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Dynamic Glazing

Introduction

Buildings account for a significant portion of the world's energy usage so it is imperative that all elements are optimized to provide energy savings. In the US, the energy lost through windows is upwards of 30% of a building's heating and cooling energy.[2] With the development of ribbon windows and much of modern architecture being characterized by large expanses of glass, glazing has become an even more critical factor in building performance and occupant comfort.

Due to major advances in material science, a new generation of glazing products known as dynamic glazing is beginning to emerge in the marketplace. Dynamic glazing may help to dramatically reduce building energy consumption, in addition to providing many other benefits. Dynamic glazing, also referred to as smart windows, are glazing units whose properties can be controlled either manually or autonomously based on environmental conditions. Passive systems respond autonomously to natural stimuli such as light (photochromic glass) or heat (thermochromic glass). Active systems, such as electrochromic glass which respond to an applied voltage, can either be manually controlled or connected to a building management system to adjust glazing properties based on a variety of setpoints. Though not every system has all the following benefits, dynamic glazing can provide self-cleaning, self-heating, solar radiation adaptation, glare modulation, and even energy generation.

There are currently numerous technologies being developed for dynamic glazing; among them, electrochromic glass is the most advanced and the most readily available for use in construction. This article will focus on electrochromic glazing, how it works, and its potential benefits.

Electrochromic Glazing

Electrochromic windows come in a variety of designs. A typical design is often constructed of five thin film layers either on a glass substrate or sandwiched between two glass substrates. These film layers consist of an electron accumulation layer, an ion conductor layer, an electrode layer, and two outer layers made of transparent conductive oxides. When a voltage is applied to the unit, lithium ions move to the electrode layer and cause a change in opacity from transparent to dark. This reaction is generally controlled through a low voltage DC power supply, and it takes less than 5 Volts to change the visual properties.[2]

Electrochromic windows are currently available in a variety of pane sizes and shapes, with numerous control and power options to choose from. Certain manufacturers are now even providing self-powered units which use photovoltaic battery systems. Most units are of a bluish color due to the tungsten trioxide often used in the electrochromic film layer. The switching of color states in electrochromic windows is relatively slow when compared to other dynamic windows and may take up to 15 minutes depending on the glazing size. This slow reaction is not necessarily disadvantageous, though, as it allows occupants to naturally adjust to daylighting changes. As with all windows, electrochromic windows need to be able to cope with a variety of environmental conditions and temperature ranges. Many manufacturers now state that they are durable for up to 30 years.

Benefits

The main benefit of electrochromic windows is that they can provide automated adjustments for solar heat gain, daylighting, and glare while still providing visual access to the outdoors. In many modern buildings, solar heat gain and glare are controlled through shading devices such as blinds. While these may effectively reduce glare, they do very little to stop solar heat gain. They also negate the main function of a window, which is to provide visual access to the outdoors. Electrochromic windows accomplish the same goals that blinds do, but more effectively and without the drawbacks - when connected to control systems and used in an appropriate building type, these windows may provide up to a 60% reduction in lighting needs and up to a 26% reduction of the cooling load.[1]

Technology is currently being developed to further improve electrochromic windows. One such technology is dual-band electrochromic glazing. This glazing provides three states the window can be set to: "bright," "cool," and "dark." The novel aspect of this technology is that, while in the "cool" state, it allows for nearly all visible light transmittance but can simultaneously block virtually all near infrared light and eliminate most solar heat gain through the window.

Conclusion

All developing technologies are riddled with challenges and hurdles to overcome. Dynamic glazing is no different. Not all buildings make use of building management systems, and for dynamic glazing to meet its potential it must be utilized in a building of the appropriate type with a well-designed building management system. Additionally, for this product to become fully accepted in the current marketplace, the technology's performance must improve, and the payback time must shrink; the current payback time for a residentially used electrochromic window is 30 years, ands for a commercially used electrochromic window it's 60 years.[1] These issues, however, are not insurmountable, and will likely be overcome as material sciences and nanomaterials continue to advance. Even with the current challenges, dynamic windows will certainly play a pivotal role in advancing building envelope construction, allowing greater freedom in future architectural design, achieving increasingly stringent energy targets, and, perhaps most importantly, reducing the building industry's overall carbon footprint.

References

1 Casini, Marco. "Active dynamic windows for buildings: A review." *Journal of Renewable Energy*, vol. 119, April 2017, pp. 923-934.

2 Sbar, Neil L., et al. "Electrochromic dynamic windows for office buildings." *International Journal of Sustainable Built Environment*, vol. 1, no. 1, 2012, pp. 125-139.

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Steam Water Heaters

Introduction

Water heaters are available which utilize various sources of energy, including electricity, steam, fuel gas, geothermal (heat pump) and solar. Today, the most commonly used energy source for domestic water heating is electricity, followed by natural gas. At the NIH campus in Bethesda, steam is the source of energy used to heat domestic and laboratory water as well as numerous other applications. Alternate heating sources for water heaters may only be used for special applications and with pre-approval by ORF.

A Brief Evolution of Water Heating

The first water heater was invented in 1868, which lead to the invention of the first storage tank-type gas water heater in 1889. At that time fossil fuels such as natural gas, oil, and coal were commonly used to heat water. Then, as electricity became commercially available electrically-powered water heaters grew to be popular, assisted by their ease of installation and low first cost. As it became more commonplace, heated water was utilized for many purposes, from residential to industrial applications.

Efficiency

Electricity is typically generated at a fairly low overall efficiency when considering the energy source is used to generate it and the transmission losses. For instance, the use of coal in a traditional power plant may convert approximately 30 to 35% of the source energy into electricity. When the transmission losses are factored into the overall efficiency, that overall system efficiency would be even lower. Using common sources of energy, such as natural gas and fuel oil, steam can be produced efficiently with fuel to steam efficiencies that exceed 80%. At NIH, the use of steam is extensive. It is utilized in several systems such as sterilizers, autoclaves, cage washers, HVAC systems and domestic hot water generation. Section 6.3.7 of the NIH DRM describes some of the characteristics of the NIH steam system.

