Frese Case study

Frese A/S

T113-770-500-001 Installation of Frese valves in machinery piping systems – A case study

Revision A

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OMT

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-	02-11-2018	First draft	ANHC	PEMJ
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Contents

1 Introduction

FRESE A/S produces advanced high-quality valves for controlling flow of liquids including water and oils.

OMT A/S has been requested by FRESE A/S to provide a case study to investigate the installation of FRESE Valves in traditional machinery systems for typical marine applications.

The study is to investigate the applications of the FRESE valves installed in traditional machinery piping systems instead of the other more traditional solutions and to quantify the advantages and opportunities of installing Pressure Independent Balancing and Control valves.

2 Scope

Based on OMTs design of machinery piping systems for marine applications, OMT shall provide proposals where the installation of the FRESE valves are considered suitable.

Typical piping systems to investigate could include:

- LT FW and HT FW Cooling Systems
- SW Cooling System
- Reefer Cooling Systems
- Ballast Water system (BWTS)
- SW systems for Scrubber installation
- Firefighting Systems
- Fuel Oil Systems
- Central Heating Systems
- Chilled Water Systems
- and other relevant systems.

For the selected systems the following parameters shall be described/calculated:

- Energy savings
- Engineering and design savings
- Installation and commissioning time
- Costs
- Description of advantages/disadvantages.

The investigation will in general be based on a comparison between a conventional design and a design where suitable FRESE valves are installed. The relevant scenarios for each system which can be but not limited to:

1. Traditional valve/orifice and no regulation of pump flow
2. FRESE valves and no regulation of pumps flow
3. Traditional valve/orifice and Variable Pump regulation
4. FRESE Valves and Variable Pump regulation

OMT shall provide simple process- and instrumentation diagrams of the selected systems.

Calculations will be performed in excel sheets converted to pdf files.

OMT will provide the final report of the case study with agreed focus on the advantages/disadvantages of installing FRESE valves in Machinery Piping systems.

3 Description of Frese Valves

The valves include 3 different types:

ALPHA (Appendix no 1)

SIGMA (Appendix no 2

OPTIMA COMPACT (Appendix no 3)

The ALPHA type valve is a simple fixed flow control type which are used in systems where there required flow has been specified and the valve is constructed for this particular flow. The valve is arranged with screw connections but can also be arranged as a wafer type solution. The ALPHA valves can be delivered up to DN 800 mm. Further description is shown in **Appendix no 1.**

The SIGMA COMPACT valve type is an adjustable valve where the required flow can be set. The valve can be built into systems with variable and constant flow systems. Further the valve has the function of a shut off valve. Further description is shown in **Appendix no 2**.

The OPTIMA COMPACT type is a remote-controlled valve which provides modulating control and still operate independently of the differential pressure of the system. Further description is shown in **Appendix no 3.**

All valves can be delivered in materials suitable for the relevant marine systems.

4 Proposed piping systems to be considered

OMT has designed different types of Ships and the design of machinery piping systems are always an important part of the delivery. The design process is coordinated together with the Client to include special features into the design. In many cases the Client is a Yard and here the focus is entirely on the costs and in some cases the Client is the Shipowner who will have another focus such as lifetime, easy operation and suitable for the number of persons dedicated for the machinery spaces.

OMT has scanned some of the recent designs for bulk carriers, container ships and Navy vessels and evaluated if any type of the FRESE valves are feasible to install. In Section 4.2 these systems are described. In Section 4.3 the systems where the application of FRESE valves are not considered feasible are shortly discussed.

4.1 Limitations

The following limitations have been decided:

As mentioned in the introduction only liquids are considered.

Dirty oils such as heavy fuel, sludge and waste oils are not included.

High viscosity fluids.

Liquids which are contaminated with pipe scales or other particles (maximum particle size 6 mm).

Max temperatures up to 120 °C and max pressure up to 7 Bar.

Flow accuracy: +/-10%.

4.2 Marine Piping systems where the installation of FRESE valves are feasible.

The application of the control valves is feasible in all kind of distribution systems where a certain flow shall be ensured with various service conditions i.e. where the system pressure is variable. Therefore, the piping systems include:

4.2.1 Low Temperature FW cooling system (LTFW)

The LTFW system is a closed circulation system which provide FW as the cooling medium to most of the machinery components within the Engine room.

The temperature of the system is typical from 10 to 60 °C with a set point of 36 °C provided by the coolers. The flow velocity is in the interval 2-3 m/s based on black steel pipes.

The flow is provided by centrifugal pumps. Often the pumps are arranged with frequency control in case of variated flow due to different modes of operations.

The system is arranged as parallel coupled consumers and the required flow and pressure are set out by the different manufacturers of equipment.

The following equipment are normally included in the LTFW circuit:

- Main Engine (Lub Oil-,Charge Air- and cylinder coolers)
- Auxiliary Engines (Lub Oil and Charge air coolers)
- Generators
- Gear Oil cooler
- Intermediate bearings
- Oil distribution cooler
- Dump Condenser (for surplus produced steam)
- Minor equipment as: Start- and service compressors, coolers for provision units, coolers for HVAC cooling units, power packs for hydraulic oil.

In **Appendix no 4a** LTFW system is shown for a Bulk Carrier of the Handy max type and in **Appendix 4b** a similar system for a Container ship. Red markings are made for application of Frese valves.

4.2.2 High Temperature FW cooling system (HTFW)

The HTFW system is a closed circulation system which are normally cooled or integrated into the LTFW system.

The temperature of the system is typical from 70 to 80 °C. The flow velocity is in the interval 2-3 m/s based on black steel pipes.

The flow is provided by centrifugal pumps. The pumps are normally not arranged with frequency control as typically specified by the Main Engine maker.

The system is arranged as parallel coupled consumers and the required flow and pressure are set out by the different manufacturers of equipment.

It is normal to include equipment which can benefit from the surplus heat dissipation.

The following equipment are normally included in the HTFW circuit:

- Main Engine (Cylinder cooling)
- Auxiliary Engines (Cylinder cooling)
- FW production units
- Central Heating units
- Preheaters

In **Appendix no 5** the HTFW system is shown for a Bulk Carrier of the Handy max type and red markings are made for application of Frese valves.

4.2.3 Sea Water Cooling System (SW)

The SW cooling system is an open system providing seawater as the cooling medium to consumers.

The design temperature is based on Class requirement to be min 32 °C up to max 50 °C. The max flow velocity is in the interval 1.5 to 2.5 m/s based on galvanized black steel pipes.

The system is arranged with centrifugal pumps taking suction from the sea chests and delivering seawater to typical the LTFW central coolers and to other consumers.

In many designs the amount of seawater cooled equipment is being limited to the central coolers only.

If using Frese dynamic valves for SW system, filters should be applied.

In **Appendix no 6** the SW cooling system is shown and red markings show possible application of Frese valves.

4.2.4 Central Heating systems

The Central Heating system is a closed circulation system which provide heated fresh water to consumers.

The temperature of the system is 70-90°C and the flow velocity is typically 1.5 to 3 m/s and the pressure is approx. 2 to 3 Bar.

The Central heating system is arranged as parallel coupled consumers and the required flow and pressure are set out by the different manufacturers of equipment.

The central heating system is used where the limited heating temperature (max 90 deg C) can be accepted. This can be seen on vessels operating on lighter fuel oils and not heavy fuel oil.

The following equipment are normally included in the Central heating system circuit:

- Air-conditioning units
- Fan coils
- Technical equipment
- Tanks

In **Appendix no 7** The Central Heating system is shown and red markings show possible application of Frese valves.

4.2.5 Chilled Water systems

The Chilled water system is a closed circulation system which provide chilled fresh water to consumers.

The temperature of the system is 6-12°C and the flow velocity is typically 1.5 to 3 m/s and the pressure is approx. 2 to 5 Bar.

The Chill water system is arranged as parallel coupled consumers and the required flow and pressure are set out by the different manufacturers of equipment.

The following equipment are normally included in the CW circuit:

- Air-conditioning units
- Fan coils
- Technical equipment

In **Appendix no 8** The chilled water system for a NAVY ship is shown and red markings show possible application of Frese valves.

4.2.6 Fresh water cooling system for refrigerated containers (Reefer cooling).

The Fresh Water cooling system is a closed circulation system which provide fresh water to water cooled refrigerated containers.

The temperature of the system is between 0-45 °C and the flow velocity is 2-3 m/s and the max system pressure is 5 Bar.

The system is arranged with parallel coupled consumers in 2 stages – cargo holds and in each cargo hold a number of containers. The system is equipped with a series of orifices to maintain a constant flow in the system to avoid freezing

Appendix no 9a The central Fresh water cooling system for refrigerated containers

Appendix no 9b The cargo hold Fresh water cooling system for refrigerated containers

4.2.7 Systems with a dedicated flow requirement.

In a number of both systems but also components the intended function is ensured by having a defined flow independent of the differential pressure. However, for most of such applications the control equipment is normally delivered and included by the Original Equipment Manufacturer. Below is a list of such equipment:

- Water Spray system for wet type exhaust gas scrubbers (**see Appendix no 10**)
- Inlet to Ballast water treatment plants, especially during the stripping process. (**see Appendix no 11**)
- Some filters with back flush functionality (for regular cleaning purpose).
- Flow control to cooling of battery packs.

4.3 Piping systems where the installation of FRESE valves are not feasible.

The following marine piping systems are not likely to be equipped with FRESE valves:

Fuel oil service systems

In these systems the pumps will be of the positive displacement type and the distribution of the fuel will not be dependent of the pump but of the provided constant pressure. The return oil flows back to the service tanks are variable and will adjust the flow for consumption.

Fuel oil transfer systems

The distribution of fuels in the bunkering process will not be controlled by the flow but by the level in the tanks.

Lubrication oil systems

The flows are defined by the Engine maker and as such not possible to distribute. For these systems OEM supplier should be involved.

Lubrication oil systems for bearings

In the case of many shaft bearings the control valves can be feasible however for some designs only one or two shaft bearings are installed.

For water lubricated bearings the Frese valves can be applicable.

Fire and deck wash systems

This system is a combination of firefighting and deck wash system. System pressure ranging from 6-10 bar.

Water mist system

The system is in use in emergency situations.

Water mist firefighting systems based on high pressure water systems. The pressure can be up to 100 Bar.

Thermal Oil Heating system

The temperature of the system is 180-200 °C and the flow velocity is 3-4 m/s and the system pressure is 8 Bar. And therefore falls out of the specification for standard range valves.

4.4 Details of systems where FRESE valves can be used.

In **Appendix no 12** the result of the scanning as mentioned in section 4 is shown.

As indicated in the table the application of FRESE valves is in general feasible in the cooling water systems where water or Brine is distributed to several consumers.

There might be some special applications where the valves must be considered feasible but this is depending on the components and their function.

Basically equipment and consumers depending on an accurate and steady flow is applicable.

4.5 Segment overview

In Appendix 13 an overview of valves for each system divided in segments can be seen.

5 Analyze of the systems

It has been decided make a more comprehensive analyze on two systems, the Low Temperature Fresh Water system (LTFW) and the Chilled Water system (CW). The systems are depicted in appendix no. 4a and appendix no. 8.

For each system some prerequisites and parameters have been used. The prerequisites vary and will be explained under each system analyze.

The following 5 parameters have been used for the analyze.

- Design cost
- Material cost
- Installation cost
- Commissioning cost
- Yearly energy consumption

The **Design cost** is representing the amount of hours it is estimated to be used for making the design of the system (calculations and diagrams).

Material cost is a compilation of cost of valves and extra costs (fx. extra piping, fittings etc.) related to the type of valves. Other material costs, like piping, fittings, instruments and equipment related to the system is evaluated to be the same no matter which type of valves is used and is not included in total cost

If used, the cost for VFD is also included in material cost

Installation cost is a compilation of estimated time for installation of pipes, components, foundations and painting. Installation of pipes is estimated to be the same no matter which type of valves is used and is not included in total cost.

Commissioning is an estimation on the number of hours used for commissioning of the systems.

And **yearly energy consumption** is calculated by using two load conditions, full load and 1/3 load and estimating the hours at each condition.

The above 5 parameters have then been used to indicate differences in the 4 scenarios mentioned in section 2.

5.1 Low Temperature Fresh Water system (LTFW)

The analysed Low Temperature Fresh Water system is taken from a bulk carrier. The analyze was performed on the entire system shown in appendix no. 4a.

Data, numbers and figures can also be seen in appendix 14

Prerequisites

- Variable load: 2 generator sets running in normal operation.

- AC-units variable load depending on outside conditions.

- Estimated at 4000 hours running on full load on pumps.

- It is assumed that all consumers flow is regulated by orifices and these orifices along with shutoff valves are going to be replaced by Frese Sigma Compact valves

Design

It is estimated that there will be a reduction of 10% in hours for the design of the system.

The reduction comes from less time needed for calculations of pressure loss and orifices

Materials

It is estimated that 10 orifices and valves can be replaced in the system, these will be replaced by Frese Sigma Compact.

Installation

It is not estimated that installation costs will vary depending on which valve is installed.

Commissioning

It is estimated that there is a 50% reduction in commissioning hours assuming that with the Frese valves you can do commissioning unit by unit or zone by zone without interference from pressure fluctuations from other consumers.

Yearly energy consumption

The LTFW system is supplied with three pumps with 50% capacity. Two pumps are running at a time with 150 m^3/h at 2.5 bar.

For simplicity in scenario 3 and 4. It is estimated that the pumps are running at full load 2/3 of the time and at 1/3 of load the rest of the time.

It is estimated that with Frese valves installed it will be possible to reduce the static pressure by 10% . The estimation is based on that designers normally add a safety margin to pressure losses. This safety margin can be reduced because you can set the exact flow on the Frese valve.

It is also possible to add Frese control valves to the system for further energy savings. However this solution has not been investigated in this case study as it will be difficult to evaluate and compare the scenarios if too many variables are taken into account.

5.1.1 Low Temperature Fresh Water (LTFW) analyze

Table 1: Cost overview

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Design cost	35,000 kr.	31,500 kr.	35,000 kr.	31,500 kr.
Material cost	11,196 kr.	37,618 kr.	51,196 kr.	77,618 kr.
Installation cost	218,400 kr.	218,400 kr.	218,400 kr.	218,400 kr.
Commissioning cost	9,600 kr.	4,800 kr.	9,600 kr.	4,800 kr.
Yearly Energy consumption	146,929 kr.	132,236 kr.	114,278 kr.	102,850 kr.

Table 1 - LTFW Cost overview

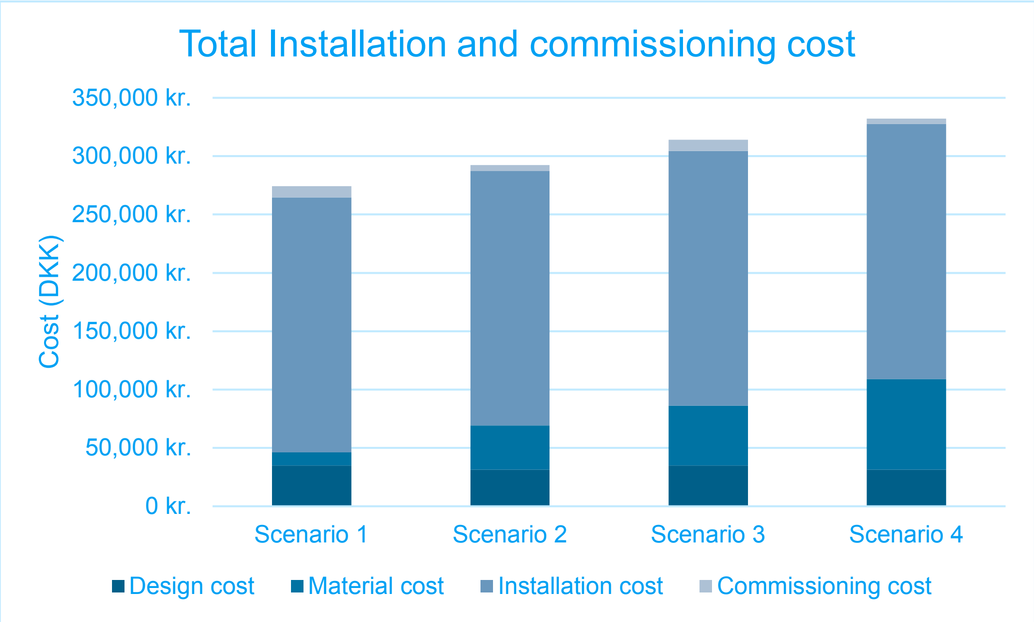


Figure 1 - LTFW Installation and commssioning cost

As seen on *Figure 1 - LTFW Installation and commssioning cost* there is a 21% total cost increase by installing Frese valves compared to a standard solution.

