University of
Stavanger

Faculty of Science and Technology

MASTER'S THESIS

Study program/ Specialization: Offshore technology, Industrial technology and asset management	Spring semester, 2010 Open access
Writer: Åsbjørn Enerstvedt	………………………………………… (Writer's signature)
Faculty supervisor: Conrad Carstensen External supervisor: Graeme Neil, BP Norway.	
Titel of thesis: VRD Plant Performance Testing Project	
Credits (ECTS): 30	
Key words: System design, System testing, Quality assurance, Performance testing, Seawater system, Centrifugal pump, Centrifugal compressor.	Pages: 63 + enclosure: 48 Stavanger, 15/06/2010 Date/year

Frontpage for master thesis
Faculty of Science and Technology
Decision made by the Dean October 30th 2009

Title of thesis:

VRD Performance Testing Project

Topic and scope of work, with activities:

Due to seabed subsidence and ageing facilities, the Valhall field is to have a new integrated Production and Hotel (PH) facility installed to exploit the remaining reserves. The new PH facility comprises a fixed steel platform installed to the south side of one of the existing platforms and linked by two bridges. PH compromises a 180 bed Quarters module and 19 000 m^3/d (oil) and 4 MSm^3/d (gas) processing deck with utilities and flare structure.

Part of the handover process from the Project team to Operation is assurance that the process and utility plant performs according to the design. To achieve this objective the project start up team needs to develop Plant Performance Test procedure that can be executed during the commissioning and early operation phases of the project.

A long with that, the candidate will look closer into one of the systems, the seawater system, and follow the process of selecting the components in a system.

Topic

1) The candidate will give a description of the quality process with verification of the requirements that has been set according to the agreement/delivery of a technical system. This includes every effort from inspection, simulations and calculation to testing of components and systems. In this thesis there is chosen a seawater system.

The quality process starts when selecting equipment and supplier and ends with handing over a complete system to production. Enlightened contents are quality assurance measures, different tests, visit to the construction area, accept criteria, relevant standards, reference literature etc.

2) The candidate will give a literature search to find relevant articles concerning the quality process of such systems. There will also be given a description of the seawater system chosen for VRD, including build-up and function. The description will include an identification of operation and maintenance.

3) The candidate will prepare a performance test/functioning test for the chosen system, and other essential systems in the VRD process module. The candidate should give suggestions to scope of quality assurance measures (f. ex. tests) that should be considered. Further on there should be explained why these tests are relevant and how the test should be carried through.

4) The candidate will prepare a performance test procedure of the following equipment.

- Export compressors
- Crude oil export pumps
- HP/LP flare knock-out drum pumps
- Firewater pumps
- Other utility pumps (e.g. cooling medium, jet water)

The candidate will hand in a detailed work plan to the institute, with a scheme over the disposal time the candidate has got for preparing the thesis.

Student: Åsbjørn Enerstvedt
Office location: BP, Trim-Towers Sandnes

External supervisor: Graeme Neil, BP Norway
Address: Forusbeen 50, Forus, Stavanger
E-mail: neilg@bp.com

Internal supervisor: Conrad Carstensen
Phone number: 97596229
E-mail: CCarsten@broadpark.no

Abstract

This master thesis is written on the subject of BP Norway’s installation of a new field centre (PH), at Valhall. The project, called Valhall Re-Development (VRD), needed to outline procedures on how to verify performance of equipment installed into the process module at PH.
The purpose of developing these procedures is to make a program on how to verify that BP Norway, as the purchaser, receives the equipment and systems they have ordered. The aim of the performance test is to verify that the equipment guarantee points are capable of achieving rated production.
Systems that have been specified in the thesis include the seawater system, where a total system description has been given along with maintenance program, operational modus and performance tests.
Other systems that have been specified through the thesis are rotational equipment like firewater pumps, cooling medium pumps, oil booster pumps, oil export pumps and export compressors. For this equipment, a brief performance verification program is outlined to verify that the equipment is capable of meeting the designed criteria’s and the specifications BP Norway has set.

Along with the technical part that evolves around the process module at PH, the thesis also consists of a literary part that discusses the various aspects of designing a new system and what phases that has to be considered. This part describes the two parties involved in a trade and what the purchaser has to consider during the designing period. In this lies verification of quality assurance, design criteria’s, performance specifications, verification tests etc.

The second part of the thesis gives a well-designed program on how to verify the promised performance and how to locate faults and mismatches. The thesis also consists of a discussion part where different aspects of the thesis are represented. This includes problem approaches related to the procedures and aspects that could lead to gaps in the resulting part.

Preface

This thesis is concerned around BP Norway's project VRD, a project of installing a new field centre at Valhall (PH). The thesis intention was to outline a program for testing the many items of equipment and systems at the new platform. Particular tests were to quality assure the performance of the equipment, to be sure that BP Norway, as the purchaser, got the agreed product.

The thesis is written during the five first months of 2010, at VRD-project's headquarter, Trim-Towers, at Sandnes. This location gave a close collaboration between the candidate and the Start-up team of the project.
The candidate has also had close relation with the University of Stavanger, and with the candidate's internal supervisor.

Through the VRD-project's common document hub, ShareCat, the candidate has had full access to all the relevant documentation of the project. This involves documents from the system designers as well as subcontractors for the different equipments.

Acknowledgments

This thesis is written in cooperation with BP Norway, and is concerned around their project VRD. I therefore have to give my biggest gratitude to this company, which I also am a proud employer of.

In BP Norway, my closest superior during the thesis has been Graeme Neil, who is the Start-Up Manager for VRD, and the process engineer Charles Honner. I therefore wish to give these two men my highest gratitude for all the help and support I have received throughout the project.

I also wish to give my internal supervisor at University of Stavanger, Conrad Carstensen, the highest of appreciations for the help and support I have received throughout the thesis.

Most of all I want to thank my team leaders at Valhall, Arvid Stavland and Dag Adolfsen, who have organized my full-time job offshore in a way that has made it possible for me to graduate through the master degree.

