Chemical Process Safety
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Lecture 31 – Sprinklers- I

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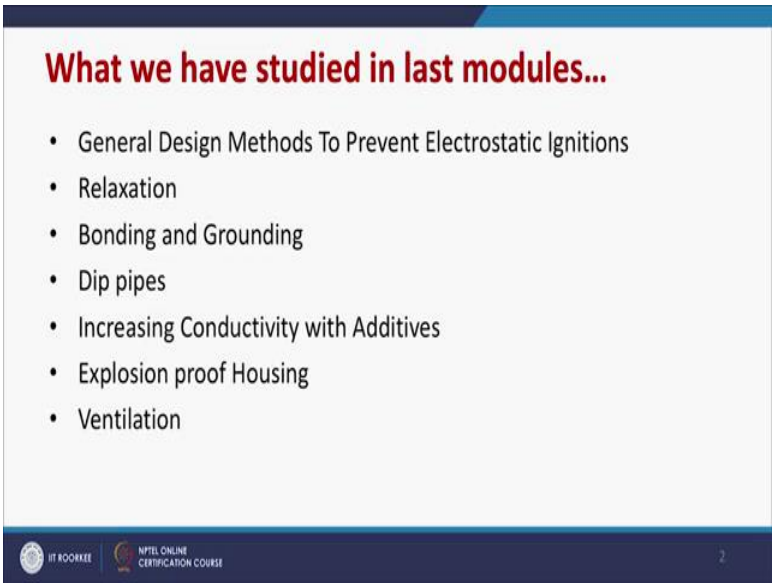

Welcome to this module of this design to prevent the fire and explosion. Up till now we have studied in different modules the general design consideration to prevent the electrostatic ignition: Relaxation, bonding, grounding, dip pipe, increasing conductivity with additives, explosion proof housing and different aspect of ventilation. In this module we will give a proper deliberation to this sprinkler system because sprinklers are a integral part of any system where the chances of fire and explosion hazards are on the higher side.

And you may find those sprinklers either in the house or different type of public places and different areas where there is a need, to install such kind of activity to prevent the fire and explosion hazard. So question arises that what is a sprinkler.

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A fire sprinkler system is an active fire protection method consisting of a water supply system, providing adequate pressure and flow rate to a water distribution piping system, onto which fire sprinklers are connected. Now this system as you can see in this particular figure, this system consists of an array of sprinkler heads connected to a water supply. So we will discuss aspect in subsequent slide and we will discuss about the anatomy of a sprinkler head.

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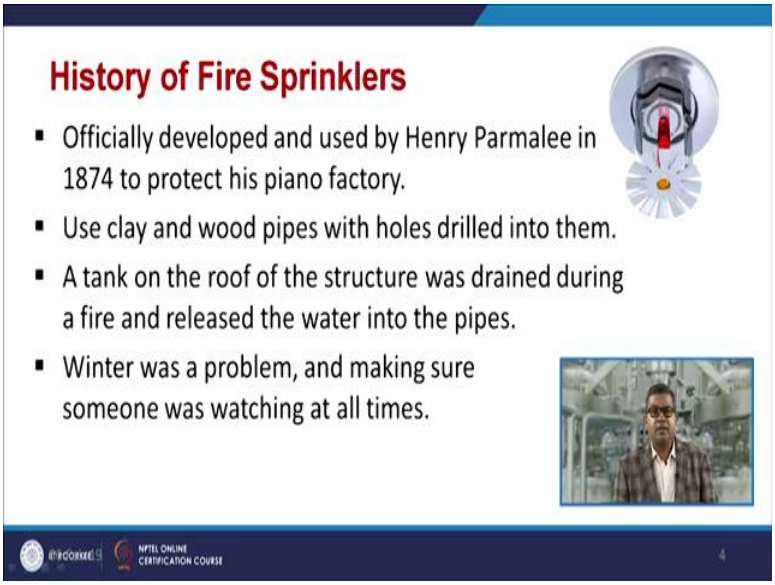

So let us have a look about the history of fire sprinklers. So officially developed and used by Henry Parmalee in 1874 to protect his piano factory because piano, he used to manufacture piano wood and there was a prominent chances of catching fire. So use clay and wood pipes with holes drilled into them, and tank on the roof of the structure was drained during a fire and released the water into pipe. So winter was a problem and making sure someone was

watching at all times. Now these four lines are very knowledgeable lines, the reason is that this gives you an idea that under what condition you should use the sprinkler system, what are the plus and minus point of a sprinkler and what are the shortcoming of the sprinkler system.

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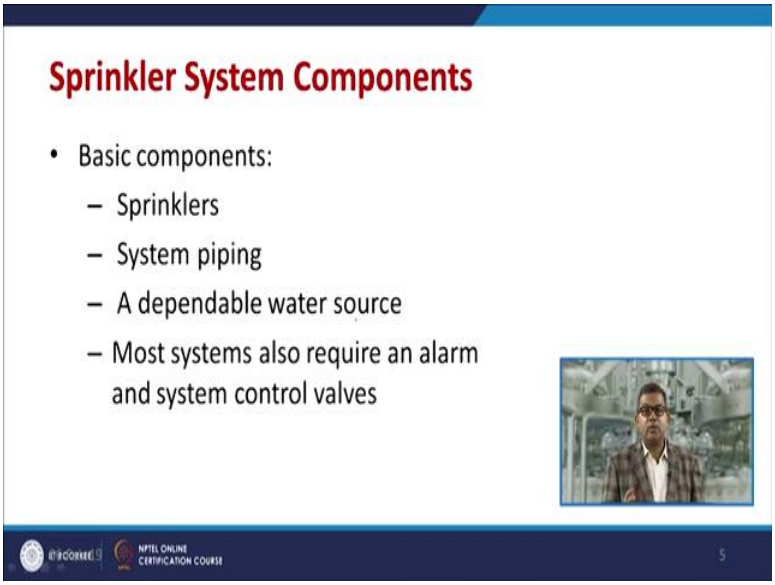

So before we go into the detail let us have what kind of basic components a particular sprinklers have. They are having the sprinklers, they are having the system piping, a dependable water supply or a water source and most systems also require an alarm and system control valves. So these are the four basic components which you require to install in sprinkler facility.

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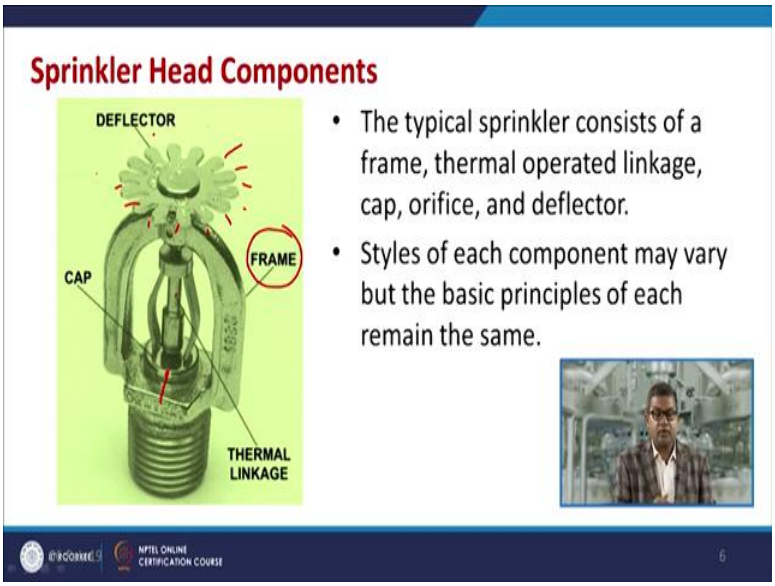

Now this is the basic anatomy of a sprinkler head component. There are four major component, one is a frame, another one is the deflector, the third one is the cap and fourth one is the thermal linkage. Now, just because everything is having its own importance, the reason is that first it should sense that there is a rise in temperature so that, the thermal property of the material in question it can sense that there is a problem and it can provide the adequate opening to the water so that the water may come out from the cap to the different deflectors. And these deflectors may spread the water to the problematic zone.

Now remember, if the thermal linkage is not functioning properly, then there may be chance that at the time of fire it may not actuate or sometimes you are working under the safe environment it may be actuated, and the property or economic losses would be on site. So that is why, the proper synchronization among four things; reflector, cap, frame should be there. So style of each component may vary but the basic principle of each remain the same. Now let us have the discussion about all four ingredients.

