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FINAL PROJECT - LS 1336

MODIFICATION OF BALLAST SYSTEM DESIGN FROM MANUALLY OPERATED TO REMOTELY OPERATED IN COMPLYING WITH ABS RULES ON BALLAST SYSTEM DESIGN OF MV. SINAR JAMBI

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DEPARTMENT OF MARINE ENGINEERING
Faculty Of Marine Technology
Sepuluh Nopember Institute Of Technology
Surabaya 2007

TUGAS AKHIR - LS 1336

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JURUSAN TEKNIK SISTEM PERKAPALAN
Fakultas Teknologi Kelautan
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LEMBAR PENGESAHAN

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TUGAS AKHIR

Diajukan Untuk Memenuhi Salah Satu Syarat
Memperoleh Gelar Sarjana Teknik
pada
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Program Studi S-1 Jurusan Teknik Sistem Perkapalan
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Surabaya
Februari, 2007

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MODIFICATION OF BALLAST SYSTEM DESIGN FROM MANUALLY OPERATED TO REMOTELY OPERATED IN COMPLYING WITH ABS RULES ON BALLAST SYSTEM DESIGN OF SINAR JAMBI

Name : **Miftakhul Arif**
NRP : **4202 100 049**
Supervisor : **Ir. Hari Prastowo, M.Sc**

ABSTRACT

Sinar Jambi is one of ship that built with rules of ABS recommendation. Ballast system of MV. Sinar Jambi has been design as branch type. Ballast system of MV. Sinar Jambi has valve that operated as manual from engine room. It is not appropriate with rules of ABS about ballast system. The rules of shipping classification are every ballast tank has to have one ballast valve that lined at each ballast tank. It prevents ballast water mixed ballast tank each another whenever pipe of ballast system are leak, because it can influence to ship stability.

To comply with ABS rules, MV Sinar Jambi needs re-design new alternative ballast system. In the re-design ballast system of Sinar Jambi, use two systems may apply in ballast system. First, pneumatic system operates ballast valve from engine room as remotely operated. For consequences, pneumatic system is owner must invest some pneumatic equipment and ballast valve with that suitable with remotely operated. Pneumatic equipment consists of actuators, solenoid valve, solenoid coil, etc. Second, electric system operates ballast valve from engine control room. By electric system, owner must invest some electric equipment and ballast valve that suitable with remotely operated. Electric equipment consists of electric motor from Keystone valve, cable, etc.

From technical analysis and data analysis, can be shown that pneumatic system actuator has advantages such as cheaper, easy to maintain, easy to operated, fast to get problem shooting, friendly to environment, etc. Electric system has advantages such as low power required; can be operated manually whenever troubleshooting accident, etc. Based on above data and analysis, pneumatic system is more suitable for actuator system for ballast system to comply with ABS rules than electric system as environment aspect, cost consequence aspect and operating aspect.

MODIFIKASI SISTEM BALLAST DARI OPERASI SECARA MANUAL KE OPERASI SECARA REMOTE SESUAI DENGAN ATURAN ABS PADA SISTEM BALLAST MV. SINAR JAMBI

Nama : **Miftakhul Arif**
NRP : **4202 100 049**
Pembimbing : **Ir. Hari Prastowo, M.Sc**

ABSTRAKSI

MV Sinar Jambi merupakan kapal yang dibangun menggunakan aturan ABS. Untuk mendapatkan sertifikat setiap sistem pada kapal harus sesuai dengan aturan ABS. Sebagai salah satu klas, ABS mensyaratkan pada setiap kapal harus mempunyai sistem ballast dengan katup ballast terletak pada masing-masing tangki ballast. Hal ini dilakukan untuk pencegahan mixing tank proses ketika terdapat kebocoran pada pipa-pipa ballast. Mixing tank proses akan mempengaruhi pada stabilitas dari kapal karena air akan mengalir bebas dari tangki ballast satu ke tangki ballast yang lain.

Dalam mendesain alternative ballast sistem (Branch Type) MV Sinar Jambi yang sesuai dengan aturan ABS, menggunakan pneumatik sistem atau elektrik sistem yang dapat dioperasikan dari engine control room. Dalam perancangan pmeumatic sistem akan memberikan konsekuensi pada pemilik kapal untuk mengeluarkan modal untuk membeli peralatan-peralatan yang akan digunakan pada pneumatik sistem. Hal ini juga berlaku pada elektrik sistem. Peralatan-peralatan pneumatik meliputi actuator, katup solenoid, solenoid coil, katup ballast yang bias dioperasikan dengan pneumatik actuator dan peralatan lainnya. Peralatan-peralatan electrik meliputi motor listrik, kabel, katup ballast yang bisa dioperasikan dengan motor listrik dan peralatan lainnya.

Dari analisa teknik dan data, maka dapat diketahui bahwa pneumatik mempunyai kelebihan antara lain murah, perawatan mudah, mudah mengoperasikannya dan cepat mengatasi gangguan sistem, dan aman. Elektrik sistem juga mempunyai kelebihan lebih rendah power yang digunakan, dapat dioperasikan secara manual bila terjadi gangguan sistem. Dengan analisa diatas maka pneumatik sistem merupakan sistem yang cocok pada ballast sistem dilihat dari segi lingkungan, modal yang dibutuhkan dan dari segi operasi.

PREFACE

First, Thanks to our god who has been giving us all out of mercy and blessing in order to finish our final project without any main mistake and obstacles, in order the final project can finish in the right time.

The final project has a title " **Modification Of Ballast System Design From Manually Operated To Remotely Operated In Complying With Abs Rules On Ballast System Design Of Sinar Jambi ".** The final project will design new ballast system with remotely operated to change existing ballast system on MV Sinar Jambi which is manually operated. New design ballast system uses pneumatic / electric actuator in complying with ABS rules. New design can be operated from engine control room. It has some advantages such as easy operation, simple design, cheap etc. It makes consequences to invest some equipment such as ballast valve, pneumatic actuator, pipe capillary etc.

I would like to say thanks to all of party, friends, Marineers02, lecturers, and graduation of marine engineering department who have helped us as morale or material in order to finish my final project. Especially thanks to member of such as:

1. My Parent always supports me in good or in bad condition.
2. Mr. Hari Prastowo, M.Sc. as my supervisor.
3. All of lecturer in marine engineering department especially Mr. Alam Baheramsyah, Surjo Widodo adjie etc.
4. Mr. Yunianto as member of Festo Company
5. Mr. Bagus as member of Tyco Valve control Company
6. Especially my friend in same supervisor: Adi Priyatmono and Johannes Gospel
7. Member of computational Laboratory community such as Ndutz, Marconez, Inal, Danie, Oka, Dadiet Telor, Asmano, Gogon, Idae, Gusdur, Roziky, Abud, Arif etc.

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9. Member of Marineers02
10. Especially for Meme and F-3 Punya

I hope all of member in above can get some rewards from our god.

The last, I know in this final project consist of some mistake and lacks, so I hope some advise and new revision for more complete of final project.

Surabaya, 9th February 2007

Miftakhul Arif

LIST CONTENT

LIST DRAWING

LIST TABLE

LIST OF SYMBOL

P	= Power
H_{Tot}	= Head Losses Total of Pump
ρ	= Density
Q	= Flow Rate
g	= Gravity Acceleration
η_{pump}	= Efficiency of Pump
▲P	= Drop pressure
K	= Friction Coefficient of valve
V	= Velocity of fluid
S.G	= Specific of fluid
K_V	= Flow rate coefficient
τ	= Torque required of valve in operation condition
$C_{Torque\ Req}$	= Torque coefficient
D	= diameter of pipe
P	= Working Pressure
SCFM	= Standard Cubic Feet Per Minute (Air Consumption of Pneumatic Actuator)
$Vol_{air\ Stroke}$	= Displacement piston actuator
n.	= amount of actuator
T	= time remaining
V	= Voltage operate
I	= Current operate
I_{CS}	= Current when Start Machine
$I_{Nominal}$	= Current in normal condition

CHAPTER I

INTRODUCTION

I.1 Background

The new rules of shipping classification are every ballast tank has to have one ballast valve that lined at each ballast tank. The rules refers to American bureau shipping that ballast pipes installed in the regions of assumed damage under damage stability consideration are to be considered damage. Ballast piping will affect damage stability consideration if :

- It is installed within the extend of assumed damage in damage stability consideration, and
- The damage to the ballast pipe will lead to progressive flooding of intact ballast tanks trough open ends in the ballast piping system.

Affected ballast piping is to be fitted with valves in the pipes in the intact tanks to prevent progressive flooding of these tanks. The valves are to be of positive closing type and operable from above the freeboard deck or from operated machinery space. Where the valves are electrically, hydraulically or pneumatically actuated, the cables or piping for this purpose are not to be installed within the extent of assumed damage, or, alternatively, the valve are to be arrange to fail in the closed position upon loss of control power.

The valves will not be required if it can be shown that, even with the progressively flooded spaces taken into consideration, the vessel still complies with the applicable damage stability criteria. (American bureau shipping, 2005)

In addition, ABS (American bureau shipping) asks to every ship that built under rules of ABS, must have ballast system as new rules of shipping classification. The rules to prevent ballast water mixed ballast tank each other whenever ballast tanks are leak.

Sinar Jambi is one of ship that built under rules of ABS. Ballast system of MV. Sinar Jambi has been design as branch type. Every ballast tank serves a ballast pipe and a ballast valve that its position at each ballast tank. Every ballast valve operates from main deck that trough valve steam as manually.

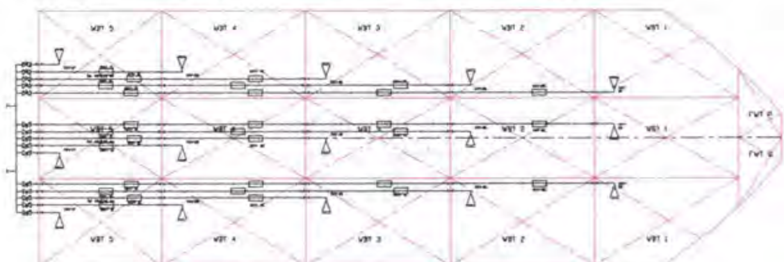


Figure 1.1 Existing ballast system of Sinar Jambi

Within a manually Ballast system, MV. Sinar Jambi must be available a specialist ship's crews for operating ballast valve. Manually system has some obstacles.

Based on the task, the author thinks that MV. Sinar Jambi needs an alternative ballast system that can be operated as automatically.

Considered on the task, the author makes a design of ballast system that using remotely operated (electro motor driven and pneumatic driven) for ballast valve, which can be operated as automatically.

I.2 Problems

For complying new ABS rules about ballast system, there are some problem to solve in final project are:

1) Why is the manually operated ballast system from Engine room not allowed on MV. Sinar Jambi?
2) What are the alternative systems for manually operated ballast on MV Sinar Jambi?
3) What are consequences arisen from the alteration of the previous design (manually operated from engine room)?
4) What is the newly detail design regarding the use of remotely operated open/close valves for ballast operational of the alternative design ballast system?

I.3 Objective

The purposes of final project are:

1. To explain the reason of not-allowed use of manually operated ballast system from engine room.
2. To generate new alternative design of ballast system using remotely operated open/close valves for ballast operational
3. To determine and calculate all parameters involved in newly design of ballast system using electrically driven or pneumatically driven open/close valves for ballast operational.
4. To introduce options for remotely operated valves of ballast system i.e. (electrically driven or pneumatically driven)

5. To determine the specification list for all equipment required in the new design ballast system using remotely operated open/close valves for ballast operational.
6. To examine the options (electrically driven or pneumatically driven) delivers the technical and cost feasibilities.
7. To describe advantage and disadvantage design looked from the point of technical and cost calculation views.

I.4 Advantages

The advantages of final project are:

1. To provide solution for application of exclusively open/close valves in ballast system as ABS recommendation.
2. To implement knowledge on remotely operated (electrically driven and pneumatically driven) open/close valves for ballast operational.

I.5 Methodology

In this research, have some purposes. The main point of final project is to design ballast system of MV. Sinar Jambi complies with a request of new rules of ABS about ballast system. In case of final project, to design ballast system trough some phases which are literature study, data collecting, design, technique analysis, Economic analysis.

a. Literature study

Literature studying has aiming to get some reference and basic theory about research. In this case, gotten by reading book, interview to specialist such electric motor, pneumatic, and searching to the internet.

With literature study hoped to get some basics idea of research and basic theory. Literature Studying has been done at center library of ITS, library Faculty of marine technology, Computer laboratory and some places which are important.

b. Data Collecting

Data collecting processing to get some information about part of research and information of instrument for ballast system at MV. Sinar Jambi. Some information needed in the research are rules of ABS about ballast system, General arrangement of Sinar Jambi, previous ballast system of Sinar Jambi drawing, electric motor, type and size of valve that used at ballast system of Sinar Jambi. Furthermore taken some anticipation and steps will do on research. Collecting data takes part information about MV. Sinar Jambi, electronic shop and workshop, etc.

c. Design and Technical Analysis

Furthermore case, having gotten the information of existing MV. Sinar Jambi ballast system, those research are design new system for ballast system. Planning system is the main project in this research. In design will take two types of ballast system, ring type and branch type. The new ballast system use pneumatically system and electrically system as prime mover for ballast valve. The new ballast systems operate from engine room or main deck. Afterwards, compare ballast system using pneumatically and electrically as prime mover for ballast valve as Technique analysis and economic analysis. With the new design (PFD) of alternative ballast system, giving us some methods design for ballast system. The new alternative system will be re-checked with rules of ABS and operational feasible.

Another that, calculating and determining all parameter in new ballast design. In this case, to calculate technique parameter such as power, type of valve, pipe size, electric motor, type of pneumatic system etc. In here, we do technique analysis to compare between pneumatically and electrically driven. From technique analysis, gotten equipments list for new ballast system for pneumatically driven and electrically driven.

Later collect equipment list and equipment spec for new design ballast system. The equipment spec will be check in the shop for availability. If the equipment has been available, the next step makes piping and instrument diagram (PID) of new design ballast system.

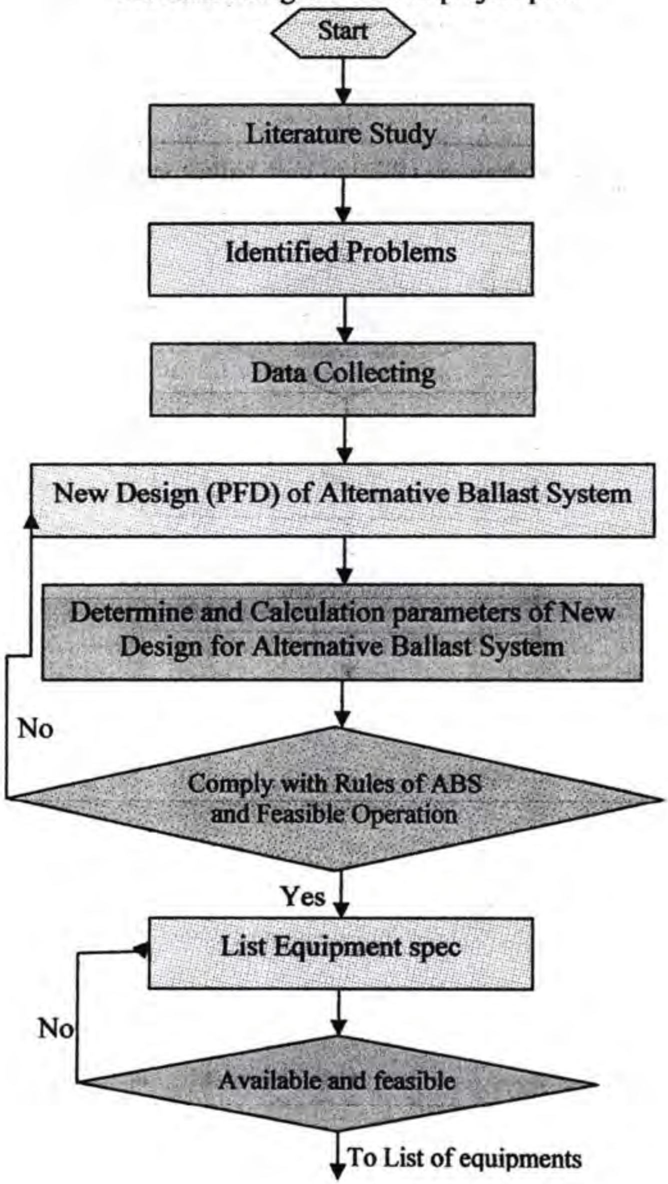
d. Cost Calculation

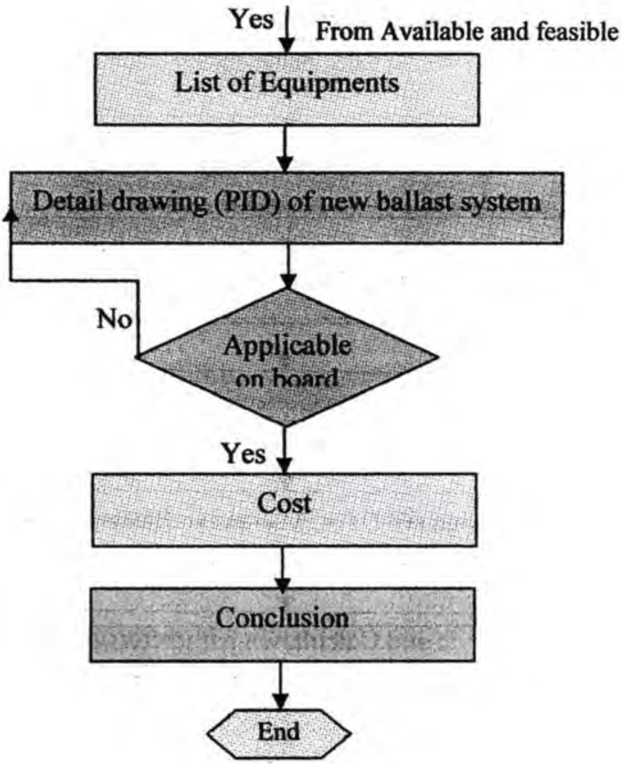
After the alternative ballast system has done, the data resulting performance of alternative ballast can be analysis. The cost calculation views consist of money invested to new alternative of ballast system MV. Sinar Jambi.

e. Conclusion

After analyzing, the step of research takes some conclusion of this research. Furthermore, show the advantages and disadvantages of ballast system as manually operated or new design ballast system using electrically driven open/close valves. To establish effective ballast system designed which using pneumatically or electrically open /close valve driven.

Flowchart diagram of final project plan




Yes
From Available and feasible
List of Equipments
Detail drawing (PID) of new ballast system
No
Applicable
on board
Yes
Cost
Conclusion
End

CHAPTER II

STUDY LITERATE

II.1 Ballast System

Ballast system provides to adjust the draft and trim of the ship through the ballast tank. The capacities of ballast system fixed calculation needed. Generally, ballast divided into two various based on the function. There are fixed ballast and unfixed ballast. Fixed ballast used to extend the draft of the ship, cannot be movement. Unfixed ballast is ballast that used to keep the stabilities of the ship particular on the loading and unloading condition. Unfixed ballast can adjust appropriate with calculation volume needed. Unfixed ballast is seawater that was entered to ballast tank.

Ballast needed to compensate the change of weight. Change of weight will be move the centre of gravity of ship. The centre of gravity will be back to the equilibrium position if ballast added to compensate the change in weight (Comstock John P, 1967).

The time is needed to full fill these ballast weight depend on the diameter of ballast pipe, capacity of pump. Therefore, the time to reach the ballast weight needed can controlled by adjust the valve.

Type of piping system for ballast system divide two, Branch type and ring type. Branch type is one ballast tank served one branch pipe and valve. Ring type is the pipes connect to each ballast tank. The last time rules for ballast system often use branch type.

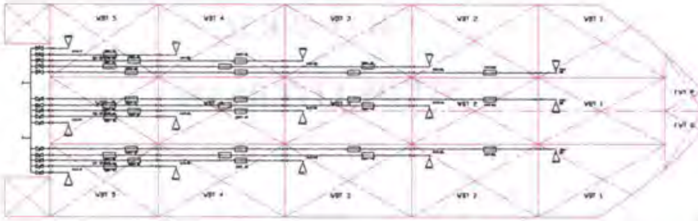


Figure 2.1 Branch type of Ballast System

II.1.1 Ballast Pump

Ballast Pump is a machine to distribute water from sea chest to ballast tank or to overboard. Parameter for ballast pump are flow rate (Q) in m^3/hr and head Pump (H) in m.

Power of pump is following formula:

$$P = H_{Tot} \times \rho \times Q \times g / \eta \text{ pump}$$

Explanation :

P =	Power of pump	(watt)
H_{Tot}=	Head total pump	(meter)
ρ =	Density of Fluid	(Kg/m^3)
Q =	Flow rate of pump	(m^3/s)
g =	Gravity	(m/s^2)
ηpump=	Efficiency of pump	

(sularso,2000)

II.1.2 Ballast valve

Actually many kind of valve are produced by industrial. Every type valve has different function. Industrial produces some types of valve such as butterfly valve, globe valve, gate valve, ball valve. Every type valve has specially operated and functions.

To determine size of valve is depend on the flow rate of fluid trough in the valve. Flow rate of fluid trough in the valve depend on the flow rate coefficient and drop pressure in the valve (Keystone valve catalogue, 2006).

To determine drop pressure in the valve is following formula:

$\blacktriangle P = (k \times v^2/(2 \times g))/10.2$

Explanation:

$\blacktriangle P$ = Drop pressure (bar)

K = Friction Coefficient of valve

V = Velocity of fluid (m/s)

g = Gravity (m/s^2)

(sularso,2000)

To determine flow rate coefficient of valve is following formula:

$Kv = Qs \sqrt{(S.G/\blacktriangle P)}$

Explanation:

$\blacktriangle P$ = Drop pressure (bar)

S.G = specific of fluid = 1

KV = Flow rate coefficient

Qs = Flow rate of fluid or pump (m^3/hr)

(Keystone valve catalogue, 2006).

After getting size and type of valve, then calculate torque required of ballast valve. Torque required is main input parameter to determine size and type of actuator such as electric or pneumatic system. Torque required of valve depends on the size and type of ballast valve. Torque required of ballast valve is available in project guide of ballast valve.

