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Efflorescence in Masonry Walls

Overview

Efflorescence is a white or light colored substance on the surface of concrete, brick, cast stone and other types of masonry walls. Efflorescence crystals are soluble alkaline salt deposits that have been brought to the surface of the wall by the migration water within the wall. All masonry will have some degree of efflorescence after construction, which is not harmful and may disappear over time or which can be removed by post-construction washing. Persistent, repeated or excessive efflorescence may indicate excessive internal moisture, rising damp or other problems which should be investigated and addressed to avoid more serious damage.

New Construction

The best way to minimize efflorescence is to ensure proper detailing and construction to minimize moisture content and control the migration of water. A number of approaches should be followed for new construction:

Wall Detailing. Walls should be detailed to minimize exposure and absorption of water. Walls should be properly flashed, following details published by the International Masonry Institute, Brick Industry Association and Sheet Metal and Air Conditioning Contractor's National Association (SMACNA). Mortar joints should be tooled and compacted. Overhangs, eaves, copings, rakes and other details should direct water away from wall surfaces.

Cavity Walls. Cavity walls should be detailed to minimize water infiltration and to provide adequate drainage for the cavity. This requires a properly detailed cavity of sufficient width, with moisture barriers, through-wall flashing and weep holes at shelf angles and all other horizontal barriers. Properly detailed flashing at doors and windows, scuppers and all other wall terminations and penetrations are required.

Landscape Walls. Masonry should be waterproofed to control rising damp, which is moisture absorbed from surrounding earth. Retaining wall backfill should be granular and adequately drained to ensure that the material is not saturated and hydrostatic pressure minimized. The ground around walls should be well drained, slope away from the wall, and not be densely vegetated.

Material Selection. Soluble salts are a component of Portland cement and can be in brick and other wall components. Selecting low alkali Portland cement, clean sand and salt-free water will reduce efflorescence. Admixtures can also be added to mortar and concrete to control efflorescence.

Material Storage. Material should be stored so that excess moisture and contaminants are not absorbed and introduced into the wall system. Masonry units should be stored under cover and elevated off of the ground.

Existing Construction

Excessive efflorescence should be removed from existing walls. Walls should be gently washed with water or a mild detergent or acidic solution that will dissolve the efflorescence salts without damaging the wall. Sandblasting, wire brushes are abrasive methods are not recommended, especially on brick and soft stone. Washing can draw out additional salts, so repeated washing may be necessary. All work on historic buildings should follow National Park Service recommendations.

To prevent the reoccurrence of efflorescence existing walls should be examined for defective mortar joints, flashing and other potential entry points for water. The building should also be examined for internal sources of excess moisture. DTR's Technical Bulletins *Unwanted Moisture in Buildings, Parts 1 and 2* examine some of the causes of excess moisture and some of the techniques for moisture investigation. If excessive moisture is found, a course of action should be undertaken to correct the problem, which may be invasive and costly or may be as simple as regrading or the maintenance of drains, gutters and other water conveyance systems.

ASTM Standards

The following standards address a number of aspects of material selection and specification:

ASTM C 67, *Standard Test Methods of Sampling and Testing Brick and Structural Clay Tile*, includes a test for determining whether masonry units are likely to cause efflorescence. Units are partially immersed in water, dried and examined for sighs of efflorescence. ASTM C 67 is of limited use, because it does not test mortar and other wall components that may contribute to efflorescence.
ASTM C 150, *Standard Specification for Portland Cement*, includes provisions for specifying low-alkali Portland cement which will reduce efflorescence in mortars and concrete.
ASTM C 1400, *Standard Guide for Reduction of Efflorescence Potential in New Masonry Walls*, provides information for reducing the potential of efflorescence in new masonry walls.

Further Reading

Brick Industry Association, Technical Note 23A, Efflorescence Causes and Prevention.
Brick Industry Association, Technical Note 20, Cleaning Brickwork.
National Park Service, Preservation Brief 1, Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings.
National Park Service, Preservation Brief 7, Dangers of Abrasive Cleaning to Historic Buildings.

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Operable Windows Considerations

Overview

The design of buildings with operable windows as a measure of sustainability is a growing trend for commercial and institutional facilities, especially in Europe. In the United States, however, operable windows are rare in new non-residential buildings. The June 2015 NIH News to Use series article, *Operable Windows*, addressed the functional incompatibilities of operable windows in laboratories and animal research facilities. This article will review the various issues and considerations regarding the application of operable windows in office and other types of non-laboratory facilities, as well as rules, regulations and liabilities.

Application

Operable windows have many potential benefits, including saving energy by providing natural ventilation, thereby reducing the load on the mechanical systems. Operable windows can also reduce or eliminate Sick Building Syndrome, caused by the build-up of volatile organic compounds (VOCs) and other indoor contaminants in inadequately ventilated, tightly sealed building. Operable windows also provide psychological benefits, including a sense of personal control and a physical connection with the exterior.

Figure 1
BAS Controlled Window

Despite these positive attributes, an assessment must be done to determine whether operable windows are appropriate for a particular project. The design team must consider various parameters such as geographical location of the facility, architectural aesthetics, owner/user's priorities, first and life cycle costs, energy savings/payback, risks, and liabilities.

Considerations

- The climate conditions of the location of the building or facility should be considered when determining the benefits of natural ventilation. The number of days with appropriate environmental conditions must be assessed. To ensure that windows are only opened during appropriate conditions the windows should be motorized and operated and monitored by a sophisticated building automation system (BAS). If a BAS system is not utilized, windows may be left open at inappropriate times, burdening the HVAC system and wasting energy. The BAS can also ensure that the minimum ventilation rates, as defined by the International Energy Code and ASHRAE, are met.

Figure 2
BAS Controlled Display

- A number of Indoor Air Quality (IAQ) issues such as outdoor noise, dust, airborne pollutants and moisture must be considered. It may also result on unexpected allergies or illnesses averting worker distraction and possibly deficiency on productivity. In a building with inoperable windows all outside air enters through the HVAC system and is monitored by the BAS, which controls the IAQ. Unless controlled by the BAS, operable windows will allow outside air to enter freely, thus losing control of IAQ. This may result in an interior which is unpleasant and unhealthy, possibly requiring pest control program tailored to the functions of the operable windows.

- Operable windows can be a security issue, presenting undesired accessibility, both from interior and exterior of the building. Considerations should be made for operable windows to be installed at higher floors.

- In new construction, the cost of operable windows is normally significantly higher than fixed windows, especially when motorized and controlled and monitored by the BAS. See Figure 1. The BAS control system is normally installed to achieve optimal HVAC system performance and IAQ. See BAS display sample in Figure 2.

Figure 3
BAS Window Status

- The cost of operable windows should be looked as part of an integrated system along with the HVAC equipment being installed. A clear and knowledgeable understanding of such integration as well as the required maintenance are very important for reliable functionality and should be implemented prior to the final design of the facility.

Conclusion

Depending on location and climactic conditions, operable windows can offer the flexibility of providing natural fresh air while saving energy. For this to be successful, however, the operable windows must be designed as an integral part of the HVAC system, controlled and monitored by the BAS. In this way the benefits of operable windows (natural ventilation, reduced HVAC load) can be realized while maintaining IAQ and HVAC system efficiency.

Life cycle cost analysis should be performed to weigh the cost of motorized windows, BAS control, monitoring and maintenance against the energy savings from reduced HVAC load. Items that are harder to quantify, like psychological benefits of a sense of personal control and a physical connection with the exterior, should be considered as well.

Further Reading

1. NIH Design Requirements Manual, 2016
https://www.orf.od.nih.gov/PoliciesAndGuidelines/BiomedicalandAnimalResearchFacilitiesDesignPoliciesandGuidelines/Documents/2016DesignRequirementsManual/NIH-DRM-Rev.%200.2%20-%20090517%20-%20Secured_508.pdf
2. A Breath of Fresh Air, Buildings, September, 2005
https://www.buildings.com/article-details/articleid/2749/title/a-breath-of-fresh-air
3. Efficient Windows Collaborative (EWC).
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Application of Energy Storage System

Introduction

In the race to reduce carbon emission, there is increasing penetration of distributed generations such as wind, solar and fuel cells in the electrical grid. The stochastic nature of the distributed generator (DG) impacts their power output, causing imbalance in supply and demand across the power system. Both supply and demand imbalance will continuously grow in coming decades, altering the natural inertia of the electrical network. This in turn will cause the grid's frequency to become less stable and deviate from its target more rapidly than in the present day. Energy Storage System (ESS) can buffer the differences between the demand and supply. Additionally, it can improve network operation by acting as uninterruptible power source to provide ride through capabilities.

Benefits of Energy Storage System

Advancements in energy storage technologies offers a wide range of technology to choose from for different applications. However, improper size and placement of ESS leads to undesired power system cost as well as the risk of voltage stability, especially in the case of high renewable energy penetration. Planning the best locations and sizes of an ESS in a power system can achieve significant benefits as follows: 1) enhance power system reliability and power quality; 2) reduce the power system cost and control high-cost energy imbalance charges; 3) minimize the potential for power loss and improve the voltage profiles; 4) serve the demand for peak load and correct the power factor. The ultimate goal is to maximize the benefits for both the DG owner and the utility by sizing the ESS to accommodate all amounts of excess generation capacity and by allocating it within the system in order to minimize the annual cost of the electricity. In addition, a cost/benefit analysis must verify the feasibility of installing an ESS from the perspective of both the utility and the DG owner.

ESS Application

There are many well developed procedures to allow proper sizing of ESS to mitigate the problems associated with the uncertainty of renewable DG units. However, successful integration of ESS with distributed generation in grid-connected applications involves much more than selecting an adequately sized system based on one of the many commercially available technologies. The optimal integration of ESS requires a thorough understanding of the following:

1) application for which the storage is being used and benefit provided to the application
2) available ESS technologies and their suitability for the application
3) requirements and constraints of integrating an ESS

Finally, an effective control strategy for ESSs is required to be developed to achieve attractive energy management.

ESS Control

ESS control strategy depends on the application and constraints of the system. As an example, ESS has potential to perform energy management and network support in standalone or grid-connected electricity distribution system. Control scheme will ensure optimal use of ESS while providing voltage support services. ESS intended for demand side management will shift energy usage in time. This energy shifting strategy can be viewed as equivalent to energy storage: the energy usage by a controllable load is managed with an aim to minimize the impact on the network (e.g., supply unbalance, frequency regulation, or network support) while maintaining the required function of the load for the benefit of the consumer.

ESS can also be deployed at grid level for frequency control. Excess power generation allows the speed of rotating machines (e.g., steam turbines on coal and gas power plants) to increase, which in turn increases the grid frequency. Similarly, lack of supply leads to a decrease in frequency. ESS intended for frequency regulation at grid level needs to coordinate operation of ESS to assist with maintaining the frequency within the nominal range.

Conclusion

As supply and demand imbalance grows, the need for applications of ESS will continuously grow. ESS must be properly sized to act as buffer between the demand and supply imbalance. Additionally, ESS technology and control must be suited for the applications.

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2. Gao, Z.; Chin, C.S.; Woo, W.L.; Jia, J. Integrated equivalent circuit and thermal model for simulation of temperature-dependent $LiFePO_4$ battery in actual embedded application. *Energies* **2017**.
3. Bruen, T.; Hooper, J.M.; Marco, J.; Gama, M.; Chouchelamane, G.H. Analysis of a battery management system (BMS) control strategy for vibration aged nickel manganese cobalt oxide (NMC) lithium-ion 18650 battery cells. *Energies*.

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Unwanted Moisture in Buildings - Part 2

Overview

Last month's Technical Bulletin reviewed unwanted moisture in buildings and some of the problems it can cause. Due to the potential effects on occupant health and building damage, the presence of unwanted moisture should be investigated as soon as it is suspected or signs appear.

This article discusses means that are available to investigate the presence of unwanted moisture so that problems can be identified and corrective actions can be implemented. Two commonly available tools to identify unwanted moisture are thermal imaging cameras and moisture meters.

Thermal Imaging Cameras

Thermal imaging, or infrared thermography (IRT) detects radiation in the long-infrared range of the electromagnetic spectrum (8,000 - 13,000 nanometers)[1] that is beyond the range of human perception (400 – 780 nanometers)[2]. The infrared energy emitted by an object is directly related to its temperature, so an IRT image is a visual representation of temperature variation. Thermal radiation can detect temperature variation in inaccessible and concealed spaces like the interior of walls, inner layers of a roofing system, sealed chases and plenums.

Temperature variation is a good indicator of the presence of moisture because excess moisture affects the temperature of material in a number of ways:

Evaporation Moisture cools the surface of a material as it evaporates, so wet materials are cooler than dry materials.

Thermal Lag Water is dense, so a porous materials with excessive moisture will change temperature more slowly than dry materials.

Thermal Resistance Porous materials with excessive moisture have a lower R (thermal resistance) value than dry materials.

Conduction Water is conductive, hence materials with excessive moisture will transfer heat by direct contact faster than dry materials.

The distribution and characteristics of temperature in a material is not always intuitive, so thermal images can be difficult to interpret accurately. Examination of thermal images by an experienced professional can provide insight into the condition of inaccessible spaces without invasive testing. The goal of thermal imaging should be identification of areas with potential temperature anomalies which should be the focus of further investigations, including invasive testing.

Moisture Meters

Moisture meters measure the electrical conductivity of a material. Because water is more conductive than most porous construction materials (e.g. wood, gypsum board), electrical conductivity is a good indicator of moisture content.

The use of a moisture meter requires direct contact with the material to be tested. This may require demolition to access materials in concealed spaces.

Moisture meters should be used with an understanding of their limitations and capabilities. All construction materials normally contain moisture, so a positive reading does not necessarily indicate excessive moisture. The measurement of many meters display a percentage of moisture content, which is often calibrated for a particular material (often construction-grade lumber) which may not be accurate for other materials. However, meters can be very useful in measuring relative moisture content between sections of the same material. It is very important that records be kept of the location and time of readings for future reference because moisture content changes and readings may not be repeatable.

Pin-type meters have two sharp pins which penetrate the test material. The moisture content is determined by measuring the electrical resistance to an electrical current passing between the pins. Pin-type meters are very accurate but are somewhat destructive as they leave holes in the material tested. Pin-type meters only work with materials that are soft enough to be penetrated by the pins.

Pinless meters produce an electromagnetic field to measure the dielectric properties of the material. Pinless meters are not as accurate, but are non-destructive and can be used more quickly over a large area.

Conclusion

Thermal imaging cameras and moisture meters are two common tools that provide temperature variation and relative moisture content, both of which are good indications of unwanted moisture in building material. Their use should be considered as means for identifying areas for further investigations so that permanent corrective actions can be taken.

References

[1]Balaras, C.A., Argiriou, A.A. (2002) Infrared Thermography for Building Diagnostics, *Energy and Buildings*

[2]Practical Aspects of Locating and Measuring Moisture in Buildings, *National Institute of Building Science*, https://c.ymcdn.com/sites/www.nibs.org/resource/resmgr/BEST/BEST1_002.pdf

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Unwanted Moisture in Buildings

Introduction

Unwanted moisture is a primary cause of deterioration of building components and systems. Over time, if not addressed, moisture can cause health issues and trigger building failures due to destruction of materials. It is in the best interest of building owners, operators and occupants to recognize moisture issues early and implement permanent corrective actions. There are many problems that are caused by unwanted moisture, both directly and indirectly, including:

- Electrochemical corrosion, including reinforcing bars, masonry anchors, HVAC equipment and other metal components.
- Discoloration and deterioration of finish materials, including gypsum board, ceiling tiles and wood products.
- Freeze-thaw cycle, which can cause cracks and failure in concrete and masonry.
- Health issues associated with the presence of mold, mildew and fungus.
- Slips and falls caused by wet or icy surfaces.
- Loss of thermal resistance value due to wet insulation.

Signs of Unwanted Moisture

Moisture will cause deterioration that will eventually be evident in surface finishes. Signs include:

- The presence of standing water or wet surfaces.
- Water stains, mold or mildew.
- Efflorescence (salt deposits), cracks or eroded mortar joints in masonry.
- Spalling or cracked concrete.
- Flaking, peeling or blistered finish surfaces.
- Musty or humid odors.
- Rust or corrosion.

When signs of moisture infiltration are observed the source should be investigated so that a comprehensive plan can be developed for mitigation and corrective actions. Destructive investigation or forensic testing may be required to determine the source.

Sources of Moisture

The primary sources of moisture in buildings include:

- Water from precipitation.
- Water from internal building systems.
- Water from the soil adjacent to the foundation walls.
- Water vapor from the exterior or from inside the building.

A properly designed and operating building will successfully manage moisture by draining it (water) or keeping it within acceptable limits (water vapor). If not managed moisture becomes unwanted. Unwanted moisture can come from both internal and external sources:

Internal Sources are from inside of the building, usually from system that are not operating properly.

- Leaks from plumbing systems that are damaged, corroded or with loose fittings or connections.
- Condensation from ducts, pipes or other improperly insulated items.
- Malfunctioning HVAC, humidification or dehumidification systems.
- Spills, overflows or other operational errors.
- Washing, rinsing or other maintenance activity using excessive water.

External Sources are from outside of the building through the envelope. Obvious locations are cracks, open joints, damaged doors and windows and other open breaches. Less obvious are conditions that are not visible but which compromise the envelope's integrity.

Walls, above and below grade:

- Below grade from saturated earth caused by a high watertable, improper runoff patterns, improperly functioning leaders, gutters or storm water conveyance systems.
- Improperly detailed, installed or maintained vapor or moisture barriers, drainage cavities, flashing or weeps.

Doors, Windows and Louvers:

- Inadequate flashing, sealant or weeps, inadequately sloped sills.
- Improperly designed louvers which are not adequately weather proof and self-draining.
- Operable units which do not close tightly, are not weather-stripped or which produce condensation.

Roofs and Plaza Decks:

- Damage, wear or puncture of the roof membrane.
- Loss of adherence of membrane to substrate.
- Failure of the seams in sheet waterproofing systems.
- Failure of roof penetration details.
- Failure of flashing and roof perimeter details.
- Lack of maintenance.

Conclusion

Unwanted moisture is a serious problem and can cause damage, deterioration and health issues. Building owners, operators and occupants should recognize unwanted moisture early, identify causes and implement permanent corrective actions.

Additional Reading

Straube, John F., *Moisture in Buildings*, ASHRAE Journal, January 2002,

Prowler, Don, *Mold and Moisture Dynamics*, Whole Building Design Guide, December 2016

Research Facility Programming

Introduction

A well-executed design, whether a research facility or other facility type, doesn't occur in a vacuum and requires informed, discerning programming. As stated in Problem Seeking[1] by William Peña, *programming* is, "the search for sufficient information to clarify, to understand, and to state the (architectural) problem". Following from this idea, *design* is the process used to solve the problem.

All too often the programming process is rushed or sometimes completely ignored and the client or owner simply hands their wish list / requirements to an A/E who is then instructed to begin design. This is bad practice for any building but can have even greater implications when dealing with research facilities. By following through with a comprehensive programming process, the owner will be confident their goals will be achieved and the A/E will be confident that design requirements have not been misinterpreted.

Data Analysis & Research

During the early stages of programming, an A/E should begin thoroughly reviewing all aspects of a proposed site or facility and gather background information. This may be through the form of site surveys, drawings from facility groups, or other sources to identify the constraints and limits on the future design. Additionally, the A/E should have expertise and experience in the type of facility being programmed, providing the researchers and owners an understanding of typical allowances for such things as equipment and research space. If an A/E is not well versed in the particular facility type, then the A/E should educate themselves on similar projects and in some cases may need input from subject matter experts.

Determining Needs & Wants

One of the most difficult aspects of establishing a project's program is separating the needs and wants of a researcher or other decision makers into tangible, and realistic goals. Fortunately, there are established methods for collecting and documenting this information. Specific and well-thought out questionnaires can aid in identifying project requirements and operational procedures. Questions must include lab workflow, processes, hazards, security, and all key lab operations. These questions are intended to spur conversation from researchers or other project team members and provide the A/E with valuable insight into the key activities that are fundamental to the success of the lab. If an A/E does not understand the processes and workflow which will be used in a lab then all stakeholders will be disappointed with the resulting design, project execution, and operation of the lab. For example, decontamination procedures must be understood for the A/E to provide appropriate finishes and infrastructure. Insightful questions during programming can alleviate significant operational and financial hardships through the life of the facility. Further, the A/E needs to use this dialogue as a means to add value to the design, e.g. provide suggestions which may improve the lab function versus accepting input without question. Some example Program Questionnaires can be found in the Design Requirements Manual (DRM) Exhibits 2.1 through 2.3.

Client interviews can also can be conducted in order to gather project information. Some of the tools used during this process can be items such as interaction matrices or bubble diagrams. Interaction matrices provide a means to document important adjacencies in a facility and additionally the criticality of the adjacency. Bubble diagrams are similar in that they provide a visual representation of the functional and operational relationships among the spaces; however, they also can go further in showing relative sizes of spaces to one another.

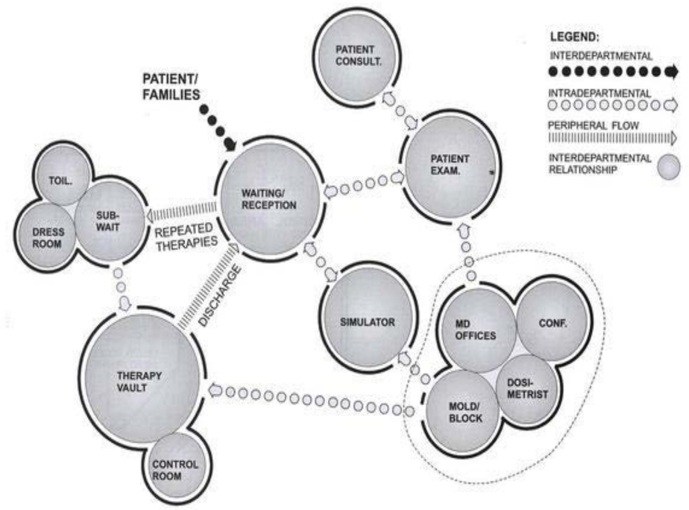

Figure 1: Typical Bubble Diagram[2]

Through these methods and others an A/E should gather enough information to determine what is feasible in terms of: space, quality, money, time, and operational efficiencies.

Conclusion

In order to proceed into design it is important that the A/E have a full grasp of the problem they are intending to solve. The programming process allows the A/E and owner or client to have a better understanding of the project's goals and limits. Programming is an intensive, fluid, and often difficult process; however, a well-programmed project will be more efficient and will allow all process to be conducted more easily, more productively, and more safely for the life of the facility.

References

[1]Peña, William, and Steven Parshall. *Problem Seeking: An Architectural Programming Primer.* John Wiley & Sons, Inc., 2001.

[2]Zim, Frank. "Cancer Center Design." *Health Architecture.* Wikifoundry. 19 May 2010. Web. 26 Jul. 2017

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Dissolved Gas Analysis of Power Transformer

Introduction

Insulating oil in an electrical power transformer, commonly known as transformer oil, serves mainly two purposes: as insulation and as a coolant (i.e. help dissipates heat). Furthermore, transformer oil prevents direct contact of atmospheric oxygen with cellulose made paper insulation of windings, which is susceptible to oxidation. The breakdown of electrical insulating materials inside a transformer generates gas that adversely affect dielectric properties of the transformer. Oil sample analysis as well as dissolved gas analysis is useful to prevent premature failure of transformer.

Properties of Transformer Oil

Generally there are two types of transformer oil used in transformers: paraffin based transformer oil and naphtha based transformer oil. Naphtha oil is more easily oxidized than paraffin oil, but oxidation product (i.e. sludge) in naphtha oil is more soluble than paraffin oil. Some of the important properties of transformer oil includes: dielectric strength, specific resistance, dielectric dissipation factor, water content, acidity, sludge content, inter facial tension, viscosity, flash point, and pour point.

Effects of dissolved gases

Degeneration of transformer oil generates various types of gases. The gases that are of interest for dissolved gas analysis (DGA) are the following: H_2 – hydrogen CH_4 – methane C_2H_4 – ethylene C_2H_6 – ethane C_2H_2 – acetylene C_3H_6 – propene C_3H_8 – propane CO – carbon monoxide CO_2 – carbon dioxide O_2 – oxygen N_2 – nitrogen. Some gas generation is expected from normal aging of the transformer insulation. Therefore, it is important to differentiate between normal and excessive gassing rates. The amount of dissolved gases and the relative distribution of these gases affect Dielectric strength of transformer oil is also known as breakdown voltage of transformer oil or BDV of transformer oil.

Dissolved Gas Analysis Procedure

The DGA procedure consists of sampling of oil from the transformer, extracting of gases from the oil and analysis of the extracted gas mixture in a gas chromatography (GC). After extraction the extracted gas mixture is fed into adsorption columns in a GC where the different gases are adsorbed and separated to various degrees and consequently reaches the detector after different periods of time. In this way the gas mixture is separated into individual chemical compounds, identified and their concentrations in volume gas STP/volume oil is calculated and expressed in pm. (STP=standard temperature and pressure).

Composition of key gases indicates particular problem (i.e. presence of H_2) indicate partial discharges (PD). Determination of ratios between gases, normally between gas levels. Figure below shows presence of different gases normal level as well as composition of gases at increasing temperatures.

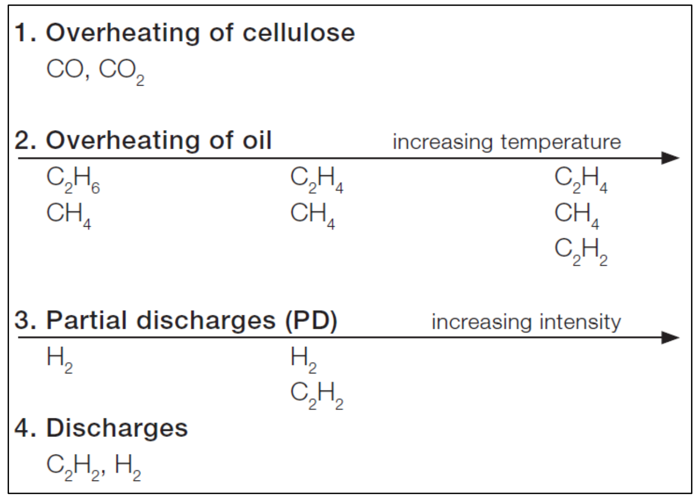

Figure 1. Characteristic key-gases, principal layout

Conclusion

DGA of transformers provides an insights into thermal and electrical stresses sustained by oil-immersed power transformers. In addition, DGA is a sensitive and reliable technique for detecting incipient fault conditions in oil-immersed transformers. DGA can help prevent further damage since test can detect incipient transformer faults. To protect the transformer from severe damage, DGA shall be performed

- When we suspect a fault (e.g. abnormal sounds).
- In case of signals from gas or pressure relay.
- Directly after, and within some weeks, after a short circuit.
- When a transformer essential to the network is taken into operation, followed by further tests after some months in operation.
- After an obvious overloading of the transformers.

References:

[1] Dissolved Gas Analysis: It Can Save Your Transformer IEEE Electrical Insulation Magazine, November/December 1989-Vol. 5, No. 6

[2] Transformer Fault Diagnosis by Dissolved-Gas Analysis
IEEE Transactions on Industry Applications, Vol. IA-16, No. 6, November/December 1980

[3] Dissolved Gas Analysis Technique for Incipient Fault Diagnosis in Power Transformers: A Bibliographic Survey
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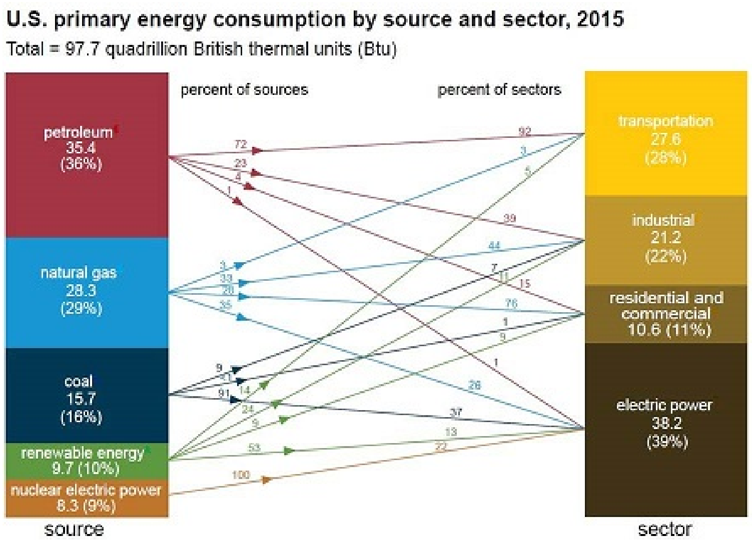
Renewable Energy Considerations (Part Three) – Dollars and Sense

Overview

Modern renewable energy technologies produce less pollution than burning fossil fuels, especially when considering net emissions of greenhouse gases. Renewable energy resources also represent secure and stable sources of energy and potential sources of economic development. Although the cost of electricity produced from renewable sources is approaching the cost of generating power from conventional sources, efforts are being made to offer even lower energy cost in the near future. Each renewable energy technology is economically feasible depending on the application. The energy consumption by source and sector in the US in 2015, shown in Figure 1 below, shows the percentage of the various energy sources, including renewables, applicable to each sector. For example, 53% of the renewable energy is used to generate electric power, while 24% is used for industrial purposes.

Figure 1 - U.S. Energy Consumption by Source and Sector, 2015[1]



Renewable Energy Sources – Highlights and Challenges

As demand for power increases, renewable energy sources are being considered for their environmental friendly and sustainable characteristics. Unlike non-renewable sources of energy such as coal, fossil fuels and natural gas, renewable sources of energy are unlimited and less affected by production fluctuation, triggering price variation with economic consequences.

Renewable energy offers reliability and abundant opportunities for future lower energy cost. According to the Department of Energy FY 2018 Congressional Budget Request, the Assisting Federal Facilities with Energy Conservation Technologies (AFFECT), subprogram of the Department of Energy (DOE), provided direct funding for renewable technology deployment in 2017.[2] In FY 2018, agencies will be expected to use technical assistance offered by Federal Energy Management Program (FEMP) in conjunction with their own funding and authorities to implement well-designed and meritorious energy management projects that increase energy efficiency, conserve water, and increase renewable energy generation at Federal facilities.

It is important to note that there are also some shortcomings and challenges with renewable energy sources, and large-scale renewable technologies should be carefully analyzed. Choosing the most appropriate location for wind, solar and hydroelectric power requires areas with suitable weather conditions for maximum energy production without being vulnerable to adverse weather that can restrict energy production. Some of the considerations for six renewable energy sources discussed in the Part 2 of this series are addressed below.[3]

Wind Power: Wind energy is increasingly competitive, becoming one of the most affordable forms of electricity today.[4] Wind power produces no water or air pollution, wind farms are economical to build and farmers can receive an income from electricity generation while the land can grow crops. Challenges include the significant visual impact wind farms create, and the need of constant wind and large areas of land.

Solar Power: Solar power, also known as photo-voltaic (PV) power does not produce water or air pollution and there is an unlimited supply of solar energy. PV can be used for power generation as well as a direct source for water heating. Challenges include dependability of sunlight, large energy storage requirements and back-up.

Geothermal Power: Geothermal power plants can count on an unlimited supply of energy and produce no air or water pollution. However, it is only available in certain areas of the world, causes pipe corrosion and has a high start-up cost.

Hydroelectric Power: Hydroelectricity is renewable, reliable and flexible. As no fuel is involved, hydroelectric power is safer than nuclear and fossil fuels. Challenges include the high cost of building dams and turbines, and dependability on weather (i.e. in times of drought, power generation may be negatively impacted by the need for safeguarding aquatic life).

Biomass Energy: Biomass such as crops, manure and garbage (waste) is abundant and renewable. After a breakdown process, municipal solid waste can produce methane used to produce heat. On the negative side, burning biomass can create pollution and may not be cost-effective.

Hydrogen Power: Hydrogen fuel is abundant, very efficient and sustainable. Although the National Aeronautics and Space Agency (NASA) has been using liquid hydrogen since the 1950's, hydrogen fuel cells are mostly used for generating electricity for both vehicles and emergency power generators. It produces power without moving parts and sound. Hydrogen power is challenged by issues such as high cost of production, safety and unavailability of adequate infrastructure for its delivery.

Energy Sources - Cost Comparison - 2016

Based on the Figure 2 currently solar power energy have higher cost than nuclear and fossil-based energy.[5] The cost per kW-hr shown in the table includes many factors such as capital investments (initial), operating cost, fuel, maintenance, as well as life cycle costs, not including federal or state incentives. Additionally, the cost shown in the table represents levelized energy cost (LEC), for comparison purposes. Federal facilities can get financial assistance to meet the Executive Order and the Energy Independence Act of 2007 for renewable energy also known as "Non-Disposable Technologies." Some of the programs include Federal Energy Efficiency Fund, Federal Finance Facilities Available for Energy Efficiency Upgrades and Clean Energy Deployment, through Energy Savings Performance Contracts (ESPCs).[6]

Figure 2 - U.S. Energy Cost 2016

Power Plant Type	Cost $/kW-hr
Coal	$0.095-0.15
Natural Gas	$0.07-0.14
Nuclear	$0.095
Wind	$0.07-0.20
Solar PV	$0.125
Solar Thermal	$0.24
Geothermal	$0.05
Biomass	$0.10
Hydroelectric	$0.08

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Laminated and Tempered Glass

Overview

Safety Glass is a generic term often used to describe glass that is stronger than standard glass, and which will not fracture into loose, sharp shards. For most new construction and renovation projects, tempered and laminated glass is used when these characteristics are required.

The use of glass is increasing in building interiors to introduce daylight deeper into a floor plate, provide views and visual connectivity, and to create sense of openness. If selected and detailed properly, tempered and laminated glass can achieve these goals without sacrificing safety, security, acoustical separation and other important design requirements.

Building codes, fire ratings and other requirements dictate the type of glass that must be used in many specific locations. In other locations, however, the designer or specifier must choose the type of glass based on performance characteristics.

Laminated Glass

Laminated glass is composed of a tear resistant plastic film (polyvinyl butyral or ethylene-vinyl acetate) laminated between two layers of glass under pressure and heat. Although the glass pieces are not stronger than standard glass, the composite multi-layer lamination results in a stronger unit. If broken laminated glass will shatter like standard glass, but the plastic film will hold the pieces of glass in the frame, reducing the chance of injury (figure 1).

Figure 1: shattered laminated glass

Laminated glass has better acoustical properties than standard or tempered glass due to the composite construction. Acoustical laminated units are available for increased performance. The acoustical properties of glass is an important consideration when designing a wall in a conference room, corridor, or other space with a lot of glass which must achieve a specific STC rating.

Additional advantages of laminated glass include:

- In thicker, multi-layer forms, laminated glass can be blast and bullet resistant.
- Laminated glass can be drilled, cut and otherwise modified in the shop or field, increasing fabrication flexibility.
- UV-absorbing additives in the plastic film can blocks up to 99% of UV transmission.
- Laminated glass does not have the optical distortion associated with heat treating.
- Laminated glass will remain in the frame when broken, unlike standard or tempered glass, providing a degree of security and separation.

A recognized standard for laminated glass is ASTM C1172[1]

Standard Specification for Laminated Architectural Flat Glass, which includes requirements for quality, type classification and test methods for specific performance characteristics.

Tempered Glass

Tempered glass is made by heating and cooling glass in a tempering furnace, which introduces internal stresses. These stresses increase the strength of the glass and cause it to crumble into granular, less hazardous pieces when broken (figure 2). Additional advantages of tempered glass include:

Figure 2: shattered tempered glass

- Tempered glass is more impact resistant than standard or laminated glass.
- Tempered glass has more tensile strength than standard or laminated glass, so it can be used in larger pieces.
- Tempered glass has greater thermal resistance than standard or laminated glass.
- Tempered glass is not a composite product, so layers are not visible at exposed edges.

A recognized standard for tempered glass is ASTM C1048[2], *Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass,* which includes requirements for quality, type classification and test methods for specific performance characteristics.

References

[1]ASTM C1172 *Standard Specification for Laminated Architectural Flat Glass*

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Renewable Energy Considerations (Part Two) – Common Renewable Energy Sources

Overview

Renewable energy options vary, and their selection should be made based on the specific technology, the geographic location and a number of other factors. Understanding the issues associated with each renewable energy source can determine the steps required for their adoption and implementation as they become a larger portion of our electric supply source.

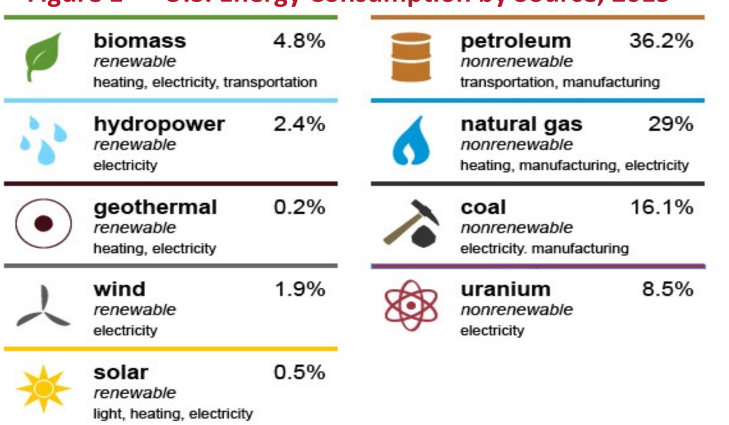
Each type of renewable energy has distinct benefits and costs. The benefits associated with each energy technology is listed below.

Six Commonly Used Renewable Energy Sources

The most commonly used types of renewable energy are wind, solar, geothermal, hydroelectric, biomass and hydrogen. They can provide substantial climate, health, and economic benefits.

Wind Power: Wind power is typically generated by large-scale wind farms which are located either on land or just off shore where they are connected to power grids that distribute their electricity to end users. Some small consumers of power also employ wind power technology where construction of transmission lines is expensive or prohibited[1]. Wind power currently provides 1.9 percent of the energy consumed in the United States (Figure 1). Though wind power has increased substantially since the year 2000, it constitutes only a small fraction of U.S. electricity supply. Wind power can be viable in areas where prevailing conditions are favorable, especially if there are mandated requirements for the production of renewable energy.

Figure 1 U.S. Energy Consumption by Source, 2015[2]



Sum of individual percentages may not equal 100 because net imports of coal coke and of electricity are not included.
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3, March 2016, preliminary data

Solar: The amount of utility-scale solar electricity capacity in the US has increased in recent years, and currently accounts for 0.6% of net electricity generated in the United States. Including rooftop solar panels and other non-utility residential, commercial and industrial solar installations, solar power's share of generation is currently 0.9 percent[3].

Geothermal Power: Geothermal power plants do not burn fuel to produce electricity, so their emission levels are very low. High temperature geothermal energy is extracted from in the Earth's crust and piped to steam turbines to drive generators to produce electricity, hot water or steam. A geothermal plant typically releases less than 1 percent of the carbon dioxide emissions of a fossil fuel plant and about 3 percent of acid rain emissions[4]. Moderate-to-low temperature geothermal resources are used for direct-use applications such as space heating or "district" heating, where a sole source of geothermal energy is used to heat multiple buildings or in some cases, a whole community. Lower-temperature, shallow-ground geothermal resources are used by geothermal heat pumps to heat and cool individual buildings.

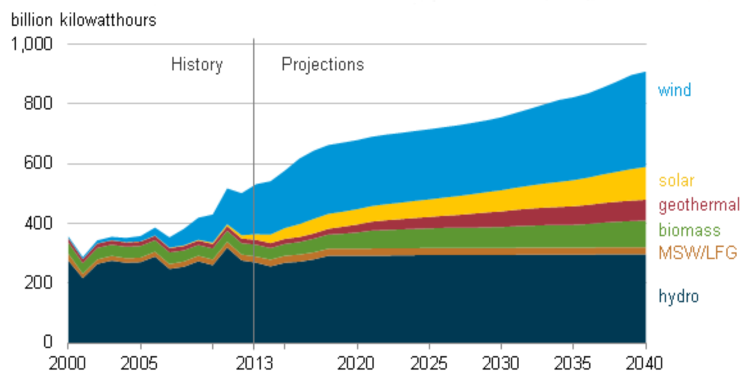
Hydroelectric Power: Most hydroelectric power comes from dammed water driving a water turbine coupled to a generator. The amount of energy extracted from the moving water depends on the volume of water and on the difference in height between the water's source and outflow. In 2015, hydropower represented 2.4 percent of the total energy consumed in the United States, lower than the level it reached in 2014[5] (Figure 2).

Biomass Energy: Biomass is organic material that comes from plants and animals, and it is a renewable source of energy responsible for 4.8% of the energy consumption in the U.S. Historically in the United States it has come from three primary sources: wood, waste, and alcohol fuels. Waste energy consists of municipal solid waste (MSW), manufacturing waste, and landfill gas. Biofuels are another source of biomass energy. Ethanol is the most popular of the alcohol fuels and, together with biodiesel, has received much attention because of growing use stemming from government mandates that require and subsidize its use[6].

Hydrogen Power: Hydrogen fuel, when produced by renewable sources of energy like wind or solar power, is a renewable fuel. Hydrogen is the simplest and most abundant element in the universe, but does not occur naturally as a gas on the Earth. Hydrogen is typically found in compounds like water[7] and in many hydrocarbons that make up fuels, such as gasoline, natural gas, methanol, and propane. Hydrogen can be transported to locations where it is needed, similar to electricity. Although hydrogen is considered a secondary renewable source, it potentially could also join electricity as an important energy carrier in the future.

In Figure 2 below, the US Energy Information Administration (EIA) outlook for renewable electricity generation shows projections on the potential development of renewable energy until the year 2040.

Figure 2
Renewable Electricity Generation by Fuel Type in Annual Energy Outlook (AEO) 2015[8]



Part three of this bulletin will present the pros and cons of the most common renewable energy sources, their impact in economics, reducing greenhouse gases and procurement for federal agencies.

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Renewable Energy Considerations (Part One)

Introduction

Earth's 2016 surface temperature was the warmest since modern recordkeeping began in 1880, according to independent analyses by NASA and the National Oceanic and Atmospheric Administration (NOAA)[1]. This rise of earth's temperature is attributed to the increase of greenhouse gases in earth's atmosphere. When sunlight strikes the Earth's surface, some of it is reflected back towards space as infrared radiation (heat). Greenhouse gases absorb this infrared radiation and trap the heat in the atmosphere, resulting in increased temperatures.

Renewable energy can play an important role in reducing greenhouse gas emissions. When renewable energy sources are used, the use of fossil fuels is reduced. Unlike fossil fuels, non-biomass renewable sources of energy (hydropower, geothermal, wind, and solar) do not directly emit greenhouse gases. Furthermore, wind and solar energy sources are inexhaustible and are constantly replenished, according to the National Renewable Energy Laboratory (NREL)[2].

Fast Facts about Greenhouse Gases

Many greenhouse gases such as carbon dioxide, methane, water vapor, and nitrous oxide, occur naturally in the atmosphere while others are synthetic (man-made), including chlorofluorocarbons (CFCs)[3], hydrofluorocarbons (HFCs) and Perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). Some of these man-made gases are used as refrigerants in the air conditioning and refrigeration industry. In October of 2000, the U.S. Department of Energy published composition of greenhouse gases both natural and man-made (Figure 1).

Figure 1

(all concentrations expressed in parts per billion)	Pre-industrial baseline	Natural additions	Man-made additions	Total (ppb) Concentration	Percent of Total
Carbon Dioxide (CO2)	288,000	68,520	11,880 (2)	368,400	99.438%
Methane (CH4)	848	577	320	1,745	0.471%
Nitrous Oxide (N2O)	285	12	15	312	0.084%
Misc. gases (CFC's, etc.)	25	0	2	27	0.007%
Total	289,158	69,109	12,217	370,484	100.00%

As shown above, CO2 is the leading greenhouse gas component.

Renewable Energy Technologies and Facts

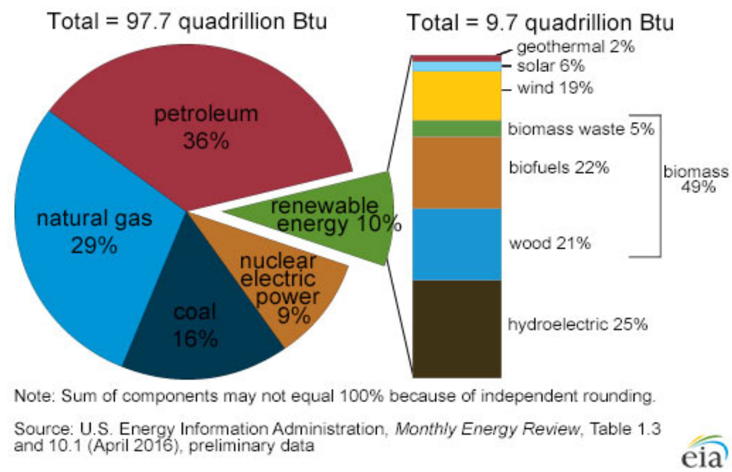
Renewable energy technologies have the potential to strengthen our nation's energy security, improve environmental quality, reduce greenhouse gases and contribute to a strong energy economy. There are six (6) commonly used renewable energy sources:

- **Biomass** is fuel that is developed from organic materials, a renewable and sustainable source of energy used to create electricity and other forms of power.
- **Geothermal** is a form of energy obtained from within the earth, originating in its core; also, energy produced by extracting the earth's internal heat.
- **Hydrogen** is a zero-emission fuel when burned with oxygen (if one considers water not as an emission) or used in a contained cell (allowing galvanic reaction) and capable of 'reversing' the reaction if needed.
- **Hydro Power** is energy derived from the movement of water.
- **Solar Power** is the conversion of energy from sunlight into electricity, either directly using photovoltaics (PV), or indirectly using concentrated solar power.
- **Wind Power** converts the kinetic energy of wind into mechanical or electrical energy through turbines.

According to the US Energy Information Administration (EIA)[4], these renewable energy technologies provided 11% of the total U.S. energy produced and 10% of the energy consumed in the U.S. in 2015 (Figure 2).

Figure 2

U.S. energy consumption by energy source, 2015



Renewable Energy Challenges

One of the most significant challenges is making renewable energy sources financially attractive and more widely adopted. For example, the amount of energy in a given amount of raw biomass tends to be significantly less than that contained in an equal amount of fossil energy, resulting in a higher cost of production. One promising process involves using chemical or thermal conversion to create biomass as energy-rich as fossil fuels, making it more economically competitive.

In addition, most renewable energy technologies are manufactured, and it is expected that increased use will result in economies of scale which will lower the cost of production.

Technological development of renewable sources will continue due to legislative efforts of both state and federal governments, including the Energy Independence and Security Act of 2007[5]. As energy demand use continues to grow in coming decades, renewable energy sources will play an increasingly important role in reducing greenhouse gas.

Part Two of this article will expand on each of the six (6) commonly used renewable energy sources and their benefits in reducing greenhouse gases.

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Carpet Fundamentals

Overview

Carpeting provides a number of benefits to a space, including acoustic absorption, underfoot comfort and a warm aesthetic. Although not appropriate in laboratory and most clinical settings, carpet can be used in administrative areas, conference rooms, and other support spaces where liquids, chemicals and biologics are not used and decontamination, aseptic conditions and low particle air quality are not required.

Carpet Types

Two types of carpeting are used in commercial and institutional facilities: broadloom and carpet tiles.

Broadloom, as its name implies, is woven on a broad loom. It is commonly available in rolls up to 15' wide, and is installed on a pad and secured at the room perimeter. Advantage of broadloom include relatively quick installation, few seams and the ability to cover minor imperfections in the underlying floor. A disadvantage is the difficulty of repairing or replacing sections of carpet.

Carpet tiles are individually installed tile modules, typically 18" to 36" square, which collectively create the carpeted floor. Carpet tiles have an integral resilient backing which adheres directly to the floor. An advantage of carpet tiles is the ability to replace sections that are damaged or worn. Disadvantages are higher first cost and the visibility of substrate imperfections.

Construction and Installation

Most carpeting is constructed with one or a blend of petroleum-based synthetic fibers: nylon, or one of a number of thermoplastic polymers (polyester, polypropylene and polytrimethylene terephthalate). Each fiber has distinct characteristics which determine the performance of the carpet. All synthetic fibers are stain-resistant and cleanable. In addition, treatments can be applied to increase stain resistance.

Nylon is used for both cut and loop pile carpets, and has very good performance characteristics, including strength, durability, resilience and stain resistance.

Thermoplastic polymers have good stain resistance and texture retention properties but are not as strong or resilient as nylon. Thermoplastic polymers generally costs less than nylon, and can be an economical option for low-traffic areas.

Broadloom carpet is typically installed on a pad which provides cushioning and increases durability. Pads can be natural fiber, rubber or polyurethane foam. Padding is available in a number of weights, and should be specified appropriately for the anticipated amount of traffic. An impermeable padding can be specified to function as a secondary moisture barrier, but should not be used as a primary barrier in damp locations.

Carpet tile fibers are manufactured directly to a resilient backing which adheres directly to the floor. The backing is typically natural or synthetic rubber, which provides cushioning and an adhesive surface for installation.

Other Considerations

Durability: Carpet tiles are generally not as durable as broadloom, and will wear at the seams in high-traffic areas. Worn areas of carpet tiles can be relatively easily removed and replaced as needed. Adequate 'attic stock' carpet tiles should be purchased and stored for replacement purposes.

Installation: Installation of both broadloom and carpet tiles requires proper floor preparation, material acclimation and skilled installers for a successful application. Broadloom is generally quicker to install since it is delivered in wide rolls and has fewer seams. Broadloom requires that all furniture be removed from a room while carpet tiles can be installed in sections by working around furniture.

Waste: The nature of broadloom installation results in more waste, and a carpet tile installation may have a longer life if worn areas are replaced.

Design: Both broadloom and carpet tiles are available in a wide range of colors and patterns. Continuous and linear patterns are less successful with carpet tiles, due to the visibility of seams, mis-matched dye lots and replacement tiles. These issues can be minimized with random or checkboard pattern designs.

Sustainability

All synthetic materials have sustainability concerns from their manufacturing. A number of manufacturers recycle carpet and non-carpet material (including plastic bottles) in their manufacturing processes. Low volatile organic compound (VOC) carpet, pads and adhesives are available. Recycled content and VOC varies by manufacturer so third party verification and certification should be specified to ensure sustainability goals are met. These include:

NSF/ANSI 140[1], Sustainability Assessment for Carpet, a widely recognized standard for sustainability evaluation and certification of carpet products.

Carpet and Rug Institute (CRI) Green Label[2], which tests carpet, cushions and adhesives to identify products with low VOCs.

Underwriters Laboratories' Standard 2809 Environmental Claim Validation[3] verifies the recycled content by identifying all materials in a product.

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