What is Scale Formation ?

Scale formations in boilers are responsible for lost efficiency, increased maintenance and operating costs not to mention lost revenue due to outages and downtime. Most scale formations in boilers can be traced to the presence of hardness in the make-up water. This hardness reacts in the high temperatures environment within the boiler to form and insoluble scale. This insoluble scale coats the heat transfer surfaces, acting as an insulator to impede heat transfer.

Hardness isn't the only cause if scale formation in boilers, other impurities such as iron, silica, copper, oil, etc. are often found in samples of boiler scale. In fact, it is rare to find scale which isn't the result of several of these impurities.

Normally pre-softening the water before feeding it to the boiler is the first step in eliminating scale formations. Even when the make-up is soft, there is still a need for chemical scale inhibitors inside the boiler. With proper treatment the problems of lost efficiency, tube damage and lost production can be avoided or greatly reduced. Proper treatment requires the right balance of chemical treatment and control.

How do I stop Scale Formation from happening ?

The first and foremost aspect of stopping scale formation is to have a good idea of the make-up water that is feeding your system. If you aren't sure, have a certified laboratory complete a fully analysis on this water so you can make an informed decision on what exactly the potential problems you may encounter. After determining these specific aspects of your make-up water then your water treatment expert can guide you through a program that fits your situation.

Just a few items that may be of concern when putting together a good water treatment program for your boiler. A complete program will include sludge build-up, pH levels, oxygen removal, condensate treatment, and alkalinity levels.

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What is corrosion ?

Corrosion in boilers can almost always be traced to one or both of two problems. The most common cause is dissolved oxygen entering the system via the feed-water. The oxygen causes very localized corrosion to occur in the form of pitting. The pits are small but deep pinpoint holes which eventually can penetrate tube walls and cause their failure. Another common cause of corrosion in boiler systems is low pH within the boiler. This reduced pH may result from carbon dioxide infiltration or form contamination by other chemicals.

Oxygen corrosion is normally controlled by driving the oxygen from the feed-water in a deaerating heater or by chemically removing it with an oxygen scavenger such as sodium sulfite.

There are many contaminates which can infiltrate a boiler system and cause low pH levels to develop. Manufacturing wastes such as sugar or acids from plating operations which can be returned to the boiler with condensate can be a source of problems because they concentrate in the boiler. Oxygen can infiltrate the boiler system at virtually any point. When dissolved, oxygen is present in boiler feed water attach on feed lines, pumps and economizers can be expected. The severity of the attach depends upon the concentration of the oxygen and the temperature of the water.

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How do I stop Corrosion ?

You can use a deaerator which is defined as a piece of equipment which heats water with steam to insure essentially complete removal of dissolved gases. There are several types of deaerator available, each having its own advantages and disadvantages.

Internal treatment for dissolved oxygen corrosion is normally accomplished by the addition of sodium sulfite. Most oxygen scavengers contain a catalyst which speeds the reaction of the sulfite with the oxygen. In systems equipped with a deaerator the sulfite should be fed to the storage tank of the deaerator or to either the suction or pressure side of the feed water pump. In systems which do not have a deaerator, the sulfite can be fed at almost any point in the feed water system, including the condensate tank.

Internal treatment for carbon dioxide is normally accomplished by the use of a volatile amine. "Amine" refers to any of a number of chemicals derived from ammonia. There are two major groups of amines in practice as water treatment chemicals today. There are normally referred to as "neutralizing amines" or "filming amines" depending upon whether they neutralize the acid formed by carbon dioxide or form a protective film on the metal.

Filming amines do not neutralize the carbonic acid which forms in condensate systems. Instead, they form a film on the metal which is non-wettable, or impervious to water. this protective film prevents the corrosive impurities from contacting the metal.
Neutralizing amines function by increasing the pH of the condensate. Normally they are fed at such a rate that the pH of the condensate is maintained slightly above 7.0. Satisfactory reduction of carbon dioxide corrosion is possible with the use of a neutralizing amine. it is necessary to supplement this type of condensate protection with an oxygen scavenger to remove dissolved oxygen.
Whether condensate corrosion is controlled by chemical treatment or a combination of mechanical and chemical methods, it is important that careful checks and testing be incorporated as a part of the treatment program. No treatment can be better than the way in which it is applied. Consult a water treatment expert to get you started on the right foot.