Åsbjørn Enerstvedt

Table of Contents

DEFINITIONS 3
UNITS 3
1 INTRODUCTION 4
2 SYSTEM DESIGN & PROJECT EXECUTION 5
2.1 DEVELOPMENT PHASES 5
2.2 CONTRACTUAL ARRANGEMENTS 6
2.3 DESIGNING A SYSTEM 7
2.4 TESTING 9
2.5 FINAL DESIGN DOCUMENTATION 10
2.6 PHASES OF A PROJECT 11
3 SEAWATER SYSTEM PH 14
3.1 SYSTEM DESCRIPTION 14
3.1.1 LP System *14*
3.1.2 HP System *15*
3.2 EQUIPMENT DESCRIPTION 16
3.2.1 LP Pump *16*
3.2.2 HP Pump *19*
3.2.3 Seawater Coarse Filter *23*
3.2.4 Electro Chlorination Generator *24*
3.3 POTENTIAL ROOT CAUSES 25
3.3.1 Water hammer (Surge) *25*
3.3.2 Pulsation *25*
3.3.3 Vibration *25*
4 PERFORMANCE TEST OF THE SEAWATER SYSTEMS 28
4.1 LP SEAWATER SYSTEM 28
4.1.1 LP Seawater Lift Pumps (84-PX-9101A/B) *29*
4.1.2 LP Seawater Lift Pump Changeover and Trip Test *31*
4.1.3 LP Seawater Coarse Filter *32*
4.1.4 Final tuning of LP seawater distribution system *33*
4.2 HP SEAWATER SYSTEM 33
4.2.1 HP Seawater Lift Pumps (84-PX-9102A/B) *34*
4.2.2 HP Seawater Lift Pump Changeover and Trip Test *36*
4.2.3 HP Seawater Coarse Filter *36*
4.2.4 Electro Chlorination Generation *37*
4.2.5 Final tuning of HP seawater distribution system *38*
5 PERFORMANCE TEST ROTATIONAL EQUIPMENT 39
5.1 COOLING MEDIUM PUMPS (45-PA-9106A/B) 39
5.2 FIREWATER PUMPS (48-XD-9107A/B) 40
5.3 OIL BOOSTER PUMPS (11-PA-9101A/B) 41
5.4 OIL EXPORT PUMPS (11-PA-9102A/B) 42
5.5 1ST STAGE GAS COMPRESSOR (23-KA-9101) 43
5.6 2ND STAGE GAS COMPRESSOR (23-KA-9102) 44
5.7 3RD STAGE GAS COMPRESSOR (23-KA-9103) 45
5.8 4TH STAGE GAS COMPRESSOR (27-KA-9104) 47

6 CALCULATION 49
7 DISCUSSION 51
8 CONCLUSION 53
REFERENCES 54
TEST SHEETS 55
APPENDICES: 64

List of Figures

FIG. 2.6.1 THE PROJECT PHASES....13
FIG. 3.2.1.1 EUREKA LINESHAFT DEEPWELL PUMP 16
FIG. 3.2.1.2 PUMP CHARACTERISTIC 84-PX-9101A/B 17
FIG. 3.2.2.1 FRANK MOHN ESP 19
FIG. 3.2.2.2 PUMP CHARACTERISTIC 84-PX-9102A/B 20
FIG. 3.2.2.3 PUMP CHARACTERISTIC 84-PX-9102A/B 21
FIG. 3.2.3.1 NORMAL FILTRATION PHASE FIG. 3.2.3.2 BACKFLUSHING PHASE....23
FIG. 3.3.3 VIBRATION MOTION (SINE WAVE)....26

List of Tables

TABLE 2.1.1 PROJECT DEVELOPMENT PHASES 5
TABLE 3.2.1.1 PERFORMANCE DIAGRAM 84-PX-9101A/B 17
TABLE 3.2.1.2 RATED POINT 84-PX-9101A/B....17
TABLE 3.2.1.3 MAINTENANCE PROGRAM FOR LP SEAWATER LIFT PUMPS (84-PX-9101A/B) 18
TABLE 3.2.2.1 PERFORMANCE DIAGRAM 84-PX-9102A/B 20
TABLE 3.2.2.2 RATED POINT 84-PX-9102A/B....20
TABLE 3.2.2.3 MAINTENANCE PROGRAM FOR HP SEAWATER LIFT PUMPS (84-PX-9102A/B) 22
TABLE 6.1 TUNING PARAMETRS 84-FIC-93294....55
TABLE 6.2 TUNING PARAMETRS 84-TIC-93286A....55
TABLE 6.3 TUNING PARAMETRS 84-TIC-93286B....55
TABLE 6.4 LP SEAWATER LIFT PUMP A 56
TABLE 6.5 LP SEAWATER LIFT PUMP B 56
TABLE 6.6 TUNING PARAMETRS 84-FIC-93233....57
TABLE 6.7 TUNING PARAMETRS 84-TIC-91771A....57
TABLE 6.8 TUNING PARAMETRS 84-TIC-91771B....57
TABLE 6.9 HP SEAWATER LIFT PUMP A 57
TABLE 6.10 HP SEAWATER LIFT PUMP B....57
TABLE 6.11 COOLING MEDIUM CIRCULATION PUMP A 58
TABLE 6.12 COOLING MEDIUM CIRCULATION PUMP B 58
TABLE 6.13 FIREWATER PUMP A 58
TABLE 6.14 FIREWATER PUMP B 58
TABLE 6.15 OIL BOOSTER PUMP A....59
TABLE 6.16 OIL BOOSTER PUMP B....59
TABLE 6.17 OIL EXPORT PUMP A....59
TABLE 6.18 OIL EXPORT PUMP B 60
TABLE 6.19 1ST STAGE GAS COMPRESSOR 60
TABLE 6.20 2ND STAGE GAS COMPRESSOR 61
TABLE 6.21 3RD STAGE GAS COMPRESSOR....62
TABLE 6.22 4TH STAGE GAS COMPRESSOR....63

Definitions

VRD	Valhall Re-Development	PFS	Power From Shore
PH	Process and Hotel	VSD	Variable Speed Drive
LQ	Living Quarter	QP	Quarter Platform
ESP	Electrical Submersible Pump	IP	Injection Platform
WP	Wellhead Platform	DP	Drilling Platform
VFN	Valhall Flank North	VFS	Valhall Flank South
UCP	Unit Control Panel	CCP	Compressor Control Panel
FAT	Factory Acceptance Test	ASC	Anti-Surge Control
LP	Low Pressure	HP	High Pressure
mlc	meter liquid column	SPM	Shock Pulse Method
LAT	Lowest Astronomical Tide	RMS	Root Mean Square
IGBT	Insulated Gate Bipolar Transistors	AHU	Air Handling Unit
PCS	Process Control System		
PCP	Production & Compressor Platform		
PDO	Plan for Development and Operation		
Bara	Absolute pressure over a perfect vacuum		
Barg	Pressure over atmospheric pressure at sea level		
HVAC	Heating, Ventilation and Air Conditioning		

Units

$A = Area\ [m^2]$

$Q = Flow\ [m^3/h],\ [m^3/s]$

$H_d = Dynamic\ head\ [mlc]$

$\rho = Density\ [kg/m^3]$

$\nu = Kinematic\ viscosity\ [m^2 \cdot s^{-1}]$

$\Delta p = Differential\ pressure\ [Pa]$

$\varepsilon = Friction\ factor\ [-]$

$d = Diameter\ [m],\ [mm]$

$Re = Reynolds\ number\ [-]$

$R = Universal\ gas\ constant,\ 8{,}314 \dfrac{kJ \cdot m}{kmol \cdot K}$

$T = Absolute\ temperature\ [K]$

$n = Polytropic\ exponent\ [-]$

$C_v = Flow\ coefficient\ [-]$

$H_h = Hydrostatic\ head\ [mlc]$

$H_p = Polytropic\ head\ [kJ/kg]$

$g = Gravity,\ 9{,}81\ m/s^2$

$p = Pressure\ [Pa],\ [kPa]$

$f = Friction\ number\ [-]$

$l = Length\ [m]$

$v = Velocity\ [m/s]$

$w = Weight\ flow\ [kg/h]$

$M = Molar\ weight\ [kg/kmol]$

$Z = Compressibility\ factor\ [-]$

$'' = Inch,\ 25{,}4\ mm$

1 Introduction

In Scandinavian mythology Valhall is described as a majestic, enormous hall of celebration in the mighty castle of Åsgard, ruled over by the great god Odin.