Table 2: Business case overview

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Investment (Material)	0 kr.	26,422 kr.	40,000 kr.	66,422 kr.
Savings on design, installation, commissioning.	0 kr.	8,300 kr.	0 kr.	8,300 kr.
Yearly energy saving	0 kr.	14,693 kr.	32,651 kr.	44,079 kr.
Payback time (year)	0	1.2	1.2	1.3

Table 2 - LTFW Business case overview

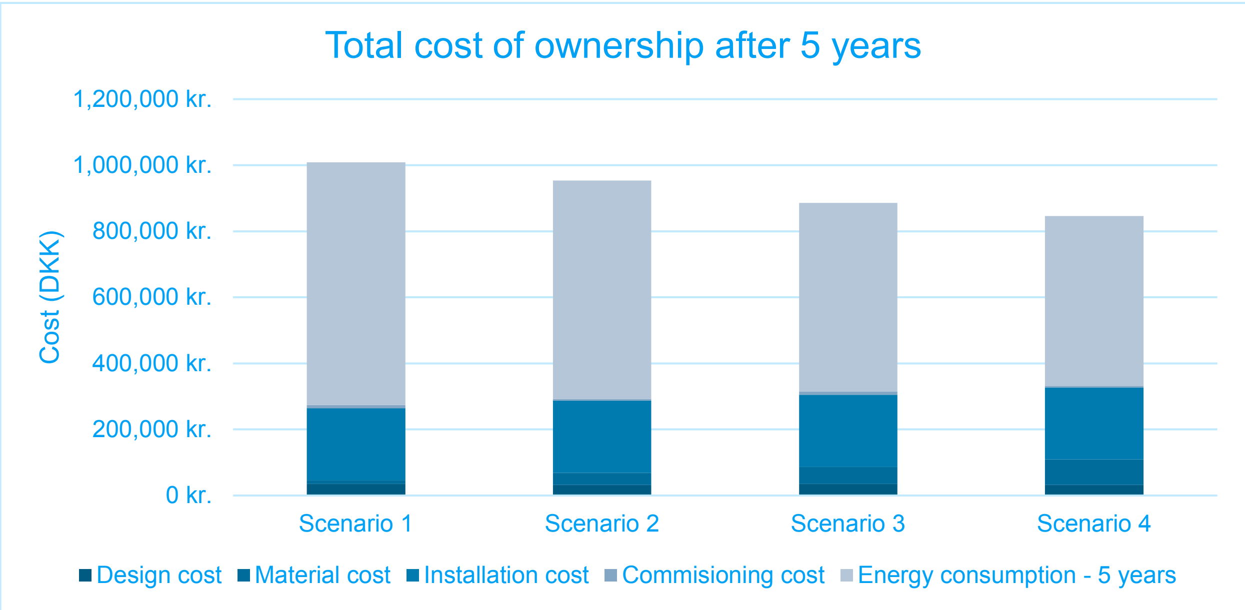


Figure 2 - LTFW Total cost of ownership

As seen on *Figure 2 - LTFW Total cost of ownership* between scenario 1 and scenario 4 there is a 160.000 Dkk or 15% savings over a period of 5 years. And as seen in *Table 2 - LTFW Business case overview* the extra cost of investment will turn positive after a period of 1.3 years.

A bigger energy saving from using VFD and Frese valves compared to scenario 1 was expected. But the most of the energy saving comes from the use of the systems and the operational use of the LTFW system does not give a lot of possibility for reducing flow.

5.2 Chilled Water system

The analysed chilled water system is taking from an offshore patrol vessel. The analyze was performed on the entire system and not only the single diagram shown in appendix no. 8.

Data, numbers and figures can also be seen in appendix 15

Prerequisites

- AC-units and fan coils dependent on outside conditions. AC-units and fan coils responsible for about 2/3 of total cooling
- Equipment estimated responsible for 1/3 of total cooling
- It is assumed that 3-way valves will be replaced by Frese Optima Compact 2-way valves
- All other valves will be replaced by Frese Sigma Compact valves.
- It is assumed that equipping VFD to a CW system with 3-way valves will reduce the differential pressure by 15% in the low load situation.

Design

It is estimated that there will be a reduction of 15% in hours for the design of the system.

The reduction comes from less time needed for calculations of pressure loss and Cv-values

Materials

The chilled water system consists of 94 consumers, whereas 95% is using 3-way valves. For the analyze there has been a summation of the valves and made a price estimation of Frese valves and standard valves. Furthermore there is added a cost difference for extra materials(pipes, fittings) related to 3-way valves. Using a 3-way valves gives some extra installation time and materials, because you have to install the bypass connection.

Installation

Under installation cost, 50 hours is added in relation with extra installation related to 3-way valves as mentioned above.

Commissioning

It is estimated that there is an 80% reduction in commissioning hours related to the fact that with the Frese valves you can do the commissioning work unit by unit or zone by zone without interference from pressure fluctuations from other consumers.

Yearly energy consumption

The chilled water system is supplied with two pumps with 100% capacity. Only one pump is running at a time with 245 m^3/h at 3.5 bar.

For simplicity in scenario 3 and 4. it is estimated that the pump is running at full load 30% of the time and at 1/3 of load the rest of the time.

For calculation of energy consumption in scenario 3 it is estimated that the total differential pressure in the system varies with 15% between full and low load. This reduction in differential pressure is assumed to occur when the chilled water is bypassed by the 3-way valve instead of going through the coils.

Given the fact that the Frese valves reduces the total flow in the system, there is bigger energy saving in scenario 4. This is because a lower flow rate results in a lower total pressure loss meaning the pump can reduce its speed even more than in scenario 3.

5.2.1 CW analyze

Table 1: Cost overview

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Design cost	70,000 kr.	59,500 kr.	70,000 kr.	59,500 kr.
Material cost	46,415 kr.	63,765 kr.	86,415 kr.	103,765 kr.
Installation cost	278200 kr.	265200 kr.	278200 kr.	265200 kr.
Commissioning cost	45,000 kr.	9,600 kr.	45,000 kr.	9,600 kr.
Yearly Energy consumption	223,986 kr.	223,986 kr.	199,987kr.	110,850 kr.

Table 3 - CW Cost overview

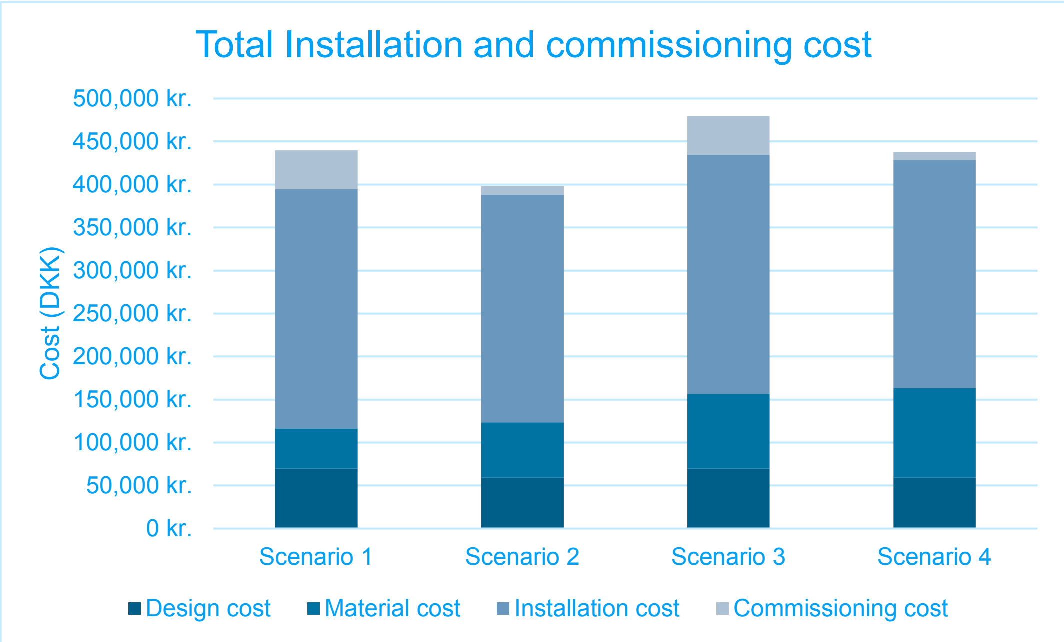


Figure 3 - CW Installation and commissioning cost

As seen on *Figure 3 - CW Installation and commissioning cost* it is actually cheaper to install Frese valves in a Chill Water system. Even though there is an added cost for the valves themselves, there is savings to the design, installation and commissioning costs.

Table 2: Business case overview

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Investment (Material)	0 kr.	17,350 kr.	40,000 kr.	57,350 kr.
Savings on design, installation, commissioning.	0 kr.	58,900 kr.	0 kr.	58,900 kr.
Yearly energy saving	0 kr.	0 kr.	23,998 kr.	113,136 kr.
Payback time (year)	0	0.0	1.7	0.0

Table 4 - CW Business case overview

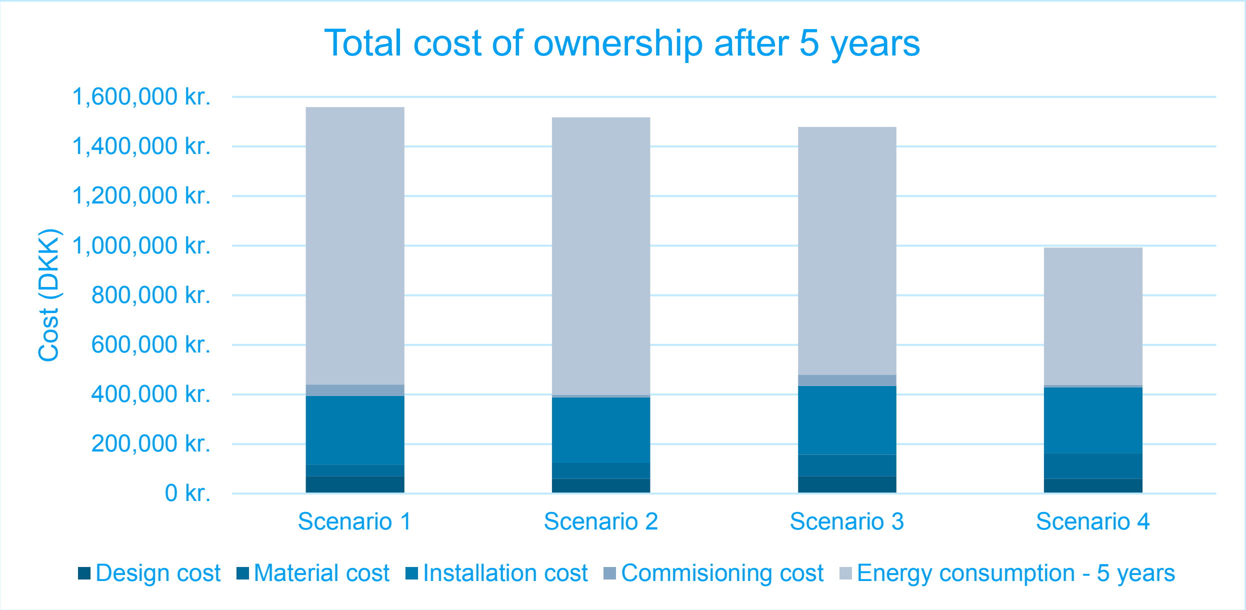


Figure 4 - CW Business case overview

As seen in *Table 4 - CW Business case overview* the savings from design, installation and commissioning results in a less costly solution gives an immediate pay-off if you simply replace standard valves with Frese valves. If you also add a VFD to the solution, the savings over a five year period accumulates to approximately 570.000 Dkk.

6 Conclusion

There is no discussion that a comparison of valves one to one results in that Frese dynamic valves are more costly than standard valves.

But if you consider the complete system in which the valves are incorporated you will see a reduction in price. This reduction reflects:

- Less time to design of system
- If replacing 3-way valves with 2-way valves a price reduction in pipes and fittings.
- Less time for commissioning, Because it is possible to do one-by-one or zone-by-zone commissioning.
- If pumps are fitted with variable frequency drives (VFD) energy savings bigger than a standard 3-way valve system can be achieved.

Of course there is also some downsides to installing the Frese dynamic valves, the valves consists of moving parts and such parts will always be sensitive to pipe scales or particles big enough to clog or halter the dynamic regulation. Maintenance will be necessary after some time.

There is also some effects of installing Frese valves which does not give a direct saving or cost reduction. But a system with dynamic valves is more robust, it is less sensitive to a consumer breakdown or change. It is also more cost effective in case of a retrofit to the system, it is possible to add or remove consumers without changing calculations or design of the system. And a following commissioning will also be less expensive.

A. List of Appendices

Appendix 1: ALPHA -description.

Appendix 2: SIGMA-description

Appendix 3: OPTIMA COMPACT-description

Appendix 4a: LTFW Bulk carrier

Appendix 4b: LTFW Container Ship

Appendix 5: HTFW Bulk carrier

Appendix 6: SW system bulk carrier

Appendix 7: Central Heating system

Appendix 8: Chilled Water System

Appendix 9a: Central Reefer cooling system

Appendix 9b: Cargo hold Reefer cooling system

Appendix 10: Scrubber unit

Appendix 11: BWTS

Appendix 12: Conclusion on part 1.

Appendix 13: Overview of valves per segment

Appendix 14: Cost calculation LTFW

Appendix 15: Cost calculation CW

Frese ALPHA - automatic balancing valve

Appendix no 1

Application

The Frese ALPHA Valves are particularly designed and manufactured for the automatic balancing of heating and cooling circuits.
The Frese ALPHA Cartridges - the second generation cartridges - are an integral part of the Frese ALPHA Valves limiting the flow at the specified level even under fluctuating pressure conditions.
The patented design of these cartridges introduces a replaceable orifice plate for higher flexibility and a resistant diaphragm for higher accuracy. From small size threaded valves (DN15) to big flanged type valves (DN800), from small heating units to district cooling applications, Frese ALPHA Valves guarantee the hydraulic balance of the system regardless pressure fluctuations.

Benefits

- Balancing of the system takes place automatically even under fluctuating pressure conditions

Design

- No need to use balancing valves in the distribution lines, main distribution lines and supply lines.
- Less time to define the necessary equipment for a hydraulic balanced system.
- No impact if the calculated distribution of pressure in the installation is not accurate.
- Security that the specified flow is also the real one
- No requirements on pipe lengths before and after the valve

Installation

- Minimized commissioning time due to automatic balancing of the system
- Cartridge solution makes flushing procedure very easy
- No need for oversized pumps and oversized control valves

Operation

- Energy savings due to elimination of overflows
- Higher comfort due to correct distribution of water in the system and to optimized function of the control valves

Features

Wide product range covering all applications:

- sizes from DN15 to DN800
- different end connections (female/female, union connections, flanges)
- dezincification resistant brass, ductile iron.
- P/T plugs, drain, combi-drain.
- Kit solution with strainer and ball-valves, solution with integral ball-valve.

- Modifications & extensions of the system do not affect the hydraulic balance in the other parts of the system.

- Tamper resistant cartridge independent of flow regulation errors during commissioning and operation of the system.

- Self-cleaning cartridge not allowing dirt to comprosmise the accuracy of the valve.

- Resistant diaphragm between the moving parts of the cartridge eliminates friction, noise and impact from water hummer.

Frese SIGMA Compact Dynamic Balancing Valve

Appendix no 2

Description

The Frese SIGMA Compact is an externally adjustable dynamic balancing valve that provides simple, accurate and reliable flow limitation and isolation in heating and cooling systems.

Application

The Frese SIGMA Compact can be used in both heating and cooling systems for the effective distribution of flow in various sections of the system.

The Frese SIGMA Compact can be used instead of traditional double regulating valves and can be installed in both variable flow systems and constant flow systems.

Operation

The Frese SIGMA Compact can be set to the required position easily by using the scale, to limit the flow rate in certain parts of a system, eliminating overflows and the unnecessary wastage of energy. The internal differential pressure control function of the Frese SIGMA Compact ensures that the set flow rate is limited irrespective of differential pressure fluctuations in the system.

The hand wheel can be used to close the valve and to open it to the preset flow.

Features

- Easy adjustment of the flow using the clear preset scale on the valve
- Hand wheel provides an isolation function up to 10 bar differential pressure
- No minimum straight pipe lengths required before or after the valve
- Built-in P/T plugs for needle system
- Size range: DN50 to DN300
- Flow range: 2,480 to 600,000 l/h
- Maximum differential pressure: 800 kPa

Benefits

- Easy to size and select as only the flow rate is required
- Simplified system design with the number of balancing valves being reduced
- Removes the requirement for main circuit or branch balancing valves in the system
- Works as a flow limiter ensuring no overflows
- Easy to install and adjust on site
- Provides flexibility if the system is modified after the initial installation
- Simplifies the commissioning process and reduces commissioning time due to automatic balancing of the system
- High level comfort for the end-users as a result of the correct balance of the hydraulic system
- Reliable operation as a dynamic balancing valve automatically finds the hydraulic balance regardless of pressure fluctuations in the system

Frese OPTIMA Compact DN10-DN50 - pressure independent balancing & control valve

Appendix no 3

Application

Frese OPTIMA Compact pressure independent balancing & control valve (PIBCV) is used in heating and cooling systems in applications with Fan Coil Units, Chilled Beams or other terminal unit applications.

Frese OPTIMA Compact provides modulating control with full authority regardless of any fluctuations in the differential pressure of the system.

Frese OPTIMA Compact combines an externally adjustable automatic balancing valve, a differential pressure control valve and a full authority modulating control valve.

Frese OPTIMA Compact makes it simple to achieve 100% control of the water flow in the building, while creating high comfort and energy savings at the same time.
An additional benefit is that no balancing is required if further stages are added to the system, or if the dimensioned capacity is changed.

Energy saving due to optimal control, lower flow and pump pressure. Maximized ΔT due to faster response and increased system stability.

Benefits

Design
- Less time to define the necessary equipment for a hydraulic balanced system (only flow data are required)
- No need to calculate valve authority. Always one.
- Flexibility if the system is modified after the initial installation

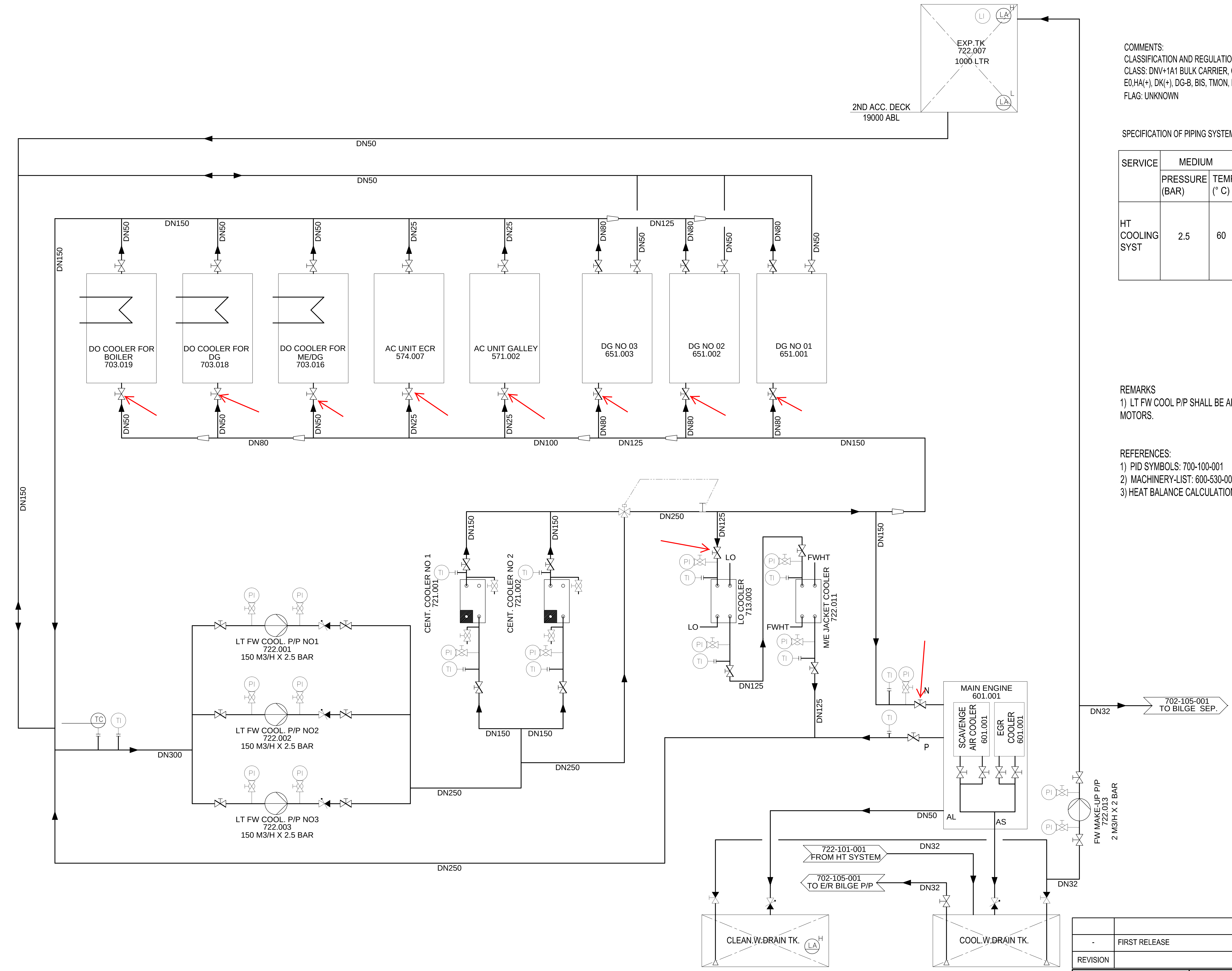
Installation
- No further regulating valves required in the distribution pipework when Frese OPTIMA Compact is installed at terminals.
- Total number of valves minimized due to the 3-in-1 design
- Minimized commissioning time due to automatic balancing of the system
- No minimum straight pipe lengths required before or after the valve.

Operation
- High comfort for the end-users due to high precision temperature control
- Longer life due to less movements of the actuator

Features

- The presetting function has no impact on the stroke; Full stroke modulation at all times, regardless the preset flow.
- The constant differential pressure across the modulating control component guarantees 100% authority.
- Automatic balancing eliminates overflows, regardless of fluctuating pressure conditions in the system.
- Thermic actuator On/Off or 0-10V, normally closed.
- Motoric actuator 0-10V, (Linear or Logarithmic) or 3 point control.
- Differential pressure operating range up to 800 kPa
- High flows with minimal required differential pressure due to advanced design of the valve
- Small dimensions due to compact housing
- Higher presetting precision due to stepless analogue scale
- Rangeabililty > 100:1

Appendix No 4



COMMENTS:
CLASSIFICATION AND REGULATIONS:
CLASS: DNV+1A1 BULK CARRIER, CSR, BC-A (HOLDS 2 & 4 MAY BE EMPTY), GRAB [20], ESP, E0,HA(+), DK(+), DG-B, BIS, TMON, BWM-T, CLEAN, RECYCLABLE
FLAG: UNKNOWN

SPECIFICATION OF PIPING SYSTEM:

SERVICE	MEDIUM		DIA	PIPE			VALVE MATERIAL		PIPE CONNEC.		TEST BAR		CLASS
	PRESSURE (BAR)	TEMP (° C)	NOMINAL DN (MM)	MATERIAL	TREATMENT						SHOP	SHIP	
					IN	OUT	BODY	INT.	JOINT	GASKET			
HT COOLING SYST	2.5	60	ALL	BLACK STEEL	ACID PICK	PAINT	BRONZE	SS 316	FLG PN10	NON ASBEST.	FUNCTION TEST	FUNCTION TEST	III

REMARKS
1) LT FW COOL P/P SHALL BE ARRANGED WITH FREQUENCY CONTROLLED ELECTRIC MOTORS.

REFERENCES:
1) PID SYMBOLS: 700-100-001
2) MACHINERY-LIST: 600-530-001
3) HEAT BALANCE CALCULATION: 722-501-001

REVISION	DESCRIPTION	DATE	SIGN	QC
-	FIRST RELEASE	2016-		

OMT

Shipyard: -

FW-LT COOLING SYSTEM

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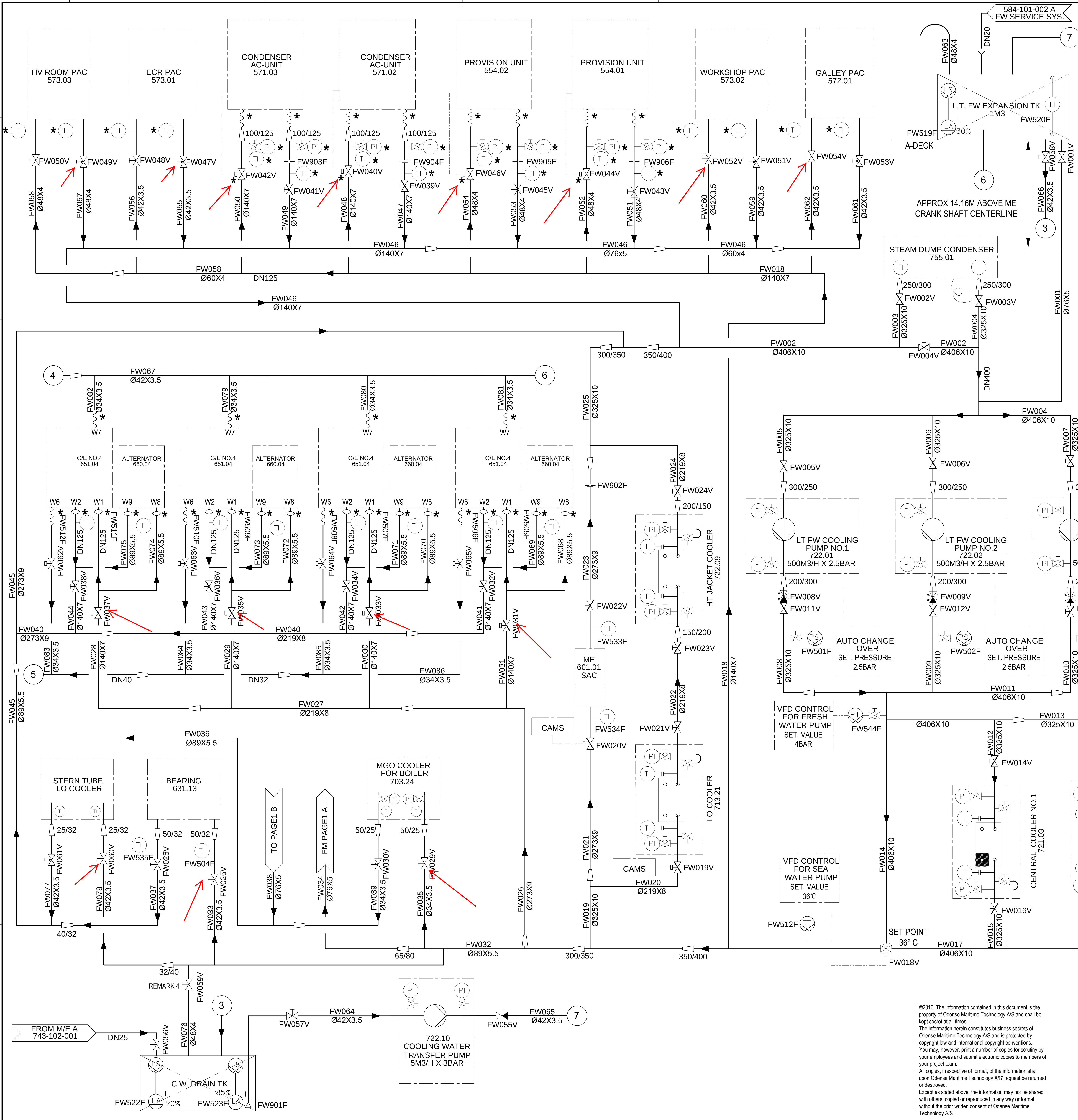
Sverigesgade 4. DK 5000 Odense C. Denmark. Tel. +45 4580 2037. Fax +45 4580 8137
www.odensemaritime.dk

Building No.: -
Scale: NTS | Size: A2
Drw.: | Date: 2015-11-17
QC.: PEMJ | Date: 2016-10-04
Drg. No.: 722-101-001
Sheet | Rev.: -

Print: 2017-06-12 11:39

REVISION	DESCRIPTION	DATE	SIGN	QC
A	REVIEWED BY YARD	2016-09-12	PEMJ	XTRSI

APPENDIX 4B



COMMENTS:

CLASSIFICATION AND REGULATIONS

I, Container Ship, Unrestricted Navigation, +Hull, +Mach, +Aut-UMS, +Aut-P, Lashing, Monshaft, Veristar hull DFL 25 years, ALP(only structure follow), In Water Survey, SDS, CleanShip Green passport, LI-HG-S2, LASHING-WW, ERS¶

SPECIFICATION OF PIPING SYSTEM:

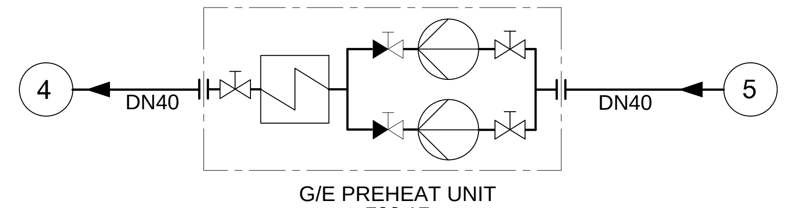
SERVICE	MEDIUM PRESSURE (BAR)	MEDIUM TEMP (° C)	DIA NOMINAL DN (MM)	PIPE MATERIAL	PIPE TREATMENT IN	PIPE TREATMENT OUT	VALVE MATERIAL BODY	VALVE MATERIAL INT.	PIPE CONNEC. JOINT	PIPE CONNEC. GASKET	PIPE CONNEC. FITT'G	PIPE CONNEC. BOLT& NUT	TEST BAR SHOP	TEST BAR SHIP	CLASS
FW COOLING SYSTEM	5	90	40 50 & ABOVE	SEAMLESS STEEL SCH40	ACID PICKLING	ACID PICKLING +PAINTING	BRONZE CAST IRON	BRONZE	FLG PN6	NON ASBESTOS	BUTT WELD.	STEEL GALV. BOLT CLASS 4.8	-	5	III

REMARKS:

1) FOR HEAT BALANCE CALCULATION, SEE 722-501-001.
2) THE PIPE SYSTEM SHALL BE EQUIPPED WITH VENT CONNECTIONS AT THE HIGHEST POSITION OF THE SYSTEM.
3) VENT AND DRAIN FOR THE COOLERS WILL BE INTEGRATED AND DETAILED BY MAKER.
4) DRAIN VALVE AT LOWEST POSITION.
5) VALVE FW031V, FW033V, FW035V, FW037V, FW068V, FW069V, FW070V, FW071V SHALL BE CONTROLLED BY LO PRESSURE OF GE.
6) THE SETTING VALUE IS JUST FOR REFERENCE, IT SHALL BE ADJUSTED BASED ON MOORING TEST.
7) VALVE FW019V, FW020V SHALL BE SHUTED DOWN WHEN ENGINE STOP.
8) VALVE FW018V SHALL BE ADJUSTED TO COOLER SIDE FIRSTLY, THEN ADJUST THE SW COOLING PUMP.
9) ITEM MARKED WITH * OR [ ] IS SUPPLIED BY MAKER.

