INTERNATIONAL FOODSERVICE DISTRIBUTORS ASSOCIATION

FUEL AND ENERGY BEST PRACTICES IN FOODSERVICE DISTRIBUTION

Prepared by

International Foodservice Distributors Association

IFDA
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About International Foodservice Distributors Association (IFDA)
When U.S. consumers sit down to eat in one of the nation's nearly one million foodservice locations, the food on the plate—and possibly the plate and tableware—has been brought there by a foodservice distributor. IFDA is the leading trade association representing foodservice distributors throughout the United States and internationally. IFDA's members include broadline, systems, and specialty foodservice distributors that supply food and related products to restaurants and other food away from home foodservice operations. IFDA members operate more than 700 distribution facilities representing more than $110 billion in annual sales.

Overview

Fuel and energy have always been important factors for foodservice distributors. In an industry that relies so heavily on fuel to deliver product and on energy to protect that product while in storage, exploring every opportunity to reduce consumption can contribute to a distributor's long-term success.

In an economic environment dominated by unpredictable fuel and energy costs, the IFDA Distribution and Logistics Committee met in February of 2009 to brainstorm ideas that should be considered to reduce fuel and energy consumption. The committee identified a series of options and best practices that distributors should consider in their efforts to control costs and reduce their carbon footprints.

This white paper will focus on transportation and warehousing. The Sections include the following:

TRANSPORTATION

- Driver Behavior
- Aerodynamics
- Equipment Specification
- Tires

WAREHOUSING

- Warehouse Design
- Energy Management Systems
- Energy Efficiency Opportunities
- Batteries

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Trailers: Kidron, Great Dane, Utility Trailer Manufacturing Co., Wabash National, L.P.

Aerodynamics: Solus Solutions and Technologies LLC

Engines: Cummins Inc., Caterpillar, Detroit Diesel Corporation

Ethanol: Food and Water Watch, Network for New Energy Choices

Fuel Cells: The Raymond Corporation, Plug Power, Inc., Oorja Protonics Inc., Nuvera Fuel Cells

Idling: XATA Corporation

Lighting: Commercial Warehouse Lighting Supplies and Accessories

Refrigeration: Thermo King, Carrier Transicold

Roofing: Insulating Coatings Corporation

Tires: Bridgestone Coporation, Michelin, Tire Retread and Repair Information Bureau

Tractors: Kenworth, Navistar, Inc., Freightliner Trucks, and Peterbilt Motors Company

Warehouse Energy Controls: Dematic Corp.

During this research, information from the following agencies and organizations was also utilized:

Smartway Transport Partnership - EPA's green program.

U.S. Energy Information Administration - Fuel pricing information.

U.S. Environmental Protection Agency - standards.

U.S. Department of Energy - Prices and perspectives.

California Resources Board - Regulations relating to emissions and idling.

National Institute of Building Sciences - For building attributes.

Berkeley National Laboratory - Automated energy systems in refrigerated warehouses in California.

Transportation

TRANSPORTATION: DRIVER BEHAVIOR

Driver techniques and habits play a major role in fuel economy. Since the majority of a driver's day is spent unsupervised, it is important that he or she is properly trained to efficiently operate a vehicle and that there are adequate programs and systems in place to monitor and control two critical areas: speed and idling.

Speed Control

Excessive speed is the largest single cause of reduced fuel mileage. Approximately half of the energy used by a truck travelling at 55 mph is consumed just to move air around the truck. At 65 mph, about two-thirds of the energy consumed is due to this. As a result, fuel economy will fundamentally decrease as operating speed is increased. For example, a truck travelling at 75 mph consumes 27 percent more fuel than one travelling at 65 mph. As a basic rule of thumb, for every mile per hour over 50, fuel mileage is reduced by 0.1 mpg.

Effective speed control programs can come in a number of forms that can be used individually or in conjunction with one another.

Mandatory compliance policies set clear expectations regarding maximum speed limits. Many foodservice fleets have already set their maximum speed limits to 65 mph or below. On a national level, organizations such as the American Trucking Association have publicly promoted enacting a national 65 mph speed limit. When considering implementing such plans, it is important to select a speed that is the most compatible with your fleet's gear ratios and engine specs. For some engines 60 mph may be appropriate, and for others it could be 62 mph.

Engine speed control governors are offered by nearly all of the engine manufacturers and provide a viable option for limiting maximum truck speed. There are, however, commercial products available that are designed to "get around" these devices undetected. Knowing this, it is good policy to have a back-up system such as a tamper-proof onboard trip recorder to monitor speed and rpm.

Incentive programs have proven to be successful in many fleets. Such programs set compliance levels, and drivers who remain within those limits receive monetary incentives for their performance.

Electronic onboard recorders (EOBRs) are not a legal requirement yet, but for many foodservice distributors they are standard operating tools utilized for multiple purposes relating to driver safety and performance while in-transit. EOBRs can be a valuable tool in monitoring a speed compliance program.

Driver training is a necessary component of any compliance program. Speed is a major factor in fuel consumption, but so is progressive shifting. A heavy foot and improper shifting habits will undermine fuel improvement efforts. Different engine models operate differently, so it is important to refer to owner and driver manuals to achieve the best engine performance. Progressive shifting training should teach drivers to:

- Use restraint when accelerating from a stop.
- Short-shift at 1,000 to 1,200 rpm in all low-range gears to reduce fuel consumption while still moving the truck;
- Use 1,500 rpm as the maximum shift point while in high gear;
- Lug the engine down to 1,150 rpm before downshifting;
- Avoid the high consumption upper-end of the power curve (1,500 to 1,800+ rpm); and
- Keep the engine boost level steady and consistent between shifts.

In-truck aids are also available to assist the driver. Digital gauge systems, for example, electronically monitor and record consumption as well as display real-time average mpg. If the needle moves into the red zone, it signals the driver to either shift the transmission or increase vehicle speed to improve fuel efficiency. If used properly, tools like this are worth their weight in gold.

Cruise control is also gaining popularity. Extra fuel is burned every time there is an upward change in speed. By setting the control as soon as the vehicle is up to

speed and avoiding rapid stops or situations requiring deceleration, a driver can maintain a more constant speed, and therefore save fuel.

Idle Reduction

An idling truck engine consumes up to one gallon of diesel fuel per hour. Two hours of unnecessary idling per power unit in a fleet of 50 trucks can result in a loss of 100 gallons a day. This could easily amount to losses of more than $1,500 per week.

Idle control programs have similar forms and rationale to speed control programs such as engine shut-down systems to limit idling, electronic onboard recorders, and incentive programs. A typical goal is to limit engine idling time to less than 5 percent. This can be accomplished many ways – from no-cost options to others costing several thousand dollars.

Anti-idling program behavioral change is the simplest route. An anti-idling program encourages drivers to turn off their engines when not in use. Educating drivers about the negative aspects of idling can play an important role in changing driver behavior. Besides wasting fuel, idling causes unnecessary engine wear, higher maintenance costs, and reduced engine life.

Some drivers mistakenly believe that starting and stopping an engine uses more fuel and/or causes additional wear and tear, when the truth is just the opposite: 10 seconds of idling consumes more fuel than turning the engine off and restarting it. Replacing such myths with facts will go a long way in obtaining buy-in and achieving the desired results.

Idling control in some locales is now mandatory. States and cities across the country are implementing idling regulations for diesel-fueled commercial vehicles citing factors including pollution, greenhouse gas emissions, health issues, and fuel consumption. Examples include California, which has a 5-minute idling limit and an automatic shutdown system requirement for all 2008+ engines. New York City cut engine idling time to one minute in school zones effective February 11, 2009.

Technologies noted earlier to control speed are also available to help control idling. These include:

- Onboard recorders or GPS tracking systems – to capture idling data for trucks while in transit; and
- Automatic engine shut controls – programmed to shut engines off automatically within a prescribed time limit determined by company policy.

Long-haul tractors have historically idled for significant periods of time. A common reason for excess idling in these vehicles is to operate an air conditioning system or electrical devices that are in the sleeper cab.

Alternative Power Source (APS) technologies include:

- Diesel-fueled APS – for cooling and electrical power. Fuel consumption equals 0.2 gallon per hour and cost, including installation, is usually between $6,000 and $8,500.
- Battery-Electric APS – for heating, cooling, and electrical power. The battery recharges while driving and operating time is up to 10 hours. Cost ranges from $4,000 to $10,000.
- Vehicle-Battery-Powered Systems – powered by the vehicle's existing battery, these systems can be used for heating and cooling only, no electrical power. Operating time is up to 8 hours and cost ranges from $550 to $1,600.
- Fuel-fired heater – for engine and/or cab heating only. Fuel consumption is between 0.02 and 0.16 gallon per hour and cost ranges from $1,000 to $3,000.
- "Plug in" Power – for heating, cooling, and cab appliances. These systems plug in to an electrical grid and require onboard AC unit, inverter/charger, and electrical connections. The approximate cost is $4,000 per truck.
- Off-Board Power Infrastructure (typically at truck stops) – for cooling, electrical, Internet, telephone, and television. Cost is typically $1.60 to $1.88 per hour for basic services (climate control) with additional cost of approximately $10 (for window adapter). One gallon of diesel is saved for every 75 minutes of use.

TRANSPORTATION: AERODYNAMICS

Drag, or air resistance, is a major consideration as trucks travel at highway speeds. Between 50 and 60 mph, 50 percent of the fuel burned is used to overcome air resistance, and the percentage increases dramatically as vehicle speeds increase. This is because drag forces depend on velocity. Countermeasures to aerodynamic drag can vary from something as simple as keeping the windows closed while driving to the carefully designed options that will be discussed below.