Valhall is also a name of one of the most significant oil and gas fields on the Norwegian shelf located in the southern corner, block 2/8.

The field has been producing oil and gas since the start-up in 1982. With three original platforms, one living quarter (QP), one drilling platform (DP) and one process and compressor platform (PCP), the field was first expanded in 1996 with one wellhead platform (WP).

The year of 2004 was a big year of expansion at Valhall, with three more platforms tied in to the original field centre, two un-manned flank platforms; flank south (VFN) and flank north (VFN), and one combined drilling and water injection platform (IP). Other tiebacks to the Valhall-complex are the un-manned Hod-field that was started up in the year of 1990.

The first estimates for the oil reservoir at Valhall was set to 247 million barrels of oil, by the end of 2004 the field had almost produced 600 million barrels of oil. With 450 million barrels still to go and an aging facility, the Valhall field needed to be upgraded. It was therefore decided to develop a new field centre that could process oil and gas until 2050. The main component would be a new combined process and living quarter platform (PH), which would phase out two of the existing platforms, PCP and QP, and in time DP.

The project, called VRD, started right after the decision was made in 2005. Big contracts were awarded to Wood Group, and their subsidiary company Mustang Engineering in Houston, for detail engineering of PH. Fabricom Stavanger would design the medications required to the existing Brownfield platforms whilst Aker Solutions would carry out the offshore construction. Heerema earned the contract for construction of the main deck, while SLP Engineering constructed the accommodation unit at their premises in Lowestoft, England.

The new platform, PH, is planned to be installed in July 2010, and will start processing oil and gas in second quarter of 2011.

In relation to the new process module a lot of equipment is installed from many different suppliers. The main objective for this thesis is to quality assure that BP Norway, as the purchaser, is getting the products they have paid for and that they are working according to the specifications and guarantees. This means to outline a program on how to test the performance of systems and different equipment. The main systems selected for this thesis is the HP and LP seawater systems, where a total description will be given along with equipment data and operational modus.

The thesis will also describe the formatives on how to design a new system from the beginning to the end. Enlightened issues in this matter are selection of contracts, testing procedures, quality assurance, design documentation etc.

2 System Design & Project Execution

2.1 Development phases

In the petroleum industry there are many players and roles, some companies are running the production of an oil field while other companies just have partner interests. Other companies again have their specialization in service, by providing the oil companies with products and services.

When an oil company has been awarded a field license and decides to develop it, they have to involve a lot of contractors and specialists to help them solve the mystery to a successful production system. The field development project consists of two main phases, called development planning and project execution.

The planning phase involves concept screening, feasibility studies and concept engineering. Concept screening takes care of the exploration part, while the feasibility studies are evolved around creating a PDO (Plan for Development and Operation) and getting it approved by the authorities and partners. When forming a PDO it is always focused on finding the best all round solution associated with commercial potential and safety, and environmental evaluations.

When the PDO is approved, which is part of the development planning, the conceptual engineering is started based on the recommendations of the PDO (Odland, 2000).

The conceptual engineering consists of:

- Final development concept (engineering basis)
- Operation and maintenance philosophy
- Safety and environmental programs
- Requirements to materials and standardization
- Master schedules and cost control estimates
- Procurement and contract philosophy

During the conceptual engineering phase the engineering basis, called Master Control Schedule, is being defined and held as a basis for technical changes in the project. Along with the Master Control Estimate, the technical concept of the project is being supported and activities and milestones are being defined.

To help out organizing schedules, resource plans, cost estimations and status reports, many projects implement a data tool called Work Breakdown Structure. This is a program that brakes down the scope of works in a hierarchy, with the work packages at the lowest level.

↓ License Award			↓ Issue PDO	↓ Start-up
Development Planning			**Project Execution**	**Operation**
Exploration (screening)	Project development (feasibility)	Conceptual engineering	Detail Engineering Procurement Construction Commissioning	Operate Maintain
			Preparation for operation	

TABLE 2.1.1 PROJECT DEVELOPMENT PHASES

The execution phase is where the detail engineering takes place, along with designing, procurement, fabrication and installation of the various systems.

2.2 Contractual Arrangements

When a company decides to invest in a particular development, there can be many parties involved. For most oil fields today this can be a difficult decision as there may be several oil companies having interests and also the government has to agree.

Procurement selection: Procurement is the acquisition of goods and/or services at the best possible total cost of ownership, in the right quantity and quality, at the right time, in the right place for the direct benefit or use of governments, corporations, or individuals, generally via a contract (Odland, 2000).
This means that a company that wants to invest in an item of equipment or supply of service has to choose a contractor to supply the goods/services, unless the company is capable of producing the goods/services themselves. Procurement is normally dealt with through a contract, where the two parties have to agree on the terms and rights. A simple procurement deal could be just to buy single item of equipment, while complex procurements could involve finding long-term partners, or even 'co-destiny' suppliers that might fundamentally commit one organization to another.
When the operator of a new development finally gets the go ahead to invest, there are several types of contractual arrangements to choose between. This is especially true when developing an offshore field development project. Different contracts that has to be considered are:

E: Engineering, where an engineering contractor is hired. This contractor has got technical, scientific and mathematical skills, to acquire, apply, design and implement a system in a safe and desired way. This includes how the system is being shaped and what kind of equipment that is needed to make sure the system work as desired.
EP: Engineering and Procurement, where a contractor is hired to perform the engineering and procurement. The company now has responsibility to gather all the equipment that is needed through sub contractors. This could be components in a system, like pumps, compressors, valves, instrumentation etc.
EPC: Engineering, Procurement and Construction. Together with engineering and procurement, the contractor also has the responsibility for construction of the system.
This includes the building and assembling of all the sub systems. The major operation in this phase is to assemble all the pipes, cables and instruments, and all the major fundamental structures.
EPCI: Engineering, Procurement, Construction and Installation. Includes every phase of the delivery of a technical system, even the installation part where the system is being hooked up against live systems at the site where it will be operated.
Turnkey: Everything above + Commissioning. In this contract the contractor handles everything including the commissioning phase of the system. This is where the system is being tested according to the requirements and objectives that the purchaser has set. After the commissioning phase the system is handed over to the client company’s Operations team and the purchaser has then received the complete product.

Other types of contracts might be put together by the joint venture-principles, where two or more companies are cooperating with each other. The key in these types of contracts is that the involved parties are benefiting from another by shearing the risk, costs and of course rewards.

2.3 Designing a system

The designer's approach to design a system is basically the same as designing one single component or a subsystem (Misra, 2008). But it differentiates a bit according to the degree on which the task is being carried out. A system is normally being designed on behalf of a customer with desirable objectives and requirements. In a selection process on what types of components are to be chosen, there should always be an evaluation to document the selection of the best technology to the right cost. It is not desirable to install prototypes in new systems because these are products that are not being properly tested and could lead to a lot of problems in operation. However, any process system is unique and is designed from the specification where it is going to be operated. In that case, we might say that every system is in effect a prototype. The difference is that a process system is being designed after the "tailor made" method, where a total quality program is outlined to secure that the product and technology is accurate for the requirements. But, it is very important to separate between equipment prototype and process system prototype.
An example on how a particular item of equipment is designed is listed as follows (Mirsa, 2008):

1. Develop one or more design concepts that satisfy the design objectives.
2. Carry out feasibility analysis for the various design concepts. This is done by using methods like theoretical analysis and simulations, or by experimentation and testing in combination with personal experience.
3. Select one of the design concepts that meet all of the design objectives. Objectives in this matter are reliability, safety and other performance goals. In this process they have to look into the whole system, from the combination down to each single part in the system hierarchy.
4. Prepare preliminary specifications and drawings.
5. Pass on the chosen design for procurement and fabrication of development hardware, to be used in the feasibility and evaluation testing of the hardware.
6. Prepare qualification test requirements, as well as production tests and inspection requirements.
7. Prepare the prototype, and work with the qualification testing and corrective design actions.
8. Prepare the final design of the prototype. This includes reviews of the original design objectives.
9. Review and approve/reject the uncertainties which is bound to the prototype.
10. When the objectives of design and other requirements are approved for manufacturing or fabrication or for the user's disposition, the complete design is to be released.

When the designer has released his prototype there are still a few tasks to perform. Examples of such functions are design-configuration control and design-change control. Design-change control is a tool used for controlling the changes made in a product. This is a request that needs to come under direct control of the top management, because the difficulties this will bring if everyone changed the design into their own matter.
Design-configuration control is more related to control of requirements for each specific product and model type of hardware. In the process of executing the first two phases of the design, we find approaches like feasibility studies and preliminary system design. This is a process every product has to go through and which there are different ways of handling. The most common practice for a design is to do a feasibility study of all the designs.

Then engineers compare the different designs, and choose the best configuration for a further more in depth study. The engineers now have to see which of the designs that would be the best to optimize, which will be executed in the preliminary design by computers.
An ideal process of a design would be to optimize every one of the chosen designs, and then select the one it would be best to proceed with. But because this is a much bigger, and more expensive operation, most companies choose the common practice for system design (Misra, 2008). When the right design is chosen for a system there are three phases of development that has to considered:

Conceptual design is the first phase where the life cycle of the system is being calculated and the foundation for the rest of the phases is being based. The conceptual design evolves from functional definition of the system, based on the requirements from the customer and other needs. This is also where the design criteria for the system are being established. The system design starts with identifying the user's needs and requirements for a fully developed system configuration that is ready for production and delivery for subsequent use. In this process it is very useful to involve the customer into the design team, to solve out deficiencies in present design and to get more specific needs based on experience.
When the needs and requirements are highlighted it is time to identify some possible design approaches, this is done in terms of performance effectiveness, maintenance, logistic support and economical criteria. Based on the results, the best alternative is selected. System specifications are now developed, and a review of the conceptual design is to be undertaken.

Preliminary system design is a step further in the process, where it is being worked with the requirements obtained from the conceptual design phase and breaks it down to subsystem level requirements to develop a system configuration. It is also the phase where the specific requirements for hardware, software, manpower, facilities, logistic support and other related resources through a functional analysis are being identified. This analysis is also used to describe functional interfaces and to identify resources for hardware, software, people, facilities and data, including their interfaces. A system design review is then undertaken to ensure that the requirements are being met, along with the allocation process, the trade-off studies and the selected design approaches are being reviewed towards the initially set of requirements. All the deviations resulting from the review are being recorded and the appropriate necessary corrective measures are being initiated.

Detail design and development is based on the results from the review of the preliminary design phase, and evolves from the system specifications. These are specifications from appropriate design-dependent parameters, technical performance measures and associated design, to criteria for characteristics, subsystems and components. The design requirements are achieved through a requirements allocation process, which identifies the detailed performance and effectiveness parameters for each of the elements in the functional analysis. This could be parameters like input- output factors, metrics etc.
A designer can now decide whether to meet the requirement of an item that is commercially available, or by modifying an already existing commercial item or design, develop and produce a totally new item to meet the specific requirements. The design is being evaluated through the fabrication phase of a prototype, or by using a physical working model. Before the firm design data is released to initiate production and fabrication, a new review is undertaken. A detail design review has objects to establish good "production baseline", and verify the adequacy and producibility of the design. The design is now being re-evaluated

through manufactory methods, schedules and cost, before the product is being "frozen" and sent to testing and for final evaluation.

Design evaluation of a system has the purpose of assessing the requirements of each level of the system hierarchy, in terms of hardware, software, facilities, people and data. The baseline is evaluated against the particular design configuration, and expectations like effectiveness, cost, time, frequency etc. are being assessed. The whole operation is done to meet the customer's expectations and deliver a successful product.

2.4 Testing

During, and after, a design phase it is always desirable to test the system against the requirements. This is done to outline faults and errors in the system, as well as pleasing the authorities and the purchaser by showing the progress. Different tests are being outlined during the design and commissioning phase, all with certain mutuality lineaments. Along with the system there shall always be included a test plan with explanations and guidelines for which test to be carried out. The test plan consists of the following contents:

- The definition and schedule of all test equipment and details of organization, administration and control responsibilities.
- The conditions of test conditions including maintenance and logistic support.
- The description of test plans for each type of testing.
- A description of the formal test phase.
- The description of conditions and provisions for the retest phase. This phase is accomplished when the acceptance criteria from the other phases are reached, and the tests are not successful.
- The test documentation.

A test plan serves as a valuable reference and indicates what is to be accomplished, requirements for the test, schedules for the processing of equipment and material for test support, data collecting and reporting methods etc.

Different tests are outlined during the design phases, all to ensure quality assurance and that the design is progressing in the right direction and goal. In the qualification procedures for new technology relevant examples of tests are (DNV, 2001):

Basic tests, specified to test the material properties to establish the key parameters in the design. Also specified to be part of the quality assurance of supplied subsystems. Examples of basic tests are material properties, dimensional accuracy, contamination level of hydraulic fluids, electrical resistance etc.

Prototype tests are qualification tests of the components and assemblies to verify the functional requirements of a new type of design. These tests are often combined with measurements and numerical analysis to verify the functions. Prototype tests can be carried out in phases including laboratory tests and full service tests, such as in shallow/deep water and with hydrocarbons etc.

FAT (Factory Acceptance Test) is a verification test of the manufacturing and assembly of a system that already has been through a prototype test. This is a test that will outline that the performance of the new system meets the requirements, and is therefore a part of the quality control procedure (quality assurance). "The tests shall verify that the probability for manufacturing and assembly failures is acceptably low" (DNV, 2001).

Typical requirements of equipment, such as a centrifugal pump, could be pump performance tests such as head versus flow, energy consumptions etc. Other parameters a FAT utilizes are level of vibration, bearing temperatures, noise level, leakages etc.
These are some examples of many acceptances criteria the provider has to refer to. To help out with this process, standards are made to help out both provider (when designing) and purchaser (when accepting) in the project phase. Well-known standards are API, ISO and NORSOK. A FAT is performed where it is most practical, normally at providers test-rig or at installation site, in order to reduce damage probability or uncertainty in the product. This is a test where the purchaser of the final product often is participating and witnesses.

Pre and post installation test is outlined during and after the system is being assembled and installed at the facility site, this to confirm the correctness of the installation.

Pilot application represents the first use of the system, and includes start up, functional tests and performance tests. These are advanced tests run to gain more experience of the system, and check out critical operations and complexity associated with this. In this phase it is desirable to test the performance of the equipment, to be sure that the purchaser is getting the product he has paid for. Example of this could again be a centrifugal pump that is being tested for performance according to head versus flow, energy consumptions etc. Also conditioning monitoring parameters are desirable to check to verify that the pump is running according to the set requirements. These tests are much like the tests outlined during the FAT.

A simpler guidance to which tests are to be performed during a design phase is the following hierarchy:

- Material testing
- Component testing
- Sub-assembly testing
- Assembly testing

Another method, called accelerated tests, is used to reduce test time and cost, and is suitable through building a theory model to simulate the desired tests. This method is depending on that the uncertainties is localized and reduced to a minimum.

2.5 Final design documentation

Some of the most important actions of a design operation lie in the documentation. This is written proof of how the system is being designed, including signatures and approvals.
The final design documentation usually includes:

- *Specification:* Performance requirements, specified environmental conditions, system performance goals and specified basic logistics requirements. Examples of this could be limits of CO_2 and NO_x pollution to the air and maximum capacity of equipment (gas compressors, crude oil pumps etc).
- *Drawings:* Coordination drawings, correlation drawings, production drawings, procurement drawings and drawings of special test equipments. For drawings related to a project it is in this context related to “as-built” P&ID’s and “red mark-up” P&ID’s. The term "as-built" is equivalent to "as-is", and is showing the exact condition of the system. “As-built” drawings can be documented either after or during

construction. After the construction phase of a system, a qualified technician collects accurate data to reconstruct the drawings back to "as-built".

During a project phase, when there are frequent changes in the "as-built" P&ID's, the drawings often gets marked with red lines to indicate minor or major adjustments in the system. This is a temporary solution, called "red mark-up", and is updated after the project phase, back to "as-built" P&ID's.

- *Parameters:* Functional parameters with their tolerances, starting at the operational use and going backward towards the supplier. The tolerances are specified such as they may be adjusted after time, for example as a result of equipment degradation. The adjustment tolerances are therefore called "funnels of tolerance", where the small end of the funnel is localized at the start, and the large end is pointing towards the future. Good examples of this could be frequency of condition monitoring samples, where the frequency of sampling in the start-up phase is very frequent and is decreasing after a time with stable conditions.

2.6 Phases of a project

Mechanical completion, Installation and Commissioning:

A technical system is normally manufactured by contractor, and then assembled and tested before it is handed over to the purchaser. Each system has to be commissioned, normally done by a commissioning team localized at the construction or installation site where the system is to be installed. The system has to go through a mechanical completion, installation and commissioning phase before it is ready for start-up. A commissioning manager leads this lather phase, and has the responsibility that every activity and objectives are being reached. The most important tasks are to assemble the systems and to functional test the components involved in the system.

Important tasks and activities in the mechanical completion, installation and commissioning phase are (ISS International, 2006):

- Visual inspections for complete and correct installation.
- Shaft alignment, where the rotational machinery is being balanced to reduce the vibration to a minimum.
- Lube oil flushing, simply flush the pipes to clean out eventual particles.
- Pressure/leak tests, to verify that the pipes, vessels and equipments are able to work with the desired pressure.
- Cabling, draw cables between instrumentation and equipment.
- Electrical commissioning, test the electrical system for function.
- Instrumentation commissioning, verify that the installed instrumentation is functioning.
- Loop testing.
- ESD Functioning test, test that the ESD system is working according to limits.
- Integration into existing site.
- As built P&ID's, update the P&ID such that these are correct.
- Functional/integration tests.
- Off-line equipment test, testing of electronic equipment that is not in direct communication (or under the control of) the main process.
- Management of spares, decide and make a plan for what kind of spare parts that needs to be in stock.

- Certification, make sure that the correct certification has been completed and has the right signatures and stamps.

Start-up phase: Start-up is the point in a project where process fluids, such as hydrocarbons (if applicable), and conditions of the equipment are established with the intent of making a final product/products. The systems are now handed over to the Start-Up Team, led by the Start-Up Manager. This phase includes start-up of the systems and functional testing. Here are some of the most important tasks and responsibilities the Start-Up Manager has before handing over the system to the Operations Team. (ISS International, 2006):

- First year operability requirements. This means stock of parts that might break down during the first year of operation. Examples of typically spare parts relevant for a centrifugal pump could be a gasket, bearings, seals, lube oil etc.
- Start-up procedure. Describing the start-up for each of the systems.
- Plant line-up. Arrange the systems up ready for start-up.
- Mechanical run-in machinery monitoring.
- GC/calorimeter calibration (Only applicable for the petroleum industry, typically involved in gas compressors and metering systems).
- Equipment troubleshooting. To detect faults and errors.
- Control-loop tuning. Verify that every control functions are in place. Typical example of this could be the response of a regulation valve
- ESD wet tests / Blow-down tests (Only applicable for the petroleum industry, typically involved in oil and gas plants).
- Surge-line setting. (Only applicable for installation of centrifugal gas compressors)
- Minimum-flow system functional tests.
- Performance and functional tests as required.
- Support training of operations personnel.
- Plant optimizing and de-bottlenecking. Defining the operational settings for each of the systems, along with the total production.
- Certification.

Operational phase: At the end of a project the systems are handed over to the Operations team that will from this point on operate and maintain the systems in normal operational modus. Typical tasks and responsibilities the Operations team has to follow up we find (ISS International, 2006):

- Pre-operations plan. Outline procedures on how to operate the systems.
- Production reporting.
- Recruit Operation and Maintenance teams. Includes training courses and education of personnel.
- Maintenance routines.
- Accepting of project engineering data.
- Operations support and maintenance contracts.
- Brownfield permit system. Decide which strategy to choose, related to the maintenance activities.
- Provide staff for commissioning and start-up teams.
- Certification.

In Fig. 2.6.1 a simplified project chart is illustrated, containing every of the mentioned phases above along with their submissions and objectives. From the left the main phases are listed up, starting with construction and further on with commissioning, start-up and operation.

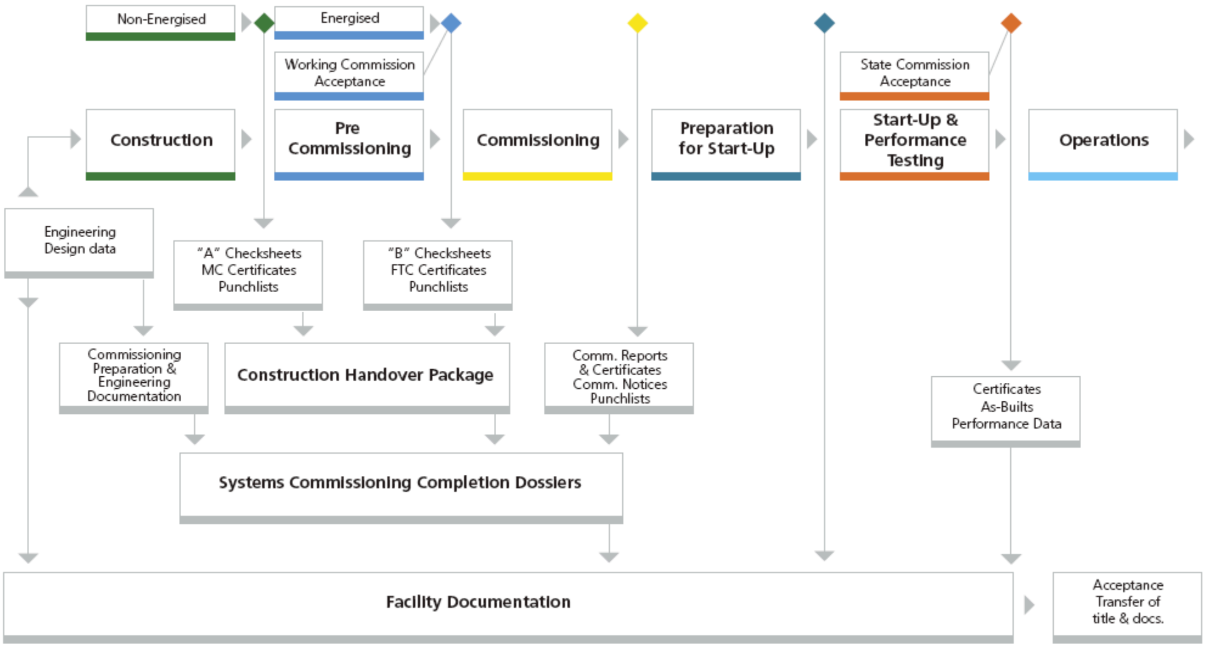

Non-Energised
Energised
Working Commission Acceptance
State Commission Acceptance
Construction
Pre Commissioning
Commissioning
Preparation for Start-Up
Start-Up & Performance Testing
Operations
Engineering Design data
"A" Checksheets MC Certificates Punchlists
"B" Checksheets FTC Certificates Punchlists
Commissioning Preparation & Engineering Documentation
Construction Handover Package
Comm. Reports & Certificates Comm. Notices Punchlists
Certificates As-Builts Performance Data
Systems Commissioning Completion Dossiers
Facility Documentation
Acceptance Transfer of title & docs.

FIG. 2.6.1 THE PROJECT PHASES

3 Seawater system PH

3.1 System description

The chosen seawater system for Valhall PH is split into two separate systems, each with their own working pressure. One LP (Low Pressure) seawater system to provide cooling medium for the cooling medium coolers, and one HP (High Pressure) seawater system to provide cooling medium to a few particular coolers, as well as keeping up the pressure on the firewater ring main, fresh water generation, service water etc.

The pumps for both of the systems are each mounted inside a caisson, which allows the systems to collect seawater at a depth of 50 m below LAT (Lowest Astronomical Tide). From this depth the seawater is transported to the platform by seawater lift pumps, namely two LP pumps and two HP pumps. The reason for this big depth is to ensure that the seawater contains as little organic pollution as possible, even in prolonged periods of the year (Carstensen, 2009).

3.1.1 LP System

In this description, reference is made to the following P&ID's: PH-ME-P-0258-001, PH-ME-P-0259-001 & PH-ME-P-0264-001.

The LP system consists of two LP seawater lift pumps (84-PX-9101A/B), where both of the pumps are designed for 100 % system flow. This means that only one of the pumps is in service at a time, while the other one is in stand-by. The two pumps are identical and are designed to deliver a rated flow of 2400 m^3/h with a discharge pressure of 3,5 barg at the topside. However, the system is designed to handle pressure all the way up to 14 barg, which is the reason why the pumps are a little over dimensioned as will be illustrated in the pump characteristic.

The pumps are called Eureka Lineshaft Deepwell Pump, and are a vertical turbine product lubricated pump that is driven by a dry mounted electrical motor. This means that the flowing seawater is lubricating the bearings and the rotational parts. Each of the pumps is mounted in a caisson, which is injected with hypochlorite and copper to prevent bio fouling.

On the topside, each of the pumps are protected by a minimum-flow valve that will secure a minimum continues flow through each of the pumps. Each of the two pumps is also equipped with a vacuum breaker to help draining the stand-by pump of water. This vacuum breaker also acts as an air release trap during start-ups. The same piece of item is located at the highest point of the seawater distribution manifold.

The pumps are lifting the seawater to the topsides where the flow is first filtrated through a coarse filter (84-CA-9119) to separate out particle contaminants. The reason for this mechanical filtration is to avoid plugging of pipes and heat exchangers. The filter is designed for 100 % flow (2400 m^3/h).

After the seawater is filtered, the flow is distributed to the two cooling medium coolers (45-HB-9101A/B) where the seawater flow receives heat energy from the cooling medium system. These coolers are dimensioned for a flow of 2400 m^3/h each.

The temperature on the cooling medium system is controlled downstream the two coolers, where a temperature controller (84-TIC-93286A/B) is controlling the seawater flow through the coolers.

The LP seawater system is also provided with a flow controller (48-FIC-93294) downstream each of the two coolers. This is a controller that is active in a change over situations between the two coolers. The controller simply measures the total seawater flow through the two coolers, and ensures that the total flow does not exceed 2400 m^3/h. If the seawater flow should increase over this value, the flow controller will override the temperature control valves and regulate these valves according to the flow.

Downstream the coolers, the seawater is gathered and injected into the LP seawater dump caisson and back to the sea.

3.1.2 HP System

In this description, reference is made to the following P&ID's: PH-ME-P-0259-002, PH-ME-P-0259-003, PH-ME-P-0259-004, PH-ME-P-0259-005 & PH-ME-P-0260-001.

The HP seawater system is provided with two identical ESP's (Electrical Submersible Pump) (84-PX-9102A/B), each designed for 100 % capacity (900 m^3/h) with a discharge pressure of 9,5 barg at the topside.

The pumps are both submerged in a caisson, which is injected with copper and hypochlorite to prevent bio fouling. Each of the pumps is equipped with their own minimum-flow regulation to ensure that the pump always gets a minimum continues flow. They are also equipped with their own vacuum breaker to help drain the stand-by pump of water. This vacuum breaker also functions as an air release trap during start-ups.

The seawater is sucked into the rotating impeller wheel through a suction strainer, and lifted to the surface through the pipe stack. At the topside the seawater flow is first filtered for particles in a coarse filter (84-CA-9129), which is a mechanical filter designed to handle 200 % of the system capacity (1800 m^3/h). After the filter, the seawater flow is distributed to the consumers.

The HP seawater system supplies to two types of consumers, essential and non-essential. The systems classified as essential are those critical for the safety of the PH installation. This system has small bore tubing communication with the firewater ring main, intended to maintain the pressure in the firewater ring main when the firewater pumps are in stand-by mode. In case of an emergency the firewater pumps will start, and there will be a reversed situation where the firewater system provides the flow to the essential users. Two check valves in series control this backflow, preventing the firewater from flowing into the non-essential consumers.

The essential users are:

- Pressure support of the firewater ring main.
- Cooling medium to the VSD (Variable Speed Drive) Cooler (60-HB-9126)
- Cooling medium to essential HVAC (Heating, Ventilation and Air Conditioning) coolers in the LQ
- Cooling medium to the emergency/essential generators on PH

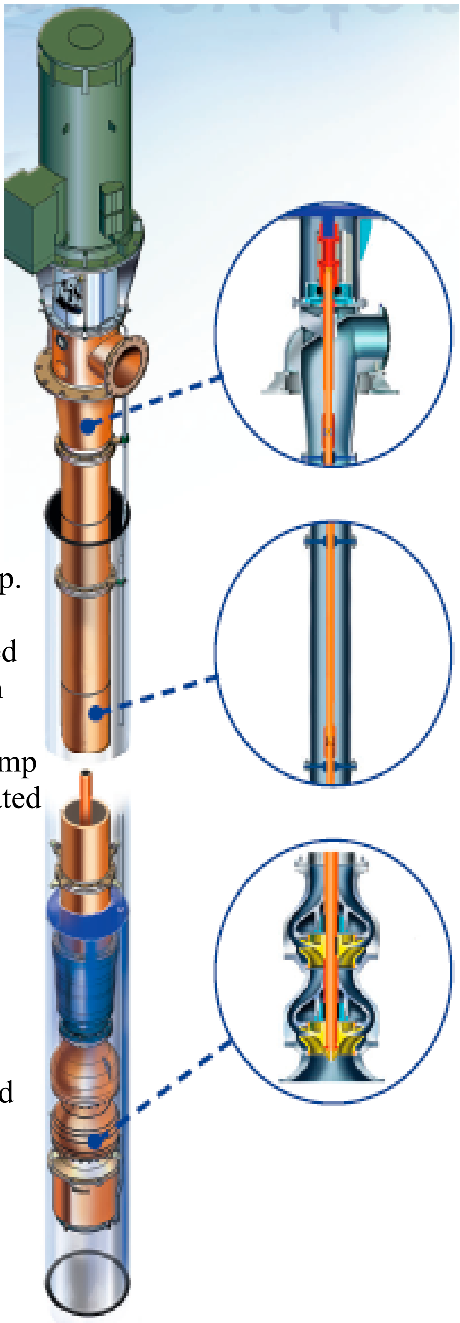
The non-essential consumers are:

- Potable water makers
- Cooling medium to non-essential HVAC coolers in the LQ
- Cooling medium to PFS (Power From Shore) transformation coolers
- Electro chlorination generator
- Utility stations

After the many consumers, the non-essential and essential water is collected and dumped into the HP seawater dump caisson and back to the sea.

3.2 Equipment description

3.2.1 LP Pump



Reference for the following description is taken from Bjørge Eureka's compendium, Eureka Seawater Lift Pumps. Technical literature regarding centrifugal pumps are found in Palgrave, 2003 and Girdhar and Moniz, 2005.

The pumps are provided by Bjørge, called Eureka Lineshaft Deepwell Pump, and are a vertical turbine product lubricated pump which is driven by a dry mounted electrical motor.

The pump is working after the principal of adding kinetic energy to the flowing medium by rotating an impeller wheel(s), and then convert the energy to static pressure in a diffuser. The diffuser increases the flowing area, which decreases the flowing speed. According to Bernoulli's principals where the energy is constant, the static pressure will increase in the flowing medium. The pump unit and the shaft are placed inside a column riser, which is again mounted inside a protection caisson. The pump unit with line shaft and impellers has got a length of 45 m, while the caisson is 85 m deep. To prevent bio fouling hypochlorite and copper are injected to the caisson. The pump unit consists of two impellers, each surrounded by pump bowls which function as diffusers. A strainer is mounted on the suction side of pump unit to prevent inflow of large marine organisms and other substances from the water. The shaft and the pump unit are supported by sleeve bearings between the two stages, lubricated by the flowing seawater. As already mentioned, the line shaft is mounted inside the riser column.

In the flange connections of the many riser column sections there are mounted journal bearings that is supporting the rotating shaft. These are also lubricated by the flowing water.

The axial forces from the impellers is to be taken by a deck head mounted thrust bearing, which is oil/grease lubricated.

The seawater flows into the inlet nozzle through the inlet strainer, and is lifted up the topside by the impeller wheels. At the topside, the seawater flows out of the column riser through a 90 degree discharge bend while the line shaft continues up to the electric motor, placed vertically above the column riser. To prevent an external seawater leakage in the point where the shaft leaves the riser column, it is installed with labyrinth seal.

FIG. 3.2.1.1 EUREKA LINESHAFT DEEPWELL PUMP

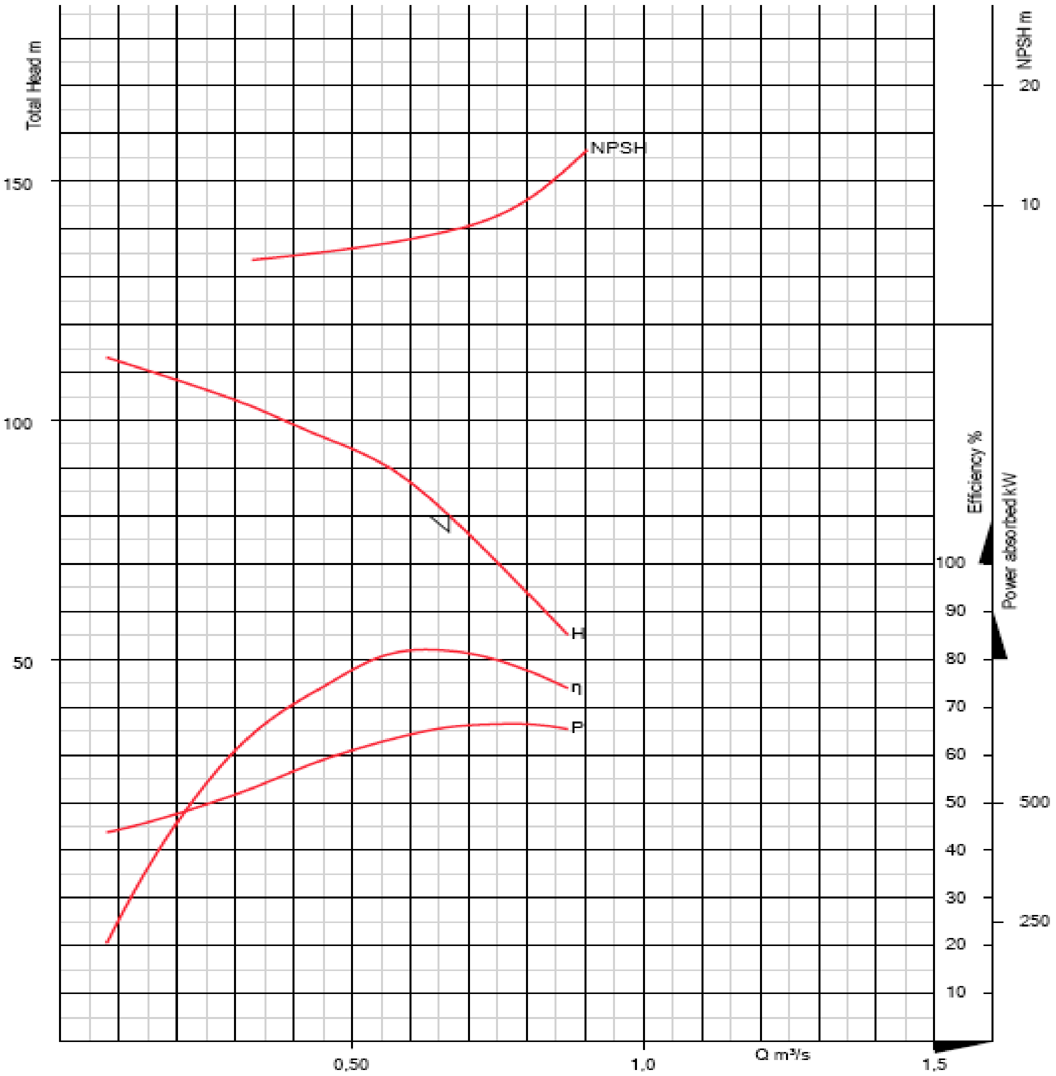


Fig. 3.2.1.2 Pump characteristic 84-PX-9101A/B

Technical data:

Performance diagram			
Imp. diam:	**514.2 mm**	**Medium:**	**Seawater**
Speed:	**1180 rpm**	**Density:**	**1027 kg/m^3**
Imp. stages:	**2**	**Visc:**	**1,0 cSt**
		Temp:	**14 deg C**

Table 3.2.1.1 Performance diagram 84-PX-9101A/B

Rated point	
Flow [m^3/h]	**2400**
Head [mlc]	**80.1**
NPSHr [mlc]	**7.9**
Power [kW]	**657.8**

Table 3.2.1.2 Rated point 84-PX-9101A/B

Material selection:

As for the material chosen for the LP seawater lift pumps, 25 Cr. Duplex is used for most of the equipment. This includes line shaft, impellers, pump bowl, column pipes, sleeves and wear rings. Reasons for choosing 25 Cr. Duplex, also known as super duplex, is because this is a material with exceptional strength and high corrosion resistance.

Maintenance:

Maintenance regimes vary between start-up and regular operation, because of run in phase and abnormal situation.

However, in normal operation, the provider of the pump, Bjørge AS, is recommending the following maintenance program for the pump:

Maintenance program for LP seawater lift pumps (84-PX-9101A/B)	
Maintenance activity	**Intervals**
Visual inspection when pump is running. Check for bearing temperature, vibration, lube oil supply etc.	Once a month.
Visual inspection when pump is stopped. Check for lube oil leakages.	Annually.
Check for vibration levels on pump and motor bearings. Motor bearings are equipped with SPM-nipple. Vibration level on pump to be checked on pump bearing house. Max level is 5 mm/s in RMS.	Once a month for the first 6 months in operation, every 3rd months after this.
Change oil in pump bearing. Pump bearing to be drained by unscrewing the drain plug at the end of the drainpipe. New oil to be filled trough the filling plug in the bearing cover. Ref doc no PH-26016-R-4800006. (Not in the appendices).	Annually. Plus every time repair work is done, that could have affects on the bearing or oil level.
Check the pump performance, and compare the data against the predicted performance curves given by Bjørge AS. Ref doc no PH-26016-R-4800015. (In the appendices).	Every 2-3 years.
Visual coupling inspection.	Every 2-3 years.
Complete dismantling of pump. Ref installation instruction. Ref doc no PH-26016-K-4800005. (Not in the appendices).	Consider every 10th years.

TABLE 3.2.1.3 MAINTENANCE PROGRAM FOR LP SEAWATER LIFT PUMPS (84-PX-9101A/B)

3.2.2 HP Pump

Reference to the following description is taken from Frank Mohn Flatøy's compendium, Technical Description Electrical Submersible Pump. Technical literature regarding centrifugal pumps are found in Palgrave, 2003 and Girdhar and Moniz, 2005.

The HP seawater lift pumps are called ESP, and are an example of a centrifugal pump with an axial flow, provided by Frank Mohn.

The pump is working after the principal of adding kinetic energy to the flowing medium by rotating an impeller wheel(s),

and then convert the energy to static pressure in a diffuser.

The diffuser increases the flowing area, which decreases the flowing speed. According to Bernoulli's principals where the energy is constant, the static pressure will increase in the flowing medium.

The pump consists of four main parts:

- Pump/Motor unit with end suction.
- Pipe stack with internal electrical power transmission system (riser pipes).
- Top plate arrangement with electrical junction box.
- Oil circulation unit.

The electrical motor is submerged into the seawater where it is provided with electrical power and is rotating the pump head, consisting of one impeller wheel. This wheel takes in the seawater flow through an inlet strainer, before lifting the flow to the topside through the outer shell of the pump house and up the water pipe section of the pipe stack.

The pump is connected to the topside via the pipe stack (47 m), