University of Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

MASTER'S THESIS

Study programmed/specialization: Petroleum Technology – Drilling and Well Engineering	Spring semester, 2018 Open
Author: Moslim Shaipov	……………………………………… (signature of author)
Faculty Supervisor: Jan Aage Aasen, University of Stavanger External Supervisor(s): Paul Tysse, Valvision	
Title of master's thesis: Drilling and Well – Valve usage in changing environment	
Credits: 30	
Keywords: Oil & Gas Production Valves Christmas tree Valve usage Failure rate Failure mechanism	Number of pages: 51 + supplemental material/other: 14 Stavanger, June 15th 2018

Acknowledgements

I would like to express my gratitude to all the people that have taken part in making it possible for me to conduct the necessary work to finish this thesis. Without the moral support I achieved from family and friends, this would not have been possible.

I would like to thank my supervisor at University of Stavanger, Professor Jan Aage Aasen, for providing me with the direction and tips in how to proceed with the writing of this thesis.

Also a big thank you goes to Valvision AS, for providing me with this interesting thesis problem that have given me a great pleasure to investigate the problem and learn along the way. Big thank you goes to Paul Tysse (Operations Director) and Leif Grønning (Managing Director) at Valvision.

Sandnes, 15.06.2018

Moslim Shaipov

Summary

Since the oil price experienced its drastic fall summer 2014, a leaner and more cost effective oil and gas production have been an important element for oil and gas companies. This is why this paper in cooperation with Valvision have investigated valve usage in changing environment with higher demands from operators with regards to cost effective solutions. In order to determine any possible problem areas on Christmas trees (XT) found on oil and gas installations, both qualitative and quantitative research methods have been performed by conducting interviews in the field and XT valves failure rate data gathering from three major oil and gas fields on Norwegian Continental Shelf (NCS). Also the general industry bias when it comes to operator`s willingness to try new valve solution to cut cost have been highlighted by performing interviews with personnel from four different oil and gas installations.

To determine any possible improvement areas for valves on XTs, 929 valves found on XTs from three different oil and gas fields have been analyzed. Both failure rates and failure mechanisms have been highlighted and presented to give an overview of possible improvement implementations for valve suppliers. This data has then been compared to the information obtained by conducting interviews with professionals working with XTs on a daily basis, to reflect current situation in the market.

The analysis found Choke valves to be the valve type on XT with highest failure rate. These valve were found to have 11.0 % failure rate. This was significantly higher then other valve types found on XT. Valve leakage and corrosion were determined as the failure mechanisms most often occurring for both Choke valves and Gate valves. Also optimization of maintenance procedures for valves on XTs were highlighted, as it was observed lack of optimal procedures within workers performing maintenance on these valves. The importance of correct valve material has also been concluded, as many of the failure causes for these valves can be linked to poor valve material choice.

List of figures

List of tables

Abbreviations

U/S – Upstream
D/S - Downstream
BOP – Blow Out Preventer
PW – Production Wing Valve
PMV – Production Master Valve
KWV – Kill Wing Valve
XT – Christmas Tree
NCS – Norwegian Continental Shelf
OPEC – Organization of the Petroleum Exporting Countries
OIM – Offshore Installation Manager
ID – Inner Diameter
OD – Outer Diameter
ANSI – American National Standard Institute
API – American Petroleum Institute
DIN – Deutsches Institut Fur Normung
ISO – International Organization for Standardization
NEMA – National Electrical Manufactures Assosiation
NS – Norsk Standard
ASME – The American Society of Mechanical Engineers
ASTM – American Society for Testing and Materials
H2S - Hydrogensulfid
CO2 – Carbon dioxide

Table of Content

1 Introduction

1.1 Background and motivation

Since summer 2014, the Oil & Gas industry experienced a big fall in oil price from its all-time high price in June 2014, down to approximately half the price to this date as can be seen in Figure 1. When demand and supply price elasticities are low, any disturbances on either side of the market can result in major price fluctuations. There is no doubt that this oil price correction has had a major impact on the entire industry. Supply disturbances had several different sources: armed conflict, new discoveries and extraction technologies, strategic shifts on the part of the Organization of the Petroleum Exporting Countries (OPEC), and so on. This has led to many new ways of working initiatives from the major players in oil and gas industry, in order to cut the cost of drilling and production of oil and gas. [1]

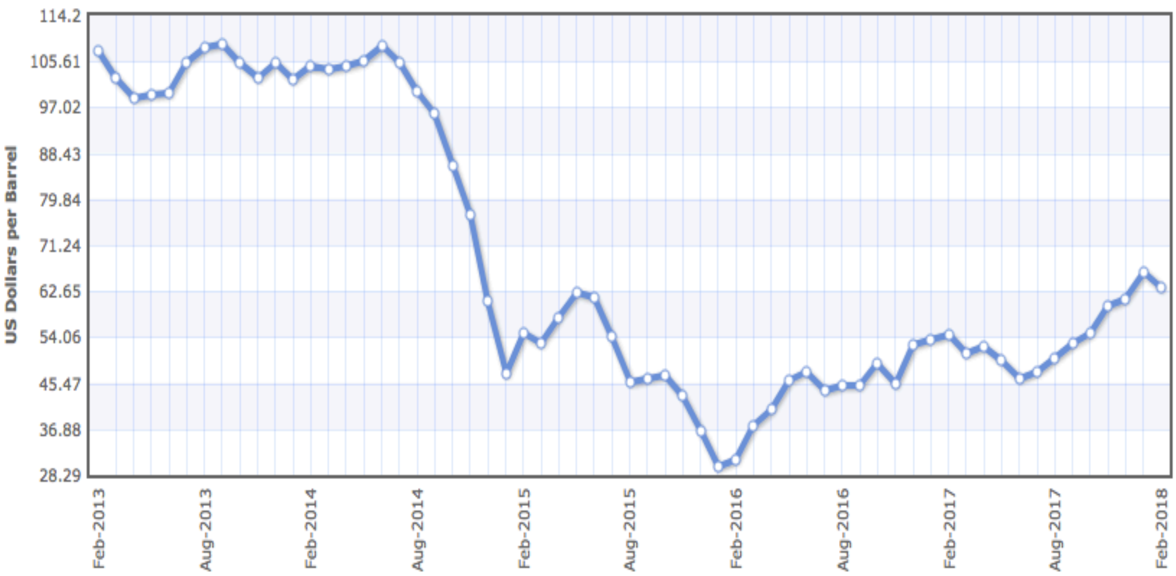

Figure 1: Crude oil price past 5 years. [2]

Since the oil price started its dive, the term breakeven have been frequently used among analytics and decision-makers in public and private sectors as indicators of oil-producing company`s economic stability. It is also being used as an indicator in oil price forecast. An oil-producing company`s breakeven oil price is the minimum price per barrel that the company needs in order to meet its expected spending needs while balancing its budget. An oil company in deficit can face pressure to raise its revenues or cut spending, which is something we have witnessed the past four years.

To cut the breakeven price, oil companies have initiated internal projects where the main objective is to cut spending in order to make profit by lowering its breakeven price. This has led to a noticeable change in the bias of the industry. Whereas with oil prices above 100 dollars per barrel a term frequently used was ”this is how we always have done it”. In todays market, that is no longer an acceptable term. Today we are seeing a much higher focus on cost-effective solutions, new technological leaps, digitalization, and so on. This is why this thesis in cooperation with Valvision, wish to investigate if the oil industry is more willing to try new way of doing things in order to cut cost when it comes to valve usage. And in order to do that, we will need to investigate if there are any areas where an improvement would be of interest, which will be this thesis`s main objective.

1.2 Research objectives

The main focus of this thesis will be to seek for any possible problem areas for valves on Christmas tree (XT). This mainly includes Gate valves and Choke valves, since these are the most important parts of a XT with potentially high risk for failure. The main objectives of this thesis are as following:

- How often do these valves (Gate valves and Choke valves) fail?
- What are the main failure causes for these valves?
- If the failure rate and general cost of these valves are higher than they should be, what should valve supplier companies focus on to deliver valve solutions with higher service quality and lower cost?
- And in general, how is the bias in the main oil companies on NCS with regards to trying new design/solutions instead of doing things the old way?

1.3 Research approach

To be able to achieve the research objectives, there will be conducted several interviews and discussions with personnel with the expertise in this subject from different oil companies. Since no available data required for this thesis objectives exist, the method of study will be contacting several oil companies in order to conduct interviews and perhaps get access to their data. Hopefully this will provide the necessary information and data to be able to get a conclusion for this thesis.

This also provides the biggest limitations for this study, since there are no guarantees that access to necessary data in order to perform an analysis will be given from oil companies. Since I have worked in the oil and gas industry for four years, and are currently working offshore as I am writing this thesis, I hope to manage to get in contact with personnel involved in work related to my thesis objectives in order to get an in depth understanding of this subject area. This I hope to achieve by being proactive asking questions and doing my research when I am offshore during the time I will be writing this thesis. This combined with contacting different oil companies when I am off schedule, hopefully someone will agree to share their failure rates of their valves for XTs and their main failure causes.

1.4 Valvision AS

Valvision deliver a wide range of high-quality valves and actuators, including urgently required and hard-to-find packages, at competitive cost and delivery times for the oil and gas industry. [3]

Valvision was established as IKM Valves in 2005, and acquired by Flux Group in 2014. Vest Ventil, established in 1996, and acquired by Flux Group in January 2015, merged with Valvision in July 2015. Valvision offices are located in Stavanger and Bergen, Norway, and Colico in Italy.

Through close cooperation with leading suppliers, Valvision has established itself as one of the lead suppliers of valves to the oil and gas industry. Valvision provide variety of manual and actuated valves for all applications both onshore and offshore.

2 Valves

This chapter will give a description of all valves (including actuators) used in a drilling operations. In particular, high pressure valves found on surface will be described in order to give the reader a better understanding of the valves used, and to give a theoretical basis of discussion of the results of this thesis.

2.1 Gate Valves

The main feature that distinguishes a gate valve is the flat face or vertical gate or wedge that slides in a track or seat which can be lifted in a direction at right angles to the valve until clear of the flow path. Gate valves are usually used for on-off services, i.e. they are intended to be either fully open or fully closed. For this reason, they are the principle valves used in open/closed applications. [4] The simplicity of the gate valve design and its application to a large number of general, low pressure-drop services makes it one of the most used valves today. It can be applied for both liquid and gas services.

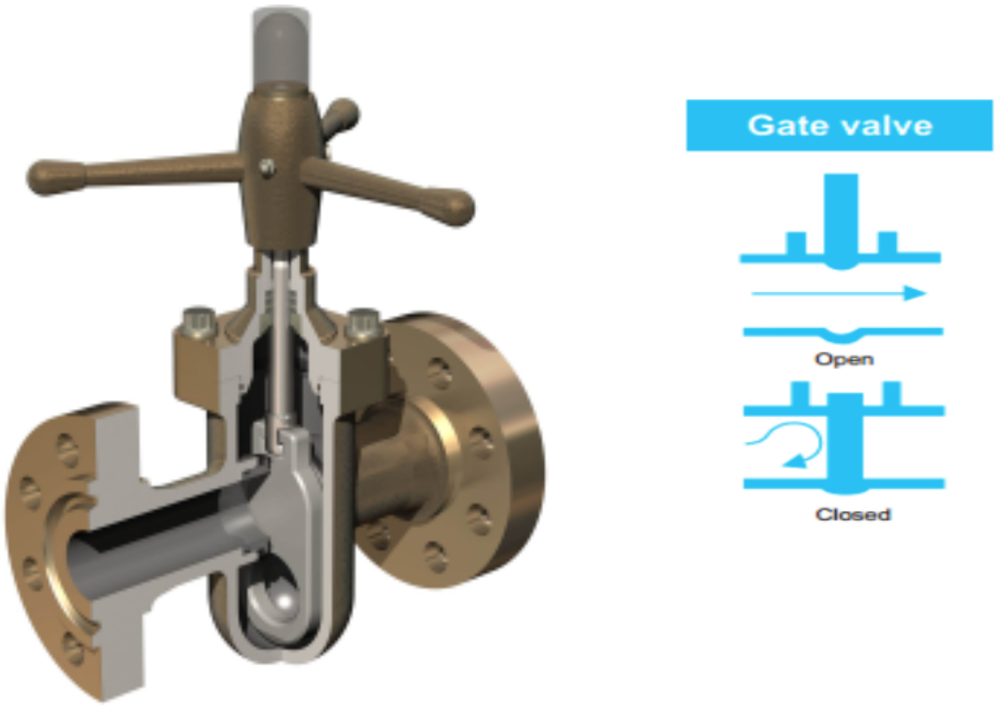

Figure 2: A standard gate valve [5]

Gate valves are best used in systems which require infrequent use of the valve. The valves are designed for full-area flow to minimize the pressure drop and allow the passage of a pipe-cleaning pig. Since most of the flow change occurs near the shutoff, the relatively high fluid velocity causes gate and seat wear and eventual leakage if the valve is used to regulate flow. This is why these valves are only supposed to be operated in either fully closed or fully open position. [5]

In Figure 3 & 4 we can see an example of sealing method of a high pressure solid slab gate valve with metal-to-metal sealing. A metal gate with a circular hole at the bottom with same size as ID of the pipe is moved in either upwards or downwards direction.

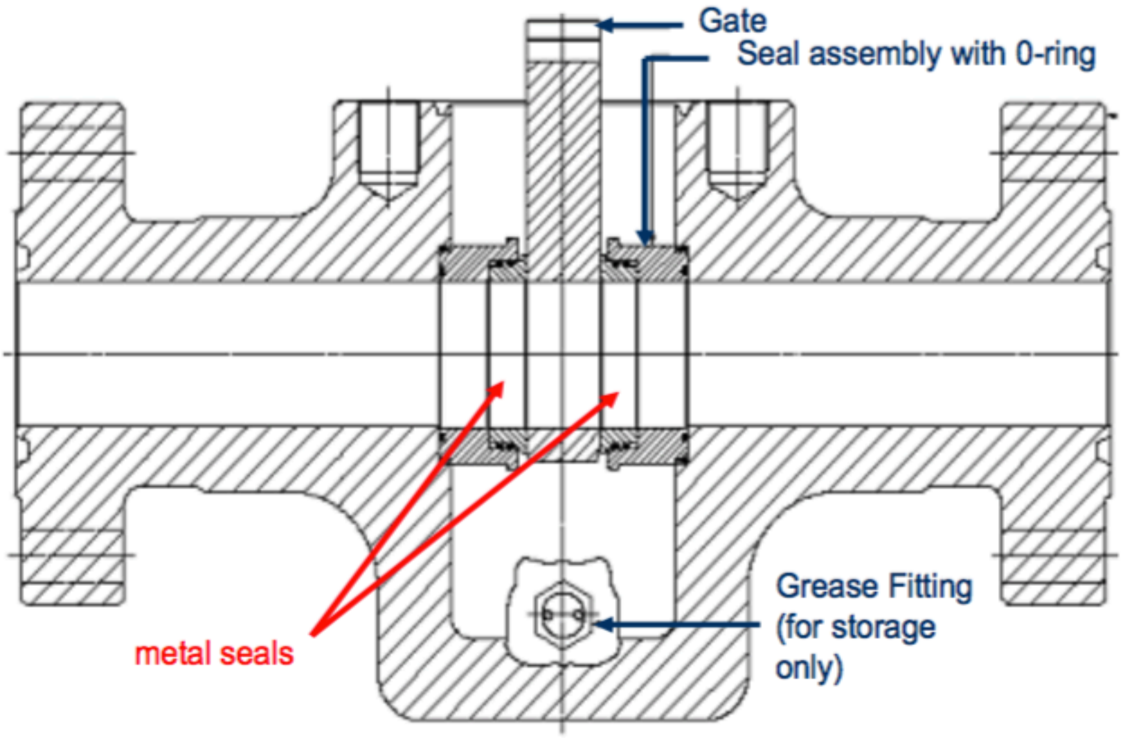

Figure 3: Parallel-slide gate sealing method [6]

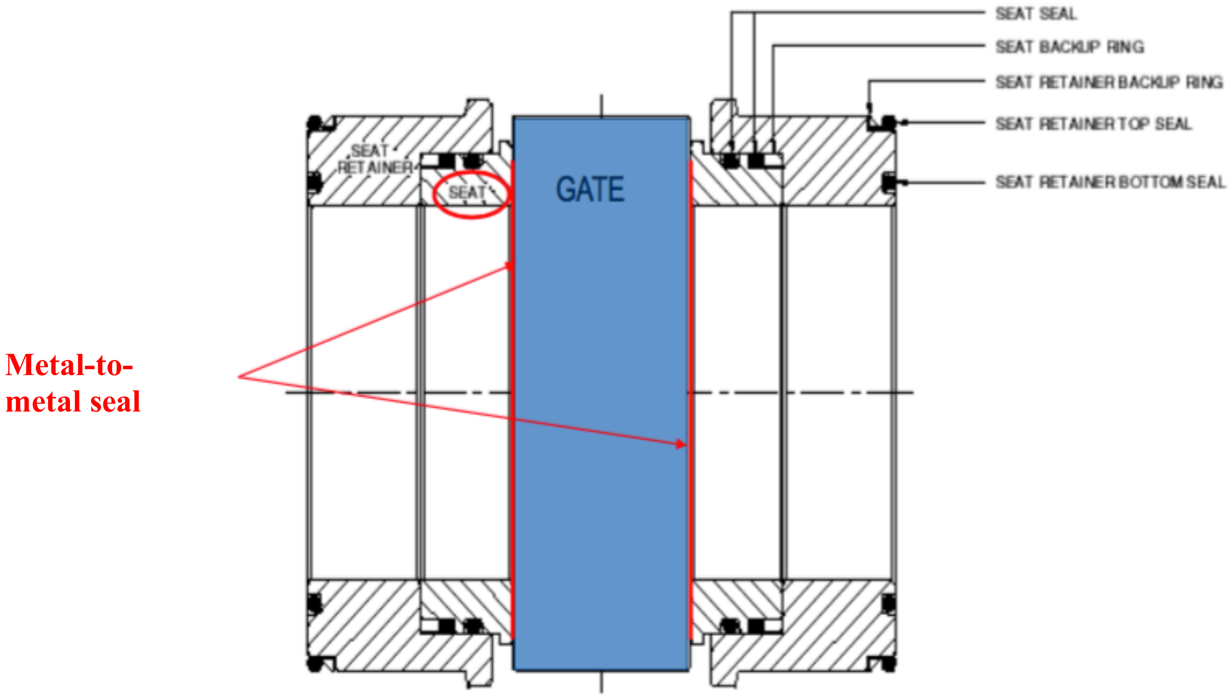

Figure 4: Closer look at sealing method [6]

When the gate is moved to the bottom of the gate valve body, the cavity of the gate is moved down from the flowing path, and the metal gate seals against the movable metal seal assembly. This is achieved by the U/S pressure acting on the gate, pushing the gate and U/S seal assembly against the D/S metal seal assembly. This creates seal in both U/S and D/S of the gate. An illustration of this is seen in Figure 5.

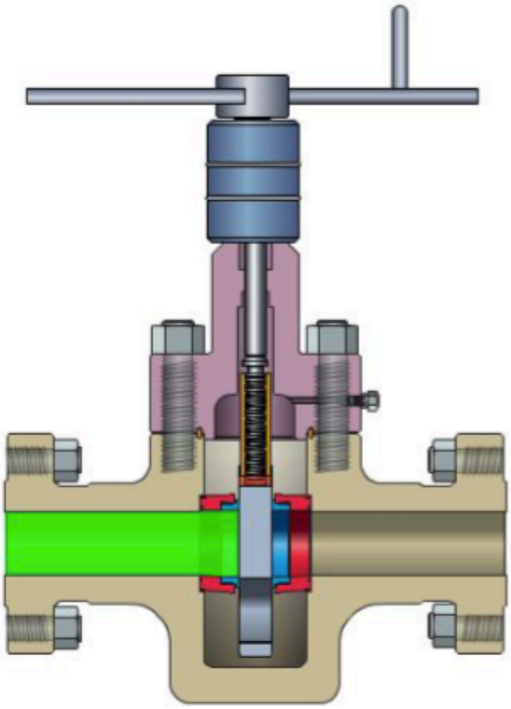
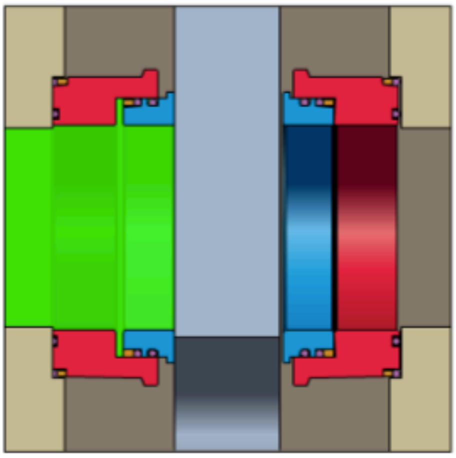

Figure 5: Seal in closed position [6]

In an open position, the gate is moved in upwards direction which aligns the gate cavity with the open bore in the gate valve and allows for passage through as shown in Figure 6.

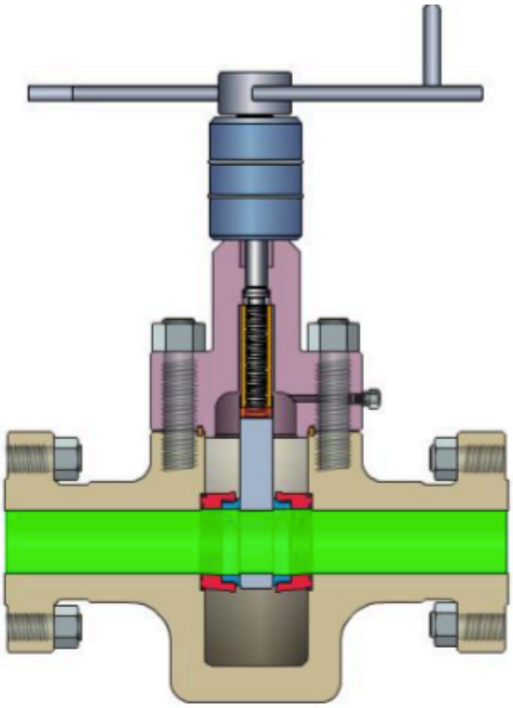
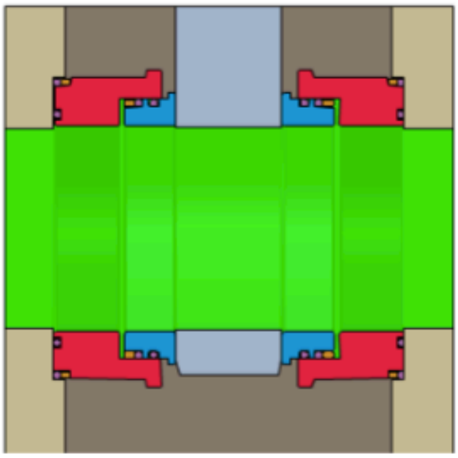

Figure 6: Seal in open position [6]

The above described type gate valve is called Solid Slab gate valve, and are the simplest type of all gate valve options. This is also why they are as popular as they are in the oil and gas industry. These valves come either with fixed seats, which means they only seal against D/S seat or they come with two movable seats, that creates a seal against both U/S and D/S seats.

In order for a solid slab gate valve to hold pressure, the stem needs to be able to move freely against the seats and not be locked against the bottom of valve body. This is usually achieved by a ¼ turn back to open position after fully closed.

Although solid slab gate valves are the most common used type of valves, there are also several other design solutions of gate valves available in the market. A short description of some of the most common ones are given bellow [4]:

- **Split Slab:** is a two-piece gate-valve that consists of two parallel halves, that normally have springs in between. The spring force only provides a contact between the seats and the gate. This contact is normally enough to avoid leakage at low pressure. This type of gate valve only provides a seal on the D/S seat.

- **Wedge-shaped:** are a popular gate valve type, this is due to that this valve have good capabilities that allow the valve to be operated with differential pressure and it can be used in both flow directions. The wedge-shaped gate valve uses two inclined seats and a slightly mismatched inclined gate that allows for tight shutoff, also against higher pressures. When the seat and gate angles are slightly mismatched, either the seat or gate is designed with some free movement to allow the seating surfaces to conform with each other as the actuator force is applied. Some common issues with this type is that solids gets accumulated at the valve body bottom, which don't allow the gate to move low enough for it to create a proper seal.

- **Expanding gate:** certain gate valves with parallel gate requires to be screwed into closed position by applying high force. Such gate valves have an expanding gate, that expands and create a seal in closed position. Double expanding gate expands both in open and closed position, while regular expanding gate normally only expands in either open or closed position. These type of gate valve are the more expensive design, but materials choice will also play a role in the cost.

2.2 Ball Valves

A ball valve comes with a circular closure element that gives on/off control of flow. The ball has a hole, also known as a bore, through its center. When the ball position is such that the bore is aligned in the same direction as the pipeline, the ball valve is in open position and fluid can flow through it. With a quarter-turn, the bore becomes perpendicular to the flow direction, which turns the valve in closed position and the fluid cannot pass through. [7]

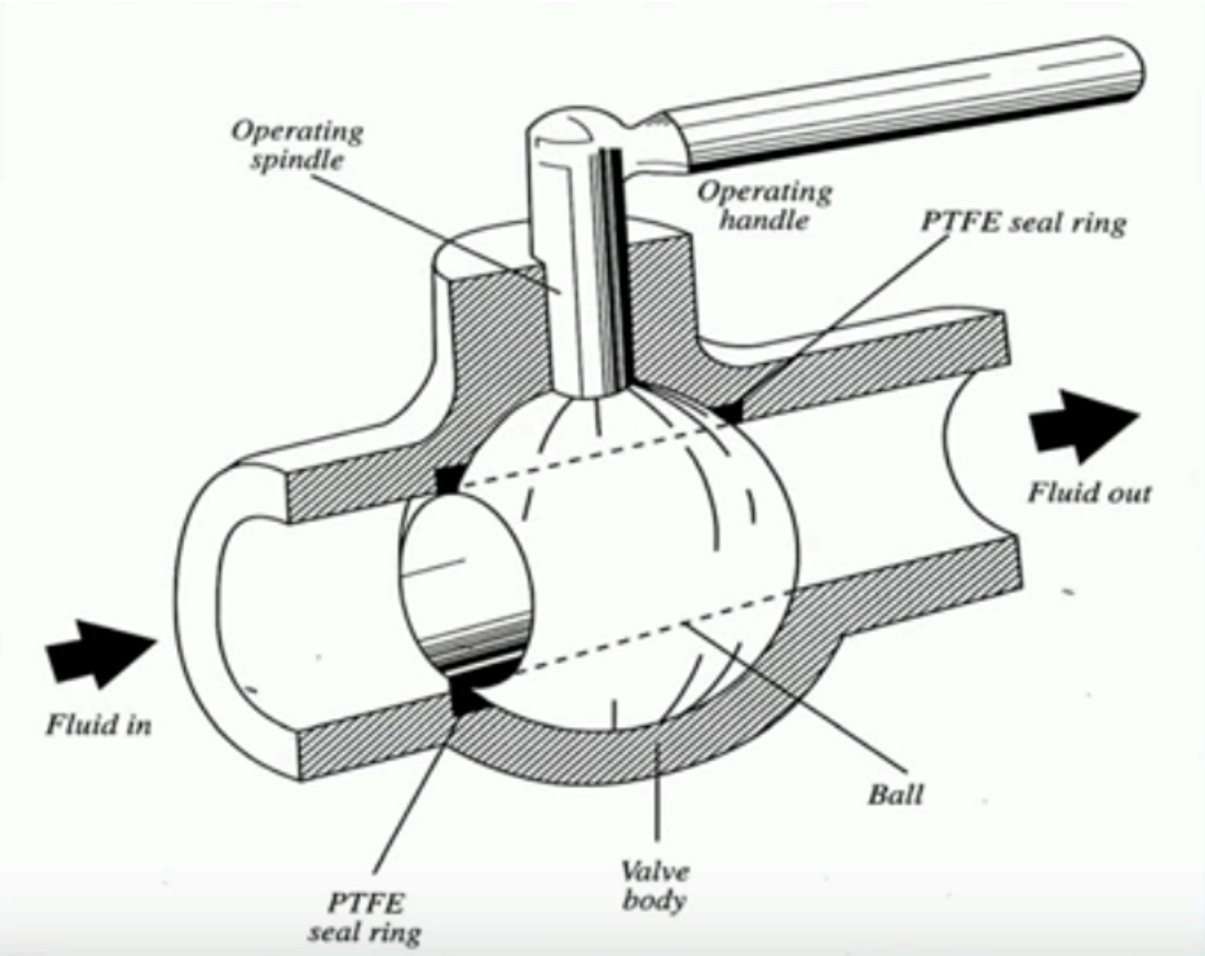

Figure 7: Cross section of a ball valve [8]

Ball valves are mostly used for application where quick operation of the valve is desired. They are considered quick-acting valves due to they only require a 90° turn of the handle to operate the valve from fully closed to fully open, and vice versa. This also minimizes the possibilities of leakage due to wear, because the 90° turn minimizes valve operation time. If high level of accuracy is not required, ball valves can also be used for throttling services. Although throttling is possible with ball valves, one should act with care because throttling causes the partially exposed seat to erode because of the high velocity flow and pressure. Eventually, the wear might lead to leakage of the valve, and maintenance will be necessary. Disassembling and redressing of a ball valve in case of leakage are normally done easily due to its simple design nature. [4]

The type of seal and seat of ball valve can vary with valve pressure rating and materials of construction. A floating seal allows two full-contact seal to be placed on both the inlet and outlet ports. The ball is supported by the seals, but does not come into contact with the body itself. A floating seal is best used for heavy duty services since they seal the flow and support the ball. The stem of a ball valve is not fastened to the ball; it normally has a rectangular end which fits into a slot cut into the ball. This allows the ball to rotate as the stem is turned. In figure 8 a simple illustration of method of operation of a ball valve is shown.