REFERENCE:

PID SYMBOLS: 700-100-001
MACHINERY-LIST: 600-530-001



G/E PREHEAT UNIT
722.17

CONNECTION:

- W1: LT FW INLET GE
- W2: LT FW OUTLET GE
- W6: FW TO PREHEATER
- W7: VENT TO EXPANSION TANK
- W8: LT FW INLET ALTERNATOR
- W9: LT FW OUTLET ALTERNATOR
- 404: COOLING MEDIA INLET
- 405: COOLING MEDIA OUTLET

OMT

Project: 3300 TEU CONTAINER VESSEL	Project No.:	
	Scale: NTS	Size: A2
FW CENTRAL COOLING SYSTEM	Drw.: SHKA	Date: 2016-07-25
	QC.: PEMJ	Date: 2016-08-05
	Drg. No.: 722-101-001	
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APPENDIX NO 5

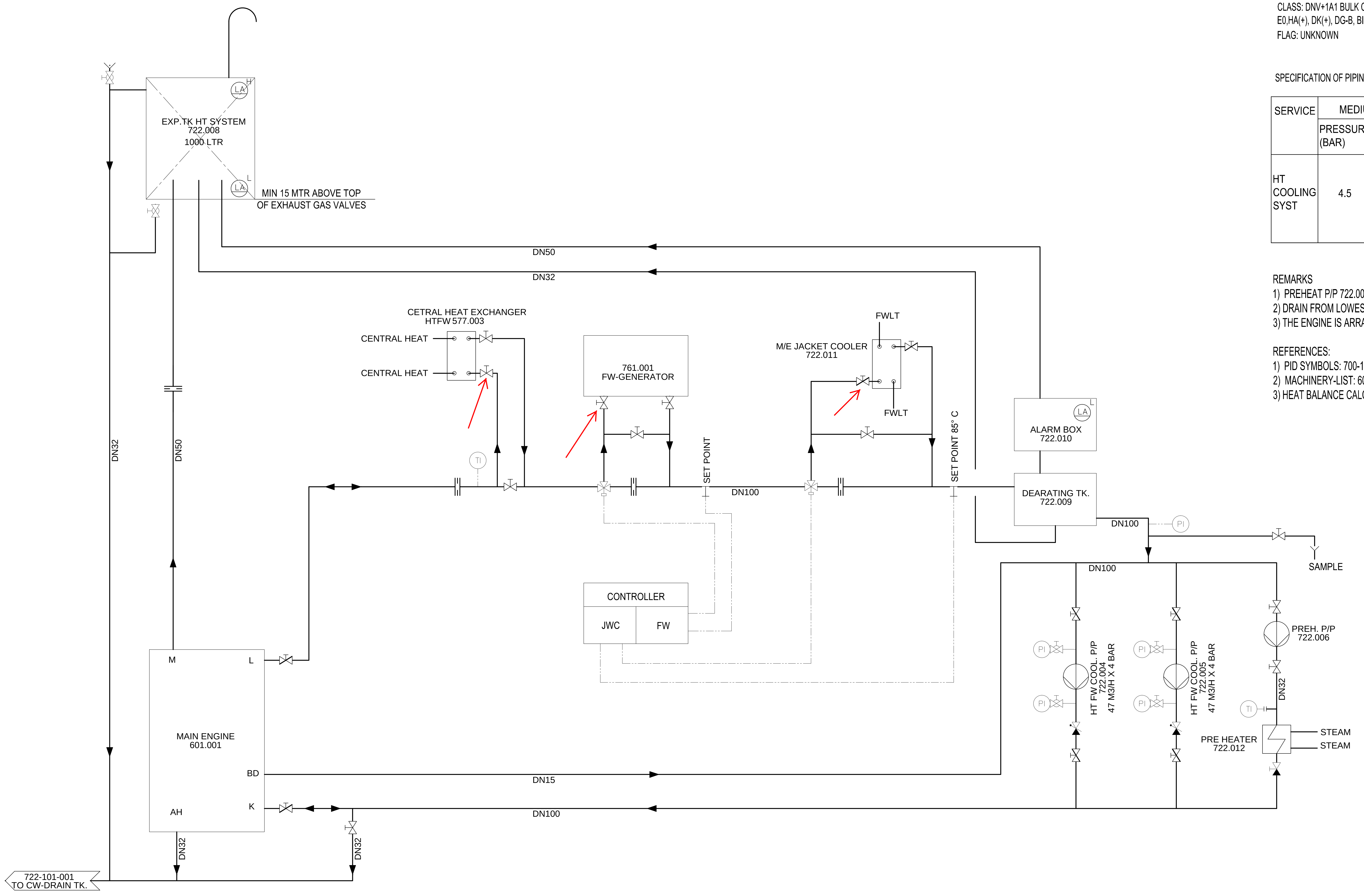
COMMENTS:
CLASSIFICATION AND REGULATIONS:
CLASS: DNV+1A1 BULK CARRIER, CSR, BC-A (HOLDS 2 &4 MAY BE EMPTY), GRAB [20], ESP, E0,HA(+), DK(+), DG-B, BIS, TMON, BWM-T, CLEAN, RECYCLABLE
FLAG: UNKNOWN

SPECIFICATION OF PIPING SYSTEM:

SERVICE	MEDIUM		DIA	PIPE			VALVE MATERIAL		PIPE CONNEC.		TEST BAR		CLAS
	PRESSURE (BAR)	TEMP (° C)	NOMINAL DN (MM)	MATERIAL	TREATMENT						SHOP	SHIP	
					IN	OUT	BODY	INT.	JOINT	GASKET			
HT COOLING SYST	4.5	100	ALL	BLACK STEEL	ACID PICK	PAINT	CAST IRON RUBBER LINED	SS 316	FLG PN10	NON ASBEST.	-	FUNCTION TEST	III

REMARKS
1) PREHEAT P/P 722.006 SHALL BE INTERLOCKED WITH MAIN HT COOL P/P
2) DRAIN FROM LOWEST POINT OF THE SYSTEM SHALL BE DRAINED CW-DRAIN SYSTEM TK.
3) THE ENGINE IS ARRANGED WITH LOAD DEPENDENT CYLINDER LINER (LDCL)

REFERENCES:
1) PID SYMBOLS: 700-100-001
2) MACHINERY-LIST: 600-530-001
3) HEAT BALANCE CALCULATION: 722-501-001



-	FIRST RELEASE	2016-		
REVISION	DESCRIPTION	DATE	SIGN	QC

OMT

Project: SEAHORSE 41
Shipyard: -
FW-HT COOLING SYSTEM

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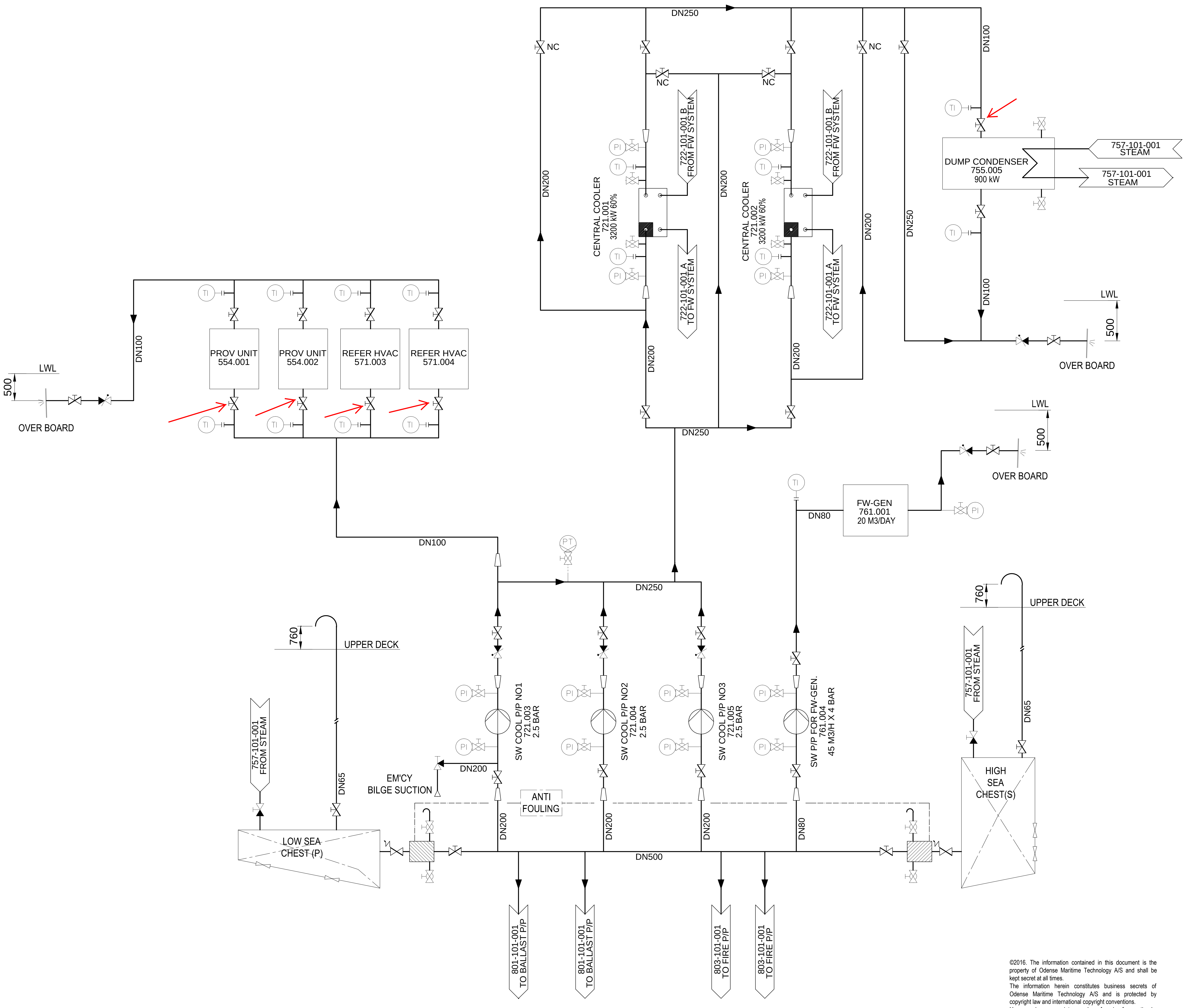
www.odensemaritime.dk

Project No.: M244
Building No.: -
Scale: NTS | Size: A2
Drw.: SHKA | Date: 2015-11-17
QC.: PEMJ | Date: 2016-10-04
Drg. No.: 722-102-001
Sheet | Rev.: -

Print: 2016-11-16 11:33

APPENDIX NO 6



COMMENTS:
CLASSIFICATION AND REGULATIONS:
CLASS: DNV+1A1 BULK CARRIER, CSR, BC-A (HOLDS 2 &4 MAY BE EMPTY), GRAB [20], ESP, E0,HA(+), DK(+), DG-B, BIS, TMON, BWM-T, CLEAN, RECYCLABLE
FLAG: UNKNOWN

SPECIFICATION OF PIPING SYSTEM:

SERVICE	MEDIUM		DIA	PIPE			VALVE MATERIAL		PIPE CONNEC.		TEST BAR		CLAS
	PRESSURE (BAR)	TEMP (° C)	NOMINAL DN (MM)	MATERIAL	TREATMENT						SHOP	SHIP	
					IN	OUT	BODY	INT.	JOINT	GASKET			
SW COOLING SYST	2.5	50	ALL	BLACK STEEL	GALV.	GALV.	CAST IRON RUBBER LINED	SS 316	FLG PN6	NON ASBEST.	-	FUNCTION TEST	III
FW GEN SYST	4	50	DN 80	BLACK STEEL	GALV.	GALV.	CAST IRON RUBBER LINED	SS 316	FLG PN6	NON ASBEST.	-	FUNCTION TEST	III

REMARKS
1) SEA CHESTS SHALL BE PROTECTED BY ZINC ANODES, CROSS OVER LINE TO BE PROTECTED BY ANTI FOULING SYSTEM.
2) TWO OF THE SW-COOLING PUMPS SHALL BE ARRANGED WITH FREQUENCY CONTROLLER
3) EACH SW-COOLING PUMP SHALL BE SIZED TO 50% OF MAX. REQUIRED FLOW

REFERENCES:
1) PID SYMBOLS: 700-100-001
2) MACHINERY-LIST: 600-530-001
3) HEAT BALANCE 722-501-001

REVISION	DESCRIPTION	DATE	SIGN	QC
-	FIRST RELEASE	2016-		

OMT

Project No.: M244	
Building No.: -	
Shipyard: -	
Scale: NTS	Size: A2
Drw.: SHKA	Date: 2015-11-17
QC.: PEMJ	Date: 2016-10-04
Drg. No.: 721-101-001	
Sheet	Rev.: -

SW COOLING SYSTEM

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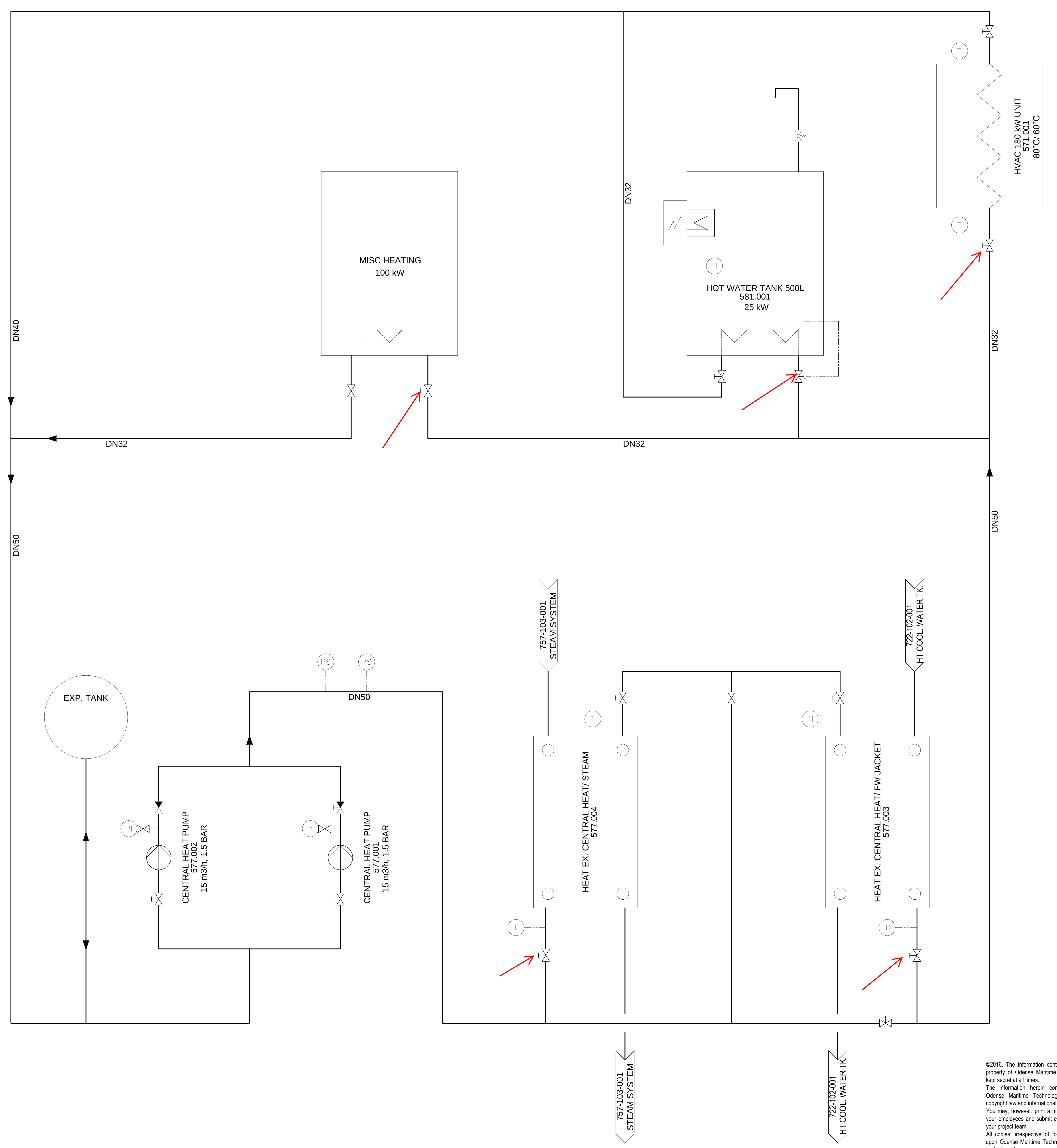
Print: 2016-11-16 11:28

Appendix no 7



COMMENTS:
CLASSIFICATION AND REGULATIONS:
CLASS: DNV+1A1 BULK CARRIER, CSR, BC-A (HOLDS 2 &4 MAY BE EMPTY), GRAB [20], ESP, E0,HA(+), DK(+), DG-B, BIS, TMON, BWM-T, CLEAN, RECYCLABLE
FLAG: UNKNOWN

SPECIFICATION OF PIPING SYSTEM:

SERVICE	MEDIUM		DIA	PIPE			VALVE MATERIAL		PIPE CONNEC.		TEST BAR		CLASS
	PRESSURE (BAR)	TEMP (° C)	NOMINAL DN (MM)	MATERIAL	TREATMENT						SHOP	SHIP	
					IN	OUT	BODY	INT.	JOINT	GASKET			
CENTRAL HEATING SYSTEM	2	80	ALL	PLASTIC	-	-	BRONZE	BRON ZE	FLG PN6	NON ASBEST.	-	FUNCTION TEST	III

REMARKS
1) PIPING SYSTEM TO BE OF APPROVED PLASTIC MATERIAL, SUITABLE FOR MAX.100°C.
2) DESIGN TEMP.: 80°C - 60°C

REFERENCES:
1) PID SYMBOLS: 700-100-001
2) MACHINERY-LIST: 600-530-001

REVISION	DESCRIPTION	DATE	SIGN	QC
-	FIRST RELEASE	2016-		

OMT

Shipyard: -

CENTRAL HEATING SYSTEM

Project No.: M244
Building No.: -
Scale: NTS | Size: A2
Drw.: ---- | Date: 2015-12-21
QC.: PEMJ | Date: 2016-10-04
Drg. No.: 577-201-001
Sheet | Rev.: -

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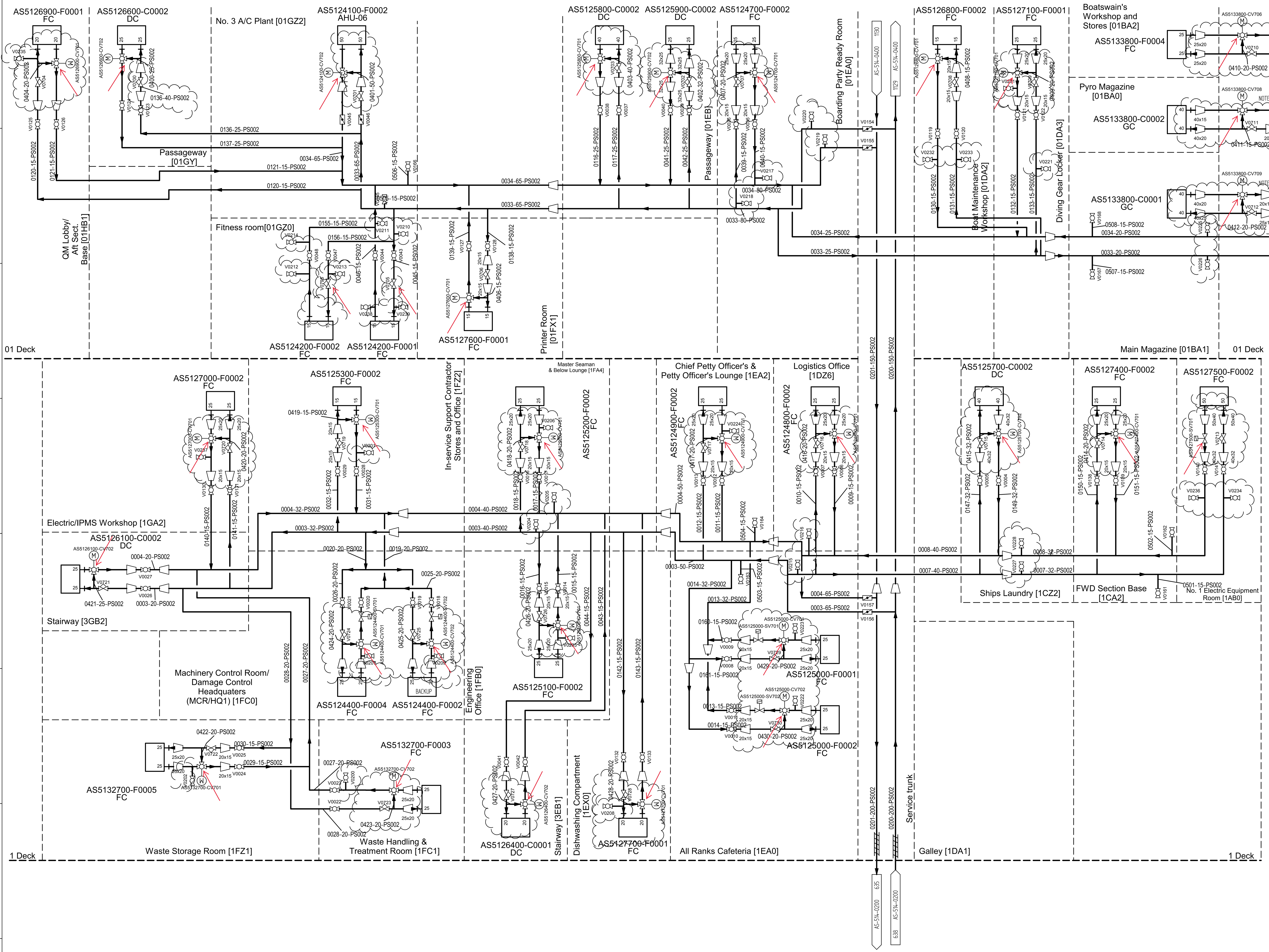
Print: 2016-10-27 10:03



Reference documents:

- AP-500-0100 AOPS Piping Specification
- AP-500-0400 Symbols on P&ID's
- AS-512-0100 HVAC Arrangement MFZ 01
- AS-512-0200 HVAC Arrangement MFZ 02
- AS-512-0300 HVAC Arrangement MFZ 03
- AS-513-0100 Ventilation System Machinery & Stabilizer Room
- AS-513-0300 Ventilation Systems for Technical Rooms DK 2 and 3, Frame 20 - 40
- AS-513-0400 Ventilation Systems for Bosun Store, Magazine and Cable Deck
- AS-513-0800 Ventilation System Bow Thruster Room
- AS-513-1100 Ventilation Systems for Propulsion Motor Room
- AS-513-1200 Ventilation Systems for Technical Rooms Deck 01 - Deck 3, Fr 94 - 111
- AS-513-1300 Ventilation Systems for Waste Handling & Treatment Room, Waste Storage Room
- AS-513-1400 Ventilation System Steering Gear
- AS-513-1800 Ventilation Systems for Emerg. Gen. Room & Battery Room
- AS-514-0100 Chilled water for HVAC system
- AS-514-0200 Chilled water for HVAC system below deck 1
- AS-514-0400 Chilled water for HVAC system above deck 02

Notes:

1) Abbreviations:
 FC = Fan Coil
 DC = Duct Cooler
 GC = Gravity Cooler
 AHU = Air Handling Unit
2) Pipes to be insulated
3) Bleeds at highest and drain at lowest points of piping shall be provided
6) AHU's, FC's and DC's shall include a stainless steel drain pan piped to deck drain
8) 10% Growth margin included
9) 3-way valves shall not be installed in following compartment
 01BA0 Pyro Magazine
 01BA1 Main Magazine

Design Pressure: 6 bar
Test Pressure: 9 bar

Revision	Description	Date	Sign.	Approved by
G	TIR4941 & TIR5025 BMI Equip. and valve	2017-05-15	JEOL	MMER
F	3D route, removed flex conn, DOC_1120_CR3	2015-09-25	JEOL	CBHH
E	Added BMI valves, CR959	2015-03-10	XCOH	JEOL
D	Revised according to AP-514-0100 Main Data	2014-12-18	CHDH	JEOL
C	Pipe spec., Comp. names, pipe routing, Typ det.	2014-09-03	JEOL	JCF
B	AS-514-0200 split into two P&ID's	2014-05-09	JEOL	JCF
A	-	2013-11-07	JEOL	JCF

OMT

Project: |

CHILLED WATER FOR HVAC ABOVE DECK 1

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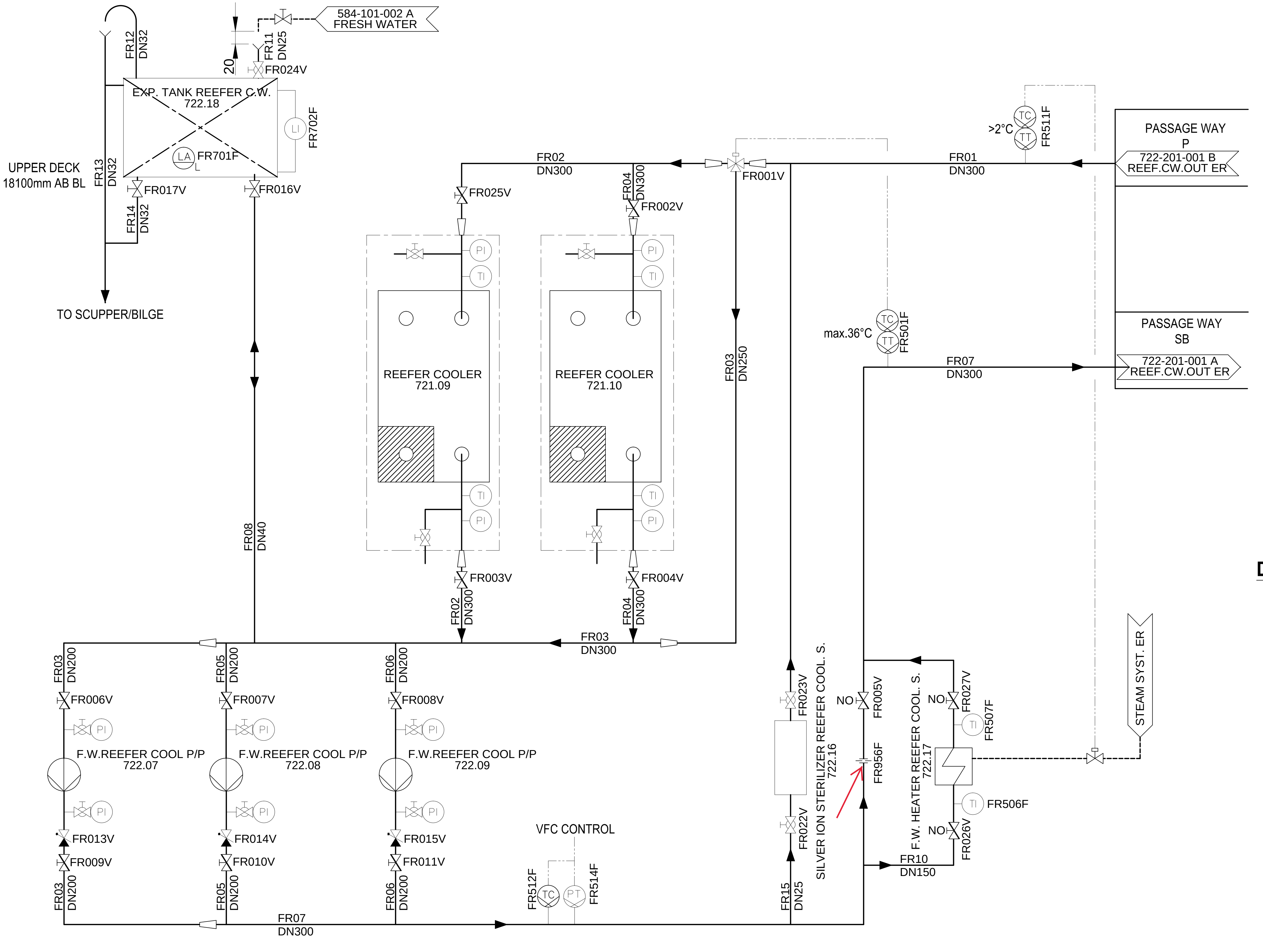
Project no.:	
Scale:	Size:
Drw.: JEOL	Date: 2013-11-07
Sign.: JCF	Date: 2013-11-07
Drg. No.: AS-514-0300	
Sheet 1 of 1	Rev.: G



REMARKS:

1) AIR POCKETS IN THE SYSTEM SHALL BE AVOIDED. IF NOT AIR VENT COCK SHALL BE ARRANGED. DRAIN TO BE INSTALLED AT LOWEST POINTS OF SYSTEM
2) THE THREE (3) 50% FW REEFER COOLING PUMPS ARE FREQUENCY CONTROLLED
3) THE LOW LEVEL ALARM IN THE EXPANSION TANK SHALL RAISE ALARM AT 20% LEVEL

DESIGN DETAILS:

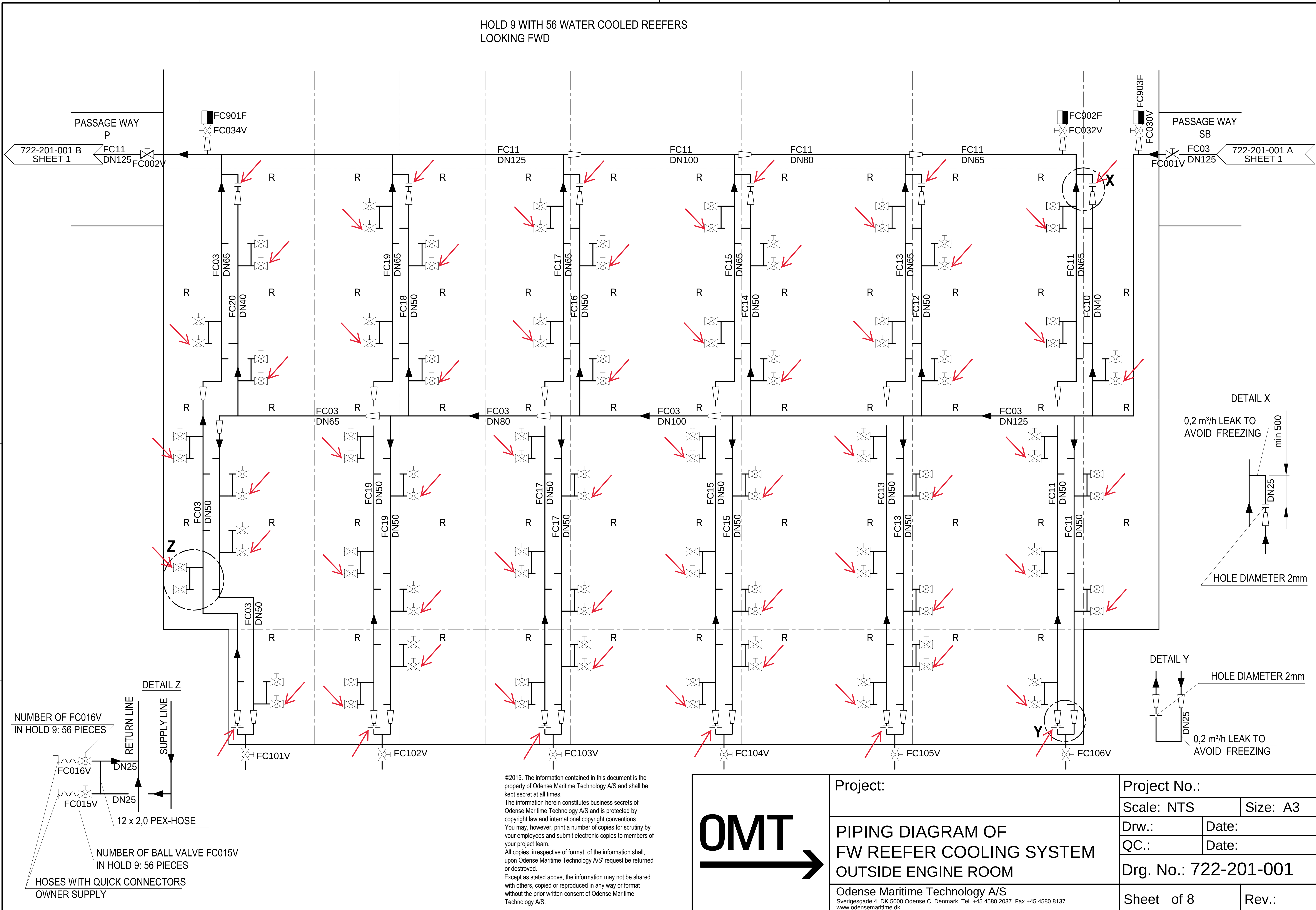
MAX WORKING PRESSURE: 5 BAR
MAX WORKING TEMPERATURE: 50°C
PIPE DIMENSIONS: SCH40
JOINTS: FLANGED PN10
PIPE MATERIALS; CARBON STEEL, PHOSPHATE, OUTSIDE TREATMENT AS SURROUNDINGS
GASKET: NON-ASBESTOS
TESTING: WORKING CONDITION
PIPE CLASS: III

VALVE-LIST: 771-201-001
PID SYMBOLS: 700-100-001
PIPE SPECIFICATION: 771-201-002
MACHINERY-LIST: 600-530-001

LR + 100A1, CONTAINER SHIP, ICE CLASS 1A FS, ECO (BWT, IHM), BWMP(S, T), *IWS, LI, SHIPRIGHT (SDA,FDA, CM, SCM, ACS(B)), +LMC, UMS, EEDI

OMT	Project:	Project No.:	
		Scale: NTS	Size: A3
	PIPING DIAGRAM OF FW REEFER COOLING SYSTEM IN ENGINE ROOM	Drw.:	Date:
		QC.:	Date:
		Drg. No.: 722-103-001	
	Odense Maritime Technology A/S Sverigesgade 4. DK 5000 Odense C. Denmark. Tel. +45 4580 2037. Fax +45 4580 8137 www.odensemaritime.dk	Sheet 1 of 1	Rev.: B

Print: 2018-10-31 10:13



OMT

Project:	Project No.:	
	Scale: NTS	Size: A3
PIPING DIAGRAM OF FW REEFER COOLING SYSTEM OUTSIDE ENGINE ROOM	Drw.:	Date:
	QC.:	Date:
	Drg. No.: 722-201-001	
Odense Maritime Technology A/S Sverigesgade 4. DK 5000 Odense C. Denmark. Tel. +45 4580 2037. Fax +45 4580 8137 www.odensemaritime.dk	Sheet of 8	Rev.:

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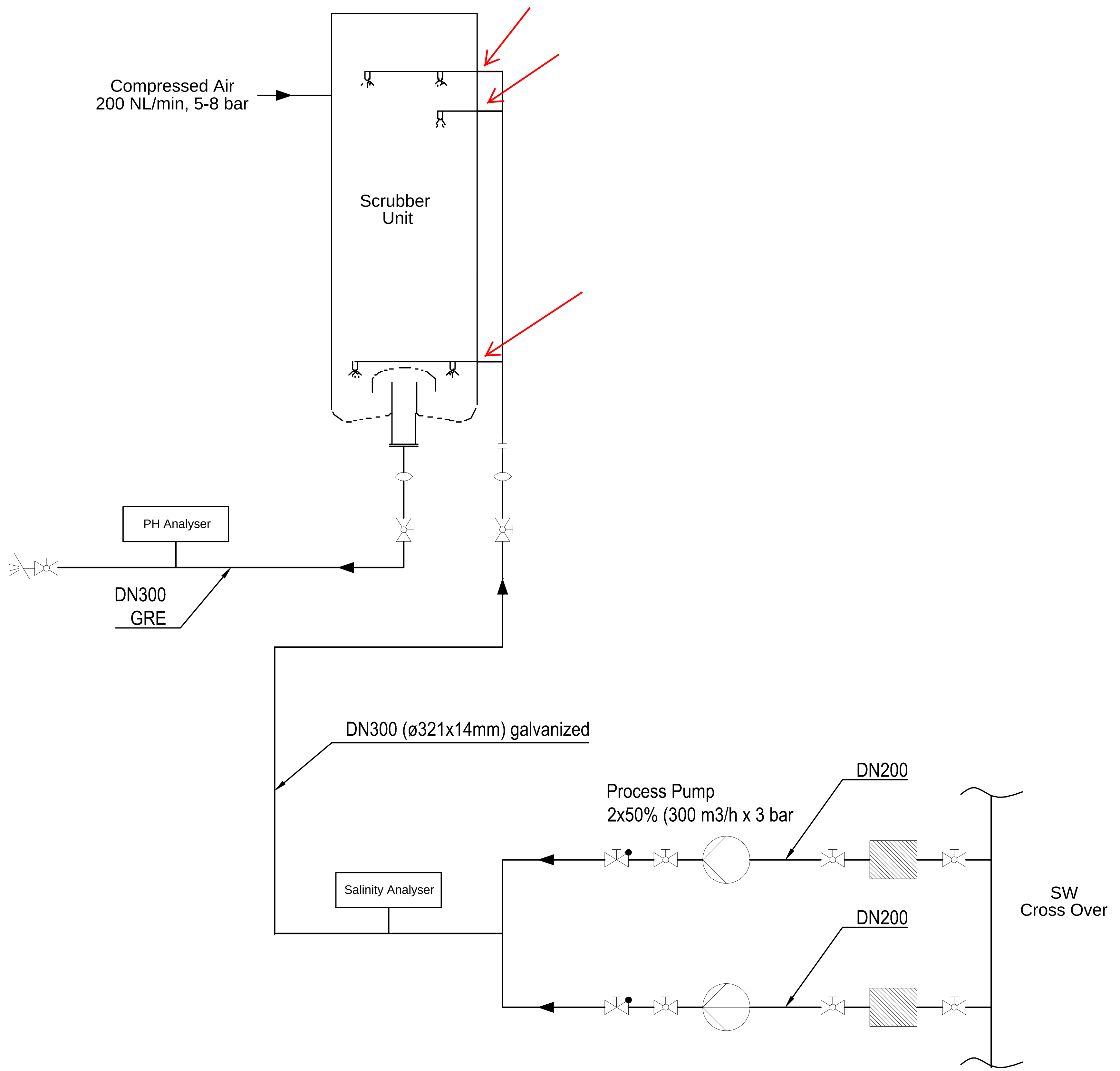
REVISION	DESCRIPTION	DATE	SIGN	QC
-	First release	2018-09-13	JEME	PEMJ

APPENDIX NO 10

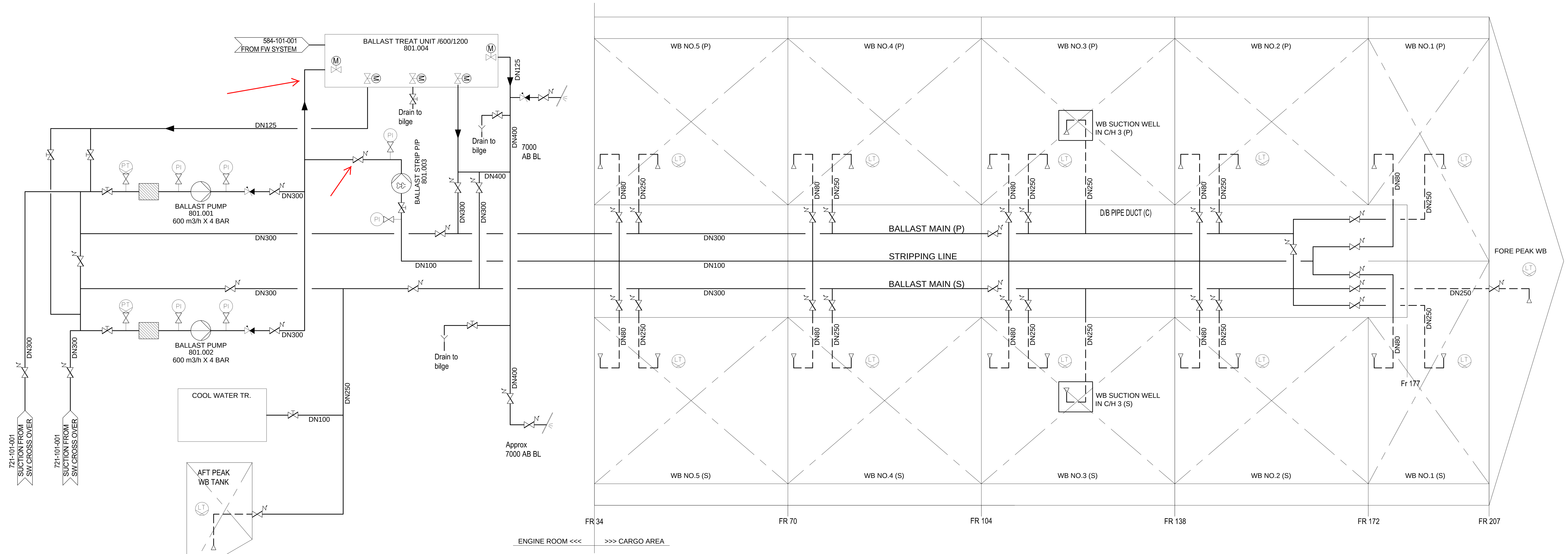


OMT
Odense Maritime Technology A/S
www.odensemaritime.com

Project: POST PANMAX BULK CARRIER	Project No.:
Flow Scheme Scrubber	Scale: NTS / Size: A3
	Drw.: JEME / Date: 2018-09-13
	Drg. No.: M262-Flow Scheme Scrubber
	Sheet 1 of 1 / Rev.: -

Print: 2018-09-28 13:33

APPENDIX NO 11



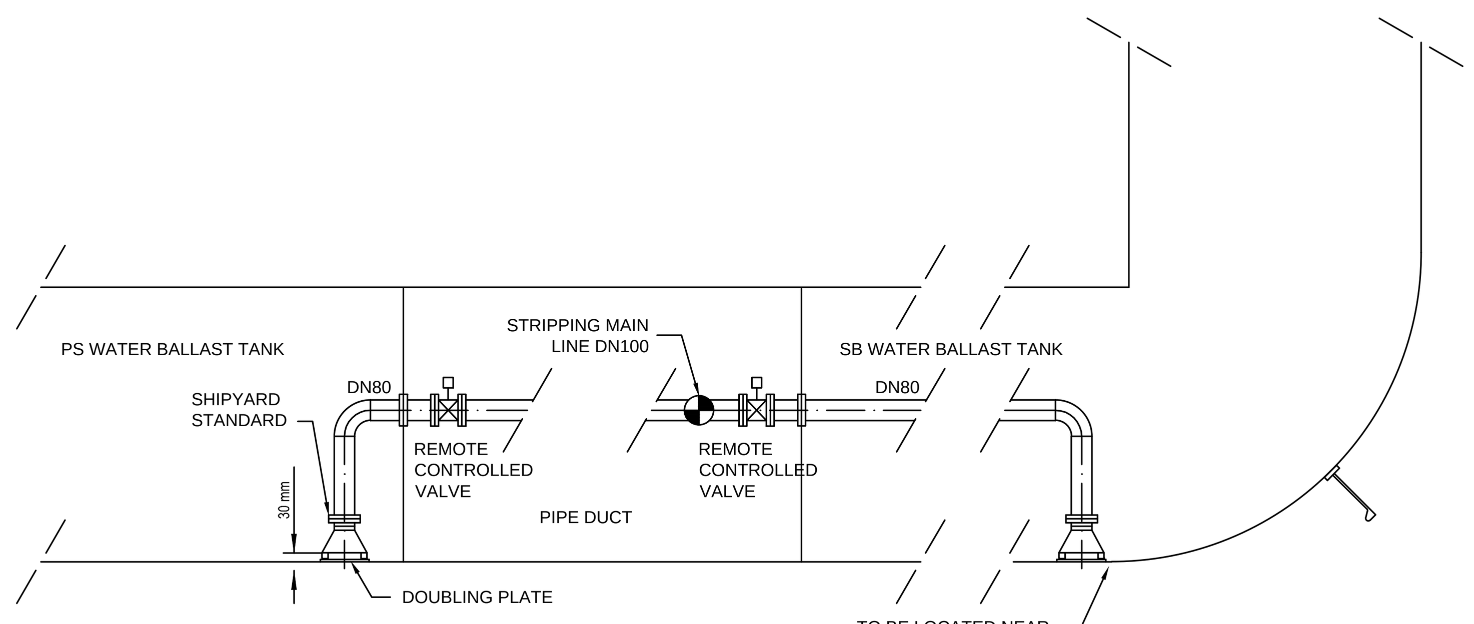
COMMENTS:
CLASSIFICATION AND REGULATIONS:
CLASS: DNV+1A1 BULK CARRIER, CSR, BC-A (HOLDS 2 &4 MAY BE EMPTY), GRAB [20], ESP, E0,HA(+), DK(+), DG-B, BIS, TMON, BWM-T, CLEAN, RECYCLABLE

SPECIFICATION OF PIPING SYSTEM:

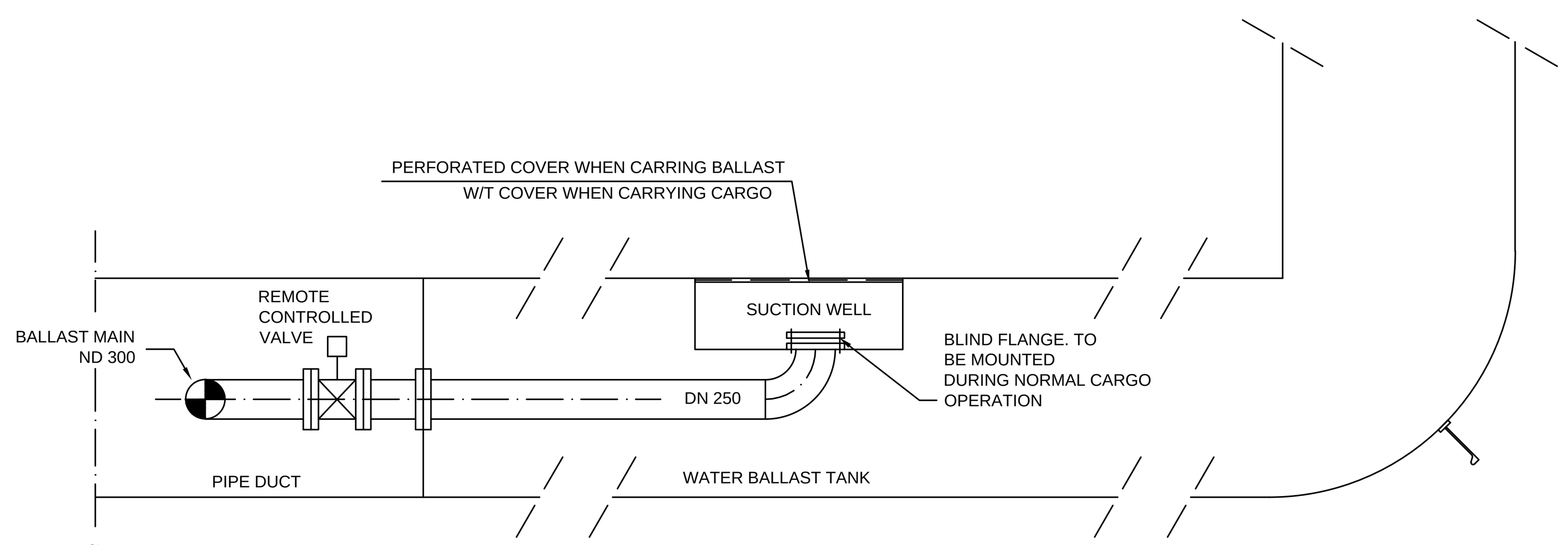
SERVICE	MEDIUM		DIA	PIPE			VALVE MATERIAL		PIPE CONNEC.		TEST BAR		CLASS
	PRESSURE (BAR)	TEMP (° C)	NOMINAL DN (MM)	MATERIAL	TREATMENT						SHOP	SHIP	
					IN	OUT	BODY	INT.	JOINT	GASKET			
BALLAST AND STRIPPING LINE IN C/H AREA	4	<50	80-300	GRE	-		RUBBER LINED	SS 316	FLG PN6	NON ASBEST.	-	FUNCTION TEST	III
BALLAST AND STRIPPING LINE IN E/R AREA	4	<50	100-400	STEEL SCH 40	GALV	GALV	BRON-ZE	BRON-ZE	FLG PN6	NON ASBEST.	-	FUNCTION TEST	

REMARKS
1) BALLAST VALVES AND PUMPS TO BE REMOTELY OPERATED FROM ENGINE CONTROL ROOM AND DECK OFFICE
2) SAMPLE POINTS SHALL BE ARRANGED IN BALLAST OVERBOARD LINES
3) THE BALLAST TREATMENT UNIT SHALL INCLUDE BY-PASS

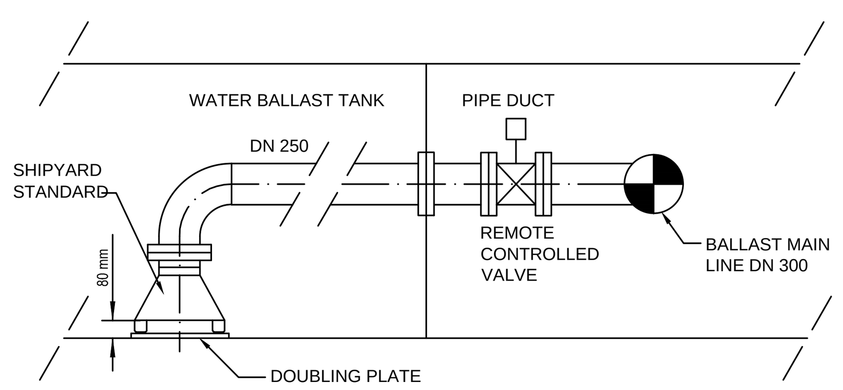
REFERENCES:
1) PID SYMBOLS: 700-100-001
2) MACHINERY-LIST: 600-530-001



TYPICAL DETAIL
DB BALLAST STRIPPING



DETAIL FOR HOLD NO. 3
BALLAST FILLING / DISCHARGE



TYPICAL DETAIL
DB BALLAST SUCTION

REVISION	DESCRIPTION	DATE	SIGN	QC
-	FIRST RELEASE	2016-		

OMT

Project: SEAHORSE 41	Project No.: M244
	Building No.:
Shipyard:	Scale: NTS / Size: A1
BALLAST SYSTEM	Drw.: SHKA / Date: 2015-11-13
	QC.: PEMJ / Date: 2016-10-04
	Drg. No.: 801-101-001
Odense Maritime Technology A/S Sverigesgade 4. DK 5000 Odense C. Denmark. Tel. +45 4580 2037. Fax +45 4580 8137 www.odensemaritime.dk	Sheet 1 of 1 / Rev.: -

Print: 2016-11-16 13:06

Appendix no 12
Overview Marine Piping Systems where installation of FRESE valves are feasible

SYSTEM	TEMP (^oC)	PRESSURE (bar)	MATERIALS	CERTIFICATE[1)]	VALVE TYPE/NO OFF			VALVE SIZE (MM)	REMARKS	OMT REF PROJECT
					ALPHA	SIGMA	OPTIMA			
LTFW	10-60	2-3	BRASS	NONE		10		50-150		BULK CARRIER
LTFW11	10-60	2-3	BRASS	NONE		11	4	40-125		CONTAINER SHIP
HTFW	60-80	2-4	BRASS	NONE	4	3		50-100		BULK CARRIER
SW	0-32	2-3	RG	NONE		3	2	25-100	Filter before valve to be considered.	BULK CARRIER
CENTRAL HEAT	70-90	2-3	BRASS	NONE		4	1	25-50		BULK CARRIER
CHILLED WATER	6-12	2-5	BRASS	NONE			100	15-80	Optima replaces 3-way valves	NAVY SHIP
REEFER COOLING	36-45	2-5	BRASS	NONE	84	378		25-50	Alpha replaces orifices and Sigma replaces Shut off valves	CONTAINER SHIP
BWTS	0-32	2-4	RG	NONE		2		250	SIGMA COMPACT REPLACES ORIFICE AND SHUT OFF VALVES.	BULK CARRIER
SCRUBBER	0-32	2-3	RG	NONE		3-5		100-250	SIGMA COMPACT REPLACES ORIFICE AND SHUT OFF VALVES.	BULK CARRIER

Notes:

1) Certificates for the valve unit will be required in accordance with Class requirement. For the proposed application no special certificates are required.
For the actuators certificate is required if unit is in an essential service system.

Appendix no 13
Overview of Marine Piping Systems where installation of FRESE valves are feasible - divided in segments

Bulk Carrier - Seahorse 41 54700 M3 Cargo ship

	VALVE TYPE/NO OFF					
SYSTEM	**ALPHA**	**SIGMA**	**OPTIMA**	**VALVE SIZE (MM)**	**OMT REF PROJECT**	**Comments**
LTFW		10		50-150	M244	
HTFW	4	3		50-100	M244	
SW		3	2	25-100	M244	
CENTRAL HEAT		4	1	25-50	M244	
BWTS		2		250	M244	
SCRUBBER		4		100-250	M262	
Total valves	4	26	3			

Container ship - Mermaid 3600, 3600 TEU container ship

	VALVE TYPE/NO OFF					
SYSTEM	**ALPHA**	**SIGMA**	**OPTIMA**	**VALVE SIZE (MM)**	**OMT REF PROJECT**	**Comments**
LTFW		11	4	40-125	M122	
HTFW	1	1		50-100	M122	
SW	0	0	0	25-100	M122	
CENTRAL HEAT	NIL	NIL	NIL	25-50	M125	Steam is typically used as heating medium on container ships
REEFER COOLING	84	378		25-50	M122	
BWTS		4		80-250	M122	
SCRUBBER		4		100-250	M122	Estimated that the scrubber setup is identical to bulk
Total valves	85	398	4			

Naval (OPV) - Offshore patrol vessel 61, 43 crrew

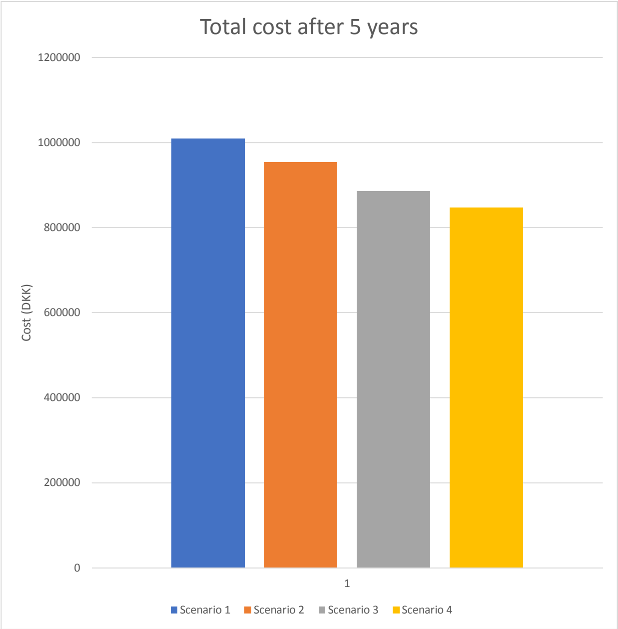
	VALVE TYPE/NO OFF					
SYSTEM	**ALPHA**	**SIGMA**	**OPTIMA**	**VALVE SIZE (MM)**	**OMT REF PROJECT**	**Comments**
LTFW	32	32		20-150	M303	
HTFW	NIL	NIL	NIL	50-100	M303	Included in Engine supplier scope
SW	3	3		300	M303	
CENTRAL HEAT		6	88	25-50	M303	
CHILLED WATER		7	81	15-50	M303	
BWTS		1		100	M303	
Total valves	35	49	169			

LTFW System

Diagram/system reference: **Appendix 4a LTFW System**

Prerequisites:
- Variable load: usually 2 gen. sets running.
- AC-units variable load depending on outside conditions.
- Estimated at 4000 hours running on full load on pumps.
- It is assumed that all consumers flow is defined by orifices and these orifices along with shutoff valves are going to be replaced by Frese Sigma Compact valves

Estimations		Standard	Frese		
Design:					
Design hours		50	45	hours	
(design hour cost)		700	700	DKK	
Total					
Materials					
Number of valves to be replaced by Frese valves		10	10	pcs.	
Costs valves/orifices		11196	37618	DKK	
Extra costs (fx VFD)		40000	40000	DKK	
Piping, fittings and instruments		0	0	DKK	Estimated to be the same no matter the scenario so set to 0 DKK
Total					
Installation:					
Piping (2100m) ND's between 15 and 200		0	0	hours	Estimated to be the same no matter the scenario so set to 0 DKK
Components (100 pcs.)		640	640	hours	
Foundation		100	100	hours	
Painting		100	100	hours	
Total		218400	218400	DKK	
Commissioning:					
Hours		32	16	hours	
(commisioning hour cost)		300	300	DKK	
Total		9600	4800	DKK	
Energi:					
Exchange rate		6.5	DKK/USD		
Energy content		240	g/kWh		
Fuel price		500	USD/ton		
Cost pr. kWh in USD		0.12	USD/kWh		
Cost pr. kWh in DKK		0.78	DKK/kWh		
Design flow	2x	150	m3/h @ 2.5 Bar		
Differential pressure		2.5	Bar		
Pump efficiency		0.65			
Power consumption for 2 pumps 150m3/h @ 2,5 Bar		31.4	kW		
Power consumption for 2 pumps 50m3/h @ 2,5 Bar		10.5	kW		
Total hours in operation		6000	hours		
Hours at full load		4000	hours		
Hours at 1/3 load		2000	hours		
Energy savings by using VFD		41860	kWh pr. year		



	Scenario 1 Traditional valve/orifice and no regulation of pump flow	**Scenario 2** Frese valves and no regulation of pump flow	**Scenario 3** Traditional valve/orifice and variable pump regulation	**Scenario 4** Frese valves and variable pump regulation
Design cost	35000 DKK	31500 DKK	35000 DKK	31500 DKK
Material cost	11196 DKK	37618 DKK	51196 DKK	77618 DKK
Installation cost	218400 DKK	218400 DKK	218400 DKK	218400 DKK
Commisioning cost	9600 DKK	4800 DKK	9600 DKK	4800 DKK
Yearly Energy consumption	146929 DKK	132236 DKK	114278 DKK	102850 DKK
Total cost	274196 DKK	292318 DKK	314196 DKK	332318 DKK
Total cost 5 years	1008843	953500	885588	846570
Investment		18122 DKK	40000	58122
Annual savings in operational costs		14693 DKK	32651	44079
Payback rate		1.23 Year	1.23 Year	1.32 Year
Lifetime savings (5 year)		73465 Dkk	163255 Dkk	220394 Dkk

Table 1: Cost overview

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Design cost	35,000 kr.	31,500 kr.	35,000 kr.	31,500 kr.
Material cost	11,196 kr.	37,618 kr.	51,196 kr.	77,618 kr.
Installation cost	218,400 kr.	218,400 kr.	218,400 kr.	218,400 kr.
Commissioning cost	9,600 kr.	4,800 kr.	9,600 kr.	4,800 kr.
Yearly Energy consumption	146,929 kr.	132,236 kr.	114,278 kr.	102,850 kr.

Table 2: Business case overview

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Investment (Material)	0 kr.	26,422 kr.	40,000 kr.	66,422 kr.
Savings on design, installation, commissioning.	0 kr.	8,300 kr.	0 kr.	8,300 kr.
Yearly energy saving	0 kr.	14,693 kr.	32,651 kr.	44,079 kr.
Payback time (year)	0	1.2	1.2	1.3

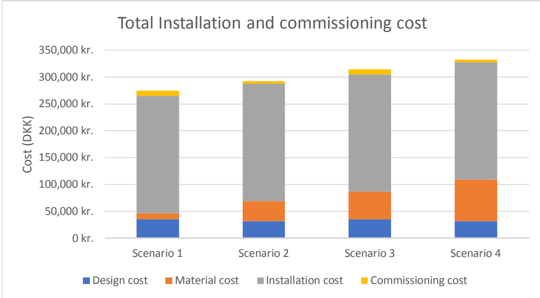


Table 3a: Total cost of ownership per year

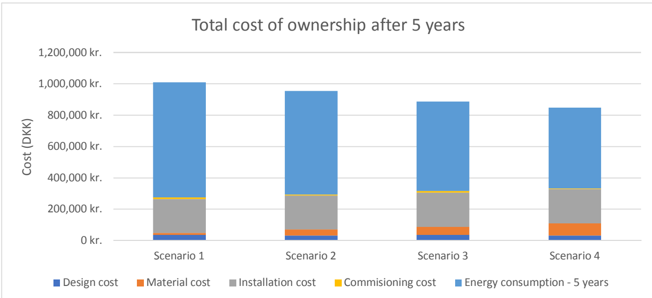
year	Scenario 1	Scenario 2	Scenario 3	Scenario 4
0	274,196 kr.	292,318 kr.	314,196 kr.	332,318 kr.
1	421,126 kr.	424,554 kr.	428,475 kr.	435,168 kr.
2	568,055 kr.	556,791 kr.	542,753 kr.	538,019 kr.
3	714,984 kr.	689,027 kr.	657,031 kr.	640,869 kr.
4	861,913 kr.	821,263 kr.	771,310 kr.	743,720 kr.
5	1,008,843 kr.	953,500 kr.	885,588 kr.	846,570 kr.
6	1,155,772 kr.	1,085,736 kr.	999,866 kr.	949,421 kr.
7	1,302,701 kr.	1,217,972 kr.	1,114,145 kr.	1,052,271 kr.
8	1,449,630 kr.	1,350,209 kr.	1,228,423 kr.	1,155,122 kr.
9	1,596,560 kr.	1,482,445 kr.	1,342,701 kr.	1,257,972 kr.
10	1,743,489 kr.	1,614,681 kr.	1,456,979 kr.	1,360,823 kr.
11	1,890,418 kr.	1,746,918 kr.	1,571,258 kr.	1,463,673 kr.
12	2,037,348 kr.	1,879,154 kr.	1,685,536 kr.	1,566,524 kr.
13	2,184,277 kr.	2,011,391 kr.	1,799,814 kr.	1,669,374 kr.
14	2,331,206 kr.	2,143,627 kr.	1,914,093 kr.	1,772,225 kr.
15	2,478,135 kr.	2,275,863 kr.	2,028,371 kr.	1,875,075 kr.

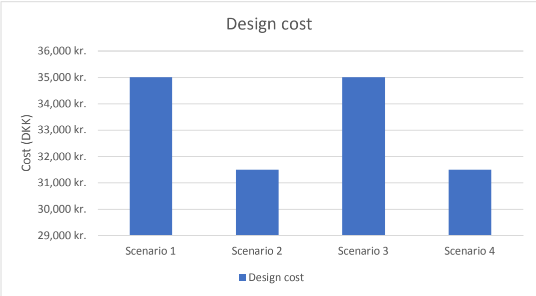
Table 3b: Total system cost savings per year

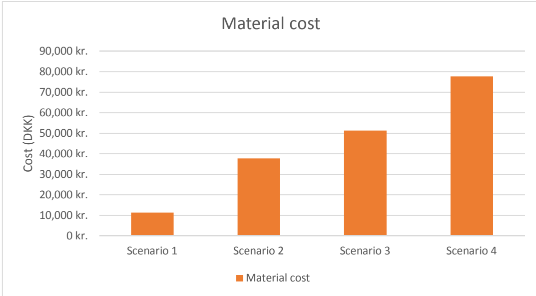
Scenario 2	Scenario 3	Scenario 4
-18,122 kr.	-40,000 kr.	-58,122 kr.
-3,429 kr.	-7,349 kr.	-14,043 kr.
11,264 kr.	25,302 kr.	30,036 kr.
25,957 kr.	57,953 kr.	74,115 kr.
40,650 kr.	90,604 kr.	118,193 kr.
55,343 kr.	123,255 kr.	162,272 kr.
70,036 kr.	155,906 kr.	206,351 kr.
84,729 kr.	188,557 kr.	250,430 kr.
99,422 kr.	221,208 kr.	294,509 kr.
114,115 kr.	253,859 kr.	338,587 kr.
128,808 kr.	286,510 kr.	382,666 kr.
143,500 kr.	319,160 kr.	426,745 kr.
158,193 kr.	351,811 kr.	470,824 kr.
172,886 kr.	384,462 kr.	514,902 kr.
187,579 kr.	417,113 kr.	558,981 kr.
202,272 kr.	449,764 kr.	603,060 kr.

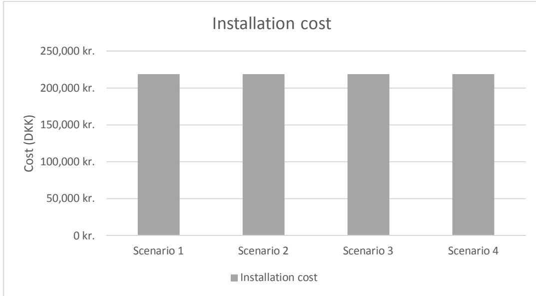
Table 4: Breakdown of total cost of ownership after 5 years

	Scenario1	Scenario 2	Scenario 3	Scenario 4
Design cost	35,000 kr.	31,500 kr.	35,000 kr.	31,500 kr.
Material cost	11,196 kr.	37,618 kr.	51,196 kr.	77,618 kr.
Installation cost	218,400 kr.	218,400 kr.	218,400 kr.	218,400 kr.
Commisioning cost	9,600 kr.	4,800 kr.	9,600 kr.	4,800 kr.
Energy consumption - 5 years	734,646 kr.	661,182 kr.	571,392 kr.	514,252 kr.
Total cost - 5 years	1,008,843 kr.	953,500 kr.	885,588 kr.	846,570 kr.
- savings 5 year		55,343 kr.	123,255 kr.	162,272 kr.

