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Cutting Energy Costs For Pharmaceutical Research

This article illustrates how a pharmaceutical research firm reduces costs for heating conditioned makeup air by 30% or more for thousands of dollars in annual savings.

Cutting Energy Costs with Laboratory Workstation Fume Hood Exhaust

by Paul A. Tetley

Laboratory facilities at pharmaceutical research and manufacturing organizations are burdened with perhaps the most expensive energy costs for heating and cooling per sq. ft. in the country. This is mainly because most laboratories — and some pharmaceutical processing facilities — require conditioned 100% makeup air for their workstation environments. Obviously these demands are responsible for creating substantially higher energy costs since makeup air must be filtered, heated, cooled, humidified, or dehumidified depending upon circumstances.

There is a practical, cost-effective method, however, to lower energy costs for natural gas, oil, or electricity significantly with resultant savings of thousands — or even hundreds of thousands — of dollars annually. This article will discuss how one pharmaceutical research organization[1] handled this problem.

This pharmaceutical research organization was confronted by the prospects of high energy costs when it recently built a new facility for chemical research activities. The company is involved in research and early stage development of drugs. While the company is independent, it occasionally forms collaborations with pharmaceutical manufacturers, setting up independent joint ventures for both production and marketing of specific drugs it helped to develop.

Even without the need to introduce 100% makeup air into the work environment, laboratory research activities at pharmaceutical firms are major energy consumers. Providing comfortable and safe workplaces for scientists and technicians requires efficient heating and cooling of ambient air. Workstation fume hoods require control and management and other energy intensive equipment and systems associ-

Figure 1. Mixed flow impeller system.