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Why all the concern about Condensate Treatment and Monitoring ?

Your Condensate is very important to your facilities overall operation, ignoring this unseen component will soon cause failures costing bottom-line dollars. Therefore, condensate must be treated with the proper chemistry. Treating your plants steam condensate is critical for several reasons, but these are the most important two reasons:

1. To insure the integrity of your equipment.
2. To keep the amount of condensate corrosion minerals that is returned to the boiler's makeup water in check.

Corrosion in your steam lines occurs when the carbonic acid builds up and begins to breakdown the metallic surfaces throughout the system. When the Carbonic acid is allowed to build, localized attacks occur due to the simple increase in CO_2, which is the breakdown product of carbonate alkalinity in the boiler, condensing with water to form H_2CO_3. This results in the "pitting" of condensate piping, which usually shows up by visual leaks at threaded junctions. Oxygen pitting occurs as steam condenses and the vacuum created pulls air into the system. Due to the localized nature of oxygen pitting, it can cause relatively quick failure in a condensate system.
The most common method of dealing with this problem is through the use of neutralizing amines. These chemicals, better known as morpholine and cyclohexylamine, neutralize the carbon acid, and increase the pH of the condensate. Corrosion of mixed metallurgy condensate systems is minimized when the pH is maintained between 8.8 and 9.0. Due to high alkalinity in boiler makeup water elevating the pH to this level may not be economical. In this case the pH should be maintained at 8.3 or higher, or a filming amine applied.
A filming amine, such as octyldecylamine, provides a non-wettable protective barrier against both carbonic acid and oxygen. When utilizing a filming amine, the pH is usually maintained between 6.5 and 7.5, so a neutralizing amine may still be required.

In order to minimize oxygen pitting one can utilize a filming amine as previously mentioned, or a volatile oxygen scavenger such as DEHA (diethylhydroxyamine.) DEHA provides better results as it scavenges oxygen and passivates or coats the condensate system, making it less susceptible to corrosion.
Depending on the treatment method chosen, condensate monitoring can vary. In all cases the following tests should be performed.

1. Soluble and insoluble iron levels.
2. pH levels at various points in your steam condensate system. It is extremely important that pH measurements be made on cooled samples. If the sample is taken hot, carbon dioxide will gas off, which results in artificially high pH measurements.

If a filming amine is utilized, the residual should be measured. The same is true if DEHA is used as an oxygen scavenger. In the latter case, a residual of 100 to 150 ppb is usually targeted. Note that this may take time (as much as 6 months) since much of the DEHA will be consumed passivating the system.

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How do I to Prevent the Most Common Boiler Problems ?

A regular inspection schedule is critical and should cover four areas: boiler, burner, controls, and system.

Preventive maintenance is the most widely used means of minimizing common problems in boilers. Unfortunately, most maintenance programs do not properly address the needs of the boiler and its related systems. Statistics indicate about two-thirds of all boiler failures and nearly all unscheduled shutdowns are caused by poor maintenance and operation.

Boiler inspection and maintenance are critical. It covers four basic areas: boiler, burner, controls, and system.
Regardless of boiler design, application, or size, the basic maintenance criteria remain the same.

Maintaining the Boiler
There are eight primary areas of the boiler itself that should he examined or inspected regularly.

Water level. The most important maintenance inspection is to check the boiler water level daily. Insufficient water causes pressure vessel damage or failure. At a minimum, steel in the pressure vessel could overheat. The condition could change the pressure withholding capabilities of the vessel, necessitating vessel repair or replacement. More seriously, a low water level could damage the equipment or building. or even cause personal injury.

Boiler blow down. Steam boilers should be blown down daily to maintain recommended dissolved solids levels and to remove sludge and sediment. Hot water boilers generally take on no makeup water and, therefore do not need to be blown down.

As the boiler takes on makeup water the solids concentration builds up. Solids accumulate in either dissolved or suspended form. Unless they are controlled dissolved solids promote carryover of water with the steam causing water hammer and damaging piping, valves, or other equipment. Carryover also raises the moisture content in the steam, affecting proper operation of equipment that uses steam.

Suspended solids, which cause sludge or sediment in the boiler, must be removed because they affect the heat transfer capabilities of the pressure vessel. Sludge buildup leads to problems ranging from poor fuel-to-steam efficiency to pressure vessel damage.

Water column blow down. Water columns on steam boilers should be blown down once each shift or at a minimum once a day. This action keeps the column and piping connections clean and free of sediment or sludge. The water column also must he kept clean to ensure the water level in the gauge glass accurately represents the water level in the boiler. The gauge glass and tricocks connected to the water column are the only means of visually verifying boiler water level.

The low-water cutoff should be checked once a week by shutting off the feed water pump and letting the water evaporate under normal steam conditions at low fire. The gauge glass should he observed and marked at the exact point at which the low water cutoff shuts down the boiler. The test verifies operation of the low-water cutoff under operating conditions. The low-water cutoff also should the removed and cleaned every six months.

Water treatment. Proper water treatment prolongs boiler life and ensure safe and reliable operation. Treatment programs are designed around the quality and quantity of raw water makeup and system design. They should be directed by a qualified water management consultant. Flue gas temperature. Flue gas temperature is a good indicator of boiler efficiency changes. The temperature should be recorded regularly and compared to those of a clean boiler under the same operating conditions. Accurately determining the affect on efficiency requires that the firing rate and operating pressure be the same.

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A rise in flue gas temperature usually indicates dirt on the fireside of the boiler or scale on the waterside. As a rule of thumb a 40-deg F rise in temperature reduces boiler efficiency 1% The cost of fireside cleaning should be compared to those of lower operating efficiencies to determine the minimum temperature rise at which the fireside should be cleaned. Other factors also affect flue gas temperature. For example, a rise in stack temperature may indicate a baffle or seal in one of the boiler's passes has failed.

Waterside and fireside surfaces. Waterside and fireside surfaces should be inspected and cleaned annually. A visual inspection provides an early warning that the vessel needs repair or water treatment or that combustion needs adjustment. Inspecting and cleaning water-column connections should receive special attention. Soot in the breeching is a fire hazard and can cause severe combustion-related problems.

Safety valves. Safety valves are the most important safety devices on the boiler They are the last line of defense for protecting the pressure vessel from overpressure. Once a year. operating pressure should be tested by bringing the relief valve to its setting. Valves should pop and reseat according to the valve stamping.

Refractory. Refractory protects steel not in direct contact with the water from overheating. It also helps maintain proper burner flame patterns and performance. If the boiler remains on all the time, refractory should be inspected twice a year. If the boiler cycles more frequently or is turned on and off daily, refractory should be inspected more often.

Heating and cooling refractory a lot shortens its life considerably. It cracks and eventually fails. Hot spots on the steel that the refractory protects indicate refractory or gasket failure. If a hot spot is found, the cause should be determined and repaired immediately to prevent the steel from failing.

Maintaining the Burner
Although burners vary by design, application, fuel, regulations, and insurance requirements, the same basic maintenance criteria must be addressed. Burner maintenance generally focuses on safety. efficiency, and reliability. Adjustments should be made only by a trained service technician using the proper instrumentation and tools.

Combustion. Poor combustion is unsafe and costly. Changes in combustion air temperature and barometric pressure, for example, impact burner performance (see table). Low excess air levels result in incomplete combustion, sooting, and wasted fuel. High excess air levels raise stack temperatures and reduce boiler efficiency. Maintaining steady excess air levels with an oxygen trim system helps ensure optimum efficiency at all times.

Visually inspecting combustion is the easiest way to detect changes that affect safety and efficiency. Changes in flame shape, color, and sound are among early indicators of potential combustion-related problems. Changes may be due to:

Large fluctuations in ambient temperatures
Changes in fuel temperature, pressure, heating value, or viscosity
Linkage movement dirty or worn nozzle
Dirty or distorted diffuser dirty fan
Dirt on the boiler fireside
Furnace refractory damage.

Visual combustion inspection should be compared to flame characteristics observed at similar firing rates with efficient combustion. However, combustion efficiency is verifiable only with a flue gas analyzer. Even if a flame appears to be good, it should be checked with an analyzer and adjusted once a month.

Fuel and air linkage. Changes in fuel and air linkage affect the combustion fuel-to-air ratio. Flame failure or a hazardous fuel rich condition may result. Proper linkage settings should be physically marked or pinned together. Linkage should be checked for positioning, tightness, and binding. Any noticeable changes should be remedied immediately.

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Oil pressure and temperature. Pressure and temperature directly affect the ability of oil to properly atomize and burn completely and efficiently. Changes promote flame failure, fuel-rich combustion, sooting, oil buildup in the furnace, and visible stack emissions. Causes include a dirty strainer, worn pump, faulty relief valve, or movement in linkage or pressure-regulating valve set point. Oil temperature changes typically are caused by a dirty heat exchanger or a misadjusted or defective temperature control.

Gas pressure. Gas pressure is critical to proper burner operation and efficient combustion. Irregular pressure leads to flame failure or high amounts of carbon monoxide. It may even cause over or under firing, affecting the boiler's ability to carry the load. Gas pressure should be constant at steady loads, and should not oscillate during firing rate changes.

Usually, pressure varies between low and high fire. Therefore, readings should be compared to those taken at equivalent firing rates to determine if adjustments are needed or a problem exists. Gas pressure irregularities are typically caused by fluctuations in supply pressure to the boiler regulator or a dirty or defective boiler gas pressure regulator.

Atomizing media pressure. When oil is burned, an atomizing medium, either air or steam, is needed for proper, efficient combustion. Changes in atomizing media pressure cause sooting, oil buildup in the furnace, or flame failure. Changes result from a regulator or air compressor problem or a dirty oil nozzle.

Fuel valve closing. If a fuel valve leaks, after burn may occur when the burner is turned off, or raw fuel could leak into a hot boiler and cause an explosion. When the burner is turned off, the flame should extinguish immediately. Prolonged burning is a hazard and demands immediate action.

Maintaining the Controls
Controls are often used to protect the boiler against unsafe operation. Flame safeguard, operating, limit, and safety interlock controls are among the most common. Of course, controls only protect the boiler if they are maintained and adjusted properly.

Flame safeguard control. Also called the primary control or the programmer, the flame safeguard control ensures safe light-off, operation, and shutdown of the burner. The control regulates purging the boiler of all gases prior to trial for ignition. It also verifies that there is no flame in the boiler prior to lightoff, and checks for a pilot before allowing the main flame to light. The control provides proof that the main flame has ignited before releasing the boiler to the run (modulation) mode. Most importantly it does not allow any action to occur if operating controls, limits, or safety interlocks are open.

In addition, this control initiates a post purge upon shutdown to remove all gases from the boiler. And it often provides a means for detecting a problem elsewhere in the system. Although the flame safeguard is designed for fail-safe operation and is quite reliable, a faulty device can be catastrophic and should not be ignored.

Operating and limit controls. These controls tell the boiler at what temperature and pressure to operate. Proper settings minimize boiler cycling, maintain proper limits for efficient system operation, and ensure the boiler shuts down when predetermined limits are reached.

Improperly set operating controls cause the burner to operate erratically and stress the pressure vessel. All these controls should be checked weekly. The scale of the control for temperature or pressure settings should not be relied upon. Settings should be verified with the actual operating temperatures and pressures on the boiler gauges.

Safety and interlock controls. Safety and interlock controls vary with state, local, and federal codes and insurance requirements. They must be operational at all times. Among the consequences of inoperable safety interlocks are personal injury, equipment or property damage, and liability for losses or damages. All interlocks should be checked weekly for proper operation. A defective control should be replaced immediately. A control should never be bypassed to make a boiler run.

Indicating lights and alarms. Indicating lights and alarms are part of the control circuit. They alert the operator to specific boiler conditions. Unfortunately, they are often neglected and do not provide the intended information. Many control circuits have test buttons to verify proper operation. Circuits that do not should be checked by simulating conditions that activate a light or alarm.

Maintaining the System
All too often, when a boiler problem occurs, the system is overlooked. The emphasis falls on the equipment and not the equipment's function in the overall system. An effective maintenance program must be based on an understanding of the entire system and the function of each piece of equipment. Only an understanding of the system provides the means for preventing the causes of system-related problems and reducing the time spent on the symptoms.

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Operating conditions. Operating parameters of the boiler room system should be recorded daily. The data provide a means for evaluating boiler operation trends that affect efficiency, downtime, and maintenance planning. The following data should be recorded.

Feed water pressure/temperature. Changes in feed water pressure affect the system's ability to maintain proper boiler water levels. A pressure drop may be caused by a leaky check valve on a standby pump or a worn pump impeller. Changes in feed water temperature are indicative of a problem in the deaerator, potential pump seal damage, loss in efficiency, dirty economizer, dirty blow down heat recovery exchanger, or excessive or insufficient condensate returns.

