

## بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قال تعالى: ( لَا يُكَلِّفُ اللَّهُ نَفْسًا إِلَّا وُسْعَهَا لَهَا مَا كَسَبَتْ وَعَلَيْهَا مَا اكْتَسَبَتْ رَبَّنَا لَا تُؤَاخِذْنَا إِنْ نَسِينَا أَوْ أَخْطَأْنَا رَبَّنَا وَلَا تَحْمِلْ عَلَيْنَا إِكْرًا كَمَا حَمَلْتَهُ عَلَى الَّذِينَ مِنْ قَبْلِنَا رَبَّنَا وَلَا تُحَمِّلْنَا مَا لَا طَاقَةَ لَنَا بِهِ وَاعْفُ عَنَّا وَارْحَمْنَا أَنْتَ مَوْلَانَا فَانصُرْنَا عَلَى الْقَوْمِ الْكَافِرِينَ (286) )

سورة البقرة

صدق الله العظيم

## **DEDICATION**

**IT'S been a pleasure to us to dedicate this thesis,**

**To our fathers,**

**To our mothers,**

**To our teachers,**

**To our friends.**

## **ACKNOWLEDGMENT**

**Firstly we thank Allah for helping us.**

And then we would like to express our gratitude and appreciations to **Eng.Abdallah Mokhtar** for all the help and guidance he provided throughout our education regarding completion of this thesis project.

Sincere thanks are due to Garri Thermal Station administration and staff specially Eng.Mohamed Ali & Eng.Hussam Eldein Mubarak

Finally, we would like to thank our friends who supported us.

## **ABSTRACT**

This research aimed at the safety relief valve and its importance in power systems to insure the safety of the facility from overpressure that caused pipelines explosion.

The research shows how to select the safety relief valve according to standards and manuals, the proper place to install the safety relief valve, the different operating conditions , and the optimum way of maintenance from periodic maintenance to break down maintenance .After that we took garri-4 thermal station main steam valve as a case study.

## مستخلص

يستهدف هذا البحث صمامات الامان واهميتها في انظمة القدرة لضمان سلامة المنشأ من زيادة الضغط المسبب لحدوث انفجارات في انابيب توصيل البخار.

هذا البحث يوضح كيفية اختيار صمام الأمان حسب المعايير والكتيبات . وتوضيح المكان المناسب لوضع صمام الأمان مع مراعاة ظروف التشغيل والطريقة المثلى للصيانة ابتداء من الصيانة الدورية وحتى صيانة التوقف. وذلك بأخذ صمام البخار الرئيسي بمحطة قري- 4 للتوليد الحراري كموضوع للدراسة.

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## ABBRIATIONS

<b>SRV</b>	Safety Relief Valve.
<b>PR</b>	Pressure Relief.
<b>MAWP</b>	Maximum Allowable Working pressure.
<b>ASME</b>	American Society of Mechanical Engineers.
<b>CFB</b>	Circulating Fluidized Bed (boilers).
<b>CMEC</b>	China Machinery Engineering Corporation.
<b>CMIC</b>	China Machinery International Industry Corporation.
<b>KRC</b>	Keweenaw Research Center (Michigan).

# **CHAPTER ONE**

## 1.1 INTRODUCTION

The Mechanical Science is considered as one of the largest fields of science. One of these fields is the hydraulic and pneumatic systems which have a wide range of usage in industrial field. These systems consists of many parts, one of these parts which plays an important role is the Valves of their different types. And the valve is a device for isolating or regulating the Flow rate of gases, liquids and slurries through Pipe work and launder systems.

Safety is the most important factor in designing a process system. Some undesired conditions might happen leading to damage in a system. Control systems might be installed to prevent such conditions, but a second safety device is also needed. One kind of safety device which is commonly used in the processing industry is the relief valve. A relief valve is a type of valve to control or limit the pressure in a system by allowing the pressurized fluid to flow out from the system.

The pressure in a system can build up by a process upset, instrument or equipment failure, or fire. When considering safety factors to minimizing the damage in industrial plant, it is important to properly select the pressure relief valve to be utilized. This design guideline covers the sizing and selection methods of pressure relief valves used in the typical process industries. It assist engineers and operations personnel to understand the basic design of the different types of pressure relief valves and rupture disks, and increase their knowledge in selection and sizing.

Pressure relief valves controls the pressurized fluid by direct contact; hence it should be designed with materials compatible with the process fluids. There are some codes and standards to govern the design and use

of pressure relief valves, but there are also some additional parameters used to select the design in a typical process.

In material selection, some important parameters are based on fluid properties and process requirements; such as temperature, pressure, chemical attack by process fluid, or corrosiveness.

There are many available guidelines developed to aid engineers in selecting and sizing the relief valves, but mostly these guidelines are developed by certain companies and might only be suitable for the application of the valves provided by their own companies. Hence, it is important to obtain a general understanding of pressure relief valve sizing and selection first. Later, whenever changes are needed in a process system, this basic knowledge is still applicable. This guideline is made to provide that fundamental knowledge and a step by step guideline; which is applicable to properly select and size pressure relief valves in a correct manner.

## **1.2 Problem statement:-**

To increase the service life of a safety relief valve by finding the optimum operation conditions and applying a continuous maintenance.

### **1.3. Objectives:-**

- 1- How to increase safety relief valve service life.
- 2- How to select safety relief valve.
- 3- Method of safety relief valve operation and maintenance due to standards.

### **1.4 Scope:**

The research is detailed study about safety relief valve design, selection, operation and maintenance.

The case study is main steam valve in Garri-4 Thermal Station, it's spring loaded full bore type and we choose it specifically because it's the most important one in the station.



# CHAPTER TWO

## **2. LITERATURE REVIEW.**

### **2.1. Background:**

Prior to Greek and Roman times, little is known about the methods used to control the flow of fluids. Some form of sluice gate was obviously used to hold and retain water in irrigation channels and we know there was some knowledge of the principles of flow because of the water clocks made by the early Egyptians.

The Greek and Roman periods saw the development of many mechanical and hydraulic machines and the first use of valves of sophisticated design. In the case of the plug cock valve, the design remained virtually unchanged until the 19th century.

Flap valves and coin valves were the forebears of the present swing and lift check valves and were used in the water force pumps. Bronze and brass plug cocks were in common use as stop valves on water mains and supply pipes to public and domestic buildings during the Roman period. A large bronze cock valve was found on Capri among the ruins of the Palace of Tiberius, built around AD25.

The early years of the 18th century marked the start of the Industrial Revolution and the arrival of the steam engine as a practical and commercial proposition. In 1698, Thomas Savery had patented his engine for the 'raising of water' and in 1705 Thomas Newcombe introduced his advanced version of Savery's engine, the atmospheric beam engine. James Watt provided the decisive step forward in the development of the steam engine when he patented the separate condenser in 1769.

During the Nineteenth Century, a number of eminent engineers directed their attention to valves, notably Timothy Hackworth, who

introduced adjustable springs instead of weights to the steam safety valve. This valve is preserved in the Science Museum in London.

Another major innovation was the introduction of the groove-packed plug cock by Dewrance & Co. in 1875. This made the valve easier to operate and more suitable for use with steam. Historical note: George Hudd, late father of a senior Stoneleigh Engineering Director, worked at the Dewrance Great Dover Street Factory with distinction for over 45 years.

In 1886, Joseph Hopkinson introduced the parallel slide valve, in which the sealing of the valve was affected by the line pressure on the disc a development which is still being manufactured today.

During the past 60 years, many other types of valves have been designed to cater for the new and hazardous processes which have been developed. Traditional valve types such as Gate and Globe valves have been reappraised as improvements have taken place in materials and the availability of new plastics and synthetic rubbers. This has also led to the development of the lubricated taper plug, diaphragm, ball and butterfly valves which have all been developed and engineered into practical and industrially acceptable products

The lubricated taper plug valve was developed during World War I by Sven Nordstrom, a Swedish engineer, who was trying to overcome the excessive leakage and sticking of ordinary plug valves. The diaphragm valve was developed by a South African engineer named Saunders, who, working in the gold mines, was faced with excessive leakage of compressed air at the glands of the valves being used. In 1929 he developed a valve using a diaphragm both to isolate the valve operating mechanism and also to act as the closing member, which proved a great

success.

The ball, or spherical plug valve, is a relative newcomer to the valve family. Initially developed for fuel systems on aircraft during World War II, the valve was further developed in the post-war years to produce the first industrial range of ball valves. During the last 30 years, many valve manufacturers have directed their attention to the ball valve and a variety of new, improved designs have been introduced. This has led to a much wider diversification and expansion of the capabilities of the ball valve for duties in practically all sections of the valve market. Reference had been made to James Watt, who made use of a butterfly valve in his steam engine, and the first Mercedes car built around 1901 introduced a butterfly valve in the fuel intake linked to the accelerator pedal. The first butterfly valves used metal-to-metal seats but, after World War II, improvements in modern synthetic rubbers for the sealing members extended the application of the butterfly valve into many industrial fields. In the last ten years, the butterfly valve has been developed further to handle much higher pressures and temperatures than previously envisaged. This design is known as the high performance butterfly valve.

The Industrial Revolution of the 18th and 19th centuries increased the pace of development of valves in terms of design and manufacture to meet the new demands from industry. These designs have been fine-tuned in the latter half of the 20th century with the advent of more sophisticated manufacturing methods and the availability of more exotic materials capable of handling the extreme pressures and temperatures of the new and superior fluids which have been developed.

## **2.2 Previous studies:**

### **2.2.1 Investigation into the Causes of Pressure Relief Valve Failure.**

**By:** B V. Hubballi<sup>1</sup>, Dr V B. Sondur , JCE, Belgaum Karnataka, India

MMEC, Belgaum Karnataka, India

#### **a. Objectives of Study:-**

- 1- Test and identify the causes of pressure relief valve failure.
- 2- Determine the service life of relief valves.
- 3- Design, maintenance and operating changes resulting from data and failure analysis can provide significant reliability improvements and reduced costs over the lifetime of a valve.

#### **b. Results and Discussions:-**

The outcome of this effort was focused on determining whether the test was adequate in size and function, and that the test procedure is capable of providing data that can support downstream statistical analysis of relief valve mechanical integrity (service life).

The valve seat, poppet wear problem involves two distinct mechanisms:

- 1- Impact of the poppet on the valve seat on valve closure and sliding of the poppet on the valve seat under the action of the system pressure.
- 2- Depending, however, on the accuracy of the poppet and the valve seat machining, it is conceivable that such misalignment may occur in valve and, therefore, be a source of valve recession. When a component

reliability program is in place to verify relief valve functionality and longevity by history, testing, disassembly and inspection, and periodic statistical review of these activities, relief valves may be replaced at any interval justified by the findings of such a program. In the absence of such a program, each relief valve shall be replaced at the frequency recommended by the relief valve manufacturer. In the absence of both a component reliability program and manufacturers' recommendations, relief valves shall be replaced every five years if not indicated earlier at annual inspection.

Having analyzed the root causes of the valve failure and considered the implications for valve design and seat and poppet materials, it is decided to investigate the potential for reducing valve recession by improving the existing design.

### **c. Conclusion:-**

Stating the root cause of valve recession is difficult. Each valve recession problem will have its own unique set of operating parameters, design features, and material combinations. The investigation, however, has clearly shown that:

A successful design of poppet valves requires a thorough analysis of both velocity and pressure fields, with the aim of improving the poppet/seat geometry.

1. Systematic observations of the feature of erosion pits and the groove showed that the predominant failure was a fatigue process. In order to detect erosion damage of the closure member or possible blockage in the valve body, it is necessary in addition to measure the pressure over the valve and to obtain data of the volume flow through the valve. This data

can best be obtained through a data transfer bus from the measurement sensors.

2. Material choice is clearly critical in addressing valve wear problems. In deciding which material combination to use, consideration should be given to deciding which is more preferable: greater valve seat wear or greater poppet wear.

Clearly, replacing poppet is less costly than replacing valve seat. Therefore, work needs to be focused on reducing poppet and valve seat wear at an acceptable level. Ultimately, however, it would be preferable not to have to replace either and to reduce the adjustment required on valve clearances, as a result of recession, to an absolute minimum. In selecting materials, consideration must be given to the relative resistance required for wear.

3. Wear may increase with valve closing velocity, system pressure, and misalignment of the poppet, valve seat and spring retainer.

This study helps us to know the causes of the valves failure like recession which is caused by erosion, also the problem of wearing. To find the minimum cost of replacing parts and maintenance.

### **2.2.2 Pressure Relief Valve Selection and Applications for Hydraulic Systems.**

**By:** Assoc. Prof. Dr. M. Sc. Ergur H. Sevil

#### **a. Objectives of study:-**

1- Operation of Relief Valves in Hydraulic Systems.

2- The Fundamentals of Sizing Rules in Selection of Relief Valves

### 3- The Characteristics of Relief Valves in Hydraulic System:

- Seat Tightness.
- Operation Temperature.
- Orifice and Sizing.
- Liquid.
- Materials.
- Blown down.

### 4- Selection Parameters of Pressure Relief Valves:

- The Selection on Location of Pressure Relief Valves.
- The Selection of Type of Pressure Relief Devices.
- The Selection of Special Features for Safety Valves.

## **b. Conclusion:-**

In the design of pressure relief systems regulations, codes and standards must be taken into account seriously. Otherwise, design assignment might be complex and time consuming. In order to execute the efficiently of design.

The application of this study in our research is to explain the importance of codes and standards in selecting and operating the safety relief valve according to specific considerations to decrease time consumption.

## **2.2.3 Use of Rupture Discs in Combination with Relief Valves.**

by: John B. Cornwell, David W. Johnson, and William E. Martinsen

### **a. Objectives of study**

- 1- Pressure Control Versus Pressure Relief
- 2- Relief Device Options

### 3- Combinations of RD & RV(rupture discs& relief valves)

#### **b. Conclusions**

Pressure relief solutions are common in industry processes to assure that the investments are protected and a safe working environment is created. Most commonly used devices to offer pressure safety are selected on the basis of specific requirements for the applications. Relief valves and rupture (bursting) discs are mostly specified, each offering their specific features and considerations and providing the system designer viable solution choices. The use of rupture discs in combination with relief valves can be done in several geometries and combinations. These configurations offer a wide range of benefits to the user; environmental, cost reduction, emission control, higher safety/reliability levels and improved performance of the plant safety systems are a direct result.

Process system designers need to evaluate the individual effects and make a selection of what geometry works best for the individual plant requirements. Industry standards and legislations are in place to assure that safe solutions are effectively used. In most applications the combined solution of rupture discs and relief valves offer more value for more benefits a true definition of “more for more”.

This study helps us to know the importance of the safety factor to protect our investment by using a combination between safety valves and rupture discs which brings more benefits and safety to the facility.

# **CHAPTER THREE**

### **3. THEORETICAL APPROACH.**

#### **3.1. Definitions:-**

**Accumulation:** A pressure increase over the set pressure of a pressure relief valve expressed as a percentage of the set pressure.

**Back Pressure:** Is the pressure on the discharge side of a pressure relief valve. Total back pressure is the sum of superimposed and built-up back pressures.

**Balanced Pressure Relief Valve:** Is a spring loaded pressure relief valve that incorporates a bellows or other means for minimizing the effect of back pressure on the operational characteristics of the valve.

**Built-Up Back Pressure:** Is the increase pressure at the outlet of a pressure relief device that develops as a result of flow after the pressure relief device opens.

**Chatter, simmer or flutter:** Abnormal, rapid reciprocating motion of the movable parts of a pressure relief valve in which the disc makes rapid contacts with the seat. This results in audible and/or visible escape of compressible fluid between the seat and the disc at an inlet static pressure around the set pressure and at no measurable capacity, damaging the valve rapidly.

**Conventional Pressure Relief Valve:** Is a spring loaded pressure relief valve which directly affected by changes in back pressure.

**Maximum Allowable Working Pressure (MAWP):** Is the maximum (gauge) pressure permissible at the top of a vessel in its normal operating position at the designated coincident temperature and liquid level specified for that pressure.

**Disc:** Movable element in the pressure relief valve which effects closure.

**Effective Discharge Area:** A nominal area or computed area of flow through a pressure relief valve, differing from the actual discharge area, for use in recognized flow formulas with coefficient factors to determine the capacity of a pressure relief valve.

**Nozzle:** A pressure containing element which constitutes the inlet flow passage and includes the fixed portion of the seat closure.

**Operating Pressure:** The operating pressure is the gauge pressure to which the equipment is normally subjected in service.

**Overpressure:** Overpressure is the pressure increase over the set pressure of the relieving device during discharge, expressed as a percentage of set pressure.

**Pilot Operated Pressure Relief Valve:** Is a pressure relief valve in which the major relieving device or main valve is combined with and controlled by a self actuated auxiliary pressure relief valve (called pilot). This type of valve does not utilize an external source of energy and is balanced if the auxiliary pressure relief valve is vented to the atmosphere.

**Pop action:** An opening and closing characteristic of a safety relief valve in which the valve immediately snaps open into high lift and closes with equal abruptness.

**Pressure Relief Valve:** This is a generic term applying to relief valves, safety valves or safety relief valves. Is designed to relieve the excess pressure and to reclude and prevent the further flow of fluid after normal conditions have been restored.

**Relieving Pressure:** The pressure obtains by adding the set pressure plus (Overpressure / accumulation).

**Safety Relief Valve:** Is a spring loaded pressure relief valve. Can be used either as a safety or relief valve depending of application.

**Set Pressure:** Is the inlet pressure at which the pressure relief valve is adjusted to open under service conditions.

## **3.2 Relief Devices:-**

There are two main types of relief devices according to working way:

### **1- Reclosing Pressure Relief Devices.**

Safety relief valve and it has two common types:

- a. Spring loaded relief valves.
- b. Pilot operated relief valves.

### **2- Non-reclosing pressure relief devices.**

Rupture disk.

## **3.3 safety relief valve:**

### **3.3.1 Brief History:-**

As soon as mankind was able to boil water to create steam, the necessity of the safety device became evident. As long as 2000 years ago, the Chinese were using cauldrons with hinged lids to allow (relatively) safer production of steam.

At the beginning of the 14th century, chemists used conical plugs and later, compressed springs to act as safety devices on pressurized vessels.

Early in the 19th century, boiler explosions on ships and locomotives frequently resulted from faulty safety devices, which led to the development of the first safety relief valves. Safety relief valve is shown in fig (3-1).

In 1848, Charles Ritchie invented the accumulation chamber, which increases the compression surface within the safety valve allowing it to open rapidly within a narrow overpressure margin. Today, most steam users are compelled by local health and safety regulations to ensure that their plant and processes incorporate safety devices and precautions, which ensure that dangerous conditions are prevented.

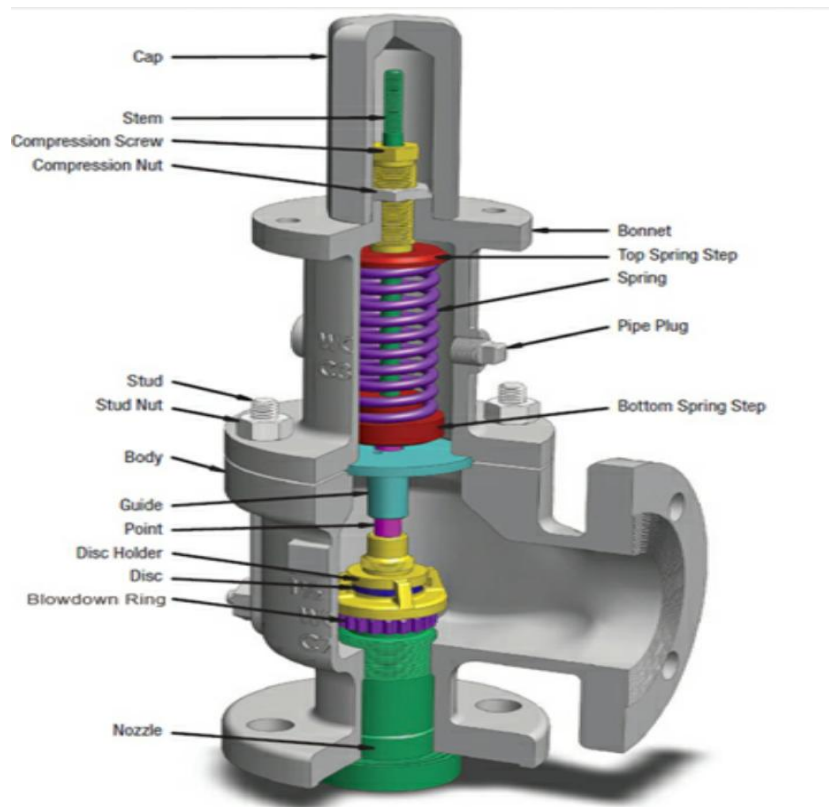


Fig (3-1)

Safety relief valve main parts

### 3.3.2 Main Function :-

The primary function of a safety valve is therefore to protect life and property.

The principle type of device used to prevent overpressure in plant is

the safety or safety relief valve. The safety valve operates by releasing a volume of fluid from within the plant when a predetermined maximum pressure is reached, thereby reducing the excess pressure in a safe manner. As the safety valve may be the only remaining device to prevent catastrophic failure under overpressure conditions, it is important that any such device is capable of operating at all times and under all possible conditions.

Safety valves should be installed wherever the maximum allowable working pressure (MAWP) of a system or pressure-containing vessel is likely to be exceeded. In steam systems, safety valves are typically used for boiler overpressure protection and other applications such as downstream of pressure reducing controls. Although their primary role is for safety, safety valves are also used in process operations to prevent product damage due to excess pressure. Pressure excess can be generated in a number of different situations, including:

- An imbalance of fluid flow rate caused by inadvertently closed or opened isolation valves on a process vessel.
- Failure of a cooling system, which allows vapor or fluid to expand.
- Electrical power failure to control instrumentation.
- Transient pressure surges.
- Exposure to plant fires.
- Heat exchanger tube failure.
- Uncontrollable exothermic reactions in chemical plants.
- Ambient temperature changes

### **3.4 Operation of Safety Relief Valve:-**

Pressure relief devices must operate as designed in order to perform their required task. Different types of problems can prevent normal operation:

- The inlet piping connected to the device must not be smaller in diameter than the inlet opening of the device. An inlet pipe that is smaller than the device inlet opening could alter the operating characteristics for which the device was designed.

- The discharge piping connected to the device must be no smaller than the discharge opening of the device. A discharge pipe that is smaller than the device discharge opening could cause pressure to develop on the discharge side multiple devices discharging into a discharge manifold or header is a common practice. The discharge manifold or header must be sized so the cross-sectional area is equal to or greater than the sum of the discharge cross-sectional areas of all the devices connected to the discharge manifold or header. Failing this requirement, the devices would be subjected to pressure on the discharge side of the device while operating. Even a small amount of pressure here could adversely affect the operation of the device.

- Constant leakage of the device can cause a build-up of scale or other solids around the discharge opening. This build-up can prevent the device from operating as designed.

- Discharge piping connected to the device must be supported so as not to impart any loadings on the body of the device. These loadings could

affect or prevent the proper operation of the device including proper reclose after operating.

- Some devices, especially on larger boilers, may have a discharge pipe arrangement which incorporates provisions for expansion as the boiler heats up or cools down. These expansion provisions must allow the full range of movement required to prevent loads being applied to the device body.

- Drain holes in the device body and discharge piping, when applicable, must be open to allow drainage of liquids from over the device disk on spring loaded valves. Any liquid allowed to remain on top of the device disk can adversely affect the operating characteristics of the device.

- Most jurisdictional requirements state the device must be "piped to a point of safe discharge." This must be accomplished while keeping the run of discharge piping as short as possible. Most jurisdictions also limit the number of 90 degree elbows that may be installed in the discharge piping. Too long of a run and multiple elbows can adversely affect the operation of the device.

### **3.4.1 Spring loaded safety valve:**

#### **a. Operation:**

The basic spring loaded pressure relief valve has been developed to meet the need for a simple, reliable, system actuated device to provide overpressure protection. (Figure 3-2) shows the construction of a spring loaded pressure relief valve. The valve consists of a valve inlet or nozzle mounted on the pressurized system, a disc held against the nozzle to

prevent flow under normal system operating conditions, a spring to hold the disc closed, and a body/bonnet to contain the operating elements. The spring load is adjustable to vary the pressure at which the valve will open.

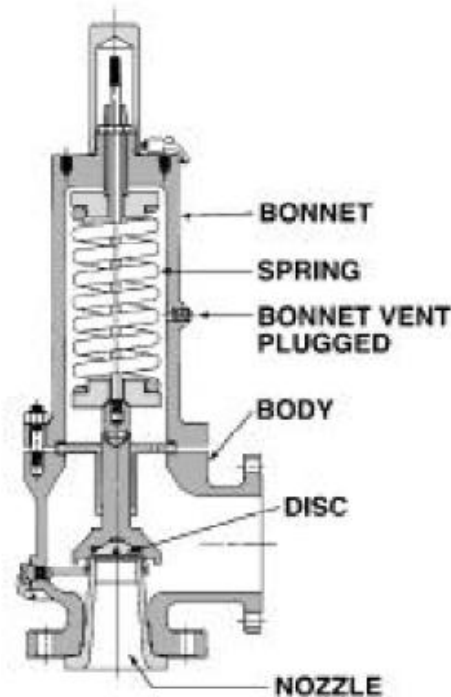


Fig (3-2)  
Spring loaded pressure relief valve.

(Fig 3-2) is a simple sketch showing the disc held in the closed position by the spring. When system pressure reaches the desired opening pressure, the force of pressure acting over Area  $A_1$  equals the force of the spring, and the disc will lift and allow fluid to flow out through the valve. When pressure in the system returns to a safe level, the valve will return to the closed position.

When a pressure relief valve begins to lift, the spring force increases. Thus system pressure must increase if lift is to continue. For this reason pressure relief valves are allowed an overpressure allowance to reach full lift. This allowable overpressure is generally 10% for valves on unfired systems. This margin is relatively small and some means must be provided to assist in the lift effort.

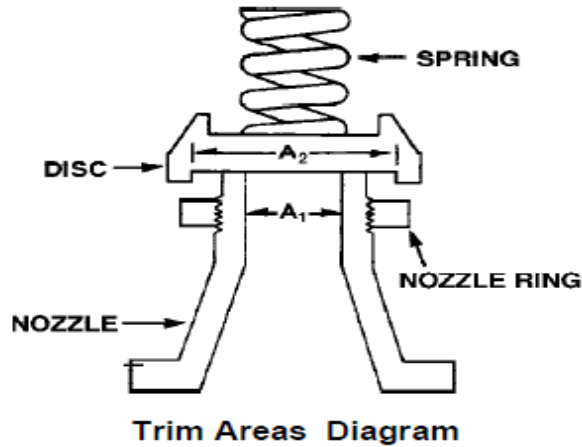
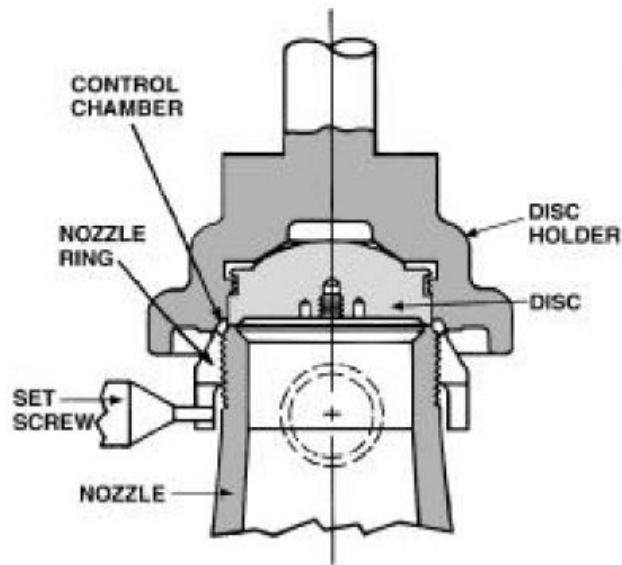


Fig (3-3)

Most pressure relief valves, therefore, have a secondary control chamber or huddling chamber to enhance lift. A typical configuration is shown in (Fig3-4). As the disc begins to lift, fluid enters the control chamber exposing a larger area  $A_2$  of the disc (Fig 3-4) to system pressure. This causes an incremental change in force which overcompensates for the increase in spring force and causes the valve to open at a rapid rate.

At the same time, the direction of the fluid flow is reversed and the momentum effect resulting from the change in flow direction further enhances lift. These effects combine to allow the valve to achieve maximum lift and maximum flow within the allowable overpressure limits. Because of the larger disc area  $A_2$  (Fig 3-3) exposed to system pressure after the valve achieves lift, the valve will not close until system pressure has been reduced to some level below the set pressure. The design of the control chamber determines where the closing point will occur.

The difference between the set pressure and the closing point pressure is called blow down and is usually expressed as a percentage of set pressure.



Fig(3-4)

Pressure relief valve trim

## **b- Design Considerations:-**

### **1. Materials of Construction:-**

Compatibility with the process fluid is achieved by careful selection of materials of construction. Materials must be chosen with sufficient strength to withstand the pressure and temperature of the system fluid. Materials must also resist chemical attack by the process fluid and the local environment to ensure valve function is not impaired over long periods of exposure. Bearing properties are carefully evaluated for parts with guiding surfaces. The ability to achieve a fine finish on the seating surfaces of the disc and nozzle is required for tight shut off. A rate of expansion caused by temperature of mating parts is another design factor.

### **2. Back Pressure Considerations:-**

Pressure relief valves on clean non-toxic, non-corrosive systems may be vented directly to atmosphere. Pressure relief valves on corrosive, toxic or valuable recoverable fluids are vented into closed systems.

Valves that vent to the atmosphere, either directly or through short vent stacks are not subjected to elevated back pressure conditions. For valves installed in a closed system, or when a long vent pipe is used, there is a possibility of developing high back pressure. The back pressure on a pressure relief valve must always be evaluated and its effect on valve performance and relieving capacity must be considered.

A review of the force balance on the disc (Figure 3-3) shows that the force of fluid pressure acting on the inlet side of the disc will be balanced by the force of the spring plus whatever pressure exists on the outlet side of the valve. If pressure in the valve outlet varies while the valve is closed, the valve set pressure will change. If back pressure varies while the valve is open and flowing, valve lift and flow rate through the valve can be affected. Care must be taken in the design and application of pressure relief valves to compensate for these variations.

### **3. Seat Leakage:**

Another important consideration in the design of a pressure relief valve is the ability to maintain tight shut off. Pressure relief valves are required to remain on systems for long periods of time under widely varying conditions of pressure and temperature. Seat leakage will result in continuous loss of system fluid and may cause progressive damage to the valve seating surfaces. Extreme leakage could result in premature opening of the valve. Allowable seat leakage limits for pressure relief valves are many orders of magnitude more stringent than required for other types of valves.

### 3.4.2 Pilot Operated Operation:

A second type of pressure relief valve which offers advantages in selected applications is the pilot operated pressure relief valve shown In (Fig 3-5).

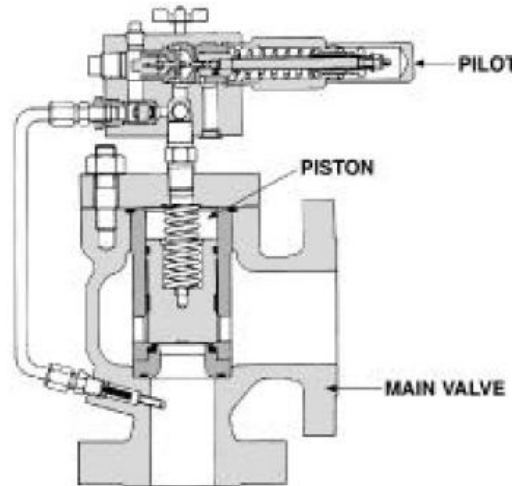


Fig (3-5)  
Snap acting Pilot operated pressure relief valve.

Pilot operated pressure relief valves consist of a main valve with piston or diaphragm operated disc and a pilot. Under normal operating conditions the pilot allows system pressure into the piston chamber. Since the piston area is greater than the disc seat area, the disc is held closed. When the set pressure is reached, the pilot actuates to shut off system fluid to the piston chamber and simultaneously vents the piston chamber. This causes the disc to open.

The pilot operated pressure relief valve has several advantages. As the system pressure increases, the force holding the disc in the closed position increases.

This allows the system operating pressure to be increased to values within 5% of set pressure without danger of increased seat leakage in the

main valve. Pilots are generally designed with a separate control for set pressure and blow down. Valves can be set to open fully at the set pressure and close with a very short blow down. Modulating pilot valve designs, as shown in (Fig 3-6), control the main valve such that minor overpressure conditions are controlled without fully opening the main valve. This limits fluid loss and system shock. Another advantage of pilot operated pressure relief valves is the reduced cost of larger valve sizes. The large spring and associated envelope is replaced by a small pilot, thus reducing the mass and cost of the valve.

Pilot operated pressure relief valves are supplied with filters to protect against foreign matter and are generally recommended for relatively clean service.

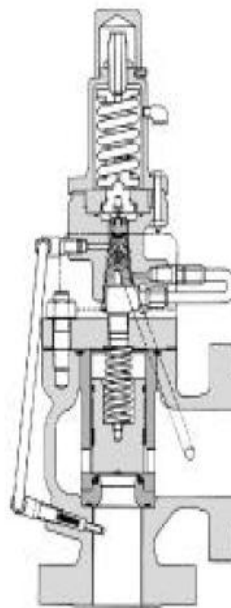


Fig (3-6)  
Modulating style Pilot operated pressure relief valve.

- **The advantages of pilot-operated pressure relief valves are:**

(a) capable of operation at close to the set point and remains closed without simmer until the inlet pressure reaches above 98% of the set pressure.

(b) Once the set pressure is reached, the valve opens fully if a pop action pilot is used.

(c) A pilot-operated pressure relief valve is fully balanced, when it exhausts to the atmosphere.

(d) pilot-operated pressure relief valves may be satisfactorily used in vapor or liquid services up to a maximum back pressure (superimposed plus built-up) of 90% of set pressure, provided that the back pressure is incorporated into the sizing calculation.

(e) A pilot operated valve is sufficiently positive in action to be used as a depressuring device. By using a hand valve, a control valve or a solenoid valve to exhaust the piston chamber, the pilot-operated PR valve can be made to open and close at pressures below its set point from any remote location, without affecting its operation as a pressure relief valve.

(f) Pilot-operated pressure relief valves can be specified for blow down as low as 2%.

(g) It applications involving unusually high superimposed back pressure.

- **The disadvantages of pilot-operated pressure relief valves are:**

(a) Not recommended for dirty or fouling services, because of plugging of the pilot valve and small-bore pressure-sensing lines. If the pilot valve or pilot connections become fouled, the valve will not open.

(b) A piston seal with the “O” ring type is limited to a maximum inlet temperature of 450°F and the newer designs are available for a maximum inlet temperature of about 1000°F in a limited number of valve sizes and for a limited range of set pressures.

(c) Vapor condensation and liquid accumulation above the piston may cause the valve to malfunction.

(d) Back pressure, if it exceeds the process pressure under any circumstance (such as during start-up or shut down), would result in the main valve opening (due to exerting pressure on the underside of the piston that protrudes beyond the seat) and flow of material from the discharge backwards through the valve and into the process vessel. To prevent this backflow preventer must be installed in the pilot operated Pressure relief valve.

(e) For smaller sizes pilot operated pressure relief valve, it is more costly than spring loaded pressure relief valve.

### **3.5 Rupture Disk:**

Rupture disk structure consists of a thin diaphragm held between flanges. It is a device designed to function by the bursting of a pressure-retaining disk fig (3-7). This assembly consists of a thin, circular membrane usually made of metal, plastic, or graphite that is firmly clamped in a disk holder. When the process reaches the bursting pressure of the disk, the disk ruptures and releases the pressure. Rupture disks can be installed alone or in combination with other types of devices. Once blown, rupture disks do not reseal; thus, the entire contents of the upstream process equipment will be vented. Rupture disks are commonly used in series (upstream) with a relief valve to prevent corrosive fluids from contacting the metal parts of the valve.

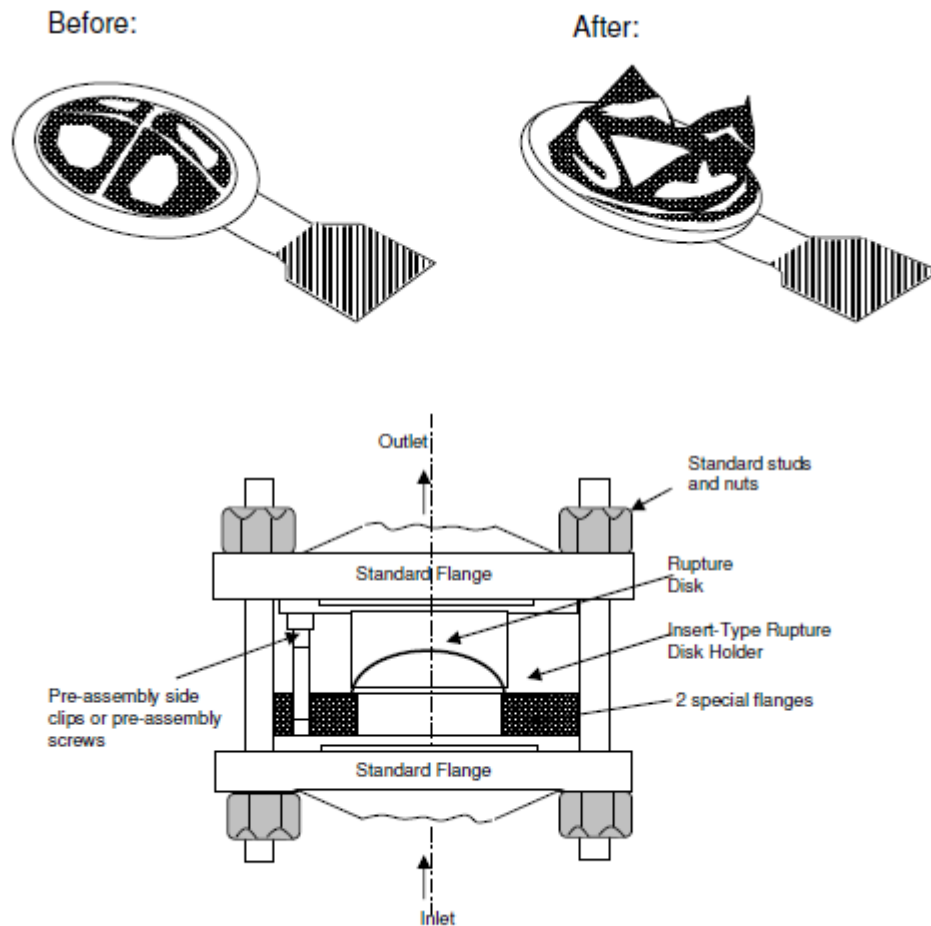
In addition, this combination is a re-closing system. The burst pressure tolerance at the specified disk temperature shall not exceed  $\pm 2$  psi for stamped burst pressure up to and including 40 psi and  $\pm 5\%$  for stamped burst pressure above 40 psi .Rupture disks can be used in any application, it can use single, multiple and combination used with other pressure relief valve (either installed at the inlet / outlet of a pressure relief valve). Rupture disk is installed at inlet of pressure relief valve when to provide corrosion protection for the pressure relief valve and to reduce the valve maintenance. When it installed at outlet of a pressure relief valve, it is functioning to protect the valve from atmospheric or downstream fluids. When used in highly corrosive fluid, two rupture disks are requiring installing together. It can use for process with high viscosity fluid, including nonabrasive slurries. The advantages and disadvantages of rupture disks show in following Table.

**Table (3-1): Advantages and disadvantages of rupture disks:**

<b>Advantages</b>	<b>Disadvantages</b>
Instantaneous full opening.	Non-reclosing (vent until inlet and outlet pressures equalize).
Zero leakage.	Requires high margin between operating and opening pressures.
Very large sizes easily and relatively economically available.	Can fail by fatigue due to pulsations of pressure.
Wide range of materials easily available.	Burst pressure highly sensitive to Temperature
Economical when exotic materials are imposed for the process.	No possibility to check the burst pressure in the field.
Virtually no maintenance.	Requires depressurizing equipment for replacement after bursting.
Full pipe bore (almost) Low pressure drop Low cost	Tolerance usually $\pm 5\%$

**Table (3-2): Rupture Disk Selection and Applications.**

<b>Type of Rupture Disk</b>	<b>Applications</b>
<p>Forward-Acting</p> <p>(a) Forward-Acting Solid Metal.</p> <p>(b) Forward-Acting Scored.</p> <p>(c) Forward-Acting Composite</p>	<p>(a) Operating pressure up to 70% of the marked burst pressure of the disk; not suitable for installation Upstream of a pressure relief valve.</p> <p>(b) Operating pressure up to 85%-90% of the marked burst pressure of the disk; withstand vacuum Conditions without a vacuum support; acceptable for installation. upstream of a pressure relief valve</p> <p>(c) Designed to burst at a rated pressure applied to the concave side; some designs are non-fragmenting and acceptable for use upstream of a pressure relief valve</p>
<p>Reverse-Acting</p> <p>(Formed solid metal disk designed to reverse and burst at a rated pressure applied on The convex side.)</p>	<p>(a) Designed to open by some methods such as shear, knife blades, knife rings, or scored lines.</p> <p>(b) Suitable for installation upstream of pressure relief valves.</p> <p>(c) Provided satisfactory service life with operating pressure 90% or less of marked burst pressure.</p>
<p>Graphite Rupture Disks</p> <p>(Machined from a bar of fine graphite that has been impregnated with a binding Compound.)</p>	<p>(a) Provided satisfactory service life for operating pressure up to 80% of the marked burst pressure and can used for both liquid and vapor service, but not suitable for installation upstream of a pressure Relief valve.</p> <p>(b) Used for vacuum or back pressure conditions with furnished with a support to prevent reverse flexing.</p>



Fig(3-7)  
Forward-Acting Solid Metal Rupture Disk Assembly

### 3.6 Comparison between relief valve and rupture disk:

The main properties of these fundamental protection devices are shown in table (3 -3) depending on the equipment to be protected and required performance, reclosing and non-reclosing devices are complementary and offer unique advantages and restrictions. The appropriate selection and preference must be determined by the design engineer or user depending on the specific application needs.

- **Table (3 -3 ): Relief valve versus Rupture disk**

<b>Properties</b>	<b>Rupture disk</b>	<b>Relief valve</b>
Complexity of device	Low	High
Investment coast	Low	High
After activation	Replace	Reset
Protection against overpressure	Yes	Yes
Protection against vacuum pressure	Yes	No
Mounting position restrictions	None	Vertical only
Installation coast	Low	High
Maintenance coast	Low	High
Requires regular recalibration	None	Yes
Affected by back pressure	Yes	Yes
Operational testing possible	None	Yes
Leak tight	Yes	No
Selection of materials of construction	Large	Limited
Size range	Large	Limited
Change of set pressure	None	Yes
Suitable for Gas, Liquid and 2 phase	Yes	No
Reaction time	Low	High
Unrestricted opening	Yes	No

### **3.7 Applications of safety relief valve:-**

Pilot operated safety valves are used in a large variety of applications. Typical applications are:

#### **1-Compressors in Gas Main Systems:**

Pilot operated safety valves are frequently used for gas transport in pipelines. The reasons are:

- Highest possible operating pressure to set pressure ratios facilitates maximum energy density of transport medium
- Vibrations from compressors lead to leakage with spring loaded safety valves

The Pop Action pilot valve is frequently used for gas applications.

#### **2-Refineries and Gas Conditioning Plants:**

Pilot operated safety valves are frequently used in refineries. The reasons are:

- Backpressure greater than 50% of set pressure because blow-down systems often include long pipe systems
- High absolute backpressures that cannot be handled with spring loaded safety valves with stainless steel bellows.

#### **3-Offshore Applications:**

On offshore platforms, more pilot operated safety valves than spring loaded safety valves are used. The reasons are:

- Lower weight and lower overall height because, compared to a spring loaded safety valve, there is no bonnet
- High set pressures with larger orifices reduce the number of valves required
- No leakage with pilot operated safety valves means a low risk of fire.

#### **4-Pulp and Paper Industry:**

Pilot operated safety valves are used with steam heated dryer drums, for example the Yankee Cylinder.

The reasons are:

- operating pressures of the dryer drums should be as close as possible to the MAWP (Maximum Allowable Working Pressure) in order to increase plant productivity.
- minimized overpressure and blow down in order to avoid a paper tear caused by fluctuating saturated steam temperatures.

#### **3.8 Operational malfunction:**

Overpressure is the result of an unbalance or interruption of the normal flows of fluids.

Pressure vessels, heat exchangers and operating equipment, and piping are designed to contain the system pressure. The design is based on the normal effect of any combination of mechanical loadings that is likely to occur. And the difference between the operating and set pressures of the pressure relieving device. The process system designer must define the minimum relief required to prevent the pressure in any piece of equipment from exceeding the maximum allowable accumulated pressure.

#### **3.9. Over pressure causes:-**

The principal causes of overpressure listed below will serve as guide to generally accept safe practices.

## **1. Closed outlets on vessels:**

Closure of a block valve on the outlet of a pressure vessel while the plant is on stream may expose the vessel to a pressure that exceeds the maximum allowable working pressure. A pressure-relieving device is required if the block valve is not locked or sealed in the open position, closer of such a valve can result in overpressure. Every control valve should be considered as being subject to abnormal operation.

## **2. Inadvertent valve opening:**

Inadvertent opening of any valve from a source of higher pressure such as high-pressure steam or process fluids should be considered. This action may require pressure relieving capacity unless provisions are made for locking or sealing the valve closed.

## **3. Check valve malfunction:**

Failure of a check valve to close must also be considered, As an example where a fluid is pumped into a process system that contain gas or vapor at significantly higher pressure than the design rating of equipment upstream of the pump, the failure of a check valve in the discharge line will result in a reversal of the liquid's flow.

## **4. Utility failure:**

The consequences that may developed from the loss of any utility service, whether plant wide or local, must be carefully evaluated. The normal utility services that could fail and partial listing of affected equipment that could cause overpressure are given in table (3-4).

## 5. Partial failure:

Evaluation of the effect of overpressure that is attributable to the loss of a particular utility service should include the chain of developments that could occur and the reaction time involved. In situations when the equipment fails but operates in parallel with equipment that has a different energy source, operating credit may be taken for the unaffected and functioning equipment to the extent that service is maintained.

**Table (3-4): possible utility failures and equipment affected**

Utility failure	Equipment affected
Electric	Pumps or circulating cooling water Boiler feed, quench or reflux fans for air cooling exchanger, cooling towers.
Cooling water	Condensers for process or utility service coolers for process fluids, lubricating oil, or seal oil
Instrument air	Transmitters and controllers process regulating valves alarm and shutdown system
Steam	Turbine drives for pumps, compressors, steam blowers, combustion air fan or electric generators
Fuel (oil, gas, est.)	Boilers, repeaters (re boiler) engine drivers for pumps or electric generators compressors, gas turbine
Inert gas	Seals, catalytic reactors, purge for instruments and equipment.

## 6. Electrical or mechanical failure:

Failure of electrical or mechanical equipment that provides cooling or condensation on process streams can cause overpressure in process vessels.

## **7. Loss of fans:**

Fans on air cooled heat exchangers or cooling towers occasionally become inoperative because of a loss of power or mechanical breakdown. On cooling towers and on air cooled exchangers where independent operations of the louvers can be maintained, credit for the cooling effect may be obtained, credit for the cooling effect may be obtained by convection and radiation in still air at ambient conditions.

Abnormal heat input from re boilers:

Re boilers are designed with a specified heat input when they are new or recently cleaned, additional heat input above the normal design can occur. In the event of failure of temperature control, vapor generation can exceed the process system ability to condense or otherwise absorb the buildup of pressure, which may include non-condensable to overheating.

## **8. Heat exchanger tube failure:**

In shell and tube heat exchangers, the tubes are subject to failure from a number of causes, including thermal shock, vibration, and corrosion. Whatever the cause, a possibility of the high pressure stream overpressure pressuring equipment in the low pressure side of the exchanger is the result. Economical design usually dictates that the higher pressure stream flow through the tubes, since this can result in a thinner shell, but this is not always the case. The pressure relationships must be known to evaluate the result of tube failure properly. The release should be determined. The possible pressure rise must be ascertained to determine. The possible pressure rise must be ascertained to determine whether additional pressure relief would be required in flow from the tube rupture were to discharge into the lower pressure stream.

# **CHAPTER FOUR**

## **4. CASE STUDY.**

### **4.1 Garri Thermal Station:**

Sudan has a rich petroleum oil resource and is known as petroleum oil exportation country. The geological reserve of reconnoitered petroleum oil has reached to 11.6 billion barrels, 86 million barrels were produced during year of 2002, and 56 million barrels of crude oil were exported. The socioeconomic status of Sudan is developing at high speed along with the petroleum oil industry.

An important limiting factor to the high speed of economic development in the country is its laggard electric foundation. For already long time now, Sudan and China have established very strong foreign relations; with very Comprehensive Corporation in the economic sector which was strengthen further by the exchange visits of the high level leaders of the two countries in the recent years. In order to help Sudan to boost its economy further, the Garri-1 combined cycles power plants with total installed capacity of 210MW which generally contracted and constructed by Ha Erbin Electric Corporation and Garri-2 power plant with the total installed capacity of 120MW have been put into commercial operation since 2003. Garri-3 power plant is in programming now.

The Khartoum Refinery Cooperation which was co-constructed by the China Petroleum Corporation and the Sudan government is located in a strategic economic development district. KRC can produce about 0. 26 million tons of sponge coke every year, and in order to utilize this resource to its maximum, the Sudan national electrical corporation

decided to construct the Garri-4 sponge coke fired CFB boiler power plant.

In July 2004, the Sudan National Electric Corporation submitted a bid for the engineering of the Garri-4 power plant, which was successfully acquired by the China Machinery Import & Export Corporation with the signature of the EPC contract in late 2004. The contract period, would be 24 months once the contract had taken effect. From March 2005 to August 2005, through comprehensive market research and negotiation, CMEC finally decided that China United Corporation would be the design subcontractor of this engineering, China CMIIC Engineering and Construction Group would be the erection and civil subcontractor of this power plant, and Dongfang Boiler Group corporation, Shanghai Steam Turbine cooperation, along with Shanghai Motor Manufacturer would be the main equipment suppliers. It was also decided that Shaanxi Northwest Power Generation Co., Ltd would be the operation contracting subcontractor and would be responsible for the Sudanese personnel training.

- **General conditions of the site**

Garri-4 power plant is located 70km north of Khartoum (capital of Sudan), 13km east of the river Nile, and is nearby the Khartoum Refinery Cooperation. The power plant covers an area of about 16ha. It has an oblong structure, with a length of: 510.00m from south to north and width of 325.00m.

The physiognomy of the site's units is of the rock-desert type, and there are some surrounding isolated, residual, denuded rock hillocks. The landform in the power plant and the substation scope is comparatively flat. Generally, the power plant is inclined to the southwest direction, the

comparative elevation of the site is between 410.85~408.49m (absolute power plant elevation system, the following are the same), among which the height difference between east and west is about 2m; the slope drop is about 1/200; with the undulation between south direction and north direction being comparative less. The free Zone substation is inclined from the southwest to the northeast direction, with a site elevation between 100.04m~99.33m, with a height difference of about 1.00m, and slope drop of about 1/150.

The site is connected with the Capital, Khartoum, via the national road with very convenient ambient transportation conditions. And the linear distance from site to Sudan port is about 800km, with an actual transportation distance of about 1300km.

- **Main projects and scope of this engineering**

This engineering was contracted by CMEC with the contract scope including Garri-4 power plant and a 220kV substation in the free-zone. The main engineering works of this power plant are :

- 1) Main power building: including two complete sponge coke fired CFB boiler units of 240 t/h, two units of 55MW condensing turbo-generator and the relevant auxiliaries.
- 2) Chemical demin station
- 3) Cooling tower and circulating water pump
- 4) Clean water basin and industrial water pump room
- 5) Industrial wastewater treatment station
- 6) Domestic wastewater treatment station
- 7) Building of fuel conveying system such as coke conveying trestle and conveying transfer station.

- 8) Building of limestone conveying system (reserved).
- 9) Building of sand (bed material) injecting system.
- 10) Building of fly ash and bottom ash conveying system.
- 11) Substation.
- 12) Air compressing station.
- 13) Oil storehouse.
- 14) Auxiliary boiler room.
- 15) Emergency diesel generator room.
- 16) Administration building.
- 17) Garage.
- 18) Firefighting station.
- 19) Equipment maintenance workshop.
- 20) Load meter room.
- 21) Bounding wall, watchtower and guard room.

After visiting Garri-4 Thermal Station, we discovered all parts of station and studied different kind of safety valves. Finally we choose the main steam's safety valve as a case study. All data discussed in the following terms.

## **4.2 Garri-4 station main steam valve:-**

### **4.2.1 Purpose:-**

The full-bore type safety valve is used for pressure vessel and boilers which is steam temperature  $<540\text{ }^{\circ}\text{C}$ , set pressure  $< 22\text{MPa}$  to prevent

steam pressure from exceeding set valve, and guarantee the facilities to run safety as shown in appendix 1.

#### **4.2.2 Construction:-**

The full-bore type valve has the advantages of large discharging coefficient exact unlocking pressure, small closing and opening pressure difference, good seal capability and convenient adjustment and so on. The main features are as follows:

##### **1. Nozzle type of valve seat.**

According to the nozzle spray medium flow theories. At the outlet of seat, the speed of flow branches sound speed, the safety valve discharge coefficient is greater than other safety valves.

##### **2. The valve disc adopts the heat stress compensatory structure.**

It is divided into valve disc and heat valve disc to reach seal purpose through making best use of heat distortion of valve disc. Heat valve disc is made into lingulate structure to avoid former leakage by its tiny spring function.

##### **3. Adjusting ring.**

There is an annular space between the top of lower adjusting ring and the lower plane of valve discs .The appropriate opening pressure can be obtained by adjusting the bottom adjusting ring. The top adjusting ring has the function of altering flowing direction of liquid which discharged by valve seat. Such function can also alter the counterforce that act on the valve disc. The position of upper ring directly influences valve closing and opening pressure difference.

#### **4. Cooler**

Cooler separates body from spring to reduce on the spring, in order that the temperature of spring is less than 200°C. So that the spring has the normal toughness and stability.

#### **5. Adjusting sleeve**

Adjusting sleeve can adjust valve's backpressure. An adjusting machine is made up of lower cone and camper of discharging stream. While adjusting sleeve moves up the valves back pressure is reduced while adjusting sleeve moves down, the valves backpressure is increased.

#### **6. Spring.**

Spring is a key part in determining the capability of valve. As for different set pressure, closing and opening pressure difference. Spring is designed differently.

7. The position where steam head port touches padding of valve let is built up with basal cobalt hard alloy. It has the capabilities of high rigidity anti-abrasion and long longevity.

#### **4.3 How to choose safety valve:**

The safety valve is an automatic discharging pressure unit for pressure equipment, containers or pipe roads. When the protected pressure rises over the permitted valve will automatically start to discharge superfluity medium and prevent the system pressure keeping on rising. When the system pressure reduces to regulated value, the valve will be able to automatically shut and make sure the system in general operation. How to choose safety valve correctly will be concerned to the user's economic

benefit and the safe for operator and equipment. The following are the ways to introduced for how to choose the safety valves:

### **1- The confirmation of working pressure grades.**

The working pressure is the quiet pressure which the head valve received while the safety valve in general operation it is as same as the working pressure of the protected system or equipment. The safety valves of the same nominal pressure can be divided various different working pressure rates according to the spring design demands.

When choosing safety valve the working pressure grades for valves should be confirmed according to the required start pressure valve.

### **2-Choosing Conditions:**

#### **A. Choosing for nominal diameter**

The nominal diameter of the safety valve will be confirmed according to the needed discharging volume of the protected system. That means the rated discharging volume for the selected safety valve should be over or near the needed discharging volume.

#### **B. Conformation of Materials**

In general condition, the users can choose according to the working temperature , pressure ranges and representative medium types those we provided the safety valves with different type's samples .

### **4.4 Safety Relief Valves Selection:-**

All these data are taken from the Chinese (HARBIN BOILER COMPANY.LTD) which provides safety relief valves for Garri-4 Thermal Station.

#### **4.4.1 Considerations of selecting a safety relief valve:**

The most critical consideration when selecting a pressure relief valve is that the valve will be capable of passing the maximum expected flow capacity. To properly select a relief valve the user must first determine the following:

1. The set pressure at which the valve is to operate. This pressure is based on the pressure limits of the system and the applicable codes. The set pressure of the primary pressure relief valve must not exceed the maximum allowable pressure of the system, but should be at least 10 percent above the maximum operating Pressure.
2. The physical properties of the fluid media to be relieved. Capacity values are given in the catalogs based on air, saturated steam, and water. Valves will relieve many other fluids, but Information such as molecular weight, specific gravity, viscosity, ratio of specific heats, compressibility factor, and process Temperature may be necessary to insure accurate valve selection.
3. The required relieving capacity. The ASME (American Society of Mechanical Engineering) Boiler and Pressure Vessel Code, American Petroleum Institute Recommended Practices, and other applicable standards have many rules for obtaining the required relieving capacity and should be referenced when making this determination.

Once the previous information has been collected, the pressure relief valve may be sized by using the capacity charts (included in each model's catalog sheet) or by performing sizing calculations. The user will also want to consider other important factors such as:

- **Connection size and type.** This information is given in the Valve Selection Guide and in each of the Model Catalog sheets. Please Note that the inlet to and outlet from a pressure relief valve must be at least as large as the valve connections to prevent valve malfunction.
- **Pipe Size.** Connection pipe sizes should not be determined by equipment connections, but rather by the relieving capacity of the Pressure Relief Valve.
- **Applicable code compliance.** The ASME Code Summary section gives important information about pressure relief valves from the code.
- **Maximum allowable seat leakage.**
- **Environmental conditions.** Environmental conditions play a significant role in how pressure relief valves operate. Extremely high ambient temperatures may affect the set pressure of the valve, extremely low temperatures combined with moisture can cause valves to “freeze up” and prevent proper operation, and vibration may severely shorten the service life of the Valve.
- **Valve options.** Each model is offered with useful options such as Pressure tight caps, lift lever options, or vibration dampening preparation.
- **Installation space.** The individual model catalogs show envelope dimensions for each configuration and size.

#### **4.4.2. Valve Selection Guide:-**

(For specific minimum/maximum temperature/pressure ranges refer to individual product sections.) As shown in table (4-1)

- **Table(4-1): Valve Selection Catalog for Steam Power Boilers :-**

<b>Steam (ASME Section I - Power Boilers)</b>					
<b>Model(s)</b>	<b>Material Body</b>	<b>Connect- Ions Trim</b>	<b>Inlet Size Range [mm]</b>	<b>Min/Max/ Press [barg]</b>	<b>Min/Max Temp [°C]</b>
<b>300, 600</b>	CS	SS	[31.75 - 152.4]	[1.0/69]	[-29/427]
<b>920, 921, 927</b> (special use – 10% blow down)	CS	SS	[12.7 - 50.8]	[1.0/96.5]	[-29/427]
<b>6010, 6021, 6121, 6182 6186, 6221, 6283</b>	Bronze	Brass	[12.7 - 63.5]	[0.69/17.2]	[-51/208]
<b>6030, 6130, 6230</b>	Bronze	SS	[12.7 - 63.5]	[0.69/20.7]	[-51/219]
<b>6252</b>	Iron	SS	[38.1 - 152.4]	[0.69/17.2]	[-29/208]

#### **4.4.3. Safety Valve Sizing:-**

After the required relieving capacity has been determined, the pressure relief valve is sized by using “Coefficient Method” This calculation method involves selecting the valve model and corresponding Flow coefficient and orifice area and then using the capacity formula for the service in which the valve will function.

- **Coefficient Method**

Follow these steps for calculating what orifice size is necessary to flow the required capacity:

1. Select the Model Family that you are interested in from the Valve Selection Guide Table (4-1).

2. Record the Flow Coefficient (**K<sub>a</sub>**) is constant for steam=0.878  
Corresponding to the service in which the valve will operate.
3. Select the proper formula(s) for the service in which the valve will operate. Calculate the minimum required orifice area.

- **Capacity Formula:-**

**Steam - Sections I (1 barg and above):-**

$$A = \frac{W}{52.5K_d * P_1 * K_{sh}}$$

Where:-

**A** = Valve effective orifice area, in<sup>2</sup>..

**W** = Mass Flow Rate, [lb/hr].

**K<sub>d</sub>** = ASME Flow Coefficient of Discharge=0.878

**P<sub>1</sub>** = Allowable Overpressure

**K<sub>sh</sub>** = Superheat Steam Correction Factor from appendix 1,2

- **EXAMPLE 1** (Steam Application)

**Given:**

Fluid: Saturated steam

Required Capacity: 40,000 lb/hr

Set Pressure: 140 psig

Overpressure: 10% (or 14 psig)

Back Pressure: Atmospheric

Inlet relieving Temperature: Saturation temperature

Molecular Weight: 18

**Find:** The correct size standard orifice to meet the given requirements.

**Solution:**

(1) Because the steam is saturated and the set pressure < 1,500 psia,

$$K_{sh} = 1.0$$

(2) Calculate an orifice effective area using Equation 4:

$$A = \frac{W}{52.5K_d * P_1 * K_{sh}} = \frac{4000}{52.5 * 0.878 * (140 + 14 + 14.7) * (1)} = 5.1 \text{ in}^2$$

(3) From Appendix 4 find the smallest standard orifice designation that has an area equal to or greater than A.

(4) Select a “P” orifice with an actual area equal to **6.38 in<sup>2</sup>**.

#### **4.5 Installation:**

1- Valve has been adjusted before delivery, it is not permitted to disassembly on site, they should be installed vertically on facilities and install plat roofs in order to adjust and overhaul.

2- Safety valves should be installed directly on drum piping and header's nipple; the inner diameter of nipple should not be smaller than the diameter of the inlet of the valves. The connecting pipe's height should be as short as possible the connection with pressure vessels should be rounded to provide smooth, unobstructed flow between the vessel and the safety valve. The strength connecting pipe should be higher enough to overcome the counterforce of the discharge pipe. As shown in fig (4-1).

3- The length from safety valve centerline to discharge valve centerline should not be larger than set valve capacity.

4- When valve discharge pipe outlet installed with silencer, should have enough flow area thus can avoid backpressure occurring and will effect operating and discharge.

5- Discharging pipe design and arrangement should prevent it from vibrating which caused by steam blowing force. In order to avoid thermal expansion of vessel and discharging pipe that result in heat stress on valve body, valve outlet should equipped with expansion joints. The inside diameter of the discharge pipes must be greater than that of the safety valve outlet and the length should be as short as possible and should be without elbow. Discharge pipe and expansion joint self-weight should not impose any load on the safety valve. They should be mounted on the other architecture. Each valve should be installed discharge pipe separately and it may cause corrosion.

6- Drainpipe should be installed solely to avoid other facility drain water flowing in the safety valve.

#### **4.6 Adjustment of full-bore type safety relief valve:-**

1- Safety valves have been adjusted in workshop according to set pressure and blow down requirement of the nameplate, upper and lower adjusting ring, adjusting sleeve and adjusting screw's positions have been adjusted and recorded, and the costumers should not change their relative position.

2-after passing acid washing ,puffing pipeline and hydraulic pressure test ,the system should be taken apart and took out the valve discs of hydraulic pressure test .the step is as following:

a. Take manual equipment down; take the locking sheath of the adjusting bolt out. Clean out the dirty in the thread ,which is add the top of the

valve stem and on the top of adjusting nut .screw valve stem nut off and adjust the distance between it and the upper plane of the adjusting screw be equal with or bigger than the valve journey.

b. Loosen the connecting bolt between cooler and body and screw the discharging pipeline of discharging chamber off.

c. Hang up hand-pulling guard vertically at the top of valve and connect it with valve completely.

d. Pull the top of valve up in vertical direction.

e. Remove the top adjusting pole, lift up cooler and oriented groupware out, and take disc groupware and hydraulic pressure test disc out.

f. Inspect the quality of sealing surface and grind to the regular extent.

g. Keep the position of the top loop and the bottom loop fixed. After being cleaning up, the inner parts of valve should be fixed again.

3- Safety valve should be adjusted one by one. While testing, system pressure should be checked at any time. When system pressure raise to 80% of safety valve set pressure. Use the manual mechanism to open the safety valve, begin to blow about 10~30 seconds, then check the discharge pipe's expansion and installation quality. If no problem, the system pressure should be kept rising and valve be tested one by one. Except the ones which be adjusted the top of the outers. Valves stem should be pressed by impacted bolt. However, the pressure should be properly. Secondly, the system pressure should be increased until the valve jumps. Finally, the system pressure should go back to the normal. After being debugged completely, it's necessary to put the 'pressure in the vessel down to 80%of regular pressure. The top impacted bolts of all the valves should be loosened, the manual machine should be installed the

top adjusting pole and the bottom-adjusting pole should be locked by your own lock. And then, the safety valve can be put into service.

#### **4.7 Maintenance of Safety Relief Valve:**

The non proper choice or operation of safety valve will cause the trouble and if the trouble is not removed in the time will affect the function and life of the valve and even more serious is that it will lose the safety protection.

The non proper choice or operation of safety valve will cause the trouble and if the trouble is not removed in the time will affect the function and life of the valve and even more serious is that it will lose the safety protection. There are two main types of maintenance:

##### **4.7.1 Breakdown (forced) maintenance:**

Forced outages for the repair or replacement of equipment parts that have failed in service can be, and often are, very costly. Through the application of proper operating procedures and careful inspection, it is possible to increase the length of time over which a safety valve can be carried on the line before any repairs are required. This, in turn, will prolong the useful life of the equipment and minimize forced maintenance.

The next tables show the breakdown problems which may occur, their causes and the proper way to solve them.

**Table (4-2): Trouble Checklist Table:-**

<b>FAULT</b>	<b>CAUSE</b>	<b>REMEDY</b>
<b>Leakage</b>	1-Presence of foreign particles between seat and plug.	1-Operate the valve once or twice subsequently. If leakage does not stop disassemble the valve and clean the trim.
	2-Seating surface galled or scratched.	2-Disassemble the valve and lap the seat.
	3-The valve is used with a fluid different from the one which it was intended for.	3-Lap seat and risk with smother finishing(if the valve originally intended for liquid, is used for gas )
	4-Valve not mounted in vertical position.	4-Changes the installation.
	5-Set pressure too close to the operation pressure.	5-Improve where possible the quality of the seating surface.

• **Table (4-3): Trouble Checklist Table:-**

FAULT	CAUSE	REMEDY
<p><b>Discharge at a pressure different from the set pressure.</b></p>	<p>1-variable back pressure</p>	<p>1-for standard valves ensure that the discharge piping diameter is equal or higher than the valve outlet diameter and that the discharge piping is not cloggy.</p>
	<p>2- The backpressure is different from the one specified in the order.</p>	<p>2-the valve must be reset for the new backpressure.</p>
	<p>3-the ring nut of the spring adjustor is loose.</p>	<p>3- Reset the valve and tightens the counter nut.</p>
	<p>4-poor trim alignment.</p>	<p>4-operate twice ore trice the valve in order to allow self-alignment of the trim.</p>
	<p>5-too much turbulence at valve inlet (reduction of the set pressure).</p>	<p>5-Modify the valve arrangement.</p>

- **Table (4-4): Trouble Checklist Table:-**

FAULT	CAUSE	RAMEDY
<p><b>Chattering</b> (reported fast opening and reclosing of the valve).</p>	<p>1- Blow down the ring not correctly positioned.</p>	<p>1- Ensure that in case of liquid the rig is in the lowest position. For gas service adjusts it correctly.</p>
	<p>2- Insufficient discharge capacity.</p>	<p>2- Ensure that discharge piping is not cloggy or too long.</p>
	<p>3- The valve is oversized.</p>	<p>3- Replace that the discharge piping is not cloggy or too long.</p>
	<p>4- Too high head losses in the upstream.</p>	<p>4- Increase the blow down by setting the blow down ring closer to the plug.</p>
	<p>5- The operating backpressure is too low.</p>	<p>5- Tightening the adjusting ring from the blug.</p>

#### **4.7.2 Preventive maintenance:**

Preventive maintenance can be defined as the systemic or periodic inspection and servicing required keeping equipment in proper operating condition. It means fixing things before they break, thus keeping equipment in continuous service or ready for service. It is important to regularly inspect and clean the diaphragm, guides and seating surface for the most effective valve performance. Frequency of valve inspection and maintenance should be based on the experience gained in each application. The optimum way to preventive maintenance of safety valve is explained in the following points:

##### **a. Daily.**

- 1- Check for steam leakage indicating damaged seat, defective parts or lodged scale. Correct immediately such faults as leaking, simmering or chattering.
- 2- Check support and anchors of discharge pipe.
- 3- Check the drain line from safety valve outlet to ensure that it is open and will function when needed.

##### **b. Monthly.**

Check each safety valve by raising the valve off the seat by lifting the lever. Keep the valve wide open for at least 10 seconds to blow dirt and scale clean from the seat. Close the valve by suddenly releasing the lever.

##### **c. Annually.**

Before and after the annual steam generator inspection and overhaul, test the operation of all safety valves. Testing is also required whenever the spring or blow back ring has been reset or adjusted.

The spare parts should be stocked for maintenance purposes as shown in appendix 6,7 and 8.

# **CHAPTER FIVE**

## **5. Results and Recommendations.**

### **5.1. Results:-**

After visiting garri-4 thermal station we found that the process of maintenance is just to replace the damaged valve by a new one. This process is very expensive and impractical. So the best solution was to apply continuous preventive maintenance and replace the corrupted part by a new one according to a specific spare part as shown in appendix 6, 7 and 8. This process will increase the life time of safety relief valve and reduce maintenance cost.

The objectives of this thesis have been accomplished from how to select a safety relief valve to how to install and operate in different conditions also how to give a suitable maintenance.

### **5.2 Recommendations:-**

After visiting Garry-4 thermal station and study the main steam safety relief valve (full bore type) we recommend that:

- 1- Apply a continuous maintenance every six months and make sure that the valve is working probably.
- 2- Make a program that selects the safety relief valve which saves time, money and give more accurate results.

Sometimes the safety relief valve fails to open automatically which causes a high pressure that could harm the system in this case the valve must be opened manually.

## References:

- 1- Karl Kolmetz , Practical Engineering Guidelines for Processing Plant Solutions ,Process Equipment Design Guidelines, KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia, February 2014.
- 2-Jekel, T. B., Claas, M., and Reindl, D. T. Development and Validation of a Bench Test Procedure for Post Mortem Testing of Relief Valves, IAR 2011 Ammonia Refrigeration Convention & Exhibition Orlando, FL March 26-30, 2011.
- 3- S. Chabane, S. Plumejault, D. Pierrat, A. Couzinet, Vibration and chattering of conventional safety relief valve under build up backpressure, Proc. 3rd IAHR International Meeting of the Workgroup on Cavitations and Dynamic Problems in Hydraulic Machinery and Systems, Brno, Czech Republic, 2009, pp. 1-14.
- 4- Harbin marine boiler & turbine research institute garri power station – plant 4august 9, 2006.
- 5- Kunkle safety and relief products technical reference kukmc- 0398-us-1412 copyright © 2004 pentair.
- 6- K. Dasgupta, R. Karmakar, Dynamic Analysis of Pilot Operated Pressure Relief Valve, Simulation Modeling Practice and Theory, Vol.10, pp. 35-49, 2002.
- 7- American Petroleum Institute, Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries, Part 1-Sizing and Selection, (7th edition, Recommended Practice 520, 2000).
- 8- Guide to Industrial Hydraulics, Maintenance Manual, (Vickers, 1998)

9- Trever kletz Design\_and\_Safety\_Handbook\_3001.5 publisher CRC press , 1 aug 1998.

10- R. W. Zappe, Valve Selection Handbook (3rd edition, Houston Gulf Publishing Company, 1991).

11- J. Watton, The Design of a Single-Stage Relief Valve with Directional Damping, The Journal of Fluid Control Including Fluidics Vol. 18, n. 2, pp. 22–35, 1988.

# APPENNDIX

- **Appendix1:** Installation of main steam safety valve in Garry-4 station



- **Appendix2:** Garri-4 thermal station



• **Appendix 3: Steam Super Heat Correction Factor:-**

**Table B - Steam Super Heat Correction Factor,  $K_{sh}$**

Set Pressure psig [barg]	Saturated Steam Temp. °F [°C]	Total Steam Temperature °F [°C]														
		280 [138]	300 [149]	320 [160]	340 [171]	360 [182]	380 [193]	400 [205]	420 [216]	440 [227]	460 [238]	480 [249]	500 [260]	520 [271]	540 [282]	560 [293]
15 [1.03]	250 [121]	1.00	1.00	1.00	.99	.99	.98	.98	.97	.96	.95	.94	.93	.92	.91	.90
20 [1.38]	259 [126]	1.00	1.00	1.00	.99	.99	.98	.98	.97	.96	.95	.94	.93	.92	.91	.90
40 [2.76]	287 [142]		1.00	1.00	1.00	.99	.99	.98	.97	.96	.95	.94	.93	.92	.91	.90
60 [4.14]	308 [153]			1.00	1.00	.99	.99	.98	.97	.96	.95	.94	.93	.92	.91	.90
80 [5.52]	324 [162]				1.00	1.00	.99	.99	.98	.97	.96	.94	.93	.92	.91	.90
100 [6.90]	338 [170]					1.00	1.00	.99	.98	.97	.96	.95	.94	.93	.92	.91
120 [8.27]	350 [177]					1.00	1.00	.99	.98	.97	.96	.95	.94	.93	.92	.91
140 [9.65]	361 [183]						1.00	1.00	.99	.98	.96	.95	.94	.93	.92	.91
160 [11.0]	371 [188]						1.00	1.00	.99	.98	.97	.95	.94	.93	.92	.91
180 [12.4]	380 [193]							1.00	.99	.98	.97	.96	.95	.93	.92	.91
200 [13.8]	388 [198]							1.00	.99	.99	.97	.96	.95	.93	.92	.91
220 [15.2]	395 [202]							1.00	1.00	.9	.98	.96	.95	.94	.93	.92
240 [16.6]	403 [206]								1.00	.99	.98	.97	.95	.94	.93	.92
260 [17.9]	409 [210]								1.00	.99	.98	.97	.96	.94	.93	.92
280 [19.3]	416 [213]								1.00	1.00	.98	.97	.96	.95	.93	.92
300 [20.7]	422 [217]									1.00	.99	.98	.96	.95	.93	.92
350 [24.1]	436 [225]									1.00	1.00	.99	.96	.96	.94	.93
400 [27.6]	448 [231]										1.00	.99	.96	.96	.95	.93
450 [31.0]	460 [238]											1.00	.96	.96	.96	.94
500 [34.5]	470 [243]											1.00	.96	.96	.96	.94
550 [37.9]	480 [249]												.97	.97	.97	.95
600 [41.4]	489 [254]												.97	.97	.97	.97
650 [44.8]	497 [258]													1.00	.99	.97
700 [48.3]	506 [263]													1.00	.99	.97
750 [51.7]	513 [267]													1.00	1.00	.98
800 [55.2]	520 [271]														1.00	.99
850 [58.6]	527 [275]														1.00	.99
900 [62.1]	533 [278]														1.00	1.00
950 [65.5]	540 [282]															1.00

• **Appendix 4: Steam Super Heat Correction Factor:-**

**Table B - Steam Super Heat Correction Factor,  $K_{sh}$**

Set Pressure psig [barg]	Saturated Steam Temp. °F [°C]	Total Steam Temperature °F [°C]														
		580 [305]	600 [316]	620 [326]	640 [338]	660 [349]	680 [360]	700 [371]	720 [382]	740 [393]	760 [405]	780 [416]	800 [427]	900 [482]	1000 [537]	1100 [593]
15 [1.03]	250 [121]	.89	.88	.87	.86	.86	.85	.84	.83	.83	.82	.81	.81	.78	.75	.72
20 [1.38]	259 [126]	.89	.88	.87	.86	.86	.85	.84	.83	.83	.82	.81	.81	.78	.75	.72
40 [2.40]	287 [142]	.89	.88	.87	.87	.86	.85	.84	.84	.83	.82	.82	.81	.78	.75	.72
60 [4.14]	308 [153]	.89	.88	.87	.87	.86	.85	.84	.84	.83	.82	.82	.81	.78	.75	.72
80 [5.52]	324 [162]	.89	.89	.88	.87	.86	.85	.84	.84	.83	.82	.82	.81	.78	.75	.72
100 [6.90]	338 [170]	.90	.89	.88	.87	.86	.85	.85	.84	.83	.82	.82	.81	.78	.75	.72
120 [8.27]	350 [177]	.90	.89	.88	.87	.86	.85	.85	.84	.83	.82	.82	.81	.78	.75	.72
140 [9.65]	361 [183]	.90	.89	.88	.87	.86	.85	.85	.84	.83	.82	.82	.81	.78	.75	.72
160 [11.0]	371 [188]	.90	.89	.88	.87	.86	.86	.85	.84	.83	.82	.82	.81	.78	.75	.72
180 [12.4]	380 [193]	.90	.89	.88	.87	.86	.86	.85	.84	.83	.82	.82	.81	.78	.75	.72
200 [13.8]	388 [198]	.90	.89	.88	.87	.86	.86	.85	.84	.83	.83	.82	.81	.78	.75	.72
220 [15.2]	395 [201]	.91	.90	.89	.88	.87	.86	.85	.84	.8	.83	.82	.81	.78	.75	.72
240 [16.6]	403 [206]	.91	.90	.89	.88	.87	.86	.85	.84	.84	.83	.82	.81	.78	.75	.72
260 [17.9]	409 [209]	.91	.90	.89	.88	.87	.86	.85	.85	.84	.83	.82	.81	.78	.75	.72
280 [19.3]	416 [213]	.91	.90	.91	.88	.87	.86	.85	.85	.84	.83	.82	.82	.78	.75	.72
300 [20.7]	422 [217]	.91	.90	.89	.88	.87	.86	.86	.85	.84	.83	.82	.82	.78	.75	.72
350 [24.1]	436 [224]	.92	.91	.90	.89	.88	.87	.86	.85	.84	.83	.83	.82	.78	.76	.72
400 [27.6]	448 [231]	.92	.91	.90	.89	.88	.87	.86	.85	.84	.84	.83	.82	.79	.76	.72
450 [31.0]	460 [238]	.93	.92	.91	.89	.88	.87	.86	.86	.85	.84	.83	.82	.79	.76	.72
500 [34.5]	470 [243]	.93	.92	.91	.90	.89	.88	.87	.86	.85	.84	.83	.82	.79	.76	.73
550 [37.9]	480 [249]	.94	.92	.91	.90	.89	.88	.87	.86	.85	.84	.83	.82	.79	.76	.73
600 [41.4]	489 [254]	.94	.93	.92	.90	.89	.88	.87	.86	.85	.84	.84	.83	.79	.76	.73
650 [44.8]	497 [258]	.95	.94	.92	.91	.90	.89	.87	.86	.86	.85	.84	.83	.79	.76	.73
700 [48.3]	506 [263]	.96	.94	.93	.91	.90	.89	.88	.87	.86	.85	.84	.83	.79	.76	.73
750 [51.7]	513 [267]	.96	.95	.93	.92	.90	.89	.88	.87	.86	.85	.84	.83	.79	.76	.73
800 [55.2]	520 [271]	.97	.95	.94	.92	.91	.90	.88	.87	.86	.85	.84	.84	.80	.76	.73
850 [58.6]	527 [275]	.98	.96	.94	.93	.92	.90	.89	.88	.87	.86	.85	.84	.80	.76	.73
900 [62.1]	533 [278]	.99	.97	.95	.93	.92	.90	.89	.88	.87	.86	.85	.84	.80	.77	.73
950 [65.5]	540 [282]	.99	.97	.95	.94	.92	.91	.89	.88	.87	.86	.85	.84	.80	.77	.73
1000 [69.0]	546 [286]	.99	.98	.96	.94	.93	.91	.90	.89	.87	.86	.85	.84	.80	.77	.73
1050 [72.4]	552 [289]	1.00	.99	.97	.95	.93	.92	.90	.89	.88	.87	.86	.85	.80	.77	.73
1100 [75.9]	558 [292]	1.00	.99	.98	.95	.94	.92	.91	.89	.88	.87	.86	.85	.81	.77	.73
1150 [79.3]	563 [295]	1.00	.99	.98	.96	.94	.92	.91	.90	.88	.87	.86	.85	.81	.77	.73
1200 [82.7]	569 [298]	1.00	.99	.98	.97	.95	.93	.91	.90	.89	.87	.86	.85	.81	.77	.73

- **Appendix 5 : Standard Nozzle Orifice Data**

<b>NOZZLE ORIFICE AREAS</b>	
<b>Size Designation</b>	<b>Orifice Area, in<sup>2</sup></b>
D	0.110
E	0.196
F	0.307
G	0.503
H	0.785
J	1.280
K	1.840
L	2.850
M	3.600
N	4.340
P	6.380
Q	11.050
R	16.000
T	26.000

- **Appendix 6 : Replacement Carbon Steel Spring Part Numbers**

Set Range PSIG	Carbon Steel Spring Part Numbers (*)						
	2"	3"	4"	6"	8"	10"	12"
1.0 to 1.3	SPR1201020120	SPR1201030120	SPR1201040120	SPR1201060120	SPR1201080120	SPR1201100120	SPR1201120120
1.4 to 1.8	SPR1201020220	SPR1201030220	SPR1201040220	SPR1201060220	SPR1201080220	SPR1201100220	SPR1201120220
1.9 to 2.4	SPR1201020320	SPR1201030320	SPR1201040320	SPR1201060320	SPR1201080320	SPR1201100320	SPR1201120320
2.5 to 3.2	SPR1201020420	SPR1201030420	SPR1201040420	SPR1201060420	SPR1201080420	SPR1201100420	SPR1201120420
3.3 to 4.2	SPR1201020520	SPR1201030520	SPR1201040520	SPR1201060520	SPR1201080520	SPR1201100520	SPR1201120520
4.3 to 5.5	SPR1201020620	SPR1201030620	SPR1201040620	SPR1201060620	SPR1201080620	SPR1201100620	SPR1201120620
5.6 to 7.2	SPR1201020720	SPR1201030720	SPR1201040720	SPR1201060720	SPR1201080720	SPR1201100720	SPR1201120720
7.3 to 9.4	SPR1201020820	SPR1201030820	SPR1201040820	SPR1201060820	SPR1201080820	SPR1201100820	SPR1201120820
9.5 to 12.2	SPR1201020920	SPR1201030920	SPR1201040920	SPR1201060920	SPR1201080920	SPR1201100920	SPR1201120920
12.3 to 15.0	SPR1201021020	SPR1201031020	SPR1201041020	SPR1201061020	SPR1201081020	SPR1201101020	SPR1201121020

- **Appendix 7: Replacement Stainless Steel Part Numbers:**

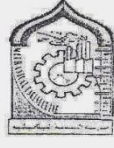
Set Range PSIG	17-7 PH Stainless Steel Spring Part Numbers (*)						
	2"	3"	4"	6"	8"	10"	12"
1.0 to 1.3	SPR1201020105	SPR1201030105	SPR1201040105	SPR1201060105	SPR1201080105	SPR1201100105	SPR1201120105
1.4 to 1.8	SPR1201020205	SPR1201030205	SPR1201040205	SPR1201060205	SPR1201080205	SPR1201100205	SPR1201120205
1.9 to 2.4	SPR1201020305	SPR1201030305	SPR1201040305	SPR1201060305	SPR1201080305	SPR1201100305	SPR1201120305
2.5 to 3.2	SPR1201020405	SPR1201030405	SPR1201040405	SPR1201060405	SPR1201080405	SPR1201100405	SPR1201120405
3.3 to 4.2	SPR1201020505	SPR1201030505	SPR1201040505	SPR1201060505	SPR1201080505	SPR1201100505	SPR1201120505
4.3 to 5.5	SPR1201020605	SPR1201030605	SPR1201040605	SPR1201060605	SPR1201080605	SPR1201100605	SPR1201120605
5.6 to 7.2	SPR1201020705	SPR1201030705	SPR1201040705	SPR1201060705	SPR1201080705	SPR1201100705	SPR1201120705
7.3 to 9.4	SPR1201020805	SPR1201030805	SPR1201040805	SPR1201060805	SPR1201080805	SPR1201100805	SPR1201120805
9.5 to 12.2	SPR1201020905	SPR1201030905	SPR1201040905	SPR1201060905	SPR1201080905	SPR1201100905	SPR1201120905
12.3 to 15.0	SPR1201021005	SPR1201031005	SPR1201041005	SPR1201061005	SPR1201081005	SPR1201101005	SPR1201121005

- **Appendix 8: Part Number For Recommended Soft Good Spare Parts:**

<b>VALVE SIZE</b>	FEP Diaphragm 20 mil (Spring Loaded)	FEP Diaphragm 10 mil (Weight Loaded)	FEP Diaphragm 20 mil (Weight Loaded)	Gasket, Outlet Fluoropolymer (bottom)	Gasket, Cover Fluoropolymer (top)	O-Ring (machined pallet) FKM
2"	DPH1201027320	DPH1200027310	DPH1200027320	GKT1220027102	GKT1200027101	0267010U2
3"	DPH1201037320	DPH1200037310	DPH1200037320	GKT1220037102	GKT1200037101	
4"	DPH1201047320	DPH1200047310	DPH1200047320	GKT1220047102	GKT1200047101	
6"	DPH1201067320	DPH1200067310	DPH1200067320	GKT1220067102	GKT1200067101	0267012U2
8"	DPH1201087320	DPH1200087310	DPH1200087320	GKT1220087102	GKT1200087101	
10"	DPH1201107320	DPH1200107310	DPH1200107320	GKT1220107102	GKT1200107101	
12"	DPH1201127320	DPH1200127310	DPH1200127320	GKT1220127102	GKT1200127101	

Sudan University of Science & Technology  
College of Engineering

School of:



جامعة السودان للعلوم والتكنولوجيا

كلية الهندسة

مدرسة الهندسة الميكانيكية

Mechanical Engineering

التاريخ: / / 2015 م

السيد / هدير المشتركة لسودانية للتوريد الحارث

السلام عليكم ورحمة الله وبركاته

الموضوع: زيارة علمية لطلاب مشروع تخرج تحت عنوان  
صمامات الأمان اختيار، تشغيل وصيانة

Safety Relief valves selection, operation and maintenance

في إطار التعاون والعلاقة المتطورة بين المؤسسات الأكاديمية والمؤسسات الصناعية نرجو  
إدارة جامعة السودان للعلوم والتكنولوجيا (كلية الهندسة - مدرسة الهندسة الميكانيكية)  
مواظبةكم الكريمة بالسماح لطلاب المشروع المذكورين أدناه بزيارة مؤسستكم الرائدة  
بغرض تجميع بعض المعلومات المتعلقة بموضوع بحث تخرجهم - والطلاب هم:

1- محمود صلاح الدين عوض حميدة

2- محمد محبوب محمد الحارث

3- مازن عبد المعتم طه

،، وتقبلو فائق الشكر والتقدير والاحترام ،،

أ. عبد الله مختار محمد  
مشرف المشروع



0920815532  
0922263564 } لا يوجد رد



بسم الله الرحمن الرحيم  
وزارة الموارد المائية والكهرباء  
Ministry Of Water Resources Electricity  
الشركة السودانية للتوليد الحراري المحدودة  
إدارة الموارد البشرية  
قسم التدريب



النمرة : ت/خ/م

التاريخ : 2015/5/19م

السيد/ مدير مجمع محطة كهرباء قرى (4)

السلام عليكم ورحمة الله وبركاته ..

بالإشارة للموضوع اعلاه، نرجو التكرم بمساعدة طلاب الهندسة الميكانيكا -  
جامعة السودان للعلوم والتكنولوجيا، وذلك من اجل اكمال بحث التخرج تحت  
عنوان ( Safety Relief Valve )، والطلاب هم :

1. محمود صلاح الدين
2. مازن عبد المنعم طه
3. محمد محجوب محمد

وشكراً .....



صورة إلى:

الملف



بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

الشركة السودانية للتوليد الحراري  
محطة توليد كهرباء قري 4  
Garri4 POWER PLANT



Ref.: .....

التاريخ 2015/05/19

السيد/ مدير وحدة أمن المصفاة  
نرجو السماح بدخول الاتي:

- |          |                     |
|----------|---------------------|
| ...../1  | محمود صلاح الدين    |
| ...../2  | هاجره عبد النعمانية |
| ...../3  | محمد محمود          |
| ...../4  |                     |
| ...../5  |                     |
| ...../6  |                     |
| ...../7  |                     |
| ...../8  |                     |
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| ...../10 |                     |
| ...../11 |                     |
| ...../12 |                     |
| ...../13 |                     |
| ...../14 |                     |
| ...../15 |                     |
| ...../16 |                     |

وذلك بغرض:

التدريب لمدة اسبوع

هالة العسيلة

عبد علي اوهاج ادريس  
محطة توليد كهرباء قري 4



وشكرا

سلامة باله خول  
لمدة ١٥ اسبوع من ١٤/٥/١٥