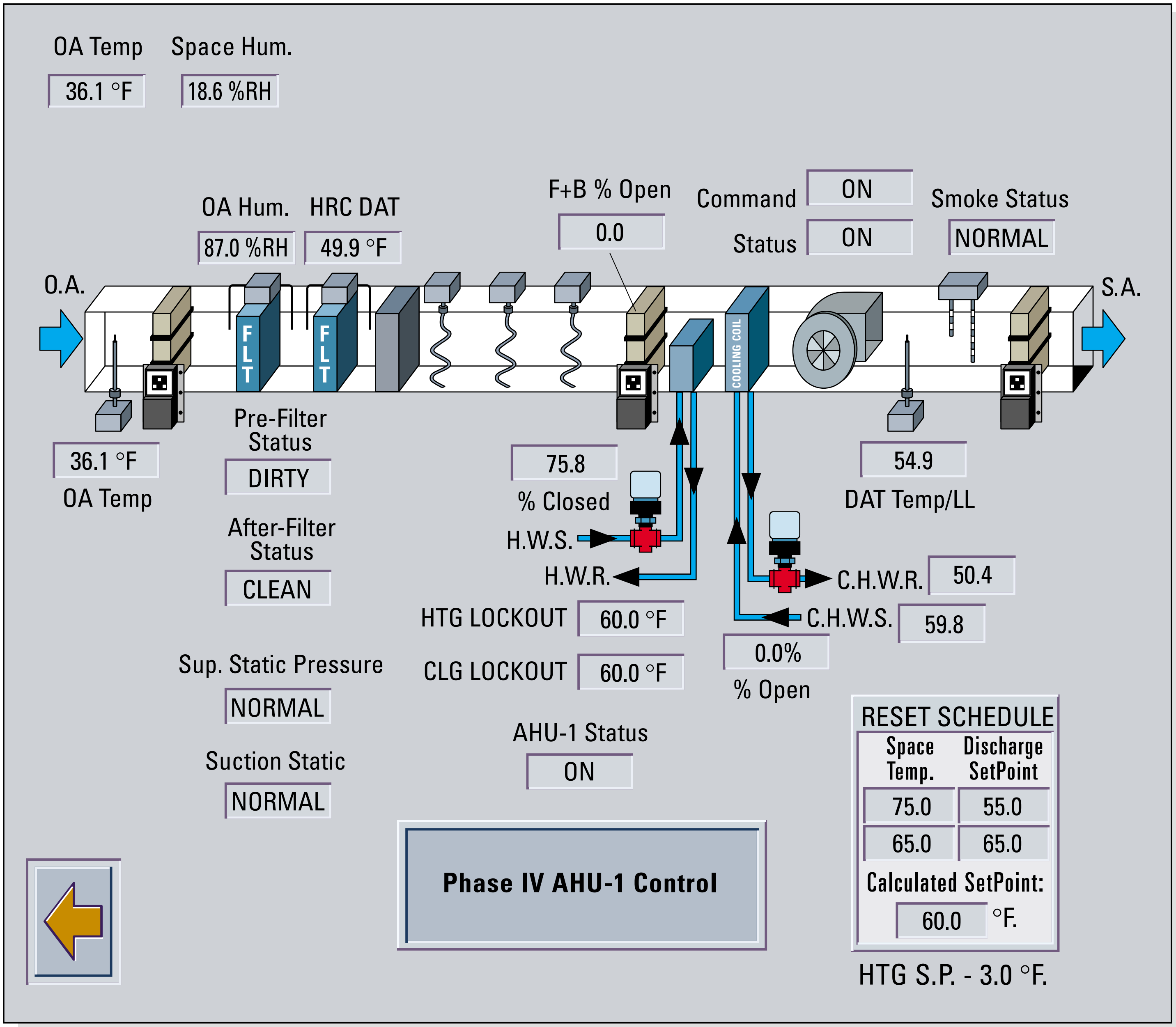


Figure 2. System status monitor – outside air temperature at 36.1°F.

ated with the research environment generally consume energy in one form or another. When you add fume hood exhaust systems on the roof – which must operate whenever a workstation is being used – it's easy to see how energy costs can mount quickly at a large research facility. At this firm, about 30,000 cu. ft. of air per minute has to be moved in and out of its new 20,000 sq. ft. research building which houses 18 laboratory workstations, each with 10' fume hoods.

The facility manager[2] at the company is responsible for the daily operation of the company's physical plant. He is involved in many areas including construction, renovation, energy conservation, and other aspects of managing a complex facility. He benchmarks the average cost to condition makeup air at $3.71 per cu. ft. per year. He said this figure is used by most building engineers. On the other hand, the total energy costs average more than $6 per sq. ft. per year.

Since code prohibits all air in the laboratory workstation environment to be recycled, it must be exhausted. This includes both the ambient air as well as the laboratory workstation fume hood exhaust, and is considered as "100% exhaust, 100% makeup." This facility is a "constant volume building," which means that the volume of air entering and exiting the building is constant. "With the cost of heating or cooling makeup air alone at nearly $4 per cu. ft. per year, clearly this issue had to be studied carefully, and a reasonable solution had to be found," the facility manager commented.

The Solution was on the Roof

The facility manager's approach to the problem was both practical and logical. In fact, most of the solution was already in place, just above his head. That's because the 18 laboratory workstation fume hoods were being exhausted on the building's roof with mixed flow impeller exhaust systems — *Figure 1*. Each system is connected to an exhaust plenum serving the workstations, and is designed to provide high efficiency exhaust and eliminate re-entrainment problems, a particularly critical issue when makeup air is introduced into a building on a constant flow basis.

The systems are designed to accommodate a unique heat recovery system (essentially a heat exchanger containing coils filled with a solution of glycol and water) that extracts ambient heat from the workstation fume hood exhaust before it is discharged above the roofline – *Figure 4*. This air glycol/water solution is transferred to the supply air handler to preheat the conditioned air entering the building. As a result, the amount of natural gas to preheat the makeup air is reduced substantially.

Reduce Heating Costs 3% for each 1°F Added

The facility manager said that in winter, "there were days when we were putting about 10°F into the makeup air simply by capturing heat from the exhaust stream" – *Figure 3*. He added that 10°F was the temperature difference between the incoming air (at the outside ambient temperature) and the air entering the intake system after it was passed through the glycol loop coils. He stated that "for every degree you add, you reduce your energy costs about 3%. So, a 10°F rise in intake air means that about 30% of energy savings can be realized." As he says, "In addition to saving our company money, we also help contribute to a cleaner environment since less fossil fuel is consumed."

With regard to overall costs – for system hardware as well as energy charges – the facility manager believes that a payback cycle of three years or less has made this solution economically sound for the company (some users have experienced actual payback in two years or less depending upon system configuration, climate, and other variables). With energy costs rising dramatically, it is expected that heating costs alone will rise 30%-50% for the 2000/2001 season over the prior year, and he believes that the company has gone in the right direction with its heat recovery systems on its laboratory fume hood exhaust fans.

Cooling Applications also Use Less Energy

Again, the facility manager cited some specifics. Since the company is located in the Northeast United States, it experiences varying temperatures during the year. Conditioned makeup air is either cooled with fume hood exhaust air during the cooling season or warmed during the heating season. The system is only usable when the outside air temperatures are below 40°F or above 80°F. "You need a big enough difference between outside and inside air to make it practical," he added – *Figure 4*. With regard to cooling air in warmer temperatures, he pointed out that if outside air, at 90°F is brought back into the building and sent through the heat recovery system, the air temperature drop is typically 4°- 5°F. Again, he equates these figures to a 3% drop in energy consumption for each 1°F drop in air temperature.

There are four different pharmaceutical research buildings at the company's complex. At the Phase 1 building, individual dedicated fans are used for exhausting individual laboratory workstation fume hoods. The newly built Phase 4 building incorporates the mixed flow exhaust systems with heat recovery capabilities – *Figure 5*. And, in the Phase 3 building, there are five laboratory workstations with associated fume hoods and dedicated fans for each of them. While he considers the Phase 1 and Phase 3 configurations less efficient by example of his success with heat recovery, he intends to change it with his "list of energy conservation strategies which I have gradually been putting in place."

The Pharmaceutical Industry Experiences "High End" Energy Costs

In fact, he added that one of the influences with regard to committing capital expenses to energy reduction is related to "rebate dollars from the local utilities." He said that, "if you are looking at two projects and one is rebatable and one is not, all other things being equal, you go after the rebate dollars." In light of this, he discussed energy cost averages for the pharmaceutical industry, adding that it is not uncommon to see $6 per sq. ft. per year for energy costs. Since he has an extensive facility management background in other industries, he added that for comparison purposes, public schools run at about $1, and hospitals (also large energy consumers) are still below $5 per sq. ft. per year (these figures are based on Northeast regional facilities where energy costs are slightly higher than the rest of the US). He stressed that the pharmaceutical industry is at the "very high end" of energy costs.

When questioned further, the facility manager said the main reason for this is the 100% conditioned makeup air which is required by code. In a hospital, for example, 80% of the air in an operating room can be recirculated as long as it's filtered through a HEPA system. In the pharmaceutical industry, "we have no opportunity for recirculating air. We just could not bring it back into the building." You can't use it through a heat wheel which is a way of recovering heat from exhaust air since many of them are based on not only getting the sensible heat out of the air, but the latent heat out of the moisture. In a chemical building or a drug research facility, this is not possible.

Heating Energy Costs are Expected to Soar

When discussing energy costs and the future, the facility manager said he expects some "serious increases in natural gas prices in the near future." He added that, for example, he has seen no positive benefits to consumers as a result of electrical power de-regulation policies on the West Coast. "After salaries, energy is the second largest expense item in the pharmaceutical research industry," he said. "It is not unusual in a facility such as ours to use 15% or more of the entire operating budget for energy, and this is not out of line for the industry," he added. Consequently, he believes strongly in selecting an engineering team when designing a new facility or planning a major renovation which has direct experience in the pharmaceutical industry, particularly with regard to the exhaust side as well as the energy reduction/consumption area.

