CERTIFICATION OF APPROVAL

Study the Failure of Steam Trap of PETRONAS Penapisan Melaka Sdn. Bhd (PPMSB)

by

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MOHD SHUHAIMI BIN MAT ISA

ABSTRACT

The objectives of this project are; to study the failure of steam trap in plant (PPMSB) and determine the root cause of the problem. Previously, according to the data that had been collected, the numbers of failure rate of steam trap in plant are too high. The intention of this project is to analyze the existing problem of steam trap in the plant and finally come out with the solution to make sure the numbers failure rate of steam trap will be reduced. This is very important to increase the efficiency of steam trap to remove condensate, air and other non-condensable gases, while not losing any live steam. Besides, this project also will focus on the function and the working principle of steam trap. Area 5 (utilities) on Production Services Department (PSD) is selected as data references which is located at PETRONAS Penapisan melaka (PPMSB).

Steam trap is the equipment function to trap the live steam and to remove condensate, air and other non-condensable gases. Basically there have three common types of steam trap which is Mechanical steam trap, Thermostatic steam trap and Thermodynamic steam trap. All of these types have same function but different characteristic and working principle.

In completing this project some of the experiment and trouble shooting have been done in order to identify the steam trap failure. Some calculation also will be involved to calculate the piping arrangement of steam trap. Microsoft office Excel and other engineering software such as ANSYS will be utilized to analyze the steam trap data and to do steam trap simulation. Other methods such as research from the internet, journals and thesis will be used for reference purposes.

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ABBREVIATIONS

ST	Steam Trap
FC	Failed Closed
FO	Failed Opened
MIY	Name of Steam Trap Manufacturer
TLV	Name of Steam Trap Manufacturer
TAR	Name of Steam Trap Manufacturer
GES	Name of Steam Trap Manufacturer
PM	Preventive Maintenance
MO	Material Order
LP	Low Pressure
MP	Medium Pressure
HP	High Pressure

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Steam is generated in the boiler and conveyed through piping to the steam-using equipment. However, in spite of the fact that the steam pipe work is usually well insulated to prevent the loss of heat, some heat will be radiated from the piping. Steam travelling along the pipe work will transfer some of the heat it is carrying to the wall of the pipe to make up the losses due to radiation, and in so doing some of the steam will condense forming condensate (hot water) in the bottom of the pipe.

If this condensate were allowed to remain in the pipe, it would both extract more heat from the steam and also gradually fill up the pipe, blocking the passage of steam with disastrous consequences. What is therefore required is a simple automatic device that will allow such condensate to drain form the pipe, without allowing steam to escape.

Such a device is known as a steam trap and its importance in maintaining the safety and efficiency of the steam system should not underestimated.

Similarly when steam finally enters the equipment, heat is transferred through the wall to the fluid or product being heated. As the steam gives up its heat it condenses, the condensate so formed beginning to collect within the steam space of the equipment. Like the steam pipe work, this condensate should not be allowed to remain, otherwise the process of heat transfer would slow down and eventually cease altogether. Therefore, the simple automatic steam trap must be used to drain away the condensate, without any steam escaping.

In summary, there have 3 important functions of steam trap:

a. To discharge condensate
b. To prevent the escape of steam
c. To be capable of discharging air and non-condensable gases

1.2 Problem Statement

A steam trap is an automatic valve that holds the steam at the load until it gives up its heat energy and condenses to water (condensate). After the steam condenses to water, the steam trap allows only the condensate to pass, thereby contributing to plant efficiency. Since steam naturally releases heat, which causes condensation, another use for traps is to keep steam lines free of condensate. If the condensate is not removed it will cause water hammer which can cause damage to valves, piping, and equipment. Considerable damage can be costly and eventually require equipment replacement.

As reported the steam trap in plant always faced a problem. Every year, the numbers of failure rate of steam trap increase seriously. This problem will give bad effect to the plant operation and PPMSB have to spend a lot of money for the maintenance cost. Based on the analysis before, there have 3 major problem of steam trap had been detected which is fail open, fail close and leaking. This project intends to find out the critical problem of the steam trap, analysis the problem and then will try to solve it. Following are some of the brief explanation about the general problem of steam trap in plant.

a. Steam trap fail open
   This is failure to contain steam thus releasing live steam into condensate discharge line after the steam trap.

b. Steam trap fail close
   This is failure to release condensate from the trapped steam. Thus condensate accumulated upstream of steam trap and the line is cold. This is dangerous for steam line and may introduce water hammering.

c. Steam trap leaking
   This is leaking thru threaded joints like the strainer's plug or inlet or outlet connection. This does not affect steam line but waste of valuable steam to atmosphere.

The intention of this project is only focus on the fail close and fails open of the steam trap. According to the data that have been collected last semester and after analyzing, the main and critical problem of steam trap are the fail close and fail open. Only a few of the steam trap faces the leaking problem.

1.3 Objectives and Scope of Study

The objectives of this project are as follows:

a. Analyze the problem of the existing steam trap by analysis the data taken from PPMSB
b. Identify the root cause of the steam trap problem.
c. Study the detail on the types of existing steam trap in term of their characteristic, application and working principle.

Basically this project, which kicked-off on 1st of August, 2003, can be divided into 2 halves. The first semester is mainly focused on the literature reviews and some data analysis about the steam trap in order to identify the main problem. There will be also some calculation activities for the steam trap. The second semester will focus on how to identify the root cause of steam trap problem. This project must be completed within the specified time frame. Figure 1 at the appendices show the process planning will be taken throughout the project for first semester and second semester.

This project is more towards the identification and understanding of the steam trap in term of types and function. Student will do some study and research to analyze the problem of steam trap. After gathering all the information, student will find the alternative solution to solve this problem and than choose one out of the alternative as the best solution. In order to make sure the solution is suitable and applicable; student will use ANSYS software to do some piping simulation. In completing this project, a few calculations also will be involved to determine the effect of piping arrangement of the steam line that contribute to the failure of steam trap.

The final stage of this project is to analyze the efficiency performance of steam trap. The analysis more focuses on the ability and effectiveness of the steam trap to function at certain period of time by reducing the maintenance cost.

CHAPTER 2

LITERATURE RIVIEW

2.1 Classification of Steam Trap

There are many of steam traps in use today, not all of which can perform well the functions previously outlined. Before the principal types of traps available are examined in detail, it will aid in understanding of their operation if they are classified by their main categories.

There are 3 main categories:

a. Mechanical steam trap
b. Thermostatic steam trap
c. Thermodynamic steam trap

Mechanical traps work on the principle of differentiating between the density of steam and condensate. For example, a float that will rise up as the condensate level rises, opening a valve, but which in the presence of steam only will not become buoyant, hence the valve remaining closed.

Thermostatic traps operate by sensing the temperature of condensate. As steam condenses, the condensate so formed is at steam temperature, but as it flows to the steam trap it loses temperature. When the temperature has dropped to a specified value below the steam temperature, the thermostatic trap will open to release the condensate.

Thermodynamic traps operate on the difference between the flow steams over a surface, compared to the flow of condensate over the same surface. Steam, or for that matter a gas, flowing over a surface creates a low pressure area, this phenomenon being used to move a valve towards the seat and eventual closure.

2.1.1 Mechanical steam trap

a) Float-Thermostatic steam trap

There are two types of float-thermostatic steam trap currently in use within many steam-based process plants. There are:

i. Float and lever
ii. Free float.

i) Principle of operation- float and lever

The main valve controlling the flow of condensate from the steam trap is connected via a lever to a hollow stainless steel ball floats on the condensate held in the body of the trap.

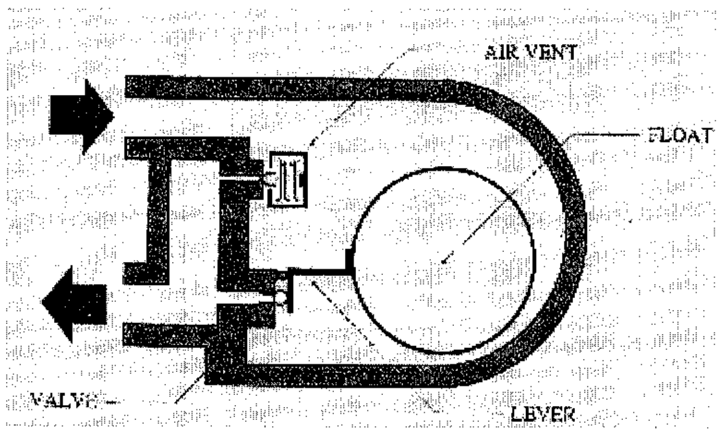

Figure 2.1: Float Thermostatic Steam Trap

When the trap is connected to the steam equipment and steam is turned on, air is pushed ahead of the steam and enters the trap first. The ball float is in its lowest position holding the valve against the seat. However, the thermostatic air vent is cold, so air is able t o pass through the orifice and into the outlet passage.

Cold condensate then follows the air into the trap body. As the condensate level rises, the float is carried upwards. The lever to which it is attached simultaneously opens the valve, allowing condensate to flow through the orifice to the trap outlet. If the rate of condensate flowing into the trap increase, the float will rise higher, thereby lifting the valve farther away from the seat and permitting more condensate to flow through the orifice.

Eventually steam reaches the trap, the associated temperature causing the thermostatic air vent to expand and close the valve onto its seat. If no condensate now flows into the trap and steam is present, the condensate level within the body will fall until the float (valve) seats itself on the valve sea, closing the valve and preventing the escape of steam.

ii) Principle of operation- free floats

The basic construction of a Free Float- Thermostatic trap is illustrated in figure above. Note that as the name implies there are no levers and the only moving part is the float itself. However, the float in this case is no ordinary float but is a high-quality precision-ground float manufactured in grade 316 L stainless steel. The valve seat is also a high quality component made from a hardened grade 420F stainless steel.

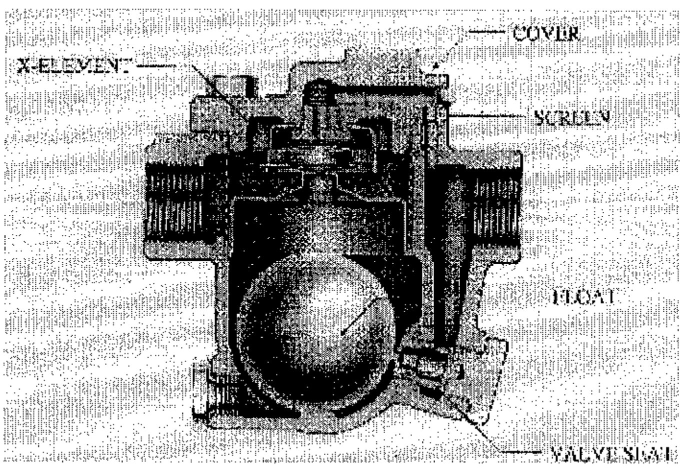

Figure 2.2: Free- Float Thermostatic Steam Trap

When the steam trap is installed and steam turned on to the equipment, air is pushed ahead of the steam and enters the trap. The air vent is cold, with the valve off its seat, allowing the air to flow freely through the orifice to the trap outlet. Cold condensate, following the air, then enters the trap causing the float to rise, opening up the valve seat and thus permitting condensate to flow out of the trap.

As the condensate rate increase, the float rolls away from the seat opening up more of the orifice to permit the increased flow to be discharged. If the rate increases until close to the maximum rated capacity of the trap orifice, the float will roll completely away from the seat. When doing so, the float turns a little within the trap so that when the condensate rate reduces and the level in the trap falls, the float is drawn once again to the seat, but now a different part of the surface area of the float comes into contact with the seat.

b) Inverted bucket steam trap

All types of inverted bucket traps work on the same principle. That is, a small inverted cylinder, which is sealed at one end, becomes buoyant when the condensate inside it is displaced by steam. Inside the trap, the cylinder or inverted bucket is linked to a lever on which the valve head is fastened. The end of the lever rests on the valve seat, thus acting as a fulcrum. At the top of the bucket is a small vent hole.

i) Principle of operation- Inverted bucket

When steam is turned on to the equipment, air is pushed a head of the steam and into the trap. The bucket is hanging down with the valve off the seat so air is pushed slowly through the orifice. Condensate then arrives at the trap, flooding it and because the bucket remains hanging down, the flow is also discharged through the orifice. Steam then enters the inlet, displacing the condensate trapped inside the bucket.

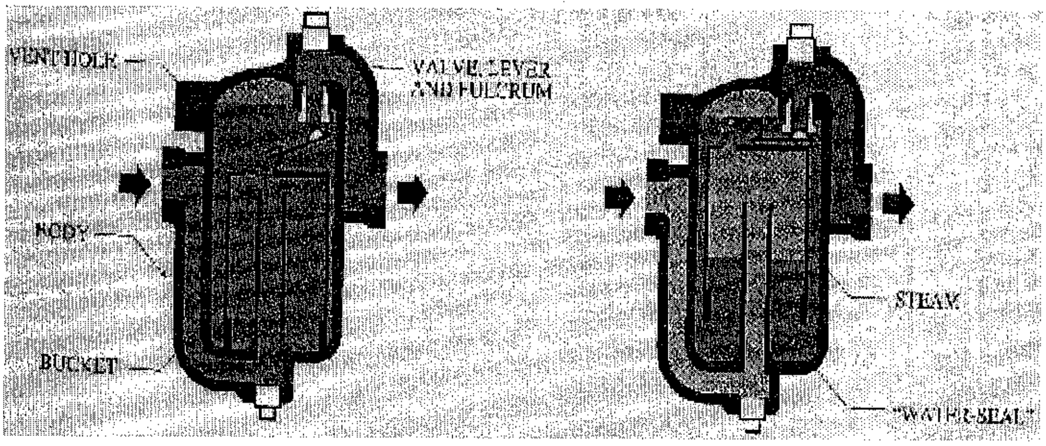

Figure 2.3: Inverted Bucket Steam Trap

This cause the bucket to become buoyant and rise, carrying the lever and valve upwards toward the seat. When the valve comes close to the seat, the high velocity flow of condensate through the orifice pulls the valve onto the seat with a snap-action.

The trap will now remain closed until condensate once again enters the inlet, displacing some of the steam through the vent hole. Simultaneously, the steam within the bucket begins to condense. The bucket losses its buoyancy and starts to sink. As it does so, it brings down the lever to which the valve is attached. The valve is finally levered away from the seat with the aid of the fulcrum at the end of the lever. With the orifice now open, condensate can once again be discharged through it until the cycle repeats itself.

If little condensate is flowing to the trap, some of the steam trapped in the bucket will condense and some will be displaced through the vent hole to condense in the cooler condensate at the top of the trap. This will cause the bucket to momentarily lose its buoyancy and the trap will cycle once again. Thus, all inverted bucket traps can waste a little steam on light condensate flow rates.

It is essential that inverted bucket steam traps are not subjected to sudden changes in steam pressure at the inlet to the trap. A rapid drop in pressure will cause the "water seal" to flash into steam. The bucket will lose its buoyancy and drop down, pulling the valve off its seat. Steam is then able to blow straight through the trap, that is, until condensate gradually collects and re-makes the water seal.

2.1.2 Thermostatic steam trap

There have two types of thermostatic steam trap which is

a. Balanced Pressure steam trap.
b. Bimetallic steam trap.

a) Balanced Pressure steam trap

There are several designs of balanced pressure steam traps available in the marketplace; all work on the same principle. This can best be understood by studying the basic trap illustrated in the figure below.

i) Principle of operation- Balanced pressure

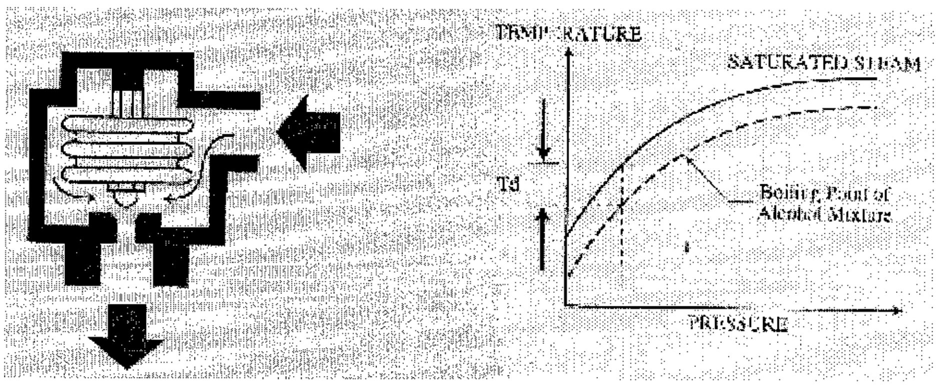

Figure 2.4: Balanced Pressure Steam Trap

The major component is the element, constructed from a bellows to which a plate has been welded at either end. The valve is fixed to one plate. During the construction, a vacuum pump is used to extract air from within the element, then a small volume of an alcohol based mixture is introduced into the space and the element is sealed. This mixture has been carefully selected to boil at a specified temperature below the boiling point of water, usually 10°C.

Therefore, when the element is heated, as the temperature approaches close to the boiling point of water at any pressure, i.e, steam temperature, the mixture within begins to boil. This generates a vapor pressure within the element that is greater than the steam pressure surrounding it thus causing the element to expand.

The relationship between the steam pressure and the boiling point of the mixture can be shown from the graph 2.4 above. Note that the boiling point follows the saturated steam curve exactly, though it is always a constant temperature below it, (Td). Hence the name balanced pressure. Note that when the balanced pressure steam trap is operating correctly, steam will never reach the element. Also the element automatically adjusts to changes in steam pressure because the associated change in temperature of the condensate generates the respective vapor pressure necessary to close the trap. The trap is also cyclic in operation.

a) Bimetallic steam trap

i) Principle of operation- Bimetallic

Bimetallic strip are made up two dissimilar metals having different coefficients of expansion, bonded together.

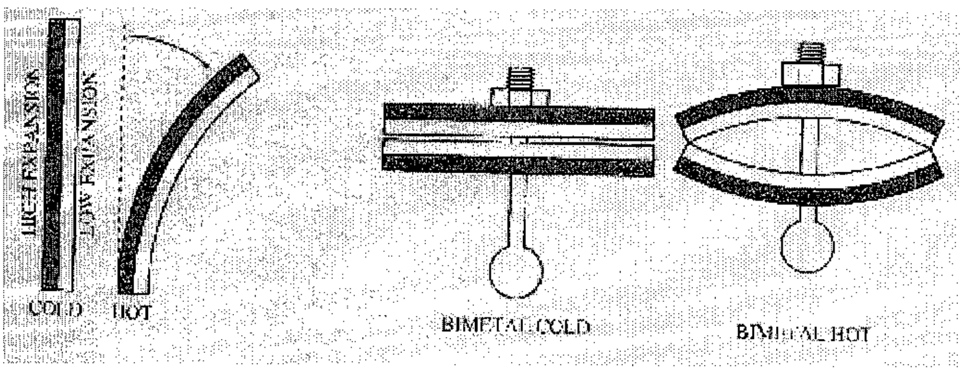

Figure 2.5: Bimetallic Steam Trap

When the strip is heated, the material with the higher coefficient of expansion will expand faster than the other, causing the strip to bend as shown in figure 2.5. Thus by constraining such trips, the force generated when they are heated can be used to move a valve onto or away from a seat. In figure 2.5 it can be seen that the bimetal disc are arranged so that each pair of disc is positioned with the low coefficient material facing each other. When the steam trap is cold, the discs are relaxed and the valve head is away from the seat so that when steam is turned on to the equipment, air and then cold condensate can flow through the trap and be discharged. As the condensate increase the temperature, that is the process begins to warm up, the bimetal discs begin to deflect. The low coefficient metals touch each other and because they are constrained, develop the force that pulls the valve head upwards towards the seat.

2.1.3 Thermodynamic steam trap

a) Thermodynamic disc steam trap

A typical form of construction of a basic thermodynamic disc steam trap is illustrated in figure 6.1. There is a body in which the seat rings have been machined; a disc, which is the only moving part; a cap, which screws onto the body; and an air insulating cover. The details of the seat rings are shown in figure 6.2.

i) Principle of operation- Thermodynamic disc

Two concentric seat rings A and B formed in the body. They are ground flat by a precision computer controlled grinding machine and then hardened. The surfaces are carefully lapped together with the disc, which is also precision ground, so that the disc seats on both rings at the same time. This is effect, isolates the inlet from the outlet and in this condition the steam trap will be closed.

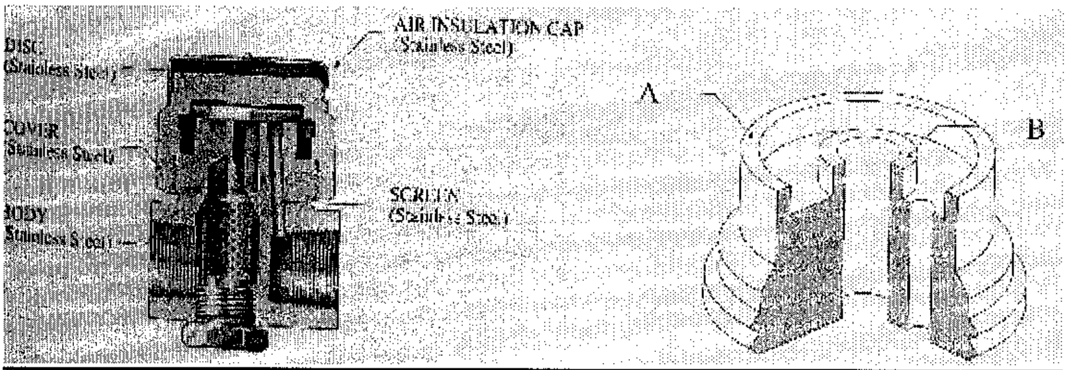

Figure 2.6: Thermodynamic Disc Steam Trap

The operation of the trap is best understood by considering the trap installed into the steam system. When steam is turned on, cold condensate and air are pushed towards the trap at low velocity. The mixture enters the trap and pushes on the underside of the disc lifting it off the seat rings, permitting the air and condensate mixture to flow through the outlet passage. (Figure 2.6)

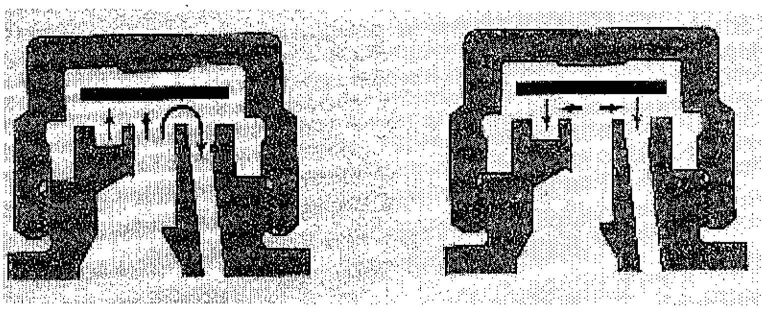

Figure 2.7: Thermodynamic Disc Steam Trap (Trap Operation)

As more steam flows into the plant and the pressure in the steam space increases, the temperature of the condensate flowing through the trap also rises. As the hot condensate flows through the inlet passage towards the underside of the disc, it senses a drop in pressure, causing some of the condensate to flash into steam. As the condensate and flash steam mixture flows radially under the disc towards the outlet, the velocity increase.

The point is reached when, with the condensate increasing in temperature, more of it flashes rapidly into steam, which now flows radially under the disc at an even faster velocity. It is now that a strange thing happens. The disc begins to move downwards toward the seat. (Figure 2.7)

The flow of high velocity flash steam on the underside of the disc creates a low pressure area that causes the disc to move downwards towards the seat. At this point, under normal condition, the disc would "hover". However, as the disc is moving closer to the seat, flash steam also flows around the edge of the disc up into the control chamber. (Figure 2.7)

Steam in the control chamber is now acting on the large surface area of the disc, which is hovering close to the seating surfaces. The force created is greater than that generated by the inlet pressure acting on much smaller area of the inlet passage. Hence the disc snaps that onto the seat, isolating the outlet from the inlet. (Figure 2.7).

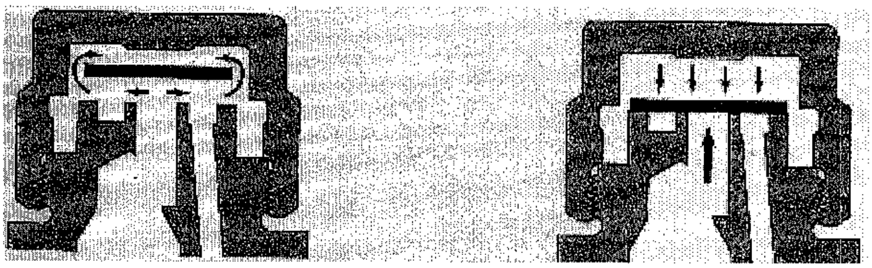

Figure 2.8: Thermodynamic Disc Steam Trap (Trap Operation)

The trap will remain closed until the steam locked in the control chamber condenses with a subsequent loss of pressure and thus, force, on the large surface of the disc. The pressure of the inlet is now sufficient to overcome this force, and the disc is pushed upwards allowing condensate to flow freely once again; flashing into steam as it does so.

2.2 Method of Testing For Steam Trap

Steam traps that are not working correctly will reduce the efficiency of a process and cost the organization valuable production. To prevent this loss, it is essential that steam traps, despite being simple low cost devices, are checked on a regular basis. Over the years several tehniques have been explored with varying degress of success. Before the latest technology can be appreciated, it is necessary to examine these other techniques and understand their limitations.

a. Screwdrivers in the air

Some individuals are convinced that they can diagnose whether a trap is working correctly by simply placing the end of their screwdrivers on the trap and putting their ear to the handle. Perhaps, if the trap has a definite cyclic/blast action and there is no other noisy machinery in close proximity, some vibration or noise may be felt. Certainly though, when the steam trap being examined has a continuous discharge characteristic or operates on a thermostatic principle, then it is impossible to deduce anything by this method.

b. Spraying water on the steam trap

Some individuals when testing traps carry with them a small spray bottle containing water that they spray onto the trap. By watching the way the water is vaporized on the trap, they attempt to determine if the steam trap is operating correctly. All this method will prove is whether the steam trap is hot or cold, the cold condition indicating a trap possibly failed closed, but by no means certain.

c. Using temperature measurement

With the development of accurate hand-held digital thermometers utilizing a themocouple, some people have attempted to use this instrument as an answer to steam trap testing. Certainly, if the trap is a thermostatic trap holding back condensate and sub-cooling it before discharging it into the return, a comparison of temperatures will prove useful.

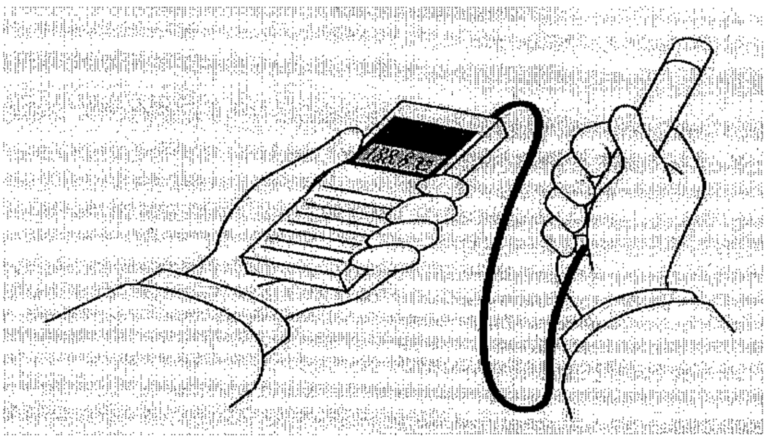

Figure 2.9: Temperature Measurement

That is, the temperature of the pipe work as it enters the steam trap can be taken and this reading compared to the temperature of the pipe adjacent to the steam equipment. If there is a lower temperature close to the trap, the chances are the trap is working satisfactorily, though it could also be partly blocked.

However such a method cannot be used to check mechanical traps, which all operate at close to steam temperature. Neither can the temperature be measured before and after the trap nor if there is a difference, the deduction made that the trap must be working. When condensate, or steam, passes from a system operating at high pressure to another at a lower pressure, the temperature will drop to that of steam at the lower pressure. So live steam blowing through a trap will drop in temperature to the lower pressure condition, the extra heat being used to dry out the live steam or produce flash steam.

d. Discharging the trap to atmosphere

Uncoupling the steam trap from the condensate return system and watching the discharge from it as it blows onto the ground will help an experienced operator to determine how well the trap is operating. With the trap having a cyclic/blast action, the diagnosis is fairly straight forward. Thus for a thermodynamic disc or an inverted ball bucket the action should be a firm discharge with a positive closure, leaving no doubt that the trap in question has closed. However, for traps with a continuous discharge characteristic such as the free float thermostatic or bimetallic, the diagnosis is not so easy. See figure below.

e. Sight glasses

The disadvantage of the technique just previously outlined is that when a trap is discharging to atmosphere, it is no longer subject to the effect of any back pressure that exists in the condensate return. The trap may therefore work perfectly satisfactorily when discharging to atmosphere, but as soon as it is coupled back into the return, it ceases to perform as it should.

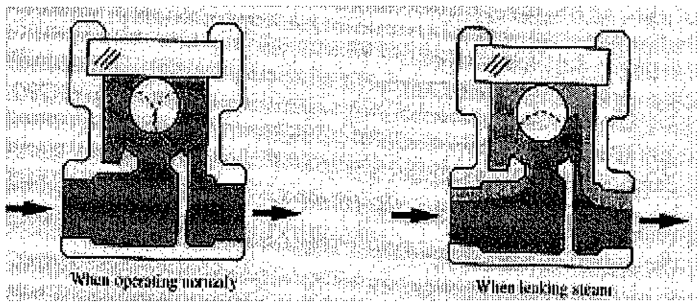

Figure 2.10: Sight Glasses

For this reason, sight glasses, which permit the inspector to observe the flow pattern of discharge after the trap while the trap is still installed in the line, have been developed. These sight glasses are particularly useful when trying to accurately set the steam-lock release valve on the free-float steam trap. Sight glasses do however require maintenance themselves and for that reason, plus the difficulties of retrofitting large numbers of steam traps, their use is generally confined to process plant applications at low level.

f. Conductivity sensing

The principle is based upon the significant difference between the conductivity of condensate compared with that of steam. Such devices are either built into the trap itself, or are incorporated into an additional fitting that requires fixing into the pipe work ahead of the inlet to the trap

g. Ultrasonic testing

The device consists of a contact probe, a hand-held amplifier with meter display and the option of headphone or a loud speaker.

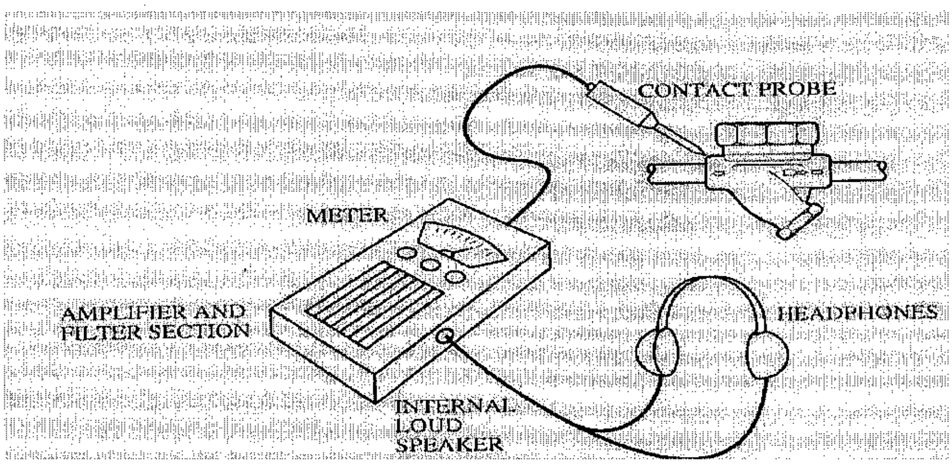

Figure 2.11: Ultrasonic Testing

The probe rather like a microphones, picks up the sound of mechanical vibrations and feeds these to an amplifier plus electronic filter, producing a signal within the ultrasonic frequency range of 35 to 45 kHz, in order to ensure that what is happening in the pipe work can be heard in the headphone and displayed on the meter. Thus with the probe held against the steam trap adjacent to its valve, the operator can watch the meter and listen in the headphone to condensate flowing through the orifice.

h. TrapMan

TrapMan is a device that incorporates the ability to measure temperature and detect sound ultrasonically. It has a built-in memory of the flow pattern of the majority of steam traps currently in use today.

Figure 2.12: Trap Man

Unlike the standard ultrasonic instruments produced for general use, TrapMan has a probe that incorporates a thermocouple for temperature measurement and an ultrasonic sensor for the detection of the high frequency sound created by flow through an orifice. This data then fed to the hand-held microcomputer, which has the temperature and sound profiles for a specific type and make of steam trap stored in its memory. It compares the test data with its sets of correct and incorrect operating profiles, and then makes its diagnosis. The user is able to input a simple code for a particular model of steam trap and, by placing the probe tip on the steam trap, use TrapMan to compare the performance of that trap at the pressure and temperature, with the data stored in the microcomputer. If the test trap compares well, TrapMan will register the trap as Good. If the trap is leaking steam, TrapMan will estimate the amount as a leak level and signal the trap as defective.

2.3 Steam and Condensate Piping

All steam systems include a source of steam, a distribution system, and terminal equipment, where steam is used as the source of power or heat.
One of the most important decisions in the design of a steam system is the selection of the generating, distribution, and utilization pressures. Considering investment cost, energy efficiency, and control stability, the pressure shall be held to the minimum values above atmospheric pressure that are practical to accomplish the required heating task, unless detailed economic analysis indicates advantages in higher pressure generation and distribution.

The piping system distributes the steam, returns the condensate, and removes air and non-condensable gases. In steam heating systems, it is important that the piping system distribute steam, not only at full design load, but at partial loads and excess loads that can occur on system warm-up. The usual average winter steam demand is less than half the demand at the lowest outdoor design temperature. However, when the system is warming up, the load on the steam mains and returns can exceed the maximum operating load for the coldest design day, even in moderate weather. Steam traps are an essential part of all steam systems. Traps discharge condensate, which forms as steam gives up some of its heat, and direct the air and non-condensable gases to a point of removal.

Ideally, the steam trap should remove all condensate promptly, along with air and non-condensable gases that might be in the system, with little or no loss of live steam. A steam trap is an automatic valve that can distinguish between steam and condensate or other fluids. Traps are classified as follows:

a) Thermostatic traps react to the difference in temperature between steam and condensate.
b) Mechanical traps operate by the difference in density between steam and condensate.
c) Kinetic traps rely on the different inflow characteristics of steam and condensate.

The following applies to all steam traps: Steam traps, regardless of type, shall be carefully sized for the application and condensate load to be handled, since both under sizing and over sizing can cause serious problems. Under sizing can result in undesirable condensate backup and excessive cycling that can cause premature failure. Over sizing might appear to solve this problem and make selection much easier because fewer different sizes are required, but if the trap fails, excessive steam can be lost.

2.4 Energy Considerations

Steam and condensate piping system have a great impact on energy usage. Proper sizing of system components such as traps, control valves, and pipes has a tremendous effect on the efficiencies of the system. Condensate is a by-product of a steam system and must always be removed from the system as soon as it accumulates, because steam moves rapidly in mains and supply piping, and if condensate accumulates to the point where the steam can push a slug of it, serious damage can occur from the resulting water hammer. Pipe insulation also has a tremendous effect on system energy efficiency. All steam and condensate piping should be insulated. It may also be economically wise to save the sensible heat of the condensate for boiler water make-up systems operational efficiency.

2.5 Steam Trap Installations

Install steam traps in accessible locations. Refer to drawings in CS&DG Section IV for a typical trap detail. Steam traps should be piped in such a way as to make service and inspection of operation as safe and efficient as possible. The sequence of piping should be: Shut off valve—Union—Strainer—Trap—Cross Tee with test valve—Check valve—Union—Shut off valve and pressure temperature gauges. This permits removing the trap set as a unit for repair, or replacement. It eliminates the safety hazard of trying to clean the strainer while the strainer is still attached to the system. It permits the most effective testing possible (observation of trap discharge). Unless otherwise indicated, install gate valve, strainer, and union upstream from the trap; install union, check valve, and gate valve downstream from trap. Install off-setting 90 degree elbow between check valve and union for easy removal of steam trap assembly.

2.6 Positioning, Piping and Trapping

Install trap below the equipment being drained so condensate will drain by gravity to the trap inlet. Pitch horizontal lines toward trap inlet. This will allow condensate to first fill inlet at trap and prevent water hammer in the line. Strainers are recommended ahead off the steam trap. Where it is not possible to install trap at a low point, provide a lift fitting or water seal at the low point. An immersion-type heat transfer surface, which has the water seal/lift fitting built into it, is shown below. A swing check valve should be installed just before the trap to prevent backflow. Overhead Discharge - If the condensate is to be discharged to an overhead return line or against a lift, it is advisable to install a swing check valve in the discharge line just beyond the trap at the bottom of the lift. Otherwise, condensate may flow back into the equipment on shutdown and, in some cases, blanket the heat transfer surfaces during operation.

The only exception to this recommendation would be in the case of certain types of traps of traps that incorporate a check valve within the trap itself. Wherever possible, install a vertical drip left or dirt pocket ahead of the trap as shown below. This provides a condensate reservoir ahead of the trap, as well as a dirt pocket to collect excess scale and dirt. The dirt leg should be blown out periodically by removing the pipe cap or plug at the bottom. Place trap as close to equipment as possible (except in the case of thermostatic traps that require a cooling leg ahead of the trap). Install trap in an accessible location for servicing and maintenance.

Before installing trap, be sure to thoroughly blow out piping under full steam pressure to eliminate scale, chips, and other foreign material. It is also advisable to install a "Y" strainer ahead of the steam trap and repeat this procedure by blowing down the strainer after the hook-up is completed. Trap each piece of apparatus individually. If more than one heat transfer surface or piece of apparatus is drained by a single trap, short-circuiting is liable to occur as pressure drops may differ. The heat transfer surface with the least pressure drop will short circuit the one with the greatest drop, resulting in uneven heating and inefficient operation. Always use inlet and discharge piping at east as arge as the pipe connections in the trap. When several traps discharge into a common header, install a swing check valve between each trap and the header to prevent reverse flow during shutdown or possible blocking off of one trap by another when they are discharging.

Bypasses have been largely eliminated nowadays due to expense of installations and loss of steam hen left open by the operator. Here a bypass is necessary, locate it at a higher level that the trap to avoid loss off pries with bucket traps. To allow for flash steam and prevent overloading, discharge piping should be amply sized. For short discharge lines, use pipe equal to trap size; for longer lines, use one size larger.

If discharge is to overhead return, make sure pressure at trap discharge is sufficient to overcome lift (calculate 1/2 pound per vertical foot), plus pressure in overhead return line and pressure drop through the heat transfer surface. It is necessary to size the steam trap based on inlet pressure of the trap for proper operation. Also, make sure total back pressure is within allowable limit for the particular make of trap.

Bucket traps should be primed before starting, otherwise they will blow steam, Close outlet valve and open inlet valve slowly until condensate fills body of trap. If insufficient condensate is present to prime properly, pour in water through test outlet. Gate valves are recommended for lines leading to and from the trap in order to provide free flow and reduce flashing. For strainer blow down or test tee, either gate or globe valves are satisfactory. Vacuum breaker - where specified by the equipment manufacturer or where the piping arrangement is such that condensate will be drawn back into the equipment due to the vacuum caused condensation of steam on shutdown, install a vacuum breaker at a high point in the apparatus or piping. Auxiliary air vent - where especially large volumes of air must be eliminated on startup and piping is such that air will not readily flow toward the trap, install an air vent at a high point opposite the steam inlet.

CHAPTER 3

METHODOLOGY

3.1 Method Utilization

Student has used a lot of systematic approaches to find the information and sources. Below are the list of methodology will be used by student throughout the project:

a. Systematic model of the design process – Used to identify the task and systematic approach that will be followed by student throughout the project.

b. Literature reviews – Used to gather the information and sources regarding with the theory and formulae of steam trap.

c. Interviewing – Used to find out the real problems of steam trap.

d. Internet – As the additional information and sources. Besides, used to survey the current existing product which are almost similar with the project

e. Steam trap test run and trouble shooting– Used to collect the additional manufacturer data and some of the operating condition of steam trap (done during industrial training at PPMSB, Sungai Udang, Melaka)

f. Software applications Microsoft Office Excel to do graph analysis.

3.2 Procedure

a) Step 1: Study & Collect the Data

i. Study on the steam trap application, the type of failure of steam trap, steam and condensate piping, effect of back pressure on piping arrangement, steam and condensate piping, energy consideration, steam trap installation and method of testing of steam trap

ii. Collect the data on the number of failure rate of steam trap before and after improvement, data of steam trap failure from 1999 to 2003 according to different manufacturers

b) Step 2: Analyze Steam Trap problem

i. Brainstorming session has been conducted with engineers and technicians to generate the idea what are the possible causes and effects contribute to the failure of steam trap of steam trap problem.

ii. Cause and Effect matrix used to determine what are the main causes and effect of the steam trap to fail.

c) Step 3: Identify Potential Root Cause

i. Why-why analysis used to identify the potential root cause of the failure of steam trap.

d) Step 4: Find out the Solution

i Find the long term and short term solution based on the PPMSB constraint and criteria.

ii. Developed the new steam trap management, process flow and new action plan

e) Step 5: Implement the Solution in Plant

i. Implement the solution according to the new procedure and management

ii. All the data before and after implement the new solution will be recorded.

f) Step 6: Collect & Analyze the Result

i. Collect all the data regarding to the number of steam trap failure before and after improvement.

ii. Analyze the data by using Microsoft Office Excel.

iii. Involve some calculation and formula to analyze the result (refer on result and discussion section)

CHAPTER 4

RESULT AND ANALYSIS

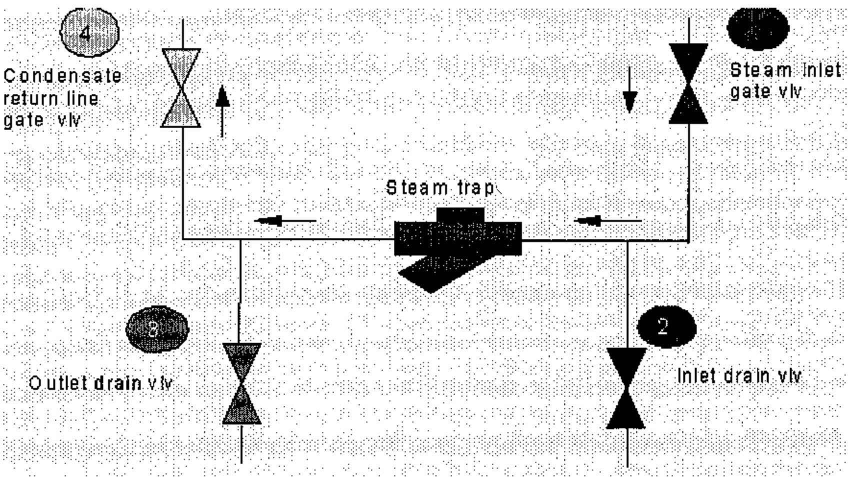

Figure 4.1: General Arrangement of Steam Trap

4.1 Data Collection and Failure Analysis

4.1.1 Steam Trap Fail Close

	1999	2000	2001	2002	2003	ALL
MIY	2	0	0	0	0	2
TLV	8	15	3	5	1	32
YAR	43	95	25	8	7	178
GES	1	2	0	0	0	3
ALL	54	112	28	13	8	215

Table 4.1: The number of steam trap failure for different manufacturer

Based on the table above, it show that the number of steam trap that fail close according to the manufacturer. The YAR have the largest value of steam trap failure. While the MIY give the smallest value of steam trap failure. Fail close means that the steam trap is failure to release condensate from the trapped steam. Thus condensate accumulated upstream of steam trap and the line is cold. This is dangerous for steam line that may introduce water hammering. When steam traps cause a back-up of condensate in a steam main, the condensate is carried along with the steam. It lowers steam quality and increases the potential for water hammer. Not only will energy be wasted, equipment can be destroyed.

Water hammer occurs as slugs of water are picked up at high speeds in a poorly designed steam main or in pipe coils or where there is a lift after a steam trap. In some systems, the flow may be at 120 feet per second, which is about 82 m.p.h. As the slug of condensate is carried along the steam line it reaches an obstruction, such as a bend or a valve, where it is suddenly stopped. The effect of this impact can be imagined. It is important to note that the damaging effect of water hammer is due to steam velocity, not steam pressure. It can be as damaging in low pressure systems as it can in high. This can actually produce a safety hazard, as a valve or a strainer can be blown out by the force of water hammer.

The main reason why fail close occur is because of the emergence of oil in live steam flow through the steam trap. When this flow occurs repeatedly, the oil will stick on the surface of seat ring and the disc. Finally the disc will permanently stick with the seat ring. As a result the steam trap fails to function as usual. The condensate can not flow out into condensate return line and than will accumulate upstream of steam trap and can cause water hammering. In order to avoid water hammering, open inlet drain valve (see figure 4.1) at upstream position to make sure all the live steam and condensate flow out to atmosphere.

4.1.2 Steam Trap Fail Open

	1999	2000	2001	2002	2003	ALL
MIY	2	0	2	2	2	8
TLV	14	21	11	1	0	47
YAR	181	67	90	53	59	450
GES	5	10	3	0	0	18
ALL	202	98	106	56	61	523

Table 4.2: The number of steam trap failure for different manufacturer

Based on the table above, it show that the number of steam trap that fail open according to the manufacturer. The YAR have the largest value of steam trap failure. While the MIY give the smallest value of steam trap failure. Fail open means that the steam traps failure to contain steam thus releasing live steam into condensate discharge line after the steam trap. Steam traps that fail open allow steam to directly enter the condensate return system. Because some steam traps operate poorly against high back pressure, the increase pressure in the condensate lines can cause several problems.

a. Poor performance of the heat exchanger due to condensate backup
b. Water hammer, the risk of which is increased by large amounts of steam in the condensate return system
c. Relief valve release, which occurs at high condensate pressure causing condensate loss from the system

In some systems, condensate loss may be due to manual bypass of the steam traps by operators attempting to drain heat exchangers in order to maintain production, allowing live steam into the condensate line. These problems not only diminish system performance, but unnecessarily increase operating costs due to losses in energy and condensate. In a typical steam system, the returning condensate contains more energy than the make-up water or can call it demin water.

Based on the study, the author found that there have two causes of steam trap fail open. The first one is because of the emergence of particle in the live steam. Taking thermodynamic types as a case study. The particle will slowly stick on the upper surface of seat ring and disc. As a result there will be gap between the disc and seat ring. This can cause the live steam will flow together with condensate into condensate return line and finally cause fail open. Sometimes the fail open also occur because of the surface of seat ring and disc was not flat anymore. This can be seen after long time operation. The surface roughness was increase and cause the gap emerges between the seat ring and disc. As a result the live steam will flow out together with condensate into condensate return line. In order to avoid the worst effect, open outlet drain valve (see figure 10) at downstream position to make sure all the live steam and condensate flow out to atmosphere.

Unit	33	34	35	51	53	54	58	64	Total
Total Population	116	71	396	151	112	30	28	210	1060
Failed Open	8	6	41	33	4	2	1	20	115
Failed Close	3	4	23	18	3	2	2	9	64
Leaking	43	17	10	0	10	0	0	1	81
Total Acc Failed ST	54	27	74	51	17	4	3	30	260
% of failed ST	46.55%	38.03%	18.69%	33.77%	15.19%	13.33%	10.71%	14.29%	49.06%
Replace Capsule	11	10	22	5	7	1	0	0	56
Replace Complete Set	43	17	13	6	0	0	0	0	79
No Acc ST repaired	54	27	35	11	7	1	0	0	135
% of repaired ST	100%	100%	47.30%	21.57%	41.18%	25%	0%	0%	51.9%

Table 4.3: The number of steam trap failure in Area 5

Basically there have three mains problem of steam trap which is fail close, fail open and leaking. In this project only two of failure will be focused which is fail open and fail closed. The leaking failure will not to cover because this failure not occurs at steam trap itself and out of my scope of study. Usually leaking occurs at the piping or at any connection of the piping.

4.2 Cause and Effect

At early stage, the brainstorming session has been conducted between the engineers in different field and department form PPMSB. The discussion intends to gain the rough ideas what are the possible causes and effects contribute to the failure of steam trap. After discussion, there have 11 causes and 4 effects identified contribute to the failure of steam trap as shown in the table 4.4. The rating show in the table below purposely to determine what are the main causes and effect of the steam trap to fail.

	Cause and Effect Matrix								
	Rating of Importance to Customer (1,3,9)	9	9	9	5				
		1	**2**	**3**	**4**	**5**	**6**	**7**	
	Process Output	**Pure Condensate**	**Condensate Temperature**	**Condensate Pressure**	**Header Pressure**				**Total**
	Process Inputs								
	Brand	1	1	1	1				32
	Type	9	9	9	1				248
	Operation	9	9	9	9				288
	Steam trap rating	9	9	9	1				248
	Pipe Insulation	5	9	5	1				160
	Maitenance survey	9	9	9	1				248
	Checklist(Survey by operator)	5	5	5	5				160
	Tools for measurement	5	5	5	1				140
	Operator awareness	9	9	9	9				288
)	Operator competency	5	5	5	1				140
I	Piping arrangement	9	9	9	1				248
2									
3									
4									

Table 4.4: Causes and Effects matrix

4.3 Why-Why Analysis

The why-why Analysis below focused on potential root cause Failed Open and Failed Closed. The lack of Preventive Maintenance (PM) and piping arrangements are the two root causes that have been identified contribute to the fail open and fail close

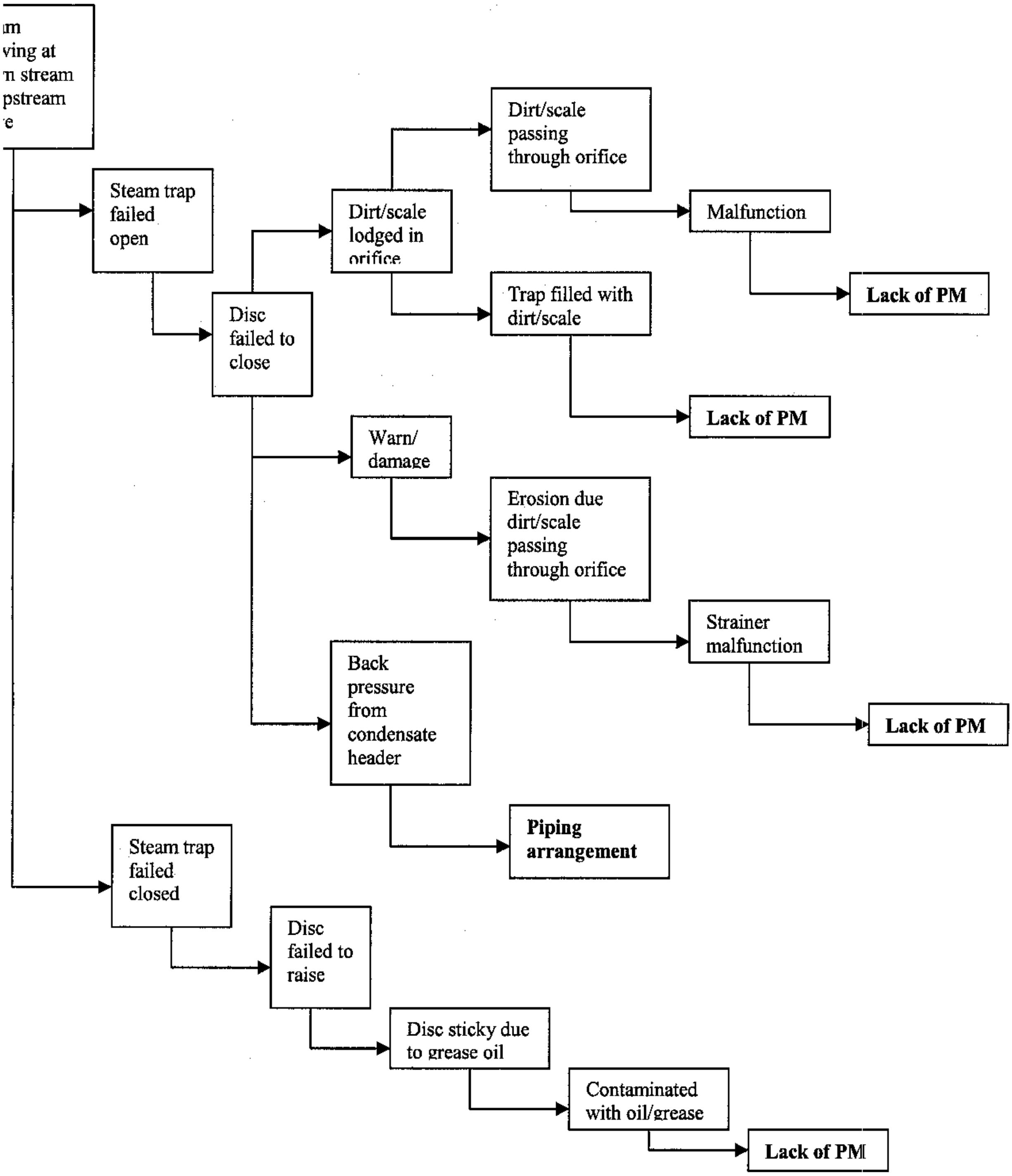

Figure 4.2: Why-why Analysis

4.4 Lack of Preventive Maintenance (PM)

After analyze the root cause of the steam trap problem, the action to solve this problem have been taken. Previously preventive maintenance (PM) for steam trap was done once a year. Regarding to the analysis of the data collected as show in figure 4.3 below, it found that this preventive maintenance should be doing frequently to minimize the steam trap failure.

Survey	Tag	Year	Area	Sublocatic	Exact Loc:	Applicatio	Nom. Pres	Survey Date	Inlet Temp	Outlet Ten
1	1	1999	11	BL-ST01	BATTERY	TRACER	45	09/21/1999	238	234
2	1	2000	11	BL-ST01	BATTERY	TRACER	45	05/11/2000	238	234
3	1	2000	11	BL-ST01	BATTERY	TRACER	45	11/22/2000	281	279
4	1	2001	11	BL-ST01	BATTERY	TRACER	45	08/09/2001	277	205
5	1	2002	11	BL-ST01	BATTERY	TRACER	45	06/11/2002	137	112
6	1	2003	11	BL-ST01	BATTERY	TRACER	45	04/02/2003	137	112
1	2	1999	11	BL-ST02	BATTERY	TRACER	45	09/21/1999	264	207
2	2	2000	11	BL-ST02	BATTERY	TRACER	45	05/11/2000	264	207
3	2	2000	11	BL-ST02	BATTERY	TRACER	45	11/22/2000	264	206
4	2	2001	11	BL-ST02	BATTERY	TRACER	45	[illegible]/09/2001	275	199
5	2	2002	11	BL-ST02	BATTERY	TRACER	45	[illegible]/11/2002	275	199
6	2	2003	11	BL-ST02	BATTERY	TRACER	45	[illegible]2/2003	275	199
1	3	1999	11	BL-ST03	BATTERY	TRACER	45	[illegible]/1999	245	201
2	3	2000	11	BL-ST03	BATTERY	TRACER	45	[illegible]	245	201
3	3	2000	11	BL-ST03	BATTERY	TRACER	[illegible]	[illegible]	[illegible]	208
4	3	2001	11	BL-ST03	BATTERY	[illegible]	[illegible]	[illegible]	[illegible]	201
5	3	2002	11	BL-ST03	BATTERY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	3	2003	11	BL-ST03	BATTERY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	4	1999	11	BL-ST04	BATTERY	[illegible]	[illegible]	[illegible]	[illegible]	208
2	4	2000	11	BL-ST04	BATTERY	[illegible]	[illegible]	[illegible]	[illegible]	208
3	4	2000	11	BL-ST04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	4	2001	11	BL-ST04	BATTERY	TRACER	[illegible]	[illegible]	[illegible]	[illegible]
5	4	2002	11	BL-ST04	BATTERY	TRACER	[illegible]	[illegible]	[illegible]	95
6	4	2003	11	BL-ST04	BATTERY	[illegible]	[illegible]	[illegible]	[illegible]	95

Lack of PM
The steam trap
only maintained
once a year

Table 4.5: Preventive Maintenance data

After doing the study and analysis, it found that this schedule have to change to reduce the rate of steam trap failure. After few hours discussion with the engineer and consider all the factors we conclude that the preventive maintenance should be conducted once for every two weeks. Following are the new steam trap management. This new steam trap management was established to make sure all the planning and new procedure will carry on smoothly.

4.4.1 New Steam Trap Management

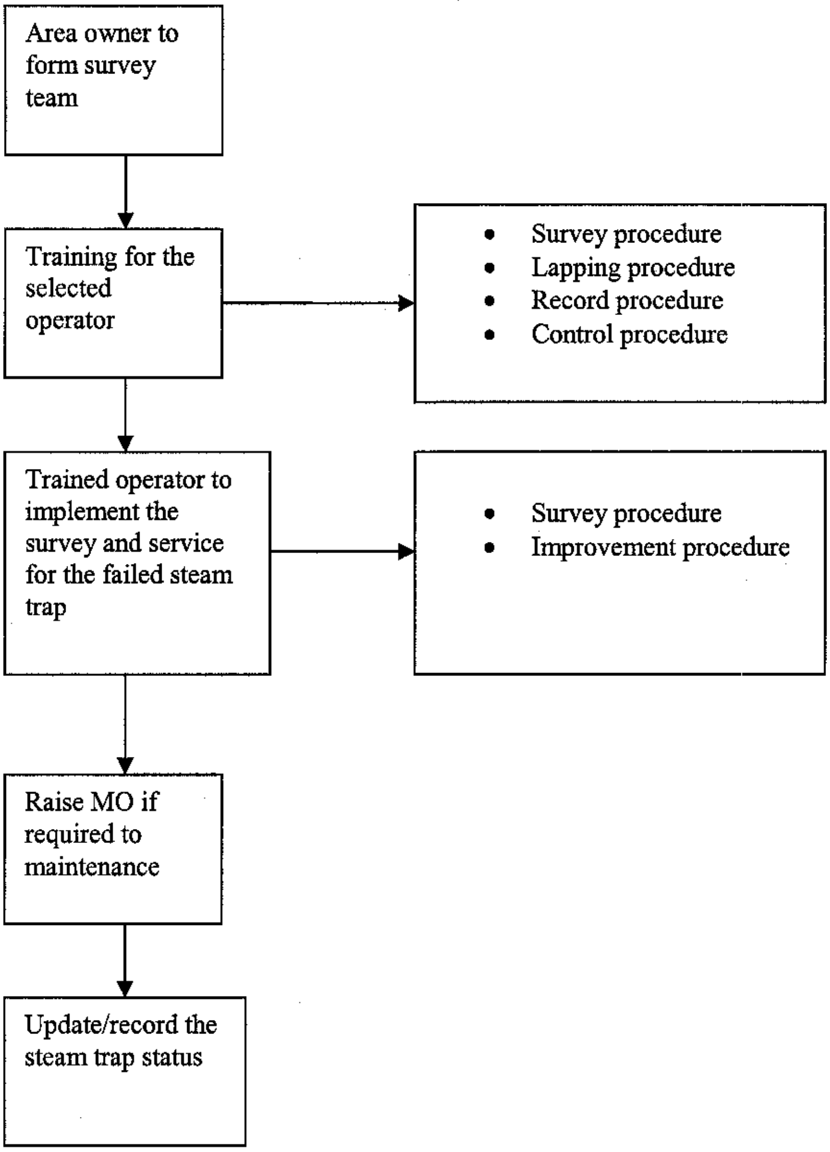

Figure 4.3: New Steam Trap Management

Other than set up new steam trap management. The new action plan and new process flow also needed as guideline to make sure all the work including survey and service done smoothly, efficiently and professionally.

4.6.2 Project Action Plan

What	How	Who	When		Deliverables
(Action to Take)	(Action Steps)	(Accountable)	Start	Finish	
To form a survey team	Pull out 2 persons for full time	Operation		Done	Survey team
New preventive maintainence procedure	Develop a new SOP	Black Belt		Done	New PM chart
Training on steam trap for 1st team	Training set up	Maintenance		Done	Trained operator
Tools for maintenance	To buy a tools	Operation		Done	New tools (Fix spanner 42,40,39mm, sand paper,timber block and thinner)
2nd training for remaining operators	To set a date and select the people to attend the training.	Operation	12-Jan-04		Selected operators
Trainer for remaining operators	To select a trainer	Maintenance	09-Jan-04		Trainer
Project Summary	Report write up	BB	12-Jan-04		
Finance Close Out Report	Report write up	BB	09-Jan-04		
SOP for survey	Review SOP	Maintenance + BB		15-Jan-04	Presentable SOP
" How to run operation checklist report "	Review the checklist	Operation + Maintenance			Completed
Survey's Log book	To prepare template for survey log book	Operation			Standard book
Continue improvement for remaining ST (1800 pcs)	By laverage	Operation	13-Jan-04		Improvement results
Categorise the area	Base on level of difficulities (I.e remote area)	Operation	12-Jan-04	1 Mac 2004	
Area distribution by shift	Base on categorised area to have the load distributed equally	Operation	01-Apr-04		
How to produce steam trap report	Develop a template for the report	Maintence+Operation			To handover to Process Owner
Steam Trap Status as per 1st Survey	Progress / Status	BB+ operation		Done	To handover to Process Owner

Figure 4.4: Project Action Plan

4.4.3 Project Process Flow

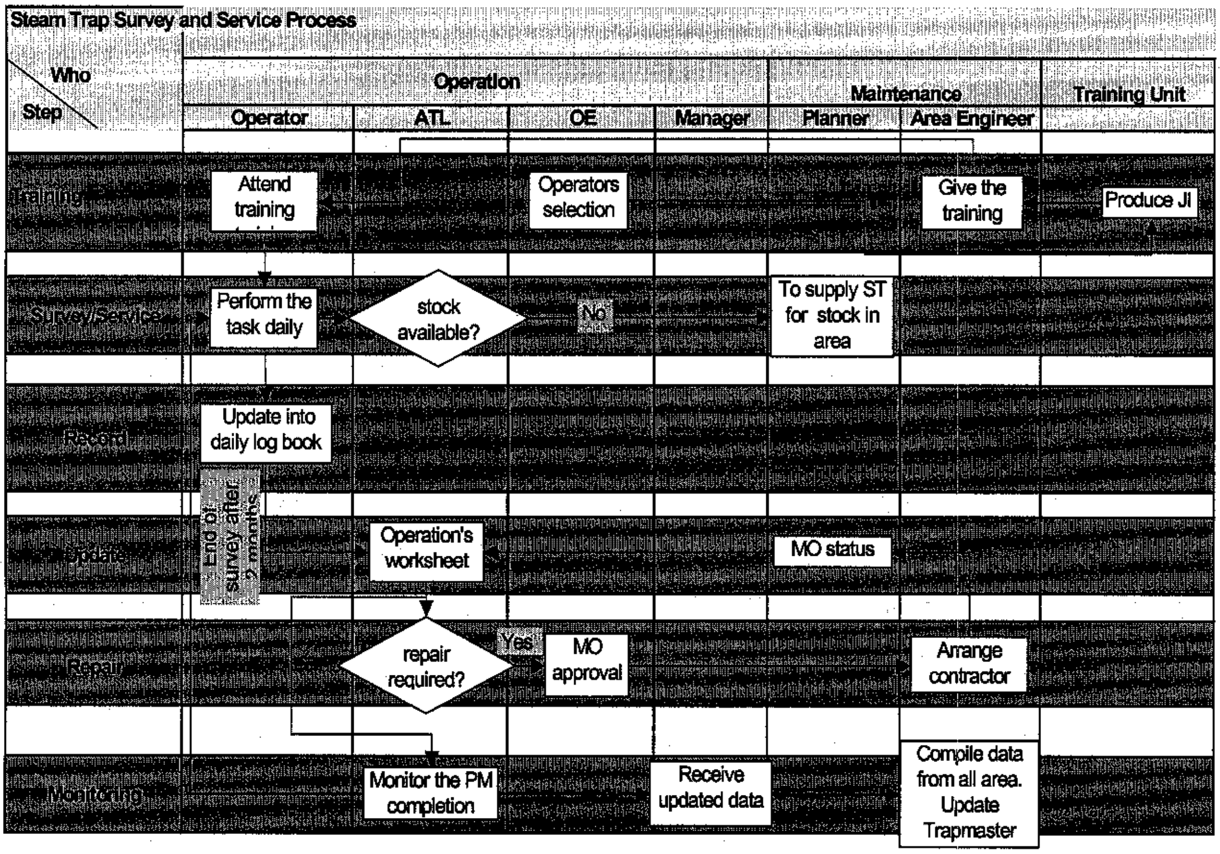

Figure 4.5: Project Process Flow

4.4.4 Result before and after implement new procedure

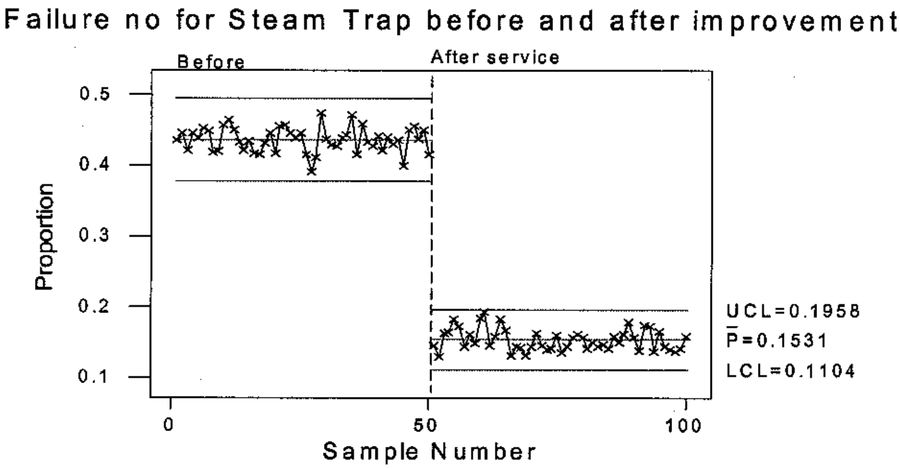

Figure 4.6: Result Before and After Improvement

a. No of sample = 640 steam trap

b. No. of failure before improvement = 278 steam trap

- Percentage of defect before improvement = 278/640

  = 43.4%

c. No. of failure after improvement = 98 steam trap

- Percentage of defect after improvement = 98/640

  = 15.3%

d. So, the percentage of improvement = 43.4% - 15.3%

  = 28.1%

4.5 Piping Arrangement

4.5.1 Effect of back pressure

When applying thermodynamic disc steam traps, an important factor to take into consideration is how they operate against a back pressure, i.e pressure in the condensate return system.

It has previously been described how the disc of the steam trap is brought close to the seat by the radial flow of high velocity flash steam under the disc. The velocity of such flow depends upon the pressure differential across the trap. i.e. the difference between the inlet and outlet pressures. If the differential is high, the velocity of flash steam is also high and the trap works well. If the velocity is low, it will not be sufficient to bring the disc towards the seat and the trap will remain open, blowing some steam. To summarize; low velocity, that is, a low pressure differential as a result of high back pressure, will cause the thermodynamic trap to blow open. This is totally the opposite of what happens to mechanical steam trap such as float or inverted bucket traps, which continue to operate against high back pressure but with a reduced capacity.

As a rule, it is safer to work on the basis that the thermodynamic disc steam trap will not operate satisfactory when the back pressure at the outlet goes above 80% of the inlet pressure to most traps, and 50% for high pressure traps

High back pressure occurs in the condensate return system as a result of either:

a. Imposing a lift to high level after the steam traps.
b. Discharging close together into a small diameter condensate return pipe.

Therefore, to prevent such intermittent high back pressure causing the trap to blow open;

a. The condensate piping manifold should be adequately sized.
b. Do not discharge directly opposite each other.

c. Imposing an adequate level after lifting the steam traps.

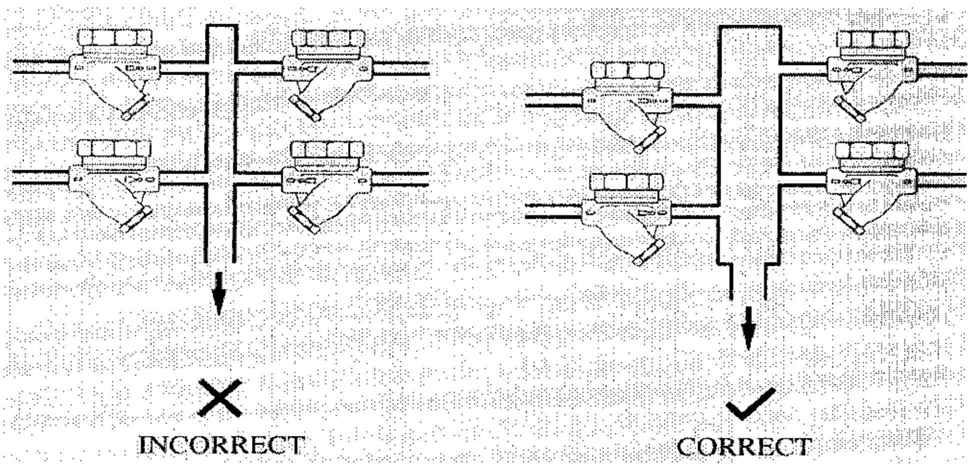

Figure 4.7: The Correct Arrangement of Steam Trap

4.5.2 The differential pressure

The differential pressure is simply the difference between the inlet and the outlet pressure. In figure below the back pressure now exists at the outlet due to the head of condensate imposed on the trap by elevating the condensate into the return pipe. As a simple rule of thumb, 1 meter of water column is equivalent to 0.11 bar g (1 meter = 0.11 bar g).

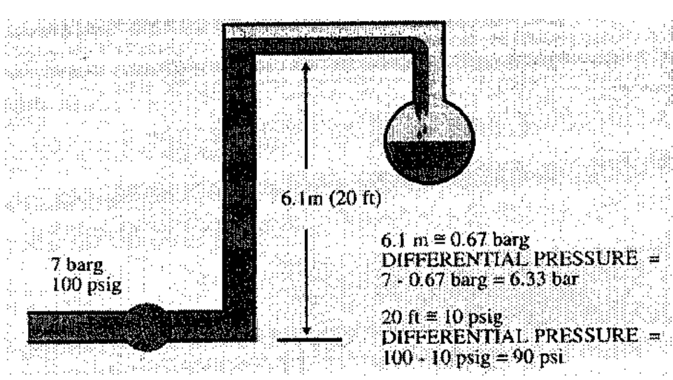

Figure 4.8: The differential pressure

It was assumed that the condensate return main at high level was under no other pressure influence. That is, condensate simply flowed along it a few feet until it ran out of the end into an open tank. In practice this is rarely the case and invariably either the pipework rises again, imposing an additional pressure farther down the line, or returns to a vessel such as a flash vessel or deaerator, which is operating at some pressure above atmospheric.

When choosing the diameter of the condensate line downstream of the trap flashing has to be considered. Even at very low pressure the volume of flash steam is many times that of the liquid if the condensate is at saturation temperature upstream of the trap (e.g during flashing from 1.2 bar to 1 bar, the volume increases approximately17 times)

In these cases it is possible to dimension the condensate line in accordance with the amount of flash steam formed. The flow velocity of the flash steam should not too high otherwise water hammer (by the formation of waves). Flow noise and erosion may occur.

A flow velocity of 15m/s at the end of the pipeline before the inlet into the collecting tank is a useful empirical value. The inside diameter of the pipeline required can be taken from table 1 (Refer Appendix).
For long pipelines (> 100m) and large condensate flowrates the pressure drop should be calculated to avoid the back pressure becoming too high. The velocity of the flash steam may be used in the calculation.

4.5.3 Calculation of condensate return height based on the inlet pressure

Steam line temperature

For LP (low pressure) = 100 °C – 200 °C

For MP (medium pressure) = 200 °C – 300 °C

For HP (high pressure) = 300 °C – 400 °C

Steam line pressure

Based on steam table for LP = 1.013 bar a – 15.5 bar a

For MP = 15.5 bar a – 86.0 bar a

For HP = 86.0 bar a – 286.0 bar a

Pressure drop in steam lines

For example:

Operating data:

Steam temperature = 200 °C

Steam pressure = 15.5 bar a

Steam flowrate = 30 ton/hr (assumption)

Nominal size (DN) = 200 mm (assumption)

So, from graph 1 (Refer Appendix), flow velocity = 30 m/s

Using graph 2 (Refer Appendix), to determine coefficient of resistance

Pipeline length 20 m...........C = 1.9

1 standard globe valve...........C = 6.3

1 tee.............................C = 3.4

3 elbows..........................C = 1.5

Total Coefficient of resistance (C) = 13.1

Using graph 3 to determine pressure drop

So, pressure drop = 0.4 bar a

Inlet pressure = initial steam pressure – pressure drop
= 15.5 bar a – 0.4 bar a
= 15.1 bar a
= 14.1 bar g (refer steam table)

Calculation of back pressure

Thermodynamic disc steam trap will not operate satisfactory when the back pressure at the outlet goes above 50% of the inlet pressure for high pressure traps,

Maximum back pressure allowed = 50% x 14.1 bar g
= 7.05 bar g

So, the differential pressure = Inlet pressure – back pressure
= 14.1 bar g – 7.05 bar g
= 7.05 bar g

Simple rule of thumb, 1 meter of water column is equivalent to 0.11 bar g back pressure (1 meter = 0.11 bar g).

Hence the maximum high of condensate return line, h = 7.05 bar g / 0.11 bar g
= 64.1 meter

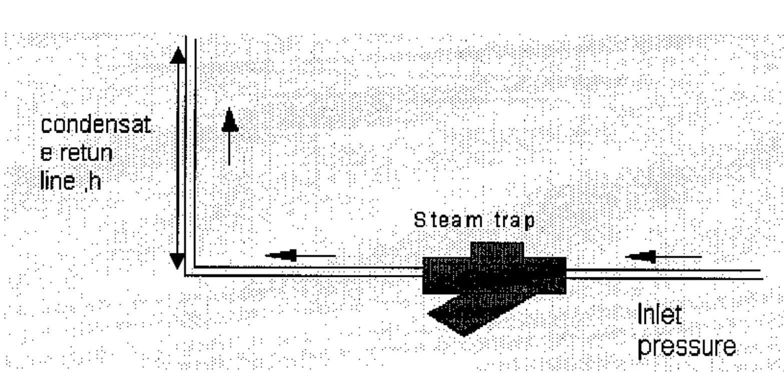

Figure 4.9: The Maximum Height of Condensate Return Line

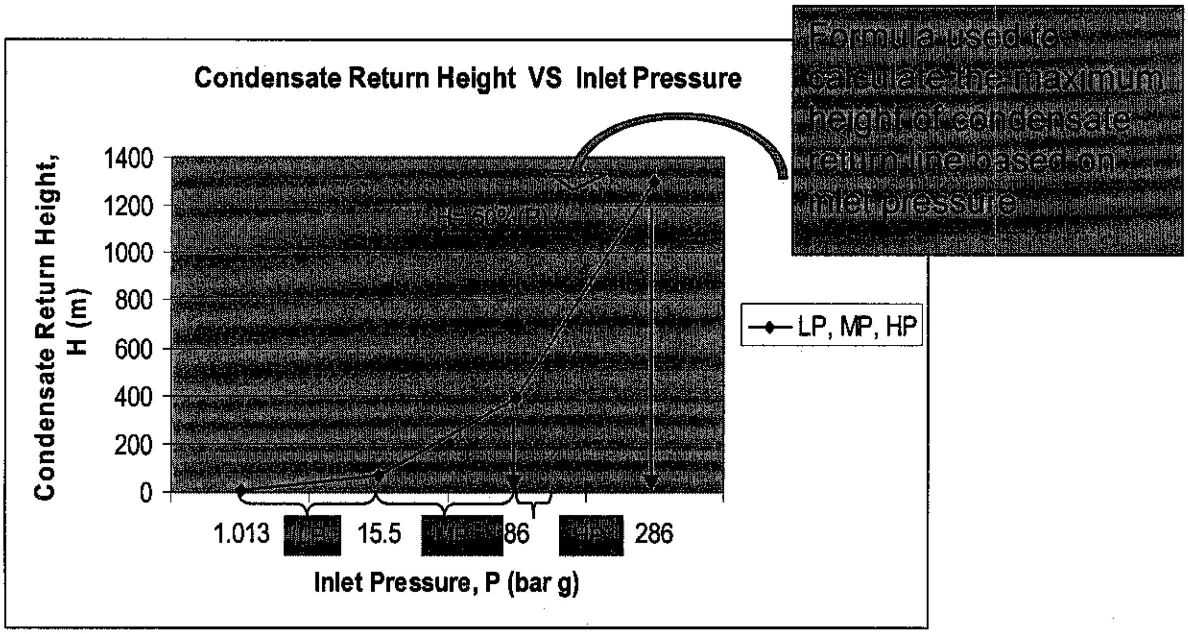

Figure 4.10: Relationship between condensate return height and inlet pressure

From the graph above, it can be conclude that the condensate return height is directly proportional to the value of inlet pressure. When the inlet pressure increase the height of condensate return line also can be increased. In order to prevent back pressure in condensate return line, the height of condensate return line can not exceed the maximum allowable high as shown in the graph 1 above.

4.8 Benefit of the Project

The following are the benefits of this project

a. Reduce hammering
b. Increase the steam production efficiency
c. Increase the return condensate.
d. Save steam losses
e. Save the capsule replacement cost

a) Save the steam losses

Take an average 20 lbs/hr per steam Trap
0.00907 Ton/hr = 78.36 MT/day

Total of steam losses = 78.36 x 358
= 28052.88 MT/Year
= 28052.88 x RM38
= RM 1,066,075.

Total population of steam trap in plant = 5437 steam traps
Total cost estimation of steam losses before improvement = 43.3% x 5437 x 1,066,075.
= RM 2.51 X 10^9

Total cost estimation of steam losses after improvement = 15.3% x 5437 x 1,066,075
= RM 8.87 X 10^8

So, the total of saving annually = RM 2.51 X 10^9 - RM 8.87 X 10^8
= RM 1.623 X 10^9

b) Save the capsule replacement cost

Normally the malfunction steam trap will be replaced even though the capsule in physically is still OK.

Cost of capsule = RM 500/unit + RM 80/installation

= RM 580/replacement.

Total of failed ST before improvement= 43.3% x 5437

= 2369 ST

Total of failed ST after improvement= 15.3% x 5437

= 832 ST

So,

Total of saving = (2369 – 832) x RM580

= RM 891,460

CHAPTER 5

CONCLUSION AND RECOMMENDATION

As a conclusion, this project is going to be challenging and all the engineering skills will be used and optimized within the time frame of two semesters. More information is needed to enhance the development of the project and an effective yet efficient schedule is required to ensure the project can be completed in time.

