TECHNOLOGY EVALUATION OF THERMAL DESTRATIFIERS AND OTHER VENTILATION TECHNOLOGIES

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ABSTRACT
Thermal Destratifiers are an emerging energy-saving technology recently evaluated by the Navy Technology Validation (Techval) Program. This paper examines the performance and cost effectiveness of this technology. The Navy is also currently evaluating Duct Sealant, CO_2 or Occupancy HVAC Control, CO_2 Ventilation Control, and Extended Surface Air Filters technologies, as will be discussed.

Each of these technologies has been or is being evaluated at multiple Navy facilities. The results of the thermal destratifier evaluation have shown that they are easily installed, and can provide continued, trouble-free use. The technology shows good potential for new construction and retrofit applications.

Thermal destratification technology has the potential to save energy and cost. The Bethesda evaluation site showed energy cost savings with a (6 year) simple payback. The Crane site saved energy used by the heating system, but did not save overall when the destratification fan energy was added.

Based on the thermal destratification evaluations, to best determine potential energy savings, parameters of a facility need to be evaluated before project initiation. Evaluation projects performed by the Navy Techval team showed facilities having a solid envelope have better savings potential. It is the Techval teamθs opinion that facilities with higher ceilings have better savings potential while the location of the heat diffusers relative to the destratification fans does not have an effect. Also, sites where electricity costs are low and the heating system energy costs are high are best. Since the fans draw low amounts of energy compared to the heating system, installations with electric resistance heating systems will benefit despite high electric costs.

Before project initiation, to help determine the potential savings of a project, the stratification profile of a facility should be investigated. Data shows that that spaces with ñexpectedò stratification, where temperature increases with height, such as seen at Bethesda, offer the best savings potential.

There was one initial problem with the destratification fans involving the fan blades cracking. This problem was fixed and has not occurred since.

Testing is ongoing for the thermal destratification technology, and based on collected data, use of the thermal destratification technology is recommended to the Navy energy community, but only after a thorough investigation of site and building parameters is completed.

Testing of all mentioned ventilation technologies continues, and a robust dataset for each technology will hopefully be obtained. Recommendations regarding these technologies will be made as the database for each is obtained.

INTRODUCTION
The Navy Techval program evaluates emerging energy-savings technologies for the Navy. Evaluations are completed by designing the site installation, installing the technology, designing a monitoring system and plan, completing the monitoring, and writing a final report. The results of projects are then posted on the Techval Web Site (http://techval-energy.nfesc.navy.mil/). This allows the entire Navy to learn about the technology to help reach itθs energy savings goals.

As part of the evaluations performed by the Techval program, a thermal destratification system, duct sealant service, CO_2 or occupancy HVAC control, CO_2 ventilation control and extended surface air filters were each installed and monitored at multiple Navy installations.

The objective of these evaluations is to determine if the technology is cost effective, and will help the Navy meet its energy reduction goals. The desired goal of the project is for a technology to reduce energy use without any maintenance issues, with a simple payback of less than 10 years.

THERMAL DESTRATIFICATION TECHNOLOGY DESCRIPTION

When air is heated, it rises. This causes air to be layered by temperature, which is called thermal stratification. In facilities with high ceilings, this results in air at the ceiling being much warmer than the air at the floor level. Locating heaters near the ceiling increases the stratification effect. Generally, temperatures increase from 0.5^{o}F to 1.0^{o}F per foot in height. If the air is stratified, the average temperature in the building will be higher than the thermostat set point, resulting in higher heating costs.

Manufacturers literature states thermal destratification fans reduce the floor-to-ceiling air temperature differential by over 80 percent. This allows fewer heat cycles and lower energy costs. In addition, the amount of heat lost to ventilation and infiltration is reduced due to the overall reduction of energy being generated. Energy and heating system savings arise from a reduced number of equipment cycles. Figure 1 shows a typical thermal destratification fan.

FIGURE 1 ï THERMAL DESTRATIFICATION FAN

Thermal destratification fans are small, quiet units typically suspended from the ceiling. A fan takes in air from above and discharges it through a nozzle, forcing a stream of air towards the floor. The area covered by a fan depends on many factors such as ceiling height and building shape. Looking at ceiling height alone, the recommended coverage area for the evaluated fan is up to 1,000 square feet (ft^2), which is for up to 40-foot ceiling heights. Sleeves can be purchased to carry more air to the lower heights, increasing the amount of area that can be covered by a fan.

Manufacturers literature states the fans are easy to install, and require minimal maintenance consisting of a periodic exterior cleaning. It states the energy usage for destratification fans is low (as low as 13W for some models).

Manufacturers literature states destratification fans can provide special assistance in the following situations:

-Environments requiring close manufacturing tolerances as the fans increase uniformity of temperature in machinery and equipment.

-Buildings requiring large door openings, allowing heat to escape (such as aircraft hangars, freight facilities and equipment maintenance facilities). The fans can reduce energy costs and improve personal comfort by reducing the time required to reheat the building.

-Buildings requiring a clean environment including food processing and high tech manufacturing which can benefit from the subtle air movement provided by the fans.

-Buildings where continuous air circulation can reduce window fogging and frosting, cause damp floors to dry quicker, and help smoke, fumes, vapors, and odors disburse faster.

-Buildings where the balancing of temperature and improved circulation can improve drying time and evenness in paint shops, varnish, adhesives, print shops, etc.

-Buildings with condensation problems such as indoor swimming pools, tennis courts, and gymnasiums.

Thermal stratification during the cooling season causes similar problems as during the heating season. The areas near the cooling equipment may be very cool while much of the occupied zone is still overly warm. In this case, some areas must be overcooled in order to maintain comfortably cool areas in the rest of the occupied zone, resulting in increased energy consumption. This is especially critical in cold storage areas or in areas with occupied mezzanines. The following are specialized cooling applications:

-Temperature-controlled warehouse applications to reduce spoilage of temperature-sensitive products.

- Buildings with products that can dry out from air drafts including refrigerated sections of grocery stores, florists, plant nurseries and greenhouses.

Thermal stratification is particularly a problem where heating and cooling systems are not properly designed and do not distribute the heating or cooling evenly throughout the occupied zone. And, a system designed for heating often allows thermal stratification to develop during cooling and vice versa. Destratification fans can help remedy these situations. However, destratification created by the fans is best achieved when the HVAC system is also designed with this in mind.

Destratification fans have benefits for both heating and cooling, and industry specialists recommend operating the fans continuously in heated and cooled spaces. The fans are not recommended for unconditioned space.

THERMAL DESTRATIFICATION EVALUATION-SITE INFORMATION

Naval Surface Warfare Center Carderock Division (NSWCCD) West Bethesda, Maryland
The serviced facility is 140 feet long and 50 feet wide with a ceiling height of 27 feet at the highest point. This 7,000ft^2 area is covered by six destratification fans. This is fewer than the recommended number of fans (1fan/1,000ft^2) due to a 10-foot high office occupying some of the floor space. The structure is a metal frame building with a concrete floor and metal siding on the walls and roof. The walls and ceiling are well insulated with fiber batting insulation. There are 6 foot windows set 4 feet off of the floor in about one-fourth of the wall space. These are double glazed windows and appear to be in good shape.

A single electric heat pump heats the room. There are 14 heating system diffusers at the ceiling, at about the same height as the destratification fans. The room is a machine shop with about 25 lathes and milling machines, and as many as eight machinists working in the room at any one time. All personnel work at the floor level. The room is occupied and heated at all times, employing a programmable thermostat. There are setback programs run by the thermostat, as well as manual changes made by occupants.

Naval Support Activity (NSA) Crane, Indiana
The serviced section is 667 feet long and 60 feet wide. This is 40,020 ft^2, which is handled by 54 destratification fans. The ceiling height is 30 feet sloping up to a 49 foot peak. Since the ceiling height is above the recommended height for the fan, a higher-than-recommended concentration of fans was used (741 ft^2/fan). Also, due to the higher ceilings, the manufacturer installed an optional higher power motor, which does not come standard for the model of fans evaluated, and costs extra.

The building structure consists of concrete floors, walls, and roof. Windows are near the ceiling and run on each side of the room for the full length of the high-bay area. There are high-bay doors at each end of the building. There is no insulation on the walls or ceiling and the windows at the ceiling are not modern, or energy efficient, and may leak. Eleven steam unit heaters heat the room with steam from a common natural gas (NG) boiler. The diffusers are 8 to 10-feet off the floor, and thus are far away from the destratification fans.

The room is used for many purposes, but primarily as an assembly area for large equipment. All personnel work at floor level. It is occupied 80 hours per week and is heated continuously, with no temperature setbacks. There is an overhead crane that runs the length and the breadth of the room at an elevation of 42 feet. The fans were required to be mounted above the crane.

Naval Air Station (NAS) Oceana, Virginia
The Air Force has installed destratification technology in airplane hangars. Manufacturer literature states they work well in such applications, including those heated by infrared. The Navy Techval Team has begun a project in a 50 ft high airplane hangar in Oceana, VA to validate this use. Data is expected in 2007.