Boiler water supply/return temperatures. On hot water systems, supply and return temperatures to the boiler are a means for evaluating the system's effect on the boiler and vice versa. The desired operating temperature set point and temperature differential across the boiler should be evaluated against the system design to determine if a potential problem exists. High temperature differentials caused by excessive load or a control malfunction could cause thermal shock and subsequently pressure vessel damage.

Makeup water use. Records of the amount of makeup water used help determine the presence of leaks or losses in the system. They also assist in developing a more effective chemical treatment program. Excessive water use indicates a change in system operation and, therefore, a change in efficiency.

Steam pressure. Steam pressure operating set points usually are based on system design and type of steam use. Pressure changes are typically caused by problems with control settings, burner operation, boiler efficiency, or, most commonly, changes in steam demand.

Leaks, noise, vibration, and unusual conditions. Checking for leaks, noise, vibration, and the like is a cost-effective way to detect system operational changes. For example, a small leak is repaired by tightening connections. By the time a leak becomes large, sealing surfaces usually are worn and major repairs are needed.

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A More In-depth Look

A maintenance program must focus on prevention to be an effective tool. Whether the maintenance program is motivated by safety, cost, reliable operation, or all of these, it is the best means of preventing common, boiler-related problems.
Automatic low-high water control equipment must be serviced on a daily basis when the boiler is in operation. A high frequency of boiler failures is the result of low water, and can be attributed to a careless boiler operator. A procedure must be established at your school to regularly clean the glass gauge column by "blowing down" the column at the start of the school day, during non-peak operating periods, and at the conclusion of the school day or shift. This ensures ability to determine the level of water in the boiler.

Low Water
A major reason for damages incurred to low pressure steam boilers is the low water within the boiler. If the condition of low water exists it can seriously weaken the structural members of the boiler, and result in needless inconvenience and cost. Low pressure boilers can be protected by installing an automatic water level control device.

Steam boilers are usually equipped with automatic water level control devices. It must be noted, however, that most failures occur due to low water on boilers equipped with automatic control devices. The water control device will activate water supply or feed water pumps to introduce water at the proper level, interrupt the gas chain and ignition process when the water reaches the lowest permissible level, or perform both functions depending on design and interlocking systems. No matter how automatic a water control device may be, it is unable to operate properly if sediment scale and sludge are allowed to accumulate in the float chamber.

Accumulations of matter will obstruct and interfere with the proper operation of the float device, if not properly maintained. To ensure for the reliability of the device, procedures must be established in your daily preventive maintenance program to allow "blow-down" the float chamber at least once a day. Simply open the drain for 3 to 5 seconds making certain that the water drain piping is properly connected to a discharge line in accordance with local Codes. This brief drainage process will remove loose sediment deposits, and at the same time, test the operation of the water level control device. If the water level control device does not function properly it must be inspected, repaired and retested to guarantee proper operation.

Low Water Cutoff - Tests and Maintenance
There are two very effective tests for low water controls on steam boilers. The first is the quick drain. or blow down test, which should be performed at a time other than a peak steam generating period. As the water is drained from the column the firing sequence is interrupted, the low water alarm signal activates and the boiler operation shuts down.

The second, and more costly method is the slow-drain test. By opening the blow down valves the water level can be checked to determine the water level in the column, the gauge glass, and the boiler. The boiler should shut down while you determine the level in the gauge glass.

As a safety precaution, the low water float chamber of hot water boilers should be tested daily, at the beginning of the shift, at the end of the shift, and once during non-peak firing periods. Time of tests and the boiler controls tested should be recorded on your Boiler Room Log.

Annually, or as required, a thorough inspection of all low water control parts shall be performed. The annual inspection should include opening and cleaning the water chamber.

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Feed Water Pumps
Old, worn and obsolete feed water pumps are sometimes overlooked as potential problems. A centrifugal pump may have worn seal rings that allow the water to chum between the suction and discharge openings.

An indicator of the latter problem is low pressure discharge. Also, by comparing the time it takes to raise the boiler water level to a predetermined level or the time to empty the condensate tank to the time it formerly required, it is possible to determine if a pump is operating properly. Also, a pump that operates quietly does not mean it is functioning properly.