In this project one equation has been produced to calculate the condensate return line based on the inlet steam pressure. For thermodynamics steam trap, the maximum height of condensate return line is 64.1 meter when the inlet pressure is medium pressure line (15.5 bar a). Graph 1 above show the relationship between the heights of condensate return lines versus inlet pressure. By using this graph the high of the condensate return line can be determined according to the steam trap inlet pressure whether it is LP, MP or HP line.

Generally there have two possible root causes that have been identified contributed to the steam trap failure which is Preventive Maintenance and piping arrangement. For the Preventive Maintenances (Survey, service and see) the new steam trap management has been introduced. By referring this new steam trap management the preventive maintenance done once in every two weeks instead of once a year. In piping arrangement, the equation to calculate high of condensate return line has been identified.

Highly recommend that, this project should be continued to study on the failure of steam trap on leakage problem. The scope of the study will be abroad not only focused on the failure of steam trap itself but also focused on the piping condition of the steam trap that contribute to the steam trap failure.

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2) A Brief Introduction to Fluid Mechanics, 2nd Edition, Donald F.Young, John Wiley & Sons INC, 2001, Page: 67 – 97

3) Introduction to Heat Transfer, 4th Edition, Frank P. Incropera, John Wiley & Sons INC, 2002, Page: 496-530

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APPENDIX

Condensate-line sizing (based on flash steam)

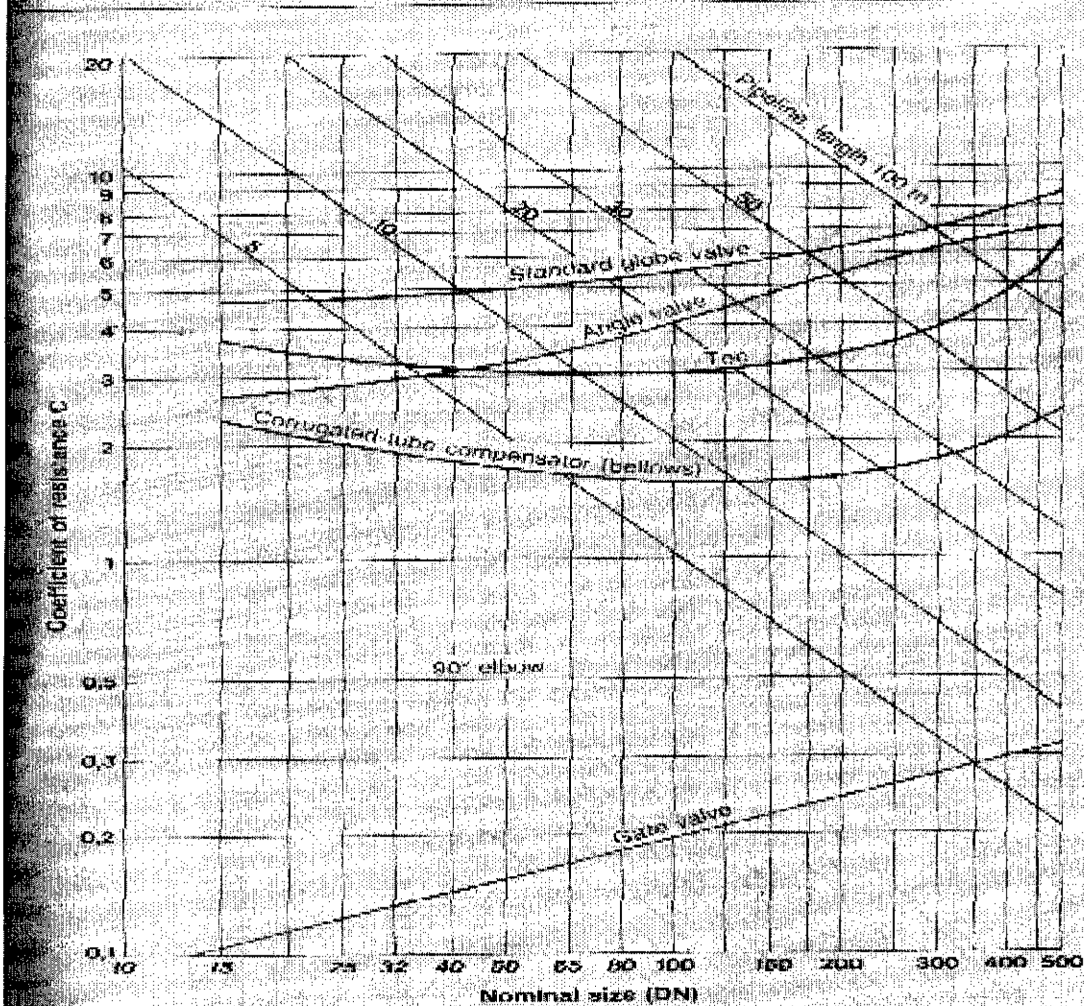
State of condensate before flashing																							
Pressure	Related boiling temperature	Pressure at end of condensate line (bar a)																					
bar a	°C	0.2	0.5	0.8	1.0	1.2	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	6	7	8	9	10	12	15	18	20
1.0	99	35.7	16.0	7.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1.2	104	37.9	18.0	10.0	6.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1.5	111	40.1	20.6	12.9	9.5	6.8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2.0	120	44.2	23.5	15.8	12.6	10.3	7.6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2.5	127	46.8	25.5	17.7	14.5	12.3	9.2	5.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3.0	133	48.8	27.1	19.2	16.0	13.9	10.7	7.3	4.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3.5	138	50.4	28.4	20.4	17.1	15.0	11.9	8.5	6.0	3.8	—	—	—	—	—	—	—	—	—	—	—	—	—
4.0	143	52.0	29.6	21.5	18.2	18.0	12.9	9.7	7.3	5.3	3.5	—	—	—	—	—	—	—	—	—	—	—	—
4.5	147	53.3	30.5	22.3	19.0	16.9	13.7	10.5	8.1	6.3	4.7	3.0	—	—	—	—	—	—	—	—	—	—	—
5	151	54.3	31.5	23.1	19.8	17.7	14.4	11.2	8.9	7.1	5.6	4.2	2.8	—	—	—	—	—	—	—	—	—	—
6	155	55.7	32.3	23.9	20.5	18.4	15.2	11.9	9.6	7.9	6.5	5.1	4.0	2.7	—	—	—	—	—	—	—	—	—
7	158	56.5	33.0	24.5	21.1	18.9	15.7	12.4	10.1	8.4	7.0	5.7	4.6	3.5	2.1	—	—	—	—	—	—	—	—
8	170	59.9	35.5	26.7	23.1	20.9	17.6	14.2	11.9	10.2	8.9	7.7	6.7	5.8	4.8	4.0	—	—	—	—	—	—	—
9	175	61.3	36.4	27.5	23.9	21.7	18.3	14.9	12.6	10.9	9.5	8.4	7.4	6.6	5.5	4.8	2.4	—	—	—	—	—	—
10	179	62.3	37.2	28.2	24.6	22.3	18.9	15.5	13.1	11.4	10.0	8.9	7.9	7.1	6.0	5.3	3.3	2.1	—	—	—	—	—
12	187	64.4	38.7	29.5	25.7	23.5	19.9	16.5	14.1	12.3	11.0	9.8	8.9	8.0	7.0	6.2	4.5	3.6	2.8	—	—	—	—
15	197	66.9	40.5	31.0	27.2	24.8	21.5	17.7	15.2	13.4	12.0	10.8	9.9	9.1	8.0	7.2	5.6	4.8	4.2	2.9	—	—	—
18	206	69.0	42.0	32.3	28.4	26.0	22.3	18.7	16.2	14.3	12.9	11.7	10.8	9.9	8.8	8.0	6.5	5.7	5.1	3.9	2.5	—	—
20	211	70.2	42.9	33.0	29.0	26.6	22.9	19.2	16.7	14.8	13.4	12.2	11.2	10.4	9.2	8.4	7.0	6.2	5.6	4.4	3.1	1.7	—
25	223	72.9	44.8	34.7	30.6	28.1	24.2	20.4	17.9	15.9	14.5	13.2	12.2	11.4	10.2	9.3	7.9	7.1	6.5	5.4	4.2	3.1	2.5
30	233	75.1	46.3	36.0	31.8	29.2	25.3	21.4	18.8	16.8	15.3	14.0	13.0	12.1	10.9	10.0	8.6	7.8	7.2	6.1	4.9	4.0	3.4
35	241	76.8	47.5	37.0	32.7	30.1	26.1	22.1	19.5	17.5	15.9	14.6	13.6	12.7	11.4	10.5	9.2	8.4	7.8	6.7	5.5	4.5	4.0
40	249	78.5	48.7	38.0	33.6	31.0	26.9	22.9	20.1	18.1	16.5	15.2	14.1	13.2	12.0	11.0	9.7	8.6	8.2	7.1	6.0	5.0	4.5
45	256	80.0	49.7	38.8	34.4	31.7	27.5	23.5	20.7	18.6	17.0	15.7	14.6	13.7	12.4	11.4	10.1	9.3	8.6	7.5	6.3	5.4	4.9
50	263	81.4	50.7	39.6	35.2	32.5	28.2	24.1	21.2	19.1	17.5	16.2	15.1	14.2	12.8	11.8	10.5	9.6	9.0	7.9	6.7	5.7	5.2

To determine the actual diameter (mm) the above values must be multiplied with the following factors:

kg/h	100	200	300	400	500	600	700	800	900	1000	1500	2000	3000	5000	8000	10 000	15 000	20 000
Factor	1.0	1.4	1.7	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.9	4.5	5.5	7.1	8.9	10.0	12.2	14.1

Table 1

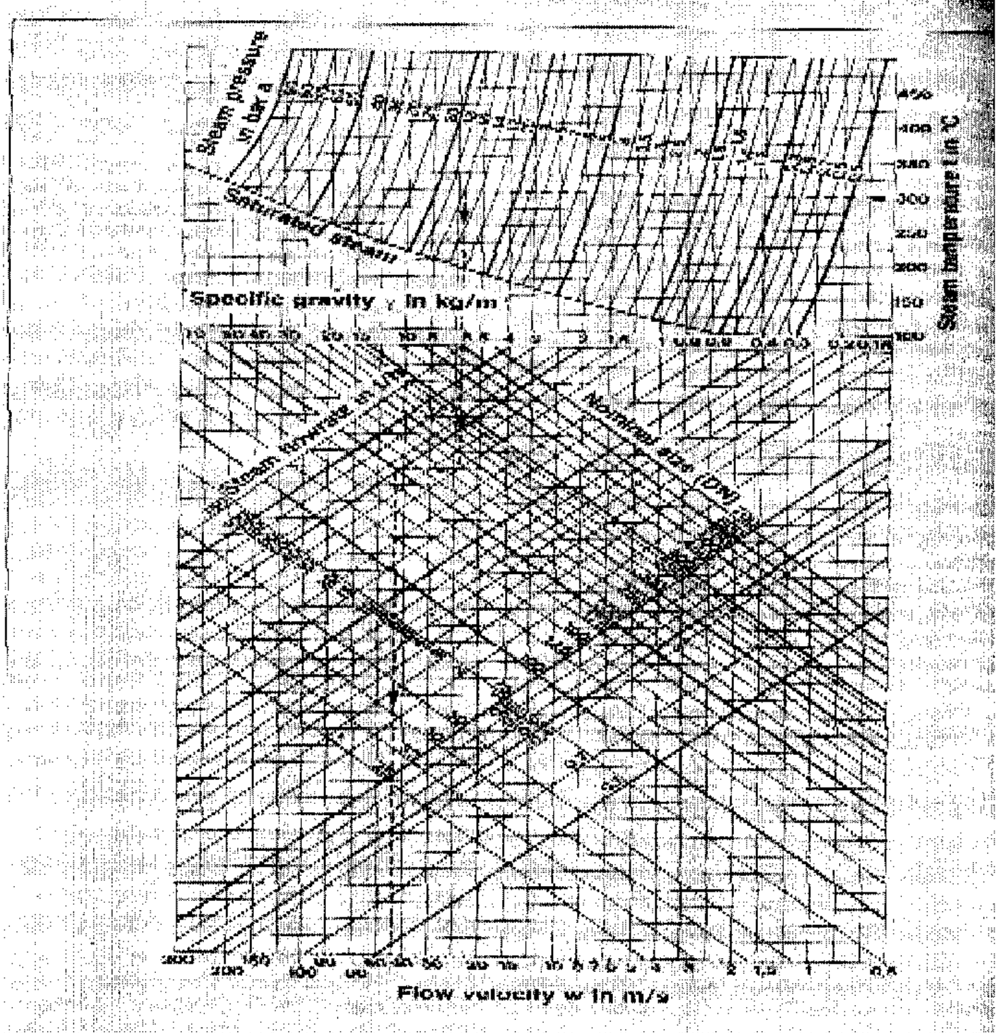
Pressure drops in steam lines



Pressure drop in steam lines
The coefficients of resistance C of all pipeline components of the same size are read in the above chart. The total pressure drop Δp in bar can be determined with the sum of all individual components (ΣC) and the operating data, see page 98.