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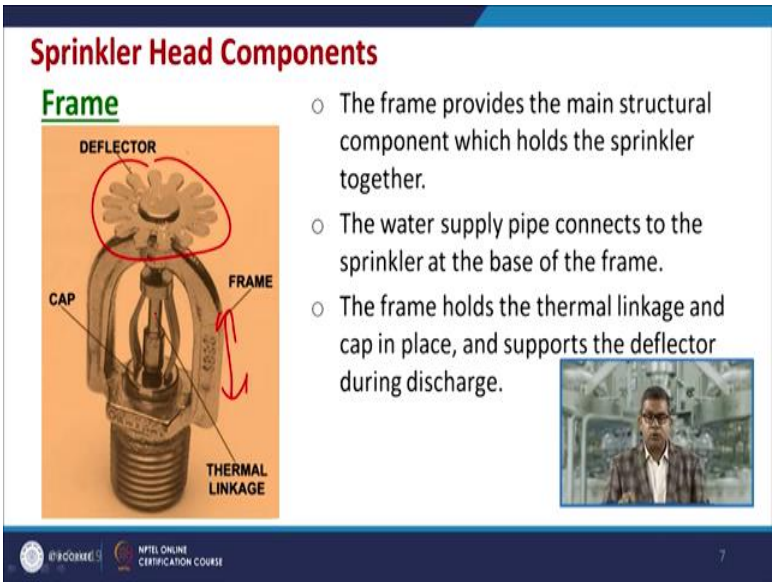

The first thing is the frame like you can see here. The frame provides the main structural component which holds the sprinkler together. The water supply pipe connect to the sprinkler at the base of the frame and the frame holds the thermal linkage, this one, and supports the deflector during the discharge so that, that can focus towards the problematic zone.

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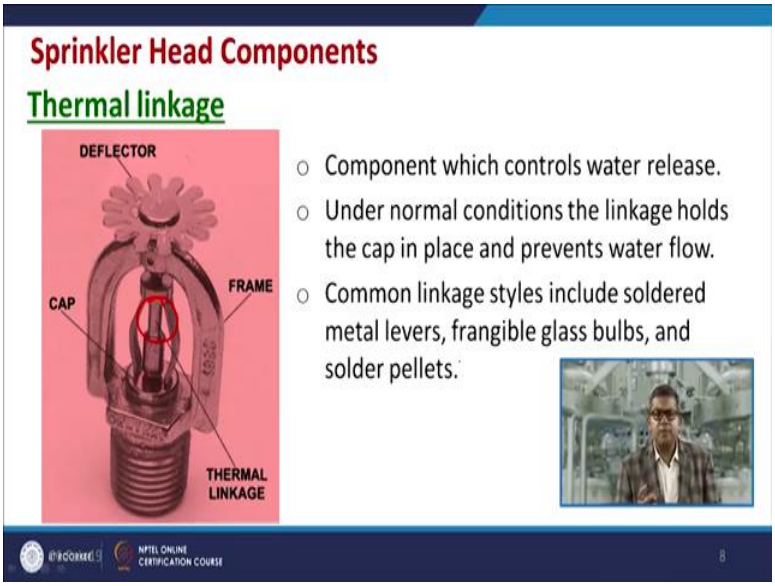

Now this one is a thermal linkage, this component which controls the water, releases. Under the normal condition the linkage holds the cap in place, this one is the cap in place, and prevents the water flow because these are the normal conditions. Now common linkages style include soldered metal lever, frangible glass bulb and solder pellets. Sometimes people may use wax and 70-80 years ago people were using the wax as a thermal linkage.

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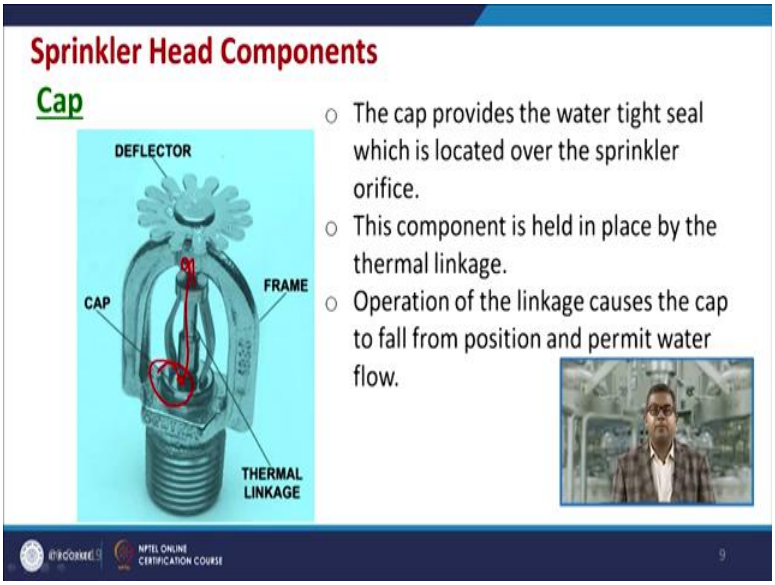

Then the cap, this one, the cap provides the water tight seal which is located over the sprinkler orifice. This one is the sprinkler orifice. Now this component is held in place by the thermal linkage, so operation of the linkage causes the cap to fall from the position and permits the water flow.

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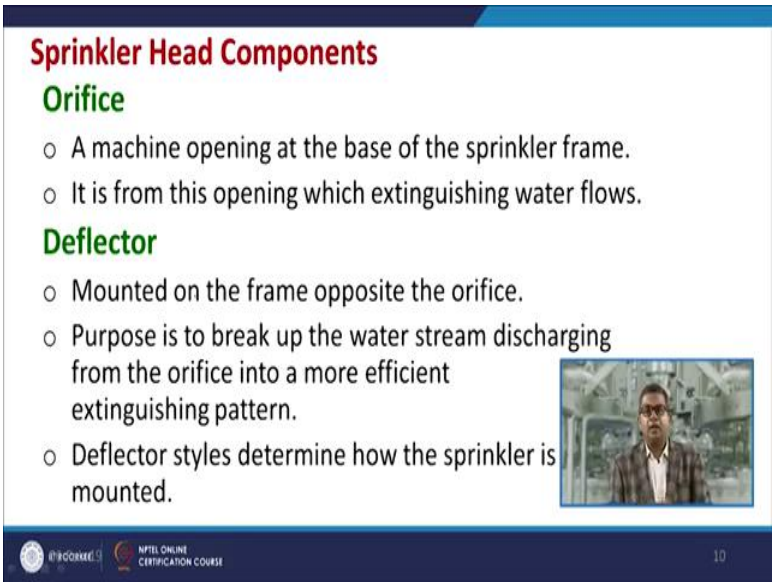

Now there is an Orifice, this is a machine opening at the base of the sprinkler frame and it is from the opening which is extinguishing the water flow so that the small droplets may appear and the excess amount of energy whatever being liberated during the course of fire may come out and may be trapped.

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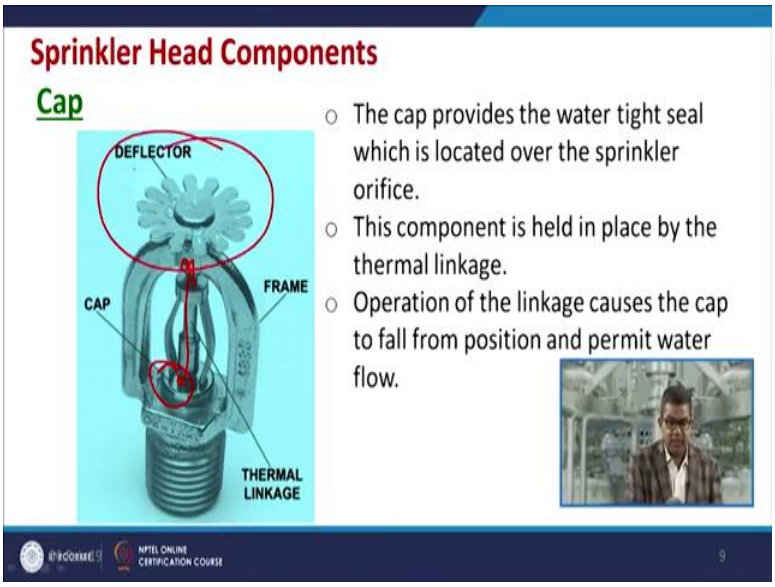

There is a deflector like this in the previous, this one is the deflector. Deflector mounted on the frame opposite to the orifice and the purpose is to break up the water stream discharging from the orifice into more efficient extinguishing pattern. And sometimes based on the requirement these deflectors are of different type. Now deflector style determine that how the sprinkler is mounted.

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Now there are various types of sprinkler heads as you can see in the figure. The pendant type, the upright type, the sidewall type and there are certain special coverage type of sprinklers. So we will take up one by one.

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Now this is the pendant head and they are usually roof-mounted. Here the roof is there, so they are roof-mounted. Now here is the anatomy of the pendant head: This is the water supply line and usually the CPVC plastic pipe, nowadays we are using this CPVC plastic pipe. Now here is the bulb. The bulb burst and when it burst then there is a release of water to this one. They are the concealed fire sprinklers, the plate or you can say the deflector in the

previous slide, so the water may come out from…this place to extinguish the fire. This is the figure or the picture of the roof-mounted pendant head sprinkler system.