To determine torque required of ballast valve is following formula:

$\tau . = (\tau_{at\ 0\ Kpa} \times C_{Torque\ Req}) + (\tau_{at\ working\ 350\ Kpa} - \tau_{at\ 0\ Kpa})$

Explanation:

τ = Torque required of valve in operation condition (Nm)

$\tau_{at\ 0\ Kpa}$ = Torque required of valve when pressure is 0 Kpa (Nm)

$\tau_{at\ working\ Kpa}$ = Torque required of valve when pressure is working Kpa (Nm)

$C_{Torque\ Req}$ = Torque coefficient

(Keystone valve catalogue, 2006).

II.1.2.1 Butterfly valve

A butterfly valve is a type of flow control device, used to make a fluid start or stop flowing through a section of pipe. The valve is similar in operation to a ball valve. A flat circular plate is positioned in the center of the pipe. The plate has a rod through it connected to a handle on the outside of the valve. Rotating the handle turns the plate either parallel or perpendicular to the flow of water, shutting off the flow. It is a very robust and reliable design. However, unlike the ball valve, the plate does not rotate out of the flow of water, so that a pressure drop is induced in the flow (en.wikipedia.org, 2006 and Stojkov, 1997).

Figure 2.2 Butterfly Valve

There are three types of butterfly valve:

- Resilient butterfly valve has a flexible rubber seat. Working pressure up to 1.6 (MPa)
- High performance butterfly valve is usually double eccentric in design. Working pressure up to 5.0 MPa
- Tricentric butterfly valve that is usually with metal seated design. Working pressure up to 10.0 Mpa (en.wikipedia.org, 2006 and Stojkov,1997).

Butterfly valves are available in several body styles and seal types. The flange type or lug style can be held between flanges of any type.

II.1.2.2 Globe valve

A Globe valve is named for their spherical body shape. The two halves of the valve body are separated by a baffle with a disc in the center. Globe valves operate by screw action of the hand wheel. They are used for applications requiring throttling and frequent operation. Since the baffle restricts flow, they are not recommended where full, unobstructed flow is required.

A bonnet provides leak proof closure for the valve body. Globe valves may have a screw-in, union, or bolted bonnet. Screw-in bonnet is the simplest bonnet, offering a durable, pressure-tight seal. Union bonnet is suitable for applications requiring frequent inspection or cleaning. It also gives the body added strength. Bolted bonnet is used for larger or higher-pressure applications. Many globe valves have a class rating that corresponds to the pressure specifications of ANSI 16.34 (en.wikipedia.org, 2006 and Stojkov,1997).

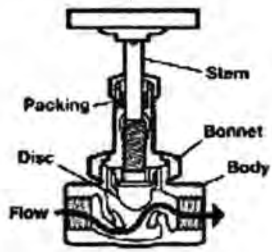


Figure 2.3 Globe valve

II.1.2.3 Gate valve

A Gate Valve or Sluice Valve, as sometimes known, is a valve that opens by lifting a round or rectangular gate/wedge out of the path of the fluid. The distinct feature of a gate valve is the sealing surfaces between the gate and seats are planar. The gate faces can form a wedge shape or they can be parallel. Gate valves are sometimes used for regulating flow, but many are not suited for that purpose, having been designed to be fully opened or closed. When fully open, the typical gate valve has no obstruction in the flow path, resulting in very low friction loss.

Gate valves are characterized as having either a rising or a no rising stem. Rising stems provide a visual indication of valve position. No rising stems are used where vertical space is limited or underground (en.wikipedia.org, 2006 and Stojkov,1997).

Bonnets provide leak proof closure for the valve body. Gate valves may have a screw-in, union, or bolted bonnet. Screw-in bonnet is the simplest, offering a durable, pressure-tight seal. Union bonnet is suitable for applications requiring frequent inspection and cleaning. It also gives the body added strength. Bolted bonnet is used for larger valves and higher-pressure applications.

Another type of bonnet construction in a gate valve is pressure seal bonnet. This construction is adopted for valves for high-pressure service, typically in excess of 2250 Psi. The unique feature about the pressure seal bonnet is that the body - bonnet joints seals improves as the internal pressure in the valve increases, compared to other constructions where the increase in internal pressure tends to create leaks in the body-bonnet joint.

Gate Valve normally has flanged ends that are drilled according to pipeline compatible flange dimensional standards. Cast

Iron, Cast Carbon Steel, Gun Metal, Stainless Steel, Alloy Steels & Forged Steels are different materials in which Gate Valves are made available (en.wikipedia.org, 2006 and Stojkov,1997).

Figure 2.4 Gate Valve

II.1.2.4 Ball valve

A **ball valve** (like the butterfly valve, one of a family of valves called *quarter turn valves*) is a valve that opens by turning a handle attached to a ball inside the valve. The ball has a hole, or port, through the middle so that when the port is in line with both ends of the valve, flow will occur. When the valve is closed, the hole is perpendicular to the ends of the valve, and flow is blocked (en.wikipedia.org, 2006 and Stojkov,1997).

Ball valves are durable and usually work to achieve perfect shutoff even after years of disuse. They are therefore an excellent choice for shutoff applications (and are often preferred to globe valves and gate valves for this purpose). They do not offer the fine control that may be necessary in

There are three general types of ball valves: *full port*, *standard port*, and *reduced port*.

- A *full port* ball valve has an oversized ball so that the hole in the ball is the same size as the pipeline resulting in lower friction loss. Flow is unrestricted, but the valve is larger.
- A *standard port* ball valve is usually less expensive, but has a smaller ball and a correspondingly smaller port. Flow through this valve is one pipe size smaller than the valve's pipe size resulting in slightly restricted flow.
- In *reduced port* ball valves, flow through the valve is two pipe sizes smaller than the valve's pipe size resulting in restricted flow (en.wikipedia.org, 2006 and Stojkov,1997).

Manually operated ball valves can be closed quickly and thus there is a danger of water hammer. Some ball valves are equipped with an actuator that may be pneumatically or motor (electric) operated. These valves can be used either for on/off or flow control. A pneumatic flow control valve is also equipped with a positional that transforms the control signal into actuator position and valve opening accordingly (en.wikipedia.org, 2006 and Stojkov,1997).

II.1.3 Ballast Pipe

Ballast pipe used to distribute water ballast from pump to tank or overboard.

The parameter ballast pipe is diameter of pipe. To determine diameter of ballast pipe is following formula:

$$D = \sqrt{4Q / \pi V}$$

Explanation:
D = diameter of pipe (m)
Q = Flow rate (m3/s)
V = Velocity of water (m/s)
(Sularso,2000)

II.2 RULES OF AMERICAN BUREAU SHIPPING

For taking certification from American bureau shipping, every ship must comply with rules of ABS. One of ABS rules is about ballast system i.e.

Ballast system

II.2.1 General

a. Application

These requirements apply to ballast systems for all vessels. For additional ballast system requirements for oil carriers, see part 5 (American bureau shipping, 2005).

b. Basic Principles

These requirements are intended to provide a reliable means of pumping and draining ballast tanks trough the provision of redundancy and certification of ballast pumps, and the provision of suitable remote control, where fitted (American bureau shipping, 2005).

II.2.2 Ballast Pump

At least two power driven ballast pumps are to be provided, one of which may be driven by the propulsion unit. Sanitary, bilge and general service pumps may be accepted as independent power ballast pumps. Alternative means of deballasting, such as an eductor or a suitable liquid cargo pump with an appropriate temporary connection to the ballast system, may be accepted in lieu of a second ballast pump (American bureau shipping, 2005).

II.2.3 Ballast piping and valve

a. Ballast Tank valves.

Valves controlling flow to ballast tanks are to be arranged so that they will remain closed at all times except when ballasting. Where butterfly valves are used, they are to be of a type with positive holding arrangement, or equivalent that will prevent movement of the valve position due to vibration or flow of fluids (American bureau shipping, 2005).

b. Remote control valves

Remote control valves, where fitted, are to be arranged so that they will close and remain closed in the event of loss of control power. Alternatively, the remote control valves may remain in the last ordered position upon loss of power, if there is a readily accessible manual means to close the valves upon loss of power.

Remote control valves are to be clearly identified as to the tanks they serve and are to be provided with position indicators at the ballast control station (American bureau shipping, 2005).

c. Vessels subject to damage stability

Ballast pipes installed in the regions of assumed damage under damage stability consideration are to be considered damaged. Ballast piping will affect damage stability considerations if:

It is installed within the extent of assumed damage in damage stability consideration,

And

The damage to the ballast pipe will lead to progressive flooding of intact ballast tanks through open ends in the ballast piping system.

Affected ballast piping is to be fitted with valves in the pipes in the intact tanks to prevent progressive flooding of these tanks. The valves are to be of a positive closing type and operable from above the freeboard deck or from a manned machinery space. Where the valves are electrically, hydraulically or pneumatically actuated, the cables or piping for this purpose are not to be installed within the extent of assumed damage, or, alternatively, the valves are to be arranged to fail in the closed position upon loss of control power.

The valves will not be required if it can be shown that, even with the progressively flooded spaces taken into consideration, the vessel still complies with the applicable damage stability criteria (American bureau shipping, 2005).

d. Ballast pipes passing trough fuel oil tanks

To minimize cross-contamination, where passing through fuel oil tanks, unless being led through pipe tunnel, ballast lines are to be of steel or equivalent [see 4-6-4/5.5.4(c)] having a thickness at least as required by column D of 4-6-2/Table 4. The number of joints in these lines is to be kept to a minimum. Pipe joints are to be welded or heavy flanged (e.g., one pressure rating higher). The line within the tank is to be installed with expansion bends. Slip joints are not permitted (American bureau shipping, 2005).

II.3 Pneumatic System

Pneumatic systems are widely used in today's environment. For designers and engineers, this means that being able to design with pneumatics in mind is critical. Most of the systems now in use are powered pneumatically. A small number of electrically operated devices is becoming available (for example the Russian arm and the rather more refined system developed by Bottomed), but at present these are restricted to the terminal device or hand where relatively low power is required. Higher powered electrical systems and hydraulic systems for artificial limbs present more difficult engineering problems, probably to the encouragement of the development of pneumatic systems.

British pneumatic systems now employ a control valve in which the gas flow increases progressively with valve opening. The valves formerly used had an undesirable characteristic in that minute valve movements produced large changes in gas flow; this offered little possibility of graded control and virtually condemned the user to operate them in an "on-off" manner (T.H. Lambert, 1967 and Trikantjono,1985).

The reason for using pneumatics, or any other type of energy transmission on a machine, is to perform work. The accomplishment of work requires the application of kinetic energy to a resisting object resulting in the object moving through a distance. In a pneumatic system, energy is stored in a potential state under the form of compressed air. Working energy (kinetic energy and pressure) results in a pneumatic system when the compressed air is allowed to expand.

To perform any applicable amount of work then, a device is needed which can supply an air tank with a sufficient amount of air at a desired pressure. This device is positive displacement compressor.

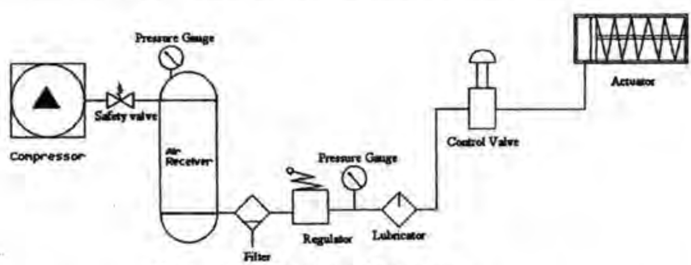


Figure 2.5 Pneumatic system

Pneumatic system consists of equipment such as:

II.3.1 Actuator

Actuator is to convert energy stored in the compressed air into mechanical motion. A linear piston is shown. Alternate tools include rotary actuators, air tools, expanding bladders, etc.

Actuator has two types in pneumatic system, single acting and double acting. Single actuator used to move light force and linier actuator. Single actuator moves, getting force from air pressure and back by damper force from spring. Double actuator moves back and forth using air pressure force from air receiver.

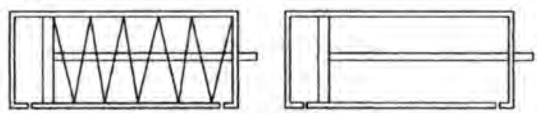


Figure 2.6 Single acting actuator and double acting actuator

To determine how much force an actuator can apply, we need to calculate the **Theoretical Force**. For a pneumatic piston actuator, that is determined by multiplying the surface area of the moving piston by the pressure applied (Sugihartono, 1985; Peter P, 1983; en.wikipedia.org, 2006). In other words, for a round piston:

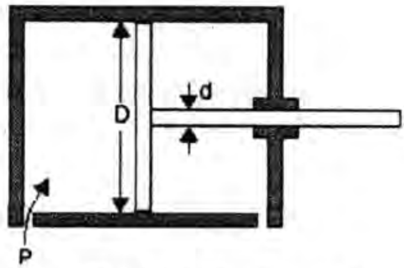


Figure 2.7 Piston actuator

Power actuator is following formula:

$$\mathbf{Ft = \pi \times D^2/4 \times P}$$

Explanations:
Ft = Force (N)
D = Diameter of Piston (m)
P = Pressure in the Piston (N/m)

Input parameter to determine type of actuator is depending on the condition and torque requirement to operate ballast valve.

Pneumatic system operates ballast valve by using air-compressed energy. To determine air consumption of pneumatic actuator is following formula:

$$\text{SCFM}=\left(\frac{vol}{1728}\right)x\left(\frac{P+14.7}{14.7}\right)x\left(\frac{cycles}{\min}\right)$$

Explanation:
Vol = Displacement piston actuator (Inch^3)
P = working pressure of system (Psi)
(Keystone valve catalogue, 2006)

II.3.2 Pipe (Tubing)

Pipe in pneumatic system is very important because it used for distributing air from compressor to air receiver tank, or from air receiver to actuator.

Size of pneumatic pipe depends on flow rate system and hole of airport actuator. Diameter of pneumatic pipe influences to response of actuator.

Based on the "Dasar-Dasar Kontrol Pneumatik" book, materials of pneumatic pipe are:

- Bronze
- Brass
- Plastic
- Steel

Figure 2.8 Plastic tubing

II.3.3 Valve of Pneumatic

Control valve is to control the flow of pressurized air from the source to the selected port. Some valves permit free exhaust from the port not selected. These valves can be actuated either manually or electrically (the valves typically provided in the First kits use dual solenoids to change the direction of the valve, based on input signals from the control system).

Pneumatic valve divided at some types usually use to direct pressurized air from reservoir tank to port or actuator of pneumatic system (Sugihartono,1985 and Trikantjono, 1985)

Directional valve are used to manage airflow, especially for starting, stopping and way of airflow. Commonly type of directional valve are used, such as 3/2 valve, 5/2 valve, 5/3 valve etc

Single acting actuator suitable with 3/2 valve although normally closed or normally opened. Double acting actuator is suitable with 5/2 or 5/3 valve although normally closed or normally opened. Pneumatic valve can be operated as manually, control and spring.

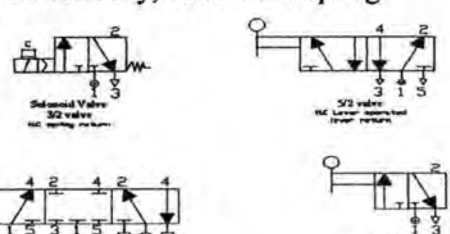


Figure 2.9 Type of pneumatic valve

Input parameters to determine of pneumatic valve are working pressure system, flow rate of system and condition of system.

II.3.4 Manifolds

Connector block (manifold) is to distribute compressed air from air receiver (buffer tank) to actuator pneumatic.

Input parameters to determine type of manifold are flow rate air compressed trough manifolds, amount of actuator and working pressured. Many kinds of manifold, one of them completed with silencer to reduce equipment noise and blanking plug to cover manifold hole.

II.3.5 Filter, Regulator, and lubricator (service unit)

Service unit in the pneumatic system is accessories. Service unit consist of 3 equipment such as: filter, Regulator and lubricator.

Figure 2.10 service unit

Every equipment, have different function. Filter refines air compressed from dust and other impurity. Regulator is to manage flow rate system and pressure from air receiver to actuator. Lubricator is to give lubricant to valve and actuator.

Filter is one of important component in pneumatic system. Filter to clean air that used in pneumatic system in order to run well. Air from compressor to air receiver tank is not being clean guaranteed. Air from compressor usually consists of things from environmental such as haze, residue of oil, dust and thing that can disturb operating of pneumatic system. Filter used to clean it, to get clean air for pneumatic system operated. Filter makes air welt to be air dry by filtering air from compressor to air receiver tank.

Input parameter to determine service unit (filter, regulator, and lubricator) are flow rate system and working pressure system.

II.3.6 Compressor and air receiver

Compressor is machine to product air pressured. Compressor takes air from environment and compacted in working pressure. Compressor need clean air from environment. Dirty or clean air from environment can effect to working efficiency of compressor.

Air receiver tank used to collect air pressurized from compressor before being used to operate pneumatic system. In this tank, air will be in constant condition as pressure, volume and temperature.

Input parameter to determine compressor and air receiver are working pressure and flow rate of actuator (system).

Importance from compressor is output pressure. Importance from air receiver is volume tank as buffer system.

To determine volume air receiver is following formula:

$$Vol_{ar} = (SCFM \times n) + (Q \times t \times n)$$

Explanations:
SCFM = air consumption
n. = amount of actuator
Q = Flow rate actuator
T = time remaining
(Yunianto,2006)

II.4 Electric System

Electric system usually used in control system. Electric system needs simple place as actuator. In industry, electric system is expensive price cause of price of electric equipment is expensive.

Electric system consists of equipment such as:

II.4.1 Electric Motor

An electric motor converts electrical energy into kinetic energy. The reverse task, which of converting kinetic energy into electrical energy, is accomplished by a generator or dynamo. In many cases, the two devices differ only in their application and minor construction details, and some applications use a single device to fill both roles. There are many types of electric motors, some smaller than a human hair others large enough to power a locomotive.

Figure 2.11 Electric motor

To determine type and size of electric motor depends on the torque required from project guide of ballast valve.

To determine power of electric actuator, need to see project guide of electric actuator. From project guide of electric actuator can understand volt and ampere operating of electric motor.

Power of electric motor is following formula:

$$P = V\, I\, Cos\varphi$$

Explanation:

P = Power of electric motor
V = Voltage operate
I = Current operate

Electric actuator is one of equipment in the engine room of MV Sinar Jambi, so it has current start. The Current that is needed to start motor is called current start. To determine current start is following formula:

$$I_{CS} = 4 \times I_{Nominal}$$

After calculating power and current electric motor, we must make distribution power from source to electric actuator. Balancing power is needed to prevent difference load between cable R, S, T. Balancing power can be shown from Junction power.

II.4.2 Cable and Safeguard

Cable is one of important equipment in electric system. Cable is used for distribute current from the source of power to equipment (electric motor).

Every equipment needs different size of cable. Sizes of cable depend on the current equipment. Size of cable and safe guard is determined using cable and safeguard table.

Table 2.1 Cable diameter and safeguard

Cable area (mm^2)	KHA (A)	Safeguard (A)
1	11	2,4,6
1.5	14	10
2.5	20	15
4	25	20
6	31	25
10	43	35
16	75	60
25	100	80

35	125	100
50	160	125
70	200	150
95	240	200
120	260	225
150	325	250
185	380	300
240	450	350
300	525	400
400	640	500
500		600
625		700
800		830
1000		1000

II.4.3 Busbar

Busbar is electric equipment that be used to distribute current from the source to machine. Busbar changes 3 Phase to 1 Phase. From 3 Phase to 1 phase needs 4 busbar. Each busbar is R line, T line, S line and neutral line.

To determine size of busbar depends on the current system and type of current (AC or DC). To determine busbar uses table of busbar.

Table 2.2 Size of Busbar

TABEL 630-1

Daftar Pembebanan yang diperkirakan untuk tenaga Penampang Persegi

Mm^2

Ukuran	Penampang	Berat	ARUS BOLAK BALIK								ARUS SEARAH							
			Dicat Jumlah Batang				Telanjang Jumlah Batang				Dicat Jumlah Batang				Telanjang Jumlah Batang			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
12 x 2	24	0,03	125	225	-	-	110	200	-	-	100	230	-	-	120	210	-	0
15 x 2	30	0,07	155	270	-	-	140	242	-	-	160	200	-	-	145	255	-	0
15 x 3	45	0,1	165	330	-	-	170	300	-	-	195	335	-	-	175	305	-	0
20 x 2	40	0,26	205	350	-	-	185	315	-	-	210	370	-	-	190	330	-	-
20 x 3	60	0,33	245	425	-	-	220	380	-	-	250	435	-	-	225	395	-	-
20 x 5	100	0,9	325	550	-	-	292	495	-	-	330	570	-	-	300	515	-	-
25 x 3	75	0,67	300	510	-	-	270	460	-	-	300	530	-	-	275	485		-
25 x 5	125	1,12	385	670	-	-	350	600	-	-	400	680	-	-	360	620	-	-
30 x 3	90	0,82	352	600	-	-	315	845	-	-	360	630	-	-	325	570	-	-
30 x 5	150	1,14	435	780	-	-	400	700	-	-	475	800	-	-	425	725	-	-
40 x 3	120	1,07	460	780	-	-	422	910	-	-	470	820	-	-	425	740	-	-
40 x 5	200	1,15	600	1000	-	-	502	900	-	-	600	1030	-	-	560	956	-	-
40 x 10	400	3,06	835	1593	2040	2800	750	1350	1650	2500	870	1350	2182	-	800	1375	1955	-
50 x 5	250	2,23	700	1200	1750	2312	630	1100	1550	2120	740	1270	1673	-	660	1150	1720	-
50 x 10	500	4,41	1025	1800	2450	3230	920	1600	2200	3000	1070	1900	2730	-	1000	1700	2400	-
60 x 5	300	2,67	825	1400	1985	2650	752	1000	1800	2400	800	1530	2200	2700	780	1430	1900	2500
60 x 10	600	5,14	1200	2100	2300	3800	1400	1850	2300	3400	1250	2200	3100	3900	1100	2000	2800	3500
80 x 5	400	3,25	1050	1800	2450	3320	952	1650	2700	2900	1150	2000	2800	3300	1000	1800	2500	3200
80 x 10	800	7,22	1540	2600	2490	4600	1400	2200	3100	4200	1650	2800	4000	5100	1410	2600	3601	4300
100 x 5	500	4,05	1300	2200	2930	3800	1200	2000	2600	3400	1400	2500	3400	4510	1252	2230	3001	3300
100 x 10	1000	8,12	1830	3100	4230	5400	1700	2700	3600	4100	2000	3600	4900	6200	1700	3200	4400	5320

II.4.4 Switch on-off

In electric, to connect or to Switch on-off is equipment to break off supply current from source to machine use switch on-off. Switch on off will be used for operating electric motor.
Input parameter to determine switch on-off are voltage and current.

