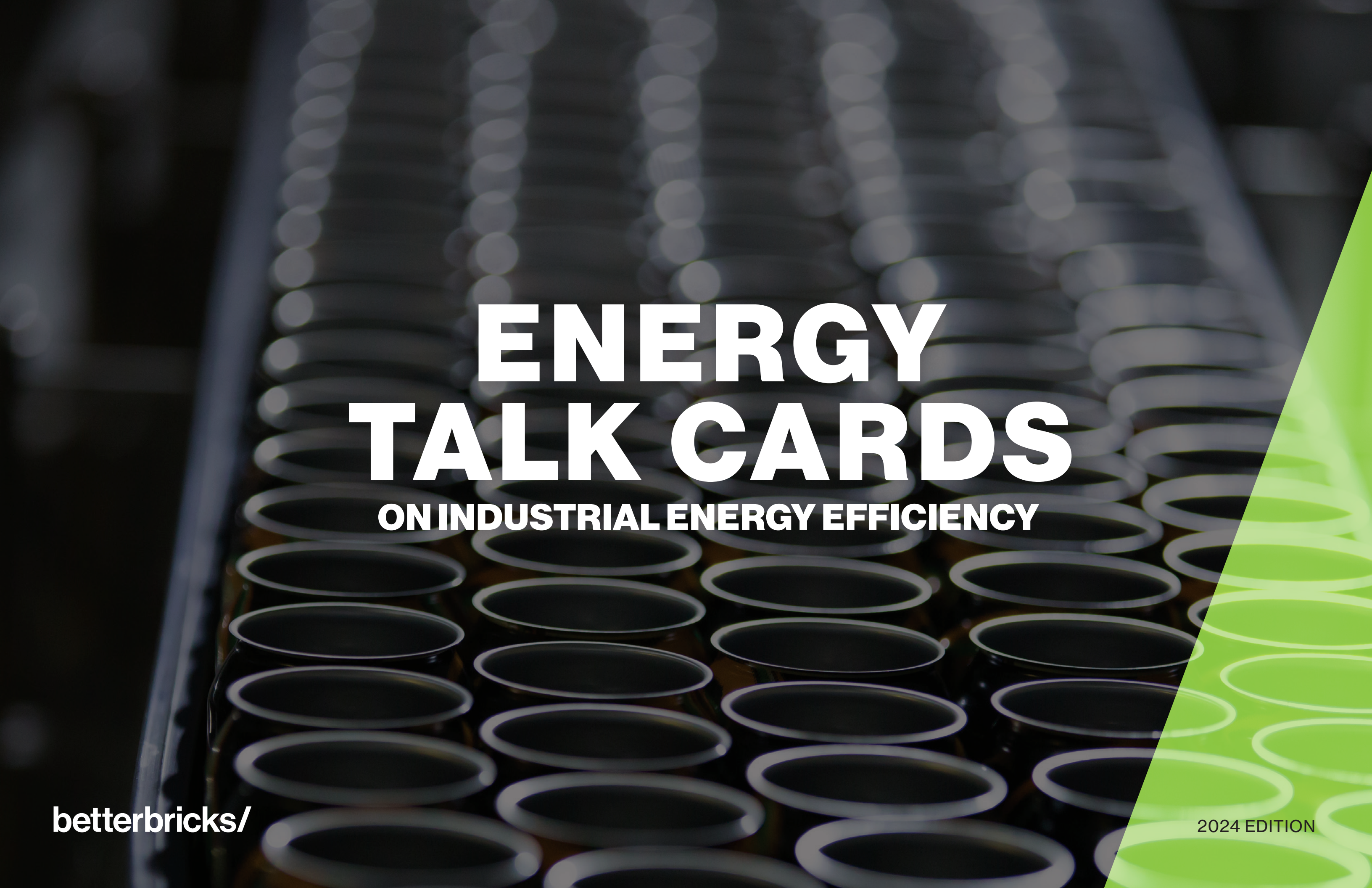

ENERGY TALK CARDS

ON INDUSTRIAL ENERGY EFFICIENCY

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2024 EDITION

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CONTACT US

Have an idea or need support?
Reach out to your utility or contact us directly!

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STRATEGIC ENERGY MANAGEMENT

SEM is a continuous improvement process that helps you

- Manage energy as a controllable expense
- Get everyone on your team working together to reduce energy use
- Implement actions that reduce energy intensity
- Increase payback on energy-related capital improvements
- Reduce O&M expenses
- Complement your company's existing continuous improvement programs
- Obtain a competitive cost advantage at the point of production

Each card contains a tip or piece of advice to keep energy top of mind among your team so you can manage energy as a controllable expense at the point of production.

HOW TO USE THESE CARDS

AUDIENCE
Production, maintenance, operations and purchasing staff and technicians.

PURPOSE
These cards provide key learning points and discussion topics on energy efficiency to engage your team in discussions onenergy use in industrial facilities. Participation is the best way to reinforce energy efficiency practices for key industrial systems in your facility.

USE
Pose questions at staff engagement events and meetings to stimulate conversation and learning. Upload cards on digital monitors in shared spaces to bring attention to energy usage site wide. Share cards digitally via email or newsletters. Print cards and post in relevant areas or on energy boards. Make card deck easily accessible via internal intranet.

RECORD
Ideas or opportunities that come out of discussions should be recorded in your project tracking platform and progress shared with your team.

MOTORS

INDUSTRIAL ENERGY TALK CARDS

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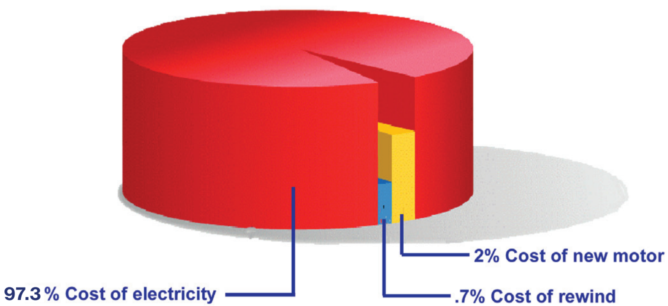
QUESTION

What is the most significant cost when purchasing and operating a motor?

ANSWER

Electricity.

It's 97.3% of the motor's 8-year cost.



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DISCUSSION

"Penny wise but pound foolish" couldn't be more relevant. Too often, first purchase cost is the determining factor. However, a motor's "life cycle costs," which include price per kWh, driven load requirement, efficiency, and hours of operation, often tower over its purchase price. Utilities offer cash incentives for O&M efforts that reduce electricity use on motors.

What are the normal cost considerations you use to purchase a new motor?

What are the additional life cycle costs to consider when making equipment-purchasing decisions?

Are there motors at our facility that'd benefit from motor speed control, possibly based on pressure or flow requirements? If so, consider upgrading to VFD control.

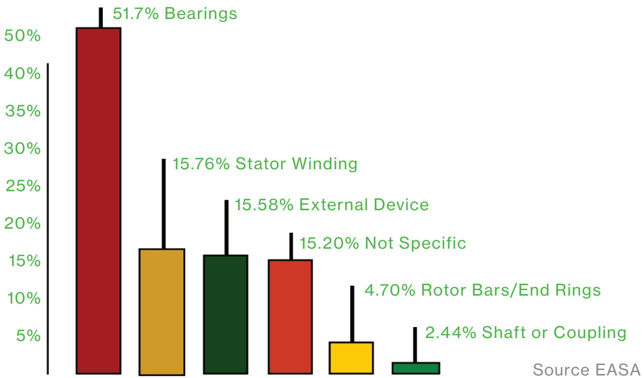
QUESTION

If a motor is in storage, how often should the shaft be turned?

ANSWER

When in storage, a motor shaft needs to be rotated every 30 days. The motor shaft needs to be rotated in order to supply sufficient grease to the bearings' surfaces, because any vibration, metal-to-metal, will cause premature failure of the motor. 52% of all motor failures are bearing related.

MOTOR SYSTEM FAILURE MODES



DISCUSSION

At the facility level, we may not be able to affect the purchase decision or all of the life cycle costs, but we can influence the driven load and hours operated.

What two driven system elements have the biggest impact on life cycle costs?

Answers

- **Hours of Operation:** If a motor is **running needlessly,** report it (or tag it) to ensure the hours of operation are reduced without harm to the motor or process.
- **Load:** If **less mechanical force** is needed to operate a motor driven system, report it (or tag it). This can reduce the driven load requirement and electricity used.

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QUESTION

Have we investigated which motors are appropriate to turn off when they are not in use?

DISCUSSION

How many motors did you find that could be turned off or put on standby?

What can we gain by turning off motors when they are not in use?

Did you know that 97.3% of the cost of owning a motor is contained in our electric bill?

The purchase price and maintenance of the motor accounts for only 2%.

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QUESTION

What is meant by electric motor efficiency?

ANSWER

It's the percentage of electrical power that is converted to mechanical power.

(Note: methods of measuring efficiency vary)

Energy Losses

	Stator Res.	Rotor Res.	Iron Core	Friction	Stray Losses	Total
Percent of Losses	6.2%	3.6%	3.1%	0.7%	1.4%	15%
Percent of Output	40%	25%	20%	5%	10%	100%

Typical 5 hp, 4 Pole, 3 Phase
85% Efficient Motor

DISCUSSION

Consider a typical, fully-loaded, 5 horsepower electric motor: 100% of the electricity goes in, but only 85% is converted to mechanical power and is available at the motor's output shaft.

The remaining 15% is lost due to resistance, stray currents, bearing friction, and motor cooling.

Most of the 15% motor inefficiency is manifested as heat and will directly contribute to a shorter motor life.

What are the benefits of a more efficient motor or motor-driven system?

Possible answers

- Higher efficiency means less electricity used, which means lower operational costs and higher production
- Higher efficiency means a longer motor life
- Higher efficiency means a more reliable motor

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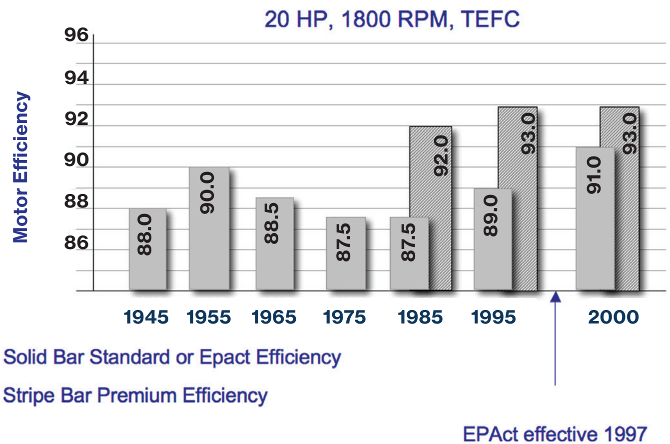
QUESTION

Do all electric motors have about the same efficiency?

ANSWER

No. Motor efficiencies and efficiency trends have varied for decades.



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DISCUSSION

A motor's quality might be difficult to define with only general rules-of-thumb. However, a national standard exists which qualifies motor efficiency, called the NEMA (National Electrical Manufacturers Association) Premium™. The NEMA Premium™ label indicates a "high performance" motor that runs at a slightly faster RPM, is more tolerant to Variable Frequency Drive (VFD) application, and meets or exceeds efficiency standards.

How are motors labeled in our facility?

What are the life cycle pros of purchasing a NEMA Premium™ motor?

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QUESTION

Have we checked with the engineering/maintenance and purchasing departments to learn about using NEMA Premium™ efficient motors in our plant?

DISCUSSION

Are there areas in this plant where it would be beneficial to upgrade to a NEMA Premium™ motor?

Do you have ideas for ways in which we could save more motor energy?

Have you learned anything about energy efficiency that you thought was interesting, or that the rest of us should know about?

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QUESTION

When a motor system component failure occurs, how should it be handled?

ANSWER

Refer to and follow a motor driven system prefailure action plan.

DISCUSSION

When a motor driven system component fails and must be removed for repair or replacement, the situation becomes ideal to advance efficiency and reliability. An action plan should be prepared and in place for each significant motor driven system component. This plan should be designed to improve Key Performance Indicators (KPIs) and give direction for the best course of action.

Here's the situation: A process line stops and it is important to get it back up and running as fast as possible. Unfortunately, haste-based decisions that don't consider electrical costs, reliability, and system impacts are very often the norm in a crisis situation. Referring to a pre-prepared action plan will not only quickly return motor function, but also ensure the greatest system advantage by improving KPIs.

What are the KPIs for our motor system?

Possible KPIs

- Is the ratio of kWh/product produced improving?
- Are motor replacements and their locations identified?
- Have haste-based decisions (due to motor failure) been reduced or eliminated?

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QUESTION

How long does the average motor last?

ANSWER

It depends upon the amount of load, environment, and duty cycle required of the motor. However, if properly applied, the average motor life is approximately seven to eight years.

DISCUSSION

It's a given that all motors will eventually fail. Put time on your side by managing consistently to take advantage of each opportunity. Develop a motor failure action plan in advance to help you prepare ahead and make upgrades to improve efficiency.

Over a period of only a few years, without a great deal of expense, if energy and system reliability impacts are advanced each time a motor fails, the majority of the facility's systems will have improved significantly. Use your action plans to consistently make the best possible decisions and enhance motor system key performance indicators. In a short period of time, you'll see positive results in facility-wide motor driven systems efficiency and reliability advancement.

Consider these issues for your motor systems

- Is RPM taken into consideration when a motor is exchanged?
- Are we looking beyond the motor at possible better efficiencies throughout the system?
- Have we taken amperage readings and confirmed the right size motor is in place?

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QUESTION

Are motors turned on as close to the start of production as possible?

And is it shut off as soon as production is complete?

DISCUSSION

How much energy is saved by only running the equipment when it's needed?

Does it always make sense to start and stop our machinery throughout the day?

Have you noticed machinery that is being used in a way that wastes energy?

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QUESTION

How much money does it cost to run a fully loaded, 20 horsepower motor twenty-four hours a day, seven days a week, for a year, if electricity is only $0.05 per kWh?

ANSWER

Simple calculation is

20 hp * 0.746 kW/hp = 14.9 kW

14.9 kW * 8760 hrs/year = 130,700 kWh/year

130,700 kWh * $0.05 kWh = $6,534

Note that depending on your utility, time of day can affect the electricity rates. Reach out to your utility contact to better understand how your rates are structured, and see if there are cost savings to operating equipment at a different time of day.

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QUESTION

Should a motor be turned off at lunch or when it's not being used?

ANSWER

Maybe. It really depends on how often the motor can be cycled and what effects there might be on production.

DISCUSSION

A loaded, unused motor is inarguably a very inefficient motor. Generally speaking, turning off a motor for one hour a day is the equivalent of upgrading from a standard efficient motor to a NEMA Premium™.

When implementing, consider the number of allowable starts for a motor, as definaed by NEMA, can vary widely. For smaller motors, the number of starts is high (10-30 per hour) while larger motors (>250 hp) may only be able to start 2-4 times/hour. Please reference the literature for your specific motor to determine how many starts are allowable.

QUESTION

Can motor over-lubrication cause loss of efficiency?

ANSWER

Yes.

DISCUSSION

Many motor manufacturers have changed to a lubricant called Polyurea, which is incompatible to most grease. Improperly applying incompatible greases may almost certainly cause bearings to fail.

Proper lubrication and correct motor maintenance procedures are important, not only for longer motor life but also for maintaining reduced energy consumption.

Too much lubrication or the wrong luabrication is more likely to cause motor failure than under-lubrication. Improper application practices and over-lubrication often results in motor windings becoming packed with grease and therefore unable to dissipate heat.

What happens if grease comes in contact with motor magnetic-wire due to over-lubrication?

Answers

- Decay of insulation materials and premature electrical failure
- Dust and fine particles will enter raceways and damage both rotating and static bearing surfaces
- Additional friction
- Collapsed bearing shields, and seals (causing a significant loss of efficiency and higher operational costs)

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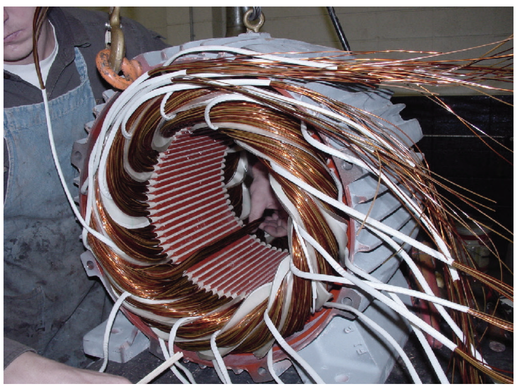
QUESTION

Does a motor lose efficiency when it's rewound?

ANSWER

Maybe not. If the failure event which caused the need for a motor rewind didn't inflict catastrophic damage to the core, and the motor service center follows Green Motors Practices' shop procedures, the motor should retain or slightly improve efficiency.

Motor rewinds may be eligible for incentives from your electric utility provider.



DISCUSSION

Two questions fit the task of rewinding motors very well:

"Do you want it done fast or done well?"

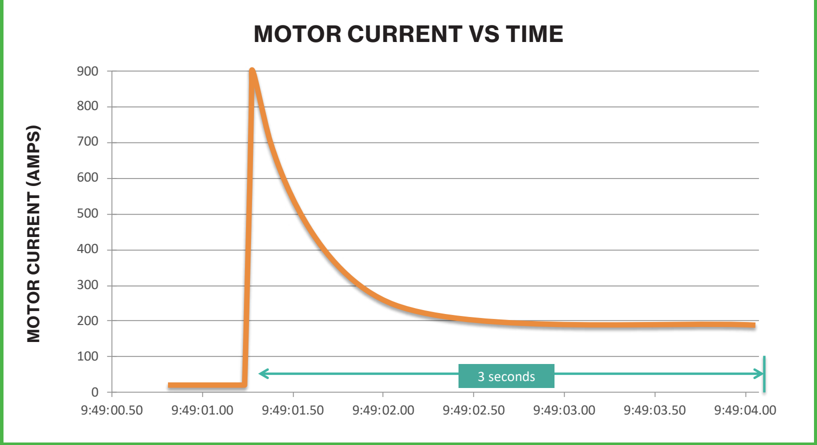
"Do you want it done cheaply or done right?"

A qualified motor service center understands efficiency is just as important as reliability and can rewind motors to sustain efficiency. Efficiency will improve, provided the failure didn't destroy the motor core, a prior rewind was done well, and the service center is given adequate time to do the work. An occasional visit with a motor service center, stressing the importance of efficiency over price, is an important activity two to four times a year.

Would it be useful for our facility's motor system team to work with a motor service center to improve efficiency?

QUESTION

What are common concerns with cycling a motor off and on? Why?



ANSWER

Motor inrush current.

Short cycling, or turning a motor off and on multiple times in a short duration.

DISCUSSION

Motor inrush current is this spike in amperage that can be observed when electric motors are started. Note that this is especially prevalent for motors with across the line starters. There is a common assumption that it is more efficient to leave a motor on when it is not needed to avoid the added cost associated with a motor inrush current penalty.

Let's take a look at the graphic on the previous page. Here we are showing motor current, measure in Amps, on the vertical axis and time on the horizontal axis. Notice the time scale here is very short.

We see a large spike in motor current, which is what we refer to as the inrush current. However, it only lasts but a very short period.

It is natural to think that this increase in amps could increase your demand charge on your electric bill leading to a belief that it is cheaper to continue to run a motor when it is not needed to avoid this motor inrush current. However, your monthly demand charge is based on the average facility-wide input power over a 15-30 minute period. Motor inrush current only results in elevated amps for about a second. Therefore, motor inrush current from turning on a single motor likely won't significantly impact your facility's demand charges.

Related, the number of allowable starts for a motor is defined by NEMA and can vary widely. For smaller motors, the number of starts is high (10-30 per hour) while larger motors (>250 hp) may only be able to start 2-4 times/hour. Please reference the literature for your specific motor to determine how many starts is allowable.

The benefit of saving energy from turning a motor off when it is not needed nearly always outweighs the negative impact motor inrush current has on your facility-wide demand charge, but the number of starts should be considered as well.

COMPRESSED AIR

INDUSTRIAL ENERGY TALK CARDS

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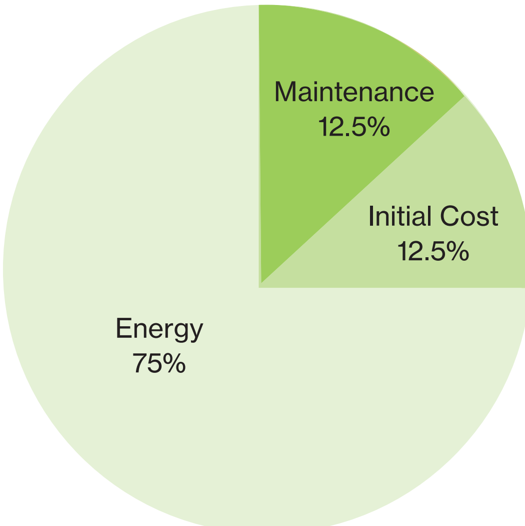
QUESTION

What is the most significant cost of running a compressed air system?

ANSWER

Energy



DISCUSSION

Compressed air is an extremely inefficient work method. For every 100 hp of energy required to operate the equipment, only 9 hp of work is delivered.

Electrical energy is 75% of the monetary cost of a compressed air system over its 10-year life.

Are we using compressed air in our facility for an application that could be performed with a less expensive method?

Potential high cost applications

- Cleaning
- Drying
- Vibration
- Open Blowing
- Cooling
- Diaphragm pumps
- Air motors (i.e. for stirring)
- Conveying

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QUESTION

What inefficient uses of compressed air are most common in manufacturing plants?

ANSWER

1. **Personal cooling** - comfort cooling with air
2. **Open hand-held blow guns or lances** - any unregulated hand-held blowing
3. **Diaphragm pumps** - commonly installed without regulators and speed control valves
4. **Cabinet cooling** - cooling electrical panels with open tools
5. **Conveying** - moving material with compressed air instead of blowers

DISCUSSION

What inefficient uses of compressed air are present in our facility?

Suggestion Offer an incentive or recognition for the person/team who identifies the most inappropriate uses of compressed air.

A facility can take various action steps to eliminate or reduce inefficient uses of compressed air. Here are a few examples from a food processing plant. Peak flow is identified in cubic feet per minute (cfm):

Opportunity	Original Peak Flow (cfm)	Operating Hours	Action Taken	Revised Peak Flow (cfm)	Average Flow Reduction (cfm)
Install nozzles on open hand-held blow guns	**200**	**6,500**	Installed nozzles	**50**	**150**
Replace vacuum generator with motor-driven vacuum pump	**1,000**	**5,000**	Motor-driven vacuum pump	**0**	**1,000**
Use fans for personal cooling instead of compressed air	**800**	**3,500**	Used fans	**0**	**800**
Replace pneumatic actuators with electric versions	**750**	**3,500**	Replaced with electric actuators	**0**	**750**
Total CFM reduction					**2,700**
Annual Savings (18kW/100cfm at $.05/kWh)	**$102,600**				

QUESTION

Where are leaks most likely to occur
and reappear in a compressed air system?

ANSWER

Leaks are most likely to occur between the main line and end use and in the equipment itself.

Leaks normally occur in the compressed air piping system where there are valves, regulators, quick disconnects, and flexible hoses with joints and o-ring seals that harden and crack. This area is known as the "dirty thirty" because it's usually within 30 feet of the end-usage point. Also, the machinery has many small hoses and tubing that eventually develop leaks. These areas are hard to reach, but still require constant attention.

DISCUSSION

Have we noticed any compressed air leaks in our plant? If so, have they been reported to the appropriate maintenance personnel?

Recall that compressed air is not free! An 1/8 inch diameter leak could cost over $2,000/year!

Where do you think leaks mostly commonly occur in this facility's compressed air system?

(Identify possible locations and ask your energy champion/ leak team to check and then report back to you.)

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QUESTION

Is the compressed air pressure kept as low as possible without having a negative effect on production?

DISCUSSION

What is meant when we talk about “negative effects” on production?

If it is having a negative effect, should we discuss this with engineering staff?

Is keeping the compressed air at a low pressure always OK?

Consider incrementally lowering the compressed air setpoint by 1-2 psig per week and observe if issues arise. This approach will help achieve the leading edge while avoiding issues. Lowering the overall pressure by incremental small amounts will help determine what a good operating pressure is.

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QUESTION

What does it mean to establish a baseline measurement (called “baselining”) for a compressed air system?

ANSWER

Baselining involves taking measurements that determine the effectiveness of your compressed air system **before any energy savings actions are implemented**.

Measurements of power, energy, pressure, leak load, flow, and temperature are needed to establish the baseline measurement.

DISCUSSION

Establishing a baseline helps you

- Better understand the dynamics of your system
- Calculate the cost at which you are currently operating
- Establish a benchmark against which future progress will be measured
- Identify action steps to improve compressed air performance (i.e. adjust controls)

What factors could give us an incorrect baseline measurement?

Potential answers

- Not using proper instruments
- Instruments out of calibration
- Not taking repeated baseline measurements over time
- Not taking baseline measurements after changes to the system

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QUESTION

What percentage of total compressed air produced constitutes leaks?

ANSWER

Up to 50%

DISCUSSION

The accepted national average for leaks in a compressed air system is 20-30% of the total compressor output. Nevertheless, in certain industries, such as wood products, where there is an excessive amount of vibration, the leak total can reach 50% of the total compressor output. Thus, leaks are a significant component of waste in a compressed air system and for that reason they deserve constant maintenance.

What could you do to significantly reduce leaks in our compressed air system?

Potential action points

- Institute regular leak detection and leak maintenance into regular maintenance procedures.
- Notify our Compressed Air Champion weekly of maintenance concerns and potential leaks.
- Invest in an ultrasonic leak detector and use the tool on a regular basis to locate and prioritize leak repair.
- Purchase high quality quick disconnects and purchase large diameter hoses.
- Install solenoid or ball valves that are closed when the machinery is unused.

Contact utility for incentives for reducing compressed air leaks.

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QUESTION

How is the total amount of leaks calculated in a typical compressed air system?

ANSWER

During a down production period, log how much compressed air flow is required to maintain the system pressure. If there are no productive compressed air uses during this period, then the logged flow represents the facilities total compressed air leak load.

DISCUSSION

In a well-maintained system, leaks are less than 10% of the system capacity.

Is this facility above or below 10% leaks?

How do I calculate my leak load?

If the machines are load/unload, then time the load duration versus the unload duration over a specific time frame, say 10 minutes. This should also be performed when production has stopped and all open-blowing applications are valved off. Use the following equation to calculate your leak load:

Leakage (%) = (Loaded time x 100)/(Loaded time + Unloaded time)

Alternative method Some compressors have percentage capacity gauges that display the percentage of the total output of the compressor. Shut down all machinery and close all open-blowing applications. Check to see what the percentage capacity gauges read and then make adjustments for total percentage if more than one machine is running. This constitutes the total leaks in the system.

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QUESTION

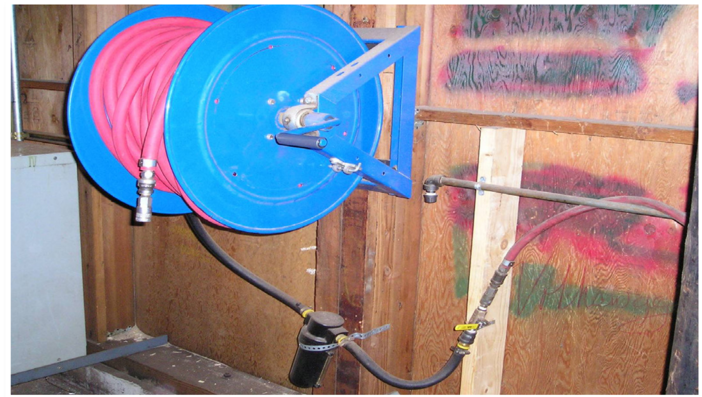
Has anyone identified inefficient uses of compressed air in our plant, such as air jets to dry cans or for personal cooling?

DISCUSSION

How much money is spent each year on compressed air in our plant?

What are some other ways that air can be wasted?

What should we do when we see a wasteful use of compressed air?



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QUESTION

How much does it cost per year to have a 1/4 inch diameter hole in a compressed air line?

ANSWER

Compressed air generation is one of the most expensive equipment systems in an industrial facility. The average U.S. manufacturing plant leaks 20-30% of the compressed air generated. This chart shows the average costs of leaks per year.

Hole Diameter (inches)	Flow (cfm)	Average Cost Per Year
1/32	1.62	$160
1/16	6.49	$628
1/8	26	$2,514
1/4	104	$10,059

* Average costs of leaks per year at 100 psig and $0.06/kWh.

DISCUSSION

How much product (use standard unit, i.e. case or pound) **do you think we have to sell to pay for this amount of lost air** (if our plant leaks 20-30%, as the national average)**?**

How many additional hours do you have to work to pay for this amount of lost air?

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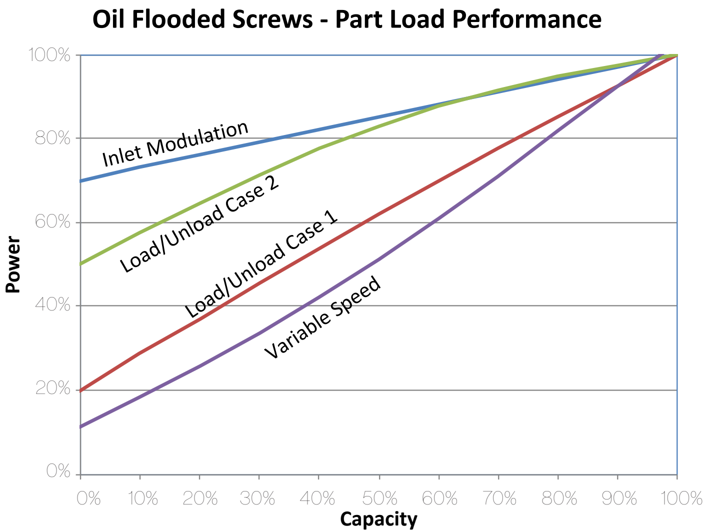
QUESTION

What is one of the least efficient, part-load control methods for an air compressor?

ANSWER

Inlet throttling or modulation.



DISCUSSION

Compressors are most efficient at full load. However, it's extremely rare that a plant requires the full capacity of a compressor. Therefore, part-loading is necessary.

More efficient part-load methods are

- Load/unload
- Start/stop
- Variable displacement
- Variable speed

Are there throttling compressors in your compressor room?

What possible methods could you use to improve part-load performance and efficiency for these compressors?

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QUESTION

If you're operating your compressor system at 10 psi higher than what is needed, how much additional energy is being used at how much greater cost (percentage)?

ANSWER

Approximately 5% more energy and 5% more money.

DISCUSSION

For every 1 psi of additional pressure, it costs 0.5% more. Another consequence of elevated pressure is increased air consumption by leaks and end-uses.

Which end-use (or department) complains first when pressure drops?

What is the minimum pressure at which our facility's compressed air system can operate?

At what pressure is our system currently operating?

Develop a KPI that relates cost to value of product and operates the system at minimum pressure.

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QUESTION

Why is dry air important?

ANSWER

Moisture in the air can

- Freeze if pipes get cold
- Rust or corrode pipes and equipment
- Ruin paint or product that comes in contact with it

DISCUSSION

Two Major Dryer Types

Refrigerated Dryer (+40°F Dewpoint)

- Uses less energy
- Sufficient dew point for many applications

Desiccant Dryer (-40°F Dewpoint)

- Can require up to 15% of a system's compressed air flow in purge
- Good for locations where piping may see temperatures below freezing
- May be necessary for sensitive equipment

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QUESTION

Should I use a refrigerated or desiccant air dryer?

ANSWER

Refrigerated dryers (+40°F dewpoint) may provide sufficient dewpoint for many compressed air systems, and use less energy than a similar sized desiccant dryer. Desiccant dryers (typically -40°F dewpoint) may be needed in locations where compressed air piping temperatures may get below freezing, or if end use equipment is particularly sensitive to moisture.

DISCUSSION

1. Does your desiccant dryer have a purge saving mode?

- Check mode
- Repair or replace sensor as needed, put into purge saving mode

2. A cycling refrigerated air dryer uses less power than a non-cycling refrigerated air dryer.

- If you have a non-cycling dryer, a capital project is to replace that with a cycling refrigerated air dryer

3. Double drying air may not result in more dry air.

- Does air in your system pass through multiple dryers (possibly different types of dryers, or dryers at the compressors, then point of use dryers as well?)
- Consider going to one quality of air, either +40°F (refrigerated air dryer), or -40°F (desiccant), and remove point of use dryers, or dryers in series

4. A heatless desiccant air dryer (without dewpoint demand controls) can require up to 15% of a system's compressed air flow in purge.

- Some desiccant dryers may be able to be retrofitted with dewpoint demand controls, to match purge flow with the compressed air load

5. A desiccant heated blower purge dryer with dewpoint demand controls is one of the more efficient desiccant dryers.

REFRIGERATION

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QUESTION

What percentage of lighting power in a cold storage facility ends up as heat load on the refrigeration system?

ANSWER

100%

DISCUSSION

Would you run an electric baseboard heater in a cold storage facility?

Each light is no different than a baseboard heater. The energy it takes to run lights ends up as heat that the refrigeration system must handle. Turning off lights saves energy and reduces energy used in your refrigeration system.

How can you reduce light energy in our plant?

Possible answers

- Reduce motion sensor occupancy time
- Establish light quality standards for areas and periodically inspect them
- Turn off lights when areas are unoccupied
- Replace HID or fluorescents with LEDs
- Disconnect fixtures in over-lit areas (a de-lamped fixture still draws energy)

QUESTION

How much do we spend on electricity per year?

Approximately what percentage of total facility electrical energy use goes towards refrigeration?

How much does it cost per year to operate our refrigeration system?

DISCUSSION

Any effort to save refrigeration energy use can save considerable money. The energy use of most refrigeration systems can be reduced by 10% with little or no investment in capital equipment.

What are some ways you could reduce refrigeration system energy use?

Possible answers / action steps

- Raise suction pressure
- Lower condensing pressure
- Turn off compressors whenever possible
- Close doors and turn off lights
- Install fast acting doors to replace curtains to keep cold air contained in high traffic areas

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QUESTION

Are temperatures in refrigerated areas kept as high as possible without negatively affecting what's supposed to be kept cool?

DISCUSSION

Room temperatures are often kept colder then necessary to ensure there is a safety factor in case temperatures rise. However, these setpoints can often be far more conservative then is needed. Review room and client temperature requirements and determine if the room temperature could be raised to be within 1-2 degrees of requirements.

Do you have any ideas for ways in which we could save more refrigeration energy?

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QUESTION

How much does it cost to leave a 10 ft x 12 ft door open to a 0°F freezer on an 80°F day?

How about to a 32°F cooler?

ANSWER

$140/day or $4,200/month for the 0°F freezer (at $0.05 kWh)

$50/day or $1,500/month for the 32°F cooler (at $0.05 kWh)

DISCUSSION

Leaving cold storage doors open is expensive and makes it more difficult to maintain space and product temperature. Open doors also lead to frosting of the floor and walls which can be a safety hazard.

How can you reduce unnecessary loads on the refrigeration system?

Possible answers / action steps

- Turn off lights in refrigerated area
- Minimize defrosts
- Maintain the highest room temperature possible
- Avoid damaging insulation and door seals
- Maintain strip curtains
- Install fast acting doors through high traffic doorways

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QUESTION

At what percentage of full load capacity does an evaporative condenser operate with only the pump running (fan is off)?

At what percentage of full load capacity does an evaporative condenser operate when running dry (pump is off)?

ANSWER

Roughly 10% for either.

DISCUSSION

The most efficient mode of operation for evaporative condensers is with the pumps and fans running.

Why might you operate our condenser with the pump or fan only?

Possible answers

- Concerns about shutting pumps down causing coil scaling
- Cold weather could cause freezing
- Poor controls
- Tradition
- Liquid ammonia settling in condensers

QUESTION

Are the doors to refrigerated spaces kept closed as much as possible?

DISCUSSION

Leaving refrigerator doors open causes unnecessary energy use, unnecessary frost buildup, and can be very expensive for the plant.

There are often good reasons that doors are left open, like needing to move forklifts through at a quick pace. There are multiple ways to help reduce infiltration to a cold space, such as installing strip curtains, upgrading to a fast acting door, or training employees on how leaving the door opens increases energy costs. Reviewing these options are key to finding the right solution for your site's situation.

What are some other reasons why refrigerated areas may heat up or lose their cool?

What energy saving actions have you taken lately?

Do you have any ideas for ways in which we could save more energy?

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QUESTION

What percentage of total plant refrigeration load is related to heat gain through insulated walls and the ceiling?

ANSWER

Less than 5%

DISCUSSION

The majority of the refrigeration load on the plant is from freezing product. The next largest refrigeration loads come from gaps in doors, opening doors, evaporator fans, and lights. Heat gain through insulated walls and the roof is just a small fraction of the total refrigeration load.

What are the loads on this facility's refrigeration system?

Possible answers

- Freezing product
- Cold storage lighting
- Evaporator fans
- Under floor heating
- Conduction through walls and the roof
- Opening doors
- Gaps in doors
- Door heating
- Defrosts
- Forklifts
- People

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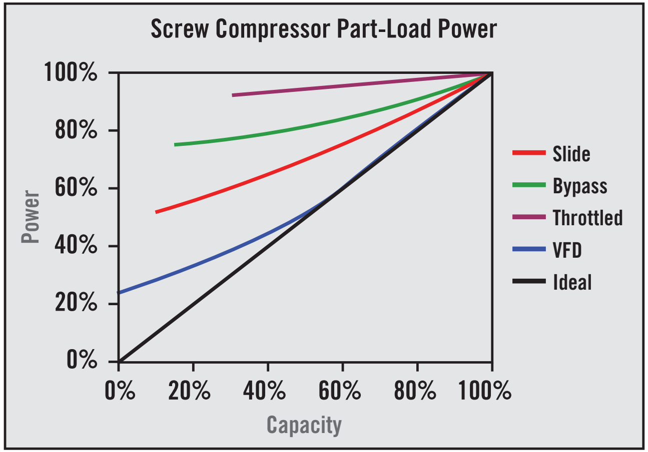
QUESTION

What percentage of full-load power does an unloaded screw compressor with slide valve capacity control draw?

ANSWER

40%



Screw Compressor Part Load Performance

DISCUSSION

Screw compressors with slide valve capacity control are very inefficient at part load. Strive to operate only one compressor at part load per suction system. Utilize a compressor that is efficient at part load, such as a VFD screw, reciprocating, or the smallest screw compressor you can get away with. It is critical to match refrigeration supply (compressors) with demand (load).

What are some variables that will vary refrigeration loads and necessitate a change in the operating compressors?

Possible answers

- Change in product that is processed
- Change in tunnels that are utilized
- Change in outdoor temperatures
- Defrosts
- People

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QUESTION

Does increasing suction pressure cause compressor capacity to increase or decrease?

Does increasing suction pressure cause compressor efficiency to increase or decrease?

ANSWER

Increase both capacity and efficiency.

DISCUSSION

Increasing suction pressure causes an increase in compressor capacity (tons of refrigeration – TR) as well as power (horsepower – BHP).

The net effect is an improvement in compressor efficiency (BHP/TR). In general, an increase in suction temperature of 1°F leads to a 2% improvement in compressor efficiency.

How can you increase suction pressure in our facility?

(Develop list of possible action steps)

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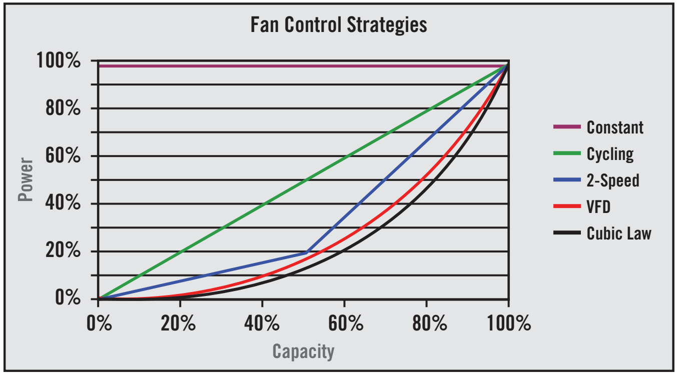
QUESTION

What percentage of full load power does a condenser fan draw at 50% speed?

ANSWER

Approximately 20%



Fan Part Load Efficiency

DISCUSSION

Power varies with the cube of speed for fans and other centrifugal devices, such as pumps. A fan at 50% speed thus draws about 20% of full load power after you account for motor and drive losses.

What are some applications where you could operate fans and pumps at reduced speeds?

Possible answers

- Condenser fans
- Evaporator fans
- Wastewater pumps
- High pressure cleanup pumps

This equipment is often eligible for utility incentives and have a less than two-year payback.

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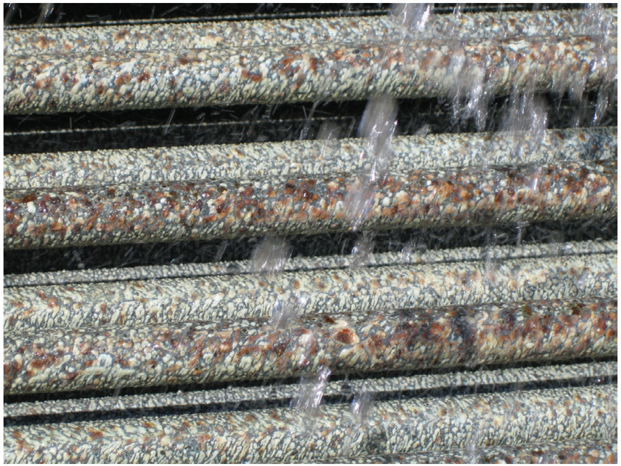
QUESTION

What percentage of condenser capacity is lost when there is 1/16 inch of scale on the condenser coil?

ANSWER

50%



Badly Scaled
Condenser

DISCUSSION

Optimizing your condenser is critical to reduce condensing temperature.

A 2°F reduction in average condensing temperature reduces refrigeration compressor energy use by 3%.

How can you ensure that our facility achieves full capacity without condensers?

Possible action items

- Keep good maintenance records
- Tighten fan belts
- Make sure that the water blow-down system is working correctly
- Periodically inspect and clean condenser coils and nozzles
- Clean condenser grills and drift eliminators
- Install high performance spray nozzles

PUMPS

INDUSTRIAL ENERGY TALK CARDS

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QUESTION

What are the recommended methods for monitoring a pumping system?

ANSWER

Recommended methods include vibration monitoring, power monitoring, flow rate or pressure monitoring and temperature monitoring.

DISCUSSION

A pumping system must be well monitored to track its operational performance. Also, tracking KPIs will help keep the system running in an optimal way, leading, potentially, to significant electricity and maintenance savings. Wireless monitoring systems can be cheaper to install than wired systems.

Do you use some of the pump system monitoring methods in your facility?

Which parameters do you track? Is the information used to improve the operation of the system?

Can you easily measure power divided by flow?
(This is like measuring miles per gallon for a car. It will show when the pump is worn, for example.)

Can we use wireless monitoring?

Would it be cheaper?

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QUESTION

What is the relationship between pump maintenance and pump energy efficiency?

ANSWER

There is a direct correlation. Pumps with significant maintenance and reliability problems are also extremely inefficient and costly to run.

DISCUSSION

Pumps with maintenance problems are an ideal opportunity to save energy.

Pumps that are throttled way back, or are running over capacity, cost much more to operate (energy) and maintain (labor cost).

Are there pumps in our facility that are throttled back or running over capacity?

Are these pumps less reliable and more costly to operate?

QUESTION

How many bypass loops and throttling valves can be found in your facility, and what could be a more efficient way to control flow?

ANSWER

More efficient ways to control flow include a pump impeller trim, putting in a smaller pump and motor, or installing a Variable Frequency Drive (VFD).

DISCUSSION

Bypass loops and throttling valves are the least efficient and most costly ways to control flow. Bypass loops and throttling valves increase energy usage and maintenance costs and decrease reliability.

Throttled valves produce significant pressure drops and are a major contributor to pump efficiency loss. A Variable Speed Drive that reduces the speed an average of 10% on a continuously running 100 hp pump can save about $10,000 per year in energy costs alone.

Variable Frequency Drives (VFDs) can eliminate the need for valves, starters, and bypass systems because they adjust pump speed automatically, according to demand. They also protect against process upsets and pressure spikes, and some have soft-starting capabilities. A 20% reduction in speed can reduce power consumption by 50% (close to $20,000 per year for the example cited above).

VFDs may qualify for incentives from your utility provider. Contact them before purchase to get more information.

Are there pump systems in our facility that would improve efficiencies with a Variable Frequency Drive?

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QUESTION

What are the organizational elements necessary to continuously improve our pump systems?

ANSWER

Pump System Champion

KPIs

A comprehensive assessment

Training for all staff

Engaging vendors in the improvement process

DISCUSSION

SEM can be used to

- Assign an Energy System Champion for your pump systems
- Identify and track progress towards KPIs
- Conduct a comprehensive energy assessment
- Train and educate staff on energy management strategies and activities

Who has been assigned to be responsible for improving this facility's pump systems?

What data is collected to track the system efficiencies over time?

Who has taken a comprehensive look at the opportunities to improve the systems?

Has our staff been trained on the proper operation of pump systems?

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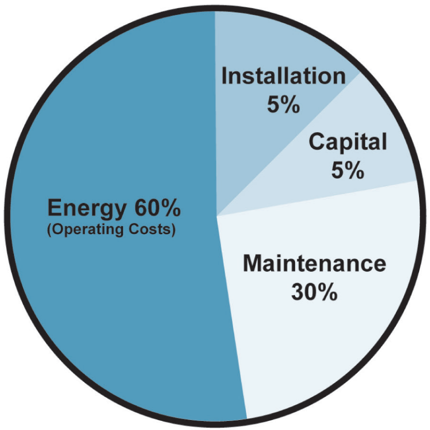
QUESTION

What percentage of the life cycle cost of a pumping system is devoted to energy and maintenance?

ANSWER

60%



LCC/TCO typical 75 hp pump
$750,000 over 20 years

DISCUSSION

Energy and maintenance costs are usually the largest expenses for pumping systems. There is a direct correlation between pump system operation and maintenance costs.

Please draw a larger version of this pie chart on a flip chart. The two smallest slices in the pie chart represent the initial cost of the pump system and installation costs. The second largest slice represents maintenance costs. The largest slice, represents energy costs, which is over 60% of the total cost of operation – and often overlooked when making purchasing decisions.

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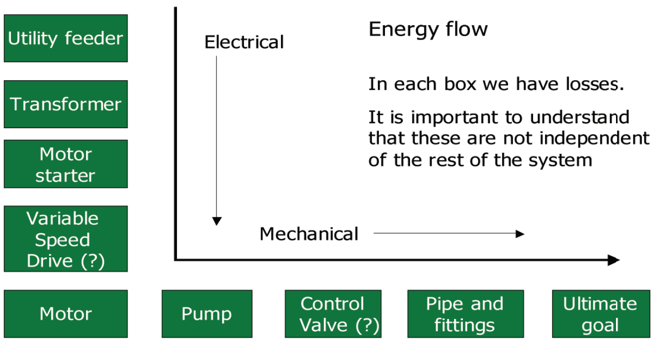
QUESTION

What are the elements of a pumping system?

ANSWER

The motor, pump, piping, valves, friction losses, leaks, and work performance.

(Review and discuss the graphic below.)



DISCUSSION

A pump system needs to be considered as a whole. Inefficiencies occur at each step, and matching supply to demand can have a multiplying effect in terms of savings back to your meter.

The motor system for a pump includes everything from the electricity entering the facility to the end-use application for the pumped fluid. There are systems losses at each step through the process.

What are the potential system losses for this facility's pump system?

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QUESTION

What are the “symptoms” of an unreliable and inefficient pump system?

ANSWER

Throttled valves (over 25% of design flow)

Normally open bypass lines

Pumps running continuously with significant variations in system requirements

Systems that are cavitating

Frequent cycling pumps in batch operation

Pumps with high maintenance costs

Large amount of recirculation, where discharge returns straight to source

Excessive vibration

DISCUSSION

Identify pump systems that show symptoms of being unreliable and inefficient, and conduct an assessment. There is a strong correlation between inefficient pump systems and “bad actors,” high maintenance costs and less reliability.

Symptoms of unreliable and inefficient pump operation also indicate that the company is wasting money on energy, maintenance costs and possibly, productivity.

- **Can you think of a particular system that has these symptoms?**
- **Who is the Champion or owner of that system?**
- **Is our electric utility available to help evaluate alternatives to improve the system?**

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QUESTION

What are some of the opportunities to improve a pump system?

ANSWER

It is important to size and operate the motor and/or pump according to process requirements. Following are a few techniques. However, before beginning these tasks, it is important to conduct a detailed analysis to determine which of these activities is most appropriate for our system.

- Trim pump impeller
- Install a variable speed drive
- Install parallel pumps where a single large pump is currently used
- Modify the fluid system – such as increased pipe diameter, removing bends and valves
- Turn off pumps that are unneeded
- Examine the system to determine if function and requirements have changed over time

DISCUSSION

System improvements can be as simple as turning a pump off and as complicated as “re-sizing” or “re-piping” the system based on current design conditions.

Can you identify any systems that are currently operating that may be oversized, and that could be turned off or improved by matching the system to current production requirements?

Many utilities offer no-cost assessments to help identify energy savings opportunities.

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QUESTION

Considering runtime and energy costs,
how much does it cost to run a 100 hp pump?

ANSWER

The cost depends on the operating conditions (not on the size of the motor). If the power requirement of a pump is 100 hp, then use the following table to estimate electrical costs:

DISCUSSION

The energy cost for operating a pumping system is significant – and warrants the effort to improve the efficiency of these systems. Energy cost depends on
the load.

How many "100 hp equivalent" pump systems do we have in our facility? What is our electrical rate in terms of $/kWh? What do we spend on electricity for the pumping system in our facility? What is our demand charge?

Pumping Energy Costs for Pump Driven by 100-hp Motor (assuming a 90% motor efficiency and 100% motor loading)					
Operating Time	Energy Costs for Various Electricity Costs				
	2 cents per kWh	4 cents per kWh	6 cents per kWh	8 cents per kWh	10 cents per kWh
1 hour	$1.60	$3.30	$4.90	$6.6.	$8.20
24 hours	$39	$79	$119	$159	$198
1 month	$1,208	$2,416	$3,625	$4,833	$6,042
1 year	$14,500	$29,000	$43,600	$58,000	$72,600

Does not include demand charges

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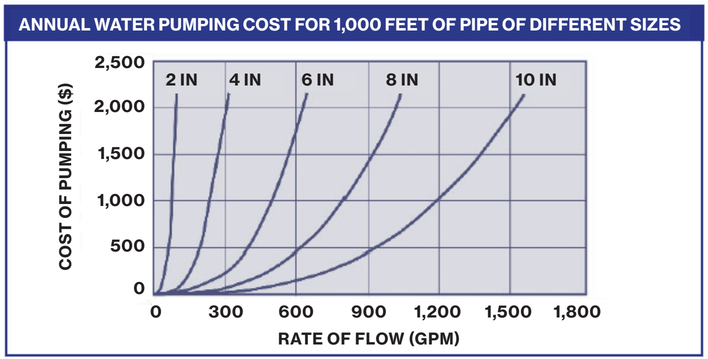
QUESTION

Considering pipe size, how much does it cost to operate our pump system?

ANSWER

Large diameter piping will be significantly more efficient. For example, for a pump operating at 600 gpm (in figure below), the annual cost for each pipe size is:

- 6-inch pipe = $1750
- 8-inch pipe = $500
- 10-inch pipe = $200



Based on 1,000 ft. for clean iron and steel pipes (schedule 40) for pumping 70°F water. Electricity rate—0.05 $/kWh and 8,760 operating hours annually. Combined pump and motor efficiency—70%.

DISCUSSION

The frictional component of pumping losses is significant, and larger size pipes will reduce energy costs dramatically.

Piping upgrades are often eligible for energy efficiency incentives from our electric utility.

What can you do to reduce the frictional component of our pumping system?

Potential answers

- Lower the flow rate
- In systems dominated by friction head, evaluate pumping costs for at least two pipe sizes and try to accommodate pipe size with the lowest life-cycle cost.
- Look for ways to reduce friction factor. If application permits, epoxy-coated steel or plastic pipes can reduce friction factor by more than 40%, proportionately reducing pumping costs.
- Compute the annual and life-cycle cost for systems before making an engineering design decision.

ELECTRICAL UTILITY

INDUSTRIAL ENERGY TALK CARDS

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QUESTION

Why should we consider saving energy?

ANSWER

It will likely lower our monthly bill!

DISCUSSION

There are often ways to do the same thing for less power. For example, LEDs us less energy then fluorescents and HID fixtures. Other systems where energy savings can typically be found:

- Compressed air
- Refrigeration
- Electric motors
- Pumps
- Fans

The equipment being driven by a motor is usually the best place to look for energy improvements.

What systems in this facility could be improved to save energy?

How can we determine the energy savings?

What other procedures or technologies can we use to save energy?

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QUESTION

What types of charges show up on the typical utility bill?

ANSWER

Basic Charge (fixed $)

Energy Charge (kWh)

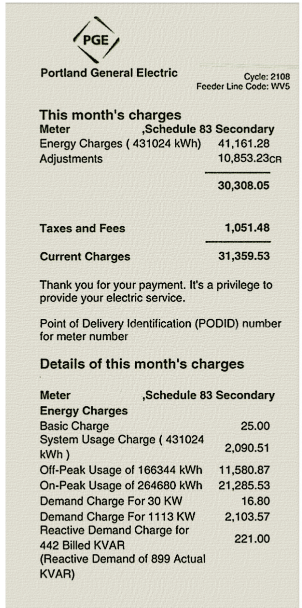
Demand Charge (kW)

Power Factor Charge (kVAR)

Local Taxes

Franchise Charges

Adjustments



PGE

Portland General Electric

Cycle: 2108
Feeder Line Code: WV5

This month's charges

Meter	**,Schedule 83 Secondary**
Energy Charges (431024 kWh)	41,161.28
Adjustments	10,853.23CR
	30,308.05
Taxes and Fees	**1,051.48**
Current Charges	**31,359.53**

Thank you for your payment. It's a privilege to provide your electric service.

Point of Delivery Identification (PODID) number for meter number

Details of this month's charges

Meter	**,Schedule 83 Secondary**
Energy Charges	
Basic Charge	25.00
System Usage Charge (431024 kWh)	2,090.51
Off-Peak Usage of 166344 kWh	11,580.87
On-Peak Usage of 264680 kWh	21,285.53
Demand Charge For 30 KW	16.80
Demand Charge For 1113 KW	2,103.57
Reactive Demand Charge for 442 Billed KVAR	221.00
(Reactive Demand of 899 Actual KVAR)	

DISCUSSION

Utilities recover costs associated with providing electric service to the customer. A utility bill reflects costs incurred by the utility for: metering/billing; customer service; purchased and generated power; substations; distribution lines and poles; transformers; and system and dispatch control.

Why do utilities break out the separate charges?

How much energy in kWh did our facility use last month?

How much demand in kW?

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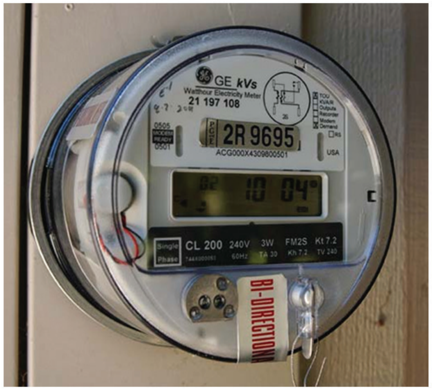
QUESTION

What information does a typical meter record?

ANSWER

Energy (kWh), demand (kW) & reactive power (kVAR).



DISCUSSION

Modern electronic meters record “pulses” with each pulse equal to an amount of energy (kWh). The meter is read by the meter reader (or in some cases, remotely) and the demand reset. The information is then used to calculate your monthly bill. In some cases, your meter records
“on-peak” and “offpeak” energy and demand. Typical on-peak times are 6 a.m. to 10 p.m., Monday through Saturday.

How often are your meters read (billing cycle)?

Where are your meters located?

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QUESTION

What factors influence your electric bill?

ANSWER

It depends on many factors, including

1. How much energy you use (kWh)

2. How much you need at any one period (kW)

3. Your power factor (kVAR) and

4. Your rate schedule

DISCUSSION

There are many factors that go into determining what rate you pay for electricity, but a general range for the Northwest is between four and six cents/kWh, demand is between $4 and $5 per kW, with kVAR being $0.50.

How much do you pay for electricity each month?

How does that change over the year?

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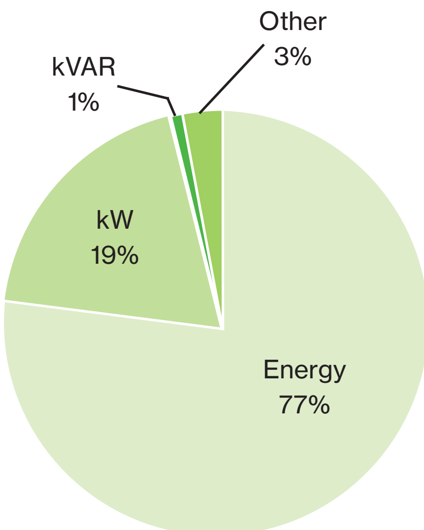
QUESTION

What costs the most on your monthly electric bill?

ANSWER

Energy use, measured in kilowatt hours (kWh).



Typical Monthly Bill

DISCUSSION

Depending on your rate schedule and how you use energy, the typical monthly bill might look something like this:

- 77% energy
- 19% kW
- 3% other
- 1% kVAR

The greatest opportunity to lower your monthly bill is to reduce your energy use through improved energy management and energy efficiency projects.

What can you do to reduce energy consumption in this facility?

Have you presented your ideas to your supervisor?

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QUESTION

Are plant lights left on when they are unneeded?

DISCUSSION

How much energy is wasted by leaving the lights on?

What kinds of lights waste the most power?

Are there any areas in our plant that would benefit from energy-saving LED light bulbs?

Many utilities offer incentives/rebates for LED retrofits.

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QUESTION

Why do utilities have different rate schedules?

ANSWER

Costs vary when serving different groups of customers.

Utilities attempt to allocate the costs among different customer groups. Non-residential rates are typically grouped by the voltage served:

- Secondary voltage is normally 480 volts or less
- Primary voltage (or feeder voltage) is 12,470 volts
- Transmission voltage (also called sub-transmission) voltage is 57,500 volts or above

For more information on your rate schedules, talk to your utility representative.

DISCUSSION

Under what conditions would it make sense for a customer to be served at a higher voltage?

What voltage is this facility served under?

Where is our utility point-of-delivery?

Who owns the transformers?

How many electric accounts do we have?

QUESTION

How do we know how much energy the equipment is using?

ANSWER

For a precise answer, energy must be directly measured or calculated.

DISCUSSION

Monitoring power (kW) is more than measuring amps with an ammeter. Energy consumption is power (kW) used over time (hr) producing kWh. Calculating energy use can be done using the following formula for 3-phase power:

kW = (volts) X (amps) X (power factor) X 1.732/1000

Energy can also be determined by manufacturer's data, pump and fan performance curves, and industry databases.

How much energy does a 50 hp motor use?

Which piece of equipment in this facility uses the most energy?

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QUESTION

How is demand determined by the electric meter?

ANSWER

Demand is internally calculated and recorded based on the highest average energy consumption over the utility monitoring interval in a billing cycle (typically 15-30 minutes).

DISCUSSION

Demand is one of the most misunderstood metering topics.

Demand is NOT:

- An instantaneous number
- Affected by the number of motors started at once or by motors starting at all

Demand is an **AVERAGE** number relating to how much energy is consumed during a metering interval. The meter records the energy consumed (kWh) and divides it by the time interval (hr). Demand is highest when the most amount of energy-consuming equipment is operating concurrently over the metering interval.

At what time of day or on which day of the month is the highest amount of energy used by this facility?

Is there anything that can be done to reduce demand?

Is it practical?

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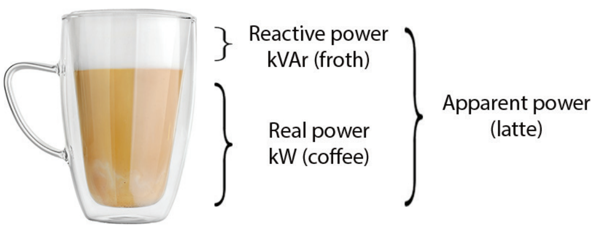
QUESTION

What is power factor?

ANSWER

Power factor is the ratio between the real power (kW) and the reactive power (kVAR). In other words, it is the ratio of the total amount of potential energy delivered to a plant to the power actually used by the plant.

Contact your utility if you suspect you have a power factor issue.



$$\text{Power factor} = \frac{\text{coffee}}{\text{coffee} + \text{froth}} \quad \frac{\text{kW}}{\sqrt{\text{kW}^2 + \text{kVAr}^2}}$$

DISCUSSION

Power factor is of concern to utilities and electricians because they must size their power lines and equipment based on the potential power delivered.

In other words, it means investing a large sum of money in larger components (wires and transformers) to serve the same useful work (power).

The primary culprit of a low power factor is large, unloaded motors. A typical facility with motors like this are sawmills and rock crushers. Typically, the best way to correct a low power factor is with capacitors.

How much does the utility charge for your facility's power factor, if any?

What percentage of the entire bill is the power factor?

What is the largest motor in this facility that is unloaded at least part of the time?

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QUESTION

How can I get more detail about my electric use than what is provided by the numbers on the monthly bill?

ANSWER

Some meters can provide the pulses gathered during each monitoring interval and will transmit them to a local data collector, or you can ask your utility if it provides this service separately.

DISCUSSION

Electronic meters have the capability to store energy information for each monitoring interval programmed into the meter. Use this information to provide insight into how your facility is using energy. Energy used during non-occupied or non-production hours can help you make decisions about shutting down equipment that is unneeded. Or, you might discover that equipment is not starting or stopping as it should.

Does your facility have access to interval metering?

If so, what can it tell you about how you use energy?

Are there any surprises looking at the data?

Have you compared the energy used during non-production or non-occupied times?

What should it be?

Can it be lowered?

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QUESTION

How do you calculate power and energy consumption?

ANSWER

There are a number of ways to figure out power, energy, and related costs! See the following calculations.

Estimating Electric Power and Energy

Electric Input power from motor nameplate

- **HP** = motor HP from the nameplate
- **Load Factor** = estimated motor capacity/loading (0-100%)
- **0.746** = HP to kW conversion factor
- **Motor Eff** = motor efficiency rating from the nameplate

$$kW = \frac{HP * Load\ Factor * 0.746}{Motor\ Eff}$$

Power from current measurement

- **V** = system voltage, measured or assumed
- **A** = measured current of load
- **PF** = power factor

$$KW = \frac{\sqrt{3} * V * A * PF}{1000} \quad \text{(3 PHASE)}$$

$$KW = \frac{V * A * PF}{1000} \quad \text{(SINGLE PHASE)}$$

Energy use from input power

- **kW** = estimated or measured power
- **Operating Hours** = annual operating hours for given piece of equipment

Operating cost from energy use

- **kWh** = estimated energy consumption
- **$/kWh** = estimated cost of energy from utility, can vary widely based on rate schedule

$$COST (\$) = KWH * \frac{\$}{KWH}$$

DISCUSSION

Electric Example You have a 40 HP motor that operates a conveyor belt

- This belt is typically loaded to about 80& of its rated capacity.
- The belt operates 24 hours per day, 7 days per week.
- The operation is shut down for two 5-day maintenance periods over the course of the year.
- The average cost of electricity is $0.05/kWh.
- REMINDER Don't forget to enter a percentage as a decimal when calculating (ex: 0.945 vs 94.5%)

Step 1 What is the electric motor input power (kW)?

Step 2 How much energy (kWh) does the motor use per year?

Step 3 What is the annual energy cost ($) for this motor?

Step 4 How much energy (kWh) would be saved if you operated the motor for only 20 hours per day?

HVAC

INDUSTRIAL ENERGY TALK CARDS

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QUESTION

In general, what should HVAC fan schedules align with?

ANSWER

HVAC fan schedules should typically align with building occupancy patterns.

Fan energy use is a function of two factors - fan power and fan operating hours. Excessive operating hours are often a result of scheduling problems.

DISCUSSION

In general, air handling units should only operate during periods of time when there are occupants present. If any air handling units are operating continuously in buildings that are unoccupied at night or on weekends, these should be the first units to assess potential schedule implementation.

Judgment needs to be applied to early morning operation for building warm-up or cool-down period to occupancy, and end of day operation when only a few people remain in the building. If end-of-day operation continues past typical closing time, there is likely to be opportunity to reduce late afternoon and evening operation through tighter scheduling of occupied periods. Even small reductions in operating periods can result in significant reductions in heating, cooling, fan, and pump energy use. For example, reducing daily runtime by one hour in a typical 12-hour day will result in at least an 8% energy use reduction.

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QUESTION

For most HVAC applications,
what drives required air flow rates?

ANSWER

Peak cooling loads typically determine air flow requirements in standard HVAC applications.

DISCUSSION

Most HVAC systems use air to remove or add heat from spaces within a building; because of the temperature limits within these systems, they normally require more air to remove heat from, or cool, a room.

Any design strategy that reduces peak cooling loads will also reduce required air flow. Design strategies such as solar shading can reduce peak load and associated air flow requirements by as much as 50%. Operational strategies such as de-energizing lights and plug loads when a room is not occupied can also reduce air flow requirements. For variable air volume systems, this reduction of internal load allows the system to automatically reduce air flow and translates to fan, cooling, and reheat energy savings.

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QUESTION

What types of fans have the poorest mechanical efficiencies? The beast?

ANSWER

Some of the best mechanical efficiencies are achieved with vane axial fans, while small centrifugal fans exhibit some of the poorest efficiencies.

DISCUSSION

Vane axial fans, sometimes referred to a propeller fans, provide some of the best mechanical efficiencies. These fans are very similar to airplane propellers, and are often used in large in-line fan applications for central variable air volume systems. Efficiencies in these applications can exceed 80%.

Small centrifugal fans with forward curved wheels, often called squirrel cage fans, display some of the poorest efficiencies. These fans are often applied in small ceiling exhaust fan applications and can have efficiencies ranging from 30-40%.

A common condition that can lead to deteriorating fan efficiency and performance is dirt build-up on fan blades and components. Build-up of dirt and grime on the leading edge of fan blades, even as little as 1/16 inch thick, can cause a 10-20% reduction in fan capacity. It is important to visually inspect fan wheels and blades and take appropriate steps to keep these surfaces clean and smooth.

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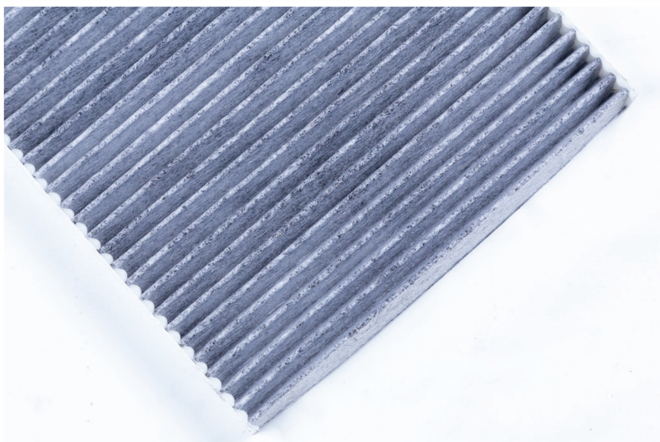
QUESTION

Do all filters have the same efficiency?

ANSWER

No - all filters are not created equal.



DISCUSSION

Upgrade existing filtration systems with extended surface area filters. These filters have a lower initial pressure drop, higher dust-holding capability, and higher structural ratings. Benefits include longer change cycles and lower pressure drops (which conserve fan energy).

Filters are sometimes changed at a regular time interval, before the end of their useful service life. Follow filter-manufacturer guidelines and use pressure drop across the filter bank as the criterion for changing filters.

How might you measure the pressure differential across a filter?

What effect could a dirty air filter have on the air handler unit? How would this affect a tenant space?

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QUESTION

How can preventative maintenance practices be implemented into systems maintenance cultures that have not formally employed these practices?

ANSWER

There are numerous opportunities to add simple component check-out procedures to normal schedule maintenance activities. Opportunities can be structured around filter replacements, motor lubrication, seasonal system lay-up and start-up, and/or combustion analysis.

Some specific ideas for simple preventative maintenance can be found in the discussion to the right.

DISCUSSION

At the time of filter change-out

- Command mixed air dampers through their full stroke to identify damper malfunction.
- Visually inspect dampers, damper linkages, and actuators to identify broken, loose, or disconnected components.
- Visually inspect coil surfaces (filter-side) for fouling or damage.
- Obtain pressure drop reading across coils to determine if coils are plugged internally.

At time of motor lubrication

- Compare amperage reading to original balancing reports or motor nameplate to determine if motor is appropriately loaded.
- Visually inspect motor drive system to confirm general operating condition (tight belts, appropriate rotational speed, good bearing conditions, etc.).
- Compare RPM of device (pump or fan) to original balancing report to determine if system is operating close to intended conditions.

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QUESTION

What are some things you can do to ensure the building's HVAC system is performing optimally?

ANSWER

Routinely examine HVAC equipment.

Fix broken, leaky, or malfunctioning dampers and valves.

Verify that outside air dampers are closed during unoccupied hours.

Investigate and modify equipment staging, sequencing, and cycling to maximize efficiencies.

Identify and correct any fans and pumps that are operating at higher capacities than necessary.

Confirm that motors and drives are operating properly, and check insulation and sealing on all equipment.

DISCUSSION

When was the last time this building's furnace or boiler was tuned-up?

Have you confirmed the accuracy of all critical digital/electronic thermostats/transmitters?

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QUESTION

How do fouled or damaged outdoor condenser coils affect cooling efficiency in packaged air-cooled HVAC refrigeration applications?

ANSWER

Fouled or damaged condenser coils reduce the ability of the refrigerant to achieve saturated or subcooled condensing conditions and can severely reduce refrigeration system efficiency.

DISCUSSION

Coil cleanliness directly affects the efficiency of heat transfer to and from the air stream, and the performance of the entire HVAC system. Measured by loss of cooling capacity or increase in required compressor work (for a given capacity), efficiency for a seriously plugged or dirty condenser coil can be reduced by as much as 50%.

A clean coil has a lower water-side and air-side pressure drop, and thus lowers fan and pump energy consumption.

Lower fan and pump energy consumption also means reduced fan and pump heat - a parasitic load for cooling processes. Cleaning dirty coils is often deferred because it is unpleasant and time-consuming, but the best coil cleaning strategy is to prevent them from becoming dirty in the first place, with regular filter maintenance (coil exterior) and water treatment (coil interior).

The most common way condenser coils are fouled is the long-term accumulation of dust and airborne particles that eventually plugs most, if not all, of the free air passages in the coil. Other airborne contaminants can also foul condensers. For example, salt air can corrode and erode coil fins. Hailstorms and human vandals are the most common sources of coil damage.

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QUESTION

In heat pump systems, when is the auxiliary electric resistance heat used?

ANSWER

Heat pump auxiliary or supplemental heat is used for two primary reasons:

1. To maintain supply air temperature when the outdoor coil is defrosting.
2. To function as back-up heat when a system needs to bring a space up to temperature quickly.

DISCUSSION

Heat pump defrost mechanisms can either occur by shutting down the compressor or reversing the cycle and operating the heat pump in cooling mode during wintertime. In either case, supplemental electric heat is required to avoid inappropriate air temperatures within the indoor air supply system.

Excessive auxiliary heat operation is not uncommon in older and small heat pumps. Auxiliary heat is typically electric resistance with an effective COP of 1. Too much auxiliary heat operation will reduce the overall heating COP of a heat pump. Consider limiting auxiliary heat operation to defrost conditions only. Quick temperature pick-up conditions can often be reduced with proper thermostat settings and programming.

QUESTION

What are symptoms of inadequate refrigerant charge?

ANSWER

The HVAC system will likely struggle to maintain room temperature setpoints and spaces will get warm. This is because inadequate refrigerant charge will reduce overall mass flow rate within a refrigerant circuit, which can cause an air conditioning unit to lose cooling capacity.

DISCUSSION

Severe loss of charge will keep refrigerant pressures below the necessary threshold for a functioning refrigeration cycle.

At that point, there will be no cooling occurring even though the compressor will be operating, at least for a time. With little or no refrigerant in the cycle, the compressor will not be properly lubricated and will fail due to excessive internal friction.

What is the best solution to recover from a failed compressor?

Should an alternate refrigerant be used to re-charge a system?

What should be done to manage systems that have outdated or outlawed refrigerants?

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QUESTION

What types of systems are particularly vulnerable to simultaneous heating and cooling?

ANSWER

Dual duct systems and Variable Air Volume (VAV) Multizone Systems

DISCUSSION

Minimizing the heating of air that has been previously cooled is the largest opportunity to save energy in most commercial office buildings. Increasing the percentage of outside air while reducing the “minimum air flow” settings on individual VAV boxes will minimize the amount of air conditioned air that must be reheated.

Some simultaneous heating and cooling is unavoidable because the systems are designed to mix hot and cold air together. However, careful attention to supply air setpoints and reset strategies can minimize energy waste.

Building control changes should be done by qualified individuals to ensure proper ventilation and energy savings.

What are some examples of simultaneous heating and cooling in air distribution? Water distribution?

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QUESTION

What are some ways that infrared imaging can be used to support HVAC diagnostics?

ANSWER

Infrared imaging can clearly indicate when piping or duct components are warm or cool. This can support an evaluation of appropriate or inappropriate heating or cooling control and functionality. For example, thermal imaging of a steam trap during active heating periods can provide indication of traps that are failing open. In this case, the condensate discharge piping would be very hot, reaching temperatures close to that of the live steam piping.

DISCUSSION

Historically, the cost of infra-red imaging equipment has been too high to justify using this technology as a regular diagnostics tool. However, the technology is becoming more widespread in the marketplace, and there are inexpensive applications that do not deliver all of the features of more expensive products, but provide basic color-coded imaging that supports much of the diagnostic use of the technology in HVAC. One example is the smartphone infrared camera attachment that can be purchased for about $250.

Additional uses for this technology include

- Envelope heat loss identification
- Electrical panel thermal imaging to identify poor connections
- Coil piping evaluation to identify leaking valves

Smart phone infrared camera attachment product data can be found at **www.flir.com/flirone/ios-android.**

QUESTION

Pneumatic control components, especially zone thermostats, are often not systematically calibrated and checked.

For thermostats that have not been calibrated in over two years, what percentage of thermostats are likely to be out of calibration?

ANSWER

Up to 70%. Half of these may be totally non-functional and would require replacement.

DISCUSSION

For older buildings with hundreds of thermostats, a sampling of thermostats can ascertain the degree of the calibration problem with two to four hours of systematic work by a technician or operator familiar with calibration techniques. Often this work will uncover other related problems, such as improper thermostat location, brittle or failed pneumatic tubing, low control pressures in part of the system, etc.

Calibration of pneumatic thermostats is not particularly difficult, but does require a basic set of calibration tools, some of which are uniquely suited to specific thermostat models and manufacturers. A calibrated, accurate thermometer or digital temperature gauge is always required. Thermostat calibration kits can be obtained at reasonable costs from control manufacturers or part distributors such as Grainger.

QUESTION

What are the top three tune-up issues that can cause programmable thermostats to operate in a suboptimal manner?

ANSWER

1. Schedules that do not match actual occupancy
2. Inappropriate unoccupied period temperature setpoints
3. Fan settings inappropriately set to cycle with compressor or furnace

DISCUSSION

Programmable thermostats have a way of drifting away from intended programming. This programming starts with the definition of occupied and unoccupied periods. Sophisticated programmable thermostats can support multiple periods separately defined for each day of the week. Each period should have a cooling and heating setpoint defined for it.

Programmable thermostats, like many other thermostats, typically have fan and system settings. Fan settings can be programmed so that the fan will cycle with a furnace or air conditioning compressor, or will run continuously during the scheduled occupied period. For most commercial buildings, fan settings should be programmed to support continuous operation during occupied periods to ensure adequate fresh air is always maintained when people are present.

Typically, occupied schedules should start one to two hours before the first significant arrival of occupants, and end when most occupants leave the building.

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QUESTION

What is a good way to diagnose excessive leakage in a pneumatic control system?

ANSWER

Monitor compressor cycling.

DISCUSSION

Pneumatic control air compressors are configured with an integral compressor air receiver and cycle to maintain a pressure setpoint in that receiver. When the control system is excessively leaky, compressors will cycle frequently and even experience extended operating periods where they do not shut off. This is often observable in real time, although it is easily determined through data logging as well.

Finding leaks in a pneumatic tubing system can be challenging. Many systems today are comprised of polyethylene tubing that can come loose from connections, be cut during remodels, or just become brittle and fail over time. Systematic survey and calibration of pneumatic control devices - thermostats, receiver-controllers, transmitters, relays, and switches - can find many leaks. Listen closely for the characteristic hiss associated with pneumatic air leaks!

What are some other maintenance considerations for pneumatic control systems?

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QUESTION

What are the primary drivers in sizing flow control valves for HVAC hydronic system applications?

ANSWER

Flow control valves should be sized to balance good flow control characteristics which improve with pressure drop against excessive pump energy use which deteriorates with pressure drop.

DISCUSSION

A good rule of thumb is to size valves so that the pressure drop through a fully open valve is between 10-25% of the entire system pressure drop. Valve size is rated in Cv coefficient with is the flow rate, in gpm, through a valve at a 1 psig pressure drop.

It rarely makes sense to have a flow control valve sized at the same size as the piping in the system - referred to as a line size valve. These valves are often oversized and can exhibit relatively poor flow control characteristics.

How much smaller than line size should valves be?

What are some circumstances where line size valves make sense?

QUESTION

Heating water valves that experience significant leak-by when commanded fully closed are a common and energy expensive problem.

What are three causes of valve leak-by?

ANSWER

1. Eroded or corroded valve seats
2. Inappropriate actuator signal
3. Loose or damaged actuator valve connections

DISCUSSION

Valve seats that have surface deterioration cannot seal completely when the valve is positioned fully closed, so water leaks through the poor internal seals. If the valve actuator is receiving an inappropriate signal, the internal valve components may not be properly positioned in conditions where the valve should be closed, even if they are in good operating condition. When this happens, the valve stays partly and inappropriately open and water will continue to flow through the valve. Loose connections between actuator and valve stem can result in a similar problem where the internal valve components are not positioned in accordance with the control signal to the actuator.

Leak-by in heating water valves can be a huge maintenance headache resulting in lack of thermal comfort and excessive energy use. This occurs commonly in small distributed reheat coil valves. Some buildings have thousands of these valves located above the ceilings of occupied spaces, and it is made worse when heating water systems are kept active throughout the entire year, including the cooling season (so that reheat coils can function).

Leak-by can also occur in central heating and pre-heat coil valves within air handling units. Because these coils are typically located upstream of cooling coils, leaking central heating coil valves not only waste heat but also increase cooling because the cooling coil has to work that much more to remove the heat added to the airstream by the leaking heating water coil valve.

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QUESTION

Effective airside economizer control can significantly reduce energy used for mechanical cooling.

What are three modes of suboptimal economizer control?

ANSWER

1. Inappropriate economizer high limit setpoint
2. Damaged mixed air damper components
3. Poorly calibrated or located sensors (mixed air, return air, and outside air temperature)

DISCUSSION

A common method of transitioning into and out of airside economizer operating mode is to use outside air temperature. Typically, above a specific fixed temperature (usually 70-75°F) the outside air dampers will return to a fixed minimum ventilation position. This setpoint is referred to as the economizer high limit. If the high limit is set too low, the dampers will return to minimum position during conditions when cooling benefits can still be achieved with continued economizer operation.

Good functional outside air and return air dampers are essential for reliable economizer control. If either damper set is damaged in consequential ways such that the dampers do not position accurately when commanded to do so, economizer control is unlikely to be working. Damaged dampers can cause both excessive outside air flow rates and insufficient outside air flow rates. Because they are dynamic HVAC control components, they can exhibit variable and changing failure modes.

Mixed air sensors are often challenging to install, and difficult to receive accurate temperature readings from. Many economizer and mixed air control sequences rely on mixed air temperature as a key control variable; if the control variable is not being measured correctly, then it is unlikely that the control sequence will be effective.

What are other methods of economizer control besides outside air temperature? In what conditions do they make sense?

What are some solutions to this problem that would prevent inappropriate economizer operation and control?

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QUESTION

What are three important issues to consider when locating an outside air temperature sensor?

ANSWER

1. Avoid direct solar radiation
2. Do not locate near an exhaust fan outlet
3. Avoid micro-climates created by proximity to black surfaces (on walls or roof)

DISCUSSION

Outside air temperature sensors are often a critical sensor component within HVAC controls systems, as outside air temperature is used as a control variable in many control sequences. It is critical to have a reliable, accurate reading under all weather conditions at all times of day and night.

Outside air temperature sensors should be regularly checked and calibrated. Strange readings are often linked to poor locations.

Some especially bad locations for outside air temperature sensors are

- Inside outside air ducts
- Locations where sun can directly shine on the sensor
- Locations where the sensor will get wet when it rains

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QUESTION

What are the primary causes of sensor error?

ANSWER

Unclibrated sensors

Incorrectly placed sensors

Failed sensors

Mistakes in control set-up

DISCUSSION

Sensor error can increase energy use, compromise occupant comfort, and prevent plant and system loads from being met. While building systems use many sensors, critical control sensors are the most likely to cause severe energy penalties. For example, while space-temperature sensors cause energy waste and comfort problems, the effect on energy is usually minor and restricted to one zone. On the other hand, errors of a critical control sensor such as the temperature of return air at the air handler can cause large energy penalties affecting many zones, yet may not cause comfort issues.

Sensor error is hard to detect unless the sensors are calibrated regularly.

Review sensor setpoints and locations and determine what changes might be necessary. For example, thermostats may have started out in optimal locations, but as the building's occupancy and use changed over time, potential new locations may merit consideration. Periodically recalibrate sensors to ensure their readings match actual building conditions.

To help prevent sensor error, make sure to

- Calibrate sensors at least annually
- Calibrate critical control sensors at least twice a year
- Replace critical control sensors on a regular schedule as they approach the end of their service lives

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QUESTION

What is a good way to find out if you can adjust the thermostat to save on space heating/cooling costs?

ANSWER

Walk through the building and talk with your tenants. Are they actually comfortable with the temperature?

DISCUSSION

You may determine that you can adjust the thermostat by a few degrees and still maintain comfort. Also explore whether you can adjust the temperature on evenings, weekends, and holidays, to reduce or increase temperatures during different seasons.

Are there hours or days when temperature settings could be adjusted?

When is the last time you confirmed the accuracy of all critical digital/electronic thermostats/transmitters?

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QUESTION

How often should critical control sensors be recalibrated?

ANSWER

Twice per year.

DISCUSSION

Critical control sensors' values drive control sequences, such as the outside air temperature or supply air temperature. Even if a sensor is correctly calibrated, it may cause errors if it is not correctly placed - such as a static pressure sensor located too near the supply fan, or an outside air sensor that is in direct sunlight.

Some indicators that sensors are not working optimally may include

- Loads are not met
- Economizer is not working
- Equipment is on when it is not needed
- Simultaneous heating and cooling is occurring
- Over or under ventilation

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QUESTION

What are some techniques to avoid chronic problems with mixed air dampers and outside air ventilation controls?

ANSWER

Functional performance tests can be executed on a regular basis to identify ongoing emergent deficiencies in damper control. Test results should be documented in writing, and used to supplement visual observation and inspection to generate work orders for damper control maintenance.

DISCUSSION

A simple functional test for dampers is to override damper control signals to position damper at full closed, 50% open, and full open. Once the signal has stabilized, the control action of the damper is documented, and differences between signal intent and actual position should be noted. Where outputs and inputs are significantly different, visually inspect the damper to diagnose reasons for the difference.

Repeat the functional test as needed.

As dampers open and close, it is useful to observe the position of the damper blades through the entire actuator stroke. This can be difficult in many systems where the dampers are internal to an air handling unit or a duct. Often the air handler will need to be shut down. In some cases, access holes will need to be cut into ducts. In both cases, damper testing will need to occur when the fan unit is not operating. This may require a temporary signal to be applied to the damper motor.

For pneumatic actuators, the pressure signal usually ranges from 0 to 15 psig. Disconnecting the pneumatic motor is a quick way to achieve a zero signal. There are many methods to manually apply a pressure signal independent of the pneumatic control system. For electric motors, the control signal will likely need to be manipulated via the digital control system using operator override functions.

QUESTION

Do small packaged rooftop units (RTUs) have unique damper issues that warrant specialized diagnostic techniques?

ANSWER

Yes. Many RTUs are equipped with 3rd party damper controls that implement economizer functionality or demand control ventilation control sequences. These are not always uniform in installation, design, or functionality. Specific testing techniques are required for specific 3rd party control elements, especially for economizer and/or demand controlled ventilation which are difficult to implement successfully in the RTU class of HVAC equipment.

DISCUSSION

Honeywell has long made a popular economizer control add-on for RTUs. The W7459 economizer controller is installed on many RTUs, and warrants some specific control optimization check-out steps: damper to diagnose reasons for the difference. Repeat the functional test as needed.

Does the controller work with older or newer sensors? The older sensor (C7650) typically works with one of four control settings (A-D) that determine one of four dry-bulb changeover temperature setpoints. The newer sensor (C7660) has eight choices to establish changeover setpoint from a low of 48°F to a high of 78°F.

Is the changeover setpoint correctly established? For most RTUs, stage one of cooling is economizer cooling, and change-over to mechanical cooling involves restoring dampers to minimum ventilation position and enabling mechanical cooling. This is referred to as non-integrated economizer control. Optimized change-over setpoints are typically in the range of 63° to 68°F for non-integrated economizer controls. This would correspond to setpoint “C” on older sensors. Newer sensors can select either 63° or 68°F as the specific changeover setpoint.

DUST COLLECTION

INDUSTRIAL ENERGY TALK CARDS

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QUESTION

Do you know what your dust collection systems are sized to achieve?

ANSWER

Dust collectors are sized based on the conveyed particulates' minimum entrainment velocities for the given duct size and filter differential pressure.

DISCUSSION

Dust collectors remove particulates in the air that have adverse environmental, health, and safety impacts. The particulates are conveyed with the dust collector airflow, and have a minimum entrainment velocity to keep them airborne. The minimum entrainment velocity and maximum duct diameter determine the dust collector required airflow.

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QUESTION

What's the impact of a low DP filter on fan power?

ANSWER

Changing out the filter media for low pressure drop filters will reduce the required maximum flow when the filter is clean, reducing fan power for most operation hours.

DISCUSSION

Achieving reduced maximum airflow for your dust collector will require a change in maximum fan rotation speed. This can be achieved with a VFD, or by changing gear ratio or fan sheaves.

Additional benefits of low pressure drop filters can include

- Longer lifetime
- Reduced downtime
- Better filtration
- Reduced maintenance labor

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QUESTION

Has your pulse-jet cleaner been optimized?

ANSWER

Optimized pulse-jet cleaners have demand controls, or have timers that have been recently tuned for pulse duration and frequency.

DISCUSSION

Compressed air pulse-jet cleaners clean filters to maximize filter effectiveness. Pulsing for the optimized duration and frequency will maximize the filter efficiency while keeping compressed air use low. Demand controls measure filter pressure differential to control pulse frequency. Induced flow pulse-jet nozzles use precision machined nozzles that supply the same cleaning capacity with reduced compressed air use.

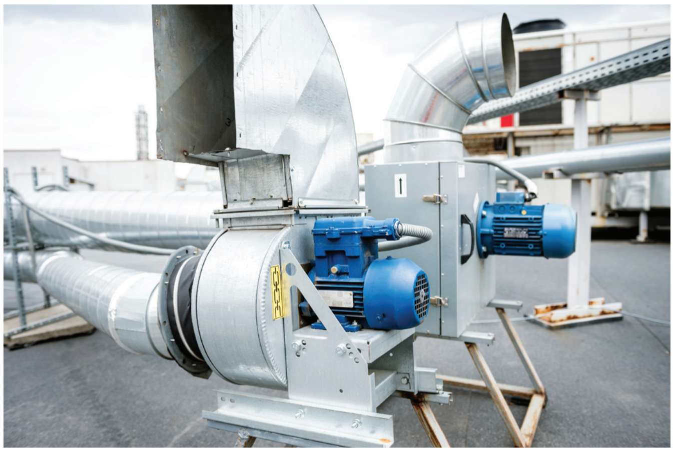
Pulse-jet cleaning effectiveness is reduced if there is a large pressure drop in compressed air supply during pulse cleaning, which can be mitigated with additional storage near the dust collector, and properly sized piping.

QUESTION

When does your constant speed fan use the most energy?

ANSWER

When the filter is clean, and airflow is highest.



DISCUSSION

Counter intuitively, the fan power is highest for constant speed fans with clean filters and high airflow.

For VFD controlled dust collectors, the fan speed is controlled on differential pressure, which reduces the fan speed when the filters are clean, and speeds up as the filter pressure drop increases to maintain airflow.

Consult with the dust collector manufacturer for what interval to clean or replace filters to ensure optimal operation.

BOILERS

INDUSTRIAL ENERGY TALK CARDS

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QUESTION

What are the four basic components of steam systems?

ANSWER

Generation

Distribution

End Use

Recovery

DISCUSSION

Poorly maintained steam systems are a common issue for older buildings that rely on large boilers for heat. Typically these buildings have hundreds of small steam traps that control the condensate within the steam system. If these are not maintained regularly, they can get stuck open and return steam back to the boiler system, resulting in wasted heat and wasted energy used to operate the boiler.

What are some of the ways that steam distribution systems lose steam, and why is this significant?

What are some ways to conduct steam trap testing?

Why is condensate recovery important?

QUESTION

What is the trap failure mode that results in the most wasted steam, and how can this be diagnosed?

ANSWER

Traps that have failed in the open position result in the most wasted steam. This is best diagnosed via thermal imaging or an ultrasonic device.

DISCUSSION

Traps can fail in two fundamental ways - either failed open or failed closed. If failed closed, then condensate backs up in the steam line, affecting process temperature. If failed open, the steam only transfers a portion of its potential heat before it passes through the process heat exchanger and out the failed trap. This means more steam must be generated at the boiler to provide the same amount of heat to the process.

Ensure that there is some load on the system upsteam of the trap when you test it. If the upstream steam control valve is closed, there is no way to know if the trap is working properly.

When is a good time of day to conduct trap failure diagnosis?

What are some visual inspection techniques that can provide an indication of traps that have failed in an open position?

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QUESTION

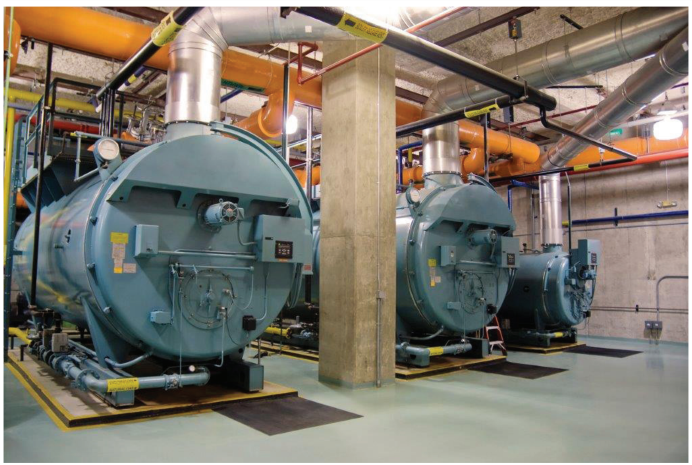
What are three ways to characterize boilers?

ANSWER

Hot water vs. steam (working fluid)

Fuel type (gas, oil, electric)

Heat exchanger / burner type (condensing, fire tube, water tube, cast iron sectional)



DISCUSSION

All three characteristics are important in discussing and evaluating boilers. Differentiation by working fluid may be the most fundamental, with fuel type second. Not all types of heat exchangers are applicable to boilers of differing working fluids or fuels.

Today's most efficient boilers are condensing boilers. Condensing refers to the operating condition where exhaust gases are cooled below the dewpoint inside of the heat exchanger. This results in liquid condensate that is moderately acidic and must be drained.

Most condensing boilers are gas-fired hot water boilers.

Is it possible to have condensing boilers that generate steam?

Is it possible to have condensing boilers that fire on fuels other than natural gas?

What are the benefits and drawbacks of various heat exchanger types? Which is preferred?

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QUESTION

Why is it important to remove any residue, soot, or scale that coats heat transfer surfaces?

ANSWER

Any residue, such as soot or scale, that coats the heat transfer surfaces of the boiler will reduce its efficiency and will also increases the likelihood of equipment failure.

DISCUSSION

Good boiler water chemical treatments are essential to maintain efficient operation. Even a thin layer of scale interferes with heat transfer, thereby decreasing combustion efficiency. A layer of soot or scale only 0.03 inches thick can reduce heat transfer by 9.5%; a layer 0.18 inches thick can reduce heat transfer by up to 69%.

Consistent and frequent small volume blowdowns is a better practice than infrequent high volume blowdown because it conserves energy, water, and chemicals. Large steam boilers with steady loads should have continuous blowdown, so that a small amount of water is drained continuously from the boiler while fresh make-up water is introduced.

Un-insulated pipes, valves, or fittings can carry a heavy energy penalty. Steam, condensate, and hot water pipes in air conditioned spaces produce a double penalty if un-insulated because the heat loss from the pipes must be removed by additional air conditioning.

Some other maintenance procedures that will help ensure optimal boiler performance include

- Remove any buildup that coats the tubes
- Develop a water chemical treatment plan
- Calibrate instruments regularly
- Examine water side surfaces for any evidence of scaling or corrosion
- Minimize boiler blowdown
- Inspect and repair insulation

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QUESTION

How much excess O_2 is enough to assure complete combustion?

ANSWER

Typically between 2-3% O_2, however it varies with the design and condition of the burner and boiler, as well as with the different firing rates of the burner.

DISCUSSION

Complete combustion is critical to ensuring efficient boiler operation. Incomplete combustion of the fuel can reduce boiler efficiency by 10% or more, while increasing excess air by 10% may only impact boiler efficiency by about 1%.

Typically, excess air of around 10-15% for a natural gas boiler is optimal to ensure complete combustion and peak efficiency, which corresponds to excess O_2 of around 2-3%. Operating with excess air beyond 10% is undesirable, as it can result in reduced efficiency and higher emissions. Therefore maintaining the optimum level of excess air across the entire firing range is preferred.

What are some signs of incomplete combustion?

At what firing rate should your boiler be tuned for optimal efficiency?

What kinds of burner controls are superior alternatives to mechanical jackshaft controls?

How often should the boiler be tuned up to ensure the combustion process is optimized?

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QUESTION

What energy losses are associated with keeping a standby boiler?

ANSWER

The standby boiler will cycle on and off, losing heat to the surroundings through radiation losses and increasing as a percentage of boiler input at reduced firing rates.

DISCUSSION

At low firing rates, such as when a boiler is maintained in a standby condition, efficiency loss can be as much as 15%. Having a standby boiler will allow quick recovery if the lead boiler fails, but it must be weighed against the large energy penalty. If a standby boiler is not critical to your operation, or if you have sufficient time to start it up manually before it's needed, or if the need is seasonal, you should consider shutting off any unnecessary boilers to prevent these energy losses.

For some operations, it is necessary to keep a stand-by boiler warm so that it can come up to temperature or pressure quickly if a lead boiler goes down unexpectedly. Typically this is accomplished by idling the burner at low fire.

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QUESTION

What are some methods
to improve boiler efficiency?

ANSWER

Install an economizer

Reduce excess combustion air

Preheat combustion air

Automatic boiler combustion controls

Proper boiler water treatment

Ensure boiler has lockouts based on outside air temperature

DISCUSSION

Some potential problems associated with the frequent starting and stopping of a boiler include

- Flow switch is malfunctioning
- Water-temperature high-limit switch is set too low
- Deadband between on/off is too narrow
- Boiler is over-firing or the flue or turbulence-inducing inserts in fire tubes may be clogged
- Heating-water pump is cycling. Boiler cycles via the system flow switch
- NG pressure at the manifold is low
- Flow of induced-draft fan is inadequate

Another explanation which is **NOT** a problem is that the load is below the minimum boiler capacity.

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QUESTION

What is a boiler economizer?

ANSWER

A boiler economizer is a heat exchanger device that captures the lost (or 'waste') heat from the boiler's hot stack gas.

DISCUSSION

Capturing what is normally lost heat reduces the overall fuel requirements for the boiler - less fuel equates to money saved and fewer emissions, since the boiler operates at a higher efficiency.

Boiler economizers improve a boiler's efficiency by extracting heat from the discharged flue gases. Because the boiler feedwater or makeup water is preheated by the economizer, the boiler's main heating circuit does not need to provide as much heat to produce the output quantity of steam or hot water.

What are the primary benefits of condensing economizers?

What are some other potential uses of recovered heat from stack economizers, beside pre-heat of boiler feedwater?

What are some other heat recovery opportunities in boiler plants besides stack economizers?

MAKE YOUR OWN CARDS

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QUESTION

ANSWER

DISCUSSION

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QUESTION

ANSWER

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ANSWER

DISCUSSION

INSPECTION CHECKLISTS

INDUSTRIAL ENERGY TALK CARDS

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EQUIPMENT OPERATION

- ☐ Process and support equipment schedules are reasonable, accurate, and match occupancy
- ☐ Shutdown and start-up procedures are posted by major pieces of equipment
- ☐ VFDs are in AUTO and are allowed to adjust speed based on demand
- ☐ Equipment and system setpoints are evaluated to ensure they align with the needs of the process

HEATING & COOLING

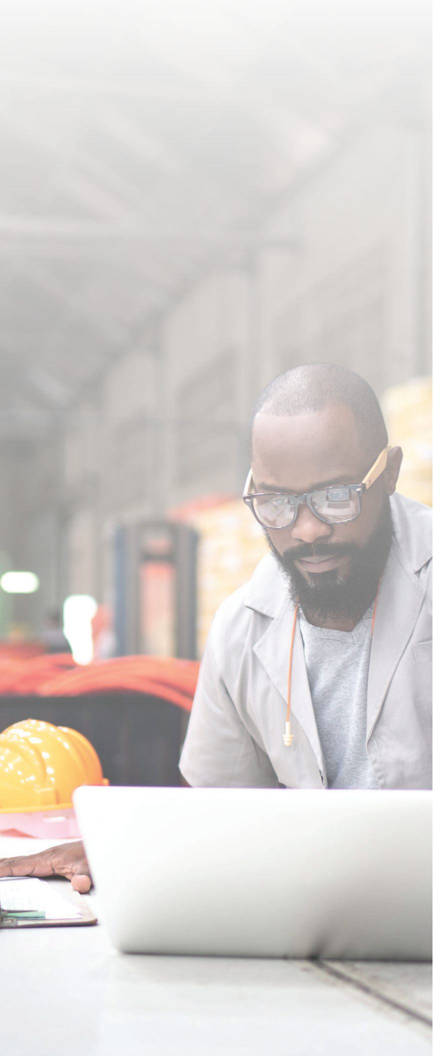
- ☐ Equipment (HVAC, boilers, motors) schedules align with occupancy/demand
- ☐ Space temperature setpoints are reasonable and setbacks are used during unoccupied periods
- ☐ Optimum start/stop is utilized where available
- ☐ Boilers and chillers are appropriately locked out
- ☐ Chilled and condenser water temperature setpoints are appropriate
- ☐ Chilled and condenser water pump operations are appropriate
- ☐ Advanced control strategies such as supply air temperature and static pressure resets are functioning where appropriate
- ☐ Boilers are routinely tuned to optimize efficiency
- ☐ Steam traps are inspected and replaced when leaking
- ☐ Filters are regularly replaced according to manufacturers' recommendations

COMPRESSED AIR

- ☐ System pressure setpoint is evaluated and lowered when possible
- ☐ Compressors with VFDs are operated in the lead position and are allowed to adjust speed based on demand
- ☐ Compressor sequencing is optimized to ensure the minimum number of compressors are in operation
- ☐ The dryer dew point setpoint is as high as possible for safe and reliable operation
- ☐ Filters are regularly replaced according to manufacturers' recommendations
- ☐ Low pressure drop filters are used where possible
- ☐ A leak audit is performed quarterly and the identified leaks are repaired
- ☐ Isolate unused equipment and areas from the compressed air system when not in use
- ☐ Turn off compressed air systems when they are not required to operate
- ☐ Ensure compressed air dryers operate in "demand" or "energy saver" mode, if available

REFRIGERATION

- ☐ Refrigerated space temperature setpoints are evaluated and raised when possible
- ☐ Suction pressure setpoints are appropriate for the temperatures required by loads on the suction group
- ☐ The minimum condensing pressure setpoint is evaluated and lowered when possible
- ☐ Floating head and suction pressure control are enabled when possible
- ☐ Compressors with VFDs are operated in the lead position and are allowed to adjust speed based on demand
- ☐ Compressor sequencing is optimized to ensure the minimum number of compressors are in operation
- ☐ Fan VFDs are allowed to adjust speed based on demand
- ☐ Defrost controls for all evaporator coils are evaluated to prevent excessive icing and/or defrosting



DUST COLLECTION

- ☐ Pulse jet cleaners using differential pressure controls are energizing when the recommended differential pressure setpoint is met
- ☐ Pulse jet cleaners using timed controls are evaluated for effectiveness
- ☐ Ensure pulse jet cleaners are interlocked to shut off when the fan shuts off
- ☐ Isolation gates and dampers are closed when possible
- ☐ If a VFD is present, the motor speed is being controlled based on system demand or duct pressure
- ☐ Filters are regularly replaced according to manufacturers' recommendations
- ☐ Low pressure drop filters are used where possible
- ☐ Turn off dust collectors when they are not required to operate

P.U.D. CHELAN COUNTY

Clark Public Utilities

EnergyTrust of Oregon

PACIFIC POWER

PSE PUGET SOUND ENERGY

Seattle City Light

SNOHOMISH COUNTY PUD PUBLIC UTILITY DISTRICT NO. 1

TACOMA POWER TACOMA PUBLIC UTILITIES