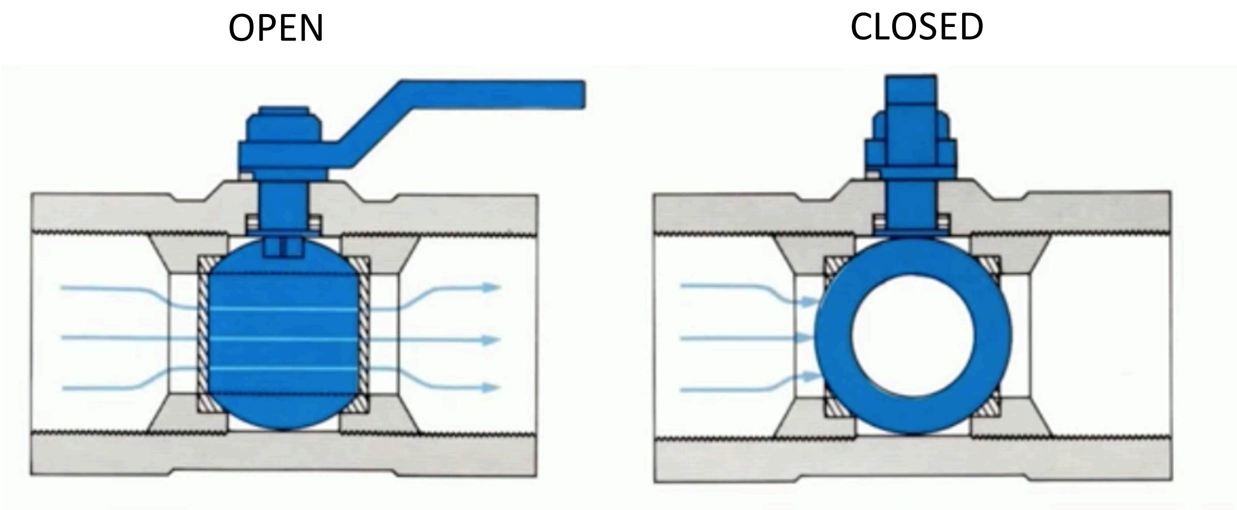

Figure 8: Ball Valve in open and closed position [8]

There are four general body styles of ball valves: fully welded, three-piece body (also called side or end-entry), split-body and top-entry. The valve operation of all types are the same, but the difference is on how the valves are manufactured and assembled. The ball valves are normally divided into three main design groups [9]:

- **Floating Ball Valve:** In a floating ball valve the ball itself floats in between the two seats and are pressed against the D/S seat by the pressure in flowing direction, and seals in such manner against D/S seat. Floating ball valves seat can both be of floating and fixed type. By using floating seats, one can achieve sealing in both U/S and D/S seat. But the most common practice is to have fixed seats in a floating ball valve. Valves with floating seats are normally available for lower working pressure applications with smaller dimensions. This is because the force against the seat increases with increased pressure and dimension.

- **Trunnion Ball Valve:** This type of ball valves is a design solution for applications with higher pressure rating and larger dimension. In this type of ball valves, the ball has additional mechanical anchoring at the top and bottom. This allows for less force from the ball against the seat under higher pressure. The seats are normally of floating type in a trunnion ball valves. The trunnion mounted stem absorbs the thrust from the line pressure, preventing excess friction between the ball and seats, so at the full rated working pressure operating torque remains low.

- **Non-Contact Rising Stem Ball Valve:** This type of ball valve uses ”tilt and turn” operation, eliminating seal rubbing which is one of the main reasons for valve failure. In closed position, the core is wedged against the seat, ensuring positive shutoff. And in open position, the core tilts away from the seal and the flow passes uniformly around the core face.

2.3 Butterfly Valves

A butterfly valve is a shut-off valve with its simpler construction, compared to other valve types. In closed position, the disc blocks the valve bore while in open position, the disc is turned to allow flow as illustrated in Figure 9 & 10. Only a quarter-turn is required to take the butterfly valve from fully open to fully closed position, and the same the other way around. For this reason, butterfly valve allows for quick opening and closure in operation. [10] [4]

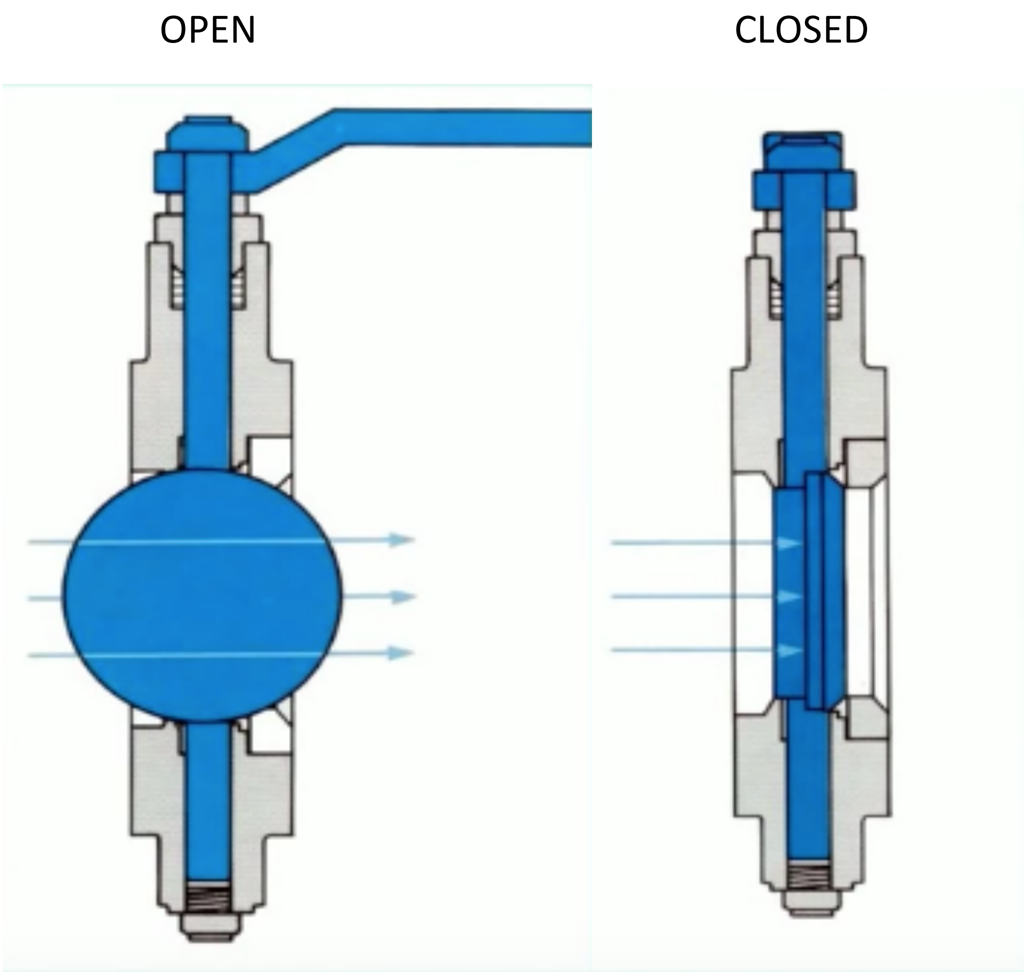

Figure 9: Butterfly Valve in open and closed position [11]

The closure element of a butterfly valve consists of a metal circular disc or vane that turns on an axis at right angles to the direction of flow in the pipe. When rotated on a shaft, the disc seals against seats in the valve body. The thin disc is always in the passageway of the flow but creates little resistance to flow.

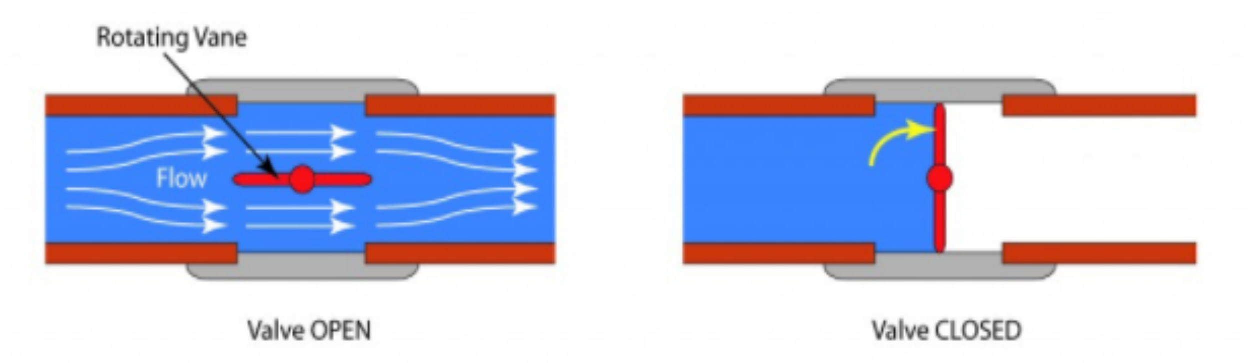

Figure 10: In a butterfly valve, a rotating vane controls flow through the valve [11]

Butterfly valves have become popular over the years due to their thin profile between flanges, making them much easier to install and lighter in weight. This simple design also makes the cost of these valves considerable lower compared to other valve designs. Several different design options exist for butterfly valves, but the most basic and common one is called a concentric butterfly valve [11]. In this type of design, the stem is centered in the middle of the valve disc, which is centered in the pipe bore. In this type of butterfly valves, the seat is of rubber type and relies on the disc having a high level of contact with the seat to have an effective seal. Normally these valves are more frequently used in low pressure applications, such as in seawater or fresh water systems on oil and gas installations.

2.4 Check Valves

The main function of check valves, also known as non-return or one-way valves, is to only allow flow in one direction in a pipeline. The main element of the valve construction is a flapper which hangs from a hinge, the flapper shaft or pin, which is installed to the underside of the bonnet inside the valve body. The purpose of the check valve design is to inhibit backflow in a pipeline. [12] [13]

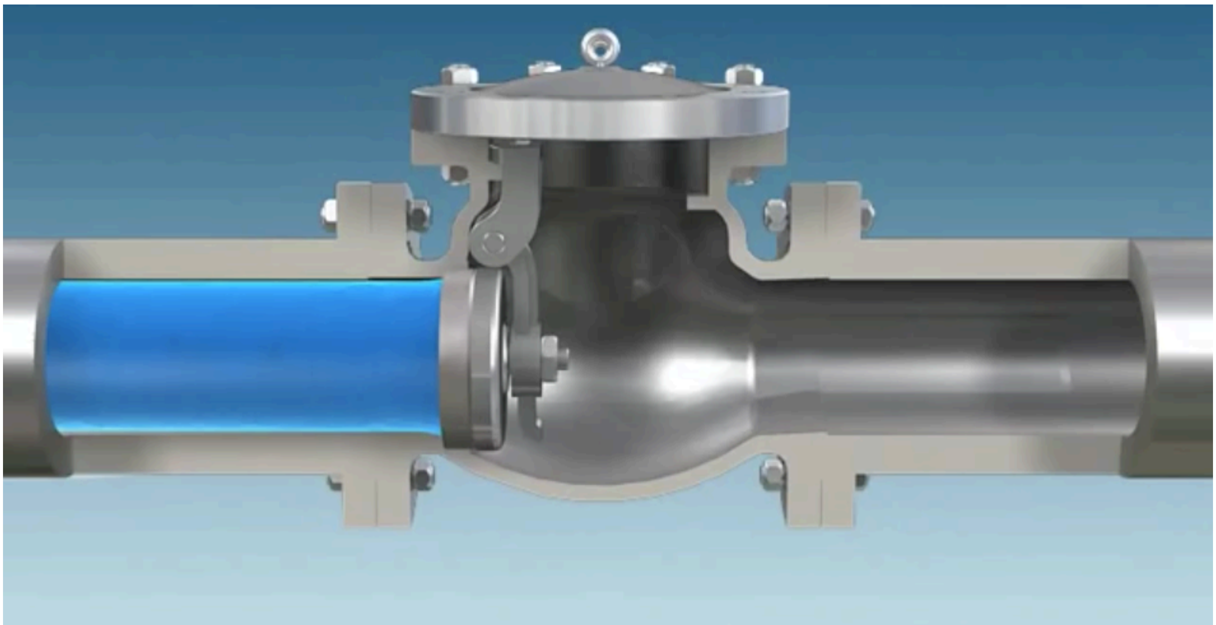

Figure 11: Swing Check Valve with zero/equal pressure on both sides. [14]

As illustrated in Figure 11, a spring hold the flapper closed until upstream pressure exceeds downstream pressure. When U/S pressure > D/S pressure, the flappers opens, and flow in flow direction is allowed. The minimum upstream pressure required to operate the valve is called the cracking pressure. From Figure 12 we can see how the flappers opens when the cracking pressure exceeds a certain pressure.

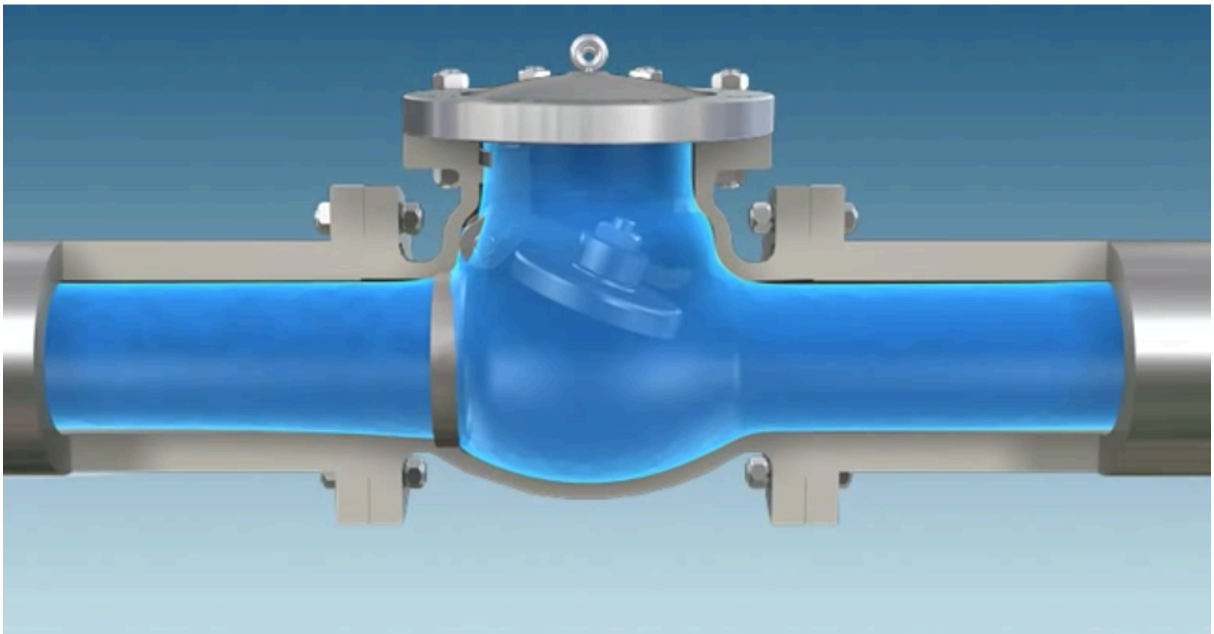

Figure 12: Flapper opens as flow reaches a certain velocity in flowing direction [14]

As U/S pressure decreases to either equal to or less than D/S pressure, the flapper closes and no backflow is allowed, Figure 13.

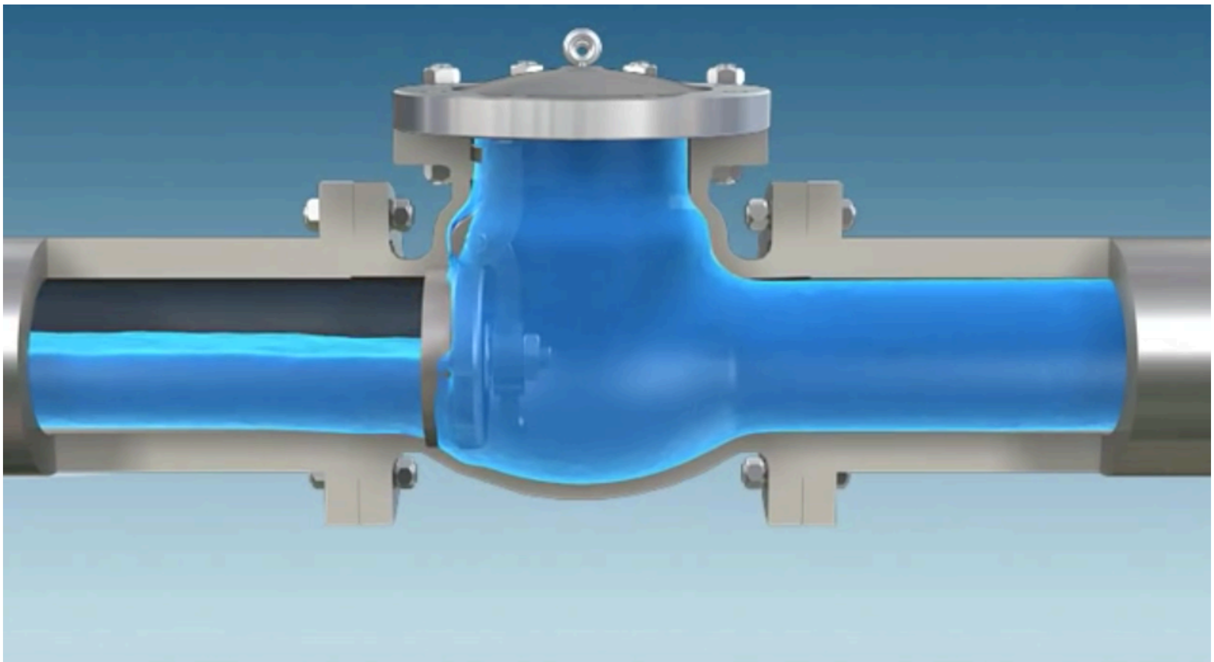

Figure 13: As flow in flow direction stops, flapper closes and inhibits backflow [14]

Due to their simple design, check valves generally operates without automation or human interaction and instead rely on the flow velocity of the fluid to open and close, meaning they usually do not have a method of outside operation, like a handle. The degree of opening on a check valve is determined by the flow rate. The higher the flow rate, the more the valve will open until it reaches its maximum, full open position. Although in some cases hydraulically operated check valves are found, these check valves can operate as normal check valve when no hydraulic pressure is applied. But when one chooses to, by applying hydraulic pressure one either lock the flapper in open or closed position. This type of check valve is used in Drill Stem Testing operations, where a hydraulically operated check valve is installed on the kill side. There are a variety of types of check valves used in oil and gas industry, including [12] [15]:

2.4.1 Ball Check Valve

Ball check valve is a check valve type in which the closing element, the movable part that block the flow, is a ball. In some cases, this ball is spring-loaded to help keep the valve closed. For ball check valve design without a spring, reverse flow is required to move the ball toward the seat and create a seat between the ball and fixed seat. Due to the spherical design, ball check valves can experience wear from prolonged used and might require frequent maintenance. Therefore, they should be designed in such way that allows for accessible and easy maintenance in the field. [12]

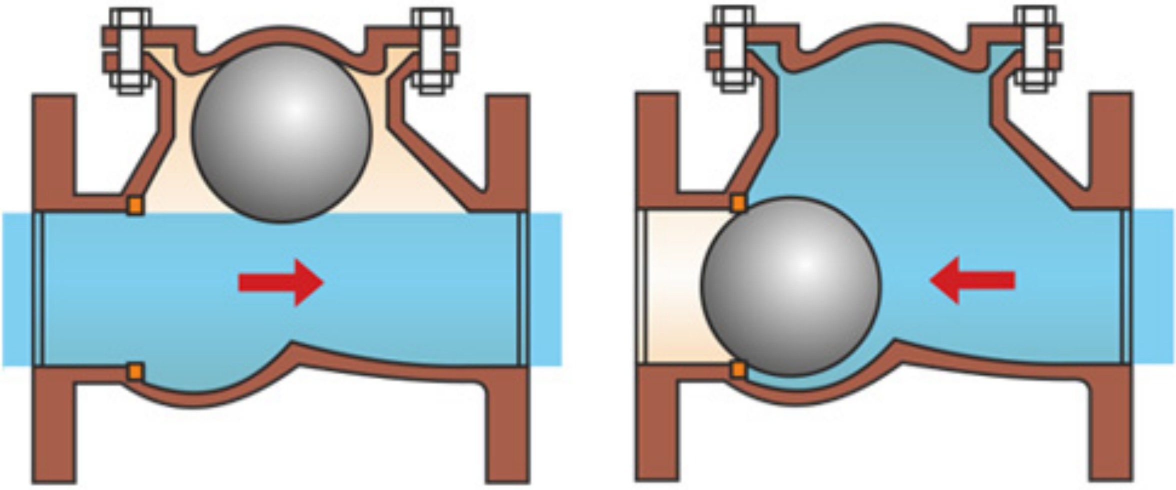

Figure 14: Ball Check Valve [16]

2.4.2 Diaphragm Check Valve

Diaphragm check valves use a rubber diaphragm positioned in such way that it creates a normally closed valve. For the diaphragm check valve to open allowing flow, the pressure on the upstream side must be greater than the pressure on the downstream side by a certain amount, also known as the pressure differential. When the pressure from the upstream side stops, the diaphragm automatically flexes back to its original closed position. In Figure 15 an illustration of a diaphragm check valve is illustrated. [12]

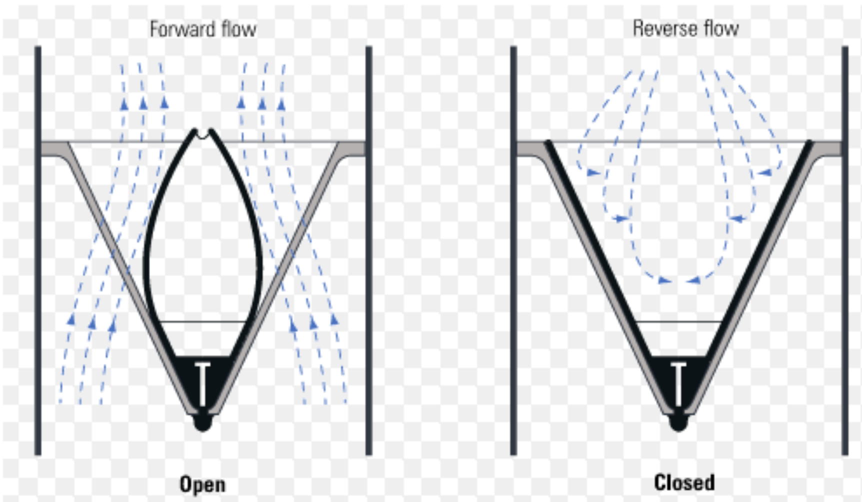

Figure 15: Diaphragm Check Valve [15]

2.4.3 Swing Check Valve or Tilting Disc Check Valve

Swing check valve or tilting disc check valve is a check valve in which the disc, the movable part to block flow, swings on a hinge or trunnion, either onto the seat to block reverse flow or off the seat to allow forward flow. The cross-section of the seat opening is either perpendicular to the centerline between the two ports or at and certain angle. Swing check valves are normally used for applications where check valves of large dimension are desired, although swing check valves can come in various sizes. A common issue caused by swing check valves is known as water hammer. This can occur when the swing check closes and the flow abruptly stops, causing a surge of pressure resulting in high velocity shock waves that act against the piping and valves, placing large stress on the metals and vibrations in the system. If not treated with care, water hammer can rupture valves, pumps and pipes within the system. In Figure 16 and an illustration of operation concept can be observed. [12]

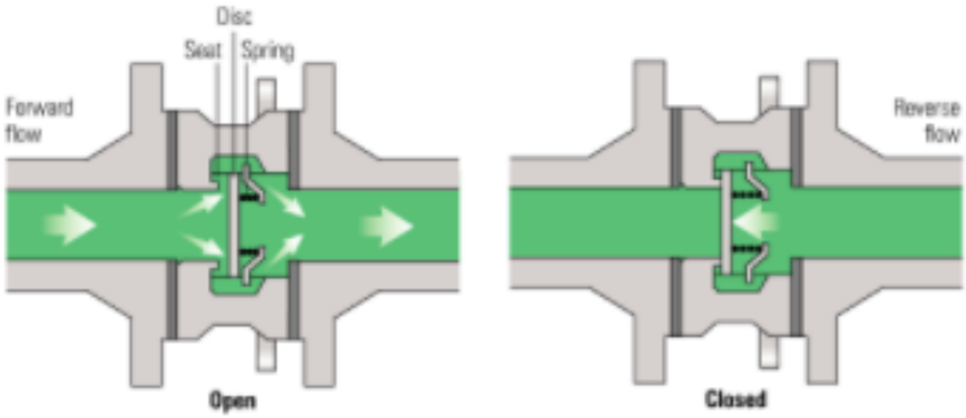

Figure 16: Disc check valve [12]

2.4.4 Stop-check Valves

Stop-check valves usually contracted similar to a swing check valve, but stop-check valves have an additional external control mechanism (an actuator, hand eel, etc.) that allows the valve to be deliberately closed regardless of flow pressure. Other than that, the principle of operation and function is the same.

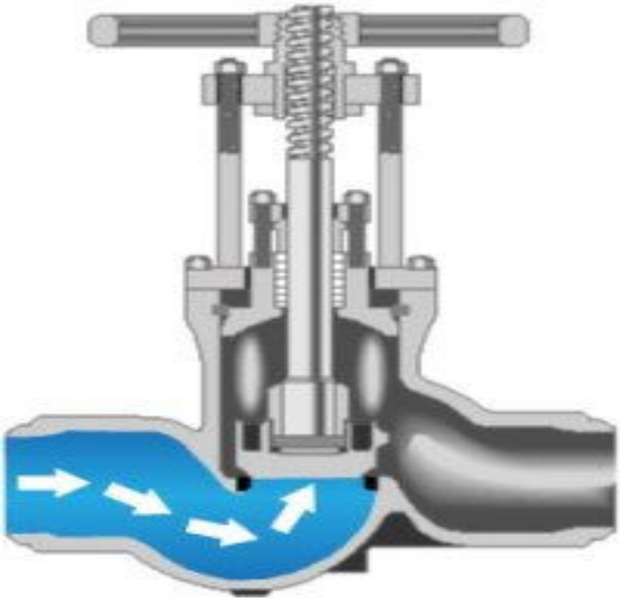

Figure 17: Stop-check valve [12]

2.5 Choke Valves

Flow and pressure control is an important part of drilling and production for oil and gas. Whether in a kick scenario in drilling operations or to optimize the production of hydrocarbons in a producing well, ability to hold a certain backpressure in order to control the bottom hole pressure is of high importance. Since use of a normal open-close valve is not fitted for such operations, choke valves are therefore the preferred option. The opening of chokes may be adjustable or fixed. The fixed openings, often called choke beans, are short flow tubes that restricts the flow in order to achieve desired flow rate or backpressure. To regulate the flow rate or backpressure using a fixed choke, choke bean needs to be changed with other opening sizes, and this requires the flow to be stopped until the choke bean is changed. The adjustable choke is most commonly used to avoid stopping the flow, as it allows to regulate the choke opening by either manual hand eel or actuator operated control panel. Both fixed and adjustable chokes are normally graduated in 64ths of an inch, but opening in percentage are also used. [17]

In production, choke valves are normally used for controlling the flow on production, reinjection and subsurface wellheads. And in drilling, choke valves are most common used on rig choke manifold, where its main use case is to circulate out a kick in a safe manner by holding a stable bottom hole pressure. In Figure 18 a simple illustration of a manual operated needle choke is presented. Although adjustable chokes come in different designs, this is the simplest form of adjustable choke valve. [18]

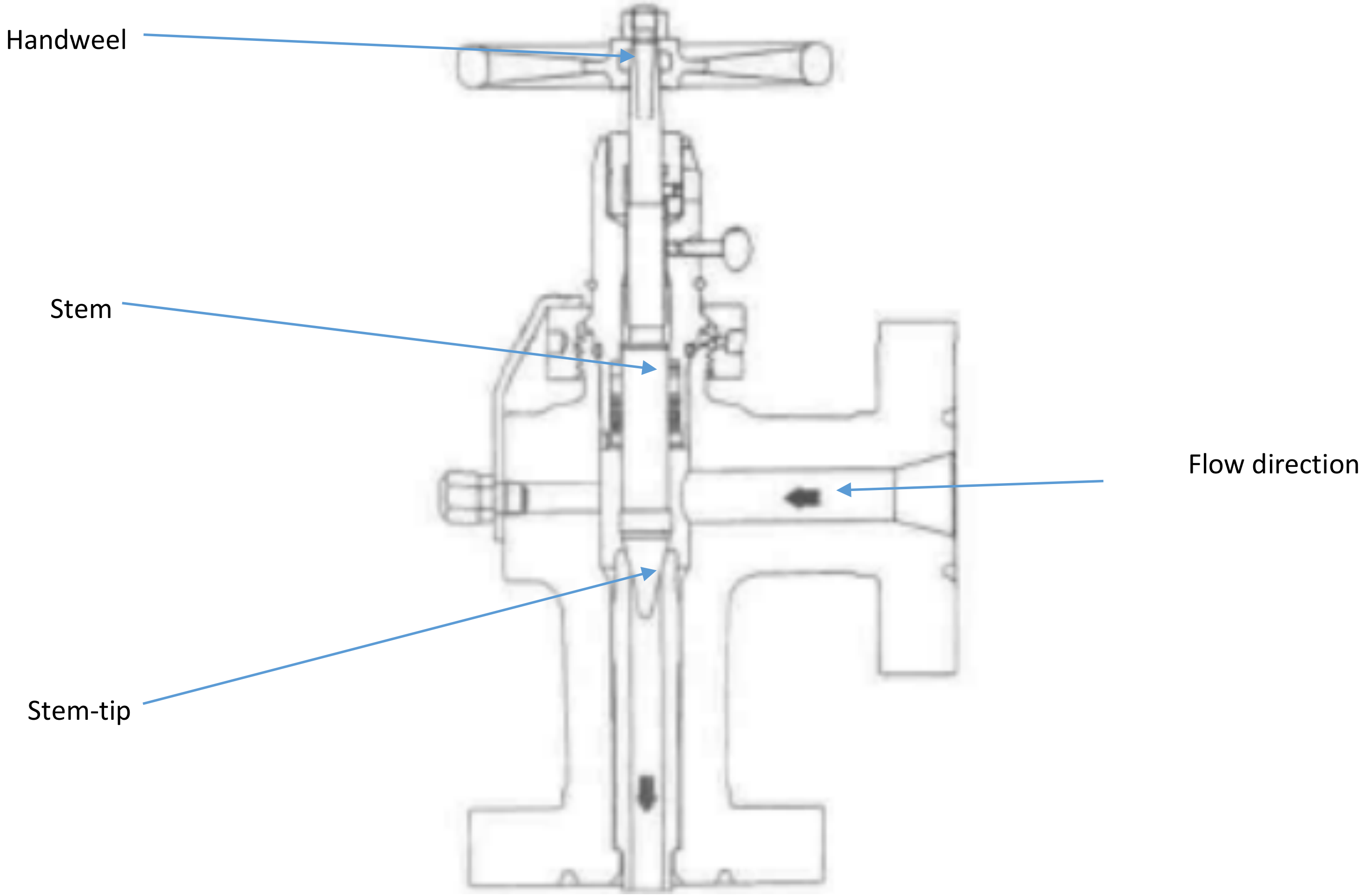

Figure 18: Adjustable needle choke [6]

Choke valves are subjected to extreme conditions which can cause erosion, corrosion and other damage. Typically, this can include high fluid velocity, slugging, sand production and multiphase of oil, gases and water. Also a choke valve has to have a very high turndown capability as it has to cover a wide range of flowrates. Thus the design of choke valves is required to be very robust with careful selection of valve configuration, flow path profiles, materials and ease of maintenance. [4]

Choke valves come in different design varieties, such as big manual needle chokes, rotary disc chokes and plug & cage choke valves. These three type of choke valves are the most used ones in oil industry, and will be briefly described in sections bellow.