Steam Water Heaters

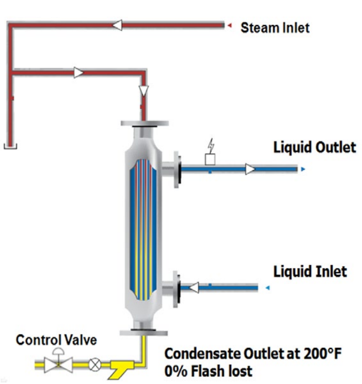
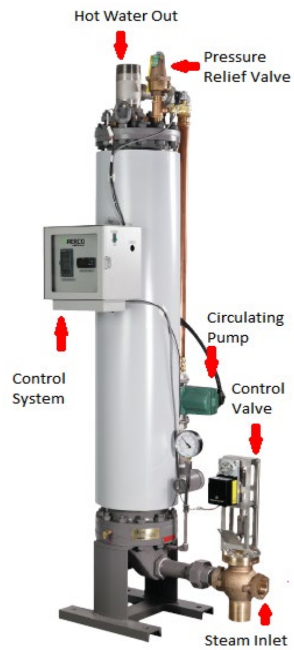


Figure 1 Basics of a Steam Domestic Water Heater [(1)]

Water heating is achieved by taking advantage of available steam using one of the various types of water heating systems. Heat exchange for water heating at NIH is accomplished using semi-instantaneous shell and tube steam type or indirect water (where high temperature water is available) heaters. A graphical example of equipment is shown in Figure 1. Appropriate materials of construction of heater shell and tube materials is essential to provide corrosion resistance as well as suitability for potable water applications. Accurate hot water temperature control is provided using modulating fail-safe pneumatically actuated or electric modulating fast positioning (with position feedback type) control valves. NIH requires that such water temperature control shall heat the water to 60°C–63°C (140°F–145°F) and tempered down to 52°C–54°C (125°F–130°F) for general potable water system distribution by a American Society of Safety Engineer (ASSE) 1017 master thermostatic mixing valve (arranged in parallel to provide N+1 redundancy). Shell and tube semi-instantaneous heaters have the advantage of requiring smaller space, as they operate without the use of a storage tank and circulating pump. Figure 2 shows a vertical double wall instantaneous water heater with a control system that includes a control valve and a built-in circulating pump. Heat exchangers utilized for potable and laboratory hot water heaters shall be double wall type. Some of these heat exchangers may require additional components, such as a storage tank and a circulating pump, which may be required to satisfy high peak demand loads. When a storage tank is required, the minimum temperature of the water shall be 60°C–63°C (140°F–145°F) to provide control of microbial growth, unless higher temperatures are needed for special applications.



Conclusions

Several factors should be considered when selecting a shell and tube, semi-Instantaneous heater, which are detailed in NIH DRM section 8.3. Hot water heaters and distributions systems are sized using Hunter's curve and compared to actual fixture / equipment to identify flowrate and maximum demand conditions.

For additional Reading

1. http://aerco.com/product/u-tube-double-wall
2. http://cemline.com/product-list/ht/
3. http://www.asse-plumbing.org/chapters/NOH_HeatTransfer-Spirax.pdf
4. https://www.phcppros.com/articles/2632-water-heater-types-and-selection-considerations
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Concrete Slab Profile Quality

Introduction

All finishes, equipment, partitions, and furniture in a facility rest on the floor slab, either directly or indirectly, so the slab must provide a flat and level bearing surface. If a slab surface is not flat and level, full contact cannot be achieved and shims, leveling legs, scribed trim pieces, and other methods of installation must be used. An uneven surface profile will also pond water and negatively impact the aesthetics and detailing of flooring. To avoid these issues slabs must be appropriately flat and level, especially in high performance facilities.

The surface profile of a slab is generally the result of workmanship and is under the control of the concrete contractor. It is incumbent of the designer to determine the required characteristics of the slab and include them in the construction documents.

In older specifications the maximum allowable surface unevenness was defined as a 1/8” deviation in 10 feet. This metric is problematic because it is not reliably replicable; it depends on where on a slab a 10-foot straight-edge is placed. However, with the advent of computerized profile measurement instruments, the quality of a slab surface can be determined more objectively and specified using F-numbers.

F-Numbers

A slab surface can vary in either flatness or levelness, and the values of each are quantified as F-numbers (Figure 1). F-numbers range from low (bad) to high (good) and should be specified appropriately for the use of the space. Very high F-numbers are costly to achieve and should only be specified where necessary in critical facilities. All slabs should have a specified F-number so that appropriate surface profiles are defined and achieved.

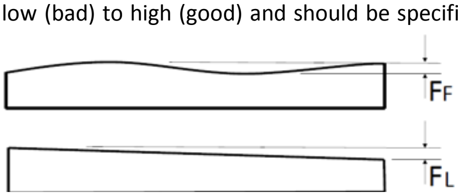

Figure 1: F_F and F_L Numbers

After the installation of a slab, profiling instruments take measurements in multiple perpendicular directions (figure 2). The F-number values for that slab are determined based on an analysis of the resulting measurements.

Flatness is a measure of waves or roughness in the concrete surface. The F-number measure of flatness is F_F. F_F range from 10 to 150. As a point of reference, F_F 50 is roughly equivalent to the traditional 1/8” deviation in 10 feet.

Levelness is the degree to which a slab tilts or pitches and varies from true level. The F-number measure of levelness is F_L. F_L also range from 10 to 150.


Figure 2: Slab profiling instrument

Concrete slabs on grade are uniformly supported and so have both F_F and F_L characteristics. Elevated slabs are subject to deflection over time and under loading, so F_L characteristics are not applicable. Elevated slabs and their support framing system should be designed with sufficient camber and stiffness to result in a surface that is appropriately level when fully loaded.

The American Concrete Institute publication ACI-302.1 provides recommended minimum F_F and F_L values for a number of facility types. The requirements of critical facilities and the technical specifications of equipment should be reviewed with users to confirm whether they exceed recommended minimums.

Corrective Actions

If a slab is not specified and built to acceptable F_F and F_L characteristics, corrective actions may be required. All corrective options are expensive, time consuming, and disruptive.

The remove and replace method involves removing sections of slab and replacing with a slab of acceptable surface quality.

Leveling compound involves scarifying portions of the existing slab and installing a self-leveling filling material. This only addresses low areas on the slab.

Grinding involves abrasively grinding or chipping material from the surface of the slab. This only addresses raised areas on the slab.

A topping slab, which provides a new surface over an entire slab, may be required if other corrective actions are not sufficient.

Resources

ASTM E1155: *Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers* - This test covers a quantitative method of measuring floor surface profiles to obtain estimates of the floor's characteristic F_F Flatness and F_L Levelness.

American Concrete Institute ACI 117: *Specification for Tolerances for Concrete Construction and Materials* - This specification provides tolerances for concrete installations including slab surfaces.

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Dielectric Fitting

Introduction

Corrosion is a maintenance issue that impacts many industries. Metal corrosion can affect a variety of industrial components, including construction materials, various types of industrial equipment, and utility piping. The HVAC and plumbing industries often deal with a specific type of corrosion known as galvanic corrosion, which can damage piping when proper measures aren't taken. However, by utilizing preventative measures like dielectric fittings and diligently employing detection methods, professionals in these industries can significantly reduce the extent and cost of galvanic corrosion.

Basic Corrosion Principles

Metal corrosion is an alteration of a metal by either a conventional chemical attack or by galvanic reaction. Atmospheric corrosion is a common example of a chemical attack: the variety of chemicals in the atmosphere like oxygen, chlorine compounds, carbon dioxide, sulfur, and water vapor corrode metals exposed to them, as seen in Figure 1. Galvanic corrosion, on the other hand, can only occur when a ferrous metal is connected to a non-ferrous metal. Ferrous metals, like black steel, malleable iron, cast iron, stainless steel, and galvanized steel, contain iron. Non-ferrous metals, like copper, brass, aluminum, and bronze, do not. The types of metals involved is not the only criteria for galvanic corrosion, though; all three (3) of the conditions listed below must be present for a reaction to occur:

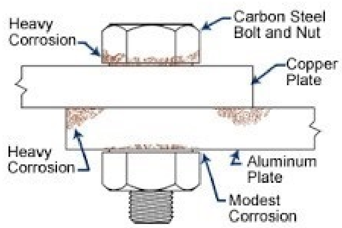

Figure 1 Chemical Attack Corrosion

- Metals with dissimilar electrochemical characteristics.
- Direct electrical contact (actual physical contact) between the metals.
- An electrolyte in contact with the metals.

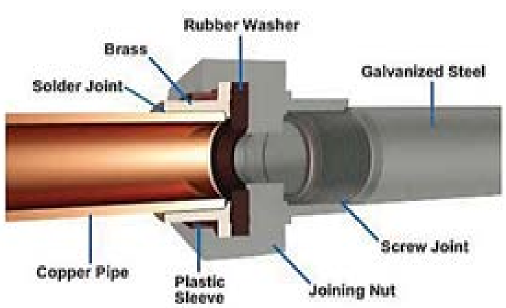

Figure 2 Anatomy of a Common Dielectric Union

Figure 2, Anatomy of a Common Dielectric Union, shows a type of fitting used to keep the appropriate conditions for galvanic reaction from arising to prevent corrosion. The intensity and speed of galvanic corrosion can be driven by the following factors:

- Potential difference between materials.
- Cathode efficiency.
- Surface areas of connected materials.
- Electrical resistance of the connection between the materials and of the electrolyte.

As indicated earlier, galvanic corrosion is the result of electrochemical corrosion that occurs when two dissimilar metals come into contact while in the presence of an electrolyte, forming an electrical couple or galvanic couple. The higher the cationic characteristics (the holding capacity for positively-charged elements) of the metal in relation to the other contacting metal, the less likelihood of corrosion there is.

Corrosion Detection

Galvanic corrosion can be detected using galvanic sensors or just plain visual inspection. The galvanic sensor system is normally used for detecting the corrosion damage of steel embedded in concrete structures, as well as for metal used in power lines, conditions that are very difficult to verify with the naked eye. However, if visual inspection can be performed, it is the simplest method for corrosion detection; the corrosion back in Figure 1, for instance, is easily visually detectable. Although visual inspections are generally effective, sometimes hidden galvanic corrosion may be taking place. A good example is piping: typical hidden corrosion can be found inside of a pipe that is showing normal physical conditions on the outside. A graphic example of such conditions is shown in Figure 3, where a dielectric union was used. Although dielectric unions are commonly used as a galvanic break, these fittings can leak under certain circumstances, meeting the three (3) conditions described previously that are necessary for galvanic corrosion to occur. Visual inspections can be further impaired when piping insulation is used. When insulation is removed from piping or equipment, moisture may penetrate under the insulation, creating conditions for corrosion to occur; however, because the corrosion is beneath the insulation, it isn't detectable by visual inspection and can be easily missed.

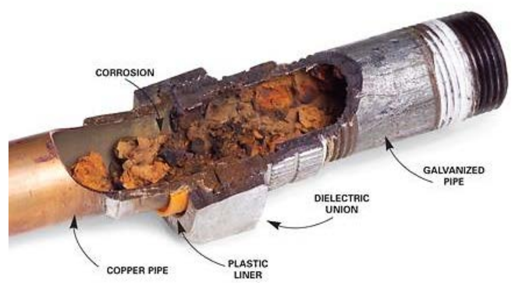

Figure 3 Galvanic Corrosion

Prevention

It's important to select the most appropriate dielectric fitting based on the ferrous and non-ferrous metals and the electrolyte (fluid) or atmosphere exposure. Piping location, vibration, and movement should also be considered, especially for the installation of dielectric fittings on continuous sections of the piping. Welding of piping should be performed prior to installing dielectric fittings, as heat can damage the isolating component or sleeve of the fitting.


Figure 4 Flange Dielectric Fitting

When using dielectric flanges, like the one in Figure 4, it's important that all components are completely separated with gaskets to avoid any possible contact between dissimilar materials. Such flanges should be fitted with plastic sleeves through the joint bolt holes and bolt gaskets, and considerations should be made when tightening the bolts, as bolts gaskets can shift or split in the process, creating a condition for corrosion. All these factors help to reduce the chance of leakage leading to corrosion.

References for Further Reading

1. https://pdhonline.com/courses/s118/s118content.pdf
2. https://www.corrosionpedia.com/definition/568/galvanic-corrosion
3. https://opp.psu.edu/sites/opp/files/3.pdf

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Healthy Design

Introduction

People spend the majority of their time in buildings, and a mounting body of evidence indicates that the buildings that they occupy have a profound impact on their health. In response, healthy design has joined sustainability as a benchmark requirement for best practice in building design.

Healthy design and sustainability are complementary principles, each providing benefits to building occupants and value to building owners. Whereas sustainability focuses on a building's impact on the environment, healthy design focuses on a building's impact on human health and wellbeing. Using healthy design principles, such as varied workspaces and increased accessibility, designers work to address the many ways that a building can facilitate healthier workspaces.

Research and Studies

A growing body of evidence highlights the impact of a building's design on occupant health. In 2015, the Urban Land Institute published Building Healthy Places Toolkit, which provides evidence-based recommendations for promoting health in buildings. This was followed in 2017 by Harvard University's The 9 Foundations of a Healthy Building, which focuses on office space design. Findings include:

- A wide range of design and construction elements are beneficial, including flexible open space for collaboration, activities, and events, and quiet spaces for concentration and focused work.
- Controls for air temperature, humidity, and acoustics should be adjustable to help create a comfortable work environment.
- Biophilic design, with natural views and materials, connect people to nature.
- Showers and lockers for employees allow running or biking to work or exercising during the day.
- Buildings constructed with low-VOC materials and finishes reduce exposure to these toxic substances.
- Good lighting leads to better sleep at night and better productivity during the day.
- Reducing noise levels improves productivity and job satisfaction.

Healthy Design Rating Systems

To address building-related health concerns, rating systems have been developed to both provide designers and owners guidance in design, and to benchmark the performance of buildings; these systems include Fitwel, WELL, and the Living Building Challenge. Fitwel was developed by the U.S. Centers for Disease Control and Prevention and the U.S. General Services Administration. Its evidence-based criteria were developed by both public health and design industry experts and are supported by more than 3,000 research studies. The Fitwel standard focuses on 12 wellness factors:

1. Location, including walkable amenities and transit
2. Building access, including multi-modal access
3. Outdoor spaces, including nearby outdoor amenities
4. Entrances and ground floor design, including improving air quality and access to health-promoting amenities
5. Stairwells, including design for increased use
6. Interior environment, including reducing harmful substances
7. Workspaces, including daylight, views, and operable shading
8. Shared spaces, including areas for physical activity and mental rejuvenation
9. Water supply, including access to fresh water
10. Cafeterias, including standards for healthy food and beverages
11. Vending machines, including providing heathy options
12. Emergency procedures, including increased safety during emergency situations

Conclusion

Building design has a significant impact on occupants' wellbeing, and healthy design principles acknowledge this and strive to provide people with work environments that promote overall wellness. Buildings designed with these principles in mind help to enhance productivity, reduce stress and sickness, increase flexibility and accessibility, and keep employees satisfied with their workspace.

Further Reading

Building Health Places Toolkit
http://uli.org/wp-content/uploads/ULI-Documents/Building-Healthy-Places-Toolkit.pdf

The 9 Foundations of a Healthy Building
https://forhealth.org/9_Foundations_of_a_Healthy_Building.February_2017.pdf

Fitwel – Center for Active Design
https://centerforactivedesign.org/fitwel

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Static Control Flooring

Introduction

Static electricity is an electric charge generated by the contact of two surfaces that have different resistance to electric current. The static electricity will discharge when brought in contact with an electrical conductor, resulting in the familiar static shock. In most cases static electricity is an annoyance, but in many laboratories static electricity can damage sensitive electronic equipment and ignite flammable material so it must be controlled.

One method of controlling static electricity is to provide a floor that does not generate a static charge, and which allows all items on the floor (people, equipment and furniture) to dissipate static charges safely and effectively to grounds. Electricity will follow all available pathways, but seeks the path of least electrical resistance. The surface of static control flooring creates a low resistance path for the flow of electricity, providing an immediate pathway to ground and preventing the accumulation of electrostatic charges.

Static control flooring can be used in a wide range of facilities but is frequently required in areas with diagnostic and imaging equipment, sensitive and calibrated electronics, data centers, clean rooms, operating rooms and rooms with flammable materials.

Types of Static Control Flooring

Static control floors are available from a number of manufacturers. Systems are proprietary, and must be installed using all flooring components and following installation instructions. Most static control floors in healthcare and laboratory facilities are vinyl, but rubber and carpet (sheet and tile) and epoxy (fluid applied) are available for special applications.

Static control flooring can be conductive or static dissipative. 'Conductive' and 'static dissipative' define different ranges of electrical resistance measured in ohms.

Conductive: The surface of a conductive floor provides a path of moderate electrical conductivity to prevent the accumulation of static charges. ANSI Defines "Conductive" as a material with a resistance of less than 1 million Ohms.[1]

Conductive vinyl flooring is generally constructed with embedded conductive filaments, so its conductive properties are intrinsic and special polish or wax is not required. Flooring is installed with conductive adhesive and/or a grid of conductive strips which is connected to the building grounding system.

Static dissipative: The charges flow through a static dissipative floor slowly and in a somewhat more controlled manner than with conductive floor. ANSI defines "Static Dissipative" as materials with a resistance between 1 million and 1 billion Ohms.[1]

Static dissipative vinyl flooring generally gains its conductive properties from a field-applied conductive polish or wax which must be maintained and reapplied. Flooring is installed with conductive adhesive which is connected by a conductive strip to the building grounding system.

Whether a conductive or static dissipative floor is specified should be reviewed carefully in consultation with the facility users, the processes to be conducted and the equipment to be protected. A floor that is too conductive may raise safety concerns for staff working with electricity. A floor that is not sufficiently conductive may not provide adequate protection. Best practice is to obtain an optimal resistance range in Ohms to use as a basis for product specification.

Other factors affecting static control in a room include humidity and the footwear of occupants. Moisture increases the conductance of air and will absorb and dissipated a static charge, so some sensitive facilities have minimum room humidity requirements. Shoes or shoe straps made of non-conductive material will generate less static and are required in some sensitive facilities.

Testing

STM7.1, Resistive Characterization of Materials - Floor Materials. This standard test method provides procedures for measuring the electrical resistance of floor materials used for the control of electrostatic charge and discharge. It also provides test methods for the qualification of floor materials prior to their installation or application, as well as test methods for acceptance and monitoring of floor materials after installation or application.

STM97.2 Floor Materials and Footwear- Voltage Measurement in Combination with a Person. This document provides test methods for the measurement of the voltage on personnel that use a footwear-flooring system where protection of electrostatic discharge (ESD) susceptible items is required.

ANSI/ESD S20.20 Protection of Electrical and Electronic Parts, Assemblies and Equipment. This standard provides administrative and technical requirements for establishing, implementing, and maintaining an ESD Control Program to protect electrical or electronic parts, assemblies, and equipment susceptible to ESD damage from Human Body Model (HBM) discharges greater than or equal to 100 volts.

Reference

1. ANSI/EDS STM 11.11-2005 Surface Resistance Measurements of Static Dissipative Planar Materials

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Condensation in Exterior Walls

Introduction

All air above 0% relative humidity contains water vapor. At any given temperature and pressure air can contain a maximum amount of vapor, which is its saturation point. If the temperature of saturated air is increased its ability to contain water is raised and additional vapor can be absorbed. If the temperature of saturated air is decreased its ability to contain water is lowered and the excess moisture condenses as liquid water. Condensation must be controlled to protect exterior wall assemblies from water damage.

Relative Humidity and Dew Point

Relative humidity is the ratio of the amount of water vapor in air to its saturation point at a given temperature. For air with a fixed amount of water vapor, the relative humidity increases as the temperature is lowered and decreases as the temperature rises. Air which is saturated has a relative humidity of 100%.