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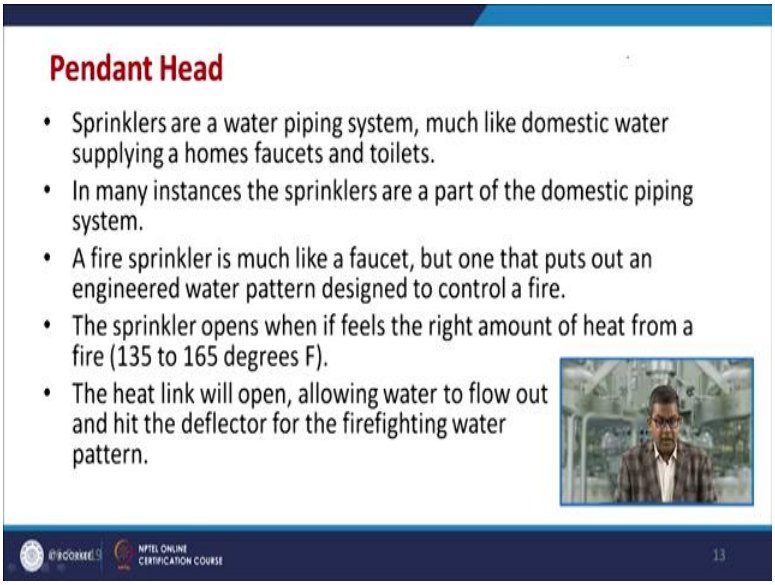

So sprinklers are the water piping system and much like domestic water supplying homes, faucet and toilets, etc. In many instances the sprinklers are part of the domestic piping system. A fire sprinkle is much like a faucet but one that puts out an engineered water pattern designed to control a fire. Because see, whenever you are having the excess water, then unnecessarily there would be a property damage, so you need to be, the sprinkler need to be focused in the problematic zone only.

The sprinkler opens when it feels the right amount of heat from the fire. Usually they are designed for a specific type of heat or temperature zone, like in this case the temperature zone is 135 to 165 degree Fahrenheit. The heat link will open allowing water to flow out and hit the deflector for the firefighting water pattern.

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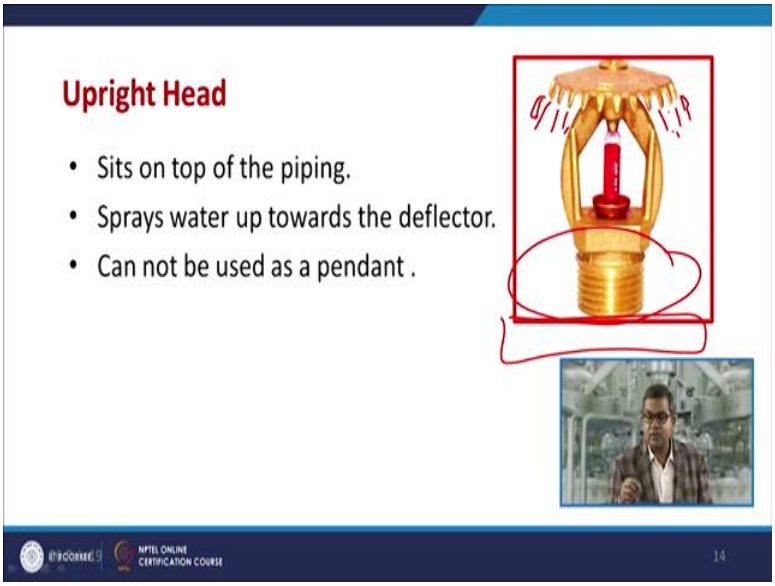

There are certain upright head type of sprinklers. They sit on the piping system and sprays water up towards the deflector like this and it cannot be used as a pendant, the reason is that the flow pattern is just reverse to the pendant type of sprinkler system.

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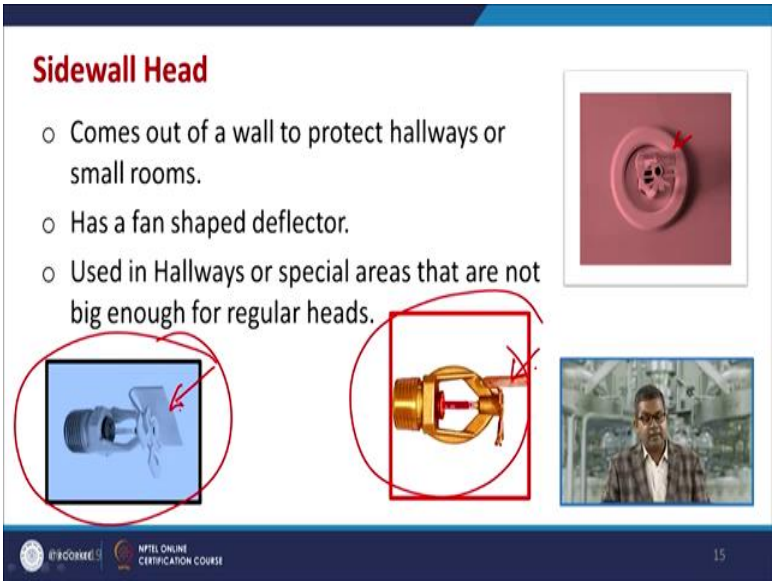

There are another type of sprinkler system, they are called a sidewall head and you can see in these figures, they are the sidewalls. Here, there is a side wall or a plate situated over there. They comes out of a wall to protect the Hallways or small rooms or you may put in the wall, so in case of any fire they can extinguish that particular fire, and has a fan shaped deflector like this and used in hallway or special area that are not big enough for the regular heads.

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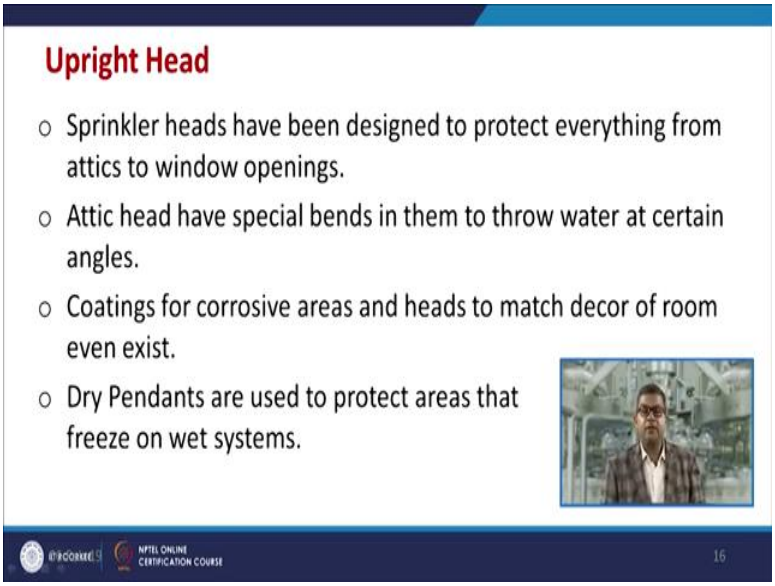

The upright head, the sprinkler head have been designed to protect everything from attics to the window opening. The attic head have special bend in them to throw the water at a certain angle. The coating for corrosive area and heads to match décor of a room even exist, that is the foremost requirement. Dry pendants are used to protect the areas that freeze on wet systems. So it is one of the remedy to avoid the freezing.

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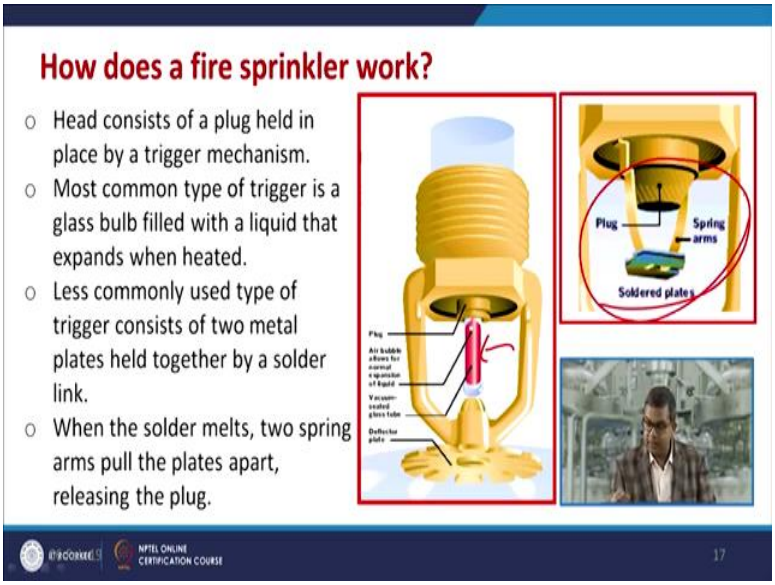

Now question arises, how does a fire sprinkler work? The head consist of a plug held in place of a trigger mechanism. And most common type of trigger is a glass bulb filled with a liquid that expands when heated. So less commonly used type of trigger consists of two metal plates held together by a solder link so that the difference in the temperature can actuate the

sprinkler. So or sometimes when the solder melts, two spring arms pull the plate apart, releasing the plug like this.