Graph 1

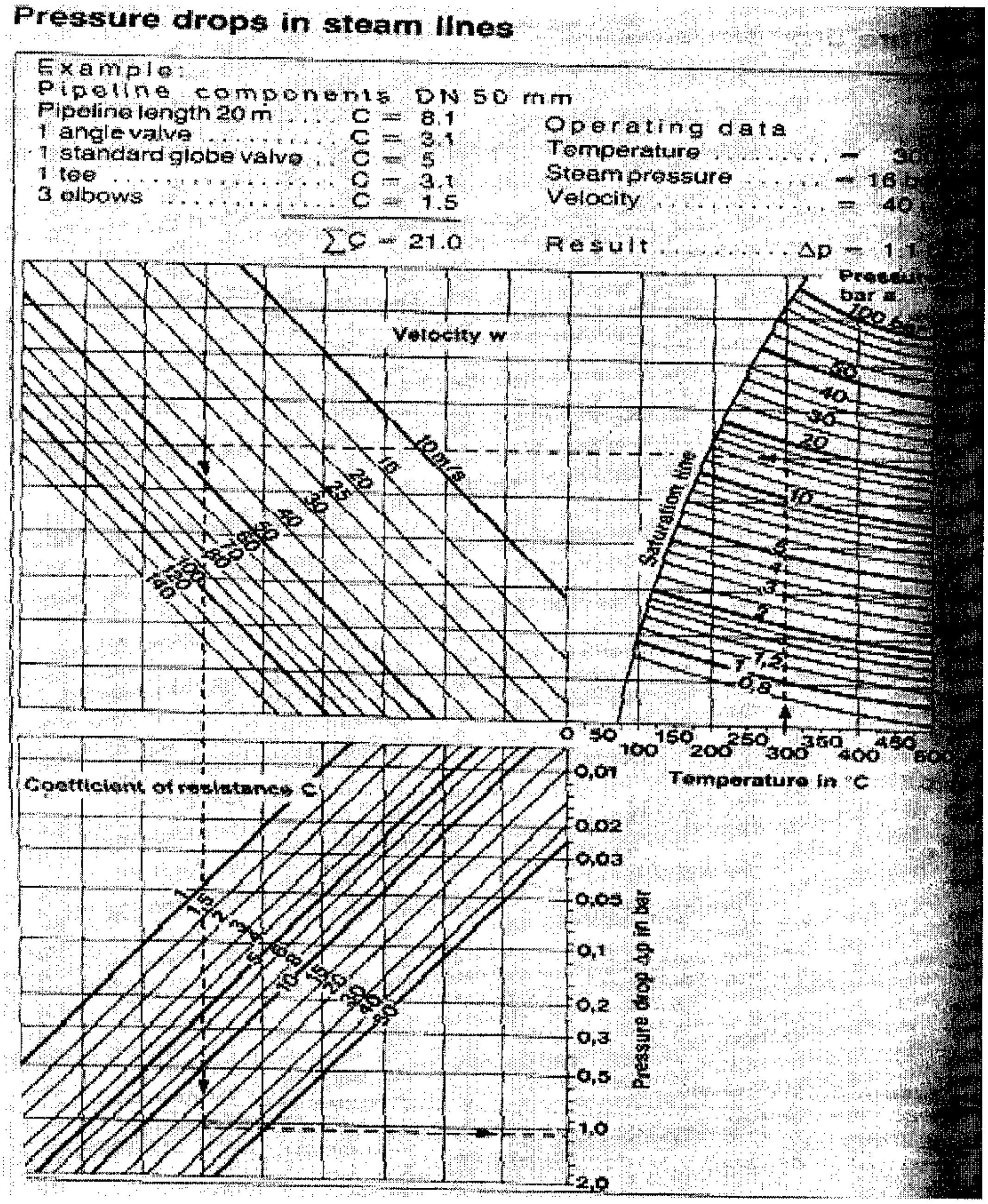
Flow velocity in steam lines



Flow velocity in steam lines

Example: Steam temperature 300°C, steam pressure 16 bar a, steam flow rate 30 t/h, nominal size (DN) 200 mm.

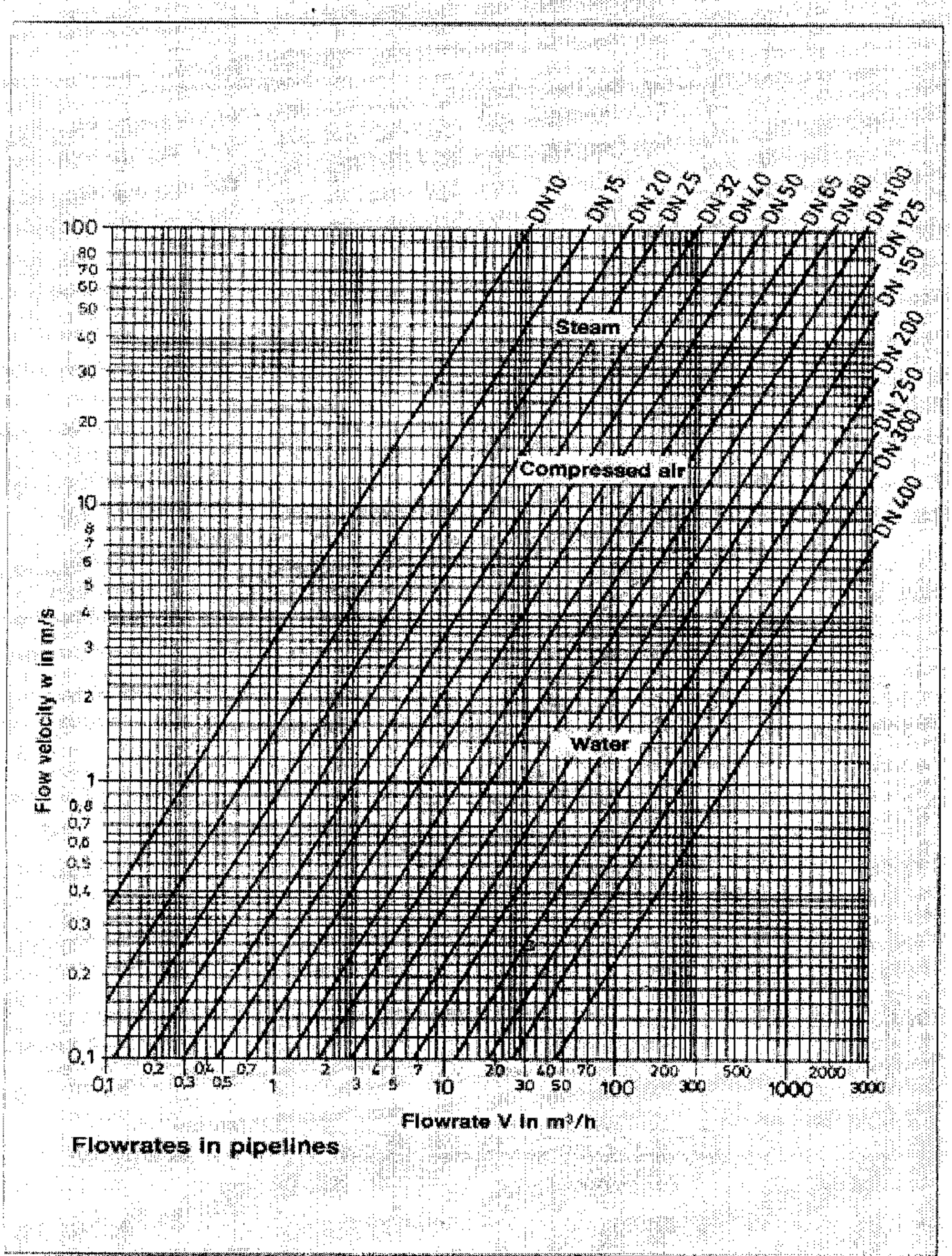
Graph 2



Pressure drops in steam lines
Example:
Pipeline components DN 50 mm
Pipeline length 20 m .... C = 8.1
1 angle valve .... C = 3.1
1 standard globe valve .. C = 5
1 tee .... C = 3.1
3 elbows .... C = 1.5
∑C = 21.0
Operating data
Temperature
Steam pressure
Velocity
Result .... Δp
Velocity w
Saturation line
Coefficient of resistance C
Temperature in °C
Pressure drop Δp in bar

Graph 3

Volume flowrates in pipelines



Graph 4

Figure 1: Steam Trap at the end of steam line

Figure 2: Internal picture in Thermodynamics disc Steam Trap

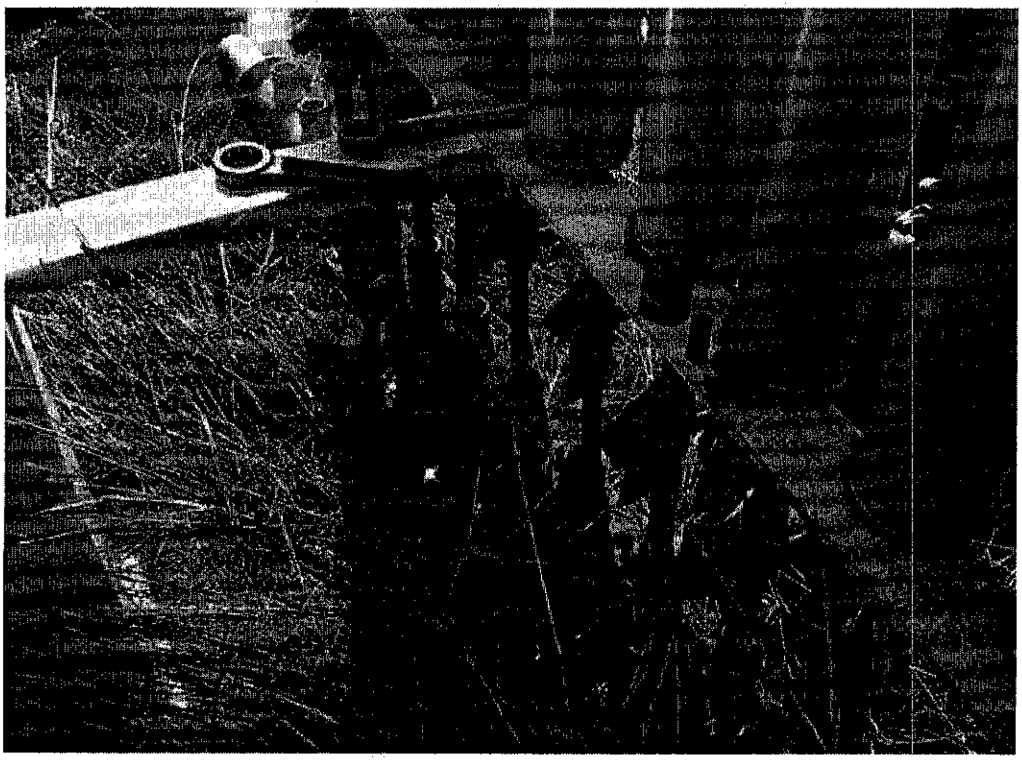


Figure 3: Steam Trap Releasing Condensate

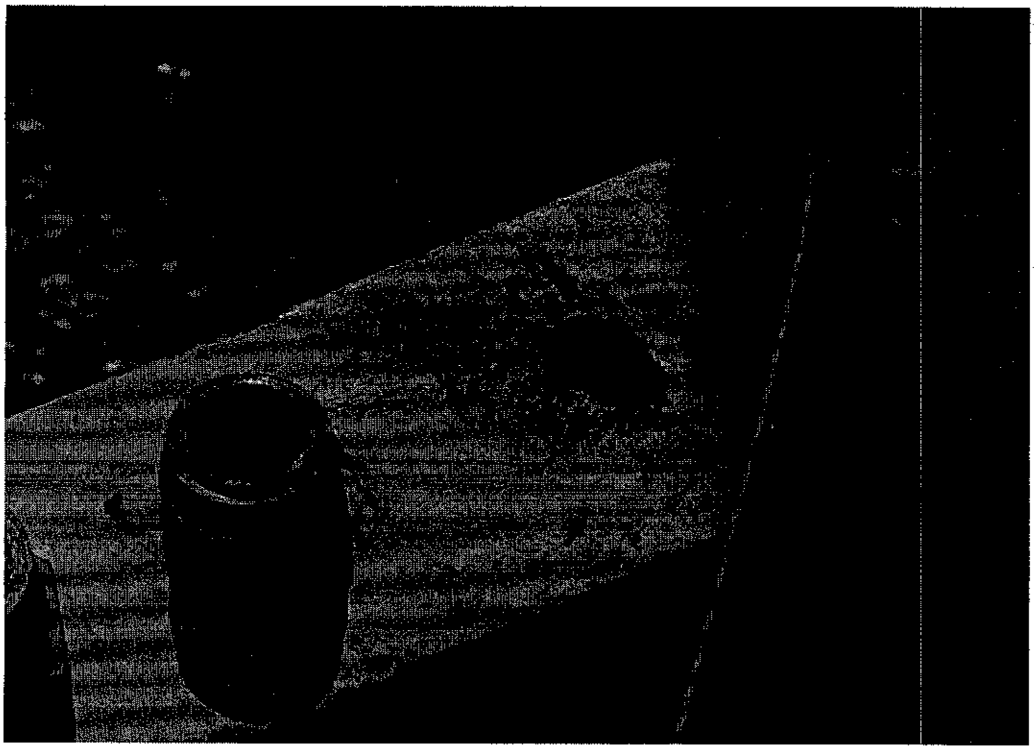


Figure 4: Show the Particle in the Steam Trap