Western Digital: Comprehensive Cleanroom Facility Renovation and Cleanliness Upgrade

Facility Description

The high-tech factory shown in figure 1 is located outside Kuala Lumpur, the capital of Malaysia, and is owned and operated by Western Digital, Inc., a US based computer hard disk drive manufacturer. Western Digital (WD) set out to renovate an existing semiconductor manufacturing plant to create a state-of-the-art hard drive manufacturing facility. The renovation called for an increase in floor area from 80,000 to 90,000 square feet and an increase in the cleanliness requirements for the cleanroom from class 10,000 to class 10.

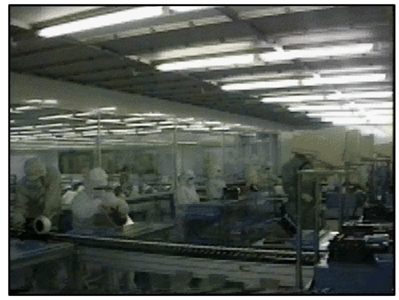

Figure 1 – The New Cleanroom

Project Description

It was expected that the increase in floor area and cleanliness would increase loads substantially. Instead, through innovative design and careful attention to system effects on energy efficiency, the remodeled building used 44% less energy than the original facility. In addition to the efficient components of the design, WD was able to eliminate the use of environmentally harmful CFCs used in the chillers.

The total renovation cost of the efficient design was equivalent to the proposed renovation costs of other project bidders who offered standard, less efficient designs. In fact, with the efficient design some costs were lower. For example, due to low pressure drops through the air and chilled water systems, the efficient design required for fewer, smaller pumps and fans. Project staff estimates that any additional efficiency related costs paid for themselves within the first year of operation.

Selected Components of the Design

RECIRCULATION FAN SYSTEM
The recirculation fans, which provide air filtration, are the largest single energy users in a cleanroom facility of this size. Fan energy requirements were reduced by lowering the pressure drop in the ducting and air filtration system. Typical designs of these systems result in 6 to 8 inches of total system pressure drop. The efficient design resulted in a total system pressure drop of 1.5 inches. This extremely low pressure drop was accomplished through the careful use of low pressure drop filters, low velocity duct design, and low pressure drop, single pass cooling coils. In addition, fans were selected to operate at 82% efficiency (typical fan efficiency is ranges from 40% to 50%) with energy efficient motors operating at 92% efficiency. Each fan was coupled with a variable speed drive, which allows demand-controlled ventilation providing 550 air changes per hour during peak hours and reducing ventilation to 100 to 200 air changes per hour on low usage days like holidays and weekends. The variable speed drives save fan energy by slowing down the fan when the flow requirements are reduced.

CHILLERS
Before renovation of the old factory, the chilled water load was carefully monitored for several months. The data from this monitoring was combined with estimates of the loads for the new facility to determine that the maximum cooling load for the new facility would be between 210 to 220 tons. The existing cooling plant consisted of two 300 ton CFC refrigerant chillers with an efficiency of 0.65 kW/ton. Instead of replacing the chillers, they were retrofitted with a CFC to HCFC conversion kit. The conversion resulted in reduction of chiller capacity to 250 tons each (still large enough for one chiller to cover the load and with the second for backup) with a resulting efficiency of 0.61 kW/ton. The cost of the

conversion was one quarter of the cost of a new chiller and both chillers were now safer for the environment and more efficient.

COOLING TOWERS

Before the renovation, large counterflow cooling towers were used. These towers were replaced with new, more efficient cooling towers (shown in figure 2). All of the cooling tower fans were fitted with variable speed drives enabling all cells to operate in parallel at slower speeds. Along with the raw efficiency improvement, parallel operation saves substantially more energy than operating fewer cells at full capacity due to the cube law for fans. Parallel operation also saves chiller energy because lower condenser water supply temperatures are achieved by spreading the water out over all of the cells.

Figure 2 – Efficient Cooling

PUMPING SYSTEMS

As with the air handlers, the chilled water and condenser water piping system design focused on low pressure drop. Figure 3 shows a sample of the smooth, low pressure drop piping layout that was installed. This type of piping layout provides for reduced turbulence due to minimal pipe friction, thus reducing the amount pump energy required to move the water through the system. The original system had pressure drops of around 100 feet, but the new layout was able to reduce that to about 35 feet. So, smaller pumps, and fewer of them, were required for the system. In addition, the new pumps were selected with efficiency in excess of 70% and 92% efficient motors.