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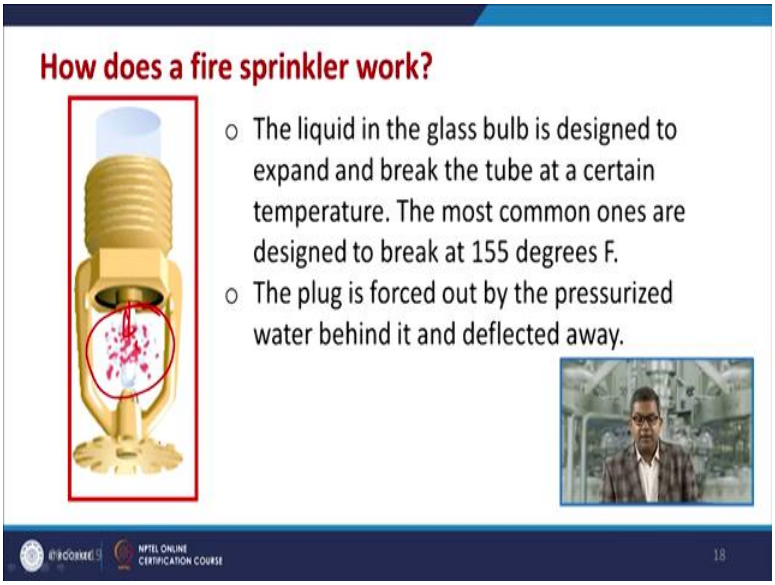

The liquid in the glass bulb is designed to expand and break up the tube, like this it is broken over here. They break the tube at a certain temperature, the temperature is specified or the most common ones are designed to break at 155 degree Fahrenheit. The plug is forced out by the pressurized water like this, here coming out pressurized water behind it and deflected away.

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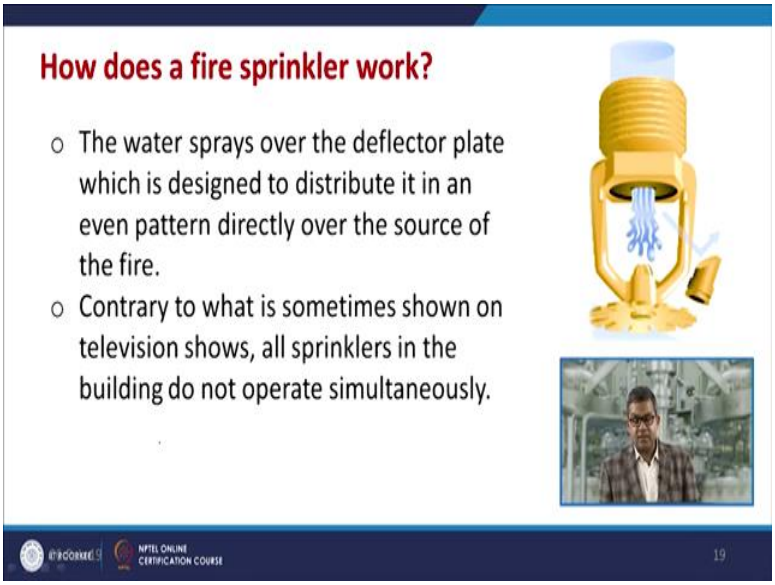

The water sprays over the deflector plate which is designed to distribute in an even pattern directly over the source of the fire. Contrary to what sometimes shown on the television, like shows, that all the sprinklers in the building do not operate simultaneously.

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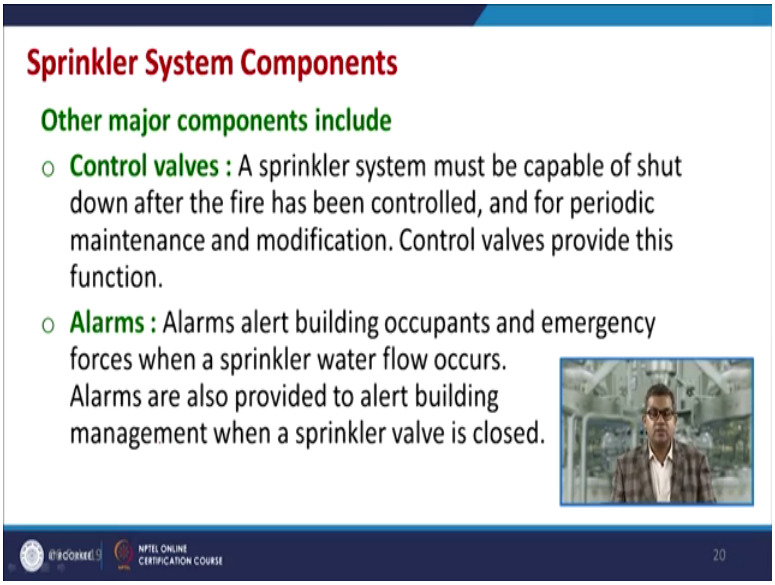

The other major component includes the control valves. The sprinkler system must be capable to shut down after the fire has been controlled and for periodic maintenance and modification. Control valves provide this function. Alarms, usually alarms alert building occupants and emergency forces. When a sprinkler water flow occurs, alarms are also provided to alert building management when a sprinkler valve is closed.

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There are certain drain and test connections. Most sprinkler systems have provisions to drain pipe during the system maintenance. The test connections are usually provided to simulate the flow of a sprinkler flow, thereby verifying the working condition of alarms. There are certain fire hose connections. The fire fighters will often supplement a sprinkler system with hoses. The firefighting tasks are enhanced by installing hose connection to the sprinkler system piping.

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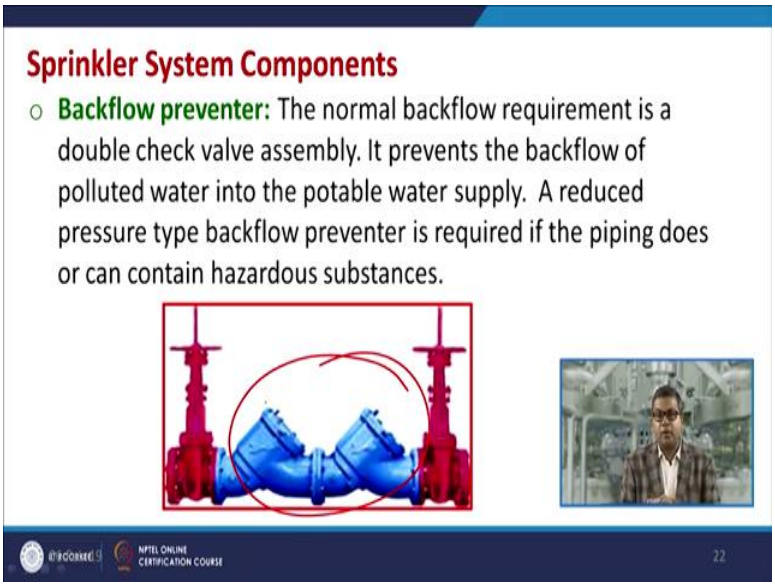

There are certain backflow preventers. The normal backflow requirement is a double check valve assembly, usually like this. It prevents the backflow of polluted water into potable water supply. So a reduced pressure type backflow preventer is required if the piping does or can contain hazardous substance. So sometimes it is the common problem in various chemical plants.

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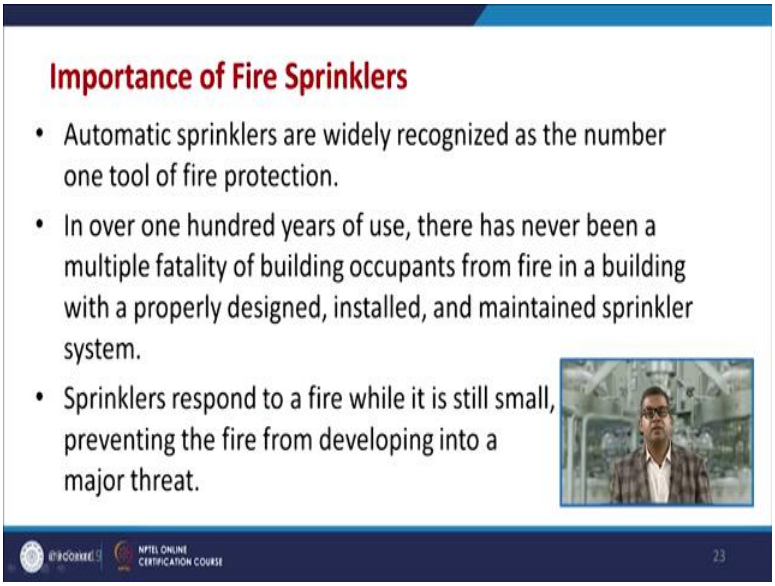

Now certain important points of fire sprinkler: The automatic sprinklers are widely recognized as the number one tool of fire protection. In over one hundred years of use, there has never been a multiple fatality of a building occupants from fire in a building with a properly designed, installed and maintained sprinkler system. The sprinklers respond to a fire while it is still small, preventing the fire from developing into a major threat. Remember we are using the sprinkler when the fire is actuated. In the previous modules we have discussed that to prevent the actuation of fire.

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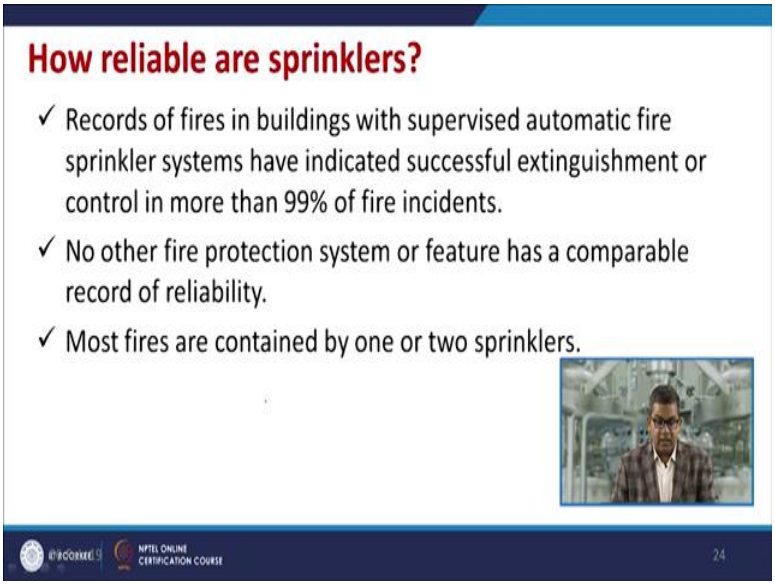

Now apart from this, the question arises that how reliable are these sprinklers. Records of fire in buildings with supervised automatic fire sprinkler system have indicated successful extinguishment or control in more than 99 percent of fire incidents. No other fire protection

system or feature has a comparable record of reliability. Most fires are contained by one or two sprinklers.

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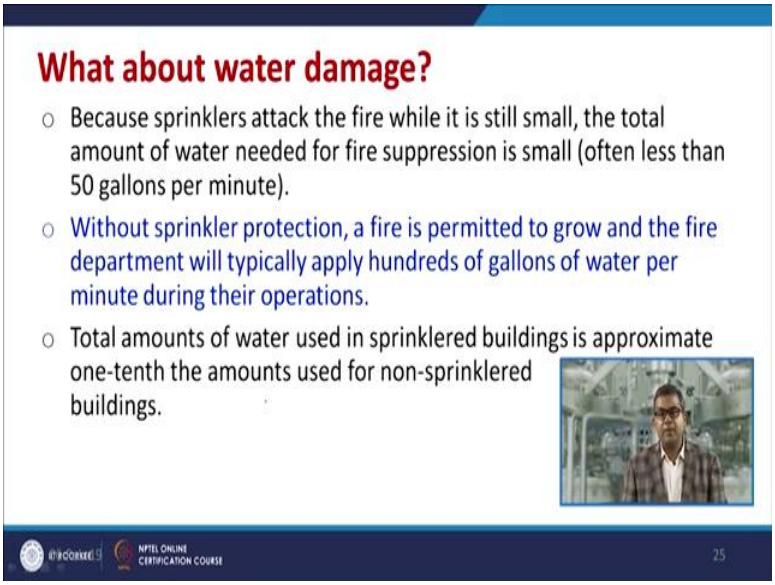

Now since these sprinklers, they are using water, then again the question arises, what about water damage. So because the sprinkler attack the fire while it is still small, the total amount water needed for the fire separation is small, often sometimes it is less than 50 gallons per minute and so on. So without a sprinkler protection a fire is permitted to grow or propagate and the fire department will typically apply hundreds of gallons of water per minute during their operation. So you can say that the sprinkler system, they are the first course of safety.

Total amount of water used in the sprinklered building is approximately one-tenth of the amount used for non-sprinklered building. So you can see that the damages, water damage is not much on the higher side.

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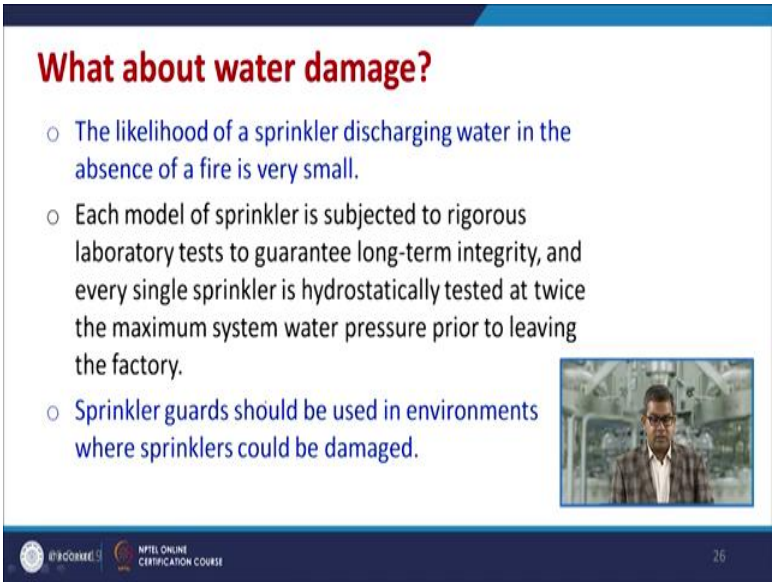

The likelihood of a sprinkler discharging water in the absence of a fire is very small, small amount of water. Each model of a sprinkler is subjected to rigorous laboratory test to guarantee the long-term integrity and every single sprinkler is hydrostatically tested at twice the maximum system water pressure prior to the leaving the factory or manufacturing facilities. A sprinkler guard should be used in environments where sprinkler could be damaged.

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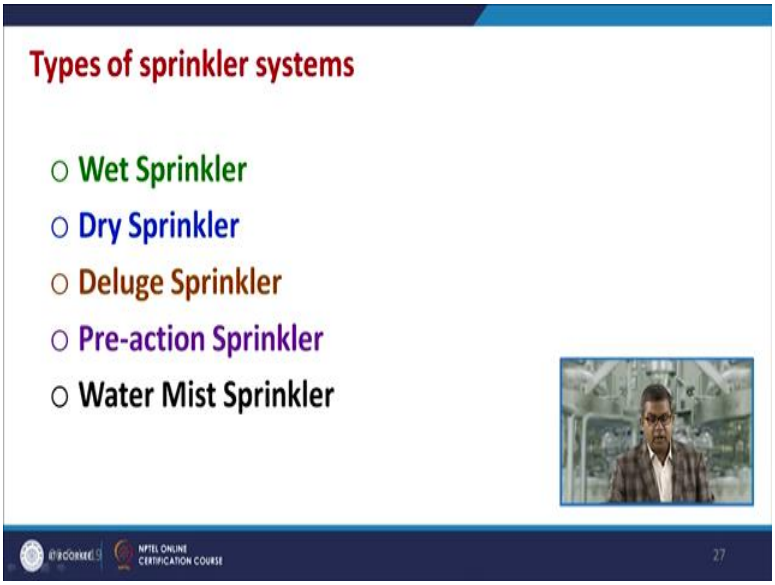

Now there are various type of sprinkler systems, like wet sprinkler, dry sprinkler, deluge type of sprinkler, pre-action sprinklers, water mist sprinklers and so on.