II.4.5 Timer

Timer in electrically is used for auto-connect and auto-break off supply current from source to machine by setting time. Input parameter to determine timer is current and voltage system.

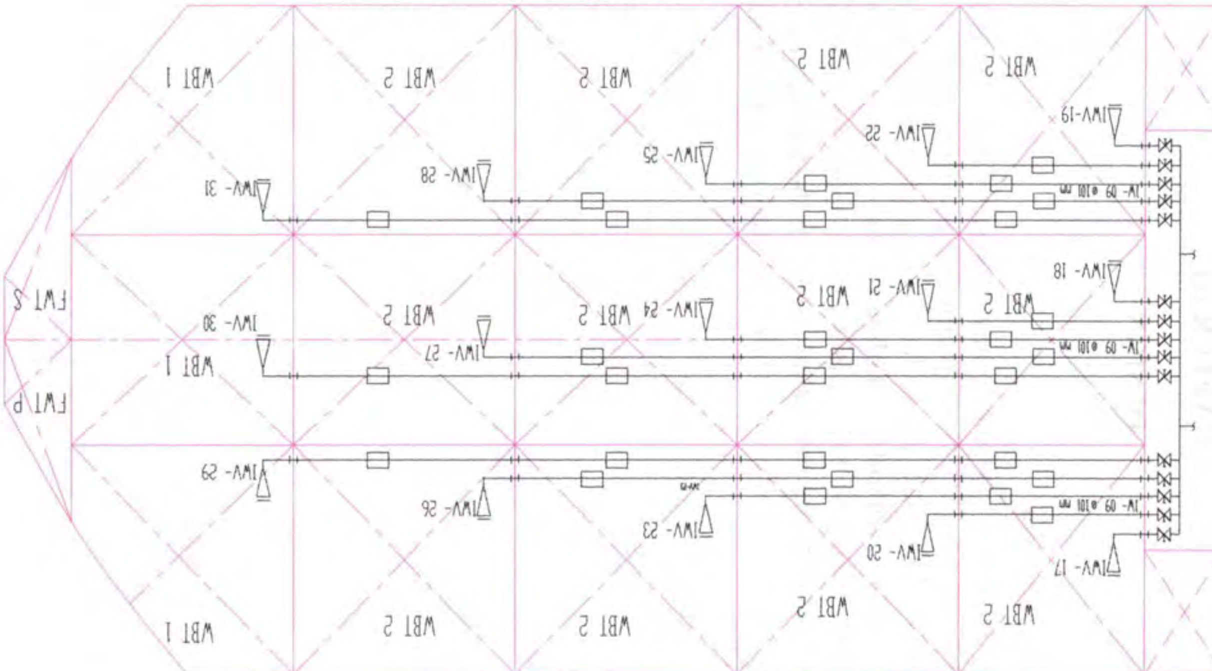
CHAPTER III

DESIGN

III.1 Ballast System

Ballast system is one of system that effects to ship stability. MV Sinar jambi has branch Type ballast system. MV Sinar Jambi has 17 ballast tanks divided 3 positions: Portside, Starboard and center. Every position has five ballast tanks from behind to forward part of ship and two ballast tanks in the engine room. See figure 3.1 existing ballast system on MV. Sinar Jambi

Figure 3.1 Existing Ballast System On MV Sinar Jambi

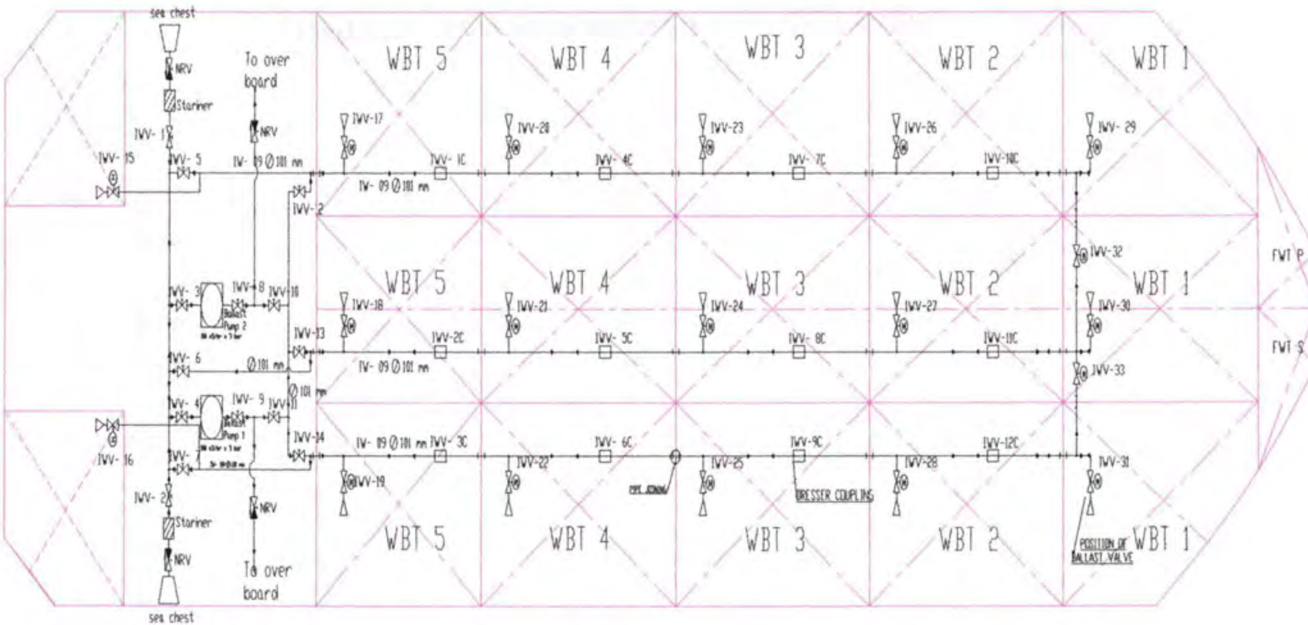


From above figure, every ballast tanks of MV Sinar Jambi serviced one branch pipe of ballast system. Every valve operates one of ballast pipe from engine room. If the ship gets load at behind, ballast tank in the front of (WBT 1) must be filled (ballasting) by ballast pump, or water ballast in the ballast tank behind trough out by ballast pump 1 and ballast tank in front of is filled water from sea chest by ballast pump 2. If the ship gets load at forward, ballast tank in the behind (WBT 5) must be filled (ballasting) by ballast pump, or water ballast in the ballast tank forward trough out by ballast pump 2 and ballast tank in behind is filled water from sea chest by ballast pump 1. If the ship gets load at portside, portside ballast tank must be filled (ballasting) by ballast pump, or water ballast in the portside ballast tank trough out by ballast pump 2 and starboard ballast tank is filled water from sea chest by ballast pump 1. If the ship gets load at starboard, starboard ballast tank must be filled (ballasting) by ballast pump, or water ballast in the starboard ballast tank trough out by ballast pump 1 and portside ballast tank is filled water from sea chest by ballast pump 2.

MV Sinar Jambi is one of ship that certified with ABS. The new rules of shipping classification are every ballast tank has to have one ballast valve that lined at each ballast tank. The rules refers to American bureau shipping that affected ballast piping is to be fitted with valves in the pipes in the intact tanks to prevent progressive flooding of these tanks. The valves are to be of positive closing type and operable from above the freeboard deck or from operated machinery space. Where the valves are electrically, hydraulically or pneumatically actuated, the cables or piping for this purpose are not to be installed within the extent of assumed damage, or, alternatively, the valve are to be arrange to fail in the closed position upon loss of control power.

In order to comply with ABS rules, MV Sinar Jambi needs re-design its ballast system. In re-design ballast system of MV Sinar Jambi, ballast System use ring type because have some advantages. A ballast valve services ballast Tanks. Ballast valve installed in ballast tank. Electric or Pneumatic actuator operate ballast valve from engine room See alternative PFD ballast system of MV Sinar Jambi.

Figure 3.2 PFD alternative ballast system of MV Sinar Jambi



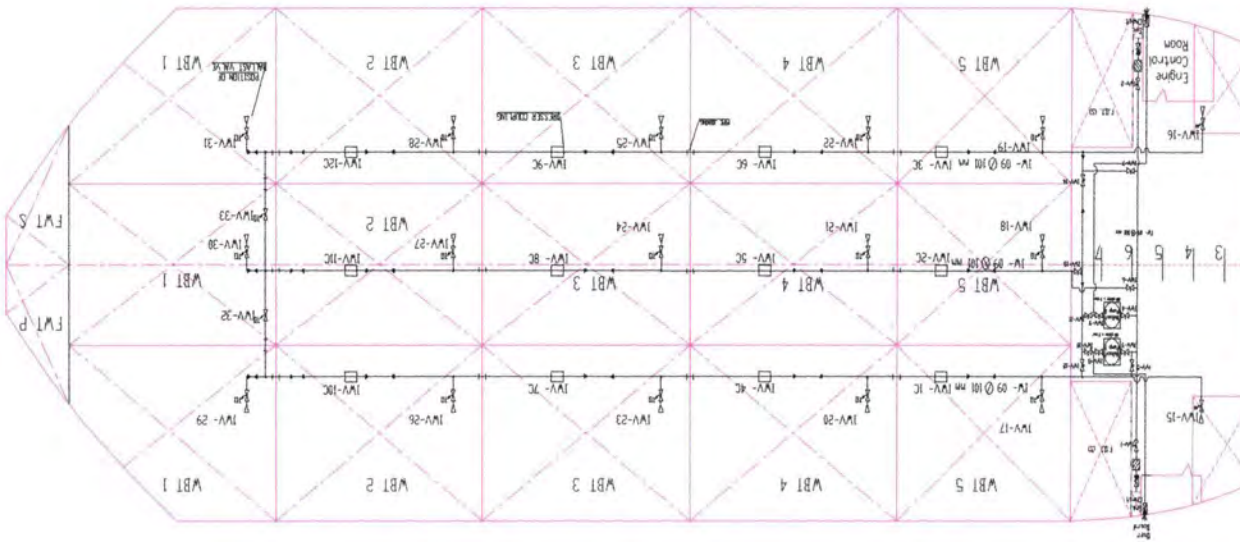


Figure 3.4 PID alternative ballast system of MV Sinar Jambi

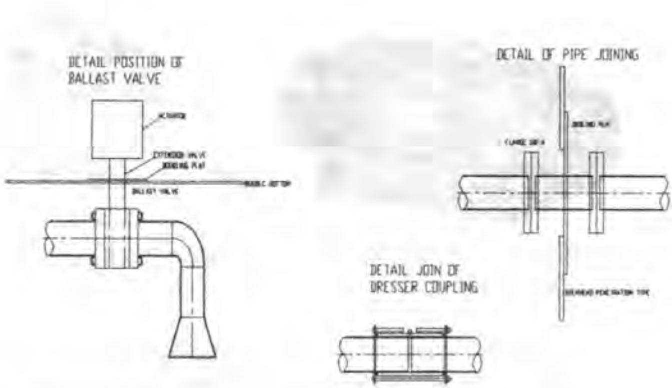


Figure 3.3 Detail position of valve and Joining pipe

III.2 Pneumatic System

In design pneumatic system as actuator of ballast valve, main input parameter is ballast system. An actuator moves a ballast valve that installed in ballast tank. MV Sinar Jambi consists of 15 ballast tanks. Pneumatic actuator moves ballast valve in MV Sinar jambi.

Pneumatic system, which used to operate ballast valve is single acting type. It means actuator of ballast valve uses spring type and in closed condition. Therefore, ballast valve opens when pneumatic actuator is running.

Actuator type is spring return or single acting. Valve control pneumatic, which suitable with single acting (spring return) is 3/2 type. For remotely operated, determined type of control valve is solenoid valve

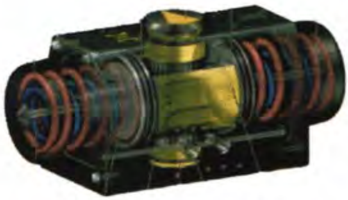


Figure 3.5 Spring Return Single acting actuator

Figure 3.6 Solenoid Valve, 3/2 N.C

Every valve control pneumatic serves an actuator. Actuator of ballast valve operated from engine room.

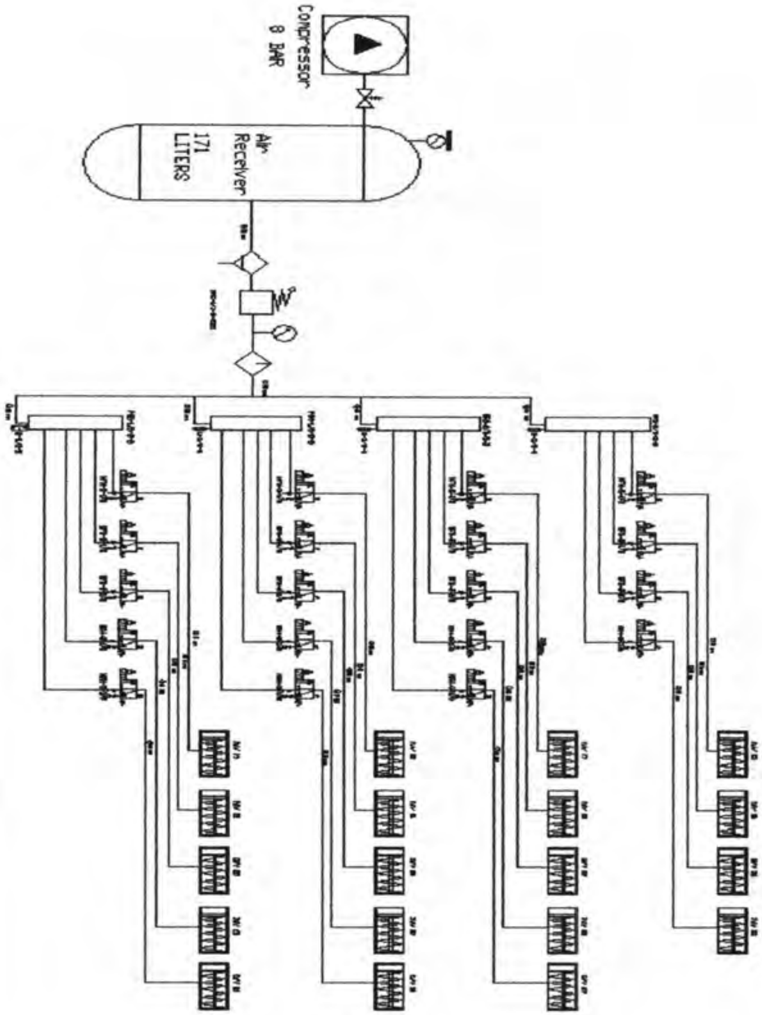


Figure 3.7 PFD Pneumatic System

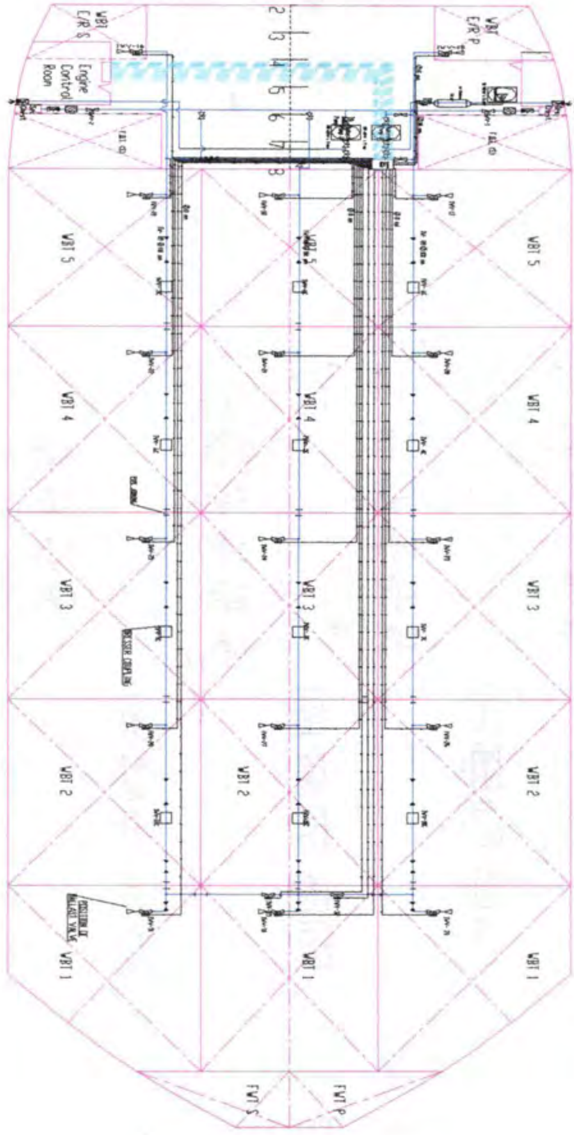
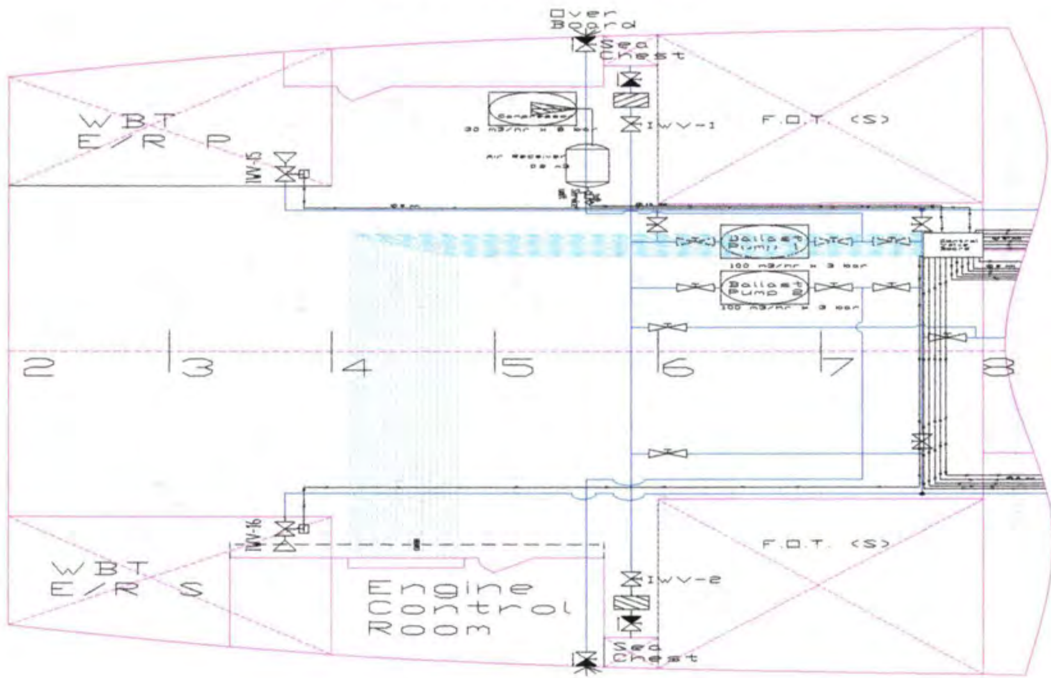


Figure 3.8 PID Pneumatic systems on Ballast system

Figure 3.9 Detail Engine Room



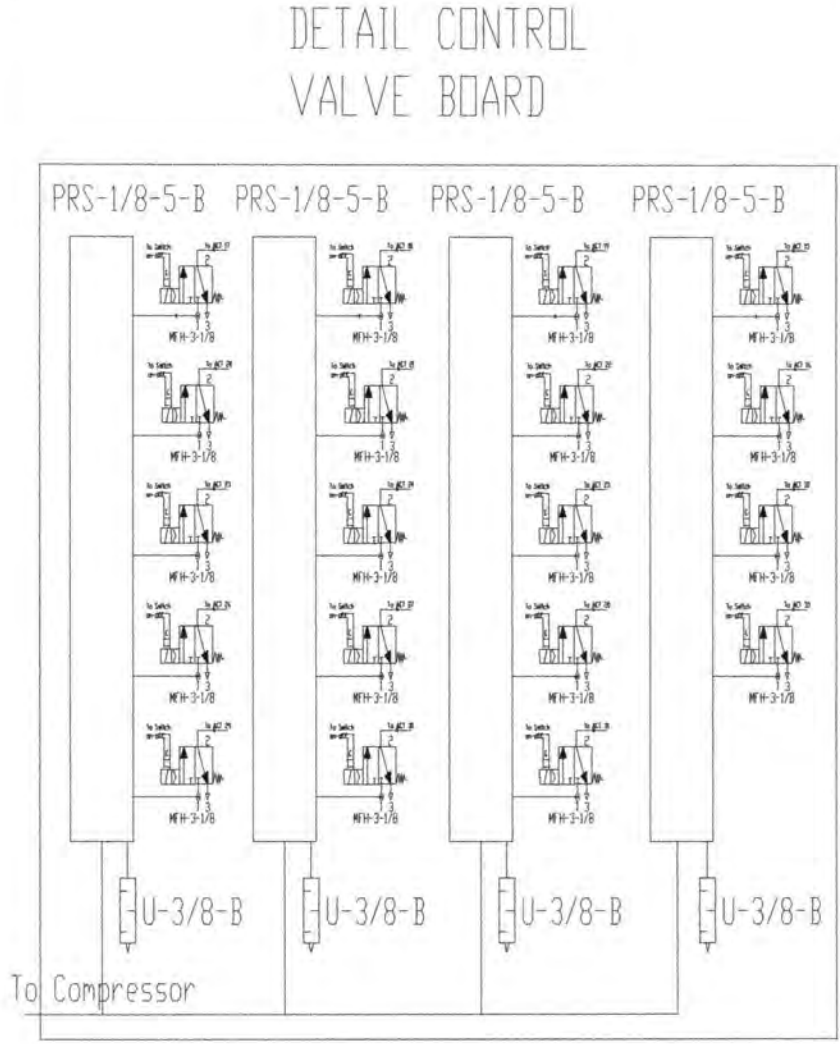


Figure 3.10 Detail Control valve board

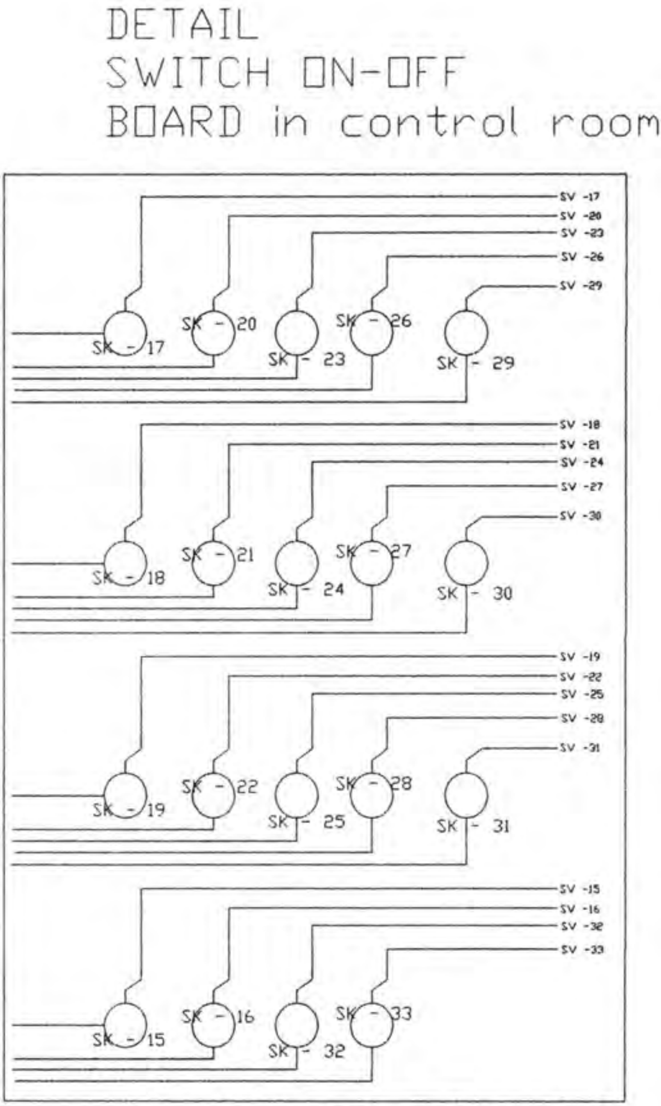


Figure 3.11 Detail Switch On-Off board

III.3 Electric System

Electric is one of systems, to be used as actuator for ballast valve. Electrically system use electric motor to operate ballast valve. While electric energy change kinematical energy to open or close valve, by an electric motor.

