

Appendix A

Background and Reference Notes

Background and Reference Notes

Unit 1

1.2.2 Identify the rights and responsibilities of the various stakeholders including the right to refuse. [5.402]

The right to refuse is defined in the act as:

Workers may refuse work that they believe is dangerous to their health or safety, or the health or safety of fellow workers;

- a) until action has been taken by the employer to the worker's satisfaction;
- b) until the OH&S committee or worker health and safety representative has investigated the matter and advised the worker to return-to-work; or
- c) until an officer has investigated the matter and has advised the worker to return to work.

Employers have clear responsibilities with respect to safety in the workplace. This is the second important aspect of the Occupational Health and Safety process. Employers specifically are responsible to:

- 1) provide and maintain a workplace and the necessary equipment, systems, and tools that are safe and without risk to the health of their workers; and
- 2) provide the information, instruction, training, supervision, and facilities that are necessary to ensure the health, safety and welfare of their workers.

The final aspect of the Occupational Health and Safety process is workers' responsibilities. Students should be aware that with rights comes responsibilities. Workers are responsible to:

- 1) protect their own health and safety and that of others workers at or near the workplace;
- 2) to cooperate with their employers and with other workers in the workplace to protect:
 - a. their own health and safety;
 - b. the health and safety of other workers engaged in the work of the employer; and
 - c. the health and safety of other workers or persons not engaged in the work place of the employer but present at or near the workplace;
- 3) use devices and equipment provided for their protection in accordance with the instructions for use and training provided, with respect to the devices and equipment.;

- 4) consult and cooperate with the OH&S committee (if there is one at the workplace) or the worker responsible for health and safety at the workplace; and
- 5) cooperate with the person at the workplace who is exercising a duty imposed by the Act or Regulations.

1.2.3 Explain the process for the reporting of risks, workplace issues and accidents. [5.402]

The following are excerpts from the Safe Work Newfoundland and Labrador website:

“An occupational health and safety committee is an advisory group made up of representatives from management and workers. The committee provides a forum for communication between the employer and the worker to address health and safety concerns in the workplace. In an effort to reduce workplace accidents and injuries, committees identify and evaluate concerns, make recommendations for corrective action and promote health and safety in the workplace. Committees are a legislated requirement of the Occupational Health and Safety Act and Regulations. In brief, the requirements for an occupational health and safety committee are as follows:

- A workplace having 10 or more workers is required to have a committee.
- A firm that has more than one workplace (i.e. retail company with stores across the province, school board with schools across a district etc.) must have a separate committee for each location if the number of workers at each location is 10 or more.
- The committee may consist of two to 12 members.
- At least half the members shall be elected by workers.
- The other half shall be appointed by the employer.
- The committee is to have two co-chairs one representing management and the other representing the workers.
- A list of committee members shall be posted in a conspicuous place at the workplace.
- Committee meetings shall be held every three months and during work hours as part of the job.
- Minutes of meetings are to be posted in the workplace and a copy is to be forwarded to the Commission.
- The committee shall participate in workplace inspections.
- Committee members are to be trained as per legislative requirements.”

“A worker health and safety representative is required in workplaces where less than 10 workers are employed. A firm that has more than one workplace (e.g., retail company with stores across the province, school board with schools across a district etc.), must have a separate worker health and safety representative for each location if the number of workers at each location is less than 10. The employer must ensure that a worker, not connected with management, is designated as the worker health and safety representative. The worker health and safety representative must be elected by other workers or appointed by the labour union if applicable. The name of this individual is to be posted in a prominent area in the workplace.

The main role of the worker health and safety representative is to monitor the health, safety and welfare of workers employed at the workplace. The worker health and safety representative is a liaison between the employer and the workers when it comes to addressing health and safety concerns at the workplace. Worker health and safety representatives identify and evaluate concerns, make recommendations for corrective actions and promote health and safety in the workplace. They also participate in workplace inspections. Worker health and safety representatives are to be trained as per legislative requirements.”

Unit 2

2.1.6 show the principles of operation of a 4 stroke cycle engine [2.404]

The intake stroke opens the intake valve, lets in the gas and air and starts the piston downwards. The compression stroke starts when the piston is at the bottom and beginning to move upward, the intake valve closes and the air fuel mixture becomes compressed. When the piston reaches the top a spark ignites the fuel air mixture, which force the piston down. This is the power stroke and the power is transferred down through the piston, the connecting rod and into the crank shaft which turns due to this power. Finally the exhaust stroke begins as the piston reaches the bottom of the cylinder and the exhaust port opens. As the piston moves up it forces the exhaust gases out through that port. Once the piston is at the top, the whole cycle starts again.

Unit 3

3.2.4 compare and contrast the three most common types of ignition used on small gas engines [2.404, 3.401]

A magneto ignition, similar to one on a chain saw or lawn mower, consists of a magnet that is moved past a coil of wire to produce an electric current. It is a little electric generator, that has been changed to produce periodic bursts of high voltage instead of continuous current. There is a bar of metal surrounded by a coil of wire, called an armature, which contains an inner coil and an outer coil with 100 times more turns of wire. When the magnet is rotated past the coil a small electric current is produced, which is magnified by the outer coil creating enough voltage for the spark. An electronic switch waits for the inner coil to reach its maximum charge before it allows the voltage to jump to the outer coil and thus create the spark.

The capacitive discharge ignition uses a high voltage power supply to charge a capacitor. It is this capacitor that discharges to charge the inner coil of the device described above. The charging of the inner coil is done from the capacitor in this case rather than from the rotation of the armature. The secondary coil once again is charged when the inner one reaches its maximum. The rest of the process remains the same.

The final type of ignition system used is the battery ignition. Battery ignitions are most common on larger vehicles, rather than small engine ones. They are found in some devices though so they will be included for completeness sake. The battery ignition works much like the capacitor system described below. Voltage from the battery is fed through the primary coil, which charges to its maximum, at which point an electronic switch engages and releases the voltage to the secondary coil which with its 100 times more wiring induces the voltage to about 20 000 volts. This then is the voltage used across the spark plug.

This is how the procedures are laid out.

- Test spark plug (Method 1)
 - Confirm plug gap and set as required
 - Hook up spark plug to a spark tester
 - Pull engine over and observe the spark produced
- Test spark plug (Method 2)
 - Put bolt in lead to see if sparks to engine

- Leave plug in lead but out of engine
- Confirm plug gap and set as required
- Check armature air gap
- Remove pull-cord assembly from the engine
- loosen the bolts on the armature assembly
- Slide the armature away from the flywheel
- Place the appropriate shim between the flywheel and the armature
- Rotate the flywheel so magnet is opposite armature and allow magnet to attract armature
- Torque armature bolts according to engine specification and remove shim
- Check for flywheel key damage
- Remove pull-cord assembly from the engine
- Attach flywheel puller to flywheel
- Remove the flywheel
- Remove the flywheel key located in slot on the end of the crankshaft.
- Examine the flywheel key for wear and/or damage
- Replace if necessary
- Reassemble ignition and engine parts
- Test engine for starting
- Check coil continuity

3.3.3 differentiate between the methods used to supply fuel in small gas engines [2.404, 3.401]

In fuel transfer there are three basic methods available to transfer the gas from the storage (tank) to the next system in the process (carburetor) . These three methods are

- Gravity feed - in this instance the gas tank is positioned above the carburetor, with a float inside to allow for exactly the right amount of gas to come out to feed the engine. Because the gas is positioned above the engine, gravity will pull it into the carburetor.
- Suction feed - in this and the next instance, the gas tank is positioned below the carburetor, and the natural suction power created by the pistons moving up and down in the cylinders moves the gas. When a piston moves down a low pressure area is created in the throat of the carburetor which then creates a difference in pressure between the tank and the carburetor. The throat is narrowed slightly to preserve the pressure difference. This difference in pressure creates a suction that moves gas from the tank into the engine (like when you suck on a pipet or hose to get water to move)
- Pressure feed - in this case the pressure is usually caused by a fuel pump, which draws gasoline from the tank and forces it into the carburetor chamber. This type of fuel feed is also known as force feed.

- 3.3.4 compare and contrast the three types of carburetors used in small gas engines [2.404, 3.401]
- The three types of carburetors we will be looking at are:
- Float Carburetor - this type has a small reservoir or float chamber of gasoline at near atmospheric pressure, ready for intake into the carburetor as needed. As the float chamber is drained of some of its gas a small float inside will let more in.
 - Vacuum Carburetor - in this instance there is no chamber but rather a vacuum operated piston attached to the fuel jet with a pin. When the vacuum is highest (i.e., when there is little or no air and fuel mixture present) the pin is pulled out permitting the fuel to flow and mix with the air.
 - Diaphragm Carburetor - this type of carburetor stills uses a chamber, but instead of a float it uses a diaphragm. The diaphragm in the chamber expands as the fuel is drawn out by equalizing pressure, and as it expands it opens a valve that lets more fuel into the chamber, this replenishing the supply.
- 3.3.5 discuss the differences between the two main types of governors used in small gas engines [2.404, 3.401]
- Two types of governors are:
Mechanical and Air Vane.
- A mechanical governor, sometimes called a counterbalance or flyweight, uses the force caused by the rotation within the engine (centrifugal) to measure the load. This measurement is compared to a set adjustment, usually set by a nut, and if it falls below a certain level, a spring opens the throttle and the engine's speed is increased.
- Air vane governors work in much the same way, but the comparison is not based on the force of the rotation but rather the air from the rotating flywheel.
- 3.3.6 describe how the three types of air cleaners used in small gas engines operate [1.405, 2.404, 3.401]
- Three common types of air cleaner
- Dry element air cleaner
 - Oil-foam air cleaner
 - Oil bath air cleaner
- The dry element air cleaner is attached directly to the intake and cleans the air by passing it through layers of cloth or felt that removes large dirt particles from the air. It is used in many engine applications and is the most common one used in automobiles.
- The oil-foam air cleaner, is essentially oil-wetted polyurethane foam, that depending on how much it is wetted will either allow good air flow or a better amount of filtering. These are common on small engines, although it is being supplanted by the dry element cleaner listed above.

The final type of cleaner is the oil bath cleaner. This cleaner uses a pool of oil and a labyrinth of coarse filter material to force air into a series of curvy paths. The air is forced to make turns that the dirt in it cannot follow due to gravity. This cleans the air effectively without passing through a special filter that may become clogged. This is not a common type used anymore. It was very popular until the 1960s and may still be found on some older engines still in use.

3.6.2 differentiate between the types of lubrication systems found on small gas engines [2.404, 3.401]

A splash lubrication system, as the name would suggest, splashes oil is up from the oil pan or oil trays in the lower part of the crankcase. Dippers on the connecting-rod bearing caps dip down into the oil pan with each crankshaft revolution to throw oil upward as drops to provide adequate lubrication to the engine mechanism.

The pressure or pump system does not rely as heavily on the mechanism of the parts to be lubricated for operation but rather on a pump system. The oil in the oil reservoir is distributed through the parts requiring lubrication by pumping it under pressure.

Unit 4

4.1.1 Understand the relationship between work and energy. [3.402, 3.403]

Work has a definite relationship with energy. To understand work we must first understand force. Force is a push or pull on an object. If the object moves then work has been done. Work is defined as the force exerted on an object multiplied by the distance the object travels while that force is exerted. From the diagram above, the force (pull) on the block, moves it a distance, so that work was done on the block to move it to the second (grey) position.

4.1.2 differentiate between kinetic and potential energy [3.402, 3.403]

Kinetic energy is known as the energy of motion, it is the energy something gets from moving, and the energy it would take to stop it. Obviously a speeding car has a significant amount of energy it can transfer to something, while a parked car does not.

Potential energy is the energy of position, or specifically the energy something gets from either its own physical properties, or its distance from the surface of the earth. Gravitational energy would be a potential energy.

4.1.3 classify the main types of energy as being either potential or kinetic [3.402, 3.403]

Types of energy -

- Radiant Energy (kinetic) - Electromagnetic energy travelling in transverse waves, including visible light.
- Stored Mechanical Energy (potential) - This is energy that is stored in an object by the application of a force; but a perfect example is a compressed spring.
- Nuclear Energy (potential) - Energy stored in the nucleus of an atom, released through a variety of processes.
- Motion (kinetic) - Purest form of Kinetic energy, energy of an object due to its motion.
- Sound (kinetic) - Sound travels in longitudinal waves of compressions and rarefactions. These alternating bands of particles have energy within them.

- Gravitational Energy (potential) - Any two bodies exert a gravitational force on each other, and this gravitational energy gets larger depending upon the size of the body and how close they are to each other.
- Thermal (kinetic) - As an object is heated, the molecules within it speed up. They are able to transfer this energy by collisions between their molecules and other object's molecules nearby.
- Electrical Energy (kinetic) - Energy caused by the flow of electrons.
- Chemical (potential) - Energy stored within the bonds of atoms and molecules.

4.2.1 describe the most common fossil and alternative fuels [2.404, 3.404]

Points to emphasize:

- Coal is a natural dark brown to black graphite like material used as a fuel, formed from organic materials.
- Petroleum Distillates is the term used to describe the variety of petroleum products that are used as fuels. They are all distilled from crude oil by a process called fractional distillation, which works due to the fact that they all have different sizes, weights and boiling temperatures. Examples are gasoline, kerosene, diesel and lubricating oil.
- Natural gas is a mixture of hydrocarbon gases that occur naturally with crude oil deposits.
- Hydrogen is a gas, usually derived from water that can be either combusted to produce energy or be used in a fuel cell to produce energy.
- Natural gas is listed in both places, because it is considered to be an alternative fuel for motive applications in buses and other forms of transportation.
- Propane is a natural gas derivative, also used as an alternative fuel for motive applications.
- Biofuel is the name given to treated waste used to produce methane, peat which is used as a combustive fuel and natural oils extracted from vegetable matter.
- Alcohol is just as the name suggests, alcohol. The most common type is ethanol which is created from fermented corn, and can be used in gasoline engines. Ethanol is considered an alternative fuel because it is renewable and burns cleaner than gasoline.

4.2.4 become aware of the Environmental Considerations involved with renewable, non-renewable and inexhaustible energy sources [2.404, 3.404]

Sustainability was introduced briefly as a topic in 3.2.2 within the student section. This section of the course will introduce it in its broadest sense. Sustainability is the ability of a process to keep going over a long period of time. Something is sustainable if it has minimal impact on its surroundings and is able to keep functioning on resources readily available. In this manner, non-renewable resources would not be considered sustainable, but renewable and inexhaustible would.

Environmental impact is the term used to describe the effect that something has on the environment. In this specific case, effects are based not only on the burning of fuels, but the production and refining of fuels. How much impact does drilling for oil, mining coal, planting corn, recovering waste have on the environment.

4.3.1 Relate the history of technological development dealing with power generation. [3.204, 3.301, 3.302]

Technological development of power generation can be summed up by the following headings

The Age of Wind and Water

- Before the modern era, humans depended upon their own muscles, draft animals and wind and water to generate power. Historically there are many examples of water wheels and windmills used to directly transfer their energy to some purpose. In most of these cases the use of mechanical energy was for a direct purpose, in close proximity to the source of power. The earliest forms of hydro-power are found in France, where dams were created to direct water to giant mills that ran on the power of the water itself.

The Age of Steam

- Late in the 1700's and early 1800's the steam engine entered the industrial world. Originally developed by Thomas Savery and Thomas Newcomen for use in coal mines as pumps, the advanced steam engine, described in the external combustion engine section, was invented by Thomas Watt. These engines, burning wood to start, used steam and its pressure as a method of producing power. It converted the power from the combustion of the material into mechanical power. Later in the 1800's, the combustive material was changed to coal, which also began the development of fossil fuels. These engines were the first step in allowing industries to become independent of their power bases. No longer would mines and mills be forced to locate close to water sources. The steam engine and its methods actually form the basis of modern combustion-based power generation stations, although the methods used today are much more advanced, the core concept remains the same.