Power Units

Tractors account for 25 percent of the drag in a tractor-trailer combination. Aerodynamic options on tractors take many shapes and have varying potential savings on fuel economy. These include:

- Streamlined hoods, bumpers and windshield angles (10 - 15%)
- Center and rear chassis fairings (1 - 2%)
- Roof-mounted air deflectors (5.5 - 6.5%)
- Aerodynamic mirrors (1 - 1.5%)
- Under hood air cleaners (1 to 2%)
- Trailer gap reductions (1 - 2.5%)

The effectiveness of any of the above options will depend on the vehicle's daily operating range. There is a misconception that aerodynamic devices only work at highway speeds, but in reality, various speeds yield various improvements. When considering aerodynamic devices be sure to confirm what the savings percentages are at varying speeds, beginning with 30 mph and increasing at 5 mph increments. This is an important consideration when calculating ROI. For example:

- If a vehicle is going to be used primarily in a city delivery application with minimal driving at highway speeds, some of the above options may not yield the ROI to justify them; or
- If a vehicle is to be used for shuttling twin-trailers to satellite drop sites, or for long-haul runs, more of the above options may be viable choices.

One must also consider the practicality of each option. For example, if a vehicle will be making deliveries to locations requiring tight turns, devices such as trailer gap reductions or rear side fairings may not be practical. It is highly recommended that you work closely with your power unit OEM or dealer representative in determining which options provide the best ROI for your type of operation.

Trailers

Trailers pose significant aerodynamic challenges. Because of their length and vertical corners, they are rectangular boxes that create 55 percent of a tractor-trailer combination's aerodynamic drag (the gap between the tractor and the trailer contributes an additional 20 percent).

Most trailer OEMs have rounded the front corners and smoothed out the angle of the corner tops to improve air flow, but since trailers are designed for cube maximization, drastic tapering or streamlining of angles would create costly financial implications.

There are, however, several aerodynamic options available for trailers:

- Trapped vortex nose devices (4% fuel savings)
- Nose cones (3% fuel savings)
- Undercarriage skirts (5% fuel savings)
- Rear boat-tails (4 - 5%)
- Wheel flow blockers (0.50 - 1.0%)

There are some aerodynamic trailer designs that make obvious sense for foodservice distributors, such as rounded corners, smooth sides, etc., but one should exercise careful due diligence when considering the more sophisticated options. Such options may be fine for long haul trailers travelling at constant highway speeds, but the majority of them are problematic for foodservice distributors because of refrigeration units mounted on the nose of the trailer, delivery areas that require tight turns, and the need to back up squarely to sealed dock doors.

Additionally, some of the options pose safety hazards such as increased potential for tipping (some side skirts create lift), the inability to properly inspect the undercarriage during pre and post trip inspections, as well as inconveniences such as access to air lines, fuel tanks, or conveyor/side-step holders under the trailer. As with power units, it is highly recommended that you work closely with your trailer OEM or dealer

representative to determine which options will provide the best ROI for your operation.

Refrigeration Units

Major manufacturers of truck refrigeration units have done a very good job of keeping up with aerodynamic designs to match new tractor styling. Sleek design, soft edges, smooth surfaces with no visible screws, and new elliptical/honeycombed grills for maximum airflow through the condenser coils are becoming the norm.

TRANSPORTATION: EQUIPMENT SPECIFICATIONS

The need for proper equipment specifications cannot be overemphasized. Basic specifications and options can have a significant impact on fuel use. One improper specification can create unnecessary costs for the life of the equipment. For this reason, it does not make good business sense to blindly accept a "standard" spec. Specifications should be "tailored" to the equipment's expected use and working environment.

Power Units

There are hundreds of specs to choose from such as chassis configuration, engine, electrical, front and rear axle, front and rear suspension, driveline, fuel tanks, wheels, interior and exterior cab features, instruments, options, paint, and more. This is a task that should not be taken lightly and should involve detailed discussion with a trusted and knowledgeable truck manufacturer representative or dealer.

When determining equipment specifications, it is critical to first understand the environment in which the equipment will operate:

- Local deliveries only?
- Longer distance deliveries?
- Combination of local/long distance?
- Shuttling twin-trailers to satellite drop sites?
- Mountainous terrain?
- Tight delivery restrictions?
- Light loads?
- Heavy loads?
- Driver skill level?

This will ensure that the capabilities of the vehicle you are purchasing or leasing "match" your operational needs. Without this exercise, the chances of receiving a vehicle with an improper engine, horsepower, gear ratio, drive train, wheel base, or cab configuration are greatly increased.

When spec'ing a power unit for fuel economy, it is recommended that you:

- Select a model that has a strong basic aerodynamic design – smooth angles and round curves.
- Carefully evaluate the aerodynamic options available such as air shields, chassis fairings, cab extenders, etc., making sure that they will be effective in your operation.
- Select the right engine and gearing for the intended operation. Engine power settings have unique torque, horsepower, and fuel consumption curves. Selecting an engine with excessive power or not enough power, or larger gear will lower potential efficiencies.
- Explore the benefits of automated transmissions and its resulting computer-controlled shifting capabilities. If you have an operation with high turnover, or a need to train drivers quickly, these may be viable options for you.
- Ensure that the vehicle's wheelbase and fifth-wheel settings are well-suited for the weights and the trailers that will be hauled. For aerodynamics, the narrower the gap between the trailer and cab the better, but it can't be so narrow that it creates contact when turning in tight spots.
- Select transmission and rear axle ratios that ensure the correct cruise rpm to match the engine's smooth spot. The wrong rpm can decrease fuel economy by 10 to 15 percent.
- Consider the terrain over which the vehicle will be travelling. You may want to spec gear splits that keep the engine in the sweet spot while climbing hills.
- Consider specs that reduce weight, such as wheels, brake drums, and fuel tanks.
- Spec tires with the least rolling resistance and the ability to handle future load weights.
- Explore trip economy dash displays that will provide drivers with instant feedback regarding fuel economy.

Specification reviews before purchase provide excellent opportunities to learn about new features that will improve mpg or changes that can be made to reduce weight. Examples, as mentioned above, include aerodynamic devices to improve air flow or proper fuel tank size and lighter wheel rims for weight reduction. As mentioned previously, work closely with your OEM or dealer representative to determine which options will provide the best results for your operation.

Trailers

Today's trailers are much stronger, lighter, and more durable than those built five years ago. Structural integrity has been improved, heavier components have been replaced with equally strong, lighter weight materials, and strength has been added to areas prone to fatigue.

The majority of trailers used in foodservice are refrigerated and include multiple temperature areas that must maintain temperature integrity for product. Refrigeration is used to remove heat from inside the insulated space. Depending on the size/insulation/age of a trailer/van and the age and model of its refrigeration unit, a single reefer unit can consume upwards of 3,500 gallons in a year.

Fatigue is a major consideration when spec'ing a trailer. As trailers go down the road or make tight turns, stress is placed on certain components or areas of the trailer. Over time these stress areas weaken, creating structural integrity issues that impact temperature control efficiency and increase fuel consumption.

Keeping this in mind, careful consideration must be given to specs that will impact fuel and energy consumption over the life of the trailer. When spec'ing a trailer for fuel economy, it is recommended that you:

- Explore each manufacturer's insulation injection processes to ensure that it prevents insulation "voids" and protects long-term insulation ability.
- Determine the optimum insulation R-factor for the trailer's expected operation. This includes walls, ceiling, and floor.
- Select snag-free interior linings with a thickness that will withstand the daily rigors of load bars and palletized product, keeping in mind that holes or cracks result in energy loss.
- Identify side post, roof bow, and floor cross-member spacing requirements that will ensure long-term structural integrity for doors and floors.
- Install heavy-duty seam-free scuff bands, at least 10 inches in height, to protect nose and side walls from day-to-day damage (and resulting refrigeration loss).
- Carefully evaluate the location and number of side doors, recognizing that each door can impact structural strength and increase the opportunity for leakage.
- Determine the thickness and type of rear door that fits your operational needs (roll-up or swing-out), recognizing that roll-up doors can be closed at a dock door without having to move the trailer.
- Select a floor surface (ribbed or flat) that provides the best air flow for the products you transport.
- Carefully evaluate the need for and number of floor drains, understanding that each drain provides an opportunity for a 250 btu to 500 btu loss per hour.
- Determine proper location of any side door pull-out steps to ensure that floor insulation degradation is kept to a minimum.
- Spec rear walk ramps with weight reduction in mind.
- Select a fuel tank capacity that minimizes weight, but does not incur additional refueling labor costs.
- Spec an exterior surface that is smooth and uninterrupted with ribbing and/or rivets.
- Select white as the roof color to reflect the sun's rays.
- Consider aluminum wheels to reduce weight.

As mentioned before, work closely with your trailer OEM or dealer representative to determine which options will provide the best results for your operation.

Refrigeration Unit

Food safety is a top priority for foodservice distributors and thermal efficiency is the key to protecting perishable products in-transit. Truck refrigeration unit OEMs have made the selection process easy by providing specialized "foodservice application" specs that are multi-compartment focused.

Multi-temperature refrigeration units allow distributors to select optimum temperatures for diverse products such as frozen foods, fresh produce, and canned goods all on

the same truck or trailer. A system of sensors determine supply and return air temperatures based on pre-set temperatures in the nose unit and rear evaporator(s).

Significant developments have taken place in recent years, including:

- Improved emissions performance to address environmental regulations;
- Improved fuel efficiency;
- Expanded use of data management and collection for documentation of food temperature throughout transport; and
- Tracking devices tied in to trailer GPS systems that enable fleet operators to track trailer temperatures by the hour.

Several choices of truck refrigeration technologies exist. The ultimate choice depends on the type(s) of equipment you operate and which application is the best "fit." Choices include:

- Diesel Engine Powered – Cooling is achieved through a diesel powered unit and occurs when the engine is running.
- Cold Plate – Cooling is achieved through the use of stored energy in cold plates and daily plug-in is required to recharge stored energy.
- Hybrid/Cold Plate – Power is generated by a chassis mounted permanent magnet generator that provides electricity to run the refrigeration system. When the chassis is not running, refrigeration is provided by cold plates. No separate diesel engine is needed and recharging takes place by driving and/or by plug-in.
- Hybrid/Electric Standby – The unit's diesel motor drives a high output electric generator that powers an all electric refrigeration system. When parked, these units may be plugged into a power supply without running the diesel engine.
- Hybrid/Cryogenics – Liquid carbon dioxide stored in a vacuum insulated tank is used as a refrigerant and as a power source for unit fans. When doors are closed at a delivery stop, the unit begins to recover from the temperature gain during the stop, and the unit runs in high mode.

When spec'ing truck refrigeration units for fuel economy, it is recommended that you:

- Identify the products you will be transporting – ice cream, frozen foods, produce, fruits, canned goods, etc.
- Do not undersize the unit. Ensure that the unit model you select has the capacity to protect your range of products efficiently.
- Determine if rear evaporators are required.
- Identify the optimum location(s) for any rear evaporator(s). Considerations include wall-mounted, ceiling-mounted, distance from the nose unit, distance from side door(s) and rear door, etc.
- Identify options that will stop the unit's engine when refrigeration is not needed and will restart the engine when refrigeration or a battery charge is needed. These can achieve a fuel savings of up to 80 percent.
- Identify options that help the driver manage the load, such as easily visible temperature read-outs, alarm systems, etc.
- Identify "trouble-shooting" options that allow the quick identification of mechanical issues.
- Consider monitoring devices that provide real-time information.

Technological advances are happening very quickly in the refrigeration industry. As stated, work closely with your OEM or dealer representative to determine which options provide the best results for your application.

TRANSPORTATION: TIRES

Tires represent approximately 20 percent of a vehicle's maintenance costs. Tire expense is typically the third highest expense for most truck fleets, following fuel and payroll, and yet is often the most undermanaged line item.

Under-inflated tires significantly affect fuel economy. An under-inflation of 10 psi can reduce mpg by as much as 5 percent. On a single vehicle averaging 50,000 miles per year, at 5.5 mpg, that reflects more than 450 wasted gallons per year.

A properly inflated tire running at 65 mph will heat up to approximately 170 degrees Fahrenheit due to friction and centrifugal force. As little as 5 psi under-inflation can cause a tire to run up to 25 degrees hotter, causing the tire to wear out 10 percent to 20 percent faster.

Under-inflation can also cause excessive flexing, which leads to premature fatigue and failure of the steel cords. This will ultimately limit the number of potential retreads from each casing.

Double-seal flow-through metal valve caps should be used on all tires to minimize air loss and the resulting under-inflation. Each valve cap contains an internal check valve, similar to the one in the stem. When an air hose or pressure gauge is applied to the valve cap, the air flows through the cap and its internal check-valve and then through the valve stem and into the tire. These caps eliminate valve leaks and prevent contaminants and water from getting into the valve mechanism. Dirt in a traditional valve stem core will prevent the valve from sealing properly and water, if frozen, can crack the valve mechanism and cause valve failure.

Note: Traditional screw-on valve caps tend to disappear because of the time and effort required to unscrew and re-screw the valve cap. Double-seal flow-through caps eliminate this issue.

Mismatched (different tread depths) tires on duals have the same effect on tires as under-inflation. A difference of one-quarter of an inch between tire tread depth will not only cause the larger tire to carry more of the load, it will force the smaller tire to drag as it rotates at the same speed as the larger tire.

To control tire expense, several things must be done:

- Purchase tires with greater carrying capacity than is needed.
- Purchase brand name tires that have a proven history of reliability in your fleet.
- Purchase tires with the most appropriate tire tread and least rolling resistance for your fleet's application.
- Purchase tires with the greatest recap potential.
- Maintain a strict tire pressure program.
- Maintain a strict tire matching program.
- Purchase wheel systems that run true.
- Maintain axle alignment.
- Keep tires balanced.
- Use double-seal flow-through metal valve caps as cheap insurance to minimize under-inflation and downtime.

Dual Tires or "Super-Singles"?

The jury is still out on this, but super-singles have not really caught on in foodservice. There are pros and cons. On one hand, by replacing two tires with one, the overall cost should be less; but on the other hand, when a super-single blows there is no remaining dual to shoulder the load.

Tire manufacturers say super-singles average 3 percent better fuel economy than duals. Supers have only four sidewalls per axle instead of eight with the duals, and have a smaller footprint than a set of duals which means less friction and rolling resistance.