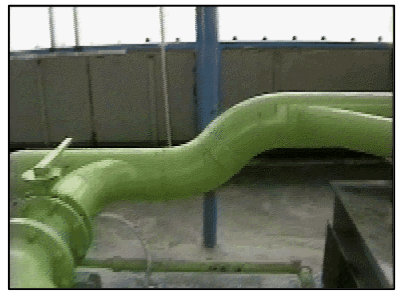

Figure 3 – Efficient Piping

LIGHTING

The factory floor lighting before the renovation consisted of 40-Watt fluorescent lamps and standard magnetic ballasts. All of the lighting was replaced with triphosphor T-8 lamps, electronic ballasts and reflectors. The resulting lighting energy use is 0.5 W/ft^2. This is contributes a significantly to energy savings since lights are often on twenty-four hours a day and seven days a week.

COMPRESSED AIR

The compressed air system was retrofitted to use refrigerant drying instead of desiccant drying. This saved 15% of the compressed air that was inadvertently vented in the drying system. These savings allowed the air compressors to run lees frequently, thus saving compressor energy.

VACUUM AIR

The new vacuum pumps were 30% to 40% more efficient than before. This provides huge energy savings because vacuum air is required throughout the day in the facility. The new units are also controlled by variable speed drives such that the pump motors require less energy when less vacuum air is required.

With conscientious design, the WD plant was made extremely efficient without an increase in the cost of the project, even though the facility was changing to a higher cleanliness class. The first cost for this project was equivalent to what an inefficient design would have cost. Even though airflow increased significantly to meet the higher cleanliness requirements, the remodeled building uses 44% less energy than the original building. These energy savings will increase the profits of the company by reducing energy related expenses. All of these measures involve common equipment and can be implemented in almost any cleanroom, especially during renovations.

Renovation Project Summary

	Before	**After**
Total Plant Area	80,000-ft^2	90,000-ft^2
Function	Semiconductor Factory	Hard Disk Factory
Cleanroom Classification	Class 10,000	Class 10
Peak Demand	1,350 kW 16.9 W/ft^2	850 kW 9.4 W/ft^2

Applicability of Plant-Wide Efficiency Improvement to the Cleanroom Industry

Renovations are common in large facilities because the industry changes on a daily basis. These renovation projects are a great opportunity to take advantage of available energy efficiency opportunities because retrofit work and new equipment are often already required. In addition, when the facilities are not able to shutdown during construction, many of these types of efficiency measures can still be implemented using techniques such as hot tapping and with careful planning.

While energy efficiency can be improved dramatically in virtually all cleanroom facilities worldwide, acquiring funding for energy efficiency is often difficult, especially in renovation applications. One key to the success of this project was that the project cost did not change due implementation of energy efficiency measures. This may seem impossible, given the fact that energy efficient equipment is typically more expensive than standard efficiency equipment. What is not obvious is that the efficient design that considers that entire system allows for installation of smaller equipment, which offsets added cost for improved efficiency equipment. For example, the improved piping design at WD allowed the required pump power to be reduced and even reduced the number of pumps required for the plant. This type of saving cascades all the way back to the large chillers by reducing parasitic loads generated by the pumps, fans, and other systems, inevitably reducing the size and cost of the chiller – a huge part of the total cost of the plant renovation.

Many, if not most, companies are seldom able to renovate existing facilities when a new facility is required. Most companies simply build a new plant. This is likely due to the fact that the largest driving factor in locating facilities is cost of operation (hence, the trend toward construction in Asia), not proximity to existing facilities or cost of construction. Of course, any new plant is ripe for energy efficient design at an even lower cost than in any possible retrofit application because the changes can be made on paper prior to construction. Unfortunately, a common barrier to implementation of energy efficiency in new facilities is management, whose need to build the plant fast (to meet rising consumer demand) is paramount, and which views efficiency as a stumbling block that will slow design and construction, possibly preventing the biggest goal: being first-to-market.