THE MYTH OF SPECIAL HIGH INDUCTION DIFFUSERS

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DEBUNKING THE MYTH

The use of the Air Diffusion Performance Index (APDI) of an installed diffuser is a proven method of designing overhead cooling systems. It has been in the ASHRAE Handbook of Fundamentals for over 30 years, and proven repeatedly to be an accurate predictor as well as measurement technique. Moreover, it is the only way of predicting conformance to the vertical stratification requirements of ASHRAE Standard 55 (Thermal Comfort).

In the mid 90's, the Electric Power Research Institute (EPRI) commissioned a study of diffusers for use with cold air. The thought was that with air cooler than the typical 55^{o}F supply temperature special diffusers were probably required. A number of tests were conducted at varying discharge temperatures, many diffuser types and varying air quantities, and an analysis and report were issued. ("Cold Air Distribution Design Manual", TR-106715, Research Project 3280-39). A copy of this report is available on Krueger's K-Select CD.

The results of this study were not altogether surprising. They concluded that the ADPI selection procedures outlined in the ASHRAE handbook, relating throw to 50 fpm to diffuser separation, work for 40^{o}F air as well as for 55^{o}F. What was not reported was that the advantages of very high induction (VHI) diffusers were more than offset by the decreased capacity and increased pressure requirement for the system. A major argument for the use of cold air distribution (CAD) systems is the 30% reduction in required air supply, and consequent reduction in duct size and fan capacity. What was found, however, is that the increased pressure requirement from VHI diffusers may more than offset the reduction in fan size. When the decreased capacity of the diffuser (based on sound levels) is factored in, the number of diffusers is typically increased by 30%. When installation and balancing costs (often $70/diffuser or greater) are factored in, the use of these VHI diffusers is often uneconomical.

The argument often used in their favor is "higher mixing". We have to ask, "higher than what"? When the ADPI in a room is actually measured, the rate of mixing is included in the throw data. It turns out that the higher the rate of mixing, the shorter the throw. As a diffuser entrains room air, the discharge momentum is "used up". ADPI can be correlated to airflow /unit area. (See "Air Distribution for Comfort and IAQ" Heating Piping and Air Conditioning, March 1998, available on the Krueger KSelect CD). When throw data and ADPI are compared, the minimum cfm/sqft for VHI diffusers is only very slightly less than for conventional high performance diffusers. But, the capacity of the VHI diffusers is often 1/3 that of the others at the same sound level, typically requiring more diffusers (and connectors, balancing, etc.)

So the only issue left is the dreaded phenomena of "dumping" at low airflow rates. Dumping is a phenomenon whereby cold air falls off the ceiling onto occupants. The EPRI studies show that again, the throw / ADPI relationships are all that is required. When throws are very short, as at low air flow rates, then ADPI is often found to be unacceptable. All the tests conducted for the EPRI study showed that the ADPI tables in the ASHRAE handbook essentially include "dumping" in the limitations.

In the end, diffuser selection should be made on the basis of traditional ADPI calculations as indicated in the ASHRAE Handbook. Providing that the ratio of T_{50} to diffuser spacing is within the guidelines provided there, there should be no objectionable dumping. Secondarily, economic issues must be considered. A diffuser is not installed at no cost. The labor to install the duct fitting, balancing damper and diffuser in the ceiling, as well as flex duct and balancing time should be considered. These often come to nearly $100/ diffuser.

If cold air is to be supplied, condensation issues must be considered. This is also a complicated issue. When everything is in steady state operation, there should be no condensation issues, as the discharge will always be higher (often surprisingly higher) than the coil leaving air temperature, which should be the building dew point. It is only on start-up, or near doorways, where there is a condensation potential. (The potential in these locations is as great with conventional systems as it is with CAD systems.) The plastic core VHI diffusers provide enough insulation that the surface temperatures do not approach dew point. Metal diffusers, however, should have some additional insulation in these special locations. Most manufacturers of plaque-type diffusers can provide insulation on the back of the plaque to prevent condensation. Three and four-cone diffusers, as well as vane type diffusers do not have this option, and should be avoided in these potential condensing applications.

SUMMARY

So in the end, claims of “very high induction” or “improved mixing” have to be viewed with the increased cost in mind. Usually, a careful balanced analysis will show that there are lower installed cost options that can provide the same ADPI based performance. Claims of improved “induction ratio” and “enhanced mixing” cannot be verified with any industry accepted measurement techniques, and therefore should not be considered in any engineering analysis. Until such time as there are other industry accepted measurement techniques, ADPI based on isothermal throw is the only accepted method of evaluating ceiling diffuser performance.