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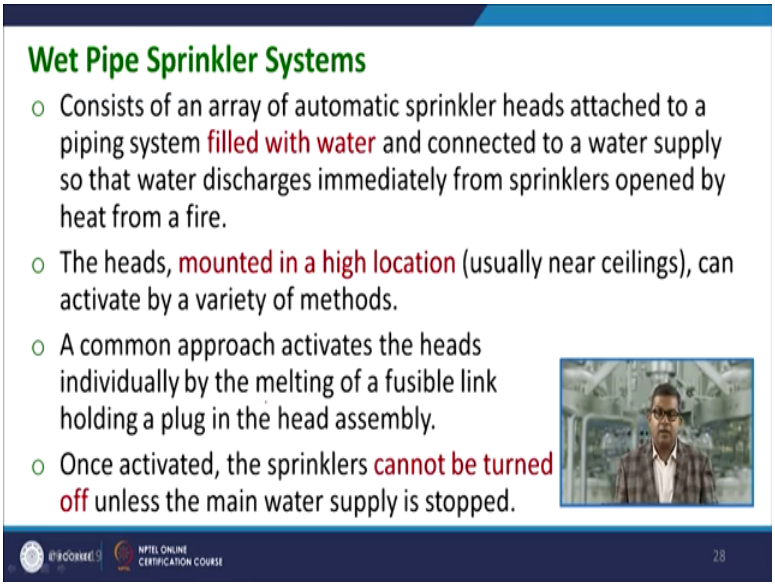

So first, let us have a look of wet pipe sprinkler system. This consist of an array of automatic sprinkler heads attached to a piping system filled with water, obviously it is wet pipe of system, so it is to be filled with the water or any fluid and connected to a water supply so that water discharges immediately from a sprinkler opened by heat from a fire. The heads, mounted in a high location, usually near the ceiling etc, so pendant type of sprinkler can be activated by a variety of methods.

A common approach of activation is by melting the fusible links which we have already discussed. So once they are activated the sprinklers cannot be turned off unless the main water supply is stopped. Thereby, they may cause a severe damage to the property also.

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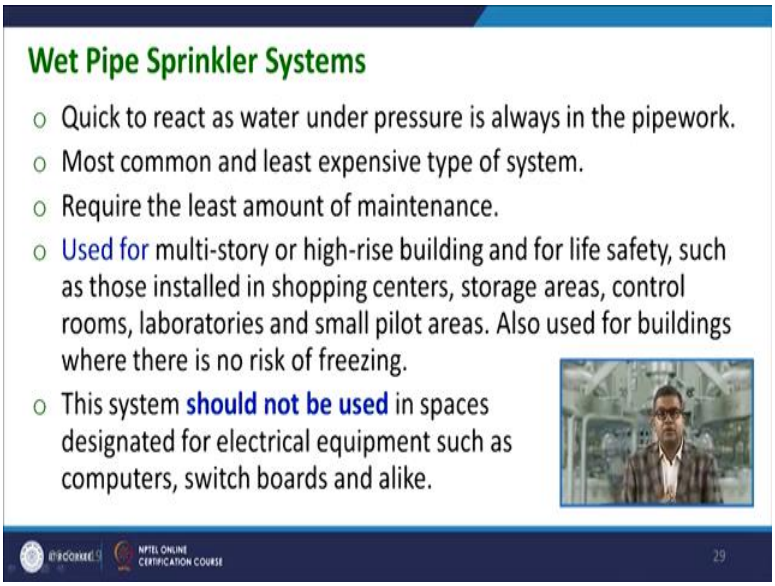

The quick to react as water under pressure is always in the pipework, so this is one of the plus point. Most common and least expensive type of the system, again this is a plus point. Require a least amount of maintenance, sometimes the corrosion, sometimes other debris may get deposited at the opening. So that is, apart from this they require a least amount of maintenance. Used for multi-story of high-rise building and for life safety, such as those installed in the shopping centers, storage arenas, control rooms, laboratories and small pilot areas. Also used for building where there is no risk of freezing.

Now this system should not be used in spaces designated for electrical equipment such as computer, switch board, etc. The reason is that the chances of steaming electricity may be high in case of a fire.

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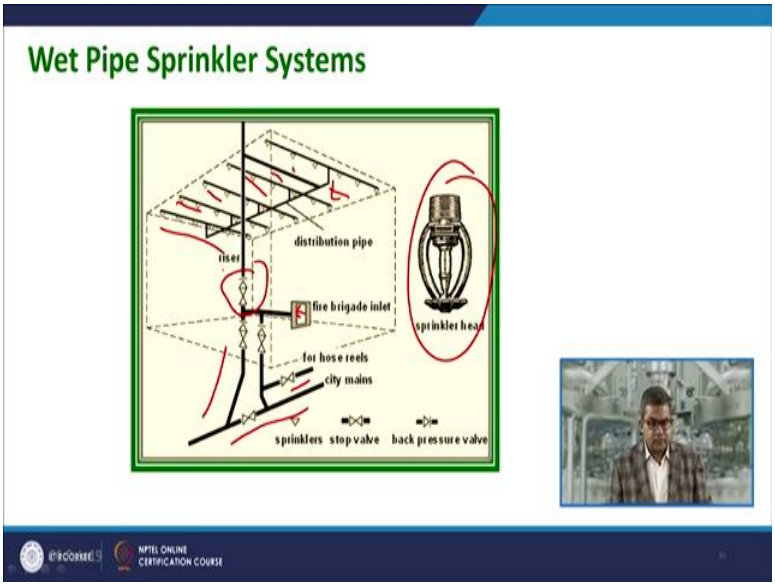

Now this is, you can see in this particular figure, this is the wet pipe sprinkler system. This is the sprinkler head and you can see the different array of wet pipe sprinkler system. You will find it in multi-storied car parking or parking where you find that pipes they are attached with the sprinkler system. So these are the distribution pipes. This is the, we can see the fire brigade inlet and these are the hose reels, etc. So this particular, and they are well supported by stop valves and back-pressure valves. So this is the very simplest arrangement or simplest array of wet pipe sprinkler system.

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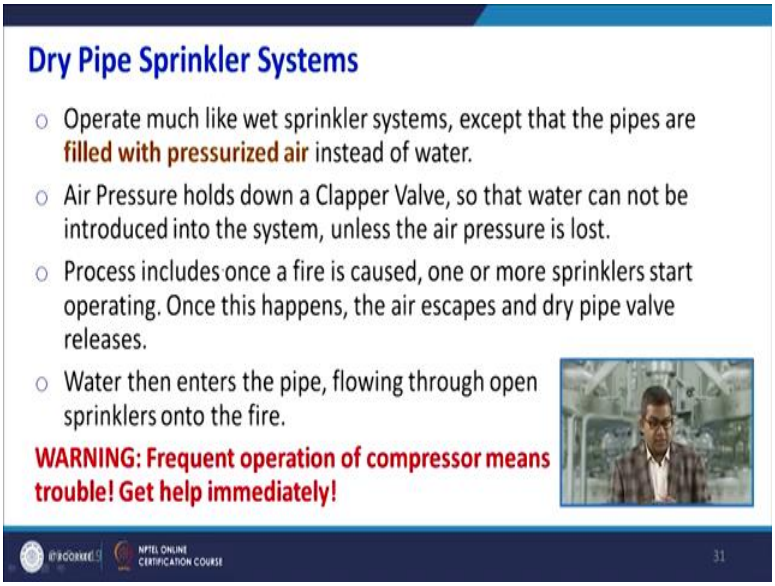

Now next in this category is the dry pipe sprinkler system. So usually they operate much like wet sprinkler system, except that the pipes are filled with pressurized air instead of water. Air pressure holds down a Clapper Valve, so that the water cannot introduce into the system unless the air pressure is lost. This process includes once a fire caused and one or more sprinklers starts operating. Once this happens, the air escapes and dry pipe valve releases. So water then enters the pipe, flowing enough open sprinkler system onto the fire. Now there is a statutory warning that frequent operation of compressor means trouble! So that means get help immediately.

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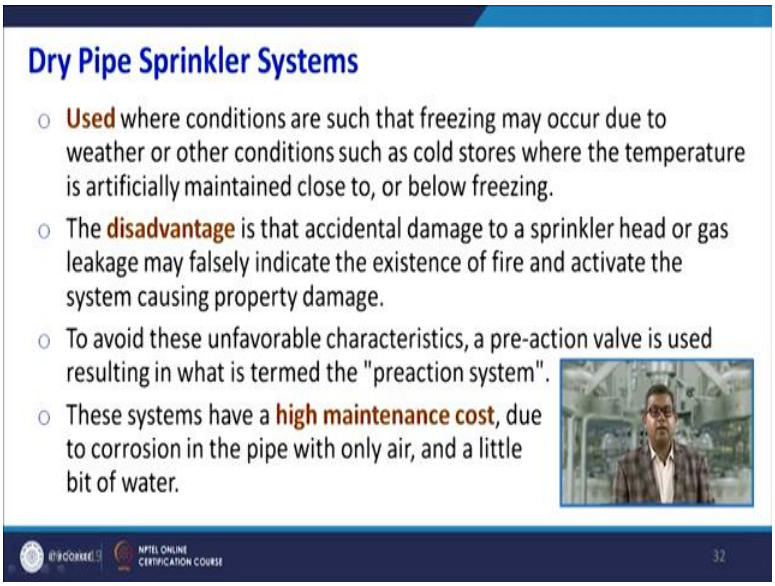

Now where to use this dry pipe sprinkler system? Used where the conditions are such that the freezing may occur due to the weather conditions, sometimes sub zero conditions etc, or other

conditions such as cold stores where the temperature is artificially maintained close to or below freezing. The disadvantage is that accidental damage to a sprinkler head or gas leakage may falsely indicate the existence of fire and activate the system causing property damage. So this is one of the serious disadvantage.

Now to avoid these unfavorable characteristics, a pre-action valve is used, resulting in what is termed as the preaction system. These systems have a high maintenance cost, due to the corrosion in the pipe with only air, and a little bit of water. That may be sometimes attributed to the humidity too. Now it is quite similar to the wet pipe sprinkler system.

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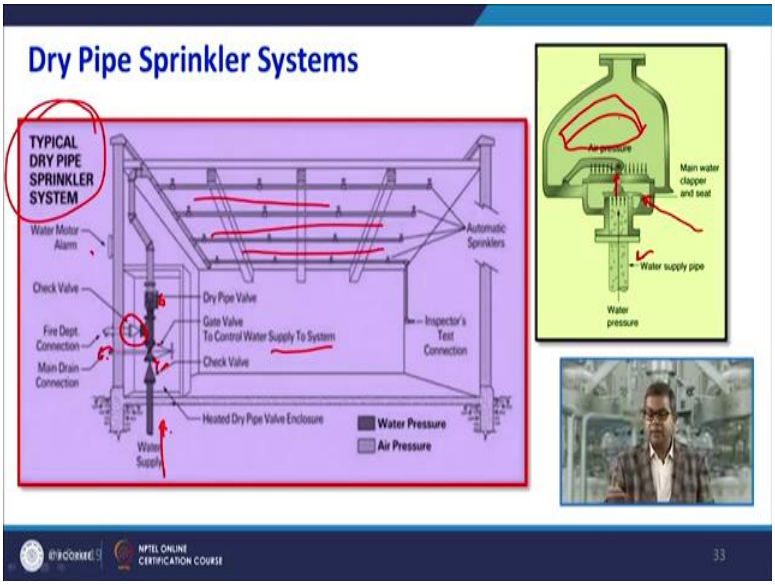

Here you can see that this array of a dry pipe, they are the automatic sprinkler. This is the dry pipe valve; Gate valve to control the water supply of the system, there is a Check valve here. And this is the water supply, so Heated pipe valve enclosure, so you can see the dark colored lines, they are the water pressure lines. There is fire department connections because sometimes they need to take the water supply in case of uncontrolled fire. This is the main drain connection; the check valve and water motor. So this is the typical dry pipe sprinkler system.

And here is the anatomy of dry pipe sprinkler system: This is the water supply line. And this is actuated with the air pressure. The main water clapper and seat, so in case of losing pressure then it automatically actuate and this valve open ups to fill the water inside the sprinkler system.

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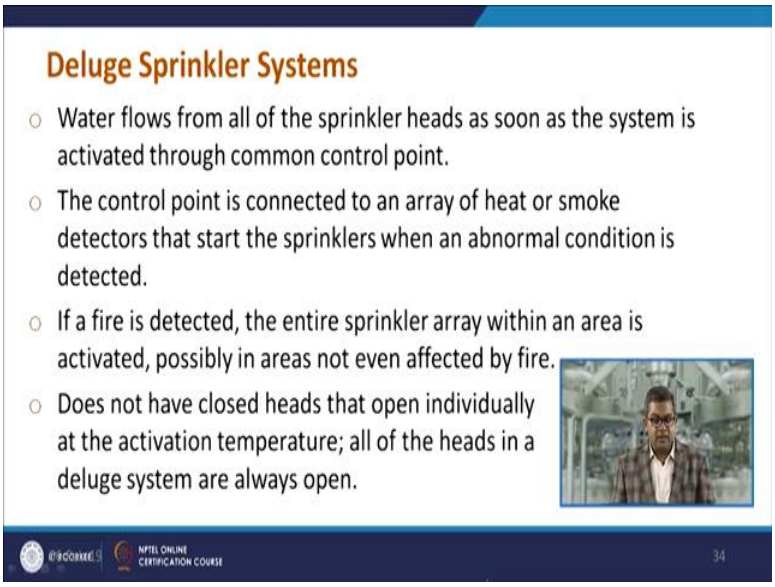

Now the next sprinkler system which we are going to discuss is the deluge sprinkler system. So water flows from all of the sprinkler head as soon as the system is activated through the common control point. The control point is connected to an array of heat or smoke detectors that starts the sprinkler when an abnormal condition is detected. Now if a fire detected, the entire sprinkler array within an area is activated and possibly in areas not even affected by fire. So it does not have closed head that open individually at the activation temperature and all the heads in a deluge system are always open.

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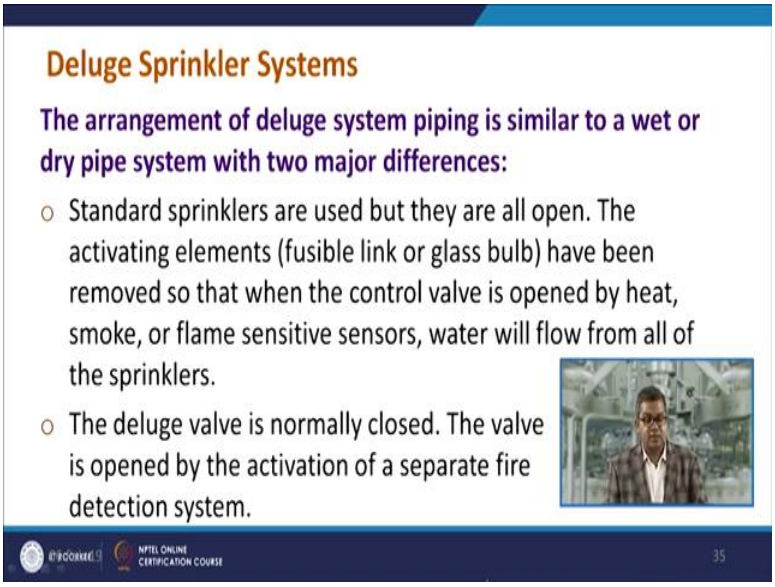

So the arrangement of the deluge system piping is similar to a wet or dry pipe system with two major differences: One is that the standard sprinklers are used but they are all open. The

activating element, that is a fusible link or a glass bulb, have been removed so that when the control valve is opened by heat, smoke, or flame sensitive sensors, water will flow from all of the sprinklers. The second difference is that deluge valve is normally closed, the valve is opened by the activation of a separate fire detection system.

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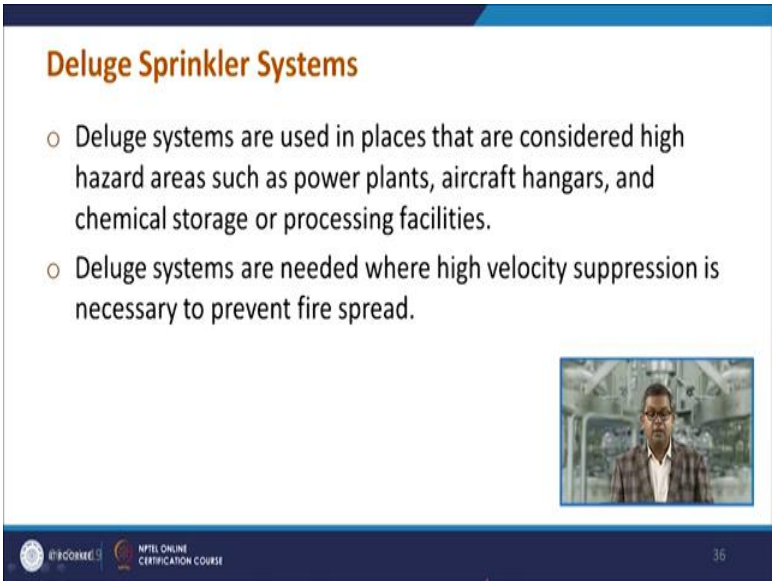

So the deluge systems are used in places that are considered high hazard areas such as power plant, aircraft hangars and chemical storage or processing facilities. So deluge systems are needed where high velocity suppression is necessary to prevent fire spread.