Weight savings can be considered also. A set of super-singles on aluminum rims can cut nearly 500 pounds from a tractor equipped with steel rims and duals. With supers on an accompanying trailer, half a ton can be cut for the combo.

Despite the benefits, super-singles have a long way to go before being fully accepted. There continue to be concerns about:

- Inability to limp to the next truck stop to replace a blowout.
- Heavy tire weight, making it hard for a single person to change a tire.
- Having to keep two inventories (duals and supers) until the entire fleet is converted.
- Availability of supers when replacements are needed on the road.
- Having to have two tire carriers under a trailer instead of one, thereby increasing costs and negating some of the potential weight savings.
- Limited ability to retread.

Until these concerns are resolved, it is doubtful we will see wide acceptance of supers in foodservice distribution.

Automatic Tire Inflation Systems

Tire inflation systems are steadily gaining popularity in foodservice fleets, and for good reason: They eliminate many of the concerns noted earlier regarding under-inflation's impact on fuel economy and operating costs. These devices connect tires to a vehicle's compressed air supply and maintain pressures to within a few pounds of a set level. The results include.

- Improved fuel consumption,
- Flats, blowouts, and road service calls are almost completely eliminated,
- Tires with slow leaks can be completely filled within a mile,
- Tire life can be extended, and
- Labor and downtime costs are significantly reduced.

Warehousing

WAREHOUSING: WAREHOUSE DESIGN

Foodservice distribution centers are typically designed to protect products at different levels of refrigeration. Properly refrigerated areas are needed for perishable products such as meat, dairy, and produce that require a range of temperatures and humidity levels, and for a wide range of products that must remain frozen.

Refrigerated warehouses are very energy-intensive and are typically custom-designed. Much thought is given to proper wall, roof, and shell insulation, as well as freezer floor construction, so as to maintain the required temperatures and reduce equipment load (and its related energy consumption).

- Freezer walls require more insulation, typically 5 or 6-inch expanded urethane metal clad panels with thermal resistance factors (R factors) ranging from R-32 to R-36.
- Freezer floors are constructed with glycol heating tubing covered with 4-inch rigid styrene and 6 inches of reinforced concrete.
- Freezer ceilings typically contain 5-inches of insulating materials with R-factors ranging from R-31 to R-50. In facilities containing both freezer and cooler space and room for future expansion, the cooler areas are often built with the same insulation as the freezers.

In addition to multiple temperature zones, foodservice distribution centers have loading docks that can significantly increase energy demand if not properly designed and managed.

- Dock door openings introduce moist air into the facility.
- Air units dehumidify the air and discharge it over interior doors to refrigerated areas to reduce moisture infiltration into the cooler and freezer areas and to reduce load on the compressors.

In both of these scenarios, dock door management (keeping doors closed and well-sealed) and adjacent interior door performance (ability to open/close quickly and restrict moisture/temperature spillage from one area to another) become critical factors in reducing energy consumption (and in protecting product integrity).

The basics of a refrigeration system are fairly straightforward and include an evaporator, a compressor, a condenser, and expansion valves. Freezers typically utilize two-stage compressors, and coolers typically use single compressors. If two-speed compressors are equipped with variable speed drives, they are more efficient when operating at less-than-full load. It is highly recommended to include high efficiency motors and variable speed drives for compressors, evaporator and condenser fans, and fluid pumps in your system design.

WAREHOUSING: ENERGY MANAGEMENT SYSTEMS

The major consumer of energy in a foodservice distribution center is refrigeration, accounting for more than half of the energy use in a typical warehouse. For this reason, most foodservice distribution centers have control systems to monitor and control the performance of their refrigeration system. These controls allow key operating factors such as temperature, pressure, level, flow, use, and demand to be monitored. There can be stand-alone controls or more complex energy management system controls. The more sophisticated controls can gather real-time data from sensors in remote locations and equipment components and automatically make programmed setting adjustments based on input.

A good case-in-point: Compressors account for approximately 70 percent of a refrigeration system's total energy load. The use of on/off switches or manual controls on compressors to adjust refrigeration capacity is inefficient as someone has to be present 24/7 to control the operation of each compressor. Advanced compressor controls are more efficient and apply capacity control that can not only turn the compressor on and off, but can also apply capacity control by adjusting the compressor motor speed through variable speed motors.

Energy management systems reduce the need to manually read and adjust equipment. They also provide real-time temperature adjustments that can impact the integrity of many perishable products. The capability of remotely controlling these energy-intensive components greatly improves the ability to achieve significant energy efficiency.

WAREHOUSING: ENERGY EFFICIENCY OPPORTUNITIES

Lighting

Lighting is the second largest consumer of energy within a distribution center at approximately 30 percent. Many warehouses use sodium or metal halide fixtures to provide lighting, especially in areas with high ceilings, however, advances in fluorescent lighting now provide a viable option.

Fluorescent tubes in conjunction with special lenses in the fixtures not only provide more light output than the sodium and halide lamps they replace, they also deliver 60 percent to 80 percent in energy savings and have lower maintenance cost. Based on savings achieved you may be eligible for federal tax incentives or rebates from utility companies.

LED (light omitting diode) lights mounted to a wall or I-beam adjacent to receiving/loading doors also provide additional energy savings. These lights utilize only 15 watts of energy as compared with traditional dock door lamps that use 150 watts. They also have a longer lamp life (50,000 hours), which reduces maintenance and replacement costs.

Skylights

Skylights may not be for everyone. Their effectiveness on energy consumption is dependant on year-round weather conditions and a distribution center's footprint in relation to the sun's path over it. For cooler climates that are heating dominant, skylight strategies that allow the least amount of heating load increase are the best performers. In hotter climates that are cooling dominant, strategies that allow the least amount of cooling load increases perform better. In either case, the amount and intensity of daylight are critical factors.

Skylights can reduce building energy use, but only if electric lighting controls exist. Without lighting controls, lighting energy consumption would remain the same.

Skylights are not recommended in refrigerated areas, but they are more suited for ambient warehouse and general office areas. In air-conditioned areas, cooling and heating energy consumption can be affected because less thermally resistant skylights are installed in place of a more thermal roof. Solar radiation through the skylight and conduction through the roof are major influencers of electric lighting power consumption.

Selection of skylight type is important. Horizontal skylights produce higher luminance in the summer and lower luminance levels in the winter. The monthly lighting energy use for raised or angled skylights is more constant throughout the year because they are able to take advantage of the low winter sun angles. Please note, a building's footprint and skylight locations are important factors of effectiveness and you should seek expert advice on this issue.

As mentioned earlier, solar radiation and conduction through the roof are important considerations. Solar radiation levels can be controlled through the use of different levels of diffuse glazing. These come in varying degrees of shading from translucent to opaque and are readily available commercially. Conduction through the roof can be affected over time by the quality of a skylight's installation. Poor installation can result in energy leakage and water leakage, both of which have costly consequences.

Doors

In order to be effective in a refrigerated environment, doors should be designed and used to prevent the infiltration of warmer and/or moist air into a refrigerated area. Infiltration accounts for approximately 50 percent of the total refrigeration load. The typical points of vulnerability include loading docks and any openings between two areas with different temperature settings or demands. Using the opening of a door between the freezer and the loading dock as an example:

- Warm/moist air from the loading dock passes through the door into the freezer;
- If the evaporator inside the freezer is above the door, it sucks up the warm/moist air and condensation falls in the form of rain or snow onto the floor, or collects on the coils;
- Ice build-up occurs on the evaporator and on the freezer floor;
- Cold air from the freezer flows out onto the loading dock floor; and
- Ice build-up or water accumulation collects on the loading dock floor.

This creates a dangerous situation for the forklift and pallet jack operators, increases energy consumption related to defrosting and restricted air flow, and reduces refrigeration effectiveness within the freezer.

There are several steps that can be taken to prevent the above from happening. Warm/moist air typically is introduced through dock doors. Supervisors should be taught to manage door openings.

- Open a dock door only when there is a truck at that door.
- Install external flexible door seals around all dock doors and ensure that all trucks backed in to those doors are backed squarely into the door seals to prevent any infiltration.
- Close a dock door immediately once the truck at that door is loaded or unloaded.

Vertical hydraulic dock door levelers can also make a big difference when preventing infiltration. These levelers do not require indented storage areas that can create openings underneath a dock door.

Because docks are high activity areas, dock doors can be particularly vulnerable to damage. All it takes is one collision with a pallet jack or forklift and a dock door can easily get bent or knocked off its rollers, creating infiltration issues. It is recommended that older rigid multi-panel doors be replaced with dock doors that have flexible break-away panels that can be easily and quickly replaced.

The primary methods of controlling door-related energy losses are by reducing air flow and minimizing the amount of time a door stays open. The following tools provide effective solutions based on the operating area.

High-speed doors are very effective for cooler or freezer applications. Choices vary and include folding, roll-up, or bi-parting. They are typically counterbalanced or counterweighted doors that roll up or open as mounted photo eyes are triggered by movement. They then close quickly after a forklift or pallet jack operator has passed through. Door movement of 100 inches per second is not uncommon. Options include windows, defrost capabilities, diagnostics, and easy re-set capabilities if hit.

Air curtains are a viable option in high movement areas where door openings are so frequent that refrigeration loss becomes problematic. Directing a high velocity air stream across the entrance of the door minimizes cross-filtration of air from one side to the other, while allowing traffic to pass through without interruption. Its control system operates a heater and fan and maintains the temperature and humidity of the air stream across the doorway to prevent condensation and humidity-related issues. Properly installed, they can reduce the rate of heat and moisture flow by more than 60 percent.

