Lesson 9: Heating, Cooling, and Ventilation

Heating, cooling, and ventilation needs in agricultural structures vary according to the uses of the structure. All structures are affected to some degree by these factors. However, for some structures, they must be carefully regulated for the structure to serve its intended purpose.

The Purpose of Insulation

Agricultural structures that serve to shelter anything that is sensitive to temperature must allow the environment of the structure to be regulated. Animals can only survive and function within a certain range of temperatures. Many chemicals must be kept at certain temperatures to remain usable and safe. Machinery is also affected by temperature and may be damaged or cease to function if not provided with appropriate shelter. Insulation is one way that structures are equipped to regulate temperatures. The materials used for insulation are varied in form and application, but they all enhance a structure's ability to regulate temperature. Insulation should slow down or stop the movement of air between the inside and outside of a building. A properly insulated building can dramatically reduce the cost of heating and cooling because the temperature of the building does not fluctuate much once the desired temperature is achieved.

Insulation works by reducing and restricting heat transfer. It inhibits conduction and convection transfers. Conduction refers to the transmission of heat through solid matter because of contact between hot and cold areas, while convection transfers occur as heat moves through a liquid or gas. Insulation can also protect against heat transfer from radiant heat, which is given off by sources of heat, such as the sun. Radiant transfers are inhibited by the use of foil on the side of the insulation that faces an air space.

A particular insulation's ability to resist the transfer of heat through the material is usually Many different types of materials are used for insulation, which is available in a wide range of R-values and levels of fire resistance. Manufacturers create their own products by combining materials and treating them expressed mathematically as an R-value. The higher the R-value is, the greater amount of insulation provided. As a general rule, a structure with insulation that has a high R-value requires less energy to maintain a desired temperature than a building with insulation with a lower R-value.

Types and Methods of Insulation

The insulation industry is progressive in the application of technology, and many different types of insulation are available for most applications. The choice of a particular type of insulation depends on factors such as cost, the suitability of the material for the application, and the adaptability of the insulating material to the structure. Cost is most often related to the insulation's R-value and the ease or efficiency with which the material may be installed. Usually, the higher the R-value, the more expensive a given material is. When considering the suitability of insulation for a particular application, one aspect that should be assessed is whether the insulation may come into contact with water from condensation or leaks, which can reduce its effectiveness. Water is detrimental to some forms of insulating material, while other materials may be water resistant but have a greater cost per unit of R-value. The structure's physical characteristics must also be considered when selecting insulation. For example, structures with solid walls of concrete or metal do not have a convenient space in which to place insulation.

When evaluating insulation, fire resistance and toxicity are also concerns. While some insulation is chemically treated to make it fire retardant, materials that are not fire resistant or that give off toxic fumes when exposed to flame should only be used in applications where they are covered with a suitable protective material, such as masonry. Also, some insulating materials may be irritating or toxic if physical contact occurs or they are ingested; these materials may be a problem in a structure that houses livestock.

chemically; specific information about a particular type of insulation must be obtained from the manufacturer or retailers. Some commonly used natural or organic insulators include cotton, cellulose, shredded bark,

shavings, sawdust, and straw. These insulators are made of natural materials and are generally cheaper. Manufactured materials used for insulation include fiberglass, rockwool, expanded mica, fiber board, cellular glass, expanded polystyrene, expanded polyurethane, urea formaldehyde, and polyisocyanurate. These insulators have a higher R-value per inch of thickness.

The methods by which insulation is applied vary. For example, depending on the method used, insulation may be placed between framing members or applied to the outside of the structure in the form of sheathing. Common methods of insulation include blanket, batt, rigid, and fill insulation.

Blanket - Blanket insulation consists of wide rolls of material, often with foil covering on one or both sides and an insulating material like fiberglass in the middle. This method of insulation is often used for insulating metal buildings and covering large sections of walls. The insulation is usually stapled to the inside walls of the structure on wide, flat surfaces.

Batt - Batt insulation is provided in rolls of material in precut sections, usually 4 to 8 feet in length and 16 inches wide with a thickness of 4 to 6 inches. However, the exact size of this material varies with the intended application. Batt insulation fits between the studs in the walls or other framework in structures and is fastened in place with staples.

Rigid - Rigid insulation is available in the form of sheathing, usually 4' × 8', in varying thicknesses. It can be made of a number of materials but is most commonly Styrofoam. It is often covered with foil on one or both sides. Rigid insulation is usually nailed in place on the outside walls of a structure before siding is applied.

Fill - The material for fill insulation is in a loose form, possibly small beads or a form resembling snowflakes. This type of insulation is generally made of fiberglass or expanded mica. It may come in bags that are simply emptied where needed, as in the cores of masonry blocks. Fill insulation may also be mechanically blown in place through a large hose that feeds the material to the desired place. Sometimes this type of material is mixed with chemicals to make it adhere to a horizontal or overhead surface and then blown into place.