Much of the statistics generated as a result of the energy savings has been logged carefully by the facility manager, and are included here for reference. As he pointed out, "On my screen I can actually see the temperature of the outside air, observe the air going over the heat recovery coil, and then note the air temperature as it passes through." He sees in real time how much heat the system puts back into the makeup air before money has to be spent in heating it; the same is true on the cooling side - *Figures 2 and 3*.

Since he feels very strongly about energy costs, consumption, and savings, the facility manager made it clear that the recent energy de-regulation policies in California have not resulted in reducing costs that were anticipated. "In other words, we are not going to de-regulate ourselves out of these high energy costs," he added. Consequently, he believes that pharmaceutical companies who are holding up energy conservation programs now because they believe de-regulation is "going to do it for them," should perhaps begin looking at other approaches. He commented that "You can tell where the rest

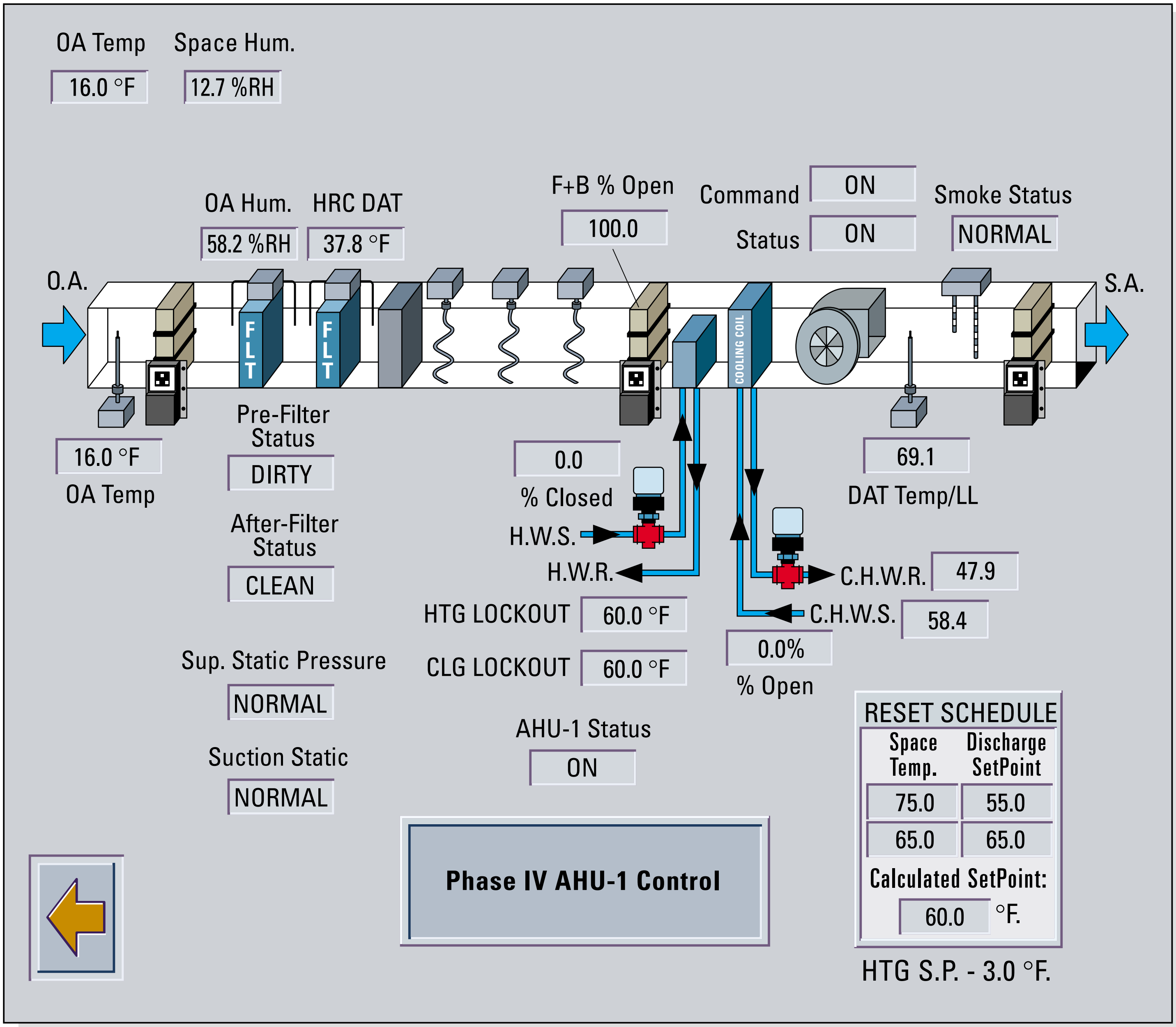


Figure 3. System status monitor – outside air temperature at 16.0°F.

of the country is going to be in a year or two by looking at California, and the early results of de-regulation there have not been good – in terms of cost and also in terms of reliability of service.” He added that he would not “depend on de-regulation to cut your energy bills; you have to work on the demand side,” he concluded.