In design electrically system as actuator of ballast valve, main input parameter is ballast system. An actuator will move a ballast valve that installed in ballast tank. MV Sinar Jambi consists of 15 ballast tanks. It means MV Sinar Jambi 15 valve will be move by a pneumatic actuator. For detail electric system, see figure electric systems on ballast system.

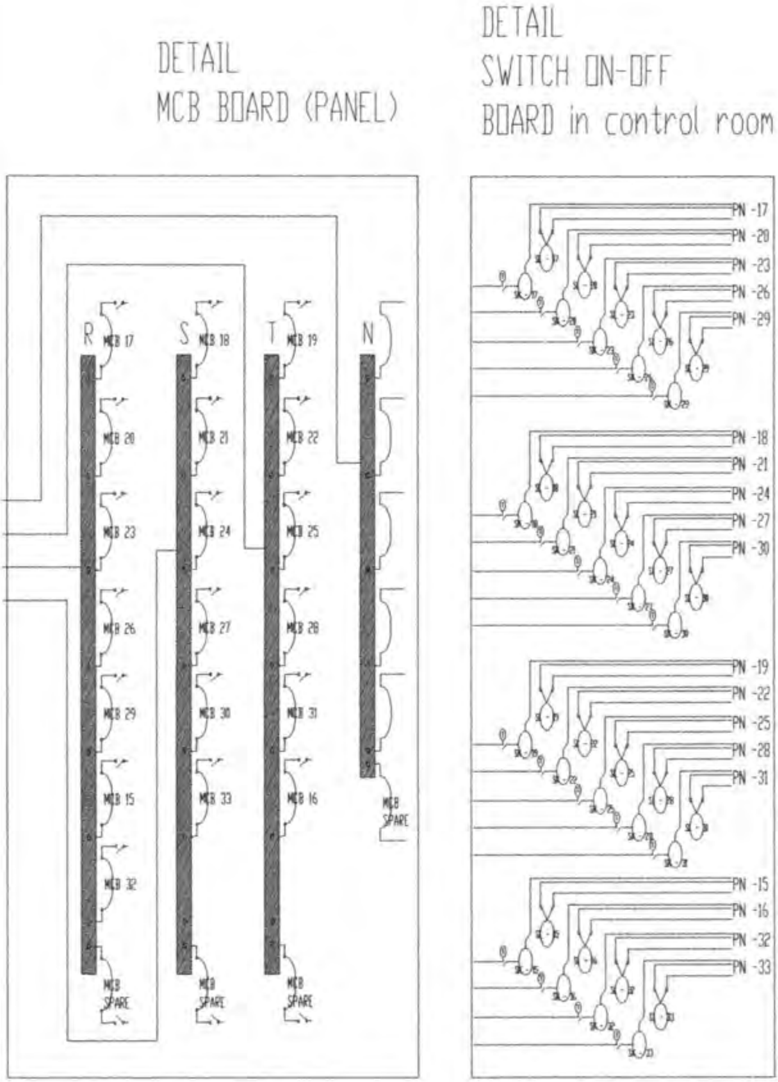


Figure 3.12 Details Panel board

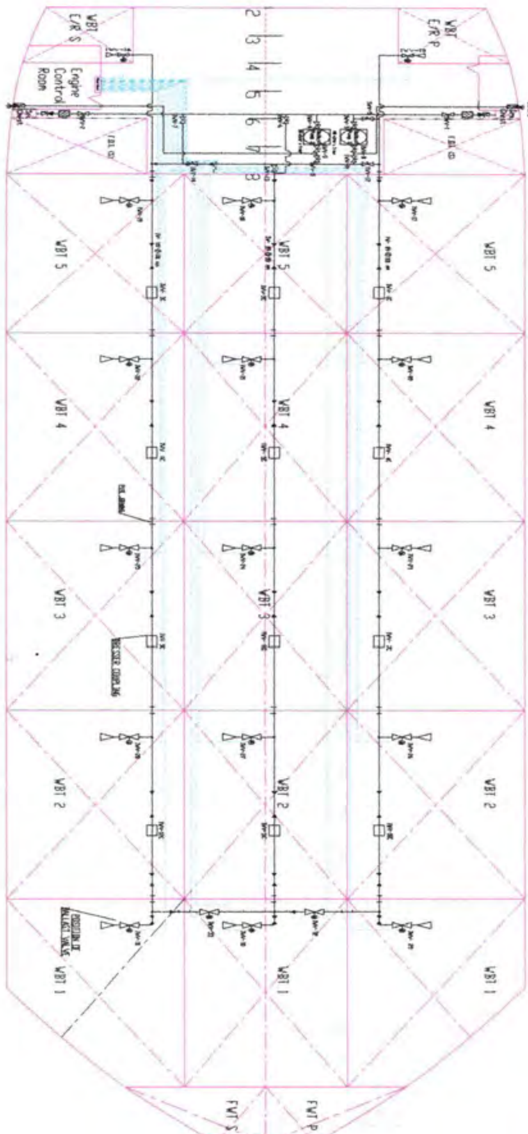
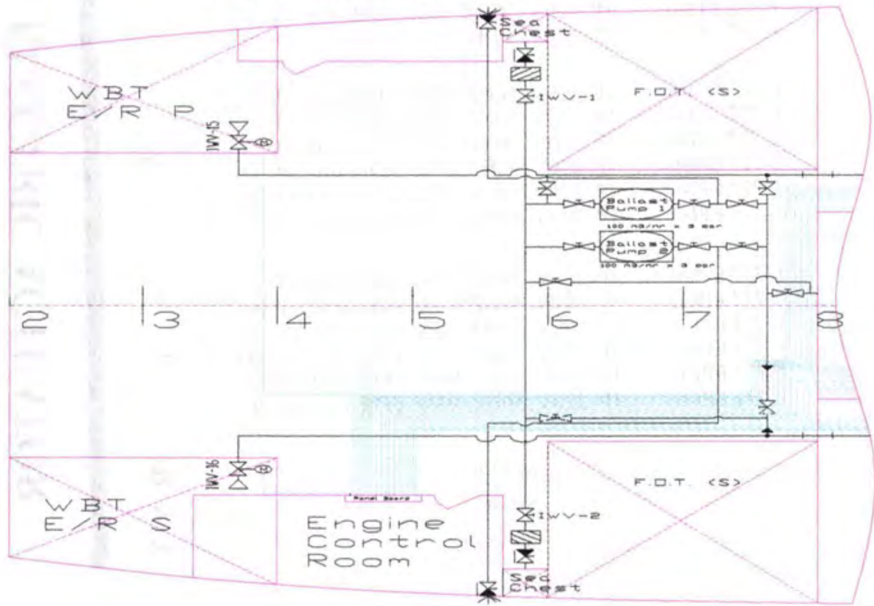


Figure 3.13 Electric systems on ballast system

Figure 3.14 Details Engine Room



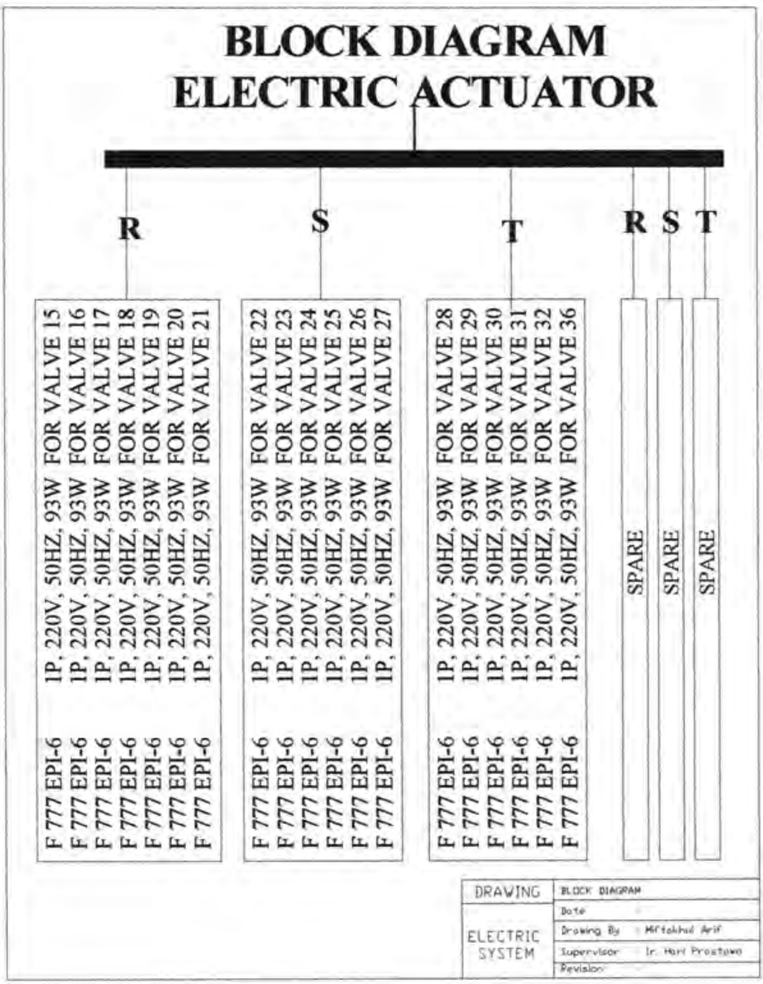


Figure 3.15 Block Diagram

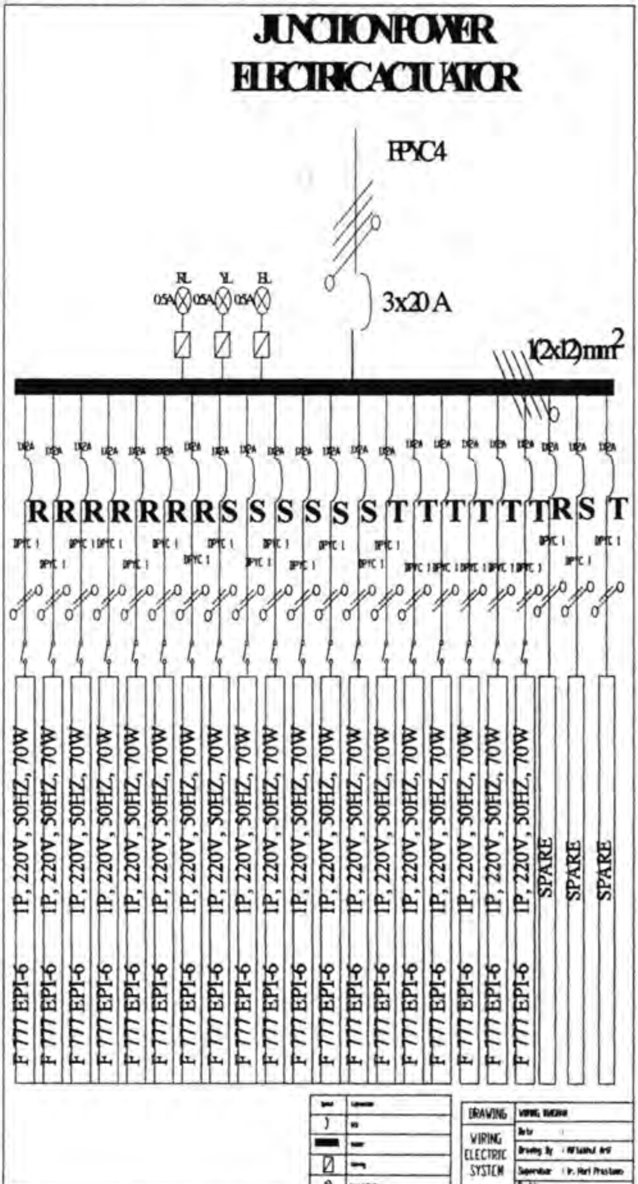


Figure 3.16 Wiring Diagram

CHAPTER IV

TECHNICAL ANALYSIS AND FEASEBILITY

IV.1. Technical Analysis

IV.1.1 Ballast System

Technical analysis for ballast system on MV Sinar Jambi is one of steps to re-design ballast system to comply with ABS rules. In re-design process, ballast system from branch type to ring type, has been definite capacity of ballast pump.

IV.1.1.1 Pipe

Technical analysis in ballast system process is calculating diameter of ballast pipe and determine fittings pipe with data from MV Sinar Jambi. MV. Sinar jambi data that used to calculate size of ballast pipe is:

Ballast pump data which existing in MV. Sinar jambi:

Merk : DESMI NSL 100-215-A02 Monobloc
Type : Vertical centrifugal
Head : 30 m
Pump Capacity (Q) $=100 m^3/hr$
Velocity of water flow (v) = 4 m/s

To determine size of ballast pipe, used following formula:

$$D = \sqrt{4Q/(v \times \pi)}$$

= √4 x 0.02778 / (4 x 3.14)
= √0.0088
= 0.094 m
= 3.7029 inch

Explanation:
D = Diameter of pipe in m
Q = Capacity of ballast pump in m^3/s
V = Velocity of water flow in (m/

To choose pipe carbon steel type which based on American B36.10 Standard

Inside diameter (dH) =	4	inches	101.6	mm
Thickness =	0.25	inches	6.35	mm
Outside diameter =	4.5	inches	114.3	mm
Nominal pipe size =	4	inches	101.6	mm

Schedule 40

IV.1.1.2 Ballast Valve

To determine type and size of ballast valve needs capacity and flow rate from main ballast valve as main parameter. Flow rate and pressure of ballast pump data is available from MV Sinar Jambi:
Pump Capacity (Q) = 100 m^3/hr
Operating Pressure (P) = 3 bar
Velocity of water flow (v) = 4 m/s
K value for butterfly valve = 0.6

Drop Pressure

Drop Pressure in the valve is caused friction losses between valve and fluid. Losses caused valve is called minor losses. Drop pressure usually depends on k value. For butterfly valve k value is 0.6.

Drop pressure is following formula:

$\blacktriangle P = (k \times v^2 / (2 \times g))/10.2$
$= (0.6 \times 4^2 / (2 \times 9.8))/10.2$
$= 0.047$ bar

Flow Rate Coefficient

Flow rate coefficient is to understand flow rate fluid trough the valve. Flow rate coefficient depends on drop pressure, type of ballast valve and flow rate of system. Specific gravity usually determine from valve maker.

To determine flow rate coefficient of valve is following formula with S.G = 1

$Kv = Qs \sqrt{(S.G/\blacktriangle P)}$
$= 100 \sqrt{(1/0.04)}$
$= 461$

Then determined ballast valve size, which has flow rate 100 m^3/hr and can operate well in 3 bars pressure. After searching in the market, definite ballast valve is keystone valve for marine application. Keystone valve has specification:

Type valve	: Butter fly valve
Valve size	: 100 mm
Figure Number	: F 611

Full open flow rate (Kv) : 807
Operating pressure (P) : 3.5 bar
Weight : 5.2 Kg
Outside diameter : 156 mm
Inside diameter : 99 mm
Drop pressure : 0.047 bar
Torque required at 0 Kpa : 34 Nm
Torque required at 350 Kpa: 37 Nm

Torque required of valve

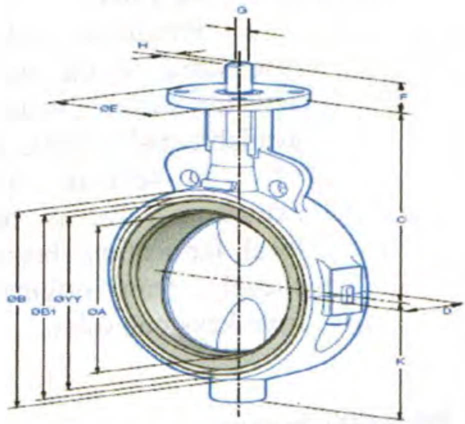
Torque required of valve is depending of operating pressure and times to operate the valve

To determine torque required of ballast valve is following formula:
Difference Torque Required at 0 Kpa and 350 Kpa

$$\blacktriangle T = T_{350} - T_0$$
$$= 37 - 34 \text{ Nm}$$
$$= 3 \text{ Nm}$$

Coefficient of torque required when operating less than once per day = 12
Torque required valve is

$$T = (T_{\text{at 0 Kpa}} \times C_{\text{Torque Req}}) + (T_{\text{at 350 Kpa}} - T_{\text{at 0 Kpa}})$$
$$= (34 \times 1.2) + 3$$
$$= 43.8 \text{ Nm} = 387.6792 \text{ Lb-in}$$



Note: F611 valve illustrated

Figure 4.1 Keystone valve F611

Table 4.1 Dimension of valve

Dimensions (mm)																		
Valve Size mm	Stem Conn. Code	ØA	ØB	ØB1	B2	C	D	ØE	F	K	Q	ØYY	Stem Conn. H x G inches	Key inches	Top Plate PCD. mm	Top Plate Hole Dia. mm	Mass F611 kg	Mass F612 kg
50	-	50	94	80	180	135	43	102	25	71	27	66	0.472 x 0.315		83	11	2.1	3.7
65	BAB	62	109	93	200	150	46	102	30	78	43	76	9/16 x 3/8		83	11	3.2	5.0
80	BAB	78	126	112	240	160	46	102	30	101	64	97	9/16 x 3/8		83	11	3.6	5.9
100	BAC	99	156	144	[illegible]	[illegible]	[illegible]	102	30	115	97	129	[illegible] x 7/16		83	11	5.2	[illegible]
125	BAD	124	169	175	300	195	56	102	30	119	113	160	3/4 x 1/2		83	11	7.6	11.5
150	BAD	151	214	198	335	210	56	102	30	142	141	181	3/4 x 1/2		83	11	8.5	13.0
200	CAE	195	267	248	397	240	60	152	32	179	188	233	7/8 x 5/8		127	14	16.0	22.2
250	CAF	245	321	305	480	275	68	152	50	219	237	290	Ø1 1/8	1/4 x 1/4	127	14	23.5	33.5
300	CAF	292	375	355	544	310	78	152	50	244	283	340	Ø1 1/8	1/4 x 1/4	127	14	32.0	51.0

Notes:

"Q" dimension is the disc chordal dimension at face of valve for disc clearance into lined pipe or fittings.
"H" dimension is the stem connection.
"G" dimension is across the stem flats.
"ØB1" dimension is to the outside of the seat.
"ØYY" dimension is to the O-ring seal.
Mass may vary depending on trim materials used.
Dimensions are nominal to ±1mm.

IV.1.1.3 Extension Valve

Extension valve connects disc valve in the ballast tank to actuator valve. Extension valve is available and suitable with distance valve to actuator valve. Usually extension valve is product from local fabrication, because it more cheaply than originally product from keystone valve.

IV.1.2 Pneumatic System

Pneumatic system uses some parameters equipment; actuator, control valve, pipe, filter, regulator, pressure gauge, compressor, and flow meter.

IV.1.2.1 Actuator

Pneumatic actuator for ballast valve uses single acting type. Main input parameter to definite type and size actuator is torque required of ballast valve. Pneumatic actuator has to have torque minimally same with torque required of ballast valve.

From above data can show that torque required of ballast valve: 43.8 Nm = 387.69 lb-in. So Pneumatic actuator must have torque more than 43.8 Nm (387.69 lb-in).