THERMAL DESTRATIFICATION OPERATIONAL PROBLEMS

Shortly after the beginning of the operation, four of the Crane fans and one of the Bethesda fans began to make a rattling noise. Upon investigation, it was determined that the fan blades were cracked due to a manufacturing anomaly. No material was ejected from the fans due to this cracking. New fans were shipped and installed at both sites. There have been no subsequent problems with the fans.

THERMAL DESTRATIFICATION MONITORING SYSTEM DETAILS

Naval Surface Warfare Center Carderock Division (NSWCCD) West Bethesda, Maryland
The temperature monitoring array has 10 nodes from 0.5 to 21 feet. The power used by the heat pump was monitored, as well as the local weather using a purchased weather station. The monitoring period lasted for 90 days of the heating season. During this period, the fans were cycled on and off every 24 hours at midnight in order to factor out variables such as weather, change in building load, etc.

Naval Support Activity (NSA) Crane, Indiana
The two temperature monitoring arrays were placed near the center length of the space. These are referred to as the ñNorthò and ñSouthò arrays in the analysis to follow. The heating system energy use was monitored, as well as the local weather using a purchased weather station. The monitoring period lasted 90 days of the heating season. During this period, the fans were cycled on and off every 24 hours at midnight in order to factor out variables such as weather, change in building load, etc.

THERMAL DESTRATIFICATION DATA ANALYSIS AND RESULTS

Figures 2 thru 5 show site parameters with and without the destratification fans. Figure 2 shows that at Bethesda, ñexpectedò stratification is seen, where the temperature increases with height. The ñaverage temperatureò at each height for the duration of the test is plotted. Figure 2 also shows that with the fans on, less heat is stored at the higher heights. The heat diffusers and fans are both at the ceiling at Bethesda. The heat from the diffusers is pushed to the floor by the fans. The resulting destratification provides energy savings as will be discussed.

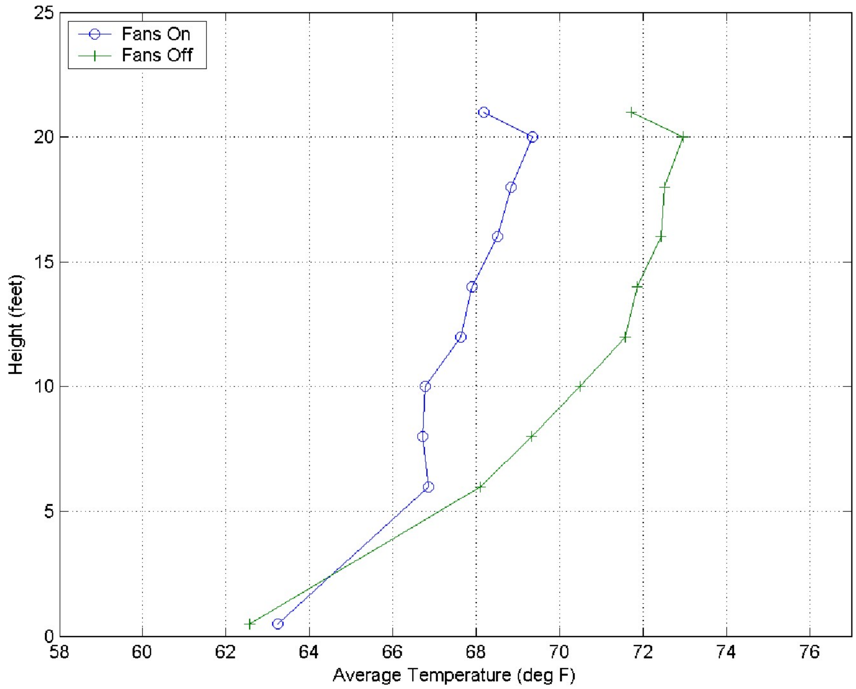

FIGURE 2 - AVERAGE TEMPERATURE OVER TEST DURATION VS. HEIGHT FOR BETHESDA

It is believed that if more sensors were placed between the six foot and the six inch level, the óFans Onô line would continue more or less vertically until it was within one to two feet from the floor, and then turn colder. The point where the óOnô and óOffô lines cross should be at the thermostat height, approximately the four foot level.

Figure 3 shows the ñnon-expectedò stratification seen at the Crane site. A temperature ñhumpò exists at the mid-height regions for both the North and South temperature arrays. This is due to the heat diffusers being located at a 10-foot height, a non-insulated ceiling, and leaky windows existing at the ceiling. Heat from the diffusers rises toward the ceiling where only some is dispersed by the fans. The rest escapes through the windows and ceiling.

