CASE STUDY

Data Center Air Cooling System Conversion Project Validated Using AFT Fathom™

Data Center Air Cooling System

General Facility Industry

Applied Flow Technology

Swanson Rink
Denver, Colorado, USA
Platinum Pipe Award Honorable Mention - Software Features and Model Creativity

Swanson Rink was tasked with developing a master plan for converting a high-rise office building into a multi-user, data center space. The client wished to use as much of the existing air conditioning system as possible, and the vertical duct system needed to be reused to make the project financially viable. The challenge was that the heating and air flow requirements were much lower for the new data center compared to the previous office space configuration.

There were two identical vertical duct systems on the north and south of the building. Each original duct system was designed for ~200,000 CFM (ft3/min), (5700 m3/min), and had pneumatic balancing dampers at two branches to each floor. The duct system serves 12 floors, for a total of 24 branches from the main duct.

> "This analysis would have been nearly impossible using hand calculation methods. The ability to have the control valves balance 24 branches simultaneously was great."

The new south air handling unit (AHU), on which the model is based, was only 35,000 CFM (1000 m3/min), and the demand will slowly diminish as the building progresses in the master plan from air conditioning for office space to ventilation for data center space. The goal was to determine how to balance the new airflow requirements to each floor using the existing oversized ductwork at design conditions and as the load decreased over time.

Rory Heim, mechanical engineer at Swanson Rink, used AFT Fathom to do a typical air-side model of the system, and determined the amount of static pressure the AHU fan required. Heim used fitting and losses in the ducts in order to keep the model clean with minimal junctions. He also named each valve with the CFM value, which allowed him to compare the desired CFM to the computed flow (see Figure 1).

The plan was for the AHU to be installed and balanced using the existing branch takeoff dampers. The dampers would be converted from pneumatic to simple manual dampers, and would be set for the initial flow/load requirements. One of the concerns of the design team was that as the AHU flow rate dropped when load was picked up by other systems, the air would take the path of least resistance to the closest dampers, and the furthest run would be starved unless the system was rebalanced.

Heim approached the problem by initially modeling each branch with a control valve. Heim used control valves and regular valves to represent the dampers. Once the system ran correctly, he recorded the "K" value from each control valve. He created a child scenario, and systematically replaced each control valve with a standard valve with the appropriate "K" value so that each branch received the same flow that it did in the control valve scenario. He was able to lower the total flow rate of the system and explore where the air went during reduced flow.

Due to the existing duct system being vastly oversized for the needed air volume, there was negligible pressure drop associated with the main duct, and the air in each branch decreased proportionally to the decrease in total flow rate.

Swanson Rink sets the standard on what it means to be a consulting engineering firm. For more than 64 years, clients have demanded their technical expertise in engineering, technology, and management services to provide solutions that are reliable, sustainable and meet customers' specific business needs. Swanson Rink focuses on solving complex problems for mission critical data centers, airports and corporate clients.