Mixed Flow Impeller Technology Prevents Re-Entrainment

While roof exhaust re-entrainment can be a serious problem, all of its negative implications may not be widely known. In fact, not only can the health of building workers be affected by exhaust reentering the building through windows, vents, air intakes, and door openings (among other possibilities), but the legal consequences can extend well beyond their employers. For example, there have been cases where building owners, consulting engineers, Heating, Ventilation, and Air Conditioning (HVAC) contractors, and even architects were named as defendants in major cases associated with employee illness and IAQ. The company’s fume hood exhaust fans use mixed flow impeller technology to send the exhaust stream hundreds of feet into the air in a powerful vertical plume, mixing outside air with exhaust gases (dilution) to prevent re-entrainment as well as eliminate odor problems. They also provide other advantages, such as inherently lower energy consumption over comparable centrifugal-type exhaust systems. With the ability to pre-heat and pre-cool makeup air prior to its introduction into the building, the systems offer substantial energy saving benefits to pharmaceutical research and manufacturing organizations.

Mixed Flow Technology Offers Performance and Cost-Savings Advantages

Mixed flow impeller-type roof exhaust systems operate on a unique principle of diluting outside air with plenum exhaust air at high discharge velocities, sending a powerful vertical

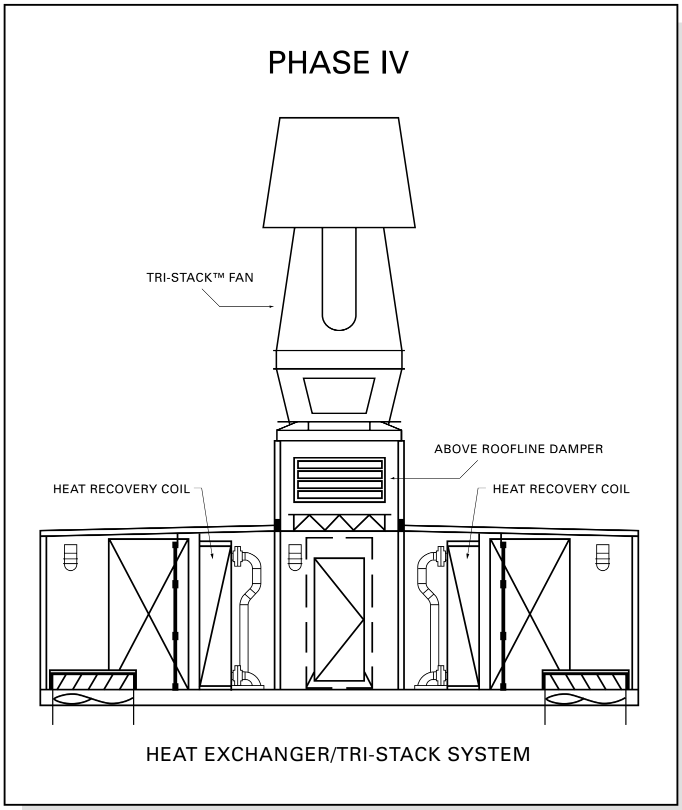


Figure 4. Heat exchanger/mixed flow exhaust system.