Figure 3 also shows the small effect the fans have on the temperature for a given height, as compared to the Bethesda data. This is to be expected due to the high ceilings, and thus the larger amount of air for the fans to destratify at the Crane site.

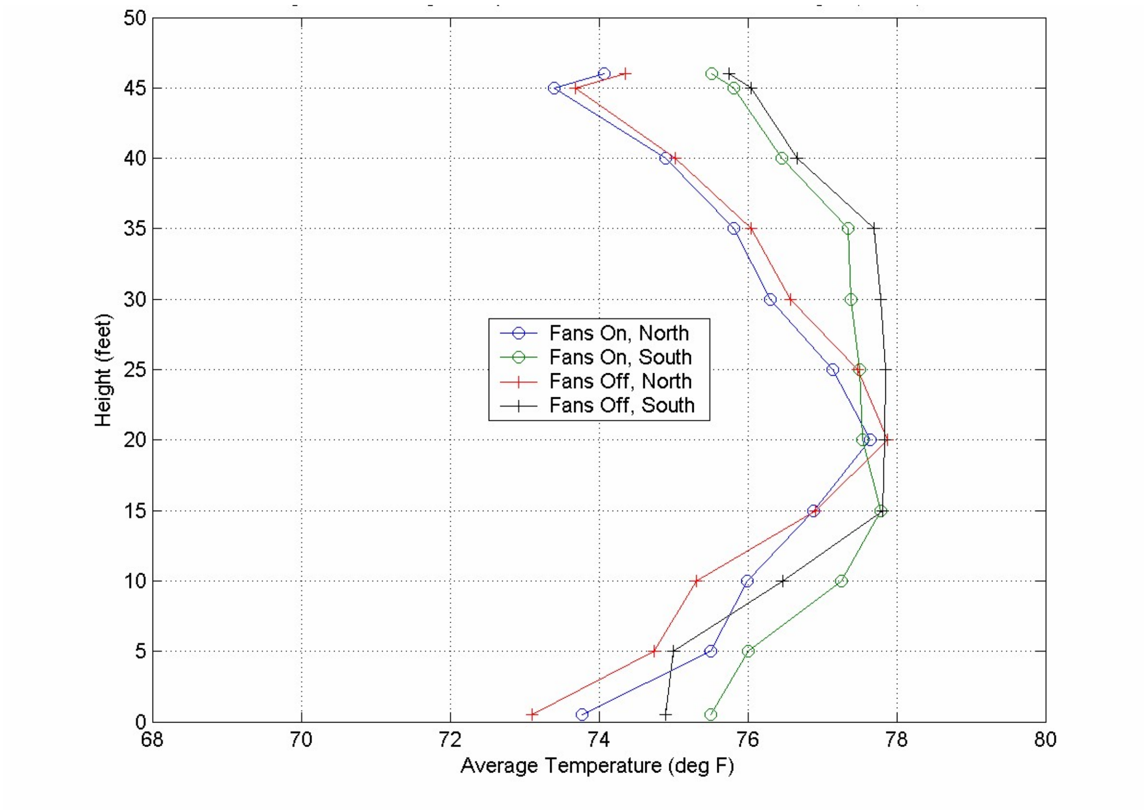

FIGURE 3 - AVERAGE TEMPERATURE OVER TEST DURATION VS. HEIGHT FOR CRANE

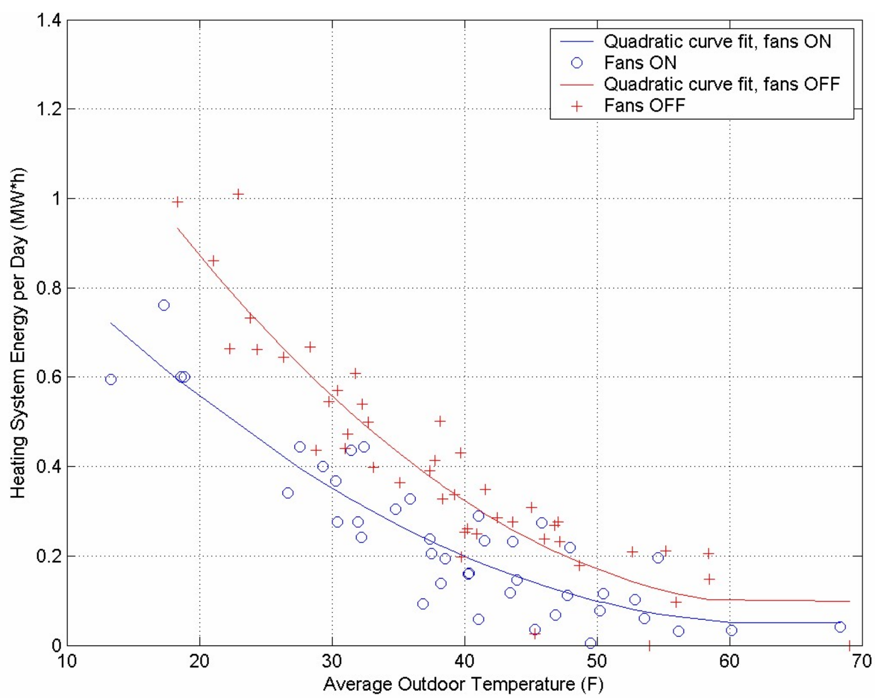

FIGURE 4 - HEATING SYSTEM ENERGY USAGE PER AVERAGE OUTDOOR TEMPERATURE FOR BETHESDA.

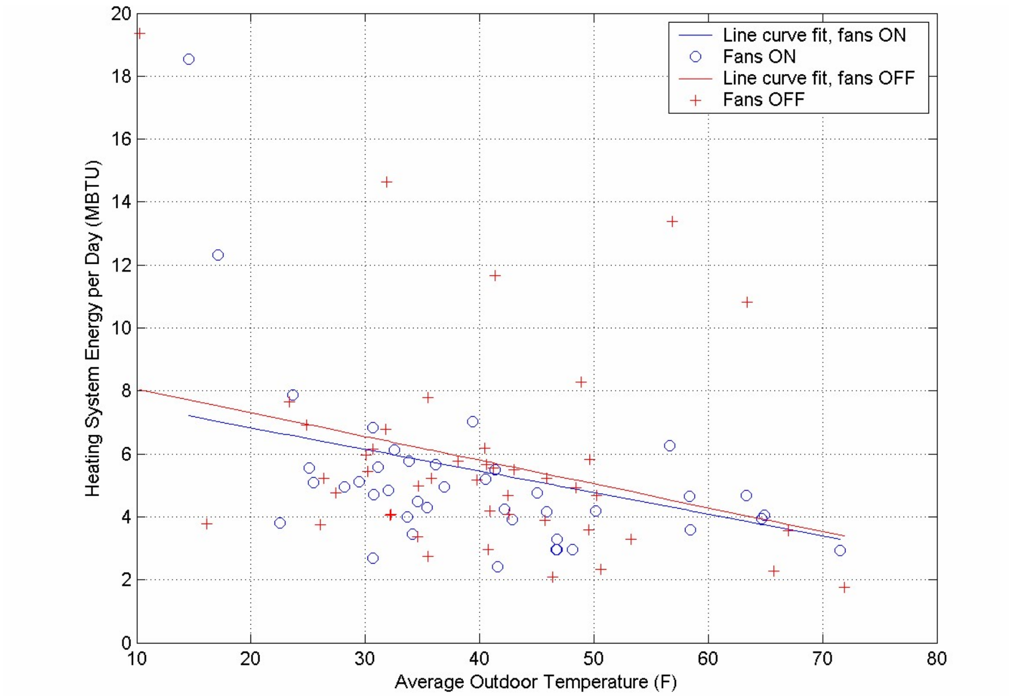

FIGURE 5 - HEATING SYSTEM ENERGY USAGE PER AVERAGE OUTDOOR TEMPERATURE FOR CRANE.

The large effects of the fans at the Bethesda site produce substantial heating system energy savings, as seen in Figure 4. For each dayôs average outdoor temperature, substantial heating system energy savings is achieved. This is not the case at the Crane site as shown in Figure 5. Due to the small amount of stratification seen at Crane, there is only minor heat system energy savings. Figure 5 also shows the decrease in variability of heat usage for a given outdoor temperature when the fans are on. This is probably due to the effects of other factors, such as opening the high-bay doors on certain days, being controlled better when the fans are on.

It is the Techval teamôs opinion that higher ceilings at a facility increase the effectiveness of the fans. This is due to the amount of thermal stratification increasing with the height of a facilitiesô ceiling. It is also the opinion of the Techval team that diffuser location has little, if any, affect on the effectiveness of the fans, as long as the building envelope is solid. It is the opinion of the Techval team that the only reason the fans were not effective at Crane was due to the poor condition of the building envelope near the ceiling. This resulted in excessive heat loss due both to conduction and infiltration. Figure 3 shows there is ñexpectedò stratification up to 15 to 20 feet, where the temperature rises with height. Then the temperature begins to decrease as heat is lost near the ceiling. Due to the introduction of cold air above the diffusers, a thermal inversion is created making it difficult to mix air above and below the diffusers. If the building were well-sealed, the temperature would continue to increase to the ceiling, since heat rises. It would not matter how high the ceiling was or where the diffusers were located. Figure 3 shows even though this thermal inversion is created, the fans move the air downward. This is evidenced by the fact that when the fans are on, the air above the diffusers becomes colder at every location as the fans blow the colder air from the ceiling. Below the diffusers the fans blow hotter air from the higher elevations, so the air temperature increases. It is the Techval teamôs opinion that the only thing keeping the destratification fan technology at Crane from not being successful is the poor building envelope, not the ceiling height or the diffuser location.

Finally, laboratory and field power usage tests were completed for the fans evaluated in this project. Laboratory tests showed power usage for the standard fan is greatly affected by current, with 58W used at 0.585A and 90W used at 0.7A. In field tests, the power usage of the fans at the Bethesda site were measured to be an average of 54W each, or 323W for the fan system. This does not include the power lost in the lines leading to the fans, which was not measured at Bethesda. At the Crane site, an optional higher power motor was installed in the fans, due to the high ceilings. Field measurements, including line loss, showed an average of 95W each, or 5,122W for the fan system. Approximately 15 percent power loss was measured in the line at this site, giving a fan-only usage of around 81W per fan. The load resistance of 18 fans at the Crane site, which were in parallel, was less than 11 Ohms. Therefore, even the small line resistance present caused a significant line loss. With power savings in mind, larger diameter and shorter length wires are desired. Though the measured line loss is significant, the final effect on energy usage and cost for the site is low because the heating system uses more power than the fans.

THERMAL DESTRATIFICATION SAVINGS POTENTIAL

The following parameters are seen at the Crane site:

Electricity $0.039/kWh
Natural Gas (NG) $0.855/therm
4,637 Heating Degree Days.

The installation ($24,700) and destratification fan ($19,696) costs for the 54 fans total $44,396 or $822/fan. For the Crane site, the fans cost $915 to operate per year. Their operation allowed less steam energy to be used, with the estimated savings being $766 per year, resulting in a net loss of $149 (or ~ 10 Mbtu) per year. Heat loss from conduction and infiltration was due to the poor building envelope.

In Bethesda, electricity costs $0.056/kWh and there are 4,240 Heating Degree Days.

For the Bethesda site, the fans cost $71 to operate per year. Their operation allowed less heat pump energy to be used, with the estimated savings of $1,466 per year, resulting in a net savings of $1,369 (~95 Mbtu) per year.

At Bethesda, the installation ($5,917) and destratification fan ($2,188) costs for the six fans total $8,105 or $1,351/fan. This, in combination with the $1,369 per year savings results in a 6-year simple payback.

This analysis shows, as expected, the installed per-fan costs decrease substantially as the number of fans increase. This and the energy costs have a dramatic affect on the economics of this technology. This analysis also shows the huge effect parameters such as building envelope have on the cost effectiveness of such projects.

THERMAL DESTRATIFICATION CONCLUSIONS

Thermal destratification technology has the potential to save energy and cost. The Bethesda evaluation site showed energy cost savings with a good (6 year) simple payback. The Crane site saved energy used by the heating system, but did not save overall when the destratification fan energy was added.

Based on the thermal destratification evaluations, to best determine potential energy savings, parameters of a facility need to be evaluated before project initiation. Evaluation projects performed by the Navy Techval team showed facilities having a solid envelope have better savings potential. It is the Techval teamǿs opinion that facilities with higher ceilings have better savings potential and the location of the heat diffusers relative to the destratification fans, does not have an effect.

Also, sites where the energy cost to power the destratification fans is low and the energy cost for the heating system is high are best. The fans draw low amounts of energy compared to an electric heating system, so that this technology is cost effective at such installations. This was seen at the Bethesda evaluation site.

Before project initiation, to help determine the potential savings of a project, the stratification profile of a facility should be obtained. This can be economically accomplished using temperature probes and data loggers. Data shows that spaces with ñexpectedò stratification, where temperature increases with height, such as seen at Bethesda, offer the best savings potential.

There was one initial problem with the destratification fans involving the fan blades cracking. This problem was fixed and has not occurred again.

