is essential to keep the clients bottom line in mind throughout the design phase. Although not all projects have baseline piping configurations that can provide clear cost savings, those that do will have a significant financial incentive to spend time investigating multiple design options, especially since the dynamic piping program makes it possible to add piping, adjust sizing, and optimize a system all while the spreadsheet models aid in choosing the best configuration for a specific project.