Vestibules are typically used at the doorway of a refrigerated storage room to permit passage of forklifts and pallet jacks while effectively reducing the exchange of air through the doorway and precipitation inside and outside of the doorway. Typically two sets of doors are required – one to enter the insulated vestibule and another at the entrance of the refrigerated area. The distance between the two doors is greater than the length of the longest piece of equipment used to transport product to or from the refrigerated storage space. Vestibules take up floor space and require two doors, which reduces its attractiveness to some.

Strip curtains are frequently used to reduce air flow between two areas with very close temperature levels or as a secondary buffer in combination with another type of door. The upside is that they save the expense of a door. The downsides include cleanliness and high maintenance when strips are knocked off.

Roofs

Black surfaced roofs can reach 190 degrees Fahrenheit in the summer. They do not reflect solar radiation, and as a result, absorb heat quickly and are slow to release it. Much of this heat is absorbed into the building interior and can significantly impact energy consumption.

White roofs, on the other hand, reflect solar radiation and release absorbed heat faster. On a 90 degree Fahrenheit day, a white reflective roof can be at 90 degrees Fahrenheit while a black roof can be 174 degrees Fahrenheit or more. These characteristics help reduce heat gain through the roof, increase the performance and efficiency of the HVAC equipment mounted to the roof, and increase insulation effectiveness. In addition, by providing a layer of protection against weather elements, reflective roof coatings can reduce the rate of aging of the roof system components and extend the life of a roof.

White roofs reduce the cooling load on buildings in hot sunny climates by releasing heat absorbed from the sun, but this may not be as attractive an alternative in cooler climates with fewer sun days per year. Because darker colors retain heat longer, the benefits of retained heat may be more attractive in some climates.

WAREHOUSING: BATTERIES

Battery-powered forklifts and pallet jacks lose approximately 14 percent of their speed over the last half of the battery charge. In 2-shift operations, battery management becomes very important, sometimes requiring 2-3 batteries per piece of equipment to ensure that as one battery wears down, there is another fully-charged battery available to keep a forklift or pallet jack running. This is an expensive and energy-draining process.

- Valuable floor space is taken up by battery charging and changing stations.
- Multiple batteries are needed for a single piece of equipment.
- Batteries' charge and change intervals have to be closely monitored to ensure that batteries are installed and ready for use at the correct time.
- If battery-change sequence is off, productivity is negatively impacted when equipment operators have to go to the battery change area and wait in line to change batteries mid-shift.
- Old batteries must be disposed of in an environmentally friendly manner, and the list goes on…

Fast-Charging Batteries

Battery fast-charging technology has helped alleviate the problems described above. It allows a single battery to be charged faster and more often without reducing battery life. As a result, only one battery is needed per piece of equipment and equipment can be charged during breaks, lunches or at the end of shifts.

Other benefits include:

- Fewer batteries,
- Improved battery utilization and equipment performance,
- Increased productivity,
- Less exposure to dropped batteries and personal injuries,
- Less exposure to lead and acid, and
- Much less energy consumption.

Fuel Cell Systems

Unlike batteries, fuel cells do not run down or require recharging; they operate as long as fuel is supplied. Fuel cell powered equipment runs at full speed all the time and never requires changing. When it is time to refuel, operators take their equipment to fueling stations where they can refuel in less than 3 minutes.

A battery chemically stores and releases electricity, while a fuel cell produces energy through the electrochemical reaction between fuel and air. A battery will run out of power and require recharging and ultimately disposal, but a fuel cell will continue to function and produce power as long as fuel and oxygen are provided.

A variety of fuels can be used including hydrogen, methanol, butane, natural gas, ammonia and liquefied petroleum gas. The two leading fuels in material handling equipment are hydrogen for battery-replacement applications and methanol for onboard recharging applications.

A fuel cell converts the chemical energy of the fuel directly into electricity. This reaction in a single fuel cell produces about a volt of electricity. Separate fuel cells must be combined into fuel cell "stacks" to increase the power it can generate, and the total potential power that can be produced depends on the size of the stack.

The benefits of using fuel cells in warehouse equipment include:

- Improved productivity – save time by eliminating battery changing.
- Quick recharge – refuel in one to six minutes.
- Constant voltage – no voltage drop towards end of shift or in cold storage areas.
- Square footage – recover battery charging/changing areas.
- Maintenance – no more charging station maintenance.
- Safety – no more battery acid exposure or accidents related to changing batteries.
- Financial incentives – federal, state, and county credits.

The future looks bright for this new technology. However, as with any new applications, it is important to make sure that you exercise due diligence before making a decision.

Conclusion

Making the right decisions about fuel and energy in the warehouse and fleet operations can provide bottom line savings and help your company reduce its carbon footprint.

A number of manufacturers mentioned in the acknowledgements section of this whitepaper (page 1) can provide insights on technologies and innovations that can help shape more efficient fuel and energy strategies.