Fan and Pump Affinity Law Clarification

The affinity law is an engineering relationship that describes the part-load power draw of a pump or fan. The affinity law states that fan/pump power varies with the cube of the change in air/fluid flow. Energy Division provided additional guidance on using the affinity law to estimate energy savings for pump/fan VFD measures and set a deadline of November 1, 2013 to begin using ED's new guidelines.

The affinity law equations are as follows:

Figure 1: Pump

$$(kW_1 \div kW_2) = (gpm_1 \div gpm_2)^n$$

where:

kW = pump power

gpm = gallons per minute

n = 3 (in ideal conditions)

Figure 2: Fan

$$(kW_1 \div kW_2) = (cfm_1 \div cfm_2)^n$$

where:

kW = fan power

cfm = cubic feet per minute

n = 3 (in ideal conditions)

The affinity law equation must be modified to reflect non-ideal conditions in Customized Solutions projects. To adjust for real-word conditions, the exponent *n* is reduced to a value less than 3. Currently, Customer's Authorized Agents can use engineering judgment to establish a more appropriate exponent to estimate the energy savings. However, beginning November 1, 2013, you must use the following guidelines to establish a more appropriate exponent to estimate energy savings in Customized Solutions projects:

Figure 3: For Systems of Fixed Geometry

	Air/Water Loop is:		
	Fully or Mostly Closed	**Semi-Closed**	**Mostly or Fully Open**
Fixed Geometry	2.4	2.2	2.0

Figure 4: For Systems of Variable Geometry

	The Pressure Setpoint is this percent of the Total Static Pressure at Maximum Flow			
	< 20%	**> 20%, < 50%**	**> 50%, < 80%**	**> 80%**
Fixed Geometry	2.4	2.0	1.5	1.0
Variable Pressure Setpoint	2.4			

Explanation of Terms

Geometry

This refers to the shape and dimensions of the path the fluid moves through — pipes, ducts, valves, dampers, filters, grills, etc.

Fixed Geometry

A system of fixed geometry has no moving parts other than the pump or fan. A chilled water system with 3-way valves at the cooling coils is also treated as fixed geometry.

Technical Support Service

The answer to any pre-application submittal inquiry is a call or click away:

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Closed vs Open Systems

In a closed system the working fluid is entirely contained by pipes/ducts and other fittings, all of which provide some significant resistance to flow. A completely open system consists of just the fan or pump, with no appreciable external resistance to flow.

Examples of Fully or Mostly Closed Systems

- Chilled water pumping system.
- Contained, in-cabinet IT cooling systems.

Examples of Semi-Closed Systems

- Condenser water loop serving open cooling towers.
- CRACs/CRAHs serving enclosed hot/cold aisles.

Examples of Mostly or Fully Open Systems

CRACs/CRAHs serving an unobstructed underfloor plenum, open aisles, open returns.

Variable Geometry

A system of variable geometry has automatically-controlled components that modulate during operation and affect the resistance to flow.

Examples:

- A chilled water system serving cooling coils equipped with automatically controlled 2-way valves.
- An air distribution system equipped with automatically controlled volume dampers.

Pressure Setpoint

This refers to a point in the system, remote from the pump or fan that is maintained at a specific pressure during operation.

In a pump system, this may be due simply to the physical configuration (for example, pumping water uphill to an open reservoir). More commonly, the setpoint is maintained by means of a pressure sensor and a control system.

Constant Pressure Setpoint

The pressure setpoint is maintained at a constant value during system operation.

Variable Pressure Setpoint

The pressure setpoint is automatically reset during system operation, such that the setpoint is lower when less flow is needed.

Please note that Customer's Authorized Agents who use the fan/pump VFD calculators in the Online Application Tool will not be impacted by this change; those calculator assumptions are not based on the affinity law. Rather, the Online Application Tool utilizes actual pump/fan curves to estimate power. The change is only relevant if you use the affinity law in other calculators, outside of the Online Application Tool.

This change is not expected to significantly alter energy savings. Again, Customized projects are required to apply these new guidelines starting November 1, 2013. (However, effective immediately any project pulled for ED Review will be subject to the new guidelines.)

As always, if you would like assistance with Express or Customized Solutions, contact Technical Support Services.

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