Testing of this technology at the Crane and Bethesda sites is complete, and based on the data collected, use of thermal destratification technology is recommended, but only after a thorough investigation of site and building parameters is completed. The project currently underway at NAS Oceana will help to add more insight into the technology, especially how it works in airplane hangars with infrared heat.

DUCT SEALANT TECHNOLOGY

In heated or cooled spaces, ductwork is often used to channel conditioned air to its needed location. Heating and cooling costs of a facility are increased due to air leaking from the ductwork into unconditioned spaces such as attics and mechanical rooms. Also, additional fan energy is required to properly condition spaces due to leaky ducts. Sealing the ductwork will minimize these effects.

Duct sealant technologies attempt to seal cracks and leaks in existing ductwork. Hence, equivalent building conditions can be maintained with a lower energy input. The resultant average energy and energy cost savings for heating and cooling a facility is reported in the industry to be in the region of 5 to 10 percent. Often, variable frequency drives (VFD) or alterations to the fan speed is required in order save energy used by the fan.

The demonstrated ductwork sealing system injects adhesive particles into an isolated duct system. As the particles accelerate through holes and cracks in the ductwork, they adhere, sealing the opening.

Duct Sealant technology is being demonstrated at NSA Orlando, NAVSTA Newport, Naval Base Bremerton Kitsap, and NAVBASE San Diego. The sealing has been conducted at 3 of the 4 sites, with post-sealing monitoring underway. Baseline monitoring continues at one site. No conclusions regarding savings have been drawn from the data obtained so far.

DUCT SEALANT SERVICE PROCESS

During an initial site visit to the prospective buildings, drawings and the actual ductwork was investigated. Trained professionals evaluated the feasibility of the technology for the given configuration, which includes the savings potential. ôDuct Blastingô was often performed, where a section of ductwork was isolated by blocking off the vents etc., and pressurizing the system, to measure the leakage percentage. The service pays off best where a high-percentage of leaks are present.

During the duct sealing process, the section to be serviced is again isolated and the sealant is injected into the ductwork, as shown in Figure 6.

Figure 6 ï DUCT SEALANT SERVICING

As the sealant is injected into the ductwork, the process is monitored by software. Graphs, such as that shown in Figure 7, are plotted so the percentage of leakage sealed is known, and it is known when to stop the sealing process.

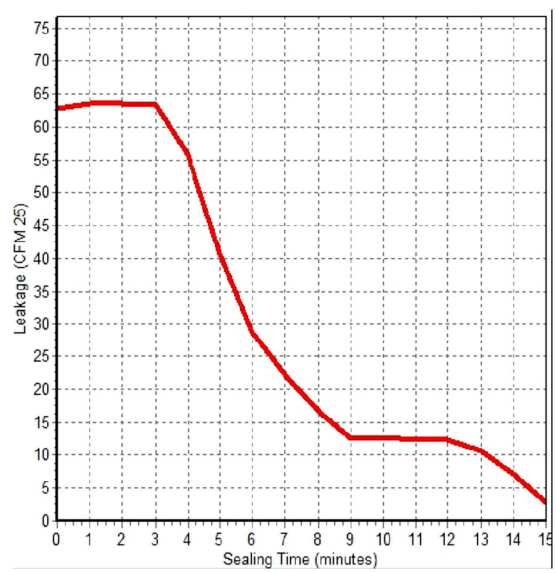

Figure 7 ï SAMPLE LEAKAGE GRAPH

DUCT SEALANT PROBLEMS DURING SERVICING

Service has been completed at 3 of the 4 sites. The only issue occurred at Naval Base Bremerton

Kitsap where the exhaust ductwork stopped at the attic floor and picked up a shared sheet rock enclosed shaft containing a plumbing vent pipe, electrical wires, and fire sprinkler pipes. This was discovered during the sealing process, when the leak percentage was not decreasing. The sealing was stopped due to the large number and size of the penetrations in the chase.

Today, tying plumbing vents into an exhaust system is against building codes in most areas. This building was built 30 years ago, and vertical chases used for return/exhaust air ductwork are not uncommon in high-rise buildings. This should be considered in future applications of the technology. A more thorough inspection and testing of the ductwork to be sealed is one possible improvement to the process. ÒDuct blastingÓ during an initial site visit, when feasible, will discover these types of existing conditions.

DUCT SEALANT RESULTS AND CONCLUSIONS

The Duct Sealant technology has sealed a high percentage of leaks in the ductwork in the demonstration buildings (usually over 95%, which is expected by the manufacturer). It is the Techval teamÕs opinion that this technology will save energy in the serviced buildings, and shows potential to save energy at other Navy facilities. Monitoring results being collected will be used for verification.