2.5.1 Needle Choke Valve

Needle choke valves are the simplest type of available choke valve designs. Needle and seat chokes, as illustrated in Figure 18, operates by a needle tip (stem tip) is moved into a seat by turning the handweel. By moving the stem tip into the seat, less opening area is achieved, and thus less flow is allowed to pass through. And it works same way the other way around, by moving the stem tip out of the seat, larger opening is achieved and more flow is allowed to pass through the choke. Needle and seat chokes can handle erosive and corrosive services. They are only meant to be used for throttling and not as complete shutoff valve type (On/Off). That is a very important point, since it has been observed several cases of damaged needle choke valves because they have been used to fully close a flow stream. [17] [18]

This type of choke valves is suited for a broad range of choke applications, including wellheads, production manifolds, choke and kill manifolds, well testing and clean-up operations. One of the main advantages of a needle and seat choke valves are that they are very easy to disassemble and maintain when needed due to their simple design. Having said that, they tend to fail more often by washed out stem-tip or seat, especially in operations with high gas rate and high flow velocity, where solid particles are present. Also needle choke valves are not the best design in terms of precision. Where high precision is required, other choke valves are often used.

2.5.2 Rotary Disc Choke Valve

The rotary disc type choke valves come with many applications, and several different choke valve sizes and pressure ratings are available. The rotary disc choke valve is well known for its high durability and precise flow control. The rotary disc choke uses a set of adjacent discs, each containing a pair of circular openings or orifices. Other shapes than circular orifices can be accomplished if preferred for some certain custom applications. The rotating disc principle consists of two carbide circular discs, each with one eccentric orifice. Normally one of the discs is fixed to the valve body, and the other is being rotated either by manual operation or by actuator to adjust or close off the opening of the choke valve. This give the option of complete shutoff over a prolonged period and precise flow rate control. Differential pressure across the discs holds one face against other. Also there are no loose or unsupported parts to cause vibration, noise, and fatigue failure. Each time the disc is rotated, it wipes clean any deposits or solids from the exposed portion of the disc`s surface. This shearing action cuts most debris and assures a tight shutoff. [19] [20]

2.5.3 Plug & Cage Choke Valve

In a plug and cage choke valve, the plug is used as the controlling element, and throttling of the flow happens on the internal diameter of the ported(?) cage. In a flowing scenario, the flow enters the choke inlet and circulates around the annulus between the body and the cage. So that it is possible to achieve the most appropriate combination of controllability and flow capacity for each application, the ports in the cage are sized and arranged in a specific manner. An important consideration when sizing the choke valve is the ability to achieve closely managed well startup while also optimizing capacity for the end of well life to maximize production. This is why the correct choice of the cage with appropriate size is very important when designing a plug and cage valve for specific application. [21] [18] [22]

The plug and cage choke valve incorporates the largest possible flow area, making it a great choice for high flowrate applications. These type of choke valves are also constructed with the plug tip and inner cage of material solid tungsten carbide for better resistance to erosion. The plug and cage choke valves are available in manually operated or actuated models.

2.6 Valve Actuators

Numerous types of devices exist for the remote operation of valves. These range from simple gearbox to more advanced motorized valves with automatic control, programmable logic controllers, microcomputers and field communications network. In basic terms, an actuator can be described as a device supplying force and motion to the closure member (ball, disc, plug, etc.) of a valve. Power-operated valve actuators, using gas pressure, hydraulic pressure or electricity, allow a valve to be adjusted remotely, or allow rapid operation of large valves. Actuators may only give the ability to open and close the valve, or may allow intermediate positioning of a valve, such as a choke valve for example. In oil industry actuators are found in all kind of applications, some of the applications are to operate valves, adjust chokes, etc. [4] [23]

There are four common types of actuators:

- Manually operated
- Pneumatic actuators
- Hydraulic actuators
- Electric actuators

2.6.1 Manual Actuators

A manually actuated valve employs levers, gears, or wheels to move the valve stem. Manual actuators are powered by hand, such as a handweel, handbar, etc. They are normally inexpensive, typically self-contained and easy to operate. However, valves of larger dimension are impossible to operate manually and some valves may be located in remote, toxic or hostile environments that prevent manual operations. As a safety feature, certain types of situations may require quicker operation than manual actuators can provide to close the valve. In such situations closing a valve manually would require more time that would be accepted in terms of safety for example. Pretty much all valves come with a manual operated actuator as a design option. [23] [4]

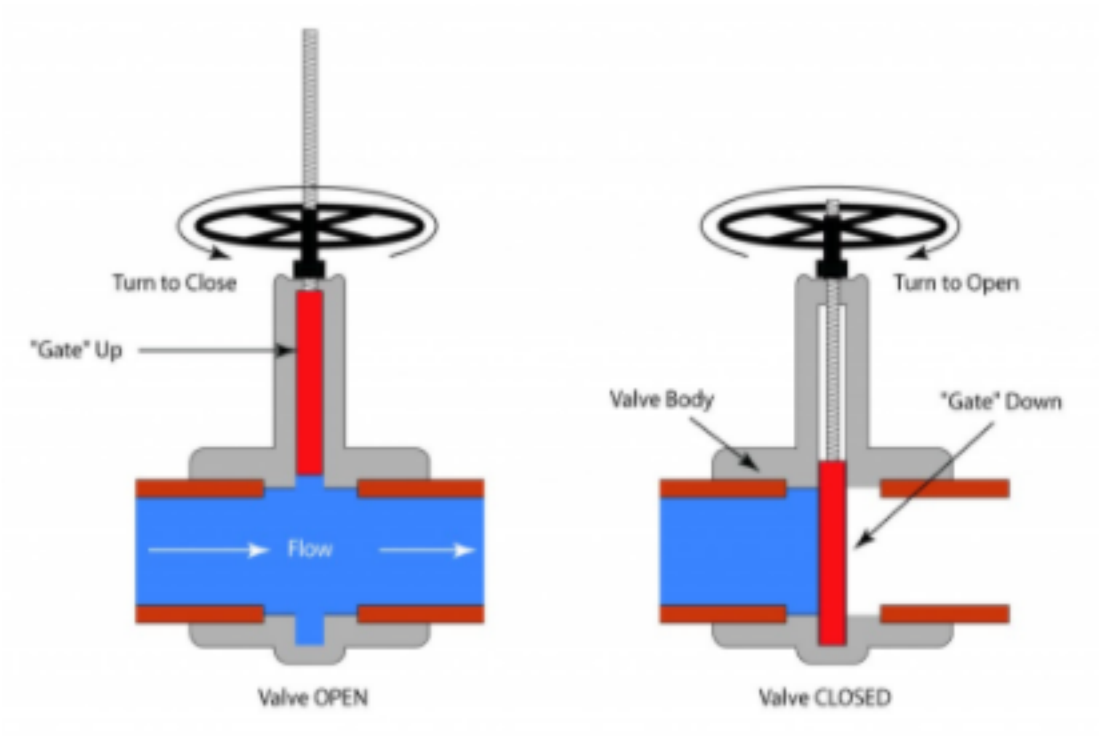

Figure 19: An example of manual actuator, where by turning a handweel the stem is moved up or down [23]

2.6.2 Pneumatic Actuators

Air (or other gas) pressure is the main power source for pneumatic valve actuators. They are used in linear or quarter-turn valves. Air pressure acts on a piston or bellows diaphragm creating linear force on a valve stem, making it possible to operate the valve from one position to another. Alternatively, a quarter- turn vane-type actuator produces torque to provide rotary motion to operate a quarter-turn valve. A pneumatic actuator can be designed to be spring-closed or spring-opened, with air pressure overcoming the spring to provide valve movement. A" double acting" actuator use air applied to different inlets to move the valve in the opening or closing direction. A central compressed air system can provide the clean, dry, compressed air needed for pneumatic actuators. In some situations, for example, regulators for compressed gas, the supply pressure is provided from the process gas stream and waste gas either vented to air or dumped into lower-pressure processing piping, although venting to atmospheric is the most common option. [23] [4]

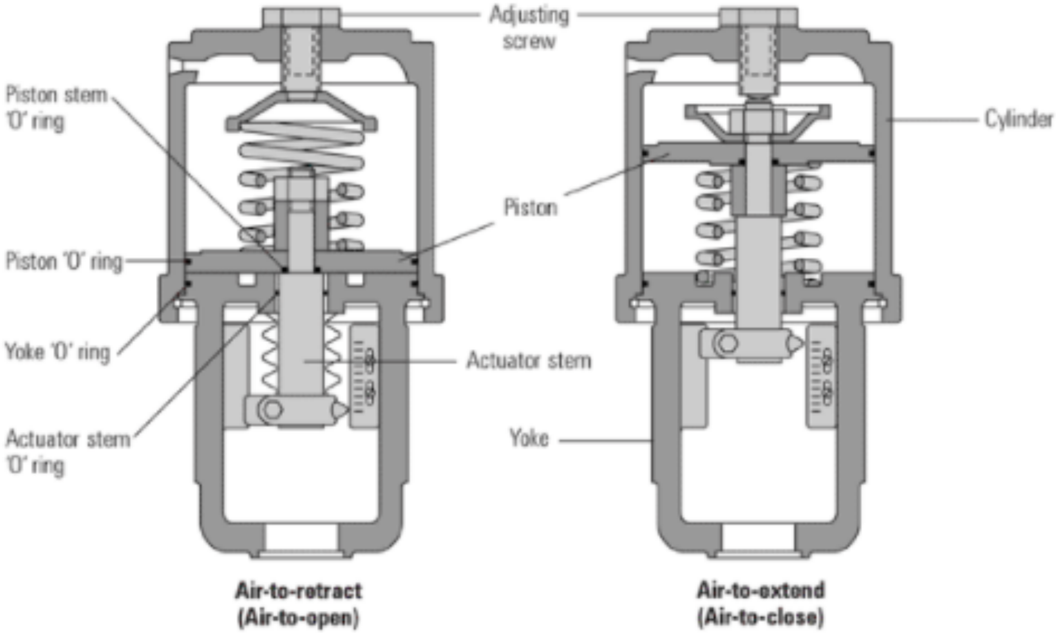

Figure 20: Piston Valve Actuator [23]

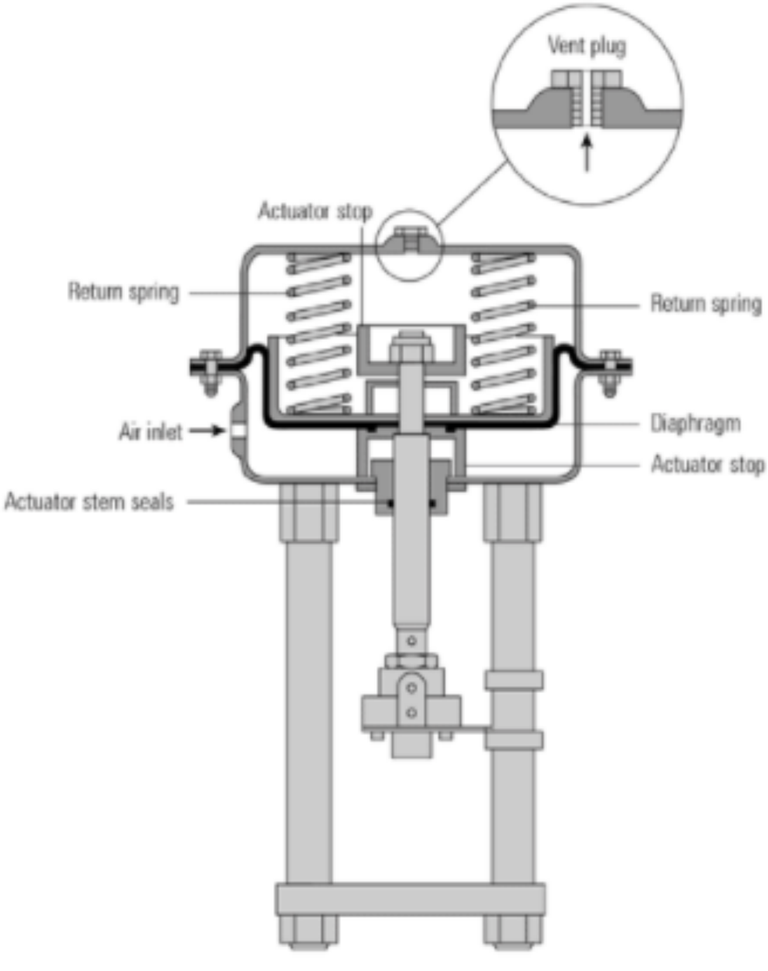

Figure 21: Diaphragm Valve Actuator [23]

2.6.3 Hydraulic Actuators

Hydraulic actuators convert fluid pressure into motion. Similar to pneumatic actuators, they are used on linear or quarter-turn valves. Fluid pressure on a piston at certain pre-set pressure provides linear thrust for gate or globe valves. A quarter-turn actuator provides the necessary torque to provide rotary motion to operate a quarter-turn valve. Often the hydraulic actuators are supplied with fail-safe features to close or open a valve under emergency circumstances. An example could be having a gate valve held closed by a loaded spring, and by applying hydraulic pressure the spring contracts, thus opening the valve. But in a case of loss of hydraulic pump pressure, the loaded spring would automatically go back to its original position. This would move the gate in upwards direction thus closing the valve. Hydraulic pressure is often supplied by a self-contained hydraulic pressure pump, which adds another component to valve design that could increase the probability for mechanical issues in use. [4] [23]

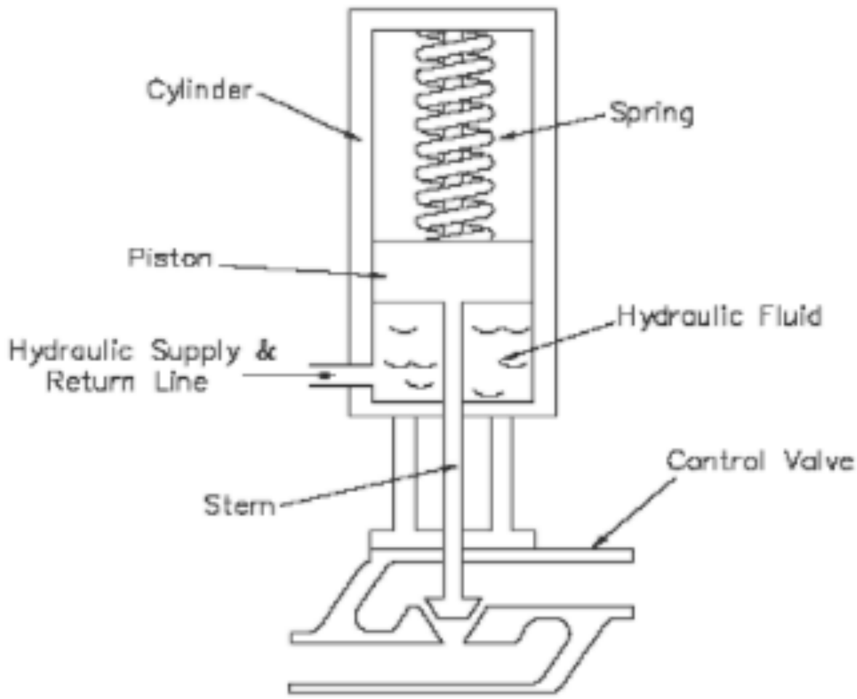

Figure 22: Hydraulic Valve Actuator [23]

2.6.4 Electric Actuators

An electric actuator uses an electric motor to provide torque to operate a valve. Generally, electric-motor actuators are designed for use on ball valves, gate valves, butterfly valves, plug valves and any mechanical equipment calling for 90deg rotation control. Their main advantages are that they often are quiet, non-toxic and energy efficient. However, electricity must be available, which is not always the case. [24] [4]

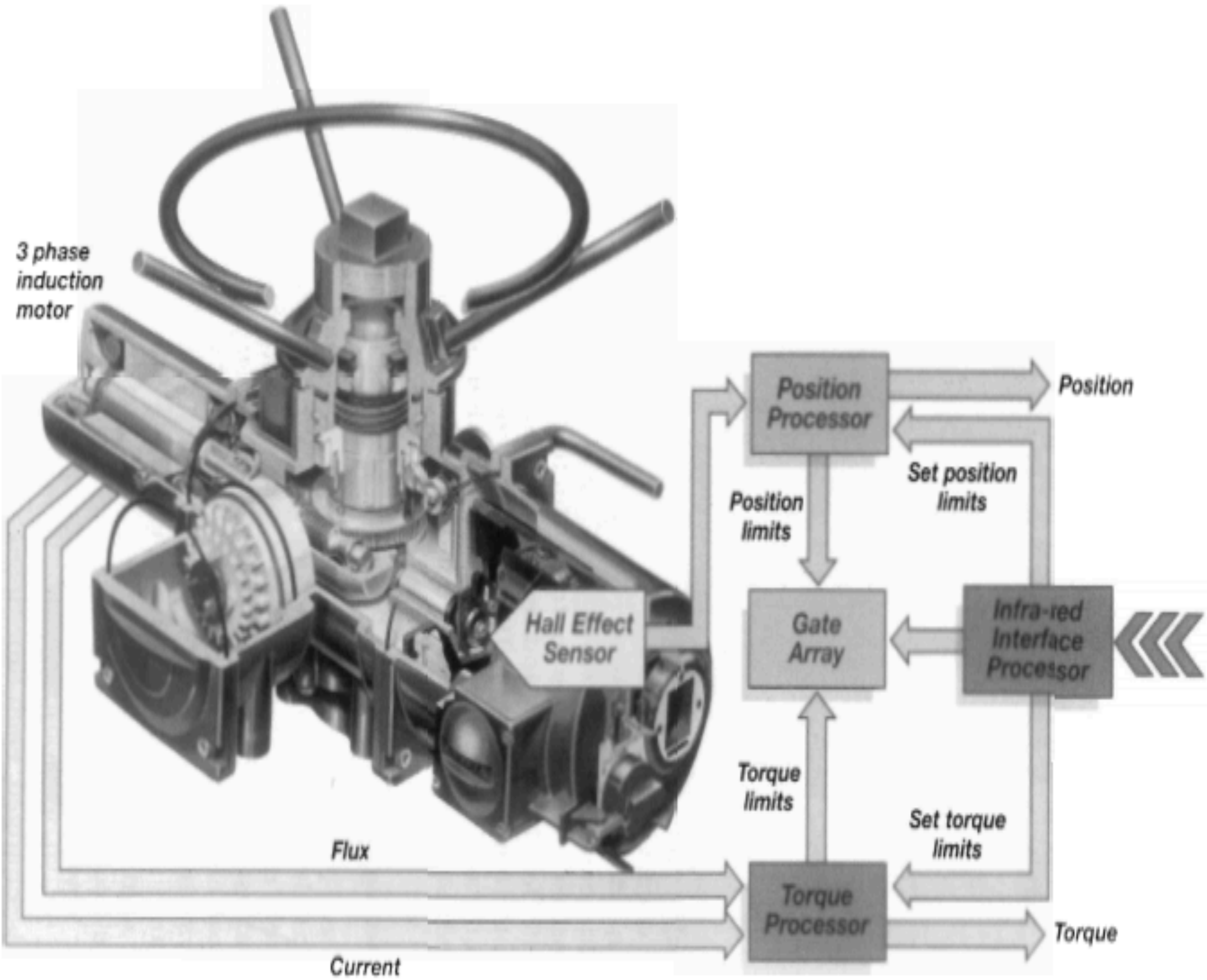

Figure 23: Electrically-operated, electronically-controlled intelligent actuator [4]

Clearly the selection of the energy system for a particular valve-operating duty is not something that can be made in isolation. Overall design considerations, safety requirements, availability of supplies and total installed initial cost and the maintenance costs all need to be considered in designing phase. It is safe to say that no single type of control valve actuator is best suited for all applications. Demands for power, speed, stiffness and precision vary and cost considerations are always present. [4]

3 Christmas Tree

Since this thesis focuses mainly on valves on production XTs, this chapter will give a basic description of the equipment and its function.

3.1 Christmas tree

A XT is an assembly of gate valves, chokes and fittings included with the wellhead during well completion. XT provides the ability to control the flow of fluids produced from or fluids injected into the well, at surface. The flow stream is normally passed through master valve and production wing valve before the flow rate is controlled by a choke valve. From here the flow is directed to rig manifold and further directed to hydrocarbons processing system. Several fitting points exist on a XT which allows an operator to either take a sample of produced fluid or bleed off pressure in between two closed valves. Also ports for pressure and temperature sensors installation exist, and this allows both personnel around wellhead area and the control room to monitor the well pressure and temperature at all times. In addition, ports for lubrication and in some cases sand monitoring possibilities exist on XTs. Also several XT also acts as a safety barrier in case the well needs to be shut in, and this is achieved by closing Master and Production wing valves. It also allows a safe access to the well bore in order to perform well intervention procedures. [25] [26]

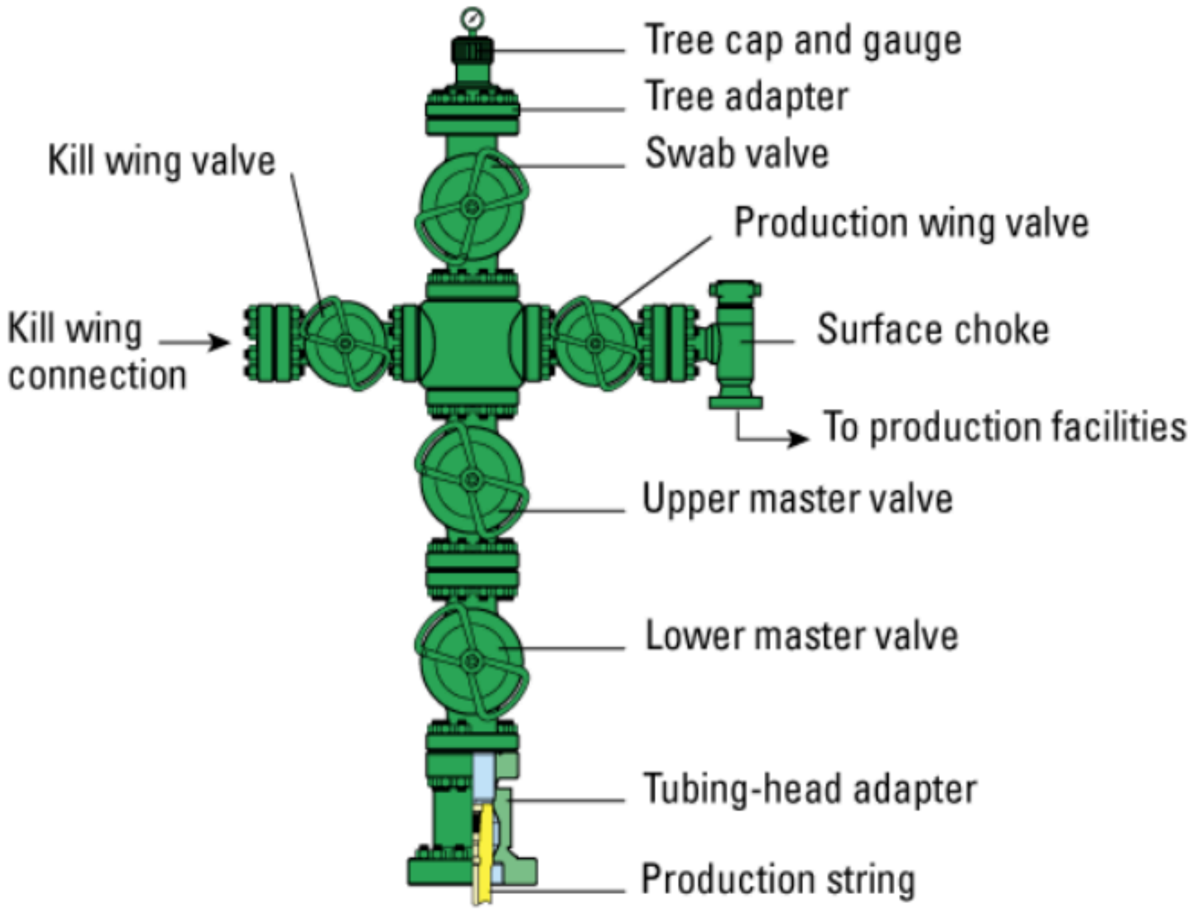

Figure 24: Standard vertical dry XT. [27]

Two main categories for XTs are wet XTs and dry XTs. Wet XTs are used for subsea wells and are installed on the seabed. While dry XTs are installed on the surface platform, above sea level. We will focus mainly on dry trees in this thesis. In the sections below, the main components of a XT will be described, in particular Dry tree which is referred to as any XT used above water level.