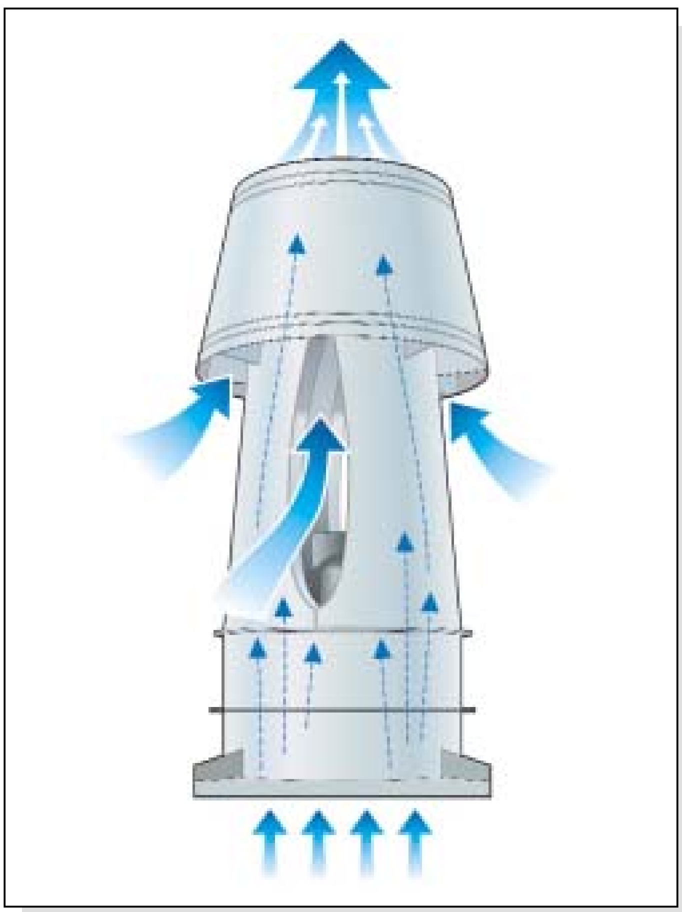


Figure 6. Typical mixed flow impeller system.