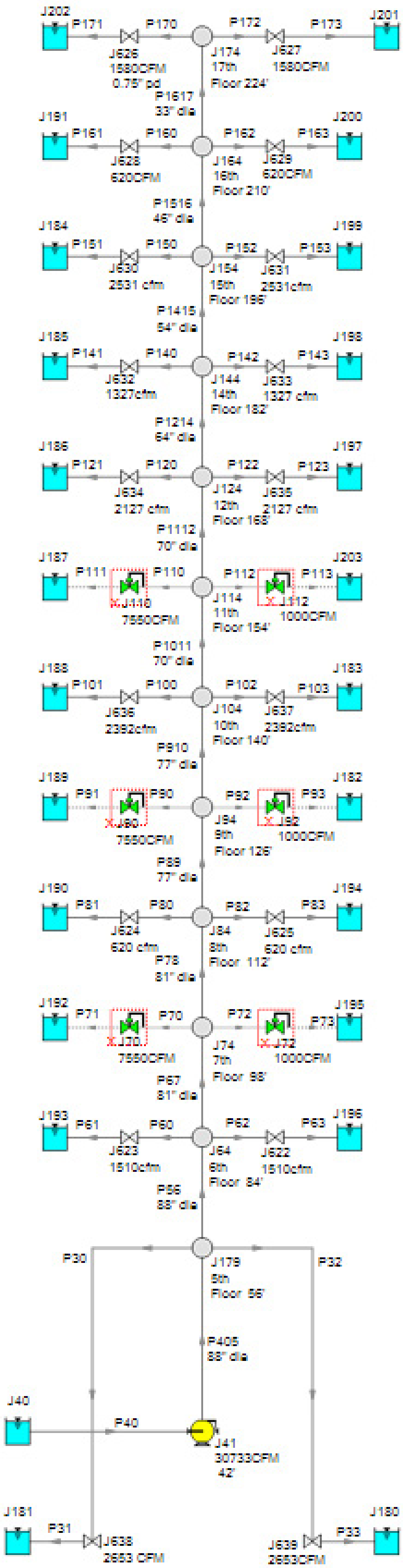

Figure 1 - AFT Fathom Model of South Air Cooling System in 12 Story Data Center

When asked about the benefits of modeling the system with AFT software, Heim said, "This analysis would have been nearly impossible using hand calculation methods. The ability to have the control valves balance 24 branches simultaneously was great."

Performing the same analysis by hand would have required simultaneous solving of 24 equations, followed by using equations to find the loss factor (K value) of each of the 24 control valves.

The ability to include junctions and fittings in the duct was very useful in keeping the presentation of the model simple and clear.

Each valve was named with the desired CFM value, allowing quick comparison in the Output tab between desired CFM (shown in the "Name" columns) and actual CFM (shown in the "Vol. Flow" columns) (see Figures 2 & 3).

Jct	Name	Vol. Flow Rate Thru Jct (ft3/min)	Vol. Flow Rate Thru Jct (m3/min)	dP Stag. Total (in. H2O std.)	dP Stag. Total (cm H2O std.)
627	1580CFM	1,579.3	44.72	0.7605	1.932
628	620CFM	619.8	17.55	0.7628	1.937
629	620CFM	619.7	17.55	0.7626	1.937
630	2531 cfm	2,530.9	71.67	0.7618	1.935
631	2531cfm	2,530.9	71.67	0.7604	1.931
632	1327cfm	1,327.5	37.59	0.7658	1.945
633	1327 cfm	1,327.5	37.59	0.7654	1.944
634	2127 cfm	2,127.1	60.23	0.7663	1.946
635	2127 cfm	2,127.1	60.23	0.7652	1.944
636	2392cfm	2,392.0	67.73	0.7684	1.952
637	2392cfm	2,392.0	67.73	0.7671	1.948
638	2653 CFM	2,651.9	75.09	0.7721	1.961
639	2653CFM	2,651.9	75.09	0.7678	1.950

Figure 2 100% AHU load case predicted airflow through dampers compared to desired airflow (in Name column), and resulting pressure drop and K value at dampers.

Jct	Name	Vol. Flow Rate Thru Jct (ft3/min)	Vol. Flow Rate Thru Jct (m3/min)	dP Stag. Total (in. H2O std.)	dP Stag. Total (cm H2O std.)
627	1580CFM	789.5	22.356	0.1901	0.4827
628	620CFM	309.9	8.774	0.1907	0.4843
629	620CFM	309.8	8.774	0.1906	0.4842
630	2531 cfm	1,265.2	35.828	0.1904	0.4836
631	2531cfm	1,265.1	35.824	0.1900	0.4826
632	1327cfm	663.7	18.795	0.1915	0.4863
633	1327 cfm	663.7	18.794	0.1913	0.4860
634	2127 cfm	1,063.6	30.117	0.1916	0.4866
635	2127 cfm	1,063.5	30.114	0.1913	0.4858
636	2392cfm	1,196.1	33.870	0.1921	0.4880
637	2392cfm	1,196.0	33.867	0.1918	0.4871
638	2653 CFM	1,326.2	37.555	0.1931	0.4905
639	2653CFM	1,325.8	37.543	0.1919	0.4874

Figure 3 50% AHU load case predicted airflow through dampers compared to desired airflow (in Name column) showing airflow to each branch reduces proportionally to AHU total flow.