From keystone valve catalog:
Product: Keystone 79U Pneumatic actuator
Actuator type: Spring return (single acting)
Actuator size : 006S
Actuator piston displacement: $21 in^3$
Output Torque : 486 lb-in
Air supply pressure: 100 Psi = 6.89 bar
Cycles / min (design) : 1

Air Consumption of ballast valve actuator as formula:

$$SCFM = \left(\frac{Airstroke}{1728}\right) x \left(\frac{supplyair + 147}{147}\right) x \left(\frac{cycle}{min}\right)$$

$$SCFM = \frac{21}{1728} x \left(\frac{100 + 14.7}{14.7}\right) x (1)$$

$= 0.09\ ft^3/min$

$= 2.69$ liters/cycle

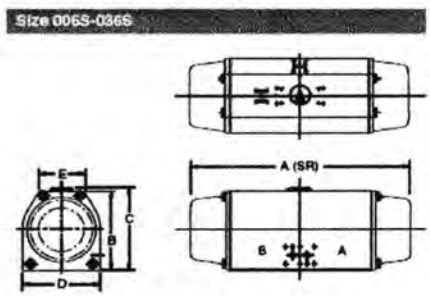


Figure 4.2 Dimension of actuator

Table 4.2 Pneumatic actuator

Actuator Dimensions (Inches)							
Actuator Size	A(SR)	A(DA)	B	C	D	D1	E
003	8.23	5.57	3.19	3.54	3.27	3.58	2.20
006	10.10	6.55	4.09	4.41	3.66	-	2.26
012	11.10	7.13	5.00	5.35	4.38	-	3.25
024	13.82	9.17	5.90	6.26	5.35	-	3.35
036	16.69	10.72	6.87	7.24	6.00	-	3.50
085/086	19.69	12.78	8.55	8.90	8.00	-	4.50
090/091	23.00	16.09	8.55	8.90	8.00	-	4.50
180/181	27.32	18.94	10.55	10.90	9.84	-	5.12

IV.1.2.2 Capillary Pipe (Tubing)

Pipe for pneumatic is called tubing. Size of pneumatic pipe depends on flow rate of actuator or air consumption of actuator. Pneumatic has function to connect and distribute air from compressor to air receiver or from air receiver to actuator.

The diameter of tubing is divided two. First diameter of pneumatic pipe takes same with diameter of airport in pneumatic actuator. This tubing is connecting solenoid valve to actuator. From project guide of pneumatic actuator, diameter of airport is ¼ "or 8 mm. Second diameter of tubing is bigger than diameter of first tubing. Second tubing is connecting air receiver to manifold (connector block). Difference of diameter pneumatic pipe gives effect to respond of actuator to open the ballast valve.

After looking for in the market, can be determined types of tubing that being used are:

1. PLN- 8 x 1.25 – NT
   Inside diameter : 5.9 mm
   Outside diameter : 8 mm
2. PLN – 10 x 1.5 – NT
   Inside diameter : 7 mm
   Outside diameter : 10 mm

This pipe is resistance to chemical, microbes, UV Radiation, hydrolysis, stress cracks and shore hardness. The material is polyethylene, free of chopper, PTFE and silicon. Possible fitting with PLN tubing is Quick Star.

IV.1.2.3 Solenoid Valve and Solenoid coil

To operate pneumatic actuator is using solenoid valve. Solenoid valve uses solenoid coil to connect to switch on-off electric. It may automatic operated from engine control room.

Input parameter to determine solenoid valve is flow rate of system and operating pressure. Flow rate of system is 0.09 ft^3/min. Operating pressure system is 100 Psi. For solenoid coil is depend on the type of solenoid valve.

Another that, type solenoid valve depends on the type of pneumatic actuator. Type of solenoid valve is 3/2 normally closed suitable with actuator with single acting type.

From above data, determined type of solenoid valve and solenoid coil:
Solenoid valve
Type : MFH – 3 – 1/8
Flow rate : Max 5000 l/min
Pressure : 1.5 bars – 8 bar
Function : 3/2 Normally closed.
Solenoid valve is suitable with Solenoid coil
Type : MSFG- 24 DC/ 42 AC
Power : 4.5 w

Figure 4.3 Solenoid valve MFH-3-1/8

Figure 4.4 Solenoid Coil MSFG 24DC/42AC

In the enclosures, explain more detail about data sheet of Solenoid valve MFH-3-1/8 and Solenoid Coil MSFG 24DC/42AC.

IV.1.2.4 Connector Block (Manifold)

Connector block is to distribute compressed air from air receiver (buffer tank) to actuator pneumatic. Amount of pneumatic actuator is 19. From solenoid valve can be determined connecting accessories.

Connector block Type is PRS1/8 5 B.

PRS 1/8 5 B has 5 holes for 5 pipes to solenoid valve. So the pneumatic system needs 3 to cover 15 solenoid valves.

The PRS 1/8 5 B need **blanking plug and silencer**. Silencer has function to decrease vibration of air compressed. Blanking plug covers one hole beside air inlet from air receiver.

Type of Silencer	: U – 3/8 B
Operating Pressure	: 0-10 bar
Flow rate	: 5,734 l/min
Type of blanking Plug	: B – 3/8

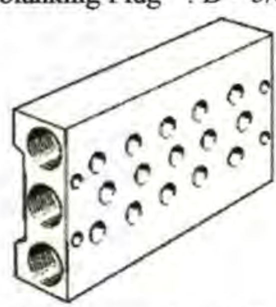


Figure 4.5 Connector Block PRS 1/8 5B

Figure 4.6 Blanking Plug B -3/8

Figure 4.7 Silencer U 3/8 B

In the enclosures explain more detail about data sheet of Connector block PRS 1/8 5 B, Silencer U – 3/8 B, and blanking Plug B – 3/8.

IV.1.2.5 Filter, Lubricator and Regulator (service Unit)

Filter and Regulator is accessories in pneumatic system. Filter has function to refine air compressed from air receiver to connector block. Regulator has function to manage in the system. From project guide pneumatic accessories of Festo, filter, lubricator and regulator is built in one. Input parameter to determine service unit is flow rate of system and pressure control.

Type of Service unit: FRC- ¼- D- MIDI
Pressure control : 0.5 – 12 bar
Flow rate : 1500 l/min

Figure 4.8 Service unit FRC- ¼- D- MIDI

In the enclosures, explain more detail about data sheet of service unit FRC- ¼- D- MIDI.

IV.1.2.6 Push in Fitting and T connection

Push in fitting and T connections are a connector between tubing and equipment such as actuator, connector block, service unit.

Push in fitting consists of three types:

- ✓ QS 1/8-8
- ✓ QS ¼-10
- ✓ QS ¼-8

T connection fitting type is QS 10.

IV.1.2.7 Air Receiver and Compressor

Air receiver in pneumatic system has function as buffer. Air receiver collect air pressured from compressor. Capacity or volume of air receiver minimally is same with air consumption of actuator scenario plus friction losses, air consumption for a few minute as repairing factor and other.

Compressor is a machine to product air pressured. Compressor take free air from environment with pressured at 1 bar. Air in compressor gets treatment in order to have high pressure. From compressor, air will out with specify pressure depend on the out put pressure of compressor.

Compressor is depending on the flow rate and pressure required from the pneumatic system. From the data actuator, pressure required is 100 Psi.

Air receiver has to operate minimal pneumatic actuator as scenario. In this case, maximal ballast valve can operate together are two. For losses factor, air consumption to operated ballast valve together is 4 ballast valves.

Capacity of air receiver is following formula:

$$Vol_{Air\ Rec} = (Air_{con} \times n) + (Q \times t \times n)$$

Amount of actuator (n) = 4 actuators
Air consumption of an actuator=2.69 L/Cyl
Flow rate of an actuator (Q)=$4.5x\ 10^{-5}\ m^3/s$
Time for factor repairing (t) = 15 min

$$Volume_{Air\ Rec} = (2.69x4)+(0.000045x15x60x4x1000)$$
$$= 171.85\ Liters$$
$$= 0.172\ m^3$$

Air Receiver is compound with compressor. Air receiver and compressor are completing with auto valve for automation operation, pressure gauge for pressure indicator, solenoid valve.

Compressor and Air receiver use existing compressor on the ship with specification:
Mark : TW-071 Launtop
Type : two stages
Capacity : 30 m^3/hr
Output Pressure : 8 bar

IV.1.2.8 Advantages Pneumatic system

Advantages of pneumatic actuators are:

- Compressed air is convenient and relatively cheap to supply
- It can be operated from engine control room
- A Piston is not self locking and it can be used against a spring so it can be

used for single shot emergency operation

- When air contact with heat, an increase in pressure caused by thermal expansion will assist the operation of the actuator
- Surplus air can be safely to the atmosphere
- The mechanical design makes it relatively cheaper than other alternatives and
- Easy to maintain
- Low risk assessments
- Simple design

IV.1.2.9 Disadvantages Pneumatic system

Disadvantages of pneumatic actuators are:

- Because no kinetic energy which is not possible to deliver an initial "hammerblow" to unseat a wedge valve
- Air is compressible medium and its ability to maintain a fix position is limited.
- Air motors are susceptible to seizure because of ingress of foreign material, or internal corrosion if the compressed air has not been sufficiently dried. This will greatly affect the performance of the actuator
- If there is trouble in the actuator of ballast valve, it cannot be operated by hands (manually). So it needs one access from engine room to void tank

(Valve position) by inserting a watertight door. If spring actuator is broken, its trouble needs a substitution actuator for new one. To change the actuator just put off the old one and insert the new one.

- Higher Power than electric system

IV.1.3 Electric System

Electric system is a system using electric for main source power to operate equipment. Valve actuator has been long time use electric system. Electric system will move electric motor to move ballast valve. Main input parameter of electric system as ballast actuator is torque required from valve. To choose type and size electric motor, having torque required as minimally as torque required from valve project guide.

Torque required of valve is 43.8 Nm (387.69 lb-in).

From project guide of keystone valve can be determined type and size of electric actuator is:

Actuator keystone 777
Type EPI-6 open Close service with speed control module

Output Torque (T)	=	54.23	Nm=	480	Lb-in
Time for 90	=		22	s	
Voltage (AC)	=		220	Volt	
I Phase	=				
Cos (α)	=		0.8		

Gear ratio = 2105 : 1
F.L.A (Full Load Ampere)= 0.4 A

Power of electric actuator is following formula:

$$
\begin{aligned}
P &= V \times I \cos(\alpha) \\
&= 220 \times 0.4 \times 0.8 \\
&= 70.04 \text{ Watt} \\
&= 0.07 \text{ Kw}
\end{aligned}
$$

Electric actuator needs four times nominal current of electric actuator when start. To determine size of cable, bus bar and protection use current start. To determine current start is following formula:

$$
\begin{aligned}
Isc &= 4 \times I \text{ nom} \\
&= 4 \times 0.4 \\
&= 1.6 \text{ A}
\end{aligned}
$$

After calculating power and current electric motor, we must make distribution power from source to electric actuator. Balancing power is needed to prevent big-difference load between cable R, S, T. Balancing power can be shown from Junction power.

Table 4.3 Junction Power

JUNCTION POWER OF ELECTRIC ACTUATOR

Junction			Equipment Name	Phase	Amount	Power / Set	Power (w)		
R	S	T				(kW)	R	S	T
			Keystone F777 Type EPI- 1 for valve 15	1	1	0.07	70.40		
			Keystone F777 Type EPI- 1 for valve 17	1	1	0.07	70.40		
			Keystone F777 Type EPI- 1 for valve 20	1	1	0.07	70.40		
			Keystone F777 Type EPI- 1 for valve 23	1	1	0.07	70.40		
			Keystone F777 Type EPI- 1 for valve 26	1	1	0.07	70.40		
			Keystone F777 Type EPI- 1 for valve 29	1	1	0.07	70.40		
			Keystone F777 Type EPI- 1 for valve 32	1	1	0.07	70.40		
			Keystone F777 Type EPI- 1 for valve 18	1	1	0.07		70.40	
			Keystone F777 Type EPI- 1 for valve 21	1	1	0.07		70.40	
			Keystone F777 Type EPI- 1 for valve 24	1	1	0.07		70.40	
			Keystone F777 Type EPI- 1 for valve27	1	1	0.07		70.40	
			Keystone F777 Type EPI- 1 for valve30	1	1	0.07		70.40	
			Keystone F777 Type EPI- 1 for valve 33	1	1	0.07		70.40	
			Keystone F777 Type EPI- 1 for valve 19	1	1	0.07			70.40
			Keystone F777 Type EPI- 1 for valve 22	1	1	0.07			70.40
			Keystone F777 Type EPI- 1 for valve 25	1	1	0.07			70.40
			Keystone F777 Type EPI- 1 for valve 28	1	1	0.07			70.40
			Keystone F777 Type EPI- 1 for valve 31	1	1	0.07			70.40
			Keystone F777 Type EPI- 1 for valve 16	1	1	0.07			70.40
			Spare						
			Spare						
			Spare						
Amount of Power							492.80	422.40	422.40

IV.1.3.1 Cable and Safeguard

By reading in cable and safeguard table, we determine size of cable and safeguard. Input parameter to determine size of cable and safeguard is current start. Size of cable and safeguard usually use more higher than current start.

From project guide electric motor from keystone valve f777

FLA = 0.4 A

I_{SC} = 4 x FLA

= 4 x 0.4

= 1.6 A

For electric safety, take the safeguard with current operation is 2 A and can be shown cable area is 1 mm^2.

Table 4.4 Cable diameter and safeguard

Cable area (mm^2)	KHA (A)	Safeguard (A)
1	11	2,4,6
1.5	14	10
2.5	20	15
4	25	20
6	31	25
10	43	35
16	75	60
25	100	80
35	125	100
50	160	125
70	200	150
95	240	200
120	260	225
150	325	250
185	380	300
240	450	350
300	525	400
400	640	500
500		600
625		700
800		830
1000		1000

Table 4.5 Safeguard and Cable calculation

No	Equipment Name	Daya [W]	Voltase [Volt]	Freq [Hz]	Phase [Φ]	Faktor daya (cos φ)	Arus [I]		Arus Pengaman [A] Circuit	Luas Penamp Kabel [mm²]	Luas Penam Busbar [mm²]	Juml Batang	Keterang
							Nominal	Start					
1	Keystone F777 Type EPI- 1 for valve 15	70	220	50	1	0.8	0.40	1.60	2	1	24	1	
2	Keystone F777 Type EPI- 1 for valve 17	70	220	50	1	0.8	0.40	1.60	2	1			
3	Keystone F777 Type EPI- 1 for valve 20	70	220	50	1	0.8	0.40	1.60	2	1			
4	Keystone F777 Type EPI- 1 for valve 23	70	220	50	1	0.8	0.40	1.60	2	1			
5	Keystone F777 Type EPI- 1 for valve 26	70	220	50	1	0.8	0.40	1.60	2	1			
6	Keystone F777 Type EPI- 1 for valve 29	70	220	50	1	0.8	0.40	1.60	2	1			
7	Keystone F777 Type EPI- 1 for valve 32	70	220	50	1	0.8	0.40	1.60	2	1			
8	Keystone F777 Type EPI- 1 for valve 18	70	220	50	1	0.8	0.40	1.60	2	1			
9	Keystone F777 Type EPI- 1 for valve 21	70	220	50	1	0.8	0.40	1.60	2	1			
10	Keystone F777 Type EPI- 1 for valve 24	70	220	50	1	0.8	0.40	1.60	2	1			
11	Keystone F777 Type EPI- 1 for valve27	70	220	50	1	0.8	0.40	1.60	2	1			
12	Keystone F777 Type EPI- 1 for valve30	70	220	50	1	0.8	0.40	1.60	2	1			
13	Keystone F777 Type EPI- 1 for valve 33	70	220	50	1	0.8	0.40	1.60	2	1			
14	Keystone F777 Type EPI- 1 for valve 19	70	220	50	1	0.8	0.40	1.60	2	1			
15	Keystone F777 Type EPI- 1 for valve 22	70	220	50	1	0.8	0.40	1.60	2	1			
16	Keystone F777 Type EPI- 1 for valve 25	70	220	50	1	0.8	0.40	1.60	2	1			
17	Keystone F777 Type EPI- 1 for valve 28	70	220	50	1	0.8	0.40	1.60	2	1			
18	Keystone F777 Type EPI- 1 for valve 31	70	220	50	1	0.8	0.40	1.60	2	1			
19	Keystone F777 Type EPI- 1 for valve 16	70	220	50	1	0.8	0.40	1.60	2	1			
	Spare								2	1			
	Spare								2	1			
	Spare								2	1			
	Amount	1338	220	50	3	0.8	4.3879	17.551	20	2.5			

After searching type and size cable, can be determined cable that is available in the market are:

Cable first type:

Type cable	: NYM Eternal
Content of cable	: 2
Size of cable	: 1.5 mm^2

Cable second type:

Type cable	: NYM Eternal
Content of cable	: 4
Size of cable	: 4 mm^2

Safeguard is used for preventive emergency if at the time there is returned current. Safeguard can directly off supply current from source.

After searching type and size safeguard, can be determined cable that is available in the market are:

Safeguard type : Merin gerin

Operating rating : 6 A

IV.1.3.2 Busbar

Busbar is used for distribute current and change from 3 phase to 1 phase.

To determine size of busbar by looked at list of busbar table. Totally power equipment in R, S, T line. Then can be calculated total current. From this data can be determined size of busbar :

Table 4.6 List of Busbar

TABEL 630-1
Daftar Pembebanan yang diperkirakan untuk tenaga Penampang Persegi

Mm^2

Ukuran	Penampang	Berat	ARUS BOLAK BALIK								ARUS SEARAH							
			Dicat Jumlah Batang				Telanjang Jumlah Batang				Dicat Jumlah Batang				Telanjang Jumlah Batang			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
12 x 2	24	0,03	125	225	-	-	110	200	-	-	100	230	-	-	120	210	-	0
15 x 2	30	0,07	155	270	-	-	140	242	-	-	160	200	-	-	145	255	-	0
15 x 3	45	0,1	165	330	-	-	170	300	-	-	195	335	-	-	175	305	-	0
20 x 2	40	0,26	205	350	-	-	185	315	-	-	210	370	-	-	190	330	-	-
20 x 3	60	0,33	245	425	-	-	220	380	-	-	250	435	-	-	225	395	-	-
20 x 5	100	0,9	325	550	-	-	292	495	-	-	330	570	-	-	300	515	-	-
25 x 3	75	0,67	300	510	-	-	270	480	-	-	300	530	-	-	275	[illegible]		-
25 x 5	125	1,12	385	670	-	-	350	600	-	-	400	680	-	-	360	620	-	-
30 x 3	90	0,82	352	600	-	-	315	845	-	-	360	630	-	-	325	570	-	-
30 x 5	150	1,14	435	780	-	-	400	700	-	-	475	800	-	-	425	725	-	-
40 x 3	120	1,07	460	780	-	-	422	910	-	-	470	820	-	-	425	740	-	-
40 x 5	200	1,15	600	1000	-	-	502	900	-	-	600	1030	-	-	580	956	-	-
40 x 10	400	3,06	835	1593	2040	2800	750	1350	1650	2500	870	1350	2182	-	800	1375	1955	-
50 x 5	250	2,23	700	1200	1750	2312	630	1100	1550	2120	740	1270	1673	-	660	1150	1720	-
50 x 10	500	4,41	1025	1800	2450	3230	920	1600	2200	3000	1070	1900	2730	-	1000	1700	2400	-
60 x 5	300	2,67	825	1400	1985	2850	752	1000	1800	2400	800	1530	2200	2700	780	1430	1900	2500
60 x 10	600	5,14	1200	2100	2300	3800	1400	1850	2300	3400	1250	2200	3100	3300	1100	2000	2800	3500
80 x 5	400	3,25	1050	1800	2450	3320	952	1650	2700	2900	1150	2000	2800	3300	1000	1800	2500	3200
80 x 10	800	7,22	1540	2800	2490	4800	1400	2200	3100	4200	1650	2800	4000	5100	1410	2800	3801	4300
100 x 5	500	4,05	1300	2200	2930	3800	1200	2000	2800	3400	1400	2500	3400	4310	1252	2230	3001	3300
100 x 10	1000	8,12	1830	3100	4230	5400	1700	2700	3600	4100	2000	3600	4900	6200	1700	3200	4400	5320

Table 4.7 maximal current Service

No	Equipment Name	Daya (w)	Voltase [Volt]	Freq (Hz)	Phase [Φ]	Faktor daya (cos φ)	Arus [I] Nominal	Arus [I] Start	Arus Pengaman [A] Circuit	Luas Penamp Kabel (mm²)	Luas Penam Busbar (mm²)	Juml Batang	Keterang
1	Keystone F777 Type EPI- 1 for valve 15	70	220	50	1	0.8	0.40	1.60	2	1	24	1	
2	Keystone F777 Type EPI- 1 for valve 17	70	220	50	1	0.8	0.40	1.60	2	1			
3	Keystone F777 Type EPI- 1 for valve 20	70	220	50	1	0.8	0.40	1.60	2	1			
4	Keystone F777 Type EPI- 1 for valve 23	70	220	50	1	0.8	0.40	1.60	2	1			
5	Keystone F777 Type EPI- 1 for valve 26	70	220	50	1	0.8	0.40	1.60	2	1			
6	Keystone F777 Type EPI- 1 for valve 29	70	220	50	1	0.8	0.40	1.60	2	1			
7	Keystone F777 Type EPI- 1 for valve 32	70	220	50	1	0.8	0.40	1.60	2	1			
8	Keystone F777 Type EPI- 1 for valve 18	70	220	50	1	0.8	0.40	1.60	2	1			
9	Keystone F777 Type EPI- 1 for valve 21	70	220	50	1	0.8	0.40	1.60	2	1			
10	Keystone F777 Type EPI- 1 for valve 24	70	220	50	1	0.8	0.40	1.60	2	1			
11	Keystone F777 Type EPI- 1 for valve27	70	220	50	1	0.8	0.40	1.60	2	1			
12	Keystone F777 Type EPI- 1 for valve30	70	220	50	1	0.8	0.40	1.60	2	1			
13	Keystone F777 Type EPI- 1 for valve 33	70	220	50	1	0.8	0.40	1.60	2	1			
14	Keystone F777 Type EPI- 1 for valve 19	70	220	50	1	0.8	0.40	1.60	2	1			
15	Keystone F777 Type EPI- 1 for valve 22	70	220	50	1	0.8	0.40	1.60	2	1			
16	Keystone F777 Type EPI- 1 for valve 25	70	220	50	1	0.8	0.40	1.60	2	1			
17	Keystone F777 Type EPI- 1 for valve 28	70	220	50	1	0.8	0.40	1.60	2	1			
18	Keystone F777 Type EPI- 1 for valve 31	70	220	50	1	0.8	0.40	1.60	2	1			
19	Keystone F777 Type EPI- 1 for valve 16	70	220	50	1	0.8	0.40	1.60	2	1			
	Spare								2	1			
	Spare								2	1			
	Spare								2	1			
	Amount	1338	220	50	3	0.8	4.3879	17.551	20	2.5			

After searching type and size busbar, can be determined busbar that is available in the market are:
Busbar type:

Type busbar	: 3 x 10 mm^2
Mark of busbar	: KB363C Hager
Operating	: AC 230/400V

IV.1.3.3 Switch on-off and electrical accessories

To operate electric motor use Switch on-off. Input parameter to determine switch on-off is current and voltage system.
Current system is 0.4 A
Voltage system is 220 V

After searching type and size switch on-off, can be determined switch on-off which is available in the market are:
Cable first type:

Type on-off	: BS 211 B
Operating	: 380 V, 1.5 KW

Accessories of electrically are:

- Lamp indicator

Lamp indicator is used to know current in R, S, T, line. Lamp indicators consist of three lamps.