Overpressure
Safe operation of a boiler is dependent on a vital accessory, the safety valve. Failure to test the safety valve on a regular basis or to open it manually periodically can result in heavy accumulations of scale, deposits of sediment or sludge near the valve. These conditions can cause the safety valve spring to solidify or the disc to seal, ultimately rendering the safety valve inoperative. A constantly simmering safety valve is a danger sign and must not be neglected. Your preventive maintenance program includes the documentation and inspection of the safety valve. A daily test must be performed when the boiler is in operation Simply raise the hand operating lever quickly to its limit and allow it to snap closed. Any tendency of a sticking, binding or leaking of the safety valve must be corrected immediately.

Steam Traps - Care and Maintenance
Steam traps have play a very important role in steam distribution systems. The service performed by steam traps is primarily to discharge condensate. Normally a steam trap can be easily and quickly selected by considering only the average operating conditions. However, an exact analysis of these conditions will give the proper data necessary for selecting the type and size for greater savings and proper plant operation. After the careful selection of the steam trap, it must be properly installed, tested, periodically inspected, cleaned and maintained to keep it operating efficiently.

Traps need cleaning periodically. A simple way to prevent dirt from entering is to drop a short length of pipe vertically below the supply to the trap (called a dirt leg) which can be cleaned easily and frequently.

Traps can be seriously damaged by scale or pipe comings in lines. A good practice is to install strainers ahead of the traps which should be inspected and cleaned frequently.

Traps are subject to severe wear if steam blows through continuously. They should be inspected for worn valve parts or a change in operating conditions.

When a steam trap fails to discharge, inspect the heating system and be certain that all units are drained with separate traps, thus guarding against short circuiting, loss of energy, and reduction of operating efficiency.

Traps operating under high pressure or superheated steam are often insulated in a manner similar to adjacent pipe lines. In such instances, they shall be fitted with dirt pockets, test valves, and drains.

Steam traps installed in areas exposed to climatic conditions will lose heat if not insulated and may freeze unless adequately protected. Discharge lines should be short and self draining and traps should be fitted with a drain tapping and valves.

Steam traps handling large volumes of air require more frequent inspection and proper venting for efficient operation. Vents shall be used to avoid air binding and ensure positive drainage. Gauge glasses shall be kept in proper repair, for they indicate whether or not the trap is working. Periodic cleaning and gauge glass replacement shall be considered as a high priority in the maintenance of steam traps.

All steam traps require protection from corrosion to prevent unnecessary deterioration. All valves, joints, and gaskets should be kept tight to avoid steam leakage and ultimate energy losses. For continuous and efficient operation. steam traps require periodic inspection and maintenance for purposes of eliminating foreign matter and obstructions in supply and discharge lines. Each steam trap at an assigned work station should be inspected as specified by the preventive maintenance program.

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Steam Trap - Troubleshooting
It is important to inspect the operation of steam traps frequently. There are many conditions under which traps may fail to operate property. The following are some of the most common reasons for trap failures:

1. Condensate does not flow into the trap:

A. Obstruction in line to trap inlet.
B. Valves leading to trap are closed.
C. Bypass open or leaking.
D. Trap may be air bound.
E. Insufficient pressure to blow condensate through orifice.
F. Improper installation of trap.
G. Accumulation of foreign matter within the trap.
H. Trap held closed by defective mechanism.
I. Strainer may be blocked.

2. Condensate fails to drain from trap.

A. Discharge valve may be closed.
B. Trap may not be large enough to handle condensate.
C. Pressure may be too low to blow the condensate through.
D. Improper installation for draining.
E. Check valve may not be holding.
F. Obstruction in return line or the line may simply be too small.

3. Trap does not shut off.

A. Trap is too small for the condensate load.
B. Trap held open by defective mechanism,
C. Overload due to excessive boiler foaming or priming.
D. Submerged steam coils leaking.
E. Differential pressure exceeds design of trap.
F. Scale or foreign matter lodged in orifice.

4. Steam blows through trap.

A. Valve mechanism does not close due to wear or defective valve.
B. Mechanism is held open by foreign matter.
C. Trap has not been properly primed or reprimed after clean-out or blow-off.
D. Bypass is open or leaking.
E. Excessive pressure for design of trap.

What is the meaning of Horse Power ?

Horse Power is a unit of measurement of the ability of a boiler to evaporate water, usually given as the ability to evaporate 34¸ lb. (15.6 kg) of water an hour, into dry saturated steam from and at 212¡F (100¡C).

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