CO_2 OR OCCUPANCY HVAC CONTROL

For this technology, a CO_2 or occupancy sensor is linked to the HVAC system either directly or through a DDC system. This allows the HVAC system output to be tailored to the occupancy density of a space, thus saving conditioning and fan power energy uses.

This technology will work best in spaces where there is variable occupancy. Spaces with regularly timed occupancy can be handled by DDC programming instead.

In the application of this technology, a designer needs to evaluate using CO_2 or occupancy sensors. Factors to consider:

- In general, occupancy sensors provide quicker control response than CO_2 sensors.

- Occupancy sensors have location and aiming issues to ensure they capture appropriate occupancy matched to the VAV zone. CO_2 sensors do not exhibit this characteristic.

- With occupancy sensors, if occupancy is intermittent on a constant basis, such as storage or work areas with occupants entering and exiting frequently, then the sensor might cycle the system on and off more than desired. This rapid cycling may have equipment life effects.

- CO_2 sensors donÕt sense occupancy alone, but the number of occupants. This may be considered more effective than occupancy sensors as it will continuously regulate to a preferred CO_2 level, which has some health-related implications. Thus, the use of occupancy sensors to regulate airflows might require the use of a higher base ventilation level to meet some space conditioning requirements.

- It is likely that occupancy sensors on a unit basis will be less costly than CO_2 sensors. It is not clear however, if single occupancy units will be able to provide the sensing coverage needed for a typical VAV zone. Application should be limited to locations where occupancy sensor capability is ensured. VAV zones with multiple rooms would likely not be a good application because of the need for multiple sensors. Open areas can be difficult to adequately cover with occupancy sensors. The best applications may be larger rooms that comprise a single zone.

It is the Techval teamÕs opinion that this technology will benefit the Navy due to energy savings in both heating and cooling seasons by reducing the amount of air that needs to be conditioned, and the fan power required.

This technology is currently being demonstrated at NAS Oceana, VA, and CDSA Dam Neck, VA to determine its potential energy savings and feasibility of application.

CO_2 VENTILATION CONTROL TECHNOLOGY

This technology uses CO_2 sensors to control outside air dampers. This reduces the amount of outside air that needs to be conditioned during periods of low occupancy. This technology is approved by ASHRAE and most building codes.

Industry literature states energy savings of 5 to 80 percent are obtained and states the technology will work best either with constant volume or

VAV systems, and in buildings with high occupational densities and variable occupancy. For example, coin-operated laundries, class rooms, libraries, auditoriums, office buildings, hospital lobbies and waiting areas, hotel lobbies, conference rooms, meeting rooms, and ballrooms.

It is the Techval teamös opinion that this technology will benefit the Navy due to energy savings in both heating and cooling seasons by reducing the amount of outside air that needs to be conditioned.

This technology is currently being demonstrated at NAVSUPPACT MID-SOUTH, Millington, TN, NAB Little Creek, VA, and NB Kitsap-Bremerton, WA, to determine its potential energy savings and feasibility of application.

EXTENDED SURFACE AIR FILTERS

The extended surface air filter offers advantages over standard (flat surface) filters by providing increased surface area for particulate capture. This allows increased particulate capture efficiencies, extends the filter life, and helps reduce pressure drop. This saves energy along with operation and maintenance costs.

The best application for these filters is in buildings with VAV systems that have VFDs on the fan motors, having long operation times. Savings are expected on constant volume systems also. Also, in wet coastal environments, their plastic housing and non-woven media work better than normal filters.

A manufacturer-stated 20 percent reduced fan energy use can result in VAV systems, which are equipped with VFDs on the fan motors, where simple paybacks of two years are predicted. The achievable savings will depend on the pressure drop rating of the existing filter being replaced.

Manufacturer literature states filter life is extended 3 to 4 times that of low efficiency filters. Filtration efficiencies are increased, leading to cleaner buildings. There is a reduced labor cost for filter replacement and disposal fees. However, the first cost of the premium filters is higher than that of standard filters, and capturing its benefits relies on a filter change schedule or plan that takes into account their increased life.

Manufacturer literature states the filters fit into housing for standard filters. For retrofit applications, a correct filter slot size needs to be determined. Many extended filter products are produced commercially, making them readily available.

It is the Techval teamös opinion that this technology will benefit the Navy due to energy savings in both heating and cooling seasons by the required fan energy.

This technology is currently being demonstrated at NAVSUPPACT MID-SOUTH, Millington, TN, US Naval Academy, Naval Base Ventura County, CA, and NAS Oceana, VA to determine its potential energy savings and feasibility.