If the temperature of unsaturated air is lowered sufficiently its relative humidity will reach 100%, which is the air's dew point. The dew point is important because it is the temperature below which condensation will occur. If the dew point occurs within a wall the wall materials at that point will become wet, which can cause material damage, reduced R-value of insulation and mold.

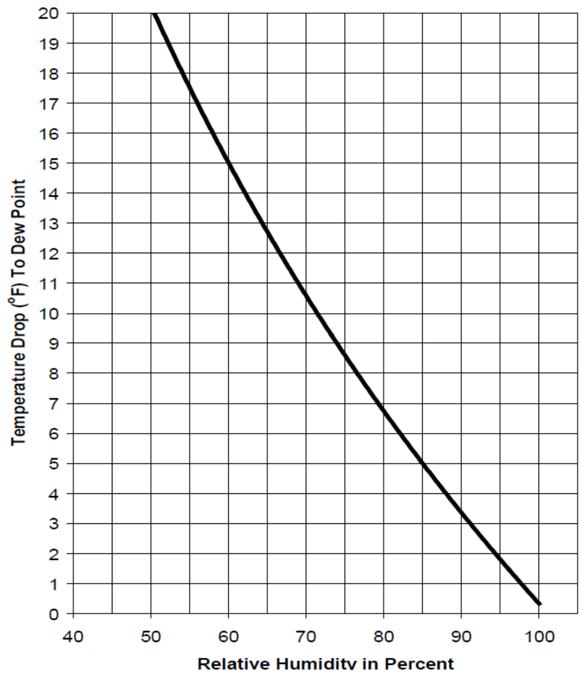
The drop in air temperature required to reach dew point and cause condensation is shown in Figure 1. For a relative humidity of 80%, a drop of 7 ^{o}F is required. For a relative humidity of 50% a drop of 20 ^{o}F is required.

Wall Construction and Detailing

Conventional exterior wall systems are not designed nor constructed to be air tight, and air and water vapor will migrate through a wall assembly in a number of ways. Vapor pressure drives vapor from areas of higher moisture content to areas of lower moisture content. Mechanical system pressurization drives air in or out of the building. Wind creates areas of high and low pressure

'Leakier' walls will permit the entrance of more air and vapor than 'tighter' walls, so exterior walls should be designed to be as airtight as possible. Some infiltration is inevitable, however, so wall assemblies should be designed with the means to control vapor's flow within the assembly and a means for vapor to exit.

One way of controlling the transmission of moisture vapor is the installation of vapor barriers or retarders. Water vapor diffuses through the wall assembly in proportion to each element's vapor permeance. A vapor barrier has no permeance and is intended to stop vapor transmission. A vapor retarder has a low permeance and is intended to slow or interrupt vapor transmission. Care must be taken to locate barriers and retarders where vapor will not be trapped at temperatures below the dew point in either heating or cooling seasons, and the vapor must have a way to dissipate. The selection of barrier vs. retarder, and the location within the wall system relative to insulation and other elements is dependent on climate and wall system design, and is determined by dew point analysis. Barriers and retarders must be installed continuously, tightly sealed and undamaged to be effective.



Cold spots or thermal bridges within walls can create areas where air temperature is lowered to the dew point and condensation occurs. An example is steel studs in a wall without continuous exterior insulation. Although the wall may have adequate insulation, the cold studs will cause areas of localized condensation.

The possibility of condensation can be reduced by:

- Reducing excess humidity in the building, which may be caused by inadequate ventilation or system malfunctions.
- Design the wall system so that the dew point is within rigid insulation or another appropriate material where condensation will not occur.
- Use vapor barriers and retarders to control the transmission of vapor in locations where analysis indicates a probability of condensation.
- Increasing the temperature of the surface on which the condensation occurs by increasing the R-value of the wall or reducing thermal bridging.

Reference

1. Condensation – Prevention and Control, Technical Notes on Brick Construction, June, 2006,

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Concrete Masonry Unit (CMU) Wall Design & Detailing

Introduction

Concrete Masonry Units (CMU) are modular units made from various mixtures of Portland cement and aggregates. The units can come in a variety of sizes, however; the most common have a face dimension of 8 inches high by 16 inches wide. These are the nominal dimensions as the actual dimension will be 3/8" shorter to allow for mortar joints.

CMU can be used to construct a wide variety of wall types and accommodate many functions. Their inherent mass and stability lend themselves to walls which perform well for sound dampening, fire partitions, areas requiring a strong substrate with little deflection, areas where abuse resistance is a concern, and areas requiring a high thermal mass.

Use at NIH Facilities

CMU walls are frequently used within NIH Facilities where a high level of abuse resistance is needed or areas subjected to frequent wet conditions. These situations often occur within animal facilities, such as at cage wash areas and large animal holding rooms. Additionally, similar needs for abuse resistance can often be found at loading docks, switchgear rooms, or other utility areas.

In order to obtain an appropriately smooth finish for CMU, NIH requires that CMU used in Animal Research Facilities utilize fine sand aggregate or ground face block. This requirement provides for a substrate which can then meet the needs of a high-performance finish system. One other major concern with detailing CMU construction in Animal Facilities is the need to prevent pest infiltration and harborage. In addition to sealing all penetrations and voids, all CMU walls require a solid top soap course, fully grouted bond beam, or otherwise completely sealed to structure without voids or gaps.

Detailing

In order to perform properly, a CMU wall needs to be installed on a solid, rigid base. Deflections of the support system need to be minimized in order to prevent cracking of the masonry. In retrofit areas where a new CMU wall is to be installed, the supporting structure should be inspected and the design strength confirmed that it will support the new CMU dead load. Details must be drawn up to appropriately connect the floor and CMU. If the wall is placed on a concrete slab, the CMU is often connected through cast or drilled dowels which are then grouted in place to form a single structural unit. The top of a CMU wall often has to be additionally braced (See Figure 1). The anchorage at the top of a CMU wall is often done through the use of steel angles. Consideration should also be provided for deflection of the slab or structure above. At some point all masonry walls will also need to be supported laterally. The maximum height to slenderness of the wall can be determined by rules of thumb which state a single wythe solid masonry wall should not exceed a height to thickness ratio of 20 and a hollow masonry wall should not exceed a ratio of 18. It should be noted that even if not reinforced vertically, all CMU walls must be reinforced horizontally.

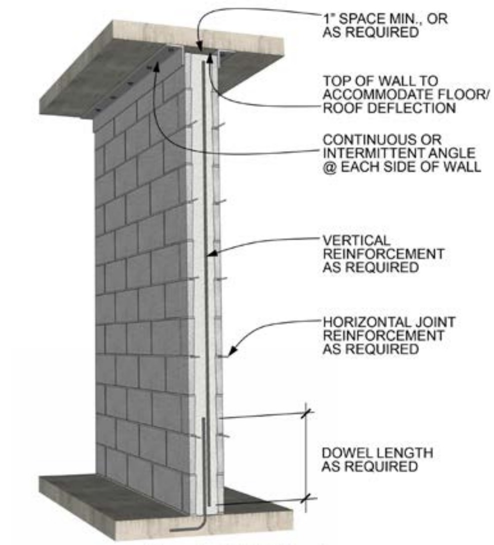

Figure 1: CMU Wall Section

Another important design consideration which is often overlooked is the layout and detailing of coursings. When improperly designed a CMU wall will have numerous non-modular pieces and require labor intensive cuts and prove difficult when placing grout. Locations of openings also need close attention and coordination. A standard 7'-0" door within a CMU wall will require an 86" opening. Eleven courses of CMU is 88" in height resulting in a 2" discrepancy between the opening and coursings. One method to resolve this issue is to specify a frame with a 4" head which is intended to be used for this condition and will fill the 2" discrepancy.

One final consideration when placing CMU is the use and location of control joints. CMU typically shrinks after it leaves manufacturing. This change must be accommodated in order to prevent cracking, spalling, and displacement of masonry. Joints are typically needed:

- Adjacent to openings
- At changes in wall height or thickness
- Between main and intersecting walls
- At maximum one half control joint spacing from corner

CMU is a versatile structural material but requires careful consideration and design to prove effective.

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1. *International Masonry Institute*. http://imiweb.org/
2. *Weber, Richard A. "Masonry Wall Systems."* Whole Building Design Guide. https://www.wbdg.org/guides-specifications/building-envelope-design-guide/wall-systems/masonry-wall-systems
3. *National Concrete Masonry Association. http://ncma-br.org/member.asp*

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Steam Traps

Introduction

The power of steam was first demonstrated in the 1st century AD in Alexandria on a device called Aeolipile, also known as a Hero's engine. The first practical use of steam power dates from 1698 and the invention of the steam driven pump. Beginning in the industrial revolution in the 18th century, steam became commonly used in driving equipment such as locomotives and pumps. In the 20th century the use of steam as motive source began declining, changing its primary use to a heating source.

When used as heating source, steam changes its state to condensate, which needs to be drained from the system for continued efficient operation. Initially steam condensate had to be remove manually by operating valves. Steam traps were subsequently developed to act as an automatic valve to remove condensate.

Types of Steam Traps

There are many types of steam traps, and selecting the appropriate type will depend on the specific application, such as steam power-driven equipment, steam-heated equipment, tracer lines and process equipment. The most common types of steam traps include:

- **Mechanical Traps:** These traps have a float that rises and drops inside the trap following the level of condensate. A linkage opens and closes the valve depending on the position of the float. These traps are categorized as inverted buckets and float traps. The float traps are also classified as free ball float and lever ball float. See Figure 1.

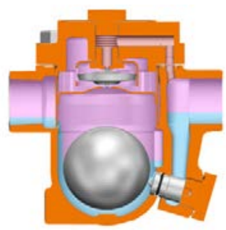

Figure 1 Free Float Trap

- **Temperature Traps:** These traps have a valve operated by means of thermal expansion or contraction. Considerations should be made when selecting this type of traps whether quick condensate removal is needed, as cool temperatures are required to open the valve. Temperature Control, Thermostatic and bimetallic are some examples of this trap type.
- **Impulse Type:** These traps operate on the principle that hot water under pressure will flash into steam when the pressure is reduced. A circular baffle keeps the entering steam and condensate from striking a cylinder or disk. Under normal condensate load, the valve opens and closes at frequent intervals. This discharges a small amount of condensate at each opening. With a heavy condensate load, the valve remains open and allows a heavy, continuous discharge of condensate. See Figure 2.

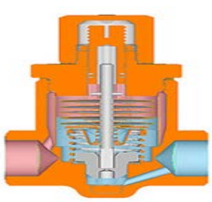

Figure 2 Impulse Trap

- **Thermodynamics Traps**: These traps respond to velocity change in the flow of compressible and incompressible fluids, which means that the valve will open even if there is only steam present, possibly causing quicker wear, even locked up trap condition.
  See Figure 3.
- Venturi Nozzle Traps: Without having failing mechanical components, steam and condensate pass through multiple stages, where the denser liquid (condensate) continuously throttles the venturi nozzle, which keeps the steam from escaping. The drawback is that it requires that the steam and the condensate are free of particles and corrosion deposits. See Figure 4.

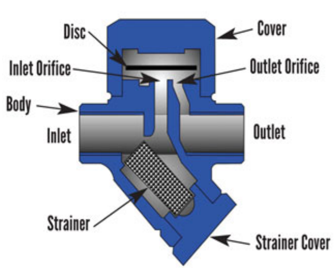

Figure 3 Thermodynamic Trap

Steam Trap Performance Assessment

Three primary methods are used to verify the performance characteristics of steam traps: visual, sound and temperature. The visual method requires the ability to distinguish flash steam and live steam through skilled observation practices. The sound method requires the ability to differentiate the correct or abnormal sound to assess the efficient function of the traps. The temperature method requires the installation of a continuous temperature measurement system capable to reading temperatures at the inlet and outlet ends of the trap and be able to generate a trending report over a specific period of time.

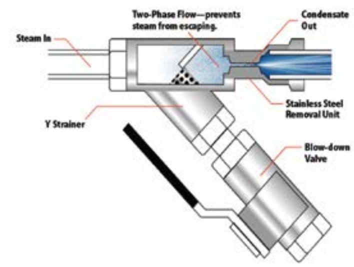

Figure 4 Venturi Nozzle Trap

Maintenance

A good steam trap preventive maintenance plan is required to prevent loss of BTU power throughout the steam distribution lines. The Industrial Controls Company (see reference below) indicates that an approximately annual failure rate of steam traps of 5% is possible. Having a good maintenance program can reduce trap failures. Some of the most notable trap malfunctions are:

- Water hammer in steam and condensate lines
- Condensate receiver is venting steam
- Condensate pump water seal failed prematurely
- Overheating or under heating in conditioned space
- The vacuum in the return lines becoming difficult to maintain
- Presence of steam in condensate return lines
- Almost equal trap inlet and outlet lines temperature
- At a plant level, boiler operating pressures are difficult to maintain, causing abnormally higher energy bills

Regularly assessing steam trap performance can provide a basis for preventative maintenance. There are several systems that can be used to accurately maintain the steam traps and to stay ahead of the potential failures including ultrasonic trap testers which can improve the steam trap monitoring plan which can detect a leaking trap. Visual testing can be assisted by thermal infrared camera imaging that can detect more accurately the differential temperature between the inlet and outlet ends of the traps. The most accurate device that has been developed is the integral thermocouple that consists of a sensor located inside a chamber in the strainer cavity and it is capable of determining, by conductivity, the physical state of the medium (steam or condensate) with undeniable results.

Reference for Further Reading

1. Trap Installation Orientation, TVL, A Steam Specialist Company
   https://www.tlv.com/global/TI/steam-theory/trap-installation-orientation.html
2. Steam Trap Testing, Proficient Technologies,
   http://proficienttechnologies.com/steam-trap-testing/
3. Testing and Maintenance of Steam Traps, Spirax/Sarco, Steam Engineering Tutorials
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Wood Preservation

Introduction

Wood is not a major construction material in most modern institutional buildings, but it is used as blocking, nailers, sleepers, cants and grounds in key assemblies. Wood is also used in site and temporary applications such as walkways, barriers and railings. Wood is utilized primarily for its low cost, ease of field fabrication and ability to hold bolts, screws and nails.

Wood used in interior finishes (floors, doors, wall panels, trim) is generally finished, in a controlled environment and subject to visual observation. When wood is used in construction assemblies it is unfinished and concealed and requires treatment to protect it from fungus, mold and wood destroying insects.

Wood in construction assemblies in contact with concrete and steel may be exposed to condensation or rising dampness (figure 1). Wood in enclosed spaces may be subject to high heat and humidity. Wood used in site and temporary applications may be exposed to the weather and in contact with the ground. All of these conditions can lead to attack by wood-decay fungus or insects which feed on the cellulose in wood and reduce its strength.

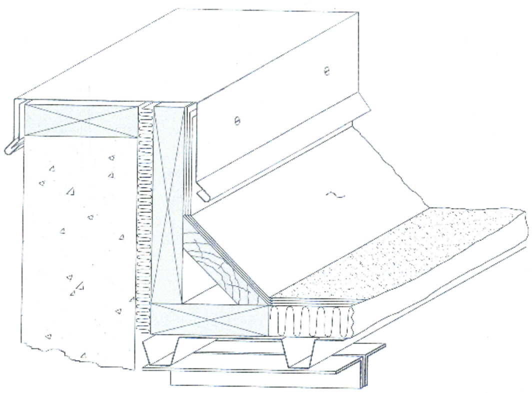

Figure 1: Wood members in a parapet detail

Options for increasing wood durability include using naturally rot resistant species (e.g. redwood and cedar) or thermally modified (torrefied) wood. The most commonly used preservation method for wood in construction assemblies is pressure-treating, where the wood is permeated with insecticides and fungicides.

Pressure-Treated Wood

The American Wood Protection Association (AWPA) is the industry organization which sets standards for pressure-treated wood. The AWPA provides Use Categories to define appropriate applications for specific products[1]. Categories typically used in institutional buildings include:

- Category UC1 for interior construction dry
- Category UC2 for interior construction damp, not in contact with the ground
- Category UC3B for exterior construction not in contact with the ground
- Category UC4A for construction in contact with the ground

For many years chromated coper arsenate (CCA) and ammoniacal copper zinc arsenate (ACZA) were industry-standard wood preservatives. Environmental and health concerns has lead to CCA and ACZA being replaced with safer alternatives, including preservatives using copper in lieu of arsenic.

The Environmental Protection Agency (EPA) registers several wood preservatives which have lower toxicity than CCA, ACZA and other older products. An overview can be found in the EPA's Overview of Wood Preservative Chemicals[2].

Considerations

When detailing with pressure-treated wood assemblies a number of items should be considered, including:

- Some wood preservatives contain metals, including copper, which cause galvanic corrosion when in contact with steel and aluminum. All steel in contact with preserved wood, including bolts and fasteners, should be stainless steel or galvanized. Steel decking, structural steel, aluminum flashing and other components should be separated from preserved wood by a flexible membrane separator.
- Wood preservatives may not be absorbed uniformly throughout a member, so cut ends should be treated with a preservative application.
- Some preservatives, including borates, can leach out of the wood so should not be exposed to flowing water or ground contact.
- Although field-applied preservatives are available and provide a level of protection, they cannot give untreated wood AWPA UC1 performance. Untreated wood which has been installed must be replaced.
- Preserved wood is protected from insects and rot, but will still absorb water and warp, check and split. Wood exposed to weather should be treated with a water repellant and detailed appropriately.
- Due to chemical content, protective equipment may be required when handling wood treated with preservatives. This is in addition to the precautions required when working with sawdust.

Reference:

[1]Americal Wood Protection Association Use Category System: User Specification for Treated Wood
http://www.awpa.com/standards/U1excerpt.pdf

[2]EPA, Overview of Wood Preservative Chemicals
https://www.epa.gov/ingredients-used-pesticide-products/overview-wood-preservative-chemicals#residential

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Corrosion Protection of Steel

Introduction

Carbon steel is widely used in all aspects of building construction due to its low cost, high strength and ease of fabrication. Corrosion is an inevitable phenomena that must be controlled to prolong the life of carbon steel components.

Corrosion

Corrosion is the natural process of the iron in steel combining with oxygen to form iron oxide. Corrosion occurs when steel is exposed to oxygen and water, which may be in the form of humid air. There are a number of factors that affect the rate of corrosion including the composition of the steel alloy and environmental conditions (e.g. temperature, humidity, salinity, pH, pollution).

Corrosion is accelerated when carbon steel is in contact with a more cathodic metal, such as copper or stainless steel. Corrosion is detrimental for a number of reasons including:

- Corrosion weakens an item by replacing high-strength steel with lower-strength iron oxide, thereby reducing the effective area and cross section.
- Iron oxide occupies greater volume than steel, so steel expands as it corrodes. Expansion can cause damage in many condition including connections, imbeds and when encased in concrete.
- Discoloration and staining is unsightly and damages finish materials. Discoloration and staining are invaluable however, as indicators of corrosion in concealed spaces and should be investigated.

Corrosion Protection

An integral part of using carbon steel in building construction is specifying protection to control corrosion. Common methods of protection include:

- Segregating the steel from air and water using coatings. Coatings can be effective but must adhere to and cover the entire assembly and become ineffective if damaged.
- Use of alternate corrosion-resistant materials, including weathering steel and stainless steel. These are effective but are cost prohibitive for many applications.
- Reducing cathodic corrosion by separating dissimilar metals or using Impressed Current Cathodic Protection (ICCP). ICCP uses DC electric current to forestall electrochemical corrosion.
- Galvanizing, which is the use of a zinc coating to serve as a sacrificial anode to protect the underlying steel. Galvanizing is durable, cost effective and is available for a wide range of steel shapes and components.