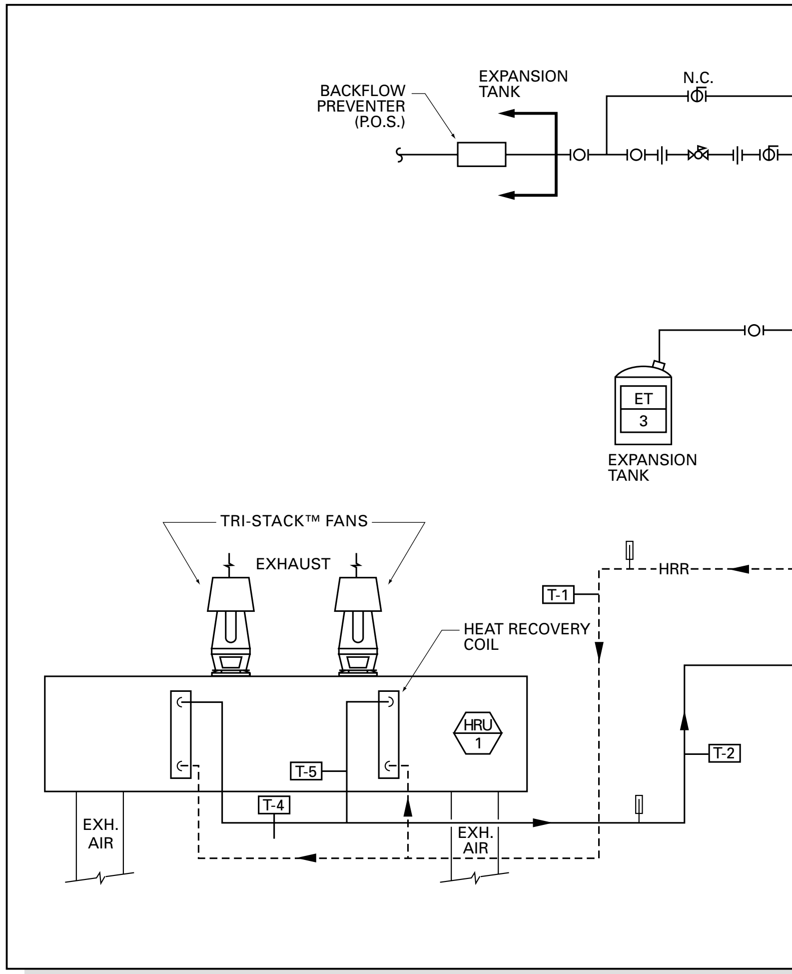


Figure 5. Run-around-coil heat exchanger recovery flow diagram.

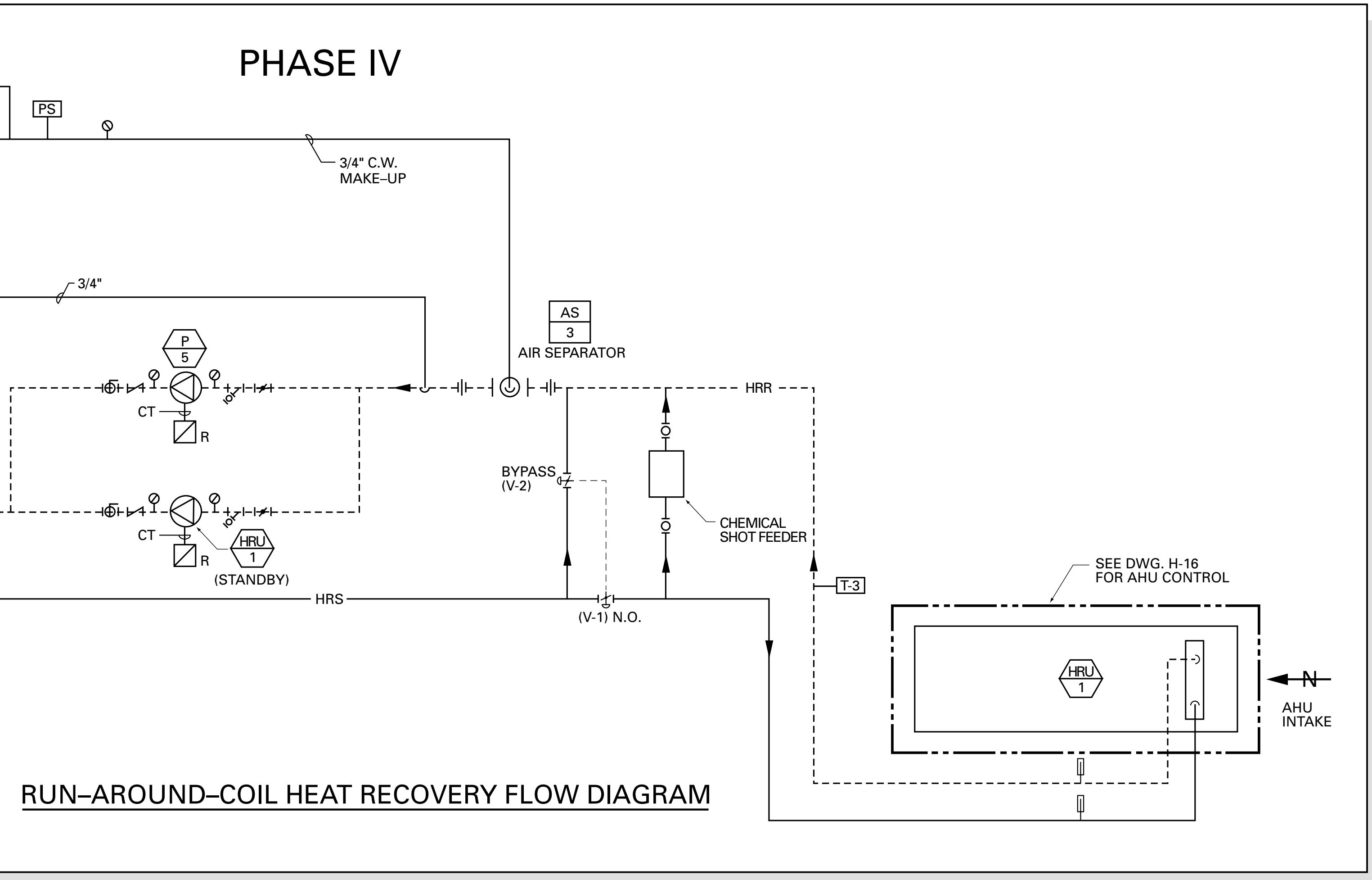
exhaust plume up to 350' high – *Figure 6*.