3.1.1 Master Valve

A master valve is located at the bottom of the XT and its function is to allow the well to flow or shut the well in when necessary. Due to the important function of a master valve, there are typically two master valves on a XT. One is called a lower master valve and another is an upper master valve. By using two valves, they together provide redundancy in case one fails. If one master valve fails, another valve can perform the same function. The type of valves normally chosen are gate valves, as gate valves provide the most sufficient characteristics for such use. It is normally the Upper master valve that is the primary used valve, and it is operated by either hydraulic or electric driven actuator. Lower master valve operates as back-up, and it is normally a manual operated valve. In Figure 25, Upper and Lower master valves are illustrated. [25]

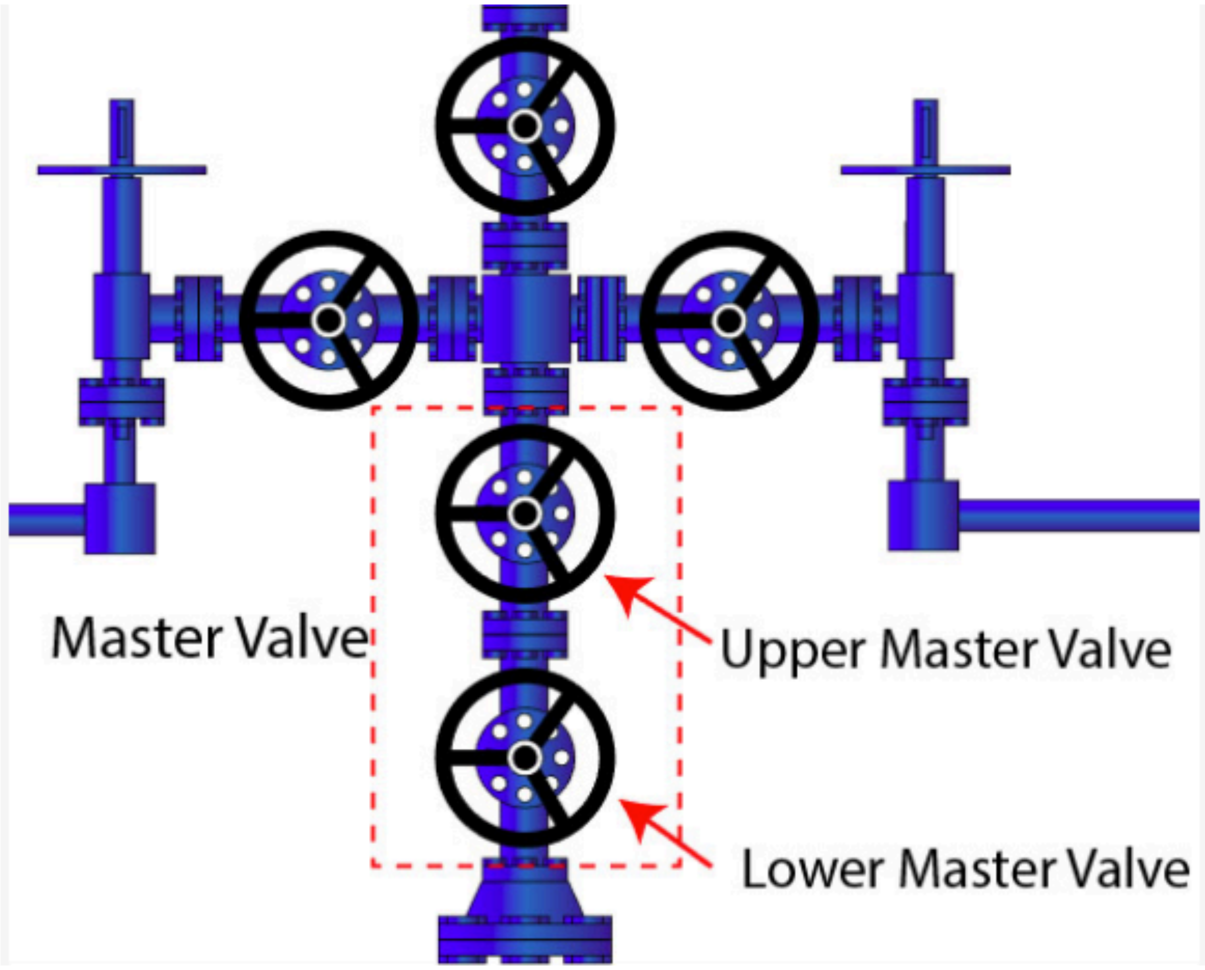

Figure 25: Christmas tree with Upper and Lower Master Valves highlighted [25]

3.1.2 Wing Valve (Production Wing & Kill Wing)

Wing valves are located on the side of a XT. A production wing valve is used to control and isolate production from the well into surface processing facilities. It is normally operated by either hydraulic or electric controlled actuators. Just like upper master valve, it is a fale-safe valve, meaning if the supply or power to the actuator is lost, it will automatically close and shut in the well. Kill wing valve is fitted on the opposite side of the production wing valve, and it is a manual operated valve. Kill wing valve acts as a connection point for well treatment or well-control purposes. [25] [26]

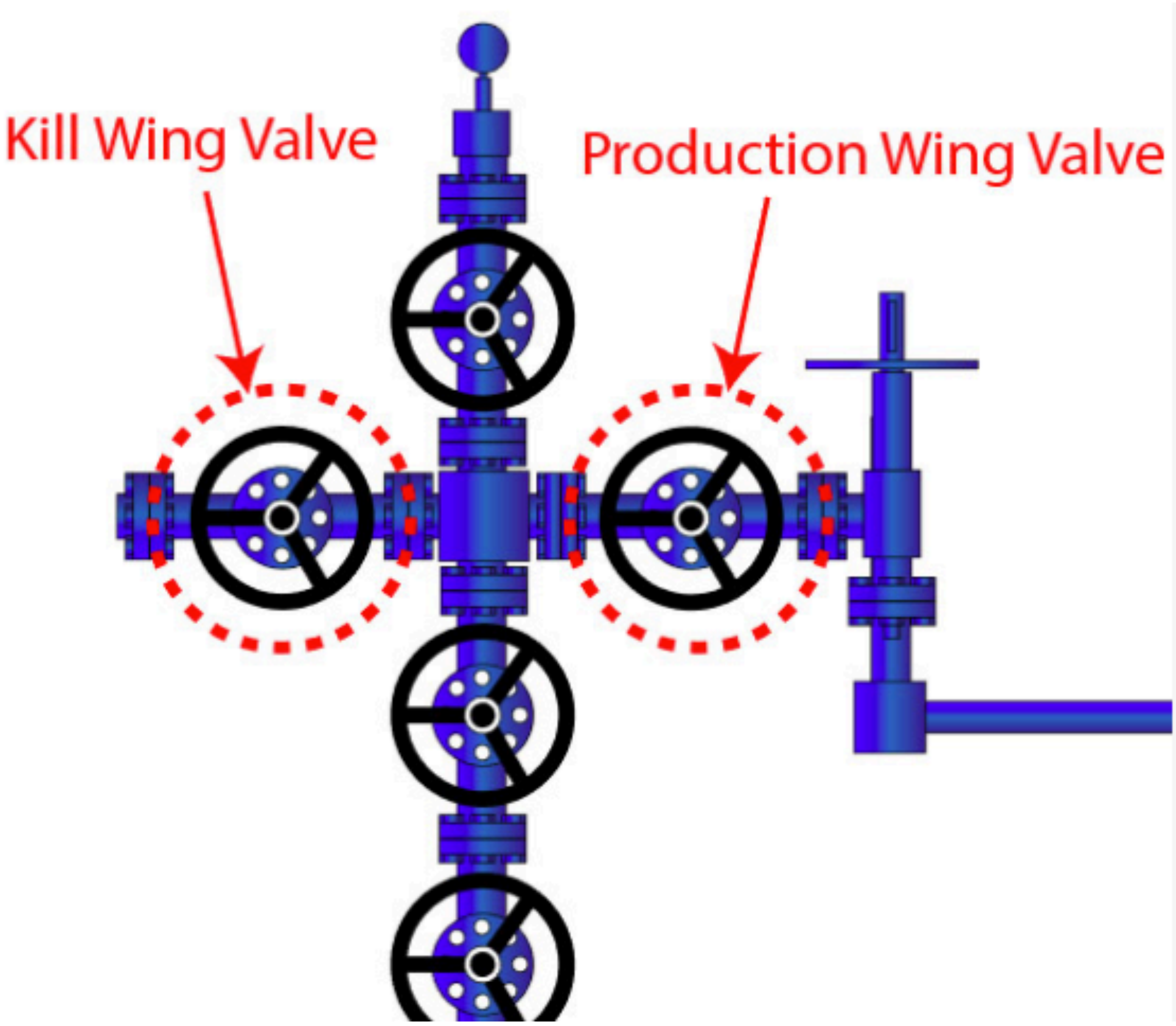

Figure 26: Production and Kill Wing Valves [25]

3.1.3 Choke Valve

Choke valve is the smallest restriction on a XT, and its main function is to control the flow rate of a well. By keeping a flow rate at a certain predetermined rate by adjusting the opening of the choke, one can avoid early water breakthrough and sand production, which will extend a well`s life time [28]. Normally a choke valve is installed after the production wing valve, but in some few cases choke valve can also be found on the kill wing side as well. Choke valve on a XT is operated by either a hydraulic or electric operated actuator. More detailed explanation about choke valves in general can be found in Chapter 2.5. [25] [26]

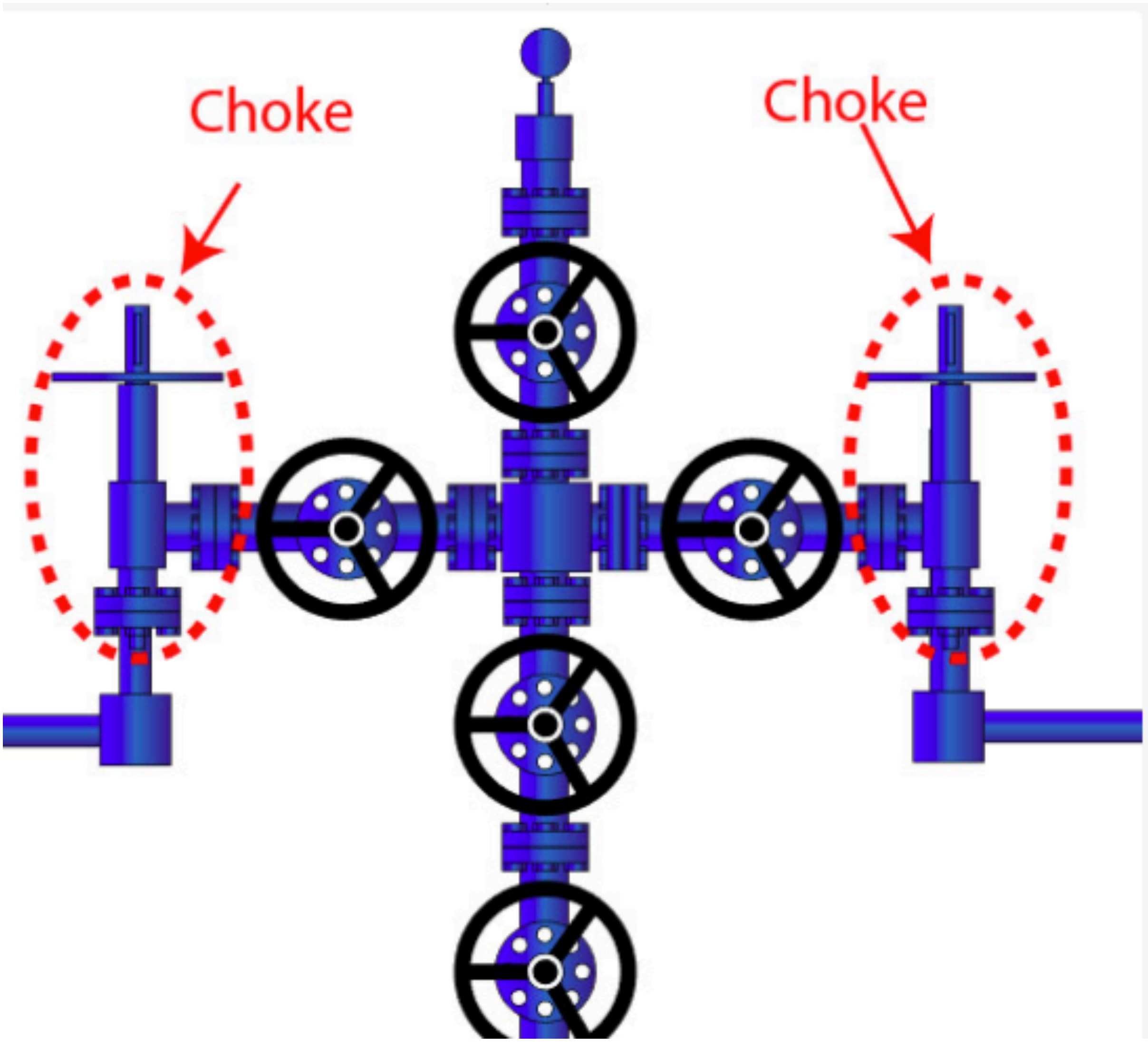

Figure 27: Choke Valve on Christmas tree [25]

4 Standards

In order to create one common requirements and specifications on NCS, NORSOK standard was created in cooperation between Statoil, Saga Petroleum and Norse Hydro in 1993. The goal here was to create one common standard for all players involved on NCS, instead of every company having their own specific internal requirements and specifications for their equipment and procedures. [29]

In these standards there are several abbreviations and referrals to other international standards, and the most common ones are:

- **ANSI** – American National Standard Institute
- **API** – American Petroleum Institute
- **DIN** – Deutsches Institut Fur Normung
- **ISO** – International Organization for Standardization
- **NEMA** – National Electrical Manufactures Assosiation
- **NS** – Norsk Standard
- **ASME** – The American Society of Mechanical Engineers
- **ASTM** – American Society for Testing and Materials

When it comes to specific standards involving valves, the most common used ones are:

- **ANSI B16.10** Face-to-Face and End-to-End Dimensions of Valves
- **ANSI B16.34** Valves – Flanged, Threaded, and Welding End
- **API 594** Wafer and Wafer-Lug Check Valves
- **API 598** Valves Inspection and Testing
- **API 600** Steel Gate Valves Flanged and Butt-welding Ends
- **API 602** Compact Steel Gate Valves Flanged, Threaded, Welding and Extended body ends
- **API 609** Lug- and Wafer- Type Butterfly Valves
- **BS 1868** Steel Check Valves (Flanged and Butt Welding Ends) for the Petroleum, Petrochemical and Allied Industries
- **BS 1873** Steel Globe, Globe Stop and Check Valves
- **BS 5155** Butterfly Valves
- **BS 5351** Steel Ball Valves for the Petroleum, Petrochemical and Allied Industries
- **BS 5352** Steel Wedge Gate, Globe and Check Valves 50 mm and smaller for the Petroleum, Petrochemical and Allied Industries
- **BS 6755 Part 1,** Testing of Valves, Production Pressure Testing Requirements
- **BS 6755 Part 2,** Testing of Valves, Fire-type Testing Requirements

Also API standard used specifically for the main equipment that have been presented in this thesis; Wellhead & Christmas Tree Equipment:

- **API 6A** – Specification for Wellhead and Christmas Tree Equipment

4.1 API

For over 90 years, API has been one of the main leaders in the development of petroleum, natural gas and petrochemical equipment and operating standards. API maintains nearly 700 standards and recommended practices. [30]

API International Standard specifies requirements and gives recommendations for the performance, dimensional and functional interchangeability, design, materials, testing, inspection, welding, marking, handling, storing, shipment, purchasing, repair and remanufacture of wellhead and Christmas tree equipment for use in the petroleum and natural gas industries.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle.

When founded in 1919, the main focus areas of API were;

- To afford a means of cooperation with the government in all matters of national concern
- To foster foreign and domestic trade in American petroleum products
- To promote in general, the interests of the petroleum industry in all its branches
- To promote the mutual improvements of its members and the study of the arts and sciences connected with the oil and natural gas industry

4.1.1 API 6A – Specification for Wellhead and Christmas Tree Equipment

This standard describes and specifies all requirements and gives recommendations for the performance, dimensional and functional interchangeability, design, materials, testing, inspection, welding, marking, handling, storing, shipment, purchasing, repair and remanufacture of wellhead and Christmas tree equipment for use in the petroleum and natural gas industries. [31]

API 6A is applicable to the following specific equipment:

- **Wellhead equipment:**
  - Casing-head housings
  - Casing-head spools
  - Tubing-head spools
  - Cross-over spools
  - Multi-stage head housings and spools

- **Connectors and fittings:**
  - Cross-over connectors
  - Tubing-head adapters
  - Top connectors
  - Tees and crosses
  - Fluid-sampling devices
  - Adapter and spacer spools

- **Casing and tubing hangers:**
    - Mandrel hangers
    - Slip hangers

- **Valves and chokes:**
    - Single valves
    - Multiple valves
    - Actuated valves
    - Valves prepared for actuators
    - Check valves
    - Chokes
    - Surface and underwater safety valves and actuators
    - Back-pressure valves

- **Loose connectors (flanged, threaded, other end connectors, and welded):**
    - Weld neck connectors
    - Blind connectors
    - Threaded connectors
    - Adapter and spacer connectors
    - Bull plugs
    - Valve-removal plugs

- **Other equipment:**
    - Actuators
    - Clamp hubs
    - Pressure boundary penetrations
    - Ring gaskets
    - Running and testing tools
    - Wear bushings

API 6A is approved by ISO the International organization for standardization, who are a worldwide federation of national standard bodies. ISO 10423 is the equivalent name for API spec 6A, and was prepared by Technical committee for Materials, Equipment and Offshore structure for petroleum, petrochemical and natural gas industries. [31]

5 Discussion

In this chapter the data obtained will be presented and analyzed. Big part of the research has been conducted with discussions in interview style on oil and gas installations to obtain an overview of the market situation today. Interviews have been conducted on drilling rigs/platforms such as:

- Island Innovator (Semi-Sub Drilling rig), Spirit Energy
- Gullfaks B (Production platform), Equinor
- Valhall DP (Production platform), AkerBP
- Maersk Invincible (Jack-up Drilling rig), Maersk

I have had this opportunity since I have been working for an oil service company as full time employee during my time writing this thesis. This has given me a hands on approach, and a proper insight into the market to get an idea of current situation. Mainly I have conducted dialogs with OIMs, Drilling Supervisors, Well Intervention Supervisors, Maintenance Engineers, Wellhead operators, Drillers and Assistant drillers both on production platforms and drilling rigs. Their experience and expertise have provided me with valuable knowledge and insight.

The majority of the numerical data used to perform an analysis for this thesis is acquired from one of the biggest oil company on NCS, but due to confidentiality, their name will remain anonymous in this thesis. Therefore, this company will be referred to as Company A further in this paper. After discussion with Reliability and Maintenance department manager at Company A, it was agreed upon that they would be willing to share failure rate/causes data for XTs (specifically gate- and choke valves) from three different major oil and gas fields, the names of these fields will also remain anonymous due to confidentiality. So in this thesis these three fields will be referred to as:

- Field A
- Field B
- Field C

For this paper, raw data for 929 XT valves from three different oil and gas fields that are operated by Company A have been analyzed. The time interval this data is obtained from goes five years back, 2013 – 2018. And in the sections below these will be organized in such manner, that a clear failure rate and failure causes for each valve on a XT can be obtained. By doing so, we will be able to see if there are any specific valves that fail more often than others, and if there are any failure causes that can be seen more often.

5.1 Failure Trend

Interviewing both offshore and onshore personnel with long experience within this segment, has given me an indication of what the most common valve problem areas were on XTs used in oil and gas industry. In order to be able to confirm this qualitative information with quantitative data, raw valve failure data will be analyzed. This will give us an illustration of failure trend for each valve type. This will be done by taking a closer look at each field by itself, and see how often each valve type on the chosen field have failed in the past five years (2013-2018).

5.1.1 Field A

In field A, there are in total 243 valves installed on all XTs. These are divided into different valve types, such as:

- Choke Valve (Plug and Cage Choke Valve)
- Hydraulic Production Master Valves (Gate Valve)
- Hydraulic Production Wing Valves (Gate Valve)
- Manual Lower Master Valves (Gate Valve)
- Manual Kill and Swab Valves (Gate Valve)
- Hydraulic Kill and Swab Valves (Gate Valve)
- Chemical Injection Valves (Gate Valve)
- Hydraulic Annulus Valves (Gate Valve)

In Table 1 the number of functional locations of each valve type in Field A is presented. It is from this data we will take a closer look at how often each of those valves have failed in the past five years, and from that calculate the failure rate (%) for each valve.

Table 1: Number of Valves in Field A (2013-2018)

Valve Type	Number of Functional Locations
XT Choke Valve	26
XT PMV, ESD	29
XT PWV	29
XT Lower Master	32
XT Manual Kill/Swab	32
XT Hydraulic Kill/Swab	29
XT Chemical injection	22
XT Hydraulic Annulus ESD	44

The next step is to look at the number of failures for each valve, which is illustrated in Figure 28.

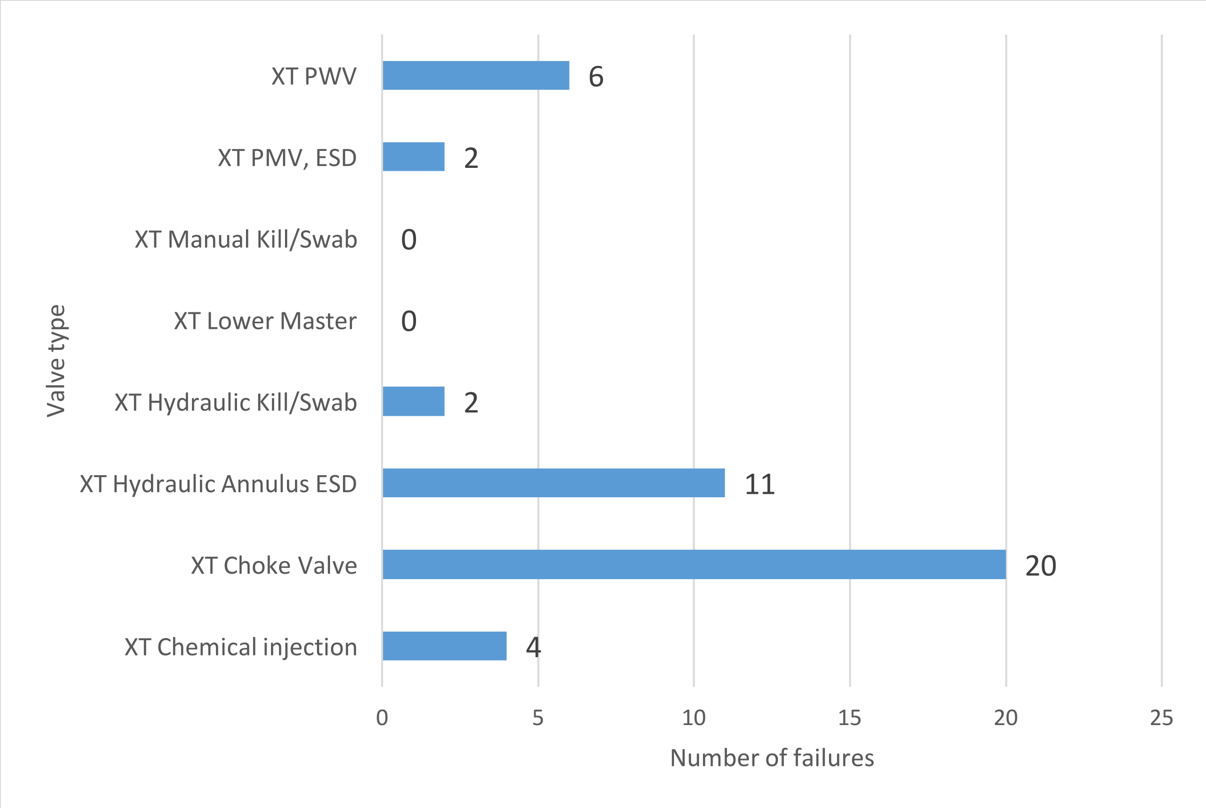

Figure 28: Number of valve failures on Field A (2013-2018)

Here a clear picture is painted with regards to which valve types have the most failures. As we can see Choke valves, Hydraulic Annulus valves and Production Wing valves have clearly more failures compared to other valves on XTs installed in Field A. But in order to get an even more clear overview, we will use the failure rate for each valve. This gives a better insight to failure trend due to each valve have normally different number of functional locations.

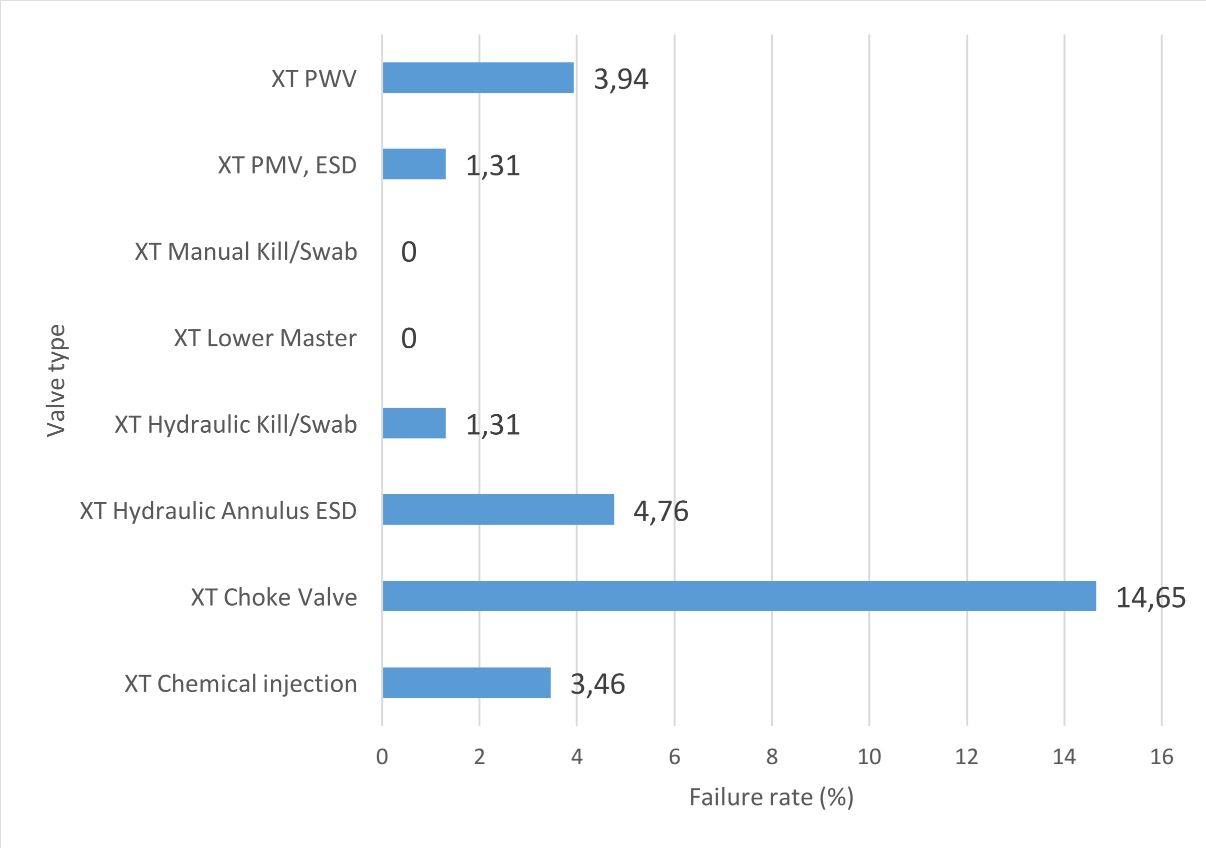

Figure 29: Failure rate on Field A (2013-2018)

To obtain the failure rate, we will calcute this by using the following equation:

$$Failure\ rate\ (\%) = \frac{Number\ of\ failed\ tests}{Number\ of\ total\ performed\ tests} * 100\% \quad (1)$$

From Figure 29 we can clearly see that Choke valve on Field A have the highest failure rate of all XT valve types. And the difference between the highest failure rate valve (Choke valve) and the next valve in line (Hydraulic Annulus valve) is significant. Choke valves have over 300% higher failure rate than the next valve in line, which in this field is Hydraulic Annulus valve, with Hydraulic Production Wing valve in a close 3rd place.

5.1.2 Field B

For Field B, I received data for in total 350 valve types found on XTs in this field. Valve types installed on XTs in this field are as following:

- Choke Valves (Plug and Cage Choke Valve)
- Hydraulic Production Master Valves (Gate Valve)
- Hydraulic Production Wing Valves (Gate Valve)
- Manual Lower Master Valves (Gate Valve)
- Manual Kill and Swab Valves (Gate Valve)
- Chemical Injection Valves (Gate Valve)
- Hydraulic Annulus Valves (Gate Valve)

Number of functional locations for each valve type in Field B are presented in Table 2. We can note that in this field all Kill and Swab valves are manually operated, which is why we have a higher number compared to Field A.

Table 2: Number of Valves in Field B (2013-2018)

Valve Type	Number of Functional Locations
XT Choke Valve	38
XT PMV, ESD	42
XT PWV	42
XT Lower Master	42
XT Manual Kill/Swab	84
XT Chemical injection	32
XT Hydraulic Annulus ESD	70

In figure 30 number of times each valve type has failed in the past five years (2013-2018) is presented. We can note that in this field Hydraulic Annulus Valve have the most failures unlike in Field A.

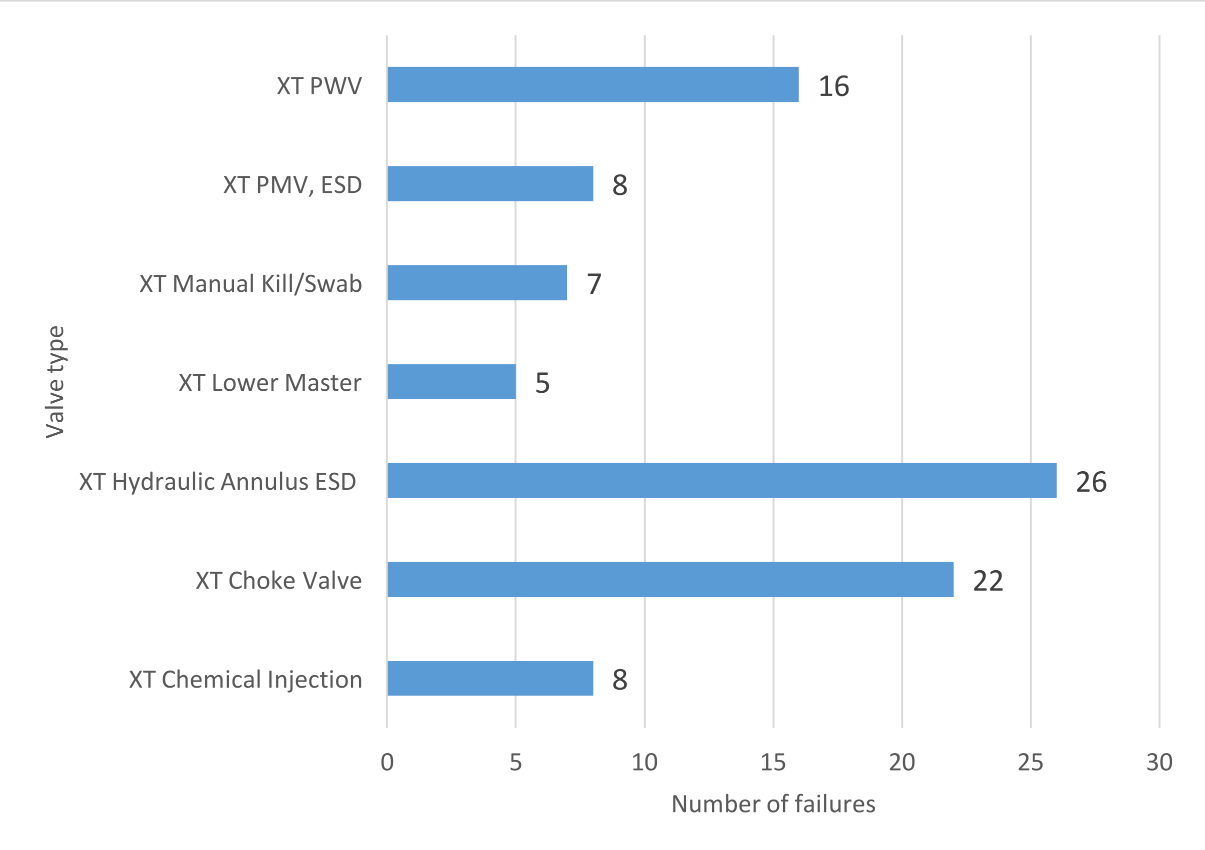

Figure 30: Number of XT valve failures on Field B (2013-2018)

This can be explained with the fact that there are clearly more Hydraulic Annulus valves installed in Field B compared to Choke valves. Just like in the previous case, also for this field we will obtain the failure rate for each valve type by using equation (1). This gives us the following failure rate as shown in Figure 31.

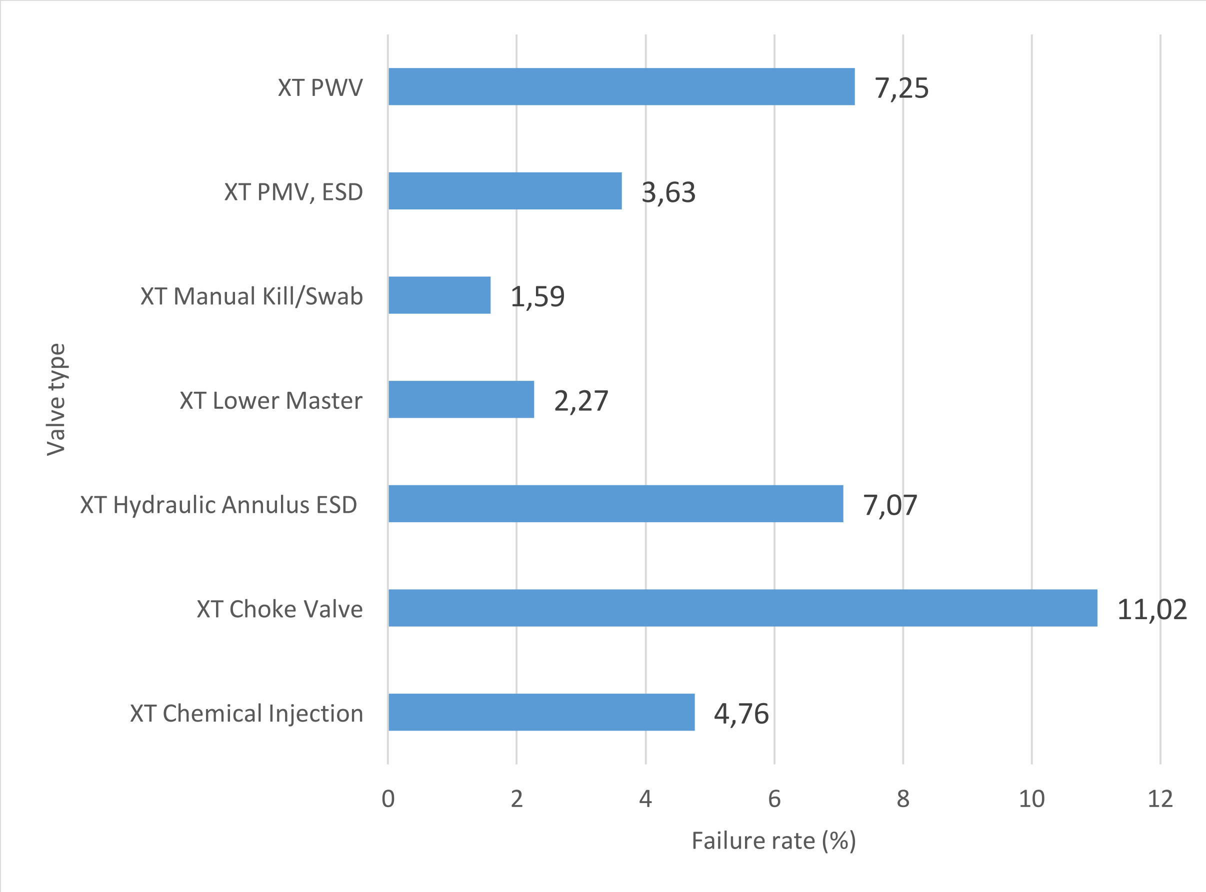

Figure 31: Failure rate on Field B (2013-2018)

Also in this case we can see a higher failure rate for Choke valves, but the difference between valve types are less significant than in Field A. Same trend is also seen with regards to the two next valve types in line with 2nd and 3rd highest failure rates (Production Wing valve and Hydraulic Annulus valve). The reason for the difference in failure rate between Choke valves and PWV/Annulus valves for these two fields could be several. Some of them are:

- Age of the field
- Reservoir/Well conditions
- Solids production
- Different valve suppliers
- Different valve design
- Different maintenance procedures
- etc.

These are some possible explanations, without having the proper data to make any conclusions, since this has not been a part of the research objective for this thesis. But this would definitely be an interesting factor to look closer into for future research.

5.1.3 Field C

For this field, data for 336 valves on XTs have been analyzed. Number of functional locations for each valve type is presented in Table 3. Valve types found on XTs in this field is as following:

- Choke Valves (Plug and Cage Valve)
- Hydraulic Production Master Valves (Gate Valve)
- Hydraulic Production Wing Valves (Gate Valve)
- Manual Lower Master Valve (Gate Valve)
- Manual Kill and Swab Valves (Gate Valve)
- Hydraulic Injection Valve (Gate Valve)
- Hydraulic Annulus Valve (Gate Valve)

Table 3: Number of Valves in Field C (2013-2018)

Valve Type	Number of Functional Locations
XT Choke Valve	39
XT PMV, ESD	42
XT PWV	42
XT Lower Master	42
XT Manual Kill/Swab	84
XT Chemical injection	31
XT Hydraulic Annulus ESD	56

Same failure trend as in previous two fields can be observed in Field C as illustrated in Figure 32. Choke valves have the most failures, with Hydraulic Annulus valves and Production Wing valves in 2nd and 3rd position. Although this number gives us a failure trend indication, a more correct trend is obtained by calculating failure rate for each valve type. Reason for this is that for this field we also have different number of functional locations of each valve type.

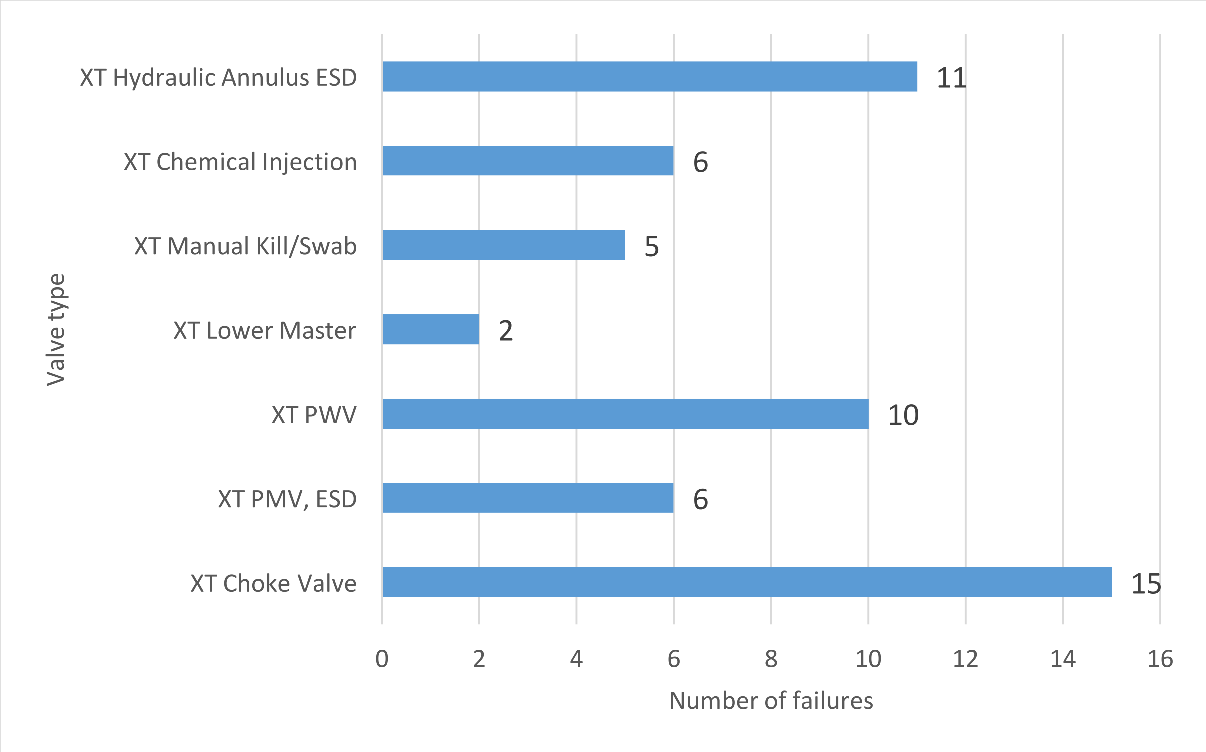

Figure 32: Number of XT valve failures on Field C (2013-2018)

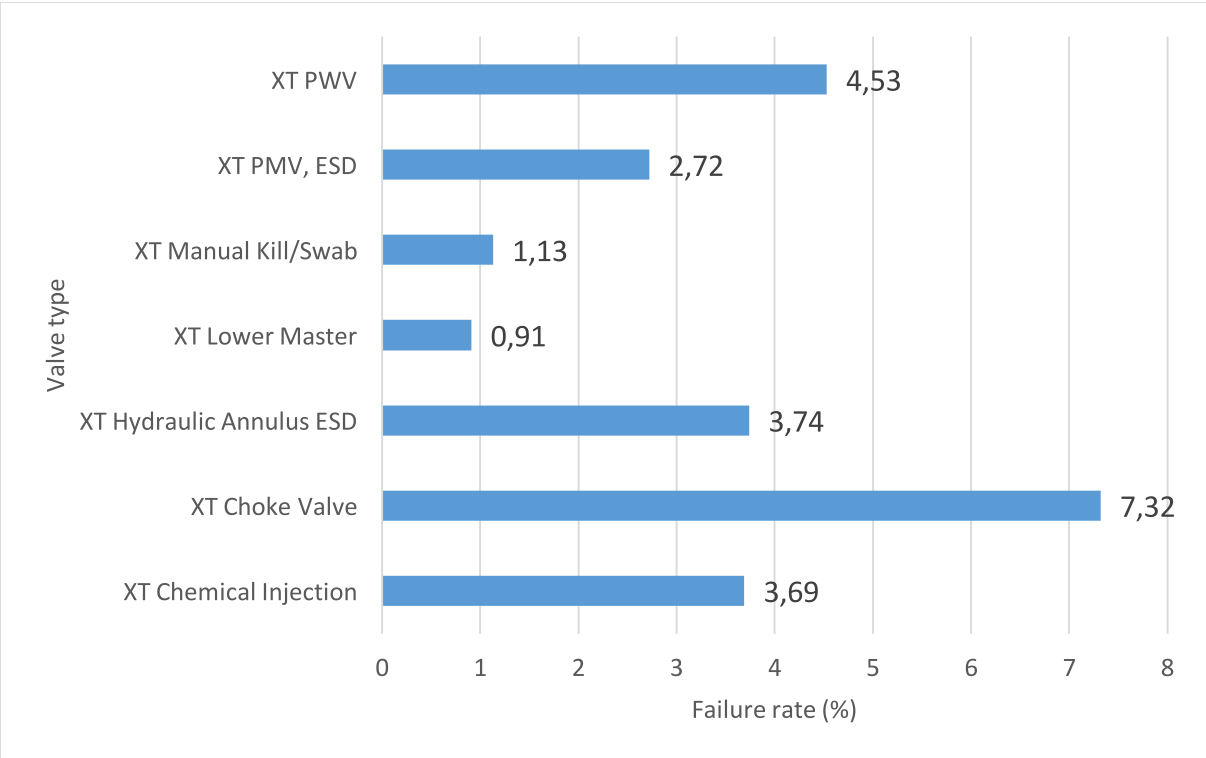

Figure 33: Failure rate on Field C (2013-2018)

The failure rate illustrates the same trend for Field C, this can be seen in Figure 33. Choke valves failure rate tops also for this field in front of Production Wing valves and Hydraulic Annulus valves as expected from previous data cases. The ratio between how often Choke valves fail compared to other valve types, are similar to Field B, and less than Field A. We could argue the same reasons for this as in previous section, to why in Field A we see higher failure rate for Choke valves compared to other two fields.

Further we will look at the total trend from these three fields combined with the qualitative input I have received from my interviews offshore workers with expertise within this segment.

5.2 Total Trend

In this section the total average failure rate from Field A, B and C will be presented. This data will then be compared with the data acquired using qualitative data gathering method by conducting interviews.

Before I received data from Company A, my main method for gathering information for this thesis was by asking questions by interviewing people every time I was offshore. The impression I then got was that people working with XTs on a daily basis offshore did not have a conclusive answer when I asked them which component on a XT in their experience failed the most. Although they had some idea of which valves they experienced the most failures with, the general answer I in most cases got was the issues they most often had was due to corrosion related issues. But there were no proper data or opinion to show if there are any specific items on a XT that fails more often than others.

Poor maintenance routines were also an answer I got often. Poor maintenance routines are something I myself who have worked offshore for four years know to be an issue. It seems like almost everyone has their own personal special understanding of the best practice or how to perform maintenance on valves (and other equipment in general).

This is why the quantitive data I received from Company A after many attempts with many oil and gas companies in Norway are so important in order to get an overview of current valve failure trend. But the most common bias within the people I talked to was that there are valves that might require maintenance more often than others with the same issue time after time, without anyone asking the question “Could the issue be wrong valve design specifically for this well?”. And could other suppliers with different valve solutions offer a more economically feasible valve solution for their XT valves? And even if this question in some cases are asked by the personnel performing maintenance and general work with these valves on a daily basis, their understanding is often that management is more afraid of trying new ways of doing things now than ever. This could be because the margin for failure is smaller now that each company`s breakeven price has been put to a test with lower oil prices, and a well known solution is perhaps seen as a safer option even though it isn’t flawless.

From the data received from Company A, it can clearly be seen that there are certain valve types that require corrective maintenance more frequently than others on a XT. This is illustrated in Figure 34.

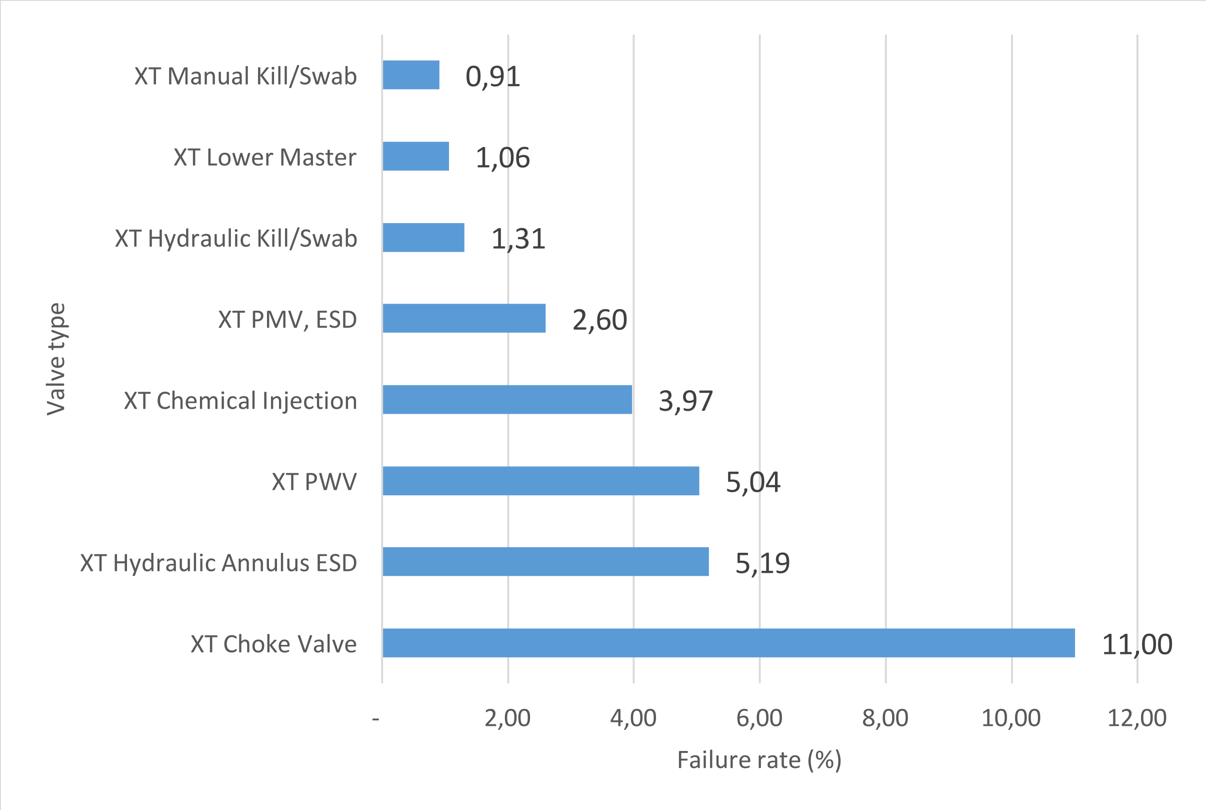

Figure 34: Total average Failure rate (%) from Field A, B and C in the past five years

As we can see Choke valves on XTs have without any doubt the highest failure rate, more than double of the next highest failure rate valve type. And in general the list from the least failure rate to the highest can be explained by several factors. The actuator choice of a valve could play a role, since we can clearly see remote operated (in most case hydraulically) valves tend to fail more often than manually operated valves. This is because there are more mechanical components in a hydraulically operated actuator valves compared to simple manually operated valves with a handweel.

The valve usage in a normal operation could also play a major role explaining why certain valves seems to fail more often than others. Manually and hydraulically operated Kill and Swab valves are valves that aren't used often in normal operations. Swab valves are only used in case of well intervention related operations and one have to run in hole with either Wireline, Coiled Tubing or in Snubbing operations. In normal production mode, this valve is kept closed and aren't operated as often as other valves. No hydrocarbon flow stream is directed through the Swab valve in normal operations either, which also would explain the reason for these valves to have low failure rate.

The same arguments could be made for manually operated Kill Wing valves and manually operated Lower Master valves. Kill Wing valves are used in case of an emergency when the well needs to be killed by bullheading kill fluid from cement line down into the well through the Kill Wing valve. Other than such emergency scenario, this valve is also used in well intervention operation. Kill Wing valve is often referred to as Service Wing Valve offshore. Usually the return line is connected to the Kill Wing valve during Coiled Tubing or Snubbing operations and pumping is required. This line belongs to the service companies who are responsible for taking returns from the well during pumping operations in the well, hence the name Service Wing valve. In normal production mode, also this valve is kept closed and no hydrocarbons are diverted through this valve. This minimizes the exposure to potentially sour service fluids (H2S, CO2, etc.) and erosive damage due to solid particles in well flow. Lower Master valves are in normal production mode always open, and are only used when Swab valve needs to be opened and Down Hole Safety valve can not be operated as a barrier together with hydraulically operated Upper Master valve. Mostly Lower Master valve is used as a back-up for Upper Master valve as a redundancy option, if Upper Master valve fails.

The remaining gate valves that are remotely operated by hydraulic actuators such as; Production Wing valves, Chemical Injection valves, Annulus valves and Production Master valves have a failure rate ranging from 2.60 % and up to 5.19 %. This is within normal numbers for these valves according to personnel working with XTs in the field that I have conducted interviews with. Reason for this is the exposure of well flow they are subjected to, and the number of times these valves gets operated in normal operations. But that does not mean the cost these failures bring aren't of interest for possible improvement area. Even if the failure rate is low, with poor maintenance procedures in place these valve failures could cost the operator a lot of money in the long run. And since my impression is that there is area for improvement when it comes to maintenance, I would suggest valve suppliers spend more time and energy in designing valves with specific and detailed step-by-step procedure for both preventive and corrective maintenance manuals to go with the valve as one package. This package should contain the necessary manual which describe in a very simple manner the step-by-step maintenance procedure, required spare parts, required tools for the task, describe the required workers for the task, how long the task should take, a sheet were potential improvements and lessons learned can be logged for next time by the workers who performed the task, etc. By having this ready-box package in a designated area easily accessible and having trained personnel who are qualified to perform such task, oil and gas operators could potentially save cost in the long run. Another option would be instead of having a big stock of many spare parts for a gate valve always available on the rig, one could implement a procedure where if a gate valve fails it just gets changed out with a new one. The old gate valve is simply sent onshore for maintenance, and a new one is installed. This can save operators time and cost of stock management since it only requires one gate valve in stock, instead of many minor components for a gate valve. This is something Valvission have started to implement with their clients, and the feedback have been very positive.

The valve with the highest failure rate is clearly the Choke valve. This valve type has on average 11.0 % failure rate from Field A, B and C data. This is a high number, and one could ask how come this type of valve have such a high failure rate? We can suggest many theories for why Choke valve tend to fail more often than other valves on XT. The simple explanation I got from offshore workers working with these valve was that they get exposed to harsh environments during operation. This is true, Choke valves have to handle both high oil and gas flowrates, solid production, erosion, high differential pressure, etc. But these are all well known factors the operators should know when choosing a valve supplier and valve design. It seems like the entire well life span of a well is not always being considered when choosing Choke valves. It is important to take into consideration for suppliers of these valves that a well will behave differently after ten years, compared to its original conditions when first put into production.

5.3 Main Failure Causes

Now that we have determined the failure rate of all valve types on XT from three major oil and gas field on NCS, we can now continue to determine the main causes behind valve failures. An important term here is Failure mechanism. In ISO - 14224 this term is described as following [32]:

"The failure mechanism is the physical, chemical or other process or combination of processes that leads to the failure. It is an attribute of the failure event that can be deduced technically, e.g. the apparent, observed cause of the failure. The failure mechanism's root cause(s) is/are coded whenever this information is available. (A separate field for this is recommended in this International Standard.) The codes on failure mechanism are basically related to one of the following major categories of failure types: a) mechanical failures; b) material failures; c) instrumentation failures; d) electrical failures; e) external influence; f) miscellaneous."

These six failure mechanism categories are described in Table 4 [32]:

Table 4: Failure mechanism [32]

Failure mechanism		Subdivision of the failure mechanism		Description of the failure mechanism
Code number	Notation	Code number	Notation	
1	Mechanical failure	1.0	General	A failure related to some mechanical defect but where no further details are known
		1.1	Leakage	External and internal leakage, either liquids or gases: If the failure mode at equipment unit level is coded as "leakage", a more causally oriented failure mechanism should be used wherever possible.
		1.2	Vibration	Abnormal vibration: If the failure mode at equipment level is "vibration", which is a more causally oriented failure mechanism, the failure cause (root cause) should be recorded wherever possible.
		1.3	Clearance/ alignment failure	Failure caused by faulty clearance or alignment
		1.4	Deformation	Distortion, bending, buckling, denting, yielding, shrinking, blistering, creeping, etc.
		1.5	Looseness	Disconnection, loose items
		1.6	Sticking	Sticking, seizure, jamming due to reasons other than deformation or clearance/alignment failures
2	Material failure	2.0	General	A failure related to a material defect but no further details known
		2.1	Cavitation	Relevant for equipment such as pumps and valves
		2.2	Corrosion	All types of corrosion, both wet (electrochemical) and dry (chemical)
		2.3	Erosion	Erosive wear
		2.4	Wear	Abrasive and adhesive wear, e.g. scoring, galling, scuffing, fretting
		2.5	Breakage	Fracture, breach, crack
		2.6	Fatigue	If the cause of breakage can be traced to fatigue, this code should be used.
		2.7	Overheating	Material damage due to overheating/burning
		2.8	Burst	Item burst, blown, exploded, imploded, etc.
3	Instrument failure	3.0	General	Failure related to instrumentation but no details known
		3.1	Control failure	No, or faulty, regulation
		3.2	No signal/ indication/alarm	No signal/indication/alarm when expected
		3.3	Faulty signal/ indication/alarm	Signal/indication/alarm is wrong in relation to actual process. Can be spurious, intermittent, oscillating, arbitrary
		3.4	Out of adjustment	Calibration error, parameter drift
		3.5	Software error	Faulty, or no, control/monitoring/operation due to software error
		3.6	Common cause/ Common mode failure	Several instrument items failed simultaneously, e.g. redundant fire and gas detectors; also failures related to a common cause.

Table 4: (Continued) [32]

Failure mechanism		Subdivision of the failure mechanism		Description of the failure mechanism
Code number	**Notation**	**Code number**	**Notation**	
4	Electrical failure	4.0	General	Failures related to the supply and transmission of electrical power, but where no further details are known
		4.1	Short circuiting	Short circuit
		4.2	Open circuit	Disconnection, interruption, broken wire/cable
		4.3	No power/voltage	Missing or insufficient electrical power supply
		4.4	Faulty power/voltage	Faulty electrical power supply, e.g. overvoltage
		4.5	Earth/isolation fault	Earth fault, low electrical resistance
5	External influence	5.0	General	Failure caused by some external events or substances outside the boundary but no further details are known
		5.1	Blockage/plugged	Flow restricted/blocked due to fouling, contamination, icing, flow assurance (hydrates), etc.
		5.2	Contamination	Contaminated fluid/gas/surface, e.g. lubrication oil contaminated, gas-detector head contaminated
		5.3	Miscellaneous external influences	Foreign objects, impacts, environmental influence from neighbouring systems
6	Miscellaneous [a, b]	6.0	General	Failure mechanism that does not fall into one of the categories listed above
		6.1	No cause found	Failure investigated but cause not revealed or too uncertain
		6.2	Combined causes	Several causes: If there is one predominant cause this should be coded.
		6.3	Other	No code applicable: Use free text.
		6.4	Unknown	No information available

The data gathered for this paper from Company A showed great lack in correct reporting of failure mechanism in their internal system, as can be seen in Appendix C, D and E. Reason for this can be many, but most likely lack in good procedures, unqualified personnel, bad reporting system and general poor reporting culture within the company. Closely 90% of malfunctions gathered from Company A are missing failure mechanism category, which is an issue that should be addressed.