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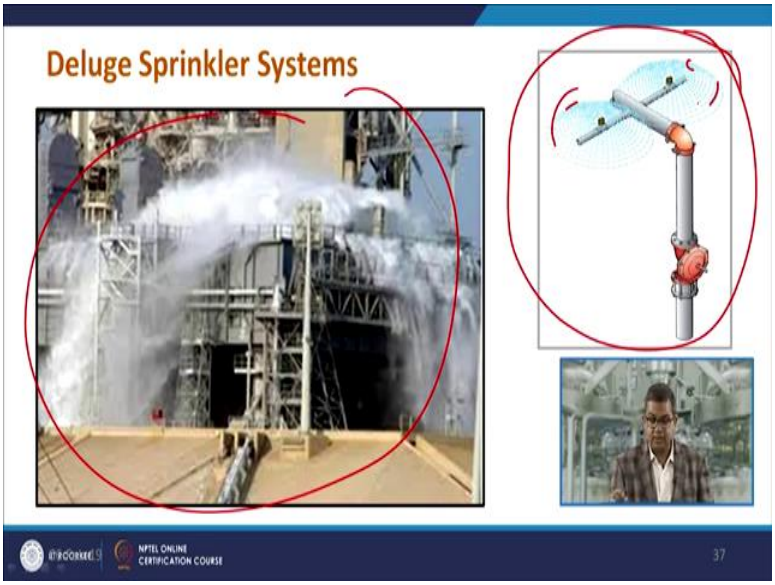

Now this is typical photograph of deluge sprinkler system and this is the functioning of how this deluge sprinkler system works, like this we can see.

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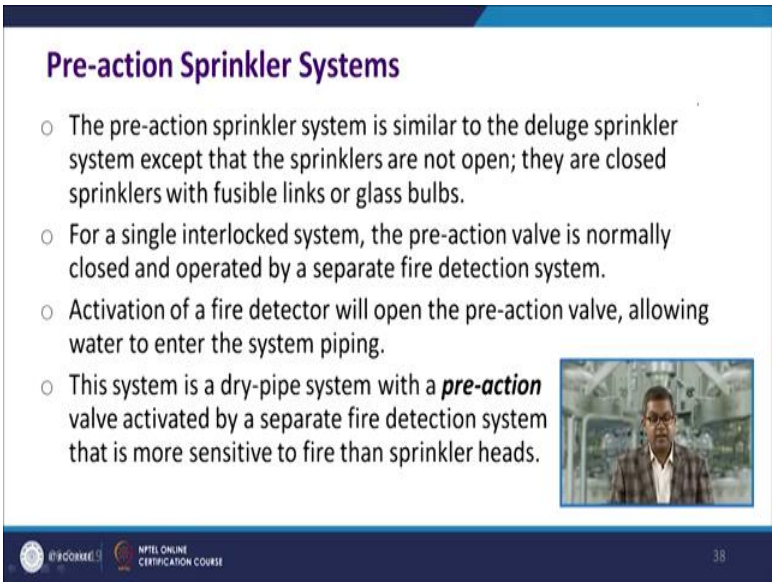

Now the last segment in this category is the preaction sprinkler system. The preaction sprinkler system is similar to the deluge sprinkler system, except that the sprinklers are not open; they are closed sprinklers with fusible link or glass bulbs. For a single interlocked system, the preaction valve is normally closed and operated by a separate fire detection system.

Activation of a fire detector will open the preaction valve, allowing water to enter the system piping. This system is a dry pipe system with a preaction valve activated by a separate fire detection system and that is more sensitive to fire than the sprinkler head.

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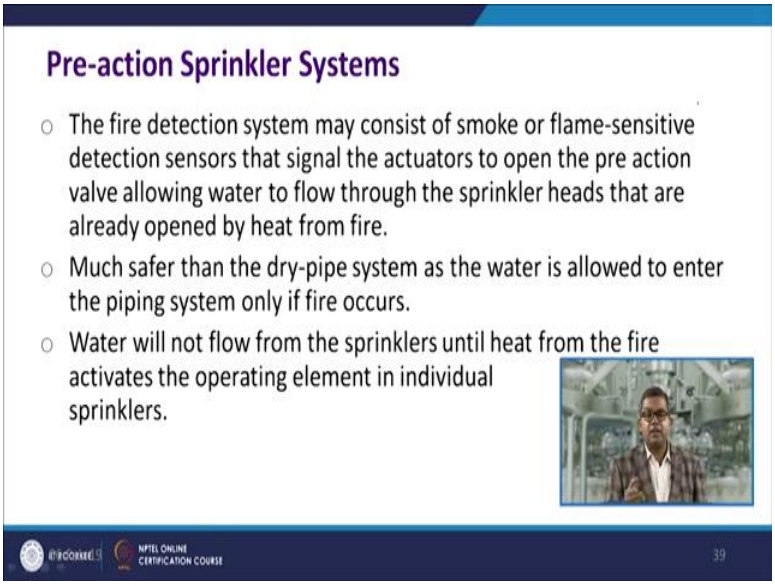

The fire detection system may consist of smoke or flame-sensitive detection sensors that signal the actuator to open the preaction valve, allowing water to flow through the sprinkler heads that are already opened by heat from fire. It is much safer than the dry-pipe system as the water is allowed to enter the piping system only if the fire occurs. Water will not flow from the sprinkler until heat from the fire activates the operating element in individual sprinkler. So you can differentiate among all the sprinkler system.

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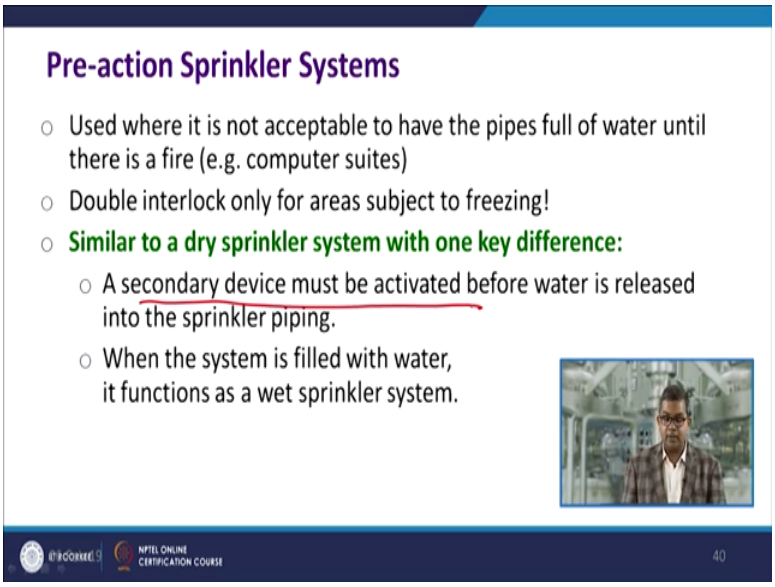

They are used where it is not acceptable to have the pipes full of water until there is a fire, that is like computer suites or etc. Double interlock only for the areas subjected to freezing, so that we can minimize the hazard. They are similar to dry sprinkler system with one key difference and that is the secondary device must be activated before water is released into the sprinkler piping. So when the system is filled with water it functions as a wet sprinkler system. So this is the only difference that a secondary device must be activated.

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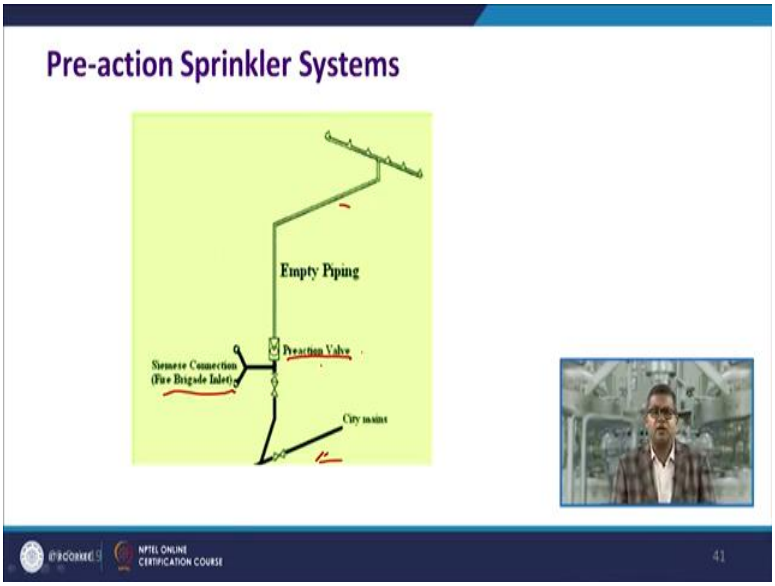

Now this is the figure which explains the preaction sprinkler system. There are the empty pipes and this is the preaction valve over here. There are fire brigade inlets etc, and this is the City mains. So this is a very small setup. Now in this particular module we have studied all kind of sprinkler system, what is the anatomy of the different sprinkler system; we have discussed all aspects, where to use and where not; advantages and disadvantages.

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And for the further reading you can have a look of references listed over here. Thank you very much.