Galvanizing

During galvanization steel is immersed in a bath of molten zinc and processed to provide a uniform zinc coating. Zinc is a reactive material that will corrode over time, so the protection provided is proportional to the coating thickness. Figure 1 lists common commercially available galvanized coatings used for cold-formed steel framing members.

Coating Designation	Minimum Requirement Total Both Sides		Thickness Nominal per Side	
	(oz/ft²)	(g/m²)	(mils)	(microns)
Galvanized				
G40/Z120	0.40	120	0.34	8.5
G60/Z180	0.60	180	0.51	12.7
G90/Z275	0.90	275	0.77	19.4

Figure 1: Zinc Coatings Weights and Thickness[1]

If the zinc coating is damaged during fabrication or installation the area should be coated with zinc-rich paint or another accepted repair method.

Interior Applications

The risk of corrosion should be assessed and galvanized steel used accordingly. The expected corrosion rate in most building interiors is relatively low due to the controlled environment. Many laboratory areas, however, are subject to high humidity, exposure to water and chemicals, frequently washed-down and otherwise are at a higher corrosion risk so galvanized components should be specified. In very high risk areas alternate materials, like stainless steel, masonry or fiberglass, should be considered in lieu of galvanized steel.

Exterior Applications

Galvanized steel in exterior building components should be protected from water contact if possible. Vapor barriers and thermal breaks should protect wall members from moisture and condensation. Exposed elements should be painted or protected by a weatherproof enclosure. Elements which are not otherwise protected should have an appropriately heavy galvanized coating.

The following ASTM standards provide specifications for the performance of galvanized steel:

ASTM-A653, *Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process*

ASTM-A924, *Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process*

ASTM-A153, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

ASTM A780, *Standard Practice for Repair of Damaged and Uncoated Areas of Hot-dip Galvanized Coatings*

References

[1]Durability of Cold-Formed Steel Framing Members, Cold-Formed Steel Engineering Institute

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Magnetically Coupled Drive

Introduction

Most industrial motors have fixed number of poles, allowing them to operate at a constant speed at designed voltage and frequency. However, many industrial processes require different operating speeds. Examples of applications include fans, centrifugal blowers, centrifugal pumps, axial-flow pumps, turbine pumps, agitators, and axial compressors. In these applications, if the motor speed is reduced 20%, motor horsepower is reduced by a cubic relationship (.8 X .8 X .8), or 51%. Due to cubic relationship between speed reduction and energy consumption, Adjustable Speed Drive (ASD) can significantly increase energy savings. This article will discuss magnetically coupled ASD.

Overview of Magnetically Coupled ASD

Magnetically coupled adjustable speed drives place a magnetic disc on the load shaft and conductor assembly on the motor shaft. By varying magnetic strength across an air gap between the motor shaft and the driven side of the coupling, variable torque is transmitted to the load, thereby reducing speed and energy consumption. There are two types of magnetic coupling used between the motor and load: fixed or electromagnets. Both types of coupling uses induced eddy current to transfer torque from motor shaft to load. Figure 1 below shows the schematic of permanent magnet coupling.

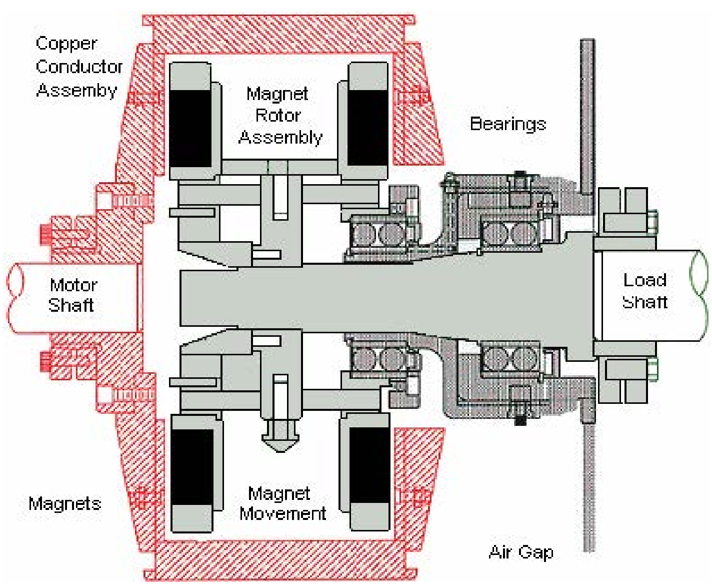

Figure 1: Magnetically coupled Drive Schematic (Schematic of Magna Drive™)

Advantages and Disadvantages

Reduced vibration, noise and misalignment: Presence of air gap between motor and load shafts reduces transmission of vibration. In addition, this also reduces noise, tolerates misalignment, provides overload protection, extends motor and equipment life and reduces overall maintenance costs.

Soft start/stop – the presence of coupling between motor and load, allows motor to slip, reducing starting current.

Power quality – Magnetically coupled ASDs introduce insignificant amounts of harmonic distortion to the power grid. In addition, they continue to function during other electrical disturbances such as voltage sag and swells.

Disadvantages of magnetically coupled ASDs include space constraint, weight constraint and efficiency. Magnetically coupled ASDs require space for coupling magnets with added weight, disallowing applications where space and weight can't be accommodated. Magnetically coupled ASDs may not be suitable for vertical shaft motors or belt-driven loads.

Magnetically coupled ASDs are only applicable in applications where maximum speed control is less than 30%. Furthermore, they only capture 60% of the energy savings obtainable by Variable Frequency Drives (VFDs). This saving further decreases as the speed decreases.

Conclusion

Magnetically coupled ASDs are applicable to niche applications where speed control range is limited (less than 30%). They are generally suitable for many rugged environments as they don't require controlled environment (typically required for VFD's), tolerate poor power quality and are immune to harmonic noise.

References:

[1] Northwest Energy Efficiency Alliance, Technology Demonstration of Magnetically-Coupled Adjustable Speed Drive Systems, https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-13879.pdf

[2] R.Saidur, S.Mekhilef, M.B.Ali, A.Safari, Applications of variable speed drive (VSD) in electrical motors energy savings, Energy Engineering, Renewable and Sustainable Energy Reviews, Volume 16, Issue 1, January 2012, Pages 543-550.

[3] Schachter N. Energy efficient speed control using modern variable frequency drives. Available online at: http://www.cimentec.com

[4] David E. Rice, Adjustable Speed Drive and Power Rectifier Harmonics-Their Effect on Power Systems Components, IEEE Transactions on Industry Applications , Volume: IA-22, Issue: 1, Jan. 1986.