Because they introduce up to 170% of free outside air into the exhaust stream, a substantially greater airflow is possible for a given amount of exhaust without additional horsepower, providing excellent dilution capabilities and greater effective stack heights over conventional centrifugal fans.

These systems reduce noise, use less energy, and provide enhanced performance with faster payback over conventional centrifugal laboratory fume hood exhaust systems. With typical energy reduction of $.44 per cfm at $.10/kilowatt-hour, these systems provide an approximate two-year ROI, therefore energy consumption is about 25% lower than with conventional centrifugal fans – with substantially reduced noise levels, particularly in the lower octave bands. They conform to all applicable laboratory ventilation standards of ANSI/AIHA Z9.5 as well as ASHRAE 110 and NFPA 45, and are listed with Underwriters Laboratory under UL 705.

The systems are designed to operate continuously without maintenance for years under normal conditions - direct drive motors have lifetimes of 200,000-hours. Non-stall characteristics of the system's mixed flow wheels permit variable frequency drives to be used for added Variable Air Volume (VAV) savings, built-in redundancy, and design flexibility.

Virtually maintenance free operation (there are no belts, elbows, flex connectors, or spring vibration isolators to maintain) eliminates the need for expensive penthouses to protect maintenance personnel under adverse conditions. Conse-



quently, additional savings of several hundreds of thousands of dollars are realized in a typical installation.

Mixed flow impeller systems are available with a variety of accessories that add value, reduce noise, or lower energy costs substantially. For example, accessory heat exchanger glycol/water filled coils for use in 100% conditioned makeup air facilities add exhaust heat to intake ventilation air to save thousands (or hundreds of thousands) of dollars in energy.

Conclusion

Recovering ambient heat prior to exhausting it outside the building is generally only cost-effective when 100% conditioned makeup air is required as in the case of this pharmaceutical manufacturer. Because there are so many variables between facilities – including physical layouts, equipment, heating/cooling systems, etc. – it makes sense to look into other methods of heat recovery and/or heat efficiency as well. And, because climate is a key factor in this equation, a full year's outside temperatures should be considered to help make a better determination as to what might be suitable. For laboratory environments, another energy conservation approach would be automated control of laboratory workstation fume hood exhaust rates based upon occupancy sensing.

References

1. Neurogen Corp., Branford, CT.
2. Bill Waldron.

About the Author

Paul A. Tetley is Vice President and General Manager of Strobic Air Corp., a subsidiary of Met-Pro Corp. Since joining the company in 1989 as engineering production manager, he has designed and/or invented many innovative Tri-Stack fan systems, an acoustical silencer nozzle, and a unique multi-fan plenum system.

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