Motorola: Cleanroom Declassification from Class 10,000 to Class 100,000[1]

Project Benefits Summary

Estimated Annual Energy Cost Savings	*$154,940*
Actual Project Cost	*$89,700*
Project Payback	*7 months*

Facility Description

The Motorola AIEG facility in Northbrook, Illinois is part of the Motorola Automotive and Industrial Electronics Group. The facility includes a 6,700-ft^2 class 10,000 cleanroom used for test and assembly of automotive electronics controllers. The building also contains office space and another production area. A single air handler serves the cleanroom and includes two parallel supply fans and two parallel return fans that supply the cleanroom through ceiling mounted HEPA filters. Each of the fans has adjustable pitch fan blades. Twelve steam humidifiers and thirteen duct-mounted electric reheat coils humidify and reheat the supply air to each room to maintain the 70°F ±2°F dry bulb and 45% ±5% relative humidity setpoints for the cleanroom.

Project Description

The purpose of this project was to reduce operational costs and energy use by reducing the cleanroom classification from class 10,000 to class 100,000. To accomplish this airflow was reduced but the ceiling grid and number of HEPA filters remained the same to allow for future flexibility in the cleanrooms. The facility currently operates at class 100,000 or better. Measures were also implemented to improve temperature and humidity control to reduce unnecessary dehumidifying when the outside air is already below the cleanroom humidity setpoint.

The air handling unit supply volume (return air and outside air) was reduced from 67,000 cfm to approximately 30,000 cfm (10 cfm/ft^2 to 5 cfm/ft^2) by shutting down one each of the supply and return fans. The pitch of the blades on the existing fans were modified to further reduce the airflow and decrease energy use. The supply air temperature setpoint had to be decreased from 67°F to 63.7°F with the reduction in supply airflow because the heat load in the room remained the same. Since dehumidification demand requires the cooling coil to cool the air to 48°F, much less energy is needed to reheat the air to meet the lower supply temperature setpoint. As a result of this improvement, the peak load for reheating the supply air is expected to drop from 412 kW to 150 kW. The actual savings are still being measured but the estimated energy use impacts are shown in table 1.

Table 1 - Estimated Energy Savings

Operation	*Previous (kWh/y)*	*Current (kWh/y)*	*Savings (kWh/y)*
Fan Operation	825,700	130,700	695,000
Reheat During Cooling	1,795,100	549,000	1,246,100
Cooling	615,800	301,600	314,200
Heating	557,700	314,000	243,700

There are huge energy savings due to the reduction in fan power and and reheating of the supply air. Obviously, turning fans off saves energy, but adjusting the pitch of the fan blades also contributes to the energy savings. When the pitch of the blades is modified, the fan will only be able to supply the amount of air required and motor energy can be minimized. Adjusting blade pitch also results in a change in fan efficiency (up or down, depending upon the original blade position), however this impact is small relative to the overall reduction in motor power required to deliver less air.

[1] Based on "Motorola AIEG, Northbrook, Illinois, Cleanroom Conversion Study." Prepared by Black &Veatch ATD; April 29, 1999.

More precise control of cooling coil dehumidification was achieved by installing a dewpoint sensor after the cooling coil. When the outdoor air dewpoint is below 45°F (the room setpoints require a dewpoint of about 48°F) during cool, dry seasons like spring and fall, the air does not need to be dehumidified. Adjustment of control of the cooling coil to only cool the air down (if cooling is needed) to meet the required 70°F dry bulb temperature setpoint then saves by reducing the energy needed to cool the air all the way down to 48°F and reducing the energy needed to reheat the air back up. This control also prevents unnecessary dehumidification by the cooling coil that, in turn, requires more steam to raise the relative humidity of the air to the required 45% setpoint.

Applicability to the Cleanroom Industry

Significant energy was saved on this project because all of the recirculated and outside air is dehumidified and reheated. Therefore, a 50% reduction in airflow not only reduces fan energy but also greatly decreases the amount of energy needed to condition the smaller quantity of air. The energy use benefits of changing cleanliness classification are vividly demonstrated by the work at Motorlola. However, very few facilities are capable of changing cleanliness classification. It is worth considering primarily for facilities that have modified operations to include less sensitive processes or in facilities where the original classification has proven far cleaner than is actually required for the manufacturing process that was implemented. The Motorola facility is quite small and this type of conversion is likely to be much more costly for a large facility, however, the energy use benefits are so large, that it is likely to be a worthwhile investment with a very short payback even in the largest facilities.

Typically, cleanroom HVAC systems use separate makeup air and recirculation units and only the makeup air from outside needs to be conditioned. This method is much more efficient because only the makeup air is dehumidified and reheated to meet the appropriate temperature and humidity setpoints when mixed with the recirculation air. Since the recirculation air is already close to the room setpoints (typically slightly warmer), it can provide a large portion of the heating needed for the makeup air when the air mixes and the amount of reheat required for the makeup air can be further reduced.