For our purpose, I have used the malfunction reports that have a failure mechanism category linked to it, and only chosen failure mechanisms that have been reported more then ones, Figure 35:

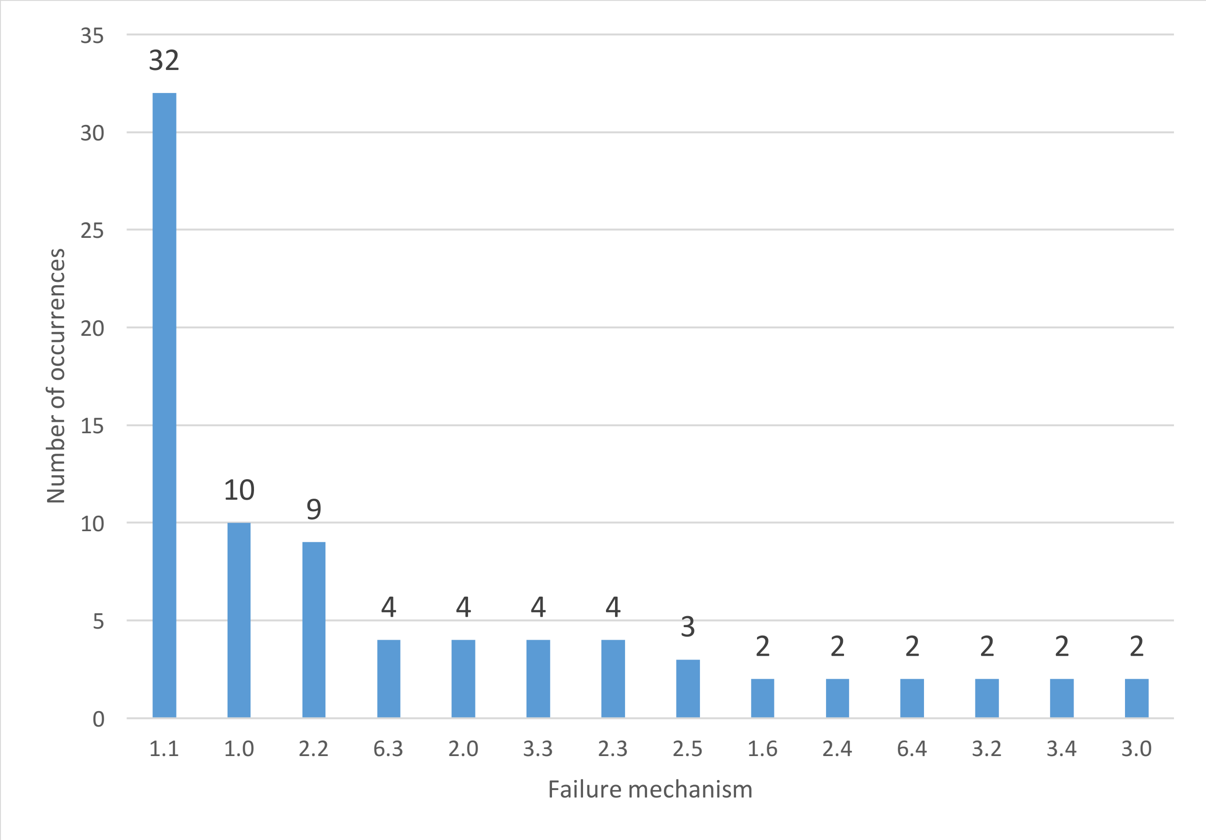

Figure 35: Number of failure mechanisms occurrences in Field A, B and C in the past five years (2013-2018)

Three failure mechanisms are reported more frequent as can be seen from Figure 35. These are 1.1, 1.0 and 2.2. From Table 4 we get [32]:

- 1.1: Mechanical failure due to leakage – External and internal leakage, either liquids or gases, were reported 32 times.

- 1.0: Mechanical failure due to general failure – A failure related to some mechanical defect but where no further details are known, were reported 10 times.

- 2.2: Material failure due to corrosion – All types of corrosion, both wet (electrochemical) and dry (chemical), were reported 9 times.

These three main failure mechanisms fit together with what was found during my interviews in the field. The most common failure mechanism experienced on these valves were leakage, mostly internal. Most common issues experienced by offshore personnel were;

- Damaged O-rings
- Damaged gate or seats (often just a small scratch on the gate will lead to leakage)
- Poor lubrication
- Build up of scale and general solid debris in the valve body (gate does not close properly)
- Wash out due to erosion inside the valve body (common issue for choke valves with high differential pressure across the choke)

Equipment failures related to corrosion is an issue oil and gas industry have battled for many years. This is especially true for installations in the North Sea, were the environment are extra inviting for corrosion on metals. Stop in production because of corrosion related equipment failure is a phenomenon that cost operators a lot of money. This is why correct choice of equipment materials are so important. Materials better suited for such applications are in these days available in the market that can handle harsh environments, but valve suppliers need to understand the stresses valves and general equipment are subjected to over the time they are intended to function. A lot of strange valve material solutions can be found on oil and gas installations today. I have myself seen one single valve consisting of several different materials. This of course lead to electrochemical corrosion between two metals with different electropositivity when they come in contact in the presence of an electrolyte. This issue can be eliminated by designing valves (when possible) using stainless steels. This has been observed in the market more and more in the recent years. Although manufacturing stainless steel valves are more expensive, the bias in the industry is that it saves maintenance cost in the longer time perspective.

6 Conclusion

After performing interviews with professionals in the oil and gas industry working with XTs and analyzing XT valves failure data from three major fields on NCS, several conclusions can be drawn. We can clearly see that Choke valves on XT have the highest failure rate with 11.0%. The scope was to identify valve problem areas on XTs, which this thesis has managed to do, with both qualitative and quantitative research methods. This thesis managed to determine the most common failure mechanisms reported for all XT valves (both Choke valves and Gate valves) from three different oil and gas fields. Although it was observed poor failure mechanism reporting practice with closely 90.0% of malfunction cases were reported without a failure mechanism linked to it. From the data that could be used, it clearly showed that internal and external leakage, mechanical failure due to general failure and material failure due to corrosion were the most commonly reported failure mechanisms. These issues can often be linked to poor material quality. In recent years, valves with better material quality such as stainless steel, have been observed more frequent on oil and gas installations. Stainless steel valves are more expensive to manufacture or purchase, but the improved maintenance cost effectivity this offers should be of interest for Valvision in order to outperform the competition in the market.

Poor maintenance routines were observed to be an issue when interviewing offshore workers. It seems like personnel have their own preferred way of doing things, instead of following a clear procedure. Reasons for this were lack of "idiot-proof" manuals that describes very clearly step-by-step each task when performing maintenance on valves. Instead, task performing personnel felt like the procedure were to generic, and they easily ignored them. Valvision have already started to address issues like these by eliminating the need for offshore personnel to perform maintenance on valves. The operator only has one fully assembled gate valve in stock, so when the gate valve in use fails, offshore personnel change it out with the back-up valve and send the defect valve onshore for repair. This saves time offshore and accomplishes lean stock management by avoiding many smaller spare part components in stock.

Another improvement option would be to deliver valves with its own specific ready-box (one for gate valve, one for choke valve, etc.) with maintenance procedure check list that the performing workers can tick of as they finish each step. This box should contain information about how many workers the task requires and estimated time for the task. All the necessary tools and spare parts for the job should be in the box and a post-job debrief scheme where lessons learned and potential improvements can be logged by workers who performed the task should be available. This box should have a designated place easily accessible, to avoid wasted time looking for manuals and tools to start the task. It should also be mandatory to link each observed valve defect to a failure mechanism category as per ISO-14224. This data could later be used for future improvement of the valves.

Also accessibility for performing maintenance on XT valves were found to be problematic. The way todays dry XTs are designed makes it very challenging to perform maintenance on them. The combination of XTs large size, the lack of space in wellhead area and the heavy weight of the valves makes simple tasks very time consuming. Usually ladders, scaffolding and overhead crane is used when performing simple tasks on XT valves. Valvision should keep this in mind when designing both Choke and Gate valve solution specific for dry XT, as this would save the operator companies a lot of money. Also with regards to HSE a more accessible valve solution would be a big improvement, as it would create a safer working environment for personnel performing maintenance on XT valves.

It was also discovered that the general bias in the oil and gas industry is more conservative when it comes to trying new suppliers than before the major oil price fall in 2014. As the margin for failure is extra tight for operator companies with changing environment with low oil price, they tend to stick to well known and safe options by continuing with same valve suppliers they are familiar with. But with tailor-made valve solutions that I believe the competent employees at Valvision can provide, great XT valve market opportunities are present. Deep understanding of the client`s needs is perhaps the biggest advantage Valvision should have as a valve supplier.

7 References

[1] I. W. Paper, Oil Prices and Global Economy.

[2] IndexMundi. [Online]. Available: https://www.indexmundi.com/commodities/?commodity=crude-oil&months=60 .

[3] V. AS. [Online]. Available: http://www.valvision.no/about.

[4] P. L. Skousen, Valve handbook, Second edition ed., 1976.

[5] GlobalSpec. [Online]. Available: https://www.globalspec.com/learnmore/flow_control_flow_transfer/valves/gate_valves .

[6] Schlumberger, "Valves".

[7] C. Schlumberger, "Slb," [Online]. Available: https://cameron.slb.com/products-and-services/valves-index/valve-academy/how-does-it-work-ball-valves.

[8] Insights.GlobalSpec. [Online]. Available: https://insights.globalspec.com/article/4579/how-do-ball-valves-work.

[9] Schlumberger, "Slb," [Online]. Available: https://www.products.slb.com/valves/valve-academy/how-does-it-work-ball-valves.

[10] Avkvalves. [Online]. Available: http://www.avkvalves.eu/en/insights/butterfly-valves/what-is-a-butterfly-valve.

[11] CTGClean. [Online]. Available: https://techblog.ctgclean.com/2012/03/valves-manual-valves-gate-and-butterfly-valves/.

[12] [Online]. Available: https://www.globalspec.com/learnmore/flow_control_flow_transfer/valves/check_valves.

[13] Wikipedia. [Online]. Available: https://en.wikipedia.org/wiki/Check_valve .

[14] M. G. Inc.. [Online]. Available: https://www.youtube.com/watch?v=StHAmZpDHi0.

[15] [Online]. Available: https://amarineblog.wordpress.com/2017/09/11/piping-flow-direction-of-valve/.

[16] NormexValves. [Online]. Available: http://www.normexvalves.com/ball_check_model_b01.html.

[17] S. Cam. [Online]. Available: https://cameron.slb.com/products-and-services/production/valves-and-valve-automation/choke-valves/h2-needle-and-seat-choke-valves .

[18] GekEngineering. [Online]. Available: http://gekengineering.com/Downloads/Free_Downloads/Well_Heads_Chokes_SSSV_Chapter_5.pdf.

[19] S. Cam. [Online]. Available: https://www.products.slb.com/valves/brands/cameron/m3d-willis-type-drilling-choke .

[20] S. Cam. [Online]. Available: https://cameron.slb.com/products-and-services/production/valves-and-valve-automation/choke-valves/mov-choke-valve .

[21] C. Slb. [Online]. Available: http://cameron.slb.com/products-and-services/production/valves-and-valve-automation/choke-valves/control-choke-valves/plug-and-cage .

[22] IceWeb. [Online]. Available: http://www.iceweb.com.au/Technical/choke-valve.htm.

[23] GlobalSpec. [Online]. Available: https://www.globalspec.com/learnmore/flow_transfer_control/valve_actuators_positioners/manual_valve_actuators.

[24] Wikipedia. [Online]. Available: https://en.wikipedia.org/wiki/Valve_actuator.

[25] DrillingFormulas. [Online]. Available: http://www.drillingformulas.com/surface-christmas-tree-dry-tree-basic-knowlege/.

[26] A. Szilas, Production and Transport of Oil and Gas, Second edition ed.

[27] G. Slb. [Online]. Available: http://www.glossary.oilfield.slb.com/Terms/m/master_valve.aspx.

[28] Valve.no. [Online]. Available: https://www.valve.no/maintenance-on-the-christmas-trees-part-1/ .

[29] M. Global, Introduction to Valves.

[30] API. [Online]. Available: http://www.api.org/about.

[31] A. P. I. (. 6A), Specification for Wellhead and Christmas Tree Equipment.

[32] ISO, Petroleum, petrochemical and natural gas industries — Collection and exchange of reliability and maintenance data for equipment (ISO 14224:2016), 2016.

Appendix

Appendix A

- In your experience, how often do these valves (in particular gate valves and choke valves) on XT fail?
- How often do you perform preventive/corrective maintenance on these valves?
- In your opinion, are the current maintenance procedures good enough for you to always follow them?
- What are the most common failure causes for these valves?
- Are your company willing to look at any potential improvements that can be done to reduce the cost of these valves?
- In this changing environment with low oil prices, are your company willing to try new valve suppliers?

Appendix B

Maintenance plant	Object type text	Number of Functional Locations	Number of Failures	Failure rate%
O&G PlantA	XT Choke Valve	26	20	14,65
O&G PlantA	XT PMV, ESD	29	2	1,31
O&G PlantA	XT PWV	29	6	3,94
O&G PlantA	XT Lower Master	32	0	0,00
O&G PlantA	XT Manual Kill/Swab	32	0	0,00
O&G PlantA	XT Hydraulic Kill/Swab	29	2	1,31
O&G PlantA	XT Chemical injection	22	4	3,46
O&G PlantA	XT Hydraulic Annulus ESD	44	11	4,76
		243		

Maintenance plant	Object type text	Number of Functional Locations	Number of Failures	Failure rate%
O&G PlantB	XT Choke Valve	38	22	11,02
O&G PlantB	XT PMV, ESD	42	8	3,63
O&G PlantB	XT PWV	42	16	7,25
O&G PlantB	XT Lower Master	42	5	2,27
O&G PlantB	XT Manual Kill/Swab	84	7	1,59
O&G PlantB	XT Chemical Injection	32	8	4,76
O&G PlantB	XT Hydraulic Annulus ESD	70	26	7,07

Maintenance plant	Object type text	Number of Functional Locations	Number of Failures	Failure rate%
O&G PlantC	XT Choke Valve	39	15	7,32
O&G PlantC	XT PMV, ESD	42	6	2,72
O&G PlantC	XT PWV	42	10	4,53
O&G PlantC	XT Lower Master	42	2	0,91
O&G PlantC	XT Manual Kill/Swab	84	5	1,13
O&G PlantC	XT Chemical Injection	31	6	3,69
O&G PlantC	XT Hydraulic Annulus ESD	56	11	3,74

Appendix C

Notificatior	Description	Description	Fail mod	Prob. code text	Fail Mec	Notif.date	ABC indic	Failure Imp	Priorit
43921552	Liten lekkasje i instrument fittings,ESV	GASLIFT SCALE INHIBITOR X-TREE A24	ELU	ISO Valves - ISO External leakage – utility medium	1.0	11.01.2015	3	U	U
45118430	Scale ventil lekker i stem brønn A27	GASLIFT SCALE INHIBITOR X-TREE A27	ELP	ISO Valves - ISO External leakage – process medium		17.01.2018	3	D	H
44067724	UPLAN:ventil på gasløft lekker i stem	SCALE INHIBITOR INJECTION ESV VALVE	ELU	ISO Valves - ISO External leakage – utility medium		01.06.2015	3	S	M
44111404	Defekt seloniode ventil	GASLIFT MASTER ESV VALVE A17	FTO	ISO Valves - ISO Failure to open on demand		09.07.2015	3	S	M
44122651	Aktuator er sleten, bør byttes A26	CHOKE	FTC	ISO Valves - ISO Failure to close on demand	1.0	22.07.2015	1	U	U
44239992	ESV10164 Scale inhib.Valve lekker i stem	GASLIFT SCALE INHIBITOR X-TREE A07	ELU	ISO Valves - ISO External leakage – utility medium	1.1	15.11.2015	3	S	M
44759348	Ventil når ikke endepunkt	GASLIFT SCALE INHIBITOR X-TREE A07	OTH	ISO Valves - CST Other		27.03.2017	3	S	M
43258970	Ventil mangler endebryter,må fikses.	GASLIFT SCALE INHIBITOR X-TREE A02	OTH	ISO Valves - CST Other		21.03.2013	3	U	U
43449589	A28 Ventil holder ikke lekkasjekriterier	GASLIFT MASTER ESV VALVE A28	INL	ISO Valves - ISO Internal Leakage		01.10.2013	3	U	U
43899243	Wing ventil A24 lekker hydraulikk	LZ1002(A24) WING VALVE	ELU	ISO Valves - ISO External leakage – utility medium	1.1	15.12.2014	3	U	U
44005451	24M FV-MULTI A26 OLJE BRØNN	LZ-1003 (A26) MASTER VALVE	OTH	CST General - CST Other	1.1	29.03.2015	3	U	U
44606920	Hydraulikk lekkasje i 3 veis Solenoid ve	LZ-1003 (A26) MASTER VALVE	ELU	ISO Valves - ISO External leakage – utility medium	1.1	10.11.2016	3	S	M
45086184	Byttet hydraulikkslange på Wing-ventil	LZ-1003 (A26) WING VALVE	OTH	ISO Valves - CST Other	1.1	16.12.2017	3	U	U
43857070	Esv 10372 feilet på første test.	C-SECTION GAS LIFT MASTER VALVE A13	OTH	CST General - CST Other	1.1	07.11.2014	3	U	U
43229910	ESV lar seg ikke stenge.	GASLIFT MASTER ESV VALVE A34	FTC	ISO Valves - ISO Failure to close on demand		19.02.2013	3	D	H
43580013	Scaleventil A34 indikerer ikke stengt	GASLIFT SCALE INHIBITOR X-TREE A34	FTC	ISO Valves - ISO Failure to close on demand		06.02.2014	3	U	U
45086905	Feil på endebryter	GASLIFT SCALE INHIBITOR X-TREE A34	OTH	ISO Valves - CST Other		17.12.2017	3	U	U
43623346	Liten lekkasje i hydraulikblokk H.Master	LZ-1007 (A33) MASTER VALVE	ELU	ISO Valves - ISO External leakage – utility medium	1.1	20.03.2014	3	U	U
43886670	ESV-10372 feilet under test 1. gang	C-SECTION GAS LIFT MASTER VALVE A13	OTH	CST General - CST Other		03.12.2014	3	D	H
43781425	Lekkasje i pakkboks på Scaleventil A13	A13 SCALE INHIBITOR LINE VALVE	ELP	CST General - CST External leakage – process medium		31.08.2014	3	U	U
45113263	HYDRAULIKK LEKKASJE FRA WING PLUGGER	LZ-1013 (A11) WING VALVE	ELU	ISO Valves - ISO External leakage – utility medium	1.1	12.01.2018	3	S	M
43199525	A13 Hydraulikk-lekkasje i aktuator Hyd	LZ-1037 (A13) MASTER VALVE	OTH	CST General - CST Other	1.1	20.01.2013	3	U	U
43273628	A38 Hydraulisk master fungerer dårlig	LZ-1005 (A38) MASTER VALVE	OTH	ISO Valves - CST Other		08.04.2013	3	U	U
43363221	Hydraulisk master lekker A31	LZ-1006 (A31) MASTER VAVLE	OTH	CST General - CST Other		03.07.2013	3	S	M
43717262	ESV 1063 har lekkasje i pakkboks	LZ-1006 (A31) WING VALVE	ELP	ISO Valves - ISO External leakage – process medium		24.06.2014	3	S	M
43822718	A31: Aktuator HM lekker hydraulikkolje.	LZ-1006 (A31) WING VALVE	ELU	ISO Valves - ISO External leakage – utility medium		06.10.2014	3	S	M
44858071	Lekkasje bleedventil chokhus	CONTROL VALVES-CHOKE	ELP	ISO Xmas trees (topside/onshore) - ISO External leakage - process medium	1.1	09.06.2017	3	D	H
45149129	Ventil går tregt mot stengt.	LZ-1007 (A33) WING VALVE	FTC	ISO Valves - ISO Failure to close on demand		10.02.2018	3	U	U
44172221	06M FV-PRO A20 BRØNN, MASTER/WING/KILL	LZ-1008 (A20) WING VALVE	LCP	ISO Valves - ISO Leakage in closed position		12.09.2015	3	D	H
43857123	xv10373 Feilet på første test	GASLIFT WING ESV VALVE A13	OTH	CST General - CST Other	1.1	07.11.2014	3	U	U
44713078	Hydraulikklekkasje i aktuator/fittings	LZ-1013 (A11) WING VALVE	OTH	ISO Valves - CST Other		15.02.2017	3	U	U
43906188	Lekkasje i lufttilførsel til Choke A17	LZ1011 - CRUDE BLCOK.	ELU	ISO Valves - ISO External leakage – utility medium	1.3	21.12.2014	3	U	U
44047305	Hydraulikk lekkasje inn på ventil	LZ-1031 (A25) WING VALVE	ELU	ISO Valves - ISO External leakage – utility medium		10.05.2015	3	U	U
43773319	A9. Vingventil stenger ikkje.	LZ-1033 (A9) WING VALVE	FTC	ISO Valves - ISO Failure to close on demand		22.08.2014	3	S	M
45071321	A25 Løs jekkespindel på aktuator	A25 FLOWLINE CHOKE VALVE	OTH	ISO Valves - CST Other	1.5	04.12.2017	3	U	U

43360318	Får ikke kjørt choke til stengt fra PCDA	LZ1002(A24) CHOKE VALVE	FTC	ISO Valves - ISO Failure to close on demand		30.06.2013	2	S	L
43491844	A24 - Choken kan ikke kjøres fra PCDA	LZ1002(A24) CHOKE VALVE	FTC	ISO Valves - ISO Failure to close on demand		11.11.2013	2	U	U
43789016	A24 - Choke går ikke stengt fra PCDA	LZ1002(A24) CHOKE VALVE	FTC	ISO Valves - ISO Failure to close on demand		06.09.2014	2	S	L
44452746	Bytte tening på Choke outletspool O-ring	LZ1002(A24) CHOKE VALVE	OTH	ISO Valves - CST Other		13.06.2016	2	X	U
45093463	Choke på A24 har feil indikator band	LZ1002(A24) CHOKE VALVE	OTH	ISO Valves - CST Other		22.12.2017	2	U	U
43967544	INTERN LUFT LEKKASJE I ACTU VIL IKKE ÅPN	GASLIFT SCALE INHIBITOR X-TREE A07	ELU	ISO Valves - ISO External leakage – utility medium	1.6	23.02.2015	3	U	U
43672267	Liten lekasje i smørenippel	LZ1002(A24) MASTER VALVE	ELP	ISO Valves - ISO External leakage – process medium	2.0	11.05.2014	3	U	U
44186739	Skifte til 1/2" chokedisc	CHOKE	OTH	ISO Valves - CST Other		24.09.2015	1	X	U
44186740	Change choke disk to 2* 1/2 on A-26	CHOKE	OTH	ISO Valves - CST Other		24.09.2015	1	X	U
43390829	Choken går ikke fra HKR	WELLHEAD LZ-1004 CRUDE BLOC	F000	Opererer ikke ved behov		03.08.2013	2	U	U
43869393	Choke på A27 lar seg ikke kjøre fra PCDA	WELLHEAD LZ-1004 CRUDE BLOC	OTH	CST General - CST Other		18.11.2014	2	U	U
44149425	skifte choke disc til 2x 3/4 på A-38	WELLHEAD LZ1005 - CRUDE BLO	PLU	ISO Valves - ISO Plugged/choked		21.08.2015	3	X	U
44215594	Change choke disc to 2*1" and back A38C	WELLHEAD LZ1005 - CRUDE BLO	OTH	ISO Valves - CST Other		23.10.2015	3	X	U
43553711	UPLAN.A31.Skifte tetting på outlet spool	LZ1006 - CRUDE BLOCK.	ELP	ISO Valves - ISO External leakage – process medium		11.01.2014	3	X	U
44120850	Korr i tetning på chooke HV1030 innløp	CHOKE	ELP	ISO Valves - ISO External leakage – process medium	2.2	20.07.2015	1	S	U
44340505	Redusere choke size A31	LZ1006 - CRUDE BLOCK.	OTH	ISO Valves - CST Other		26.02.2016	3	X	U
43585459	A20. Skifte pakning på outletspool Choke	LZ1008 - CRUDE BLOCK.	ELP	ISO Valves - ISO External leakage – process medium		10.02.2014	3	X	U
44261490	S-CMR. Change choke disk to 2* 2 on A-20	LZ1008 - CRUDE BLOCK.	OTH	ISO Valves - CST Other		05.12.2015	3	U	U
43269296	A15 Choke går tregt	LZ1009 - CRUDE BLOCK.	OTH	CST General - CST Other		03.04.2013	3	U	U
43622063	A15 - Choken går ikke ved difftrykk	LZ1009 - CRUDE BLOCK.	FTO	ISO Valves - ISO Failure to open on demand		18.03.2014	3	S	M
43642137	A15 - Choken går ikke ved difftrykk	LZ1009 - CRUDE BLOCK.	FTO	ISO Valves - ISO Failure to open on demand		07.04.2014	3	S	M
43881167	Bytte av choke disc A17	LZ1011 - CRUDE BLCOK.	OTH	ISO Valves - CST Other		28.11.2014	3	U	U
44858827	korrosjon i tetningsflate innløp HV1130	LZ1013 - CRUDE BLOCK.	ELP	ISO Valves - ISO External leakage – process medium	2.2	10.06.2017	2	S	L
44811624	Chok må åpnast for status før oppstart	LZ1011 - CRUDE BLCOK.	OTH	ISO Valves - CST Other		29.04.2017	3	U	U
44816666	Ødelagt kabel til choke-A17	LZ1011 - CRUDE BLCOK.	DEX	ISO Valves - CST Defective EX Protection		04.05.2017	3	U	M
45180429	A17: Bytte av produksjonschoke	LZ1011 - CRUDE BLCOK.	OTH	ISO Valves - CST Other		08.03.2018	3	X	U
43841114	Korr. i flens på choke, A30 i M08	RESERVERT TERJE SOLHEIM AKER	ELP	ISO Valves - ISO External leakage – process medium	2.2	23.10.2014	2	S	L
43963407	Bytte til Større choke størelse 2"x 2"	LZ1013 - CRUDE BLOCK.	OTH	ISO Valves - CST Other		18.02.2015	2	X	U
44284842	Sjekk actuator på choke A-34	WELLHEAD LZ1036 - CRUDE BLO	FTC	ISO Valves - ISO Failure to close on demand	2.4	03.01.2016	3	D	H
45196630	A11: Bytte av produksjons choke	LZ1013 - CRUDE BLOCK.	OTH	ISO Valves - CST Other		22.03.2018	2	X	U
44041009	Bytte chokedisk til 2 x 1/2"	LZ1015 - CRUDE BLOCK.	OTH	ISO Valves - CST Other		05.05.2015	3	X	U
44041225	Bytte Choke disker til "2x 1/2"	LZ1015 - CRUDE BLOCK.	OTH	ISO Valves - CST Other		05.05.2015	3	S	M
44336889	A06. Choken lekker. Skiftes ved FV	LZ1015 - CRUDE BLOCK.	LCP	ISO Valves - ISO Leakage in closed position		22.02.2016	3	U	U
44509958	Bytte O-ring outletspool på HV1150	LZ1015 - CRUDE BLOCK.	OTH	ISO Valves - CST Other		11.08.2016	3	X	U
44798030	Endebrytere choka A6 virket ikke	LZ1015 - CRUDE BLOCK.	OTH	ISO Valves - CST Other		16.04.2017	3	S	M
45221861	Choke går ikke i auto, må jekkes opp.	LZ1015 - CRUDE BLOCK.	FTO	ISO Valves - ISO Failure to open on demand	3.0	15.04.2018	3	S	M
45130061	A32 choke vil ikke gå i auto	WELLHEAD LZ-1020 CRUDE BLOC	BRD	ISO Valves - CST Breakdown	3.0	26.01.2018	3	D	H

43792388	A32 - Choke går ikke stengt fra PCDA	WELLHEAD LZ-1020 CRUDE BLOC	FTC	ISO Valves - ISO Failure to close on demand		09.09.2014	3	S	M
43908202	Skifte pakning outlet spool	WELLHEAD LZ-1020 CRUDE BLOC	ELP	ISO Valves - ISO External leakage – process medium		23.12.2014	3	X	U
43996902	A32.Choke går ikke stengt fra PCDA.	WELLHEAD LZ-1020 CRUDE BLOC	FTC	ISO Valves - ISO Failure to close on demand		20.03.2015	3	S	M
44834163	Juster endebryter for gassløft wingventi	GASLIFT WING ESV VALVE A15	OTH	ISO Valves - CST Other	3.3	18.05.2017	3	U	U
45180526	A37: Bytte av produksjonschoke	WELLHEAD LZ-1022 CRUDE BLOC	OTH	ISO Valves - CST Other		08.03.2018	3	X	U
44738024	A40 Bytte til større choke	WELLHEAD LZ1023 - CRUDE BLO	OTH	ISO Valves - CST Other		08.03.2017	2	X	U
44193761	Sjekke evt. skifte choke discer A31	LZ1006 - CRUDE BLOCK.	PLU	ISO Valves - ISO Plugged/choked	5.1	01.10.2015	3	S	M
44052871	A25-Choke lar seg ikke operere V&B111918	A25 FLOWLINE CHOKE VALVE	BRD	ISO Valves - CST Breakdown		16.05.2015	3	S	M
44423153	Hydr.lekkasje actuator WV A-27	GATE	ELU	ISO Valves - ISO External leakage – utility medium	6.0	17.05.2016	3	U	U
45180428	A04: Bytte av produksjonschoke	LZ1034 - CRUDE MANIFOLD VALVE	OTH	ISO Valves - CST Other		08.03.2018	1	X	U
43403372	A34 - Choken går ikke ved høyt difftrykk	WELLHEAD LZ1036 - CRUDE BLO	FTO	ISO Valves - ISO Failure to open on demand		16.08.2013	3	S	M
43651960	A34 Choke fungerer dårlig v.difftrykk	WELLHEAD LZ1036 - CRUDE BLO	FTO	ISO Valves - ISO Failure to open on demand		18.04.2014	3	U	U
43840871	A34.Skifte pakning på outlet spool Choke	WELLHEAD LZ1036 - CRUDE BLO	ELP	ISO Valves - ISO External leakage – process medium		23.10.2014	3	X	U
43996861	A34.Choke går ikke fra PCDA.	WELLHEAD LZ1036 - CRUDE BLO	FTO	ISO Valves - ISO Failure to open on demand		20.03.2015	3	S	M
43282037	Hydratplugg i krysset. ESV-1132	LZ-1013 (A11) MASTER VALVE	FTC	ISO Valves - ISO Failure to close on demand	6.3	16.04.2013	3	U	U
43861102	S-CMR 24M FV-MULTI A18 OLJE BRØNN	WELLHEAD LZ1038 - CRUDE BLO	INL	ISO Valves - ISO Internal Leakage		10.11.2014	2	S	L
45217370	A18: Bytte av prod choke	WELLHEAD LZ1038 - CRUDE BLO	OTH	ISO Valves - CST Other		11.04.2018	2	X	U
44668792	BYTTE SMELTESIKRING SWOB A7	SWAB VALVE A7	OTH	ISO Valves - CST Other		06.01.2017	3	U	U
45086728	Luftlekkasje på filterregulator.	LZ1015 - CRUDE BLOCK.	OTH	ISO Valves - CST Other	6.3	17.12.2017	3	S	M
44111313	Defekt seloniode ventil	GASLIFT WING ESV VALVE A17	FTO	ISO Valves - ISO Failure to open on demand		09.07.2015	3	S	M
44636338	Flytte ventil 1 boltehull	GASLIFT WING ESV VALVE A17	OTH	ISO Valves - CST Other		06.12.2016	3	X	U
44023475	01M FV-PRO A11 GASSLØFT	GASLIFT WING ESV VALVE A11	INL	ISO Valves - ISO Internal Leakage		19.04.2015	3	D	H
43488368	Lekkasje Gassløft wing A07	GASLIFT WING ESV VALVE A07	C000	Lekkasje, utvendig		07.11.2013	3	D	H
43674636	Gassløft ving lekker mer enn 10%kravet	GASLIFT WING ESV VALVE A07	OTH	CST General - CST Other		13.05.2014	3	U	U
43987138	03M FV-PRO A07 GASSLØFT	GASLIFT WING ESV VALVE A07	LCP	ISO Valves - ISO Leakage in closed position		12.03.2015	3	D	H
44055394	Ventil feilet på lekasjetest, 3 forsøk.	GASLIFT WING ESV VALVE A07	INL	ISO Valves - ISO Internal Leakage		19.05.2015	3	S	M
44560950	Skade på hydraulikkslange GL wing A2	GASLIFT WING ESV VALVE A02	STD	ISO Valves - ISO Structural deficiency		30.09.2016	3	U	U
45094771	Drypplekasje XV-10223 A37	GASLIFT WING ESV VALVE A37	ELU	ISO Xmas trees (topside/onshore) - ISO External leakage – utility medium		25.12.2017	3	U	U
43615338	A40. Lekasje i pakkboks på GV.	GASLIFT WING ESV VALVE A40	ELP	ISO Valves - ISO External leakage – process medium		11.03.2014	3	S	L
43986084	01M FV-PRO A25 GASSLØFT	GASLIFT WING ESV VALVE A25	LCP	ISO Valves - ISO Leakage in closed position		11.03.2015	3	D	H
43403592	Ventilen ville ikke stenge	GASLIFT WING ESV VALVE A34	FTC	ISO Valves - ISO Failure to close on demand		16.08.2013	3	S	M
45172051	HM A27 For lang lukke tid	LZ-1004 (A27) MASTER VALVE	DOP	ISO Valves - ISO Delayed operation	6.4	02.03.2018	3	U	U

Appendix D

Notification	Description	Description	Fail mode	Prob. code text	Fail Mech	ABC indic.	Failure Imp	Priority
43179256	TEKNISK TILBAKEMELDING, SE ACTIVITIES	CHOKE VALVE WELL SLOT 40	OTH	ISO Valves - CST Other		3	U	U
43186659	03M FV-PG B36 GASSLØFT	GASLIFT INNER VALVE WELL B36	D000	Lekkasje, innvendig		3	S	M
43199560	*S!* 12M FV-PRO-G B39 GASSLØFT MASTER	GASLIFT MASTER VALVE B39	LCP	ISO Valves - ISO Leakage in closed position		3	D	H
43199578	--	GASLIFT WING VALVE B39	OTH	CST General - CST Other		3	D	H
43226929	TEKNISK TILBAKEMELDING, SE ACTIVITIES	CHOKE VALVE WELL SLOT 16	OTH	ISO Valves - CST Other		3	U	U
43228254	Finner ikke endepos ved stengt ventil.	MASTER VALVE WELL SLOT 27	OTH	ISO Valves - CST Other		3	U	U
43237332	Lekkasje i slange/fittings wing B07	WING VALVE WELL SLOT 07	ELU	ISO Valves - ISO External leakage – utility medium	1.1	3	U	U
43245290	Choke lekker i stengt stilling	CHOKE VALVE WELL SLOT 21	LCP	ISO Valves - ISO Leakage in closed position	1.1	3	U	U
43247507	Choke lekker i stengt B07.	CHOKE VALVE WELL SLOT 07	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43249130	Diffus pakkbokslekkasje B-12	GASLIFT INNER VALVE B12	ELP	ISO Valves - ISO External leakage – process medium	1.1	3	S	M
43263272	Scale ventil B08	SCALE INHIBITOR X-TREE B08	B000	Feil eller manglende instrumentsignal		3	U	U
43264995	Får ikke tilbakemeld på steng Ving B22	WING VALVE WELL SLOT 22	OTH	ISO Valves - CST Other		3	U	U
43265015	Får ikke tilbakemelding på åpen Ving B11	WING VALVE WELL SLOT 11	OTH	ISO Valves - CST Other		3	U	U
43267804	06M FV-PRO B03 BRØNN, MASTER/WING	MASTER VALVE WELL SLOT 03	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43270445	B-09: Utbedre lekkasje på hydr.masterv.	MASTER VALVE WELL SLOT 09	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43280767	*S!* 01M FV-PG B36 GASSLØFT	GASLIFT WING VALVE B36	D000	Lekkasje, innvendig		3	U	U
43296769	Feil med tilbakemld. i PCDA	GASLIFT OUTER VALVE WELL B26	B000	Feil eller manglende instrumentsignal		3	S	M
43325436	Ventil lekker fra stem/ventilhus	GASLIFT SCALE INHIBITOR X-TREE B11	ELU	ISO Valves - ISO External leakage – utility medium		3	S	M
43325441	Lekkasje fra stem/pakkboks	GASLIFT SCALE INHIBITOR X-TREE B11	ELP	ISO Valves - ISO External leakage – process medium		3	S	M
43361601	Mistanke om restriksjon i choke	CHOKE VALVE WELL SLOT 05	J000	Liten feil, mangel eller avvik		3	U	U
43362120	B30 Choke. Mistanke om skade. Åpne/insp.	CHOKE VALVE WELL SLOT 30	E000	Mekanisk skade, korrosjon, slitasje		2	U	U
43371192	Feil på endebrytere wing B32	WING VALVE WELL SLOT 32	OTH	ISO Valves - CST Other		3	S	H
43389059	Hyd lekkasje på supply linje wing B-05	B05 WING VALVE	ELU	ISO Valves - ISO External leakage – utility medium		3	U	U
43389060	Hyd lekkasje på supply linje wing B-30	WING VALVE WELL SLOT 30	ELU	ISO Valves - ISO External leakage – utility medium		3	U	U
43405467	B10 Wing lekker ut ifra stempakning	B10 WING VALVE	ELP	ISO Valves - ISO External leakage – process medium		3	S	M
43405899	01M FV-PRO B03 BRØNN, MASTER/WING	MASTER VALVE WELL SLOT 03	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43413267	01M FV-PG B05 GASSLØFT	B05 GAS LIFT MASTER VALVE	H000	Sviktet under drift		3	U	U
43425694	*S!* 24M FV-MULTI B34 OLJE BRØNN	CHOKE VALVE WELL SLOT 34	OTH	ISO Valves - CST Other		3	S	M
43433017	*S!* 03M FV-PG B25 GASSLØFT	GASLIFT INNER VALVE B25	D000	Lekkasje, innvendig	R00	3	S	M
43435291	Lekk pakkboks Vingventil B18	WING VALVE WELL SLOT 18	ELP	ISO Valves - ISO External leakage – process medium	1.1	3	D	H
43447818	Ving B31 vise feil på pcda	WING VALVE WELL SLOT 31	DOP	ISO Valves - ISO Delayed operation		3	S	M
43447832	01M FV-PG B35 GASSLØFT	GAS LIFT MASTER VALVE WELL SLOT B35	INL	ISO Valves - ISO Internal Leakage		3	S	M
43448894	GLM B-35 intern lekk.	GAS LIFT MASTER VALVE WELL SLOT B35	LCP	ISO Valves - ISO Leakage in closed position		3	D	H
43460441	*S!* 01M FV-PG B36 GASSLØFT	GASLIFT WING VALVE B36	LCP	ISO Valves - ISO Leakage in closed position	1.1	3	U	U
43479279	*S!* 24M FV-MULTI B23 OLJE BRØNN	MANUAL MASTER VALVE B23	BRD	CST General - CST Breakdown		3	D	H
43483226	Manuell master ventil på B-23 lekk	MANUAL MASTER VALVE B23	BRD	CST General - CST Breakdown		3	D	H
43489760	Manuell master ventil på B-23 lekk	MANUAL MASTER VALVE B23	BRD	CST General - CST Breakdown		3	D	H
43496282	Internlekkasje i Swab-ventil B-15	SWAB VALVE B15	OTH	CST General - CST Other	1.1	3	S	M
43505617	Restriksjon over choke B-34	CHOKE VALVE WELL SLOT 34	PLU	ISO Valves - ISO Plugged/choked		3	U	U
43509501	*S!* 03M FV-PG B11 GASSLØFT	GASLIFT MASTER VALVE B11	OTH	CST General - CST Other	1.1	3	U	U
43509606	1 mnd. test av GLM B11	GASLIFT MASTER VALVE B11	INL	ISO Valves - ISO Internal Leakage		3	U	M
43512903	01M test av GLM B35	GAS LIFT MASTER VALVE WELL SLOT B35	INL	ISO Valves - ISO Internal Leakage		3	U	U
43520644	Teknisk tilbakemelding se Activities	CHOKE VALVE WELL SLOT 12	OTH	ISO Valves - CST Other		3	X	U
43525730	Øke chokestørrelse i brønn B-24	CHOKE VALVE WELL SLOT 24	OTH	ISO Valves - CST Other		3	X	U

43532447	B-41 redusere choke fra 2x1 til 2x3/4"	CHOKE VALVE WELL SLOT 41	OTH	ISO Valves - CST Other		3	X	U
43532477	Øke chokestørrelse i brønn B-03	CHOKE VALVE WELL SLOT 03	OTH	ISO Valves - CST Other		3	X	U
43532527	B-32 Red.choke fra 2 x 3/4" til 2 x 1/2"	CHOKE VALVE WELL SLOT 32	OTH	ISO Valves - CST Other		3	X	U
43538531	*SS!* 12M FV-MULTI B08 OLJE BRØNN	SWAB VALVE B8	OTH	CST General - CST Other		3	U	U
43538542	*SS!* 12M FV-MULTI B08 OLJE BRØNN	MANUAL MASTER VALVE B8	OTH	CST General - CST Other		3	U	U
43549624	1 mnd. test av GLM B11	GASLIFT MASTER VALVE B11	LCP	ISO Valves - ISO Leakage in closed position		3	S	M
43554433	*S!* 24M FV-MULTI B32 OLJE BRØNN	WING VALVE WELL SLOT 32	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43556998	*S!* 06M FV-PRO B40 BRØNN, MASTER/WING	MASTER VALVE WELL SLOT 40	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43571858	12M FV-MULTI B31 OLJE BRØNN	WING VALVE WELL SLOT 31	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43572818	Choke B-34 stenger ikke ved signal.	CHOKE VALVE WELL SLOT 34	FTC	ISO Valves - ISO Failure to close on demand		3	U	U
43577139	Installere 2 x 1/2" choke B16	CHOKE VALVE WELL SLOT 16	OTH	ISO Valves - CST Other		3	U	U
43592915	Choke B-26 regulerer ikke	CHOKE VALVE WELL SLOT 26	OTH	ISO Valves - CST Other	3.1	3	D	H
43596920	B-24: Redusere chokestørrelse	CHOKE VALVE WELL SLOT 24	OTH	ISO Valves - CST Other		3	X	U
43598696	TEKNISK TILBAKEMELDING, SE ACTIVITIES.	WING VALVE WELL SLOT 09	OTH	ISO Valves - CST Other	3.4	3	U	U
43616681	Lekkasje i smørenippel GLW B-36	GASLIFT WING VALVE B36	ELP	ISO Valves - ISO External leakage – process medium		3	U	U
43617735	*S!* 03M FV-PG B25 GASSLØFT	GASLIFT INNER VALVE B25	INL	ISO Valves - ISO Internal Leakage		3	U	U
43617759	*S!* 12M FV-MULTI B25 OLJE BRØNN	WING VALVE WELL SLOT 25	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43618643	*S!* 12M FV-MULTI B25 OLJE BRØNN	MANUAL MASTER VALVE B25	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43618798	Choke går ikke fra HKR. Programfeil.	CHOKE VALVE WELL SLOT 26	FTO	ISO Valves - ISO Failure to open on demand	3.3	3	U	U
43625219	*S!* 01M FV-PG B04 GASSLØFT	B04 GAS LIFT MASTER VALVE	INL	ISO Valves - ISO Internal Leakage		3	S	M
43625944	Lekk Gassløft master B04	B04 GAS LIFT MASTER VALVE	LCP	ISO Valves - ISO Leakage in closed position		3	D	H
43626647	Gassløft master B04 lekker over kriterie	B04 GAS LIFT MASTER VALVE	LCP	ISO Valves - ISO Leakage in closed position		3	S	M
43639162	Redusere choke B2 fra 2x2" til 2x1 3/16"	CHOKE VALVE WELL SLOT 02	OTH	ISO Valves - CST Other		3	X	U
43639233	*FR* Cavitasjon inconelbelegg Choke B32	CHOKE VALVE WELL SLOT 32	STD	ISO Valves - ISO Structural deficiency	2.1	3	S	M
43639260	B-22: Bytte choke til 2x2"	CHOKE VALVE WELL SLOT 22	OTH	ISO Valves - CST Other		3	X	U
43648599	Teste Gassløft Master ventil B04	B04 GAS LIFT MASTER VALVE	INL	ISO Valves - ISO Internal Leakage		3	X	U
43655303	GL ving B11 viser ikke åpen i PCDA	GASLIFT WING VALVE B11	OTH	ISO Valves - CST Other	4.6	3	S	M
43660396	Gir ikke stengt tilbakemelding	MASTER VALVE WELL SLOT 01	OTH	ISO Valves - CST Other		3	U	U
43667267	Stor innvending lekkasje på H.Master B41	MASTER VALVE WELL SLOT 41	LCP	ISO Valves - ISO Leakage in closed position	1.1	3	D	H
43708862	B-13, Gassløft master, feil indikasjon	GASLIFT MASTER VALVE B13	OTH	ISO Valves - CST Other	3.3	3	S	M
43716035	Choke til B-01 åpner ikke fra PCDA	CHOKE VALVE WELL SLOT 01	FTO	ISO Valves - ISO Failure to open on demand		3	U	U
43724126	B-24: Redusere choke størrelse	CHOKE VALVE WELL SLOT 24	OTH	ISO Valves - CST Other		3	X	U
43746445	B-42: øke choke til 2*2"	CHOKE VALVE WELL SLOT 42	OTH	ISO Valves - CST Other		3	X	U
43766620	B24: Redusere til 2*1" choke	CHOKE VALVE WELL SLOT 24	OTH	ISO Valves - CST Other		3	X	U
43771949	Hydraulisk master feilet på første test	MASTER VALVE WELL SLOT 06	OTH	CST General - CST Other		3	U	U
43775129	B32 ekstern lekkasje på Ving ventil	WING VALVE WELL SLOT 32	ELU	ISO Valves - ISO External leakage – utility medium		3	U	U
43788375	Bytte av chokehus B24	CHOKE VALVE WELL SLOT 24	STD	ISO Valves - ISO Structural deficiency	2.3	3	S	M
43788869	O-ringspor mangler, Wing full av smuss	WING VALVE WELL SLOT 34	OTH	ISO Valves - CST Other	1.0	3	U	U
43789341	*FR* Errodert chokehus til B24	CHOKE VALVE WELL SLOT 24	ELP	ISO Piping - ISO External leakage – process medium	2.3	3	S	M
43811393	Hydraulikklekkasje ving B06	WING VALVE WELL SLOT 06	ELU	ISO Valves - ISO External leakage – utility medium		3	S	M
43812629	Hydraulikklekkasje fittings ving B02	WING VALVE WELL SLOT 02	ELU	ISO Valves - ISO External leakage – utility medium		3	U	U
43819749	Lekkasje .Tree Cap B37	SWAB VALVE B37	ELP	CST General - CST External leakage – process medium		3	S	M
43825930	B-02: Bytte til 2*2" choke disker	CHOKE VALVE WELL SLOT 02	OTH	ISO Valves - CST Other		3	X	U
43829468	03M FV-PRO B32 BRØNN, MASTER/WING	WING VALVE WELL SLOT 32	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43856875	Teknisk tilbakemelding se Activities	CHOKE VALVE WELL SLOT 26	FTC	ISO Valves - ISO Failure to close on demand	2.0	3	S	M

43856877	Ikke kjørbar fra CCR.Aktuator svært treg	CHOKE VALVE WELL SLOT 26	FTC	ISO Valves - ISO Failure to close on demand	1.0	3	U	U
43866945	Hydraulik lekkasje i HMV B-15	MASTER VALVE WELL SLOT 15	ELU	ISO Valves - ISO External leakage – utility medium		3	U	U
43870119	01M FV-PRO B32 BRØNN, MASTER/WING	WING VALVE WELL SLOT 32	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43888607	Feil på ventil 03M FV-PRO-G B12 GASSLØFT	GASLIFT INNER VALVE B12	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43889785	*S!* 12M FV-MULTI B12 OLJE BRØNN	MASTER VALVE WELL SLOT 12	INL	ISO Valves - ISO Internal Leakage		3	U	U
43903173	MM reagerer ikke på gir ved operering	Manual Master Valve B18	FTC	ISO Valves - ISO Failure to close on demand		3	S	M
43907769	01M FV-PRO B06 BRØNN, MASTER/WING	MASTER VALVE WELL SLOT 06	FTC	ISO Valves - ISO Failure to close on demand		3	U	U
43909994	Smørenippelen er dårlig GLM B36	GASLIFT INNER VALVE WELL B36	ELP	ISO Valves - ISO External leakage – process medium		3	U	H
43915923	Choke går kun mot stengt	CHOKE VALVE WELL SLOT 01	BRD	CST General - CST Breakdown		3	S	M
43934060	01M FV-PRO B12 BRØNN, MASTER/WING	MASTER VALVE WELL SLOT 12	INL	ISO Valves - ISO Internal Leakage		3	U	U
43951798	B-24, ekstern lek. av hydraulikk på ving	WING VALVE WELL SLOT 24	OTH	ISO Valves - CST Other		3	U	U
43951800	B-32, ekstern lek. av hydraulikk på ving	WING VALVE WELL SLOT 32	OTH	ISO Valves - CST Other		3	U	U
43951865	Lekker hydraulikk olje ut av ventilblokk	MASTER VALVE WELL SLOT 28	OTH	ISO Valves - CST Other		3	U	U
43951869	B-26, lekk av hydraulikk på H.Master	MASTER VALVE WELL SLOT 26	OTH	ISO Valves - CST Other		3	U	U
43959839	Ventil feilet ved test	B03 GAS LIFT MASTER VALVE	INL	ISO Valves - ISO Internal Leakage		3	S	M
43959840	NOPO:Ventil feilet ved test	B03 GAS LIFT MASTER VALVE	INL	ISO Valves - ISO Internal Leakage		3	S	M
43960147	*S!* 06M FV-PRO B36 BRØNN, MASTER/WING	WING VALVE WELL SLOT 36	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
43960698	Intern lekkaskje i Wing ventilen B-36	WING VALVE WELL SLOT 36	LCP	ISO Valves - ISO Leakage in closed position		3	S	M
43961663	Lekk choke B24	CHOKE VALVE WELL SLOT 24	INL	ISO Valves - ISO Internal Leakage		3	S	M
43969651	B-39: Bytte til 2*2 choke disk	CHOKE VALVE WELL SLOT 39	OTH	ISO Valves - CST Other		3	X	U
43988111	Første av to 01M tester Gassløftmaster	GASLIFT INNER VALVE B25	INL	ISO Valves - ISO Internal Leakage		3	U	U
43988204	Andre av to 01M tester GLM B26	GASLIFT INNER VALVE B25	INL	ISO Valves - ISO Internal Leakage		3	U	U
43989603	*S!* 03M FV-PG B25 GASSLØFT	GASLIFT INNER VALVE B25	OTH	CST General - CST Other	1.1	3	S	M
43991915	*S!* 06M FV-PRO B11 BRØNN, MASTER/WING	WING VALVE WELL SLOT 11	INL	ISO Valves - ISO Internal Leakage		3	U	U
43994540	Choke B-22 lekker	CHOKE VALVE WELL SLOT 22	LCP	ISO Valves - ISO Leakage in closed position		3	S	M
43995472	Choke bytte B-39	CHOKE VALVE WELL SLOT 39	OTH	ISO Valves - CST Other		3	X	U
43997564	Choke B-01 lekker i stengt posisjon	CHOKE VALVE WELL SLOT 01	LCP	ISO Valves - ISO Leakage in closed position	1.1	3	S	M
44000375	B12 BRØNN, MASTER feilet på 1 forsøk	MASTER VALVE WELL SLOT 12	LCP	ISO Valves - ISO Leakage in closed position		3	S	M
44012517	Choke lekker	CHOKE VALVE WELL SLOT 24	LCP	ISO Input devices - ISO Leakage in closed position		3	S	M
44012638	Choke på B38 lekker innvendigt	CHOKE VALVE WELL SLOT 38	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
44020348	B-16 choke bytte til 2x3/4	CHOKE VALVE WELL SLOT 16	OTH	ISO Valves - CST Other		3	X	U
44031729	B-33 reduksjon av choke størrelsen	CHOKE VALVE WELL SLOT 33	OTH	ISO Valves - CST Other		3	X	U
44046550	2" rør til closed drain er tett	CHOKE VALVE WELL SLOT 36	BRD	ISO Valves - CST Breakdown		3	S	M
44049012	Ventilen lukket ikkje med stengesignal	MASTER VALVE WELL SLOT 32	FTC	ISO Valves - ISO Failure to close on demand		3	U	U
44051940	Defekt gear til swob/kroneventil	SWAB VALVE B38	BRD	ISO Valves - CST Breakdown		3	S	M
44073617	Lekker i sladrespor ville ikke trutne.	CHOKE VALVE WELL SLOT 13	ELP	ISO Valves - ISO External leakage – process medium		3	S	M
44086899	01M FV-PRO B11 BRØNN, MASTER/WING	WING VALVE WELL SLOT 11	LCP	ISO Valves - ISO Leakage in closed position		3	S	M
44098906	B42: Choke går ikke på signal fra PCDA	CHOKE VALVE WELL SLOT 42	FTC	ISO Valves - ISO Failure to close on demand		3	U	U
44107721	Choke B05 lar seg ikke operere fra PCDA	CHOKE VALVE WELL SLOT 05	FTC	ISO Valves - ISO Failure to close on demand		3	S	M
44112029	B-20: redusere choke fra 2x2"til 2x3/4"	CHOKE VALVE WELL SLOT 20	OTH	ISO Valves - CST Other		3	X	H
44115754	01M FV-PRO B12 BRØNN, MASTER/WING	MASTER VALVE WELL SLOT 12	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
44116679	Choke B-30 går ikkje frå PCDA	CHOKE VALVE WELL SLOT 30	FTO	ISO Valves - ISO Failure to open on demand		2	D	M
44144524	B-20: øke choke fra 2x3/4" til 2x1 3/16"	CHOKE VALVE WELL SLOT 20	OTH	ISO Valves - CST Other		3	X	U
44151082	B27: Treg MMV ved 12 M FV.	MANUAL MASTER VALVE B27	DOP	ISO Valves - ISO Delayed operation		3	U	U
44152521	B-23: Bytte choke fra Cv27 til Cv100	CHOKE VALVE WELL SLOT 23	OTH	ISO Valves - CST Other		3	X	U

44157947	Teknisk tilbakemelding se Activities	CHOKE VALVE WELL SLOT 35	OTH	ISO Valves - CST Other		3	U	U
44162578	B-19: Bytte choke til 2x1 1/2"	CHOKE VALVE WELL SLOT 19	OTH	ISO Valves - CST Other		3	X	U
44175964	03M FV-PRO B32 BRØNN, MASTER/WING	WING VALVE WELL SLOT 32	INL	ISO Valves - ISO Internal Leakage		3	U	U
44185338	B-19: Øke choke til 2*2"	CHOKE VALVE WELL SLOT 19	OTH	ISO Valves - CST Other		3	X	U
44185340	B-10: Bytte choke før oppstart	CHOKE VALVE WELL SLOT 10	OTH	ISO Valves - CST Other		3	X	U
44189893	Ventil stengte ikke på kommando	SCALE INHIBITOR VALVE WELL B24	FTC	ISO Valves - ISO Failure to close on demand		3	S	M
44191322	B-23: Bytte choke fra Cv100 til Cv27	CHOKE VALVE WELL SLOT 23	OTH	ISO Valves - CST Other		3	X	U
44214490	B-28: Redusere choke til 2x1/2"	CHOKE VALVE WELL SLOT 28	OTH	ISO Valves - CST Other		3	X	U
44235689	B38: Internlekksje i MMV	MANUAL MASTER VALVE B38	INL	ISO Valves - ISO Internal Leakage		3	U	U
44246947	Ving B07 lekker litt i sladrehullet	WING VALVE WELL SLOT 07	INL	ISO Valves - ISO Internal Leakage		3	U	U
44248820	B33: Utbedre tilbakemelding hydr. master	MASTER VALVE WELL SLOT 33	OTH	ISO Valves - CST Other		3	U	U
44253422	B-10: Bytte choke før oppstart	CHOKE VALVE WELL SLOT 10	OTH	ISO Valves - CST Other		3	X	U
44256609	Hydraulikklekkasje i aktuator	B10 WING VALVE	ELU	ISO Valves - ISO External leakage – utility medium		3	U	U
44265725	ESV mister åpne signal	GAS LIFT MASTER VALVE B08	OTH	ISO Valves - CST Other		3	U	U
44265846	ESV mister åpne signal	WELL B07 GAS LIFT ESV VALVE	OTH	ISO Valves - CST Other		3	U	U
44266727	Innvendig lekkasje i HMV, B38	MASTER VALVE WELL SLOT 38	INL	ISO Valves - ISO Internal Leakage		3	S	M
44274851	Endebryter på PWV B39 må justeres.	WING VALVE WELL SLOT 39	FTO	ISO Valves - ISO Failure to open on demand		3	U	U
44278083	Choke B34 lekker	CHOKE VALVE WELL SLOT 34	INL	ISO Valves - ISO Internal Leakage		3	D	H
44283013	Wing B42 viser moving. Endbryter feil	WING VALVE WELL SLOT 42 - Temporary Remo	OTH	ISO Valves - CST Other		3	U	M
44284847	Ventilen mister stengt signal	WING VALVE WELL SLOT 27	OTH	ISO Valves - CST Other	3.4	3	U	U
44295511	Hydraulikkoljelekkasje fra aktuator HMV	MASTER VALVE WELL SLOT 34	ELU	ISO Valves - ISO External leakage – utility medium		3	S	M
44306621	HMV på B32 actuator trenger maling etter	MASTER VALVE WELL SLOT 32	OTH	ISO Valves - CST Other	6.3	3	X	U
44314557	Choke B16 Går ikke selv må sveives	CHOKE VALVE WELL SLOT 16	OTH	ISO Valves - CST Other		3	U	U
44319021	Slitt choke B-36	CHOKE VALVE WELL SLOT 36	INL	ISO Valves - ISO Internal Leakage		3	S	M
44319559	Intern lekkasje i HVV på B-09	WING VALVE WELL SLOT 09	LCP	ISO Valves - ISO Leakage in closed position		3	S	M
44331123	B26 wing får ikke stenge signal	WING VALVE WELL SLOT 26	OTH	ISO Valves - CST Other	3.2	3	U	U
44337161	B-24: Øke choke til 2x1 3/16"	CHOKE VALVE WELL SLOT 24	OTH	ISO Valves - CST Other		3	X	U
44353501	B-24: Øke choke til 2x2"	CHOKE VALVE WELL SLOT 24	OTH	ISO Valves - CST Other		3	X	U
44356431	Åpner ikkje med signal fra PCDA	CHOKE VALVE WELL SLOT 24	FTO	ISO Valves - ISO Failure to open on demand		3	S	M
44369198	Choken B01 lekker i stengt posisjon	CHOKE VALVE WELL SLOT 01	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
44373819	ESV14006, Wing på B40 ville ikke stenge	WING VALVE WELL SLOT 40	FTC	ISO Valves - ISO Failure to close on demand	6.4	3	U	U
44373985	Skifte Choke til ny Inconellbelagt type	CHOKE VALVE WELL SLOT 20	OTH	ISO Valves - CST Other		3	X	U
44376462	B31 Wing stenger ikke på første forsøk	WING VALVE WELL SLOT 31	FTC	ISO Valves - ISO Failure to close on demand		3	S	M
44381555	B26 Wing klarte ikke stenge uten hjelp	WING VALVE WELL SLOT 26	FTC	ISO Valves - ISO Failure to close on demand		3	D	H
44382184	Wing på B30 stengt ikke ved stengesignal	WING VALVE WELL SLOT 30	FTC	ISO Valves - ISO Failure to close on demand		3	D	H
44384797	B08 wing lukker ikke ved stengesignal	WING VALVE WELL SLOT 08	FTC	ISO Valves - ISO Failure to close on demand		3	S	M
44403004	Bytte til 2x2" choke brønn B10	CHOKE VALVE WELL SLOT 10	OTH	ISO Valves - CST Other		3	X	U
44404276	Ødelagte styretapper i Chokehus B-39	CHOKE VALVE WELL SLOT 39	OTH	ISO Valves - CST Other		3	U	U
44405082	*S!* 01M FV-PRO B23 GASSLØFT	GASLIFT INNER VALVE WELL B23	INL	ISO Valves - ISO Internal Leakage		3	S	M
44409375	Diffus lekk Ving ventil B05	B05 WING VALVE	ELP	ISO Valves - ISO External leakage – process medium		3	U	U
44409377	Diffus lekasje, målt ved Termografi	GASLIFT INNER VALVE WELL B26	ELP	ISO Valves - ISO External leakage – process medium		3	U	U
44414788	Brønn B23 - Bytte til Cv100 choke	CHOKE VALVE WELL SLOT 23	OTH	ISO Valves - CST Other		3	U	U
44414790	Brønn B20 - Bytte til 2x2" choke	CHOKE VALVE WELL SLOT 20	OTH	ISO Valves - CST Other		3	X	U
44415554	Bytte fra 2x3/4"choke til 2x2" choke B17	CHOKE VALVE WELL SLOT 17	OTH	ISO Valves - CST Other		3	X	U
44434550	Blindflens korrodert killventil B38	KILL VALVE B38	ELP	ISO Valves - ISO External leakage – process medium	2.2	3	S	M