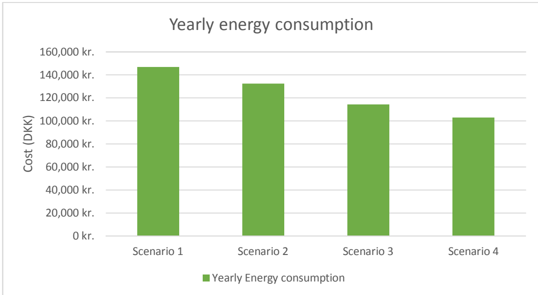


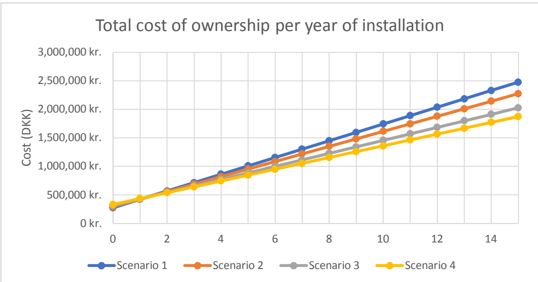

Design cost
36,000 kr.
35,000 kr.
34,000 kr.
33,000 kr.
32,000 kr.
31,000 kr.
30,000 kr.
29,000 kr.
Cost (DKK)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Design cost

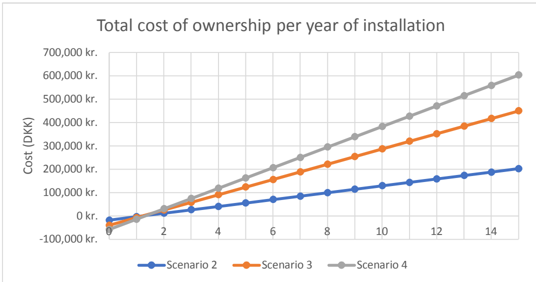

Material cost
90,000 kr.
80,000 kr.
70,000 kr.
60,000 kr.
50,000 kr.
40,000 kr.
30,000 kr.
20,000 kr.
10,000 kr.
0 kr.
Cost (DKK)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Material cost


Installation cost
250,000 kr.
200,000 kr.
150,000 kr.
100,000 kr.
50,000 kr.
0 kr.
Cost (DKK)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Installation cost


Commissioning cost
12,000 kr.
10,000 kr.
8,000 kr.
6,000 kr.
4,000 kr.
2,000 kr.
0 kr.
Cost (DKK)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Commissioning cost


Yearly energy consumption
160,000 kr.
140,000 kr.
120,000 kr.
100,000 kr.
80,000 kr.
60,000 kr.
40,000 kr.
20,000 kr.
0 kr.
Cost (DKK)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Yearly Energy consumption


Total cost of ownership per year of installation
3,000,000 kr.
2,500,000 kr.
2,000,000 kr.
1,500,000 kr.
1,000,000 kr.
500,000 kr.
0 kr.
Cost (DKK)
0
2
4
6
8
10
12
14
Scenario 1
Scenario 2
Scenario 3
Scenario 4

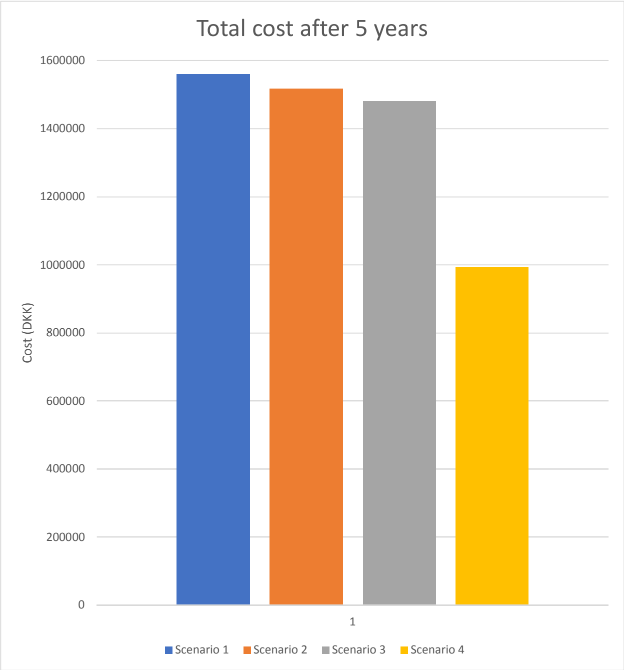

Total cost of ownership per year of installation
700,000 kr.
600,000 kr.
500,000 kr.
400,000 kr.
300,000 kr.
200,000 kr.
100,000 kr.
0 kr.
-100,000 kr.
Cost (DKK)
0
2
4
6
8
10
12
14
Scenario 2
Scenario 3
Scenario 4

Chilled Water System

Diagram/system reference: Appendix 8 CW System

Prerequisites
- AC-units dependent of outside conditions. AC-units responsible for about 2/3 of total cooling
- Equipment responsible for 1/3 of total cooling and estimated running full speed
- It is assumed that 3-way valves for AC-units will be replaced by Frese Optima Compact valves.
- All other valves in question will be replaced by Frese Sigma Compact valves.
- It is assumed that equipping VFD to a CW system with 3-way valves will reduce the differential pressure by 15% in the low load situation.

Estimations		Standard	Frese		
Design:					
Design hours		100	85	hours	
(design hour cost)		700	700	DKK	
Total					
Materials					
Number of valves to be replaced by Frese valves		94	94	pcs.	
Costs valves/orifices		26390	63765	DKK	
Extra costs related to VFD		40000	40000	DKK	
Extra costs related to 3-way valves		20025	0		Added cost for using 3-way valves
Total					
Installation:					
Piping (2100m) ND's between 15 and 200		0	0	hours	
Components (100 pcs.)		850	800	hours	Added hours for extra installation of 3-way valves
Foundation		20	20	hours	
Painting		200	200	hours	
Total		278200	265200	DKK	
Commissioning:					
Hours		150	32	hours	
(commisioning hour cost)		300	300	DKK	
Total		45000	9600	DKK	
Energi:					
Exchange rate		6.5	DKK/USD		
Energy content		240	g/kWh		
Fuel price		500	USD/ton		
Cost pr. kWh in USD		0.12	USD/kWh		
Cost pr. kWh in DKK		0.78	DKK/kWh		
Design flow	1x	245	m3/h @ 3.5 Bar		
Differential pressure		3.5	Bar		
Pump efficiency		0.65			
Power consumption for 1 pump 245m3/h @ 3,5 Bar		35.9	kW		
Power consumption for 1 pump 80m3/h @ 3,5 Bar		11.7	kW		
Power consumption for 1 pump 245m3/h @ 3,0 Bar		30.8	kW		
Total hours in operation		8000	hours		
Hours at full load		2000	hours		
Hours at 1/3 load		6000	hours		
Energy savings by using VFD		145046	kWh pr. year		



	Scenario 1: Traditional orifice and no regulation of pump flow	Scenario 2: Frese valves and no regulation of pump flow	Scenario 3: Traditional orifice and variable pump regulation	Scenario 4: Frese valves and variable pump regulation
Design cost	70000 DKK	59500 DKK	70000 DKK	59500 DKK
Material cost	46415 DKK	63765 DKK	86415 DKK	103765 DKK
Installation cost	278200 DKK	265200 DKK	278200 DKK	265200 DKK
Commisioning cost	45000 DKK	9600 DKK	45000 DKK	9600 DKK
Yearly Energy consumption	223986 DKK	223986 DKK	199987 DKK	110850 DKK
Total cost	439615 DKK	398065 DKK	479615 DKK	438065 DKK
Total cost 5 years	1559543	1517993	1479550	992315
Investment		-41550 DKK	40000	-1550
Annual savings in operational costs		0 DKK	23998	113136
Payback rate		#DIV/0! Year	1.67 Year	-0.01 Year
Lifetime savings (5 year)		0 Dkk	119992 Dkk	565678 Dkk

Table 1: Cost overview

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Design cost	70,000 kr.	59,500 kr.	70,000 kr.	59,500 kr.
Material cost	46,415 kr.	63,765 kr.	86,415 kr.	103,765 kr.
Installation cost	278,200 kr.	265,200 kr.	278,200 kr.	265,200 kr.
Commissioning cost	45,000 kr.	9,600 kr.	45,000 kr.	9,600 kr.
Yearly Energy consumption	223,986 kr.	223,986 kr.	199,987 kr.	110,850 kr.

Table 2: Business case overview

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Investment (Material)	0 kr.	17,350 kr.	40,000 kr.	57,350 kr.
Savings on design, installation, commissioning.	0 kr.	58,900 kr.	0 kr.	58,900 kr.
Yearly energy saving	0 kr.	0 kr.	23,998 kr.	113,136 kr.
Payback time (year)	0	0.0	1.7	0.0

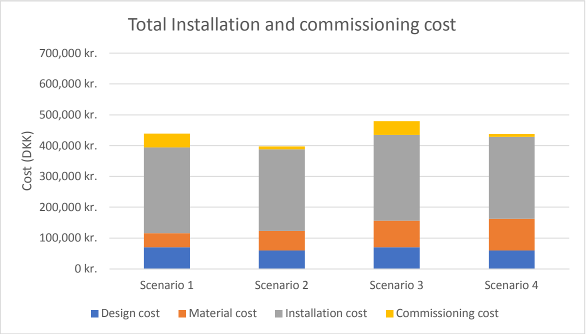


Table 3a: Total cost of ownership per year

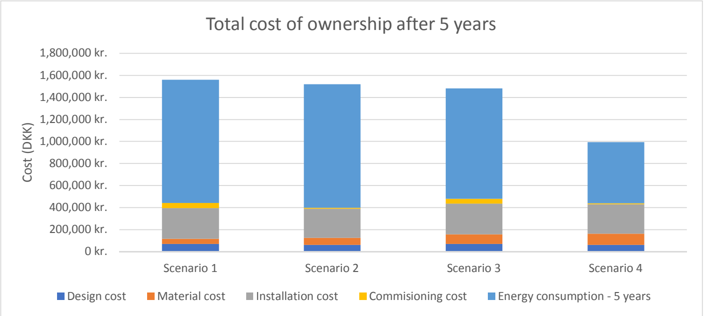
year	Scenario 1	Scenario 2	Scenario 3	Scenario 4
0	439,615 kr.	398,065 kr.	479,615 kr.	438,065 kr.
1	663,601 kr.	622,051 kr.	679,602 kr.	548,915 kr.
2	887,586 kr.	846,036 kr.	879,589 kr.	659,765 kr.
3	1,111,572 kr.	1,070,022 kr.	1,079,576 kr.	770,615 kr.
4	1,335,557 kr.	1,294,007 kr.	1,279,563 kr.	881,465 kr.
5	1,559,543 kr.	1,517,993 kr.	1,479,550 kr.	992,315 kr.
6	1,783,528 kr.	1,741,978 kr.	1,679,537 kr.	1,103,165 kr.
7	2,007,514 kr.	1,965,964 kr.	1,879,524 kr.	1,214,015 kr.
8	2,231,499 kr.	2,189,949 kr.	2,079,512 kr.	1,324,865 kr.
9	2,455,485 kr.	2,413,935 kr.	2,279,499 kr.	1,435,715 kr.
10	2,679,470 kr.	2,637,920 kr.	2,479,486 kr.	1,546,565 kr.
11	2,903,456 kr.	2,861,906 kr.	2,679,473 kr.	1,657,415 kr.
12	3,127,441 kr.	3,085,891 kr.	2,879,460 kr.	1,768,265 kr.
13	3,351,427 kr.	3,309,877 kr.	3,079,447 kr.	1,879,115 kr.
14	3,575,412 kr.	3,533,862 kr.	3,279,434 kr.	1,989,965 kr.
15	3,799,398 kr.	3,757,848 kr.	3,479,421 kr.	2,100,815 kr.

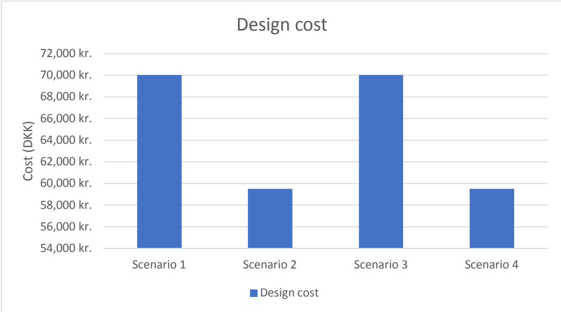
Table 3b: Total system cost savings per year

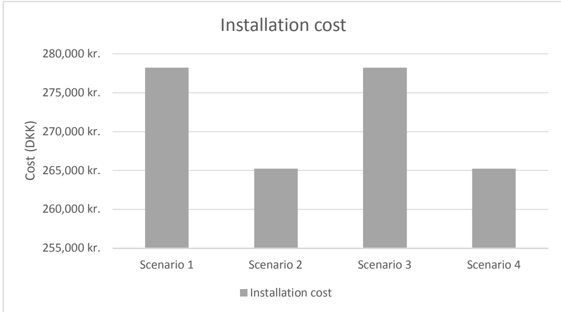
Scenario 2	Scenario 3	Scenario 4
41,550 kr.	-40,000 kr.	1,550 kr.
41,550 kr.	-16,002 kr.	114,685 kr.
41,550 kr.	7,997 kr.	227,821 kr.
41,550 kr.	31,995 kr.	340,956 kr.
41,550 kr.	55,994 kr.	454,092 kr.
41,550 kr.	79,992 kr.	567,227 kr.
41,550 kr.	103,991 kr.	680,363 kr.
41,550 kr.	127,989 kr.	793,499 kr.
41,550 kr.	151,988 kr.	906,634 kr.
41,550 kr.	175,986 kr.	1,019,770 kr.
41,550 kr.	199,984 kr.	1,132,905 kr.
41,550 kr.	223,983 kr.	1,246,041 kr.
41,550 kr.	247,981 kr.	1,359,176 kr.
41,550 kr.	271,980 kr.	1,472,312 kr.
41,550 kr.	295,978 kr.	1,585,447 kr.
41,550 kr.	319,977 kr.	1,698,583 kr.

Table 4: Breakdown of total cost of ownership after 5 years

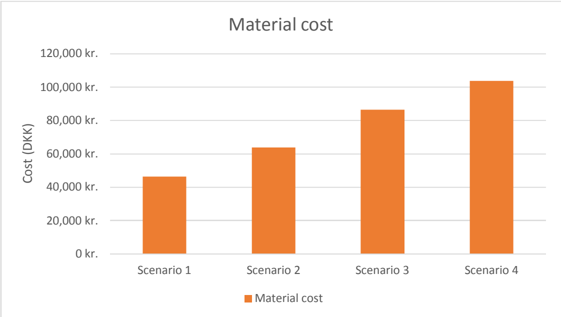
	Scenario1	Scenario 2	Scenario 3	Scenario 4
Design cost	70,000 kr.	59,500 kr.	70,000 kr.	59,500 kr.
Material cost	46,415 kr.	63,765 kr.	86,415 kr.	103,765 kr.
Installation cost	278,200 kr.	265,200 kr.	278,200 kr.	265,200 kr.
Commisioning cost	45,000 kr.	9,600 kr.	45,000 kr.	9,600 kr.
Energy consumption - 5 years	1,119,928 kr.	1,119,928 kr.	999,935 kr.	554,250 kr.
Total cost - 5 years	1,559,543 kr.	1,517,993 kr.	1,479,550 kr.	992,315 kr.
- savings 5 year		41,550 kr.	79,992 kr.	567,227 kr.

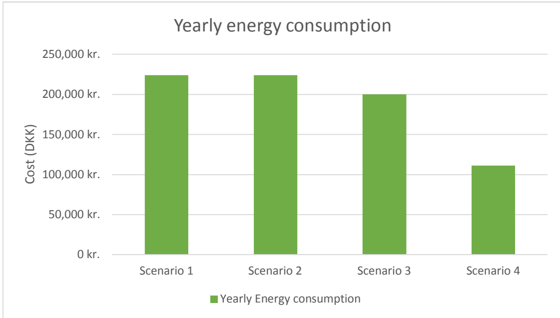


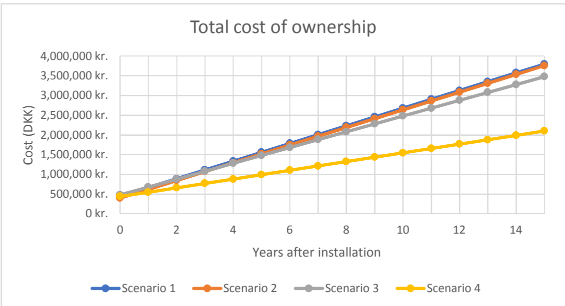

Design cost
72,000 kr.
70,000 kr.
68,000 kr.
66,000 kr.
64,000 kr.
62,000 kr.
60,000 kr.
58,000 kr.
56,000 kr.
54,000 kr.
Cost (DKK)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Design cost

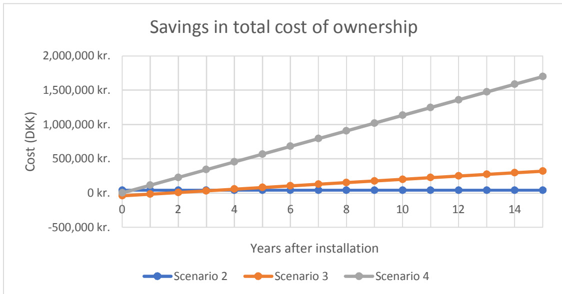

Installation cost
280,000 kr.
275,000 kr.
270,000 kr.
265,000 kr.
260,000 kr.
255,000 kr.
Cost (DKK)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Installation cost


Commissioning cost
50,000 kr.
45,000 kr.
40,000 kr.
35,000 kr.
30,000 kr.
25,000 kr.
20,000 kr.
15,000 kr.
10,000 kr.
5,000 kr.
0 kr.
Cost (DKK)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Commissioning cost


Material cost
120,000 kr.
100,000 kr.
80,000 kr.
60,000 kr.
40,000 kr.
20,000 kr.
0 kr.
Cost (DKK)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Material cost


Yearly energy consumption
250,000 kr.
200,000 kr.
150,000 kr.
100,000 kr.
50,000 kr.
0 kr.
Cost (DKK)
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Yearly Energy consumption


Total cost of ownership
4,000,000 kr.
3,500,000 kr.
3,000,000 kr.
2,500,000 kr.
2,000,000 kr.
1,500,000 kr.
1,000,000 kr.
500,000 kr.
0 kr.
Cost (DKK)
0
2
4
6
8
10
12
14
Years after installation
Scenario 1
Scenario 2
Scenario 3
Scenario 4


Savings in total cost of ownership
2,000,000 kr.
1,500,000 kr.
1,000,000 kr.
500,000 kr.
0 kr.
-500,000 kr.
Cost (DKK)
0
2
4
6
8
10
12
14
Years after installation
Scenario 2
Scenario 3
Scenario 4