After searching type and size indicators lamp, can be determined indicators lamp that is available in the market are red, yellow and green. It will be connect to R, S, and T cable line.

- Voltmeter

Voltmeter is used as voltage indicator. After searching type and size voltmeter, can be determined voltmeter which is available in the market are Kings.

- Ampere meter

Ampere meter is used as ampere indicator. After searching type and size voltmeter, can be determined voltmeter that is available in the market are Kings.

IV.1.3.4 Timer

Timers in this system are used as breaker off current supply by setting time operation. In this design will use digital timer. After searching type and size timer, can be determined digital timer which is available in the market are Brenensthul.

IV.1.3.5 Advantages Electric system

Advantages of electric systems are:

- Owing to valve gearing, position stability can be maintained
- Electric motors can be integrated with process control systems

- Electric motors that have been adequately protected from the environment are clean and do not generate dirt or moisture
- No surplus energy to be dispersed
- The electric supply generates a stiff stroke that does not fluctuate
- Low Power
- If ballast system there is trouble, ballast system can operate with manually operated.

IV.1.3.6 Disadvantages Electric system

Disadvantages of electric systems are:

- Expensive
- Complex in design and requires higher level of maintenance
- High risk
- Stay put mode when there is a power failure
- Electric cables must be protected in a high temperature environment
- Electric power is not easily stored
- Electrical equipment must be protected from moisture
- Electric motors must be intrinsically safe in hazardous areas.

IV.2 Checklist Equipment

In the alternative of ballast, systems design MV. Sinar Jambi will make consequences such: invest some new equipment, easy relatively to operate ballast system, etc.

From the technical data analysis, we can determine some equipment that must be carried out for system.

IV.2.1 Ballast system equipment

Ballast system is system to distribute seawater from and to ballast tank. Ballast system consists of equipment in the below table.

Table 4.1 Checklist equipment of ballast system

No	Equipment	QTY	Type and Model	Principal particular
1	Strainer	2	-	-
2	Gate valve	2	-	Size 100 mm
3	Butterfly valve (Manually operated)	14	-	Size 100 mm
4	Screw down stop And check valve	2	-	Size 100 mm
5	Butterfly valve (remotely operated)	19	Keystone valve (F611)	Size 100 mm
6	Extension Valve	19		
6	Pipe	240 m		Size 100 mm
7	Pump	2	Vertical centrifugal	Casing : Cast Iron
			DESMI NSL 100-215-A02 Monobloc	Impeller : Bronze
				Shaft : stainless steel
				Duty : 100 m3/hr@30 m head

IV.2.2 Pneumatic system equipment

Pneumatic system in this design is for actuator ballast valve. By pneumatic system, ballast valve can operate from control room.

Pneumatic system needs equipment which is in the below table.

Table 4.2 Checklist equipment of Pneumatic system

No	Equipment	QTY	Type and Model	Principal particular
1	Actuator	19	Keystone actuator F79U 006 S	Air Supply = 100 psig Spring return Torque = 486 lb-in
2	Tubing (Capillary Pipe)	650 m	PLN-8x 1.25 NT	size 8 mm
		10 m	PLN-10x 1.5 NT	Size 10 mm
3	Solenoid valve	19	MFH -3-1/8	
4	Solenoid Coil	19	MSFG-24DC/42AC	
5	Push in fitting	19	QS-1/8-8	
		19	QS-1/4-8	
		2	QS-1/4-10	
		4	QS-3/8-10	
6	Connector block	4	PRS-1/8-5-B	
7	Silencer	4	U-3/8-B	
8	Blanking Plug	16	B-3/8	
9	Push in T	3	QST-10	

	Connection			
10	Service Unit	1	FRC-1/4-D-MIDI	
11	Switch on-off	19	BS 211 B	
12	Cable	285 m	NYM 1.5 mm^2	
13	Panel	1	60 x 40	
14	Air Compressor and air receiver	1	TW-071 Launtop Two stage	Q = 30 m^3/hr P= 8 bars

IV.2.3 Electric system equipment

Electric system is using electric motor to operate ballast valve. Electric system can operate from control room. To support electric system needs some equipment in the below table.

Table 4.3 Checklist equipment of Electric system

No	Equipment	QTY	Type and Model	Principal particular
1	Electric motor	19	Keystone actuator F777	1 Phase, 220V
2	Cable	2300m	NYM Eternal	2 x 1.5 mm^2
		25 m	NYM Eternal	4 x 4 mm^2
3	Switch On-off	19	BS 211 B	10 A,380 V 1.5 KW

4	Selector	19		
5	MCB	19	Merin Gerin	1 Phase 6 A
		1	Merin Gerin	3 Phase 20 A
6	Busbar	1	KB363C Hager	AC 230/400V
7	Indicator Lamp and fuse	3		
8	Voltmeter	3	Kings	500 V
9	Ampere meter	3	Kings	200 A
10	Panel	1		60 x 40
11	Digital Timer	19	Brenensthul	

IV.3. Cost Calculation

IV.3.1 Ballast System Cost

From the Checklist equipment data, can be shown that must invest new equipment and other, use existing equipment in the MV. Sinar Jambi.

Some equipment existing in the MV Sinar Jambi for ballast system is:

Table 4.4 List of existing equipment for ballast system

No	Equipment	QTY	Type and Model	Principal particular
1	Strainer	2	-	-
2	Gate valve	2	-	Size 100 mm
3	Butterfly	14	-	Size 100

	valve (Manually operated)			mm
4	Screw down stop And check valve	2	-	Size 100 mm
o r c o 9 n o r	Pump F	2	Vertical centrifugal	Casing : Cast Iron
			DESMI NSL 100-215-A02 Monobloc	Impeller : Bronze
				Shaft : stainless steel
				Duty : 100 m3/hr@30 m head

Consequence, alternative ballast system needs new equipment for infestation. For detail cost must be invested include in the below table.

Table 4.5 Cost of Ballast System

No	Equipment	QTY	Type and Model	Price	
				@ Rp	Total
1	Butterfly valve (remotely operated)	15	Keystone valve (F611)	1.104.000	20.976.000
2	Pipe	240m		114.916	27.850.000
3	Extension Valve	19		460.000	8.740.000
Amount					57.296.000

With above data, can be shown that cost must be invested as consequence alternative ballast system on MV. Sinar jambi is Rp. 57.296.000.

IV.3.2 Pneumatic System Cost

From above data, there are some equipment of pneumatic system are existing in the ship and some of them is must be invested.

From above data, pneumatic equipment that existing in the ship is air Compressor and air Receiver. In addition, other pneumatic equipment is must be invested. For detail, cost of pneumatic system is in the table of pneumatic system cost.

Table 4.6 Cost of Pneumatic System

No	Equipment	QTY	Type and Model	Price	
				@ Rp	Amount
1	Actuator	15	Keystone actuator F79U 006 S	1.941.200	36.882.200
2	Tubing (Capillary Pipe)	650m	PLN-8x 1.25 NT	23.700	15.405.000
		10 m	PLN-10x 1.5 NT	32.800	328.000
3	Solenoid valve	19	MFH -3-1/8	856.000	16.264.000
4	Solenoid Coil	19	MSFG-24DC/42 AC	122.100	2.319.900
5	Push in fitting	19	QS-1/8-8	20.100	381.900
		19	QS ¼-8	20.700	393.300
		4	QS-3/8-10	28.000	112.000

		2	QS-1/4-10	25.400	50.800
6	Connector block	4	PRS-1/8-5-B	469.500	1.878.000
7	Silencer	4	U-3/8-B	134.400	537.600
8	Blanking Plug	16	B-3/8	15.100	241.600
9	Push in T Connectio n	3	QST-10	72.200	216.600
10	Service Unit	1	FRC-1/4-D-MIDI	1.109.900	1.109.900
11	Switch on-off	19	BS 211 B	15.000	285.000
12	Cable	285	NYM 1.5 mm^2	3.800	1.083.000
13	Panel board	1	60 x 40	255.000	255.000
Amount					77.744.400

With above data can be shown that cost must be invested as consequence Pneumatic system actuator on MV. Sinar jambi is Rp. 77.744.400.

IV.3.2 Electric System Cost

From checklist equipment data of electric system, we can determine new equipment must be invested. Electric system will take source of power from generator in ship. The source of power will take from center MSB of electric system in the ship.

Some equipment electric systems that must be invested for pneumatic system actuator are

Table 4.7 Cost of Electric System

No	Equipment	QTY	Type and Model	Price	
				@Rp	Amount
1	Electric motor	19	Keystone actuator F777	3.707.600	70.444.400
2	Cable	2300m	NYM1.5 mm^2 Eternal	3.800	8.740.000
		25m	NYM 4 mm^2 Eternal	17.000	425.000
3	Switch On-off	19	Kings BS 211 B	15.000	285.000
4	Selector	19		20.000	380.000
5	MCB	19	Merin Gerin	46.000	874.000
		1	Merin Gerin	46.000	46.000
6	Busbar	1	KB363C Hager	63.000	63.000
7	Indicator Lamp and fuse	3		14.000	42.000
8	Voltmeter	3	Kings	50.000	150.000
9	Ampere meter	3	Kings	50.000	150.000
10	Panel	1	60 x 40	255.000	255.000
11	Digital Timer	19	Brenensthul	155.000	2.945.000
Amount					84.799.400

With above data, can be shown that cost must be invested as consequence electric system actuator on MV. Sinar jambi is Rp. 84.799.400.

To determine the effective actuator system in the ballast system of MV Sinar Jambi, with compare cost of pneumatic system actuator or electric system actuator.

To determine the cheapest cost of actuator system for ballast system is following formula:

$$Cost_{Pneumatic\ System\ Actuator} = Cost_{Ballast\ system} + Cost_{Pneumatic\ system}$$
$$= 57.296.000 + 77.744.400$$
$$= 135.040.400$$

$$Cost_{Electric\ System\ Actuator} = Cost_{Ballast\ system} + Cost_{Electric\ system}$$
$$= 57.296.000 + 84.799.400$$
$$= 142.095.400$$

From above calculation can be shown that Pneumatic system is suitable for actuator system of ballast system in MV Sinar Jambi.

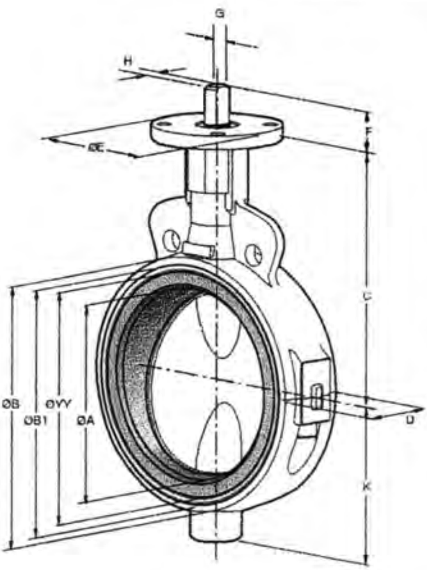
The difference cost between pneumatic system and electric system as actuator ballast valve in MV Sinar Jambi is following formula:

$$Difference\ Cost = Cost_{Electric\ Sys\ Act} - Cost_{Pneumatic\ Sys\ Act}$$
$$= 142.095.400 - 135.040.400$$
$$= 7.055.000.$$

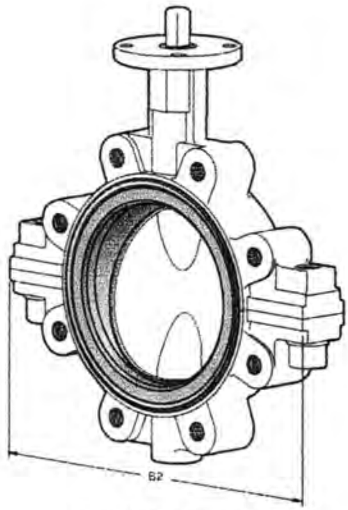
The difference cost between pneumatic actuator and electric actuator is Rp. 7.055.000. It means, pneumatic system is more benefit than electric system for actuator of ballast valve in MV Sinar Jambi.

APPENDIX

Butterfly Valves - Figure 611 & 612
50mm - 300mm



Note: F611 valve illustrated



Note: F612 valve illustrated

Dimensions (mm)

Valve Size mm	Stem Conn. Code	ØA	ØB	ØB1	B2	C	D	ØE	F	K	Q	ØYY	Stem Conn. H x G inches	Key inches	Top Plate PCD. mm	Top Plate Hole Dia. mm	Mass F611 kg	Mass F612 kg
50	-	50	94	80	180	135	43	102	25	71	27	66	0.472 x 0.315		83	11	2.1	3.7
65	BAB	62	109	93	200	150	46	102	30	78	43	78	9/16 x 3/8		83	11	3.2	5.0
80	BAB	78	125	112	240	160	46	102	30	101	64	97	9/16 x 3/8		83	11	3.6	5.9
100	BAC	99	156	144	268	180	52	102	30	115	87	129	5/8 x 7/16		83	11	5.2	8.3
125	BAD	124	189	175	300	195	56	102	30	119	113	160	3/4 x 1/2		83	11	7.6	11.5
150	BAD	151	214	196	335	210	56	102	30	142	141	181	3/4 x 1/2		83	11	8.5	13.0
200	CAE	195	267	248	397	240	60	152	32	179	188	233	7/8 x 5/8		127	14	16.0	22.2
250	CAF	245	321	305	480	275	68	152	50	219	237	290	Ø1 1/8	1/4 x 1/4	127	14	23.5	33.5
300	CAF	292	375	355	544	310	78	152	50	244	283	340	Ø1 1/8	1/4 x 1/4	127	14	32.0	51.0

Notes:
"Q" dimension is the disc chordal dimension at face of valve for disc clearance into lined pipe or fittings.
"H" dimension is the stem connection.
"G" dimension is across the stem flats.
"ØB1" dimension is to the outside of the seat.
"ØYY" dimension is to the O-ring seal.
Mass may vary depending on trim materials used.
Dimensions are nominal to ±1mm.

ıcipated Seating & Unseating Torque Values - Nm (Standard Seats)

ve	Shut Off Pressure kPa/(bar)					
	Normal Service					
	0 (0)	350 (3.5)	700 (7)	1000 (10)	1400 (12)	1600 (16)
	13	13	13	14	15	15
	18	19	20	21	23	25
	25	26	27	30	33	36
	34	37	40	44	49	51
	53	58	63	70	80	85
	74	81	88	99	113	120
	132	148	164	188	219	235
	211	241	271	315	374	403
	303	345	387	451	536	578

onditions that vary from those noted, then apply the following Application Factor ıliers:

ıted less than once per day	x 1.2
ervice with gas or air	x 1.5
ervice with abrasives, cement	x 1.7
ation oils	x 0.5
erature - lower than minus 4.5°C	x 1.2
- higher than 93°C	x 1.2
ical attack: Consult factory	

ıly the as noted Application Factor Multipliers:
ı the base torque value by selecting the required valve size from the left hand column ı read across to the intended line pressure column. Note the torque value. (You can ırpolate between line pressure values.)
ı the zero pressure torque for the same valve on the same row and subtract this zero ssure torque from the value in step 1.
tiply the zero pressure torque value by the expected Application Factors.
ı the difference between the zero pressure torque and the line pressure torque (value of ı 2 plus value of step 3) to give the new torque value specific to the actual service ditions.

ıle:
ım Figure 611 DEE2 AS 2129 E valve is to be used in a clean water application. The essure is 1600 kPa (16 bar) @ 100°C. The valve may only cycle twice per month.
ıing the Normal Service Torque Values table Base Torque value for 150mm @ 1600 kPa 5 bar) = 120Nm
ıd torque value at zero kPa = 74 Nm
ıbtract 120 - 74 = 46Nm
ıltiply zero pressure torque value by Application Factors
ıplication Factors:
ıerated less than once per day = x 1.2
ımperature higher than 93°C = x 1.2
ıultiply Application Factors 1.2 x 1.2 = 1.44 (round off to 1.4)
x 1.4 = 104 Nm
ıd the difference between zero pressure and line pressure, as per step 2 to the value termined in step 3.
+ 104 = 150Nm

ıw torque value for this valve, specific to the actual service conditions is 150 Nm.

Note:

1. *The charted seating and unseating torques are the sum of all friction and for opening and closing of the disc against the indicated pressure differential for normal service.*
2. *Normal Service: Clean liquid service at temperatures between minus 4.5°C to 93°C with no internal deposition or chemical attack.*
   Operated a minimum of once per day.
3. *The relationship between values are linear, therefore you can interpolate between nominated values.*
4. *The effect of dynamic torque is not considered in tabulation.*
5. *In sizing operators it is not necessary to include safety factors.*

Notes

*These stroke times are approximate under no load conditions. Actual times may vary slightly with load conditions near maximum torque rating of the actuator and the setting of the travel limit switches.

Faster speeds are for 20% duty (ON/OFF only) motors and slower speeds are for 80% duty (ON/OFF or Modulating) motors.

Performance data - Open/Close service

Actuator Model	Gear Ratio Electric	Gear Ratio Manual	Handwheel Rim Pull Lbs.	Torque Output Lb.-Ins.	Time for 90° Travel (seconds)*	Weight (Lbs.)
EPI-3	1700:1	70:1	15	300	8 or 17	8.8
EPI-6	1025:1	61:1	16	600	10 or 21	20
EPI-13	1025:1	61:1	30	1300	10 or 21	20
EPI-36	1140:1	65:1	65	3600	11 or 22	53
EPI-51	1140:1	65:1	75	5100	11 or 22	53
EPI-91	3420:1	195:1	90	9100	30 or 60	110
EPI-151	3420:1	195:1	90	15100	30 or 60	110

Performance data - Open/Close service with Speed Control Module

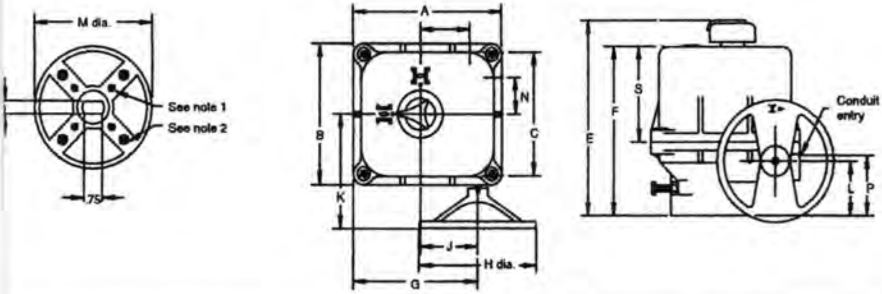
Actuator Model	Gear Ratio Electric	Gear Ratio Manual	Handwheel Rim Pull Lbs.	Torque Output Lb.-Ins.	Time for 90° Travel (seconds)*	Weight (Lbs.)
EPI-6	2105:1	61:1	16	480	22-180	20
EPI-13	2105:1	61:1	30	1040	22-180	20
EPI-36	2205:1	65:1	65	2880	23-180	53
EPI-51	2205:1	65:1	75	4080	23-180	53
EPI-91	6615:1	195:1	90	7280	61-300	110
EPI-151	6615:1	195:1	90	12080	61-300	110

Performance data - Modulating service with Servo-Amplifier

Actuator Model	Gear Ratio Electric	Gear Ratio Manual	Handwheel Rim Pull Lbs.	Torque Output Lb.-Ins.	Time for 90° Travel (seconds)*	Weight (Lbs.)
EPI-3	3500:1	70:1	15	300	18-54	8.8
EPI-6	2105:1	61:1	16	600	22-66	20
EPI-13	2105:1	61:1	30	1300	22-66	20
EPI-36	2205:1	65:1	65	3600	23-69	53
EPI-51	2205:1	65:1	75	5100	23-69	53
EPI-91	6615:1	195:1	90	9100	61-183	110
EPI-151	6615:1	195:1	90	15100	61-183	110

Motor data by size

ctuator		120 VAC 1 Phase		220 VAC 1 Phase		220 VAC 3 Phase		440 VAC 3 Phase		575 VAC 3 Phase		12 VDC		24 VDC	
lodel	Service	F.L.A.	L.R.A	F.L.A.	L.R.A	F.L.A.	L.R.A	F.L.A.	L.R.A	F.L.A.	L.R.A	F.L.A.	L.R.A	F.L.A.	L.R.A
PI-3	Open/Close (8 sec. for 90°)	0.90	1.00	0.60	0.70	--	--	--	--	--	--	1.80	4.30	0.90	7.00
PI-3	Open/Close (17 sec. for 90°)	0.50	0.60	0.30	0.40	--	--	--	--	--	--	2.40	4.30	1.30	7.00
PI-3	Modulating (18 sec. for 90°)	0.50	0.60	0.30	0.40	--	--	--	--	--	--	2.40	4.30	1.30	7.00
PI-6	Open/Close (10 sec. for 90°)	2.10	2.80	1.00	1.30	0.50	2.00	0.30	0.90	--	--	22.00	41.00	11.00	51.00
PI-6	Open/Close (21 sec. for 90°)	0.70	1.20	0.40	0.60	0.60	2.00	0.20	0.90	--	--	10.00	41.00	5.00	51.00
PI-6	Modulating (22 sec. for 90°)	0.70	1.20	0.40	0.60	0.60	2.00	0.20	0.90	--	--	10.00	41.00	5.00	51.00
PI-13	Open/Close (10 sec. for 90°)	2.40	2.80	1.20	1.30	0.60	2.00	0.40	0.90	--	--	26.00	41.00	14.00	51.00
PI-13	Open/Close (21 sec. for 90°)	1.10	1.30	0.50	0.60	0.70	2.00	0.30	0.90	0.30	0.90	12.00	41.00	6.00	51.00
PI-13	Modulating (22 sec. for 90°)	1.10	1.30	0.50	0.60	0.70	2.00	0.30	0.90	0.30	0.90	12.00	41.00	6.00	51.00
PI-36	Open/Close (11 sec. for 90°)	3.20	9.00	2.10	4.50	1.10	5.20	0.60	2.80	--	--	32.00	41.00	18.00	51.00
PI-36	Open/Close (22 sec. for 90°)	1.90	6.00	0.80	2.90	1.00	5.20	0.50	2.80	--	--	24.00	41.00	12.00	51.00
PI-36	Modulating (23 sec. for 90°)	1.90	6.00	0.80	2.90	1.00	5.20	0.50	2.80	--	--	24.00	41.00	12.00	51.00
PI-51	Open/Close (11 sec. for 90°)	4.10	9.00	2.40	4.50	1.60	5.20	0.80	2.80	--	--	--	--	--	--
PI-51	Open/Close (22 sec. for 90°)	2.30	6.00	1.50	2.90	1.10	5.20	0.60	2.80	0.50	2.20	--	--	--	--
PI-51	Modulating (23 sec. for 90°)	2.30	6.00	1.50	2.90	1.10	5.20	0.60	2.80	0.50	2.20	--	--	--	--
PI-91	Open/Close (30 sec. for 90°)	3.50	9.00	2.50	4.50	1.70	5.20	0.90	2.80	--	--	--	--	--	--
PI-91	Open/Close (60 sec. for 90°)	2.20	6.00	1.00	2.90	1.10	5.20	0.60	2.80	--	--	--	--	--	--
PI-91	Modulating (61 sec. for 90°)	2.20	6.00	1.00	2.90	1.10	5.20	0.60	2.80	--	--	--	--	--	--
PI-151	Open/Close (30 sec. for 90°)	5.00	9.00	3.10	4.50	2.40	5.20	1.20	2.80	--	--	--	--	--	--
PI-151	Open/Close (60 sec. for 90°)	2.70	6.00	1.90	2.90	1.20	5.20	0.70	2.80	0.50	2.20	--	--	--	--
PI-151	Modulating (61 sec. for 90°)	2.70	6.00	1.90	2.90	1.20	5.20	0.70	2.80	0.50	2.20	--	--	--	--



ensions (inches)

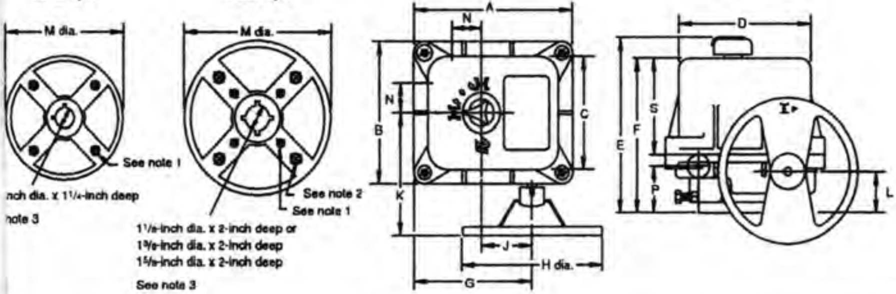
Enclosure	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	S
B, G, S	6.38	5.75	4.75	5.38	7.72	6.88	5.32	5.00	2.44	4.75	2.19	4.00	1.37	2.23	2.00	4.56

s

tapped holes in actuator are 1/4-20UNC
1 3/4-inch bolt circle straddling centerline.

tapped holes in actuator are 3/8-16UNC
3 1/4-inch bolt circle straddling centerline.

3. Two 3/4-inch NPT conduit entries available.
4. 'S' dimension is the clearance required to remove cover.
5. Torque switches are not available in Size 1.
6. Depth of bore is 1.25 inches.



nsions (inches)

Enclosure	A	B	C	D	E	F	G	H	J	K	L	M	N	P	S
, G, H	8.94	7.56	6.62	8.11	9.60	8.63	6.90	8.00	3.13	6.53	2.32	4.00	2.06	2.44	6.38
, C, F	8.96	7.56	7.48	8.88	9.63	8.72	7.24	8.00	3.13	6.76	2.43	4.00	2.28	2.56	5.31
, J, L	10.25	8.88	6.88	8.25	10.38	9.38	7.56	6.00	3.13	7.56	2.32	4.00	2.06	2.38	7.69
, G, H	11.50	9.50	8.25	10.25	13.00	11.95	9.06	12.00	4.31	8.50	3.81	6.00	2.81	4.00	7.88
, C, F	10.18	9.02	8.94	10.10	12.96	12.05	8.92	12.00	4.31	8.00	3.93	6.00	2.68	4.37	6.89
, J, L	12.38	10.38	8.38	10.38	13.06	12.06	9.38	12.00	4.31	8.56	3.81	6.00	2.76	3.88	8.63

pped holes in actuator are 3/8-16UNC
1/4-inch bolt circle straddling centerline
es 2-5.

pped holes in actuator are 1/2-13UNC
inch bolt circle straddling centerline for
and 5 only.

3. Keyways to accept a 1/4-inch square key for 1 1/8-inch diameter bore, 5/16-inch square key for 1 3/8-inch diameter bore, and 3/8-inch square key for 1 5/8-inch bore.
4. Two 1-inch NPT conduit entries available.
5. 'S' dimension is the clearance required for cover removal.

Notes

1. Operating times under no load for air pressures from 40 psig to 100 psig. (Times based on actual measurements.)
2. Total time is defined as time required from switching solenoid valve to completion of 90 degree stroke.
3. Stroke times can be increased or decreased dramatically by using speed controls, oversized pilot valves or quick-exhaust valves.
4. Air Consumption:
   Cubic inches shown in chart represent actual free air volume in either open or close direction. Air consumption will vary depending on supply pressure. To determine standard cubic feet per minute use the following formula:

Double Acting SCFM =

$$\left(\frac{\text{Open + Close Vol. in}^3}{1728}\right)\left(\frac{\text{Supply Air psig + 14.7}}{14.7}\right)\left(\text{Cycles/Min}\right)$$

Spring Return SCFM =

$$\left(\text{Air Stroke Vol. in}^3\right)\left(\frac{\text{Supply Air psig +14.7}}{14.7}\right)\left(\text{Cycles/Min}\right)$$

Example: Calculate SCFM for size 036 double acting using 80 psig air supply and 5 cycles/minute.

Double Acting SCFM =

$$\left(\frac{119 + 83}{1728}\right)\left(\frac{80 + 14.7}{14.7}\right)\left(5\right) \quad \text{SCFM} = 3.77$$

5. All Double Acting Actuator operating times are based on using a standard Tyco 5/2 solenoid valve with nominal .7C_V.
6. All Spring Return Actuator operating times are based on using a standard Tyco 3/2 solenoid valve with nominal .4C_V.

Double Acting Actuator Operating Times (seconds)

Actuator Size	Stroke Time	Total Time
003	0.16	0.24
006	0.26	0.37
012	0.45	0.64
024	0.90	1.22
036	1.32	1.76
065/066	3.60	5.10
090/091	4.50	6.30
180/181	5.90	7.90

Spring Return Actuator Operating Times (seconds)

Actuator Size	Stroke Time		Total Time	
	Air	Spring	Air	Spring
003S	0.30	0.35	0.40	0.42
006S	0.50	0.50	0.52	0.54
012S	0.63	0.68	1.00	1.10
024S	1.40	1.60	2.10	2.30
036S	2.10	2.20	2.60	2.90
065S/066S	3.60	4.50	4.80	5.80
090S/091S	8.70	5.20	9.50	6.30
180S/181S	12.60	10.75	12.90	11.20

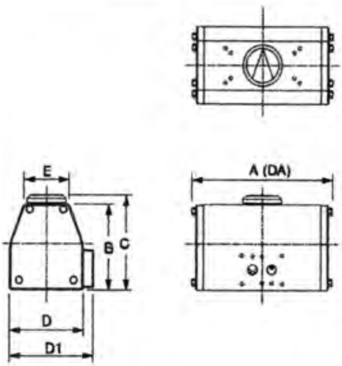
Actuator Piston Displacement (in³)

Actuator Size	Open-Double Acting Air Stroke - Spring Return	Close - Double Acting
003	11	8
006	21	14
012	38	28
024	79	56
036	119	83
065/066	215	161
090/091	292	204
180/181	591	409

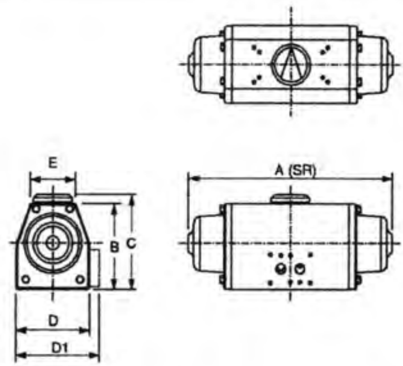
Actuator Weight (lb.)

Actuator Size	Double Acting	Spring Return
003	2.7	3.3
006	5.7	7.9
012	7.7	12.5
024	16.7	26.0
036	27.0	38.0
065/066	41.9	75.0
090/091	63.9	99.2
180/181	99.2	158.7

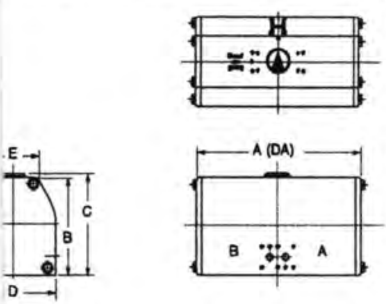
003



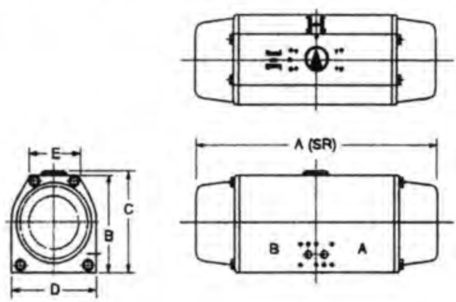
Size 003S



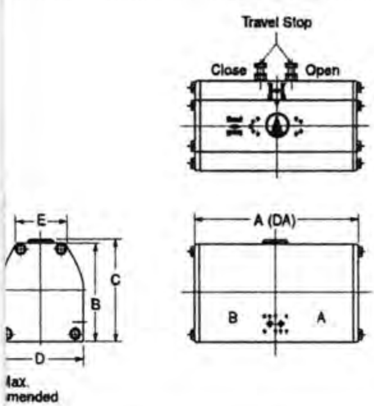
006-036



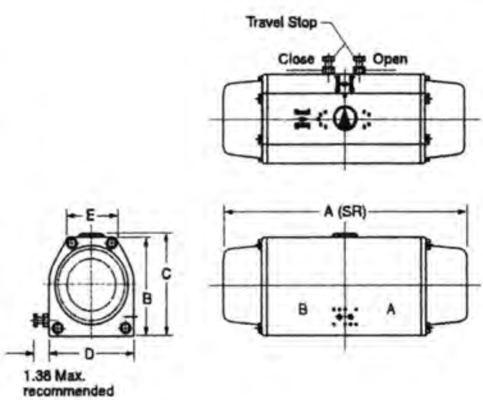
Size 006S-036S



065-181



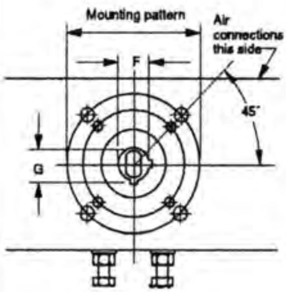
Size 065S-181S



General Information

A. A comprehensive range of adaptors are available to suit all Tyco valve stems.

B. Actuators can be mounted parallel or perpendicular to valve flow.



Notes

Each body has both types of accessory mounting pads.

1. Tyco standard mounting pad
2. NAMUR mounting pad

Sizes 065 to 181

1. On sizes 065 to 181, the total travel of 100 degrees allows for end-of-travel adjustment of 5 degrees over and 7 degrees under at both open and close positions.
2. Travel stop bolts (when present) must not be used for manual override.
3. Mounting pattern with 5.00 PCD is only available on 180/181 size with the use of a 0.75 thick mounting plate.

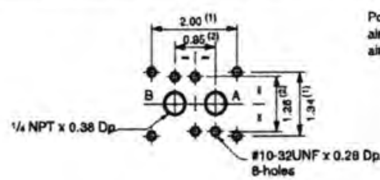
Actuator Dimensions (inches)

Actuator Size	A(SR)	A(DA)	B	C	D	D1	E
003	8.23	5.57	3.19	3.54	3.27	3.58	2.20
006	10.10	6.55	4.08	4.41	3.66	–	2.26
012	11.10	7.13	5.00	5.35	4.38	–	3.25
024	13.82	9.17	5.90	6.26	5.35	–	3.35
036	16.69	10.72	6.87	7.24	6.00	–	3.50
065/066	19.69	12.78	8.55	8.90	8.00	–	4.50
090/091	23.00	16.08	8.55	8.90	8.00	–	4.50
180/181	27.32	18.94	10.55	10.90	9.84	–	5.12

Mounting Dimensions (inches) - 79U

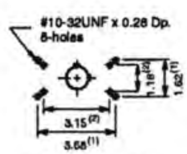
Actuator Size	Shaft Bore F	Keyway Size G	Keyway Size Width	Key Size	Mounting Patterns PCD	Mounting Patterns Mounting Holes
003	0.814 Dia.	0.855	0.189	3/16 Sq.	1.75	4 x 1/4-20UNC x 0.38 Dp.
006/012	1.004 Dia.	1.060	0.252	1/4 x 3/16	3.25	4 x 3/8-16UNC x 0.56 Dp.
024/036	1.128 Dia.	1.250	0.252	1/4 Sq.	3.25 5.00	4 x 3/8-16UNC x 0.56 Dp. 4 x 1/2-13UNC x 0.63 Dp.
065	1.128 Dia.	1.250	0.252	1/4 Sq.	5.00	4 x 1/2-13UNC x 0.63 Dp.
066	1.380 Dia.	1.523	0.315	5/16 Sq.	5.00	4 x 1/2-13UNC x 0.63 Dp.
090	1.628 Dia.	1.808	0.378	3/8 Sq.	5.00 6.50	4 x 1/2-13UNC x 0.63 Dp. 4 x 3/4-10UNC x 1.00 Dp.
091	1.882 Dia.	2.058	0.504	1/2 x 3/8	5.00 6.50	4 x 1/2-13UNC x 0.63 Dp. 4 x 3/4-10UNC x 1.00 Dp.
180	1.882 Dia.	2.058	0.504	1/2 x 3/8	5.00 6.50	4 x 1/2-13UNC x 0.63 Dp.[3] 4 x 3/4-10UNC x 1.00 Dp.
181	2.257 Dia.	2.437	0.504	1/2 x 3/8	5.00 6.50	4 x 1/2-13UNC x 0.63 Dp.[3] 4 x 3/4-10UNC x 1.00 Dp.

Accessory Drillings to Actuator Body (inches)

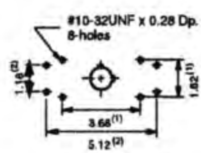


Port Hole Drillings
air port 'B' - CLOSED
air port 'A' - OPEN

* On sizes 180/181 drillings are aligned vertically (not horizontally as shown) with Port A at top.



Top mounting drilling sizes 003 to 036



Top mounting drilling sizes 065 to 181

Actuator Shaft Top Detail (inches)

Size	Shaft Bore
003	0.814 Dia. x 0.855 x 0.189 Keyway (3/16 Sq. Key)
006/012	1.004 Dia. x 1.060 x 0.252 Keyway (1/4 x 3/16 Key)
024/036/065/066/090/091/180/181	1.128 Dia. x 1.250 x 0.252 Keyway (1/4 Sq. Key)

put Torques (lb.in.) for Single Acting (spring return) Actuators

ator	Spring Rating (psig)	Spring End	Spring Start	Air Torque	Air Supply in psig 40	50	60	80	100	120
5	40	62	104	Start	81	123	165	250	334	418
				End	39	81	123	208	292	376
	60	100	162	Start			127	212	296	380
				End			65	150	234	318
	80	137	221	Start				175	259	343
				End				91	175	259
	100	174	279	Start					222	306
				End					117	201
5	40	123	200	Start	151	232	312	474	635	796
				End	74	155	235	397	558	719
	60	197	312	Start			238	400	561	722
				End			123	285	446	607
	80	272	425	Start				325	486	647
				End				172	333	494
	100	346	538	Start					412	573
				End					220	381
5	40	245	395	Start	288	445	601	915	1228	1542
				End	138	295	451	765	1078	1392
	60	391	616	Start			455	769	1082	1396
				End			230	544	857	1171
	80	536	836	Start				624	937	1251
				End				324	637	951
	100	709	1058	Start					764	1078
				End					415	729
3	40	482	783	Start	583	896	1209	1836	2462	3088
				End	282	595	908	1534	2161	2787
	60	771	1221	Start			920	1546	2173	2799
				End			470	1096	1728	2349
	80	1059	1660	Start				1258	1885	2511
				End				657	1284	1910
	100	1347	2098	Start					1597	2223
				End					846	1472
	40	718	1149	Start	874	1342	1810	2746	3882	4618
				End	443	911	1379	2315	3251	4187
	60	1149	1794	Start			1379	2315	3251	4187
				End			734	1670	2606	3542
	80	1579	2438	Start				1885	2821	3757
				End				1026	1962	2898
	100	2006	3083	Start					2392	3328
				End					1317	2253
/066S	40	1395	2896	Start	1681	2586	3491	5300	7109	8919
				End	813	1718	2623	4432	6241	8051
	60	2226	3530	Start			2660	4469	6278	8088
				End			1356	3165	4974	6784
	80	3059	4578	Start				3636	5445	7255
				End				2117	3926	5736
	100	3892	6064	Start					4612	6422
				End					2440	4250
'081S	40	1772	2874	Start	2135	3284	4433	6731	9029	—
				End	1033	2182	3331	5629	7927	—
	60	2827	4484	Start			3376	5676	7974	—
				End			1721	4019	6317	8615
	80	3885	6093	Start				4618	6916	9214
				End				2410	4708	7006
	100	4948	7703	Start					5858	8156
				End					3098	5396
181S	40	3637	5905	Start	4389	6750	9111	13833	18554	23276
				End	2122	4482	6843	11565	16286	21008
	60	5810	9212	Start			6938	11660	16381	21103
				End			3537	8258	12980	17701
	80	7983	12518	Start				9487	14209	18930
				End				4952	9673	14395
	100	10155	15825	Start					12036	16758
				End					6367	11008

Address of supplier

Inquiry

FESTO

Sender | **Billing address** | **Delivery address**

INFORMATION			Please quote in all enquiries
Date of order:	13/12/2006	Customer no.:	ITS-Miftah
Date of delivery:		Customer order no.:	
Editor:		Form of delivery:	
No. of order:		Notices:	

Part no.	TYPE	PRODUCT NAME	QTY.	UNIT PRICE	DISC.	TOTAL PRICE
7802	MFH-3-1/8	Solenoid valve	15	856.000,00	0,00	12.840.000,00
4527	MSFG-24DC/42AC	Solenoid coil	15	122.100,00	0,00	1.831.500,00
153004	QS-1/8-8	Push-in fitting	15	20.100,00	0,00	301.500,00
11901	PRS-1/8-5-B	Connector block	3	469.500,00	0,00	1.408.500,00
6843	U-3/8-B	Silencer	3	134.400,00	0,00	403.200,00
3570	B-3/8	Blanking plug	3	15.100,00	0,00	45.300,00
153008	QS-3/8-10	Push-in fitting	3	28.000,00	0,00	84.000,00
153131	QST-10	Push-in T conne..	2	72.200,00	0,00	144.400,00
186497	FRC-1/4-D-MIDI	Service unit	1	1.109.900,00	0,00	1.109.900,00
153007	QS-1/4-10	Push-in fitting	2	25.400,00	0,00	50.800,00
193405	PLN-8x1,25-NT	Plastic tubing	50	23.700,00	0,00	1.185.000,00
193406	PLN-10x1,5-NT	Plastic tubing	10	32.800,00	0,00	328.000,00
153005	QS-1/4-8	Push-in fitting	15	20.700,00	0,00	310.500,00
					Final total:	20.042.600,00

Signature

FESTO

Data sheet

Part no.: **6843**

U-3/8-B

Silencer

Feature	Data/description
Assembly position	Any
Operating pressure	0 - 10 bar
Flow rate to atmosphere	5,734 l/min
Operating medium	Compressed air, filtered, unlubricated Filtered, lubricated air Dried compressed air, lubricated or unlubricated
Sound pressure level	80 dB(A)
Ambient temperature	-10 - 70 °C
Product weight	37 g
Pneumatic connection	G3/8
Materials information for shock absorber insert	PE
Materials information for screw-in stud	Aluminium die cast
Materials note	Copper and Teflon-free

PT.Festo
Jl.Sultan Iskandar Muda No.68
Jaksel 12240

FESTO

Data sheet

Part no.: **153005**

QS-1/4-8

Push-in fitting

Feature	Data/description
Size	Standard
Nominal size	7 mm
Type of seal on screw-in stud	coating
Design structure	Push/pull principle
Operating pressure	-0.95 - 10 bar
Operating medium	Compressed air, filtered, unlubricated Filtered, lubricated air
Corrosion resistance classification CRC	1
Ambient temperature	0 - 60 °C
Max. tightening torque	12 Nm
Product weight	15 g
Pneumatic connection	R1/4 for tubing, 8mm outside diameter
Materials information, housing	Brass
Materials information for thread seal	PTFE
Materials information for tubing seal	NBR
Hose clamping segment material data	High alloy steel, non-corrosive Brass

PT.Festo
Jl.Sultan Iskandar Muda No.68
Jaksel 12240

FESTO

Data sheet

Part no.: **153007**

QS-1/4-10

Push-in fitting

Feature	Data/description
Size	Standard
Nominal size	8.5 mm
Type of seal on screw-in stud	coating
Design structure	Push/pull principle
Operating pressure	-0.95 - 10 bar
Operating medium	Compressed air, filtered, unlubricated Filtered, lubricated air
Corrosion resistance classification CRC	1
Ambient temperature	0 - 60 °C
Max. tightening torque	12 Nm
Product weight	20 g
Pneumatic connection	R1/4 for tubing, 10mm outside diameter
Materials information, housing	Brass
Materials information for thread seal	PTFE
Materials information for tubing seal	NBR
Hose clamping segment material data	High alloy steel, non-corrosive Brass

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Jaksel 12240

FESTO

Data sheet

Part no.: **153004**

QS-1/8-8

Push-in fitting

Feature	Data/description
Size	Standard
Nominal size	6 mm
Type of seal on screw-in stud	coating
Design structure	Push/pull principle
Operating pressure	-0.95 - 10 bar
Operating medium	Compressed air, filtered, unlubricated Filtered, lubricated air
Corrosion resistance classification CRC	1
Ambient temperature	0 - 60 °C
Max. tightening torque	7 Nm
Product weight	15 g
Pneumatic connection	R1/8 for tubing, 8mm outside diameter
Materials information, housing	Brass
Materials information for thread seal	PTFE
Materials information for tubing seal	NBR
Hose clamping segment material data	High alloy steel, non-corrosive Brass

PT.Festo
Jl.Sultan Iskandar Muda No.68
Jaksel 12240

FESTO

Data sheet

Part no.: **153008**

QS-3/8-10

Push-in fitting

Feature	Data/description
Size	Standard
Nominal size	8.5 mm
Type of seal on screw-in stud	coating
Design structure	Push/pull principle
Operating pressure	-0.95 - 10 bar
Operating medium	Compressed air, filtered, unlubricated Filtered, lubricated air
Corrosion resistance classification CRC	1
Ambient temperature	0 - 60 °C
Max. tightening torque	22 Nm
Product weight	26 g
Pneumatic connection	R3/8 for tubing, 10mm outside diameter
Materials information, housing	Brass
Materials information for thread seal	PTFE
Materials information for tubing seal	NBR
Hose clamping segment material data	High alloy steel, non-corrosive Brass

PT.Festo
Jl.Sultan Iskandar Muda No.68
Jaksel 12240

FESTO

Catalogue page

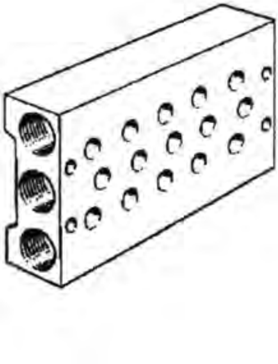
Part no.: 11901

Page:1

PRS-1/8-5-B

Connector block

Tiger Classic



Manifold assembly
Mounting strip PAL-... for 2 to 6 valve positions with 3/2 and 5/2-way valves (sizes: G1/8, G1/4, G1/2)
Scope of delivery: 1 mounting strip, 2 mounting brackets, 1 reducing nipple and 4 sealing rings, 1 blanking plug and sealing rings for the hollow bolts
Hollow bolt VT-...
Hollow bolt VT-...-AJK-P, VT-...-AJS-P, VT-...-AJ-P for separate compressed air supply
Blanking cap VTM-... for blanking vacant positions

MOFH-3-1/4 is not suitable for manifold mounting.

Mounting block PRS-... for 2 to 6 valve positions with 5/2-way valves (sizes: G1/8, G1/4)
Scope of delivery: 1 mounting rail, 3 blanking plugs, 3 sealing rings

Blanking plate PRSB-... for blanking vacant positions

Hollow bolt VT-...-PRS with sealing ring and 3 O-rings
Hollow bolt VT-1/8-AJK-P, VT-1/4-AJ-P for separate compressed air supply

PT.Festo
Jl.Sultan Iskandar Muda No.68
Jaksel 12240

FESTO

Data sheet

Part no.: **153131**

QST-10

Push-in T connector

Feature	Data/description
Size	Standard
Nominal size	8 mm
Design structure	Push/pull principle
Operating pressure	0 - 10 bar
Operating medium	Compressed air, filtered, unlubricated Filtered, lubricated air
Corrosion resistance classification CRC	1
Ambient temperature	0 - 60 °C
Pneumatic connection	for tubing, 10mm outside diameter

PT.Festo
Jl.Sultan Iskandar Muda No.68
Jaksel 12240

FESTO

Data sheet

Part no.: **186497**

FRC-1/4-D-MIDI

Service unit

Feature	Data/description
Size	Midi
Series	D
Actuator lock	Rotary knob with lock
Assembly position	Vertical +/- 5°
Grade of filtration	40 µm
Condensate drain	manual rotary
Design structure	Filter regulator with pressure gauge Proportional standard oil-mist lubricator
Max. condensate volume	43 cm3
Bowl guard	Metal bowl guard
Pressure gauge	with pressure gauge
Pressure control range	0.5 - 12 bar
Inlet pressure 1	<= 16 bar
Max. pressure hysteresis	0.2 bar
Standard nominal flow rate	1,500 l/min
Operating medium	Compressed air
Medium temperature	-10 - 60 °C
Ambient temperature	-10 - 60 °C
Product weight	1,440 g
Mounting type	Line installation with accessories
Pneumatic connection, port 1	G1/4
Pneumatic connection, port 2	G1/4
Materials information, housing	Zinc die-casting

PT.Festo
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FESTO

Data sheet

Part no.: **4527**

MSFG-24DC/42AC

Solenoid coil

Feature	Data/description
Assembly position	Any
Min. pickup time	10 ms
Duty cycle	100%
Characteristic coil data	24V DC: 4.5W 42V AC: 50/60Hz, AL7.5W,HL6W
Permissible voltage fluctuation	+/- 10 %
Medium temperature	-10 - 60 °C
Protection class	IP65
Ambient temperature	-5 - 40 °C
Product weight	65 g
Electrical connection	Plug vanes for MSSD-F 3-pin
Mounting type	With knurled nut
Materials information, housing	PA
Materials information, plug	Steel
Material information, coil	Copper

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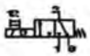
FESTO

Data sheet

Part no.: **7802**



MFH-3-1/8

Solenoid valve

Feature	Data/description
Nominal size	5 mm
Type of actuation	electrical
Sealing principle	soft
Assembly position	Any
Manual override	detenting
Design structure	Poppet seat
Type of reset	mechanical spring
Type of piloting	Piloted
Flow direction	non reversible
Valve function	3/2 closed
Operating pressure	1.5 - 8 bar
Control pressure characteristics (diagram)	Diagram
Standard nominal flow rate	500 l/min
Switching time off	28 ms
Switching time on	9 ms
Operating medium	Dried compressed air, lubricated or unlubricated
Medium temperature	-10 - 60 °C
Protection class	IP65
Ambient temperature	-5 - 40 °C
Product weight	240 g
Electrical connection	Via F coil, must be ordered separately
Mounting type	Optional with through hole

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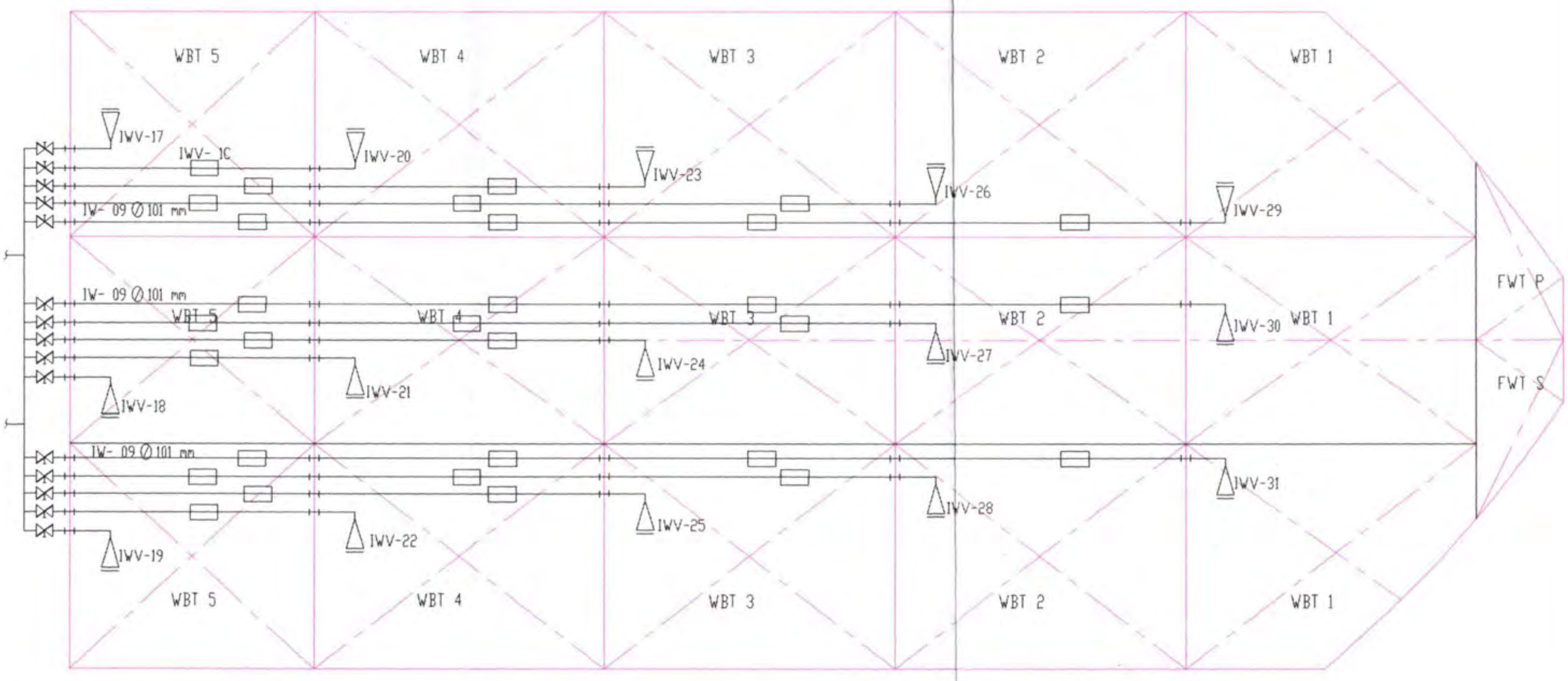
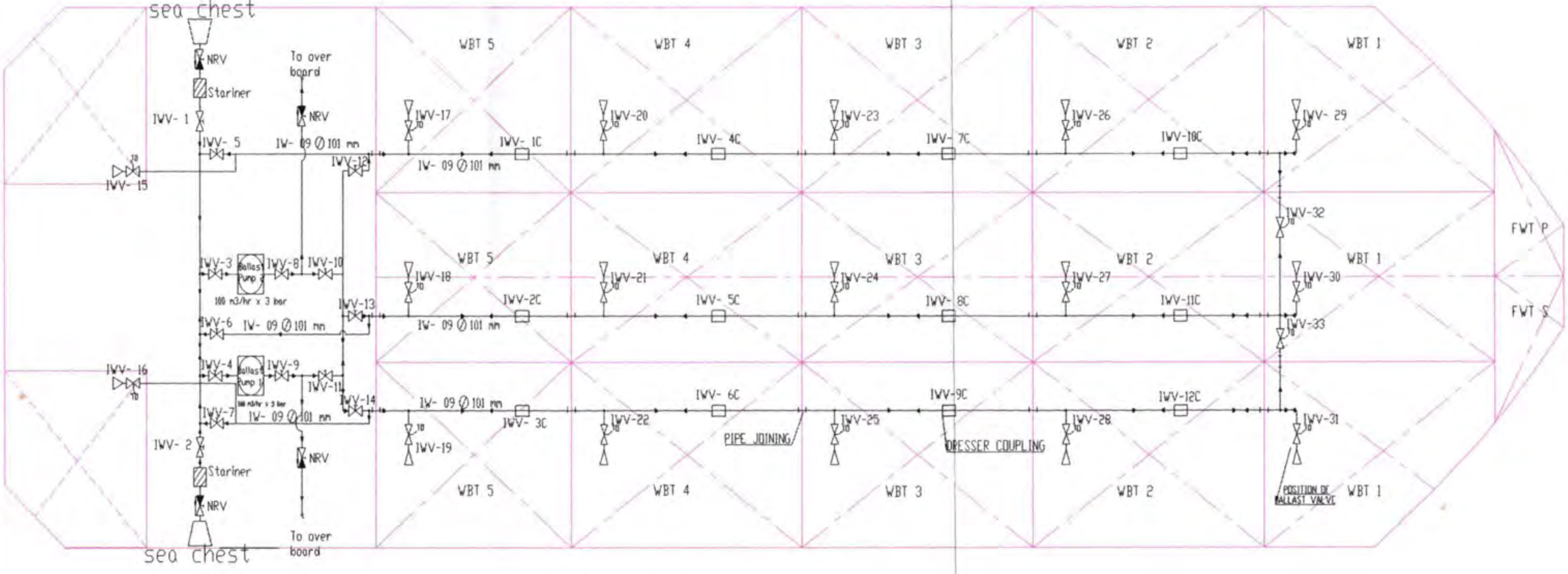
Jaksel 12240

EXIXTEING BALLAST SYSTEM



EXISTING BALLAST SYSTEM OF MV SINAR JAMBI

NEW DESIGN BALLAST SYSTEM OF MV. SINAR JAMBI

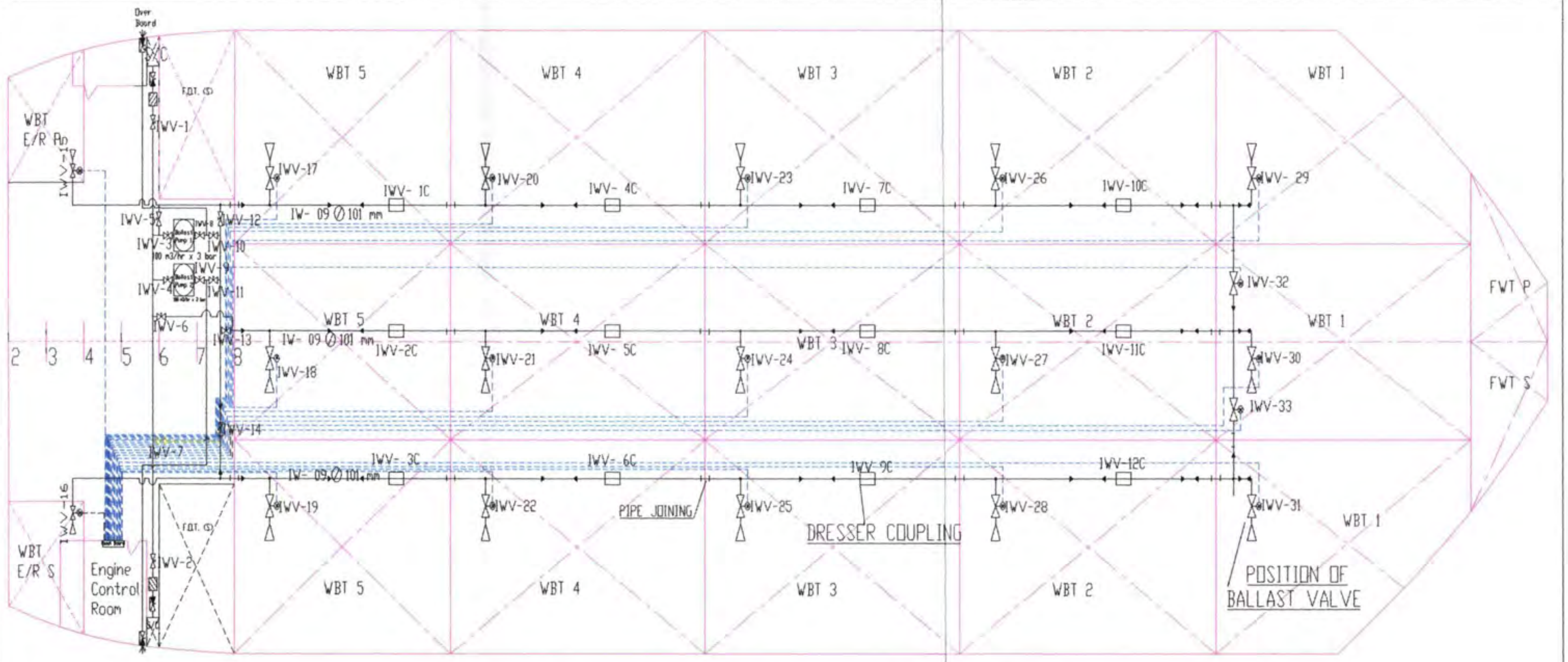


NEW DESIGN BALLAST SYSTEM OF MV SINAR JAMBI

Symbol	Explanation	Symbol	Explanation
(bell symbol)	Bell-Mounted Pipe End	(pump symbol)	Centrifugal Pump
(valve symbol)	Butterfly valve	(NRV symbol)	Non Return Valve, Straigh, Screw Down
(valve symbol)	Butterfly valve with remote control actuator	(strainer symbol)	strainer

DRAWING	Date	:
PFD BALLAST SYSTEM	Drawing By	: Miftakhul Arif
	Supervisor	: Ir. Hari Prastowo
	Revision	:

NEW DESIGN BALLAST SYSTEM OF MV. SINAR JAMBI WITH ELECTRIC ACTUATOR

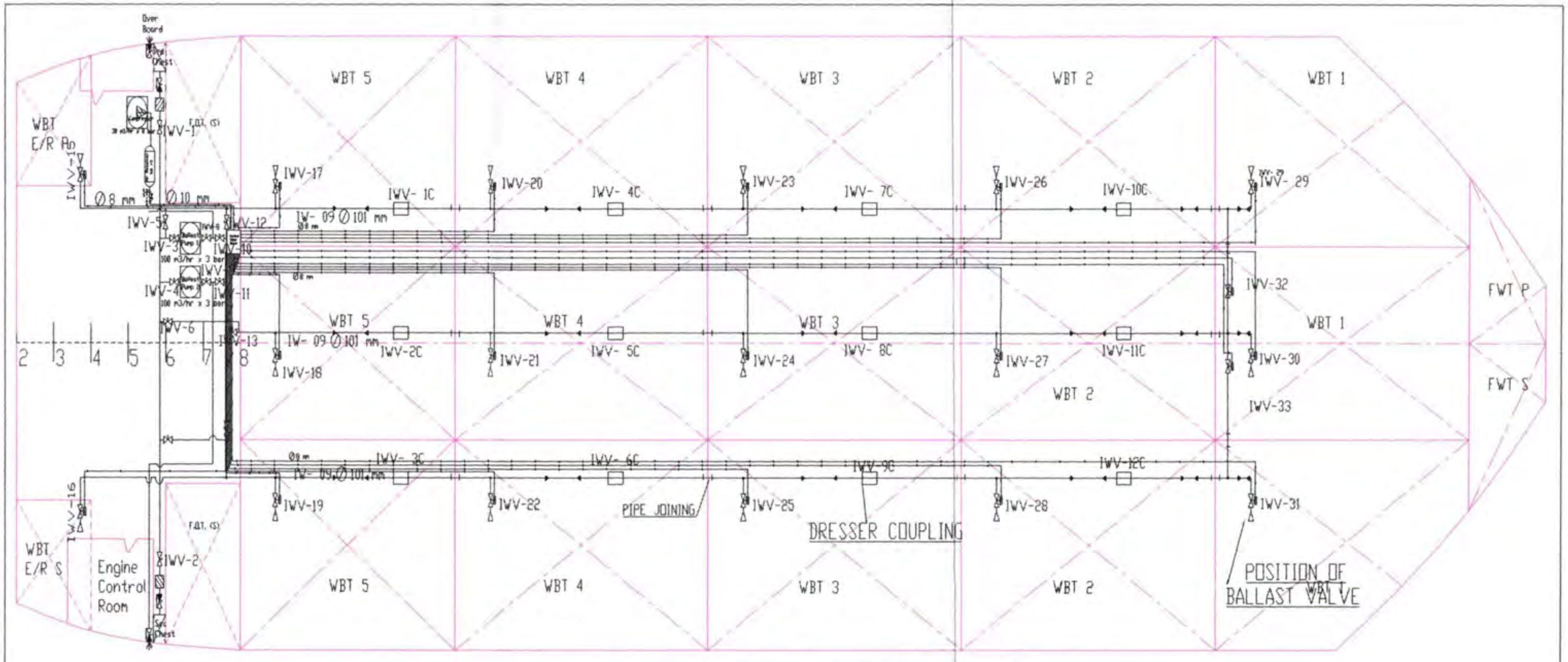


EXISTING BALLAST SYSTEM OF MV SINAR JAMBI WITH ELECTRIC ACTUATOR

Symbol	Explanation	Symbol	Explanation	Symbol	Explanation
⍋	Bell-Mounted Pipe End	⬭	Centrifugal Pump	- - - - - -	Electric Cable
⋈	Butterfly valve	⋈	Non Return Valve, Straigh, Screw Down	————	Ballast Pipe
⋈	Butterfly valve with electric motor actuator	▨	strainer		

DRAWING	Date :
PFD BALLAST SYSTEM	Drawing By : Miftakhul Arif
	Supervisor : Ir. Hari Prastowo
	Revision :

NEW DESIGN BALLAST SYSTEM WITH PNEUMATIC ACTUATOR



EXISTING BALLAST SYSTEM OF MV SINAR JAMBI WITH PNEUMATIC ACTUATOR

Symbol	Explanation	Symbol	Explanation	Symbol	Explanation
Δ	Bell-Mounted Pipe End		Centrifugal Pump	-*-*-*-	Tubing (Pipe Capillary)
	Butterfly valve		Non Return Valve, Straigh, Screw Down	———	Ballast Pipe
	Butterfly valve with Pneumatic actuator		strainer		Compressor

DRAWING	Date	:
PFD BALLAST SYSTEM	Drawing By	: Miftakhul Arif
	Supervisor	: Ir. Hari Prastowo
	Revision	:

PROFILE

My name is Miftakhul Arif, was born in December 7^{th} 1983 on Lamongan city. My habits are football, traveling and reading. I am a Moslem. I have favorite football team is Juventus.

When 1999 I have finished junior high school in SMP 45 Sukodadi, then 2002 I have finished senior high school in SMA BPPT Al Fattah Lamongan. In 2002 I enter Sepuluh Nopember Institute of Technology in Marine Engineering Department by using UMPTN Test. I take UMPTN test in D3 Teknik Mesin ITS.

At the University, I join some student organizations such as Kajian Al Mi'roj, Mahkamah Konstitusi Mahasiswa, Community of Lamongan student in ITS, Community of Marine Student etc. I am active in social organization namely IPNU Pucuk.

I have some award such as The Young Lamongan Award; Finalist of PKMI DIKTI 2005, etc. I like to study about piping system. I would like to be piping engineer. I have finished my study in 9 semeters. I hope by finishing final project, can useful for me and all of people who read this final project.