44448956	B-15: Bytte til større choke 2x1 1/2"	CHOKE VALVE WELL SLOT 15	OTH	ISO Valves - CST Other		3	X	U
44449799	Gassløft master B-06 stenger ikke helt	GASLIFT INNER VALVE WELL B06	OTH	ISO Valves - CST Other	1.0	3	S	M
44449801	Gassløft master B-23 stenger ikke helt	GASLIFT INNER VALVE WELL B23	OTH	ISO Valves - CST Other	1.0	3	S	M
44455403	B30 wing lukker ikke ved stengesignal	WING VALVE WELL SLOT 30	OTH	ISO Valves - CST Other	1.6	3	S	M
44468701	Choke på B-03 er feil justert	CHOKE VALVE WELL SLOT 03	INL	ISO Valves - ISO Internal Leakage		3	S	M
44470072	Fjerne Scale ESV og blinde på B-22	GASLIFT SCALE INHIBITOR X-TREE B22	OTH	ISO Valves - CST Other		3	X	U
44476454	Gassløfmasterventilen lekker	GASLIFT INNER VALVE WELL B23	LCP	ISO Valves - ISO Leakage in closed position		3	S	M
44476488	ZSL på ESV11124 trenger justering	GASLIFT WING VALVE B11	OTH	ISO Valves - CST Other	3.2	3	S	M
44521284	*FR* skadet incornell belegg HV11007	CHOKE VALVE WELL SLOT 10	ELP	ISO Valves - ISO External leakage – process medium	2.4	3	S	M
44547034	Lekker scale i pakkboks	SCALE VALVE WELL B15	ELU	ISO Valves - ISO External leakage – utility medium		3	D	H
44563566	Aktuator Hydraulisk Master B-01	MASTER VALVE WELL SLOT 01	BRD	ISO Valves - CST Breakdown	2.5	3	D	H
44580979	Lekker hydraulik olje i HMV B10	B10 MASTER VALVE	OTH	ISO Valves - CST Other		3	S	M
44608910	Lekkasje GLM ventil B23	GASLIFT INNER VALVE WELL B23	LCP	ISO Valves - ISO Leakage in closed position		3	D	H
44613895	B-30 Skifte innmat i choken til større.	CHOKE VALVE WELL SLOT 30	PLU	ISO Valves - ISO Plugged/choked	2.0	2	D	M
44616421	Mindre lekkasje fra sladrehull på choke	CHOKE VALVE WELL SLOT 10	ELP	ISO Valves - ISO External leakage – process medium		3	X	U
44640867	Ving B06 lekker hydraulikk i sladrehull	WING VALVE WELL SLOT 06	OTH	ISO Valves - CST Other		3	U	U
44679776	Feilet på første forsøk. 2 forsøk ok	GASLIFT INNER VALVE WELL B23	LCP	ISO Valves - ISO Leakage in closed position	6.1	3	S	M
44699597	B-16: skifte til større choke 2 x 1 1/2"	CHOKE VALVE WELL SLOT 16	OTH	ISO Valves - CST Other		3	X	U
44729712	Mauell master står "stuck" i åpen pos.	MANUAL MASTER VALVE B27	FTC	ISO Valves - ISO Failure to close on demand		3	D	H
44751999	B-33: Bytte fra 2x3/4" til 2x1" choke	CHOKE VALVE WELL SLOT 33	OTH	ISO Valves - CST Other		3	X	U
44815687	Diffus lekkasje B31 gassløft master	GASLIFT MASTER VALVE B31	ELP	ISO Valves - ISO External leakage – process medium		3	U	U
44815733	Diffus lekkase B26 gassløft master stem	GASLIFT INNER VALVE WELL B26	ELP	ISO Valves - ISO External leakage – process medium		3	U	U
44816506	B07: Ventil stoppet i halvåpen posisjon	WING VALVE WELL SLOT 07	FTC	ISO Valves - ISO Failure to close on demand		3	U	U
44828648	Lekker i pakkboks	SCALE VALVE WELL B06	ELP	ISO Valves - ISO External leakage – process medium		3	D	H
44832168	B-32 Bytte til større choke 2 x 3/4"	CHOKE VALVE WELL SLOT 32	OTH	ISO Valves - CST Other		3	X	U
44839466	Lekker i Pakkboks Scale B06	SCALE VALVE WELL B06	ELU	ISO Valves - ISO External leakage – utility medium		3	S	M
44842683	B-17, Swab ventil lekker	SWAB VALVE B19	LCP	ISO Valves - ISO Leakage in closed position		3	S	M
44843345	B-17, SWAB ventil lekker	SWAB VALVE B17	LCP	ISO Valves - ISO Leakage in closed position		3	S	M
44847266	Montere MSAS Spool B02	GAS LIFT MASTER VALVE B02	OTH	ISO Valves - CST Other		3	X	U
44874067	Lekk dofty ring på wireline snap kobling	MASTER VALVE WELL SLOT 37	ELU	ISO Valves - ISO External leakage – utility medium		3	D	H
44874586	Choke bytte B-22: Fra 2x2" til 2x1"	CHOKE VALVE WELL SLOT 22	OTH	ISO Valves - CST Other		3	X	U
44908609	For lang stengetid i henhold til krav	MASTER VALVE WELL SLOT 28	DOP	ISO Valves - ISO Delayed operation		3	U	U
44922491	Scale ventil viser feil i PCDA	SCALE INHIBITOR X-TREE B08	OTH	ISO Valves - CST Other		3	S	M
44938570	Lekker hyd. olje sladrehull master B-28	MASTER VALVE WELL SLOT 28	ELU	ISO Valves - ISO External leakage – utility medium		3	U	U
45009853	Mindre enn diffuse lekkasje i stem GLW	B19 GAS LIFT WING VALVE	ELP	ISO Valves - ISO External leakage – process medium		3	U	U
45013827	Wing ventiler stenger ikke på kommando	WING VALVE WELL SLOT 29	FTC	ISO Valves - ISO Failure to close on demand		3	S	M
45045367	Choke på B-12 lekker i sladdrehull	CHOKE VALVE WELL SLOT 12	ELP	ISO Valves - ISO External leakage – process medium		3	D	M
45045498	Intern lekasje i SWAB på B-27	SWAB VALVE B27	INL	ISO Valves - ISO Internal Leakage		3	S	M
45056276	Defekt CIV ventil, Kontakt med brønn	GASLIFT SCALE INHIBITOR X-TREE B17	INL	ISO Valves - ISO Internal Leakage		3	D	H
45075429	Svetting i deling på Choke B-02	CHOKE VALVE WELL SLOT 02	ELP	ISO Valves - ISO External leakage – process medium		3	X	U
45079254	ESV Scale B22 lekker	GASLIFT SCALE INHIBITOR X-TREE B22	INL	ISO Valves - ISO Internal Leakage		3	U	U
45084347	Feiler på første forsøk	MASTER VALVE WELL SLOT 12	LCP	ISO Valves - ISO Leakage in closed position		3	U	U
45095962	B35 Wing svettelekkasje hydr. blindplugg	WING VALVE WELL SLOT 35	ELU	ISO Valves - ISO External leakage – utility medium	1.1	3	U	U
45099950	Hydraulikklekasje i kransen på Wing	WING VALVE WELL SLOT 37	ELU	ISO Valves - ISO External leakage – utility medium		3	U	U
45116106	Øke choke fra 2x1/2" til 2x2"	CHOKE VALVE WELL SLOT 28	STD	ISO Valves - ISO Structural deficiency		3	X	U

45118329	PRODUKSJONS WING LEKKER B-05	B05 WING VALVE	INL	ISO Valves - ISO Internal Leakage		3	S	M
45119737	Lekkasje i ving ventil ESV-11924	B19 GAS LIFT WING VALVE	ELP	ISO Valves - ISO External leakage – process medium		3	D	H
45120113	Bytte choke fra 2x3/4" til 2x2"	CHOKE VALVE WELL SLOT 27	OTH	ISO Valves - CST Other		3	X	U
45124635	B-05 Wing lekkasje-- DUPLIKAT	B05 WING VALVE	INL	ISO Valves - ISO Internal Leakage		3	D	H
45135084	Justere gangtid på Wing B-20	WING VALVE WELL SLOT 20	DOP	ISO Valves - ISO Delayed operation		3	U	U
45135085	Justere gangtid på master B-20	MASTER VALVE WELL SLOT 20	DOP	ISO Valves - ISO Delayed operation		3	U	U
45139853	Lekker hydr.olje ut sladrehull ved oprsj	B16 GAS LIFT WING VALVE	ELU	ISO Valves - ISO External leakage – utility medium		3	U	U
45140205	B07 wing stenger saktere enn krav	WING VALVE WELL SLOT 07	DOP	ISO Valves - ISO Delayed operation		3	U	U
45141133	Hydraulikk lekkasje fra sladrehull/flens	WING VALVE WELL SLOT 06	ELU	ISO Valves - ISO External leakage – utility medium		3	U	U
45144496	B09 wing stenger for tregt	WING VALVE WELL SLOT 09	DOP	ISO Valves - ISO Delayed operation		3	U	U
45144498	B09 hydr. master stenger for tregt	MASTER VALVE WELL SLOT 09	DOP	ISO Valves - ISO Delayed operation		3	U	U
45150219	B05 wing stenger for tregt	B05 WING VALVE	DOP	ISO Valves - ISO Delayed operation		3	U	U
45150422	B12 hydr. master lekker i stengt	MASTER VALVE WELL SLOT 12	LCP	ISO Valves - ISO Leakage in closed position		3	S	M
45150456	B02 GL wing lekker gass i sladrehull	GASLIFT OUTER VALVE WELL B02	ELP	ISO Valves - ISO External leakage – process medium		3	S	M
45168435	manuell fakkelventil på gassløft lekker	GASLIFT WING VALVE B01	OTH	ISO Valves - CST Other		3	U	U
45188181	Defekt endebryter "åpen posisjon"	WING VALVE WELL SLOT 17	OTH	ISO Valves - CST Other		3	U	U
45207429	B11 GLW diffus gasslekkasje i stempaknin	GASLIFT WING VALVE B11	ELP	ISO Valves - ISO External leakage – process medium		3	S	M
45207762	Lekkasje i plugg fra ventil	B05 MASTER VALVE	ELP	ISO Valves - ISO External leakage – process medium	1.1	3	U	U
45208927	Lekkasje fra sladrehull GLW B-02	GASLIFT OUTER VALVE WELL B02	ELP	ISO Valves - ISO External leakage – process medium	1.1	3	S	M
45213499	Ingen tilgang til smøreplugg for ventil	SWAB VALVE B22	OTH	ISO Valves - CST Other		3	X	U
45221176	*FR* Erosjon i slitebelegg Chokehus B19	CHOKE VALVE WELL SLOT 19	OTH	ISO Valves - CST Other	2.3	3	U	U
45222795	Lekkasje i O-ring - B07	CHEMICAL INJECTION WELL B07 VALVE	OTH	ISO Valves - CST Other		3	U	U
45222796	Scale ventil drypper i pakkboks.	SCALE INHIBITOR ESV 13526	STD	ISO Valves - ISO Structural deficiency		3	U	U
45232633	IR Kamera MA13800 17 % LEL	WING VALVE WELL SLOT 38	ELP	ISO Valves - ISO External leakage – process medium		3	U	U
45232638	IR Kamera ESV11122 0 % LEL	GASLIFT MASTER VALVE B11	ELP	ISO Valves - ISO External leakage – process medium		3	U	U

Appendix E

Notification	Description	Description	Fail mode	Prob. code text	Fail Mech	Notif.date	ABC indic.	Failure Imp	Priority
43178994	01M FV-PRO C39 BRØNN, MASTER/WING	MASTER VALVE WELL SLOT 39	LCP	ISO Valves - ISO Leakage in closed position		01.01.2013	3	U	U
43197728	Choke C21 fungerer ikke	CHOKE VALVE WELL SLOT 21	FTO	ISO Valves - ISO Failure to open on demand		18.01.2013	3	S	M
43199524	Underkjent test av gassløft master, C-13	GASLIFT MASTER VALVE C13	D000	Lekkasje, innvendig	R80	20.01.2013	3	D	H
43214478	Kraftig erosjon i utløpsspool HV2051	PROD WATER FROM CD2001	OTH	ISO Valves - CST Other	2.3	04.02.2013	2	S	L
43222611	Bytte hyrdaulikkslange- utgått på dato	GASLIFT MASTER VALVE C19	OTH	ISO Valves - CST Other		12.02.2013	3	U	U
43222682	Bytte hyrdaulikkslange- utgått på dato	GASLIFT WING VALVE C19	OTH	ISO Valves - CST Other		12.02.2013	3	U	U
43239920	Topside choke M-ramme ikke opererbar	CHOKE VALVE FLOWLINE 2 EAST	FTC	ISO Valves - ISO Failure to close on demand	5.2	02.03.2013	3	S	M
43242474	Masterventil lekker i sladrehull	MASTER VALVE WELL SLOT 11	ELU	ISO Valves - ISO External leakage – utility medium	1.1	05.03.2013	3	U	U
43249294	Choke går ikke i auto	CHOKE VALVE WELL SLOT 33	FTO	ISO Valves - ISO Failure to open on demand		12.03.2013	3	D	H
43257797	01M FV-PRO-G C13 GASSLØFT	GASLIFT MASTER VALVE C13	D000	Lekkasje, innvendig		19.03.2013	3	S	M
43264884	24M FV-MULTI C26 OLJE BRØNN	MASTER VALVE WELL SLOT 26	FTC	ISO Valves - ISO Failure to close on demand		28.03.2013	3	U	U
43269346	Dårlige tettningsflater	CHOKE VALVE WELL SLOT 26	OTH	ISO Valves - CST Other	2.2	03.04.2013	3	U	U
43277946	01M FV-PRO-G C13 GASSLØFT	GASLIFT MASTER VALVE C13	D000	Lekkasje, innvendig		12.04.2013	3	D	H
43278455	Vasking med diesel på ESV-11322	GASLIFT MASTER VALVE C13	D000	Lekkasje, innvendig		12.04.2013	3	D	H
43279983	C-13 Gassløft master lekker for mye	GASLIFT MASTER VALVE C13	D000	Lekkasje, innvendig		13.04.2013	3	S	M
43304562	C42 BRØNN wing ventil	WING VALVE WELL SLOT C42	LCP	ISO Valves - ISO Leakage in closed position		09.05.2013	3	U	U
43313488	GLMaster feil på tilbakemelding i stengt	GASLIFT MASTER VALVE C27	OTH	ISO Valves - CST Other		19.05.2013	3	U	M
43335824	Wing lakk ved funksjonstest	WING VALVE WELL SLOT 12	LCP	ISO Valves - ISO Leakage in closed position		09.06.2013	3	D	H
43410585	FR_RS13 C05 HV2051 Del.FL108	PROD WATER FROM CD2001	OTH	ISO Valves - CST Other	2.11	22.08.2013	2	S	L
43416267	Montere choke, brønn C-33	CHOKE VALVE WELL SLOT 33	FTO	ISO Valves - ISO Failure to open on demand		28.08.2013	3	S	M
43423019	Wingventil når ikke endebryter åpen	WING VALVE WELL SLOT 11	FTO	ISO Valves - ISO Failure to open on demand		04.09.2013	3	U	U
43476453	Dårlige tetninger på GW ventil C-33	GASLIFT OUTER VALVE WELL C33	ELP	ISO Valves - ISO External leakage – process medium		27.10.2013	3	S	M
43484895	GL C39 Låsemutter på pakkboks mangler	GASLIFT SCALE INHIBITOR X-TREE C39	C000	Lekkasje, utvendig		04.11.2013	3	U	U
43498303	C37 Wing Endebryter åpen defekt	WING VALVE WELL SLOT 37	BRD	ISO Valves - CST Breakdown		17.11.2013	3	U	U
43500466	GL Master gir ikke tilbakemelding stengt	GASLIFT MASTER VALVE C27	BRD	ISO Valves - CST Breakdown		19.11.2013	3	S	M
43540826	C-42 Wingventil mister tilbakemelding	WING VALVE WELL SLOT C42	OTH	ISO Valves - CST Other		27.12.2013	3	U	U
43552432	Manuell master feiler på test.	MASTER VALVE WELL SLOT 29	OTH	ISO Valves - CST Other	6.3	09.01.2014	3	S	M
43555602	Ingen tilbakemelding på stengt ventil	WING VALVE WELL SLOT 18	OTH	ISO Valves - CST Other		13.01.2014	3	U	U
43561842	G.L Wing C-03 har ventilstem lekkasje	GASLIFT WING VALVE C03	ELP	ISO Valves - ISO External leakage – process medium		18.01.2014	3	U	U
43561848	G.L Wing C-33 har ventilstem lekkasje	GASLIFT OUTER VALVE WELL C33	ELP	ISO Valves - ISO External leakage – process medium		18.01.2014	3	U	U
43597401	Wing får ikkje tilbakemelding i stengt.	WING VALVE WELL SLOT 34	OTH	ISO Valves - CST Other		22.02.2014	3	U	U
43658316	Lekker vann ut aktuator dren	WING VALVE WELL SLOT 34	ELP	ISO Valves - ISO External leakage – process medium		26.04.2014	3	S	M
43712433	Feilet første test HMV C38	MASTER VALVE WELL SLOT 38	LCP	ISO Valves - ISO Leakage in closed position		19.06.2014	3	U	U
43744221	Kjemikalie ventil lekker i stem/pakkboks	ESP 3 WELL C04 SCALE VALVE	ELP	ISO Valves - ISO External leakage – process medium		21.07.2014	3	D	H
43842995	Ikke tilbakemelding på ventil i stengt	WING VALVE WELL SLOT 34	OTH	ISO Valves - CST Other		24.10.2014	3	U	U

43894151	Tilbakemelding på åpen ventil feiler.	GASLIFT MASTER VALVE C39	OTH	ISO Valves - CST Other		09.12.2014	3	U	U
43924734	Får ikke tilbakemelding stengt	WING VALVE WELL SLOT 34	FTC	ISO Input devices - ISO Failure to close on demand	4.0	14.01.2015	3	D	M
43963260	Bytte Choke på C-36	CHOKE VALVE WELL SLOT 36	OTH	ISO Valves - CST Other		18.02.2015	3	X	U
43964029	Lekker Scaleinhibitor fra pakkboks i ESV	GAS LIFT SCALE INHIBITOR X-TREE C20	ELP	ISO Valves - ISO External leakage – process medium	1.1	19.02.2015	3	S	M
43995812	Bytte choke hus	CHOKE VALVE WELL SLOT 16	STD	ISO Valves - ISO Structural deficiency	1.4	19.03.2015	3	U	U
44001116	Skifte choke på brønn C-26	CHOKE VALVE WELL SLOT 26	OTH	ISO Valves - CST Other		25.03.2015	3	X	U
44015480	06M FV-PRO C11 BRØNN, MASTER/WING	WING VALVE WELL SLOT 11	LCP	ISO Valves - ISO Leakage in closed position		10.04.2015	3	U	U
44029057	Visuell sjekk Choke C41 HV14107	VALVE,CHOKE, C41	STD	ISO Valves - ISO Structural deficiency		24.04.2015	3	S	M
44040109	Bytte til choke 2*1" i brønn C-36	CHOKE VALVE WELL SLOT 36	OTH	ISO Valves - CST Other		04.05.2015	3	X	U
44058758	Lekkasje i hydraulisk nåleventil	GASLIFT WING VALVE C03	ELU	ISO Valves - ISO External leakage – utility medium		22.05.2015	3	S	M
44093674	Scale ventil lekker i stem pakning	WELL C38 SCALE INHIBITOR LINE VALVE	ELP	ISO Valves - ISO External leakage – process medium		23.06.2015	3	D	H
44098404	Gir ikke tilbake melding i PCDA	GASLIFT MASTER VALVE C27	OTH	ISO Valves - CST Other		26.06.2015	3	U	U
44098977	Korr. i tetningsflaten på HV2051 i C05	PROD WATER FROM CD2001	OTH	ISO Valves - CST Other	2.2	27.06.2015	2	S	L
44156630	GM ventil C-36 lekker i stempakning	WELL C36 GAS LIFT MASTER VALVE	ELP	ISO Valves - ISO External leakage – process medium		28.08.2015	3	U	U
44158303	Lekkasje i backseat på Hydraulisk master	MASTER VALVE WELL SLOT 37	OTH	ISO Valves - CST Other		29.08.2015	3	U	U
44173845	Ekstern lekkase	GASLIFT WING VALVE C12	ELP	ISO Valves - ISO External leakage – process medium	1.1	14.09.2015	3	S	M
44202652	C-06 Scale ventil lekker i stem	GASLIFT SCALE INHIBITOR X-TREE C06	ELU	ISO Valves - ISO External leakage – utility medium		11.10.2015	3	D	H
44221376	Choke C-31 fungerer ikke optimalt	CHOKE VALVE WELL SLOT 31	BRD	ISO Input devices - CST Breakdown		29.10.2015	3	S	M
44269709	Fjør i aktuator knekt	WING VALVE WELL SLOT C42	BRD	ISO Valves - CST Breakdown	1.0	14.12.2015	3	S	M
44327231	Korr.ringspor flens mot EV11904 C19	KILL VALVE C19	ELP	CST General - CST External leakage – process medium	2.2	12.02.2016	3	S	M
44327346	Korr.ringspor flens mot EV11404 C14	KILL VALVE C14	ELP	CST General - CST External leakage – process medium	2.2	12.02.2016	3	S	M
44349869	**Ventil lekker i stemmen	MANUAL MASTER VALVE C34	OTH	CST General - CST Other		05.03.2016	3	S	M
44473379	Lekk stem SWAB C19	SWAB VALVE C19	ELP	CST General - CST External leakage – process medium	1.1	01.07.2016	3	D	H
44481636	Restriksjoner i HV2050 på CD2014	PROD WATER FROM CD2014	PLU	ISO Valves - ISO Plugged/choked		11.07.2016	2	S	L
44483961	Bytte choke for C--40	CHOKE VALVE WELL SLOT 40	OTH	ISO Valves - CST Other		13.07.2016	3	X	U
44484844	Skifte til større choke i C-29	CHOKE VALVE	OTH	ISO Valves - CST Other		14.07.2016	3	X	U
44496207	C-10 hyd master lekker hydraulikkolje	MASTER VALVE WELL SLOT 10	ELU	ISO Valves - ISO External leakage – utility medium		27.07.2016	3	S	M
44532183	C06 scale ESV stemlekkasje	GASLIFT SCALE INHIBITOR X-TREE C06	ELU	ISO Valves - ISO External leakage – utility medium	1.1	03.09.2016	3	S	M
44569739	Ventilen stenger ikke på signal.	WING VALVE WELL SLOT 23	FTC	ISO Valves - ISO Failure to close on demand		08.10.2016	3	D	H
44585034	Korrosjon i ventilhus. Brønn C21	CHOKE VALVE WELL SLOT 21	ELP	ISO Valves - ISO External leakage – process medium	2.2	23.10.2016	3	U	U
44590892	Bytte til større choke i brønn C-36	CHOKE VALVE WELL SLOT 36	OTH	ISO Valves - CST Other		27.10.2016	3	X	U
44638205	Hydraulisk Master virker dårlig, C-42	MASTER VALVE WELL SLOT 42	OTH	ISO Xmas trees (topside/onshore) - CST Other	1.0	07.12.2016	3	D	H
44638207	Swab er svært tung å operere	SWAB VALVE C42	BRD	ISO Valves - CST Breakdown	1.0	07.12.2016	3	D	H
44645443	Wing ventil går hakkete, bør byttest.	WING VALVE WELL SLOT C42	FTC	ISO Valves - ISO Failure to close on demand	2.5	13.12.2016	3	U	U
44654299	Skift discer til CV100 choke brønn C12	CHOKE VALVE WELL SLOT 12	OTH	ISO Valves - CST Other		21.12.2016	3	X	U
44689582	C10 master lekker hyd.olje i aktuator	MASTER VALVE WELL SLOT 10	ELU	ISO Valves - ISO External leakage – utility medium		25.01.2017	3	S	M

M

44804660	Vis. inspeksjon jetv.choke CD2014 C05M	PROD WATER FROM CD2014	OTH	ISO Valves - CST Other		24.04.2017	2	X	M
44811562	Sannsynligvis knekt fjær i aktuator	WING VALVE WELL SLOT 32	STD	ISO Valves - ISO Structural deficiency	2.5	29.04.2017	3	S	M
44838415	C-01 Kill.ving er defekt	KILL VALVE ESP#1 C1	BRD	ISO Xmas trees (topside/onshore) - CST Breakdown		22.05.2017	3	S	M
44845862	Hydr.lekkasje aktuator - sladrehull.	MASTER VALVE WELL SLOT 39	ELU	ISO Valves - ISO External leakage – utility medium		29.05.2017	3	U	U
44850994	Ekstern lekkasje jetvannschoke FD1 C05	PROD WATER FROM CD2002	ELP	ISO Valves - ISO External leakage – process medium		02.06.2017	2	S	L
44852426	Tilbakemelding's kabel på Choke må bytte	CHOKE VALVE WELL SLOT 38	DEX	ISO Valves - CST Defective EX Protection		03.06.2017	3	U	U
44854768	Snu bonnet for å komme til smøreplugg.	SWAB VALVE C38	OTH	ISO Valves - CST Other		06.06.2017	3	U	U
44874376	15 Diffus lekk wing ventil C21 Avsluttet	WING VALVE WELL SLOT 21	ELP	ISO Valves - ISO External leakage – process medium	1.1	22.06.2017	3	X	U
44878050	Feil på tilbakemelding i åpen HMV C-37	MASTER VALVE WELL SLOT 37	OTH	ISO Valves - CST Other		26.06.2017	3	U	U
44885351	Stengte ikke under ESD test 02.07.2017	WING VALVE WELL SLOT 37	FTC	ISO Valves - ISO Failure to close on demand		03.07.2017	3	D	H
44886151	GL master C18 lekker i pakkboks	WELL C18 MASTER VALVE GASLIFT	ELP	ISO Valves - ISO External leakage – process medium		03.07.2017	3	D	H
44900167	Bytte stem pakning ESV13222 Gass løft	GASLIFT INNER VALVE C32	OTH	ISO Valves - CST Other	2.0	15.07.2017	3	S	M
44926067	Mangler verktøy til choker	CHOKE VALVE FLOWLINE 2 NORTH	FTO	ISO Valves - ISO Failure to open on demand		08.08.2017	3	S	M
44984285	Wing C21. Lekkasje i pakkboks	WING VALVE WELL SLOT 21	ELP	ISO Valves - ISO External leakage – process medium	1.1	26.09.2017	3	D	H
45012439	Restriksjon i choke brønn C03	C03 OIL PROD WELL CHOKE VAL	PLU	ISO Valves - ISO Plugged/choked		17.10.2017	3	S	M
45018828	HMV C-29 Stenger ikke	MASTER VALVE WELL SLOT 29	FTC	ISO Valves - ISO Failure to close on demand		24.10.2017	3	D	H
45086713	Gikk ikke å stenge ventil MMV C-18	MANUAL MASTER VALVE C18	BRD	ISO Valves - CST Breakdown	1.0	17.12.2017	3	S	M
45100020	Ekstern lekkasje ESV-12126	SCALE VALVE WELL C21	ELP	ISO Valves - ISO External leakage – process medium		01.01.2018	3	S	M
45112429	Lekk choke når den står stengt C31	CHOKE VALVE WELL SLOT 31	LCP	ISO Valves - ISO Leakage in closed position		11.01.2018	3	S	M
45147393	Feil tilbakemelding choke C18 i PCDA	CHOKE VALVE WELL SLOT 18	OTH	ISO Valves - CST Other	3.3	09.02.2018	3	U	U
45148854	Lekkasje på "blåventil"/ nåleventil C31	KILL VALVE C31	ELP	ISO Valves - ISO External leakage – process medium	1.1	10.02.2018	3	U	U
45159319	Hydraulikk lekkasje i wing actuator	WING VALVE WELL SLOT 34	ELU	ISO Valves - ISO External leakage – utility medium		19.02.2018	3	U	U
45181447	Brønn C-14 - bytte flens nedstrøms.	WING VALVE WELL SLOT 14	OTH	ISO Valves - CST Other		09.03.2018	3	X	U