The Age of Electricity

- Later in the 1800's electrical power came on the scene and with it a revolution in how energy was used. Mechanical and chemical energy was now converted into electrical energy and that energy was transferred over great distances to be used. Thomas Edison and Nicola Tesla had a tremendous impact at this time, developing the light bulb and alternating current

respectively. On the one hand the light bulb created a market for electrical power, and on the other, alternating current allowed that power to be transferred over great distances. With the advent of electrical motors the ability to transfer power over distances allowed industries to be located further away from their power sources, and inevitably lead to the widespread use of electricity.

- Hydro power dams became hydro-electrical, and steam started to be used to drive armatures. Coal fired electrical generation plants started dotting the landscape in Europe and North America.

The Atomic Age

- With the widespread use of electricity in the early to mid 1900's, different ways to produce the power started to be explored. Steam turbines and fossil fuel generating plants became more efficient, and the demand for electricity grew. With the advent of the second world war and the enormous amounts of power required to run the manufacturing centers of the major powers of the time, more ways to generate electricity needed to be found. Nuclear power became that answer after the war. Nuclear power plants, based on the early work of Marie Curie and followed up by Enrico Fermi, started to appear across the world. The power generation was relatively cheap, but the side effects of nuclear waste and the dangers of the technology created issues and several incidents in the past 30 years, such as Three Mile Island and Chernobyl did not help. Still it is the third highest produced power in this country.

Alternative Power

- Using the wind, water and the sun to generate power would be familiar to someone from 400 years ago. The technologies of the conversion of energy make it possible. Photo-voltaic cells, wind turbines, wave power, tidal power, geothermal, hydro-power all of these have started to surge in the past few years. In some ways it is easy to see why, as the high cost of fossil fuels, the unpopularity of nuclear power and the decrease in areas to use for hydro-electric dams have lead to an increase in funding for these "alternatives".

4.3.4 describe the common qualities of power generation technology

All common standard power generation technologies use a turbine and pressurized liquid of some sort. In coal and oil fired generation plants, water is heated to steam using a combustive fuel, and in the conversion, pressure is created in a series of pipes. That steam under pressure is forced through a turbine that turns an armature within a generator that produces electricity. In almost every case of heat/steam power generation this is how it is done. Variations may occur but the central action is the same.

In a step by step format that process can be outlined as:

- Step 1 - Water is heated
- Step 2 - Water converts to steam
- Step 3 - The conversion creates high pressure due to the greater space water takes up as a gas in comparison to a liquid
- Step 4 - The high pressure steam drives through a series of pipes and spins a turbine
- Step 5 - Turbine spins an armature within a generator

Obviously hydro-electric power generation occurs in a more direct fashion, with the water spinning the turbine directly. This is also true of the new technologies, such as wind and solar, where wind power turns the armature directly and solar cells create electricity as a process in the photo-voltaic cells.

Unit 5

5.1.3 review the legislation dealing with the use of windmill and solar power generation methods in Newfoundland and Labrador [1.405]

Excerpts from the Newfoundland and Labrador Energy Plan.

Some homeowners and small business operators have requested permission to install small generation units to produce power for themselves with the ability to feed some back into the system when they can produce more than they need. The Provincial Government will ensure that regulatory support is in place for customers who wish to develop these alternatives themselves on a small scale, through a net metering policy. NLH and Newfoundland Power have told Government they will make a joint proposal to the PUB to implement net metering for small-scale renewable energy sources, with due regard for safety, the environment and the community.

There are currently two limits in place by Newfoundland Power & Newfoundland and Labrador Hydro on wind generation. These are an 80 MW Economic Limit and a 130 MW Technical Limit. The 80 MW economic limit is the amount of wind generated electricity that is economically feasible to be added to the existing grid. The second higher limit of 130 MW is an estimate of the total amount of power that can be produced, in excess of what already exists, considering the current electrical grid in our province. We have no feasible route to export any more surplus thus it is of no use to produce it. This is the significance of the Lower Churchill 2009 limit.

5.2.2 outline the historical use and development of windmill technology [1.405]

Ancient Persians used wind energy to pump water before the birth of Christ. The world was explored by wind-driven ships long before engines were invented. The Dutch refined its design and used wind energy to drain marshes, and lakes. Eventually this technology was exported to the New World. As recently as the 1920s, over a million wind turbines pumped water and provided electricity to farms in North America.

5.2.3 describe the planned wind-farm technology to be used in Newfoundland and Labrador [1.404, 1.405, 2.404]

Specifications of the projected windfarm. Points to emphasize:

- \$45 Million Investment
- 27 MW Installed Capacity
- 38 Vestas V47 Wind Turbines
- Interconnection at NP Laurentian Substation
- 15 km of access roads

- 8 km overhead transmission line
- 95 GWh annual generation (enough to power 10 000 homes)
- Reduction of 75 000 tons of CO₂ Greenhouse gas annually
- Located between Lawn & St. Lawrence
- A second site is proposed for Fermeuse producing another 25 MW
- St. Lawrence's 27 MW + Fermeuse's 25 MW leaves ~ 30 MW for future development, if we factor in NL Power & NL Hydro 80 MW Economic Limit (Described in note to follow).

5.3.2 outline the historical use and development of solar cell technology [1.405]

Photoelectric Effect

Discovered in 1839 by Edmund Bequerel, who noted that when certain substances were exposed to sunlight they produced a minute electrical current. The photoelectric effect was further refined and described by Albert Einstein in research that won him a Nobel prize in 1905. The first actual module was built by Bell Laboratory in 1958. It was very expensive and had little use potential. That is until the race for outer space began in the 1960's. Solar cell technology came into its own over this decade as satellites and capsules used them for a power source. They were also extensively refined and advanced such that the technology became cheaper and easier to produce. The next big jump for the solar cell occurred in the late 1970's and early 1980's. The energy crisis and the high cost of petroleum-based fuels moved solar cells from space to the main stream and a variety of products for home-generation and off-the-grid became available.

5.4.1 describe the components and function of a standard residential electrical service [1.405]

Main hot bus – distributes 120 Volts electricity to the household electrical system. Current electrical code requires two hot bus bars be included in the assembly of the panel. (Note: several appliances in the house require 220 volts).

Neutral bus bar-Bus bar within the service panel to which all neutral wires are attached to complete the circuit.

Ground Wire- Terminals for ground wires bundled with NMC cables are attached to the panel or may be attached to a ground wire bus.

Main Power switch- largest switch contained in the panel, usually located at the top of the panel. This switch is used to control

the flow of electricity into panel. The main is usually labeled with the number of amps that it is rated for.

Breakers-the most common component found in the service panel. Breakers are protection device that limits the amount of current that can be safely controlled within the circuit. If the limit is exceeded the breaker will trip (turn off) until the excess load is removed. The breaker can then be reset and the circuit restored. Note that a 15 amp breaker is capable of carrying 1700 watts of power.

GFI Breakers- special breakers that are installed in areas where the risk of shock are increased such as a bathroom of outside receptacles. In some cases a GFI receptacles maybe used which are located at site of access. These units are recognizable by the reset and test button built into the unit.

5.5.3 explain how a fuel cell can produce electricity [1.405]

A fuel cell is an electrochemical energy conversion device that converts chemicals directly into electricity. Fuel cells converts hydrogen and oxygen into water as a product of this process electricity is produced. Fuel cells will run indefinitely as long as the chemicals continue to flow into the cell.

A basic fuel cell is made up of an electrolyte layer which separates the reactants from each other and prevents them from mixing. The electrodes are catalysts where the electrochemical reactions occur. Bipolar plates are used to conduct the electricity out of the cell to the consuming device.

Fuel is constantly feed to the anode side of the electrolyte side of the cell and an oxidant (oxygen) is supplied to the cathode. An electrochemical reaction takes place at the electrodes to produce electricity.

5.5.4 differentiate between the types of fuel cell and their applications [1.405]

Types of fuel cells - Points to emphasize:

- Polymer Exchange Membrane Fuel Cells - Holds the most promise of being used in transportation applications. Uses water as an electrolyte, and has low operating temperature. This is the type of fuel cell that is part of the Ballard fuel cell experiments.
- Solid Oxide Fuel Cells - Used in large scale stationary power generating applications. It use very high temperature.
- Alkaline Fuel Cells - Oldest of the cells used in US space travel,

susceptible to contamination and expensive to produce. Uses alkaline electrolyte

- Molten-Carbonate Fuel Cell - Used in large scale energy production facilities. High temperature.
- Phosphoric-Acid Fuel Cells - Slower in its endothermic reaction, not suitable for the transportation industry. Uses acid as its electrolyte.
- Direct Methanol Fuel Cell - Expensive to operate uses large amounts of platinum as an electrolyte.

5.6.2 outline the historical use and development of heat pump technology [1.401, 1.405]

The Paleo-Indians used hot-springs as a source of geothermal energy as early as 10,000 years ago. The ground source heat pump is not new technology and has been used in different forms for many years.

In 1852 Lord Kelvin developed the concept of the heat pump.

In the 1940's Robert C. Webber further developed the idea of using this technology as a heat source. While experimenting with his deep freezer he noticed that when he dropped the temperature of the freezer there was rise in the temperature of the fluid in the pipes after it circulated through the system. He ran this hot fluid to his home boilers to heat the water and provide heating in the house.

He also developed the idea of the taking the heat from the ground through a system of pipes and Freon gas and using this to heat the home and thus developed the ground source heat pump.

In the 1970's Dr. James Bose, a professor at Oklahoma State University, used this technology to take heat from one source (swimming pool) and put it through pipes in the ground to cool it. This was the beginning of the new era in geothermal systems.

5.6.3 differentiate between the different types of heat pump installations [1.401, 1.405, 2.401]

There are two types of ground source heat pumps:

Closed Loop System

This system uses a continuous loop of pipe buried under ground. The solution inside the pipe gets cooled by a refrigeration system to a temperature lower than the surrounding soil. As it circulates through the pipe it absorbs the heat from the soil and this heat gets extracted when it reaches the compressor again.

Open Loop System

This system uses an underground water source. This water is extracted directly to the heat exchanger and the heat is taken out. The water is then released to an above ground body of water or down another well.

There are two types of air source heat pumps

Air to air

This is the most common system in use today. It takes the heat from the outside air and transfers it to a forced air system inside the home. This works in reverse for cooling.

Air to water

Works in a similar way as air to air. This system takes heat from the outside air and uses it to heat water in a hydronic system inside the home. Once again the system works in reverse for cooling. The heat pump extracts the heat from the water inside the hydronic system of the home and pumps it to the air outside of the home.

5.7.2 define R-value in terms of energy loss over square footage of a material [1.405, 3.401, 3.402]

R- value is defined as A commercial unit used to measure the effectiveness of thermal insulation. Thermal conductance is measured in BTU's of energy conducted times inches of thickness per hour of time per square foot area per Fahrenheit degree of temperature difference between two sides of the material. The R value of the insulator is defined to be the inverse of the thermal conductance per inch.

Delineation

- R-value
- U-value
- Methods of heat transfer
 - Conduction
 - Convection
 - Radiation

U-Value: A commercial unit of thermal conductance. Refers to the conductance through an insulator as measured in BTU's of energy conducted times inches of thickness per hour of time per square foot of area per °F of temperature difference between the two sides of the material. The U factor is numerically equal to 1 divided by the R-Value. This unit is also referred to as the overall heat transfer coefficient and is basically the reciprocal of R-Value. This value measures the rate of heat transfer through a building material and as such a smaller U-Value is better. Knowing the U-Value of a given building material and the temperatures on both sides of the material one can calculate the rate of heat loss for that structure. More precisely $R = 1/U$

5.7.3 Differentiate between different insulation types and their appropriate use in residential construction/renovation. {1.401, 1.405, 2.404}

Delineation

- R-value
- Batt or blanket insulation
- Loose-fill insulation
- Rigid board insulation
- Spray-foam insulation
- Radiant Barrier Insulation

Batt or Blanket insulation

One of the most common types used in houses in this province is the batt or blanket insulation. Sometimes associated with the brand name, this insulation is usually fiberglass based and pink. The insulation is called batt, because that is the way it is created and packaged.

Loose-fill insulation

Defined as small particles of fiber, foam, or other materials that can conform to any space without disturbing any structures or finishes. Its ability to conform makes it well suited for retrofits and for places where it's difficult to install some other types of insulation. There are three common types of loose fill including cellulose, fiberglass and mineral wool. Each of the types has different R-Values, densities, and weights that should be considered for the various applications. Cellulose has the highest R-Value per inch thickness.

It is important to note that each of the three types is produced using recycled waste material. Cellulose made primarily from recycled newsprint, most fiberglass contains 20% - 30% recycled glass and mineral wool is usually produced from 75% post-industrial recycled content.

Over time loose-fill insulation can lose some of its R-Value because of settling, especially in attic cavities. Cellulose settles more than rock wool or fiberglass by up to 20% compared to 2%-4% for the latter. Obvious solution is to install 20% more to offset the settling. (Settling can be avoided in wall cavities by completely filling cavity to proper density).

Safety:

- Insulation should cover top plate of wall but not eave vents.
- Electrical devices require 3 inches clearance.
- Pipes for heat sources such as stoves should only be insulated with fiberglass or rock wool as cellulose will smolder.
- Some research suggests that fiberglass particles can cause cancer if inhaled and that the additives for fire retardants and insecticides may also be harmful to breathe.
- Care must be taken to ensure insulation fibers are not drawn into air distribution systems by properly sealing ducts.
- Proper PPE must be worn during installation including respirator, eyewear, and clothing such as gloves, long sleeved shirts, and pants to minimize contact.

Rigid Board Insulation:

Usually made of fiberglass, polystyrene, or polyurethane and comes with very high R-Values ranging from R-4 to R-8 per inch. Often used below grade on foundation applications as well as exterior of walls.

In conjunction with damp-proofing rigid insulation on a foundation aides with site drainage as well as reducing interior condensation in basements.

Three basic types of rigid board insulation include expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate (ISO). EPS has the lowest R value of the three and ISO having the highest of the three.

Spray-foam Insulation:

One of the best forms of insulation as far as R-Value is concerned. Has been around for years for use in appliances such hot water boilers and refrigerators but is relatively new in the housing industry. Its major advantage is that it can virtually eliminate air infiltration by sealing and filling even the smallest cracks. It is more expensive than more traditional insulating methods, can really only be used during new construction and is quite messy. It can sometimes also delay other subcontractors such as electricians and plumbers.

- Some types of spray foam insulation actually add structural strength to a wall or ceiling. It increases its shear and racking strength.
- It is sprayed on by professional installers.
- Classified as an air barrier material.
- Works well to dampen common household noises such as plumbing noises.

Radiant Barrier Insulation:

Usually consist of a thin sheet or coating of highly reflective material such as aluminum that is designed to reflect heat or thermal energy away from a structure to keep it cool, or attracting it to keep it warm. Most often these barriers are rigid or semi-rigid boards. Installed correctly in an attic situation a radiant barrier system can help to cool an attic in summer and absorb heat during winter months. The use of any insulation requires good skin, eye and breathing protection. Workers involved in the installation of insulative materials should wear good strong gloves, have their body covered by rough material to prevent irritation of the skin, and, as in all residential construction aspects, wear safety eye wear. In this instance as the risk is based in small airborne particulates the most appropriate type of safety eye-wear is goggle type.

The most serious risk to the installer in this instance is to their breathing. The same small airborne particulates that are a risk for the eye or skin are a much more pronounced risk for the lungs and air ways. A CSA

approved breath mask should be used when handling any type of insulation at all times.

Beyond the hazards to the individual when installing such materials, there are inherent hazards that need to be considered within the construction area. Some types of insulation are flammable and need to be covered by an approved fire-rated material and not left open to the air.

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