The Importance of Ventilation

Ventilation is the movement of air through an area, either naturally, because of convection air currents, or mechanically. Poor ventilation can be unhealthy and dangerous. For example, methane gas, which can asphyxiate animals and may be explosive, is a by-product of decaying organic matter and can build up to hazardous levels in areas with inadequate ventilation. Fumes given off by some substances can be toxic if they accumulate in an enclosed space. Poorly ventilated buildings promote the growth and transmittal of disease-causing microorganisms because of increased temperatures and moisture levels within the structure. The ventilation of a structure will affect air temperature, moisture level, number of microorganisms, and concentrations of odor and gases. Proper ventilation can control temperature and moisture levels, thus reducing the growth of microorganisms. It can also diminish odor problems and prevent the accumulation of dangerous gases.

Windows and doors alone are often able to provide suitable ventilation and should be planned carefully since they can be a simple and economical way to ventilate a structure. Fans and blowers are also commonly used in agricultural structures to assist with ventilation. Mechanical ventilation can involve the use of elaborate systems with duct work and electronic thermostat switches to activate a fan or may be as simple as a window fan or roof-mounted turbine vent.

Ventilation is often effective at lowering temperatures. However, at times structures can become too hot even with ventilation. Animals may be unable to function well if a building is too hot; problems such as not breeding, weight loss, and terminated pregnancies may result. In these cases, mechanical cooling is necessary, although it may be costly. Water evaporative systems are sometimes used. These systems vaporize water, thus increasing the humidity while circulating the air and cooling the structure. Another option is the use of refrigeration systems (air conditioners), an expensive but effective solution if designed and used properly. Before installing equipment to cool a structure,

the system should be considered carefully, and professional advice should be sought in most cases to avoid complications. For example, animals that depend on respiration to cool themselves can be adversely affected by temperature and humidity changes.

Supplemental heating is sometimes necessary in agricultural structures. Systems and designs vary, but as a rule, structures are heated using radiant, floor, or unit systems. Heat may also be produced by furnaces or boiler systems using air, water, or a combination of both as a transfer medium.

When radiant heating systems are used, radiant heat passes through the air until it comes into contact with an object, such as an animal, and passes on its energy as heat. It will not heat objects out of its path. Gas or electricity may be used to power these systems. An example is an infrared heater.

Floor systems are usually designed to heat specific areas, such as a nursery in a farrowing house. Hot water pipes or electric elements may be buried just below the surface of the floor. These systems may be powered by electricity, natural gas, or ground-source heat pumps, in which the ground heats the water.

Unit heaters are used to heat the air in a general area of a structure. These heaters often use fans to circulate the air after heating it. They may be powered by a variety of fuels, such as propane, natural gas, or electricity. Unit heaters are similar to the heaters found in large gymnasiums, shops, or stores, with a heating unit mounted overhead and a fan blowing the heated air from the heater.

Boilers and furnaces are large commercial appliances utilizing a system of pipes, ducts, or vents to transfer heat to where it is needed. Boilers heat hot water that is pumped to radiators, while furnaces heat air and blow it through ductwork to the rest of the building. They may be powered by fuels such as propane, natural gas, electricity, or wood.

One important term to understand when dealing with heating is BTU. BTU stands for British thermal unit; one BTU is equal to the amount of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit. This term is used when describing a system's heating ability.

Types of Heating Systems

Consulting with a heating professional is recommended when planning a large system. Safety concerns, such as the proper delivery of the fuel or power, ventilation for by-products like carbon monoxide, and potential fire hazards, makes the installation of heating systems a critical area of construction. The amount of heat needed as well as the cost of installation and operation are questions that must be answered accurately for the overall heating system to be suitable for the structure.

Feasibility of Solar Heating

The solar energy reaching the earth is estimated at 100,000 times the total of all the energy output from all existing power stations. However, this type of energy is not always easy to utilize effectively. Fortunately for all life on earth, this energy is quite diffuse by the time it reaches earth. Solar energy is also not consistent on a daily basis. These factors, as well as the cost of systems for collecting solar energy, have made solar heating a possibility but not often a first choice. At times when fossil fuel prices have risen sharply, as in the 1970s, a great deal of research into the applications of solar technology in the agricultural industry has taken place. However, as prices stabilized, research turned more toward efficient uses of fossil fuels since they provide very controlled and predictable energy amounts.

Passive solar heating is feasible if a building has a consistent solar exposure not obstructed by trees, other buildings, clouds, or other items that block the sun's rays. This type of heating makes greenhouses effective, as greenhouses utilize passive solar heat to maintain temperatures.

Passive solar energy can be used to help heat structures fairly simply. Orienting structures and windows to take advantage of solar energy is sometimes advantageous. Positioning a structure so that its south wall has windows and an unrestricted plane with no trees, buildings, or other obstacles will allow solar energy to enter the structure naturally. Covering the windows with an insulating material at sundown will help

the structure to retain the heat. Strategically placing large water containers, such as 55-gallon barrels, or building with stone or masonry where they can be warmed by the sun will also help heat the structure. They act as storage units that collect and hold the sun's heat, releasing it back into the structure over a period of time.

Insulation reduces heat transfer through a building. Many different types of insulating material are available, and each type should be evaluated by considering the structure's needs and the costs, hazards, and benefits of the insulation. Ventilation should also be carefully evaluated since it can affect the safety of a structure. Another factor that should be considered when constructing a building is whether a heating systems is needed, and if so, what type of system is appropriate. Systems for heating buildings (and cooling them, if necessary) can be customized to meet most needs. Structures can also be designed to make use of passive solar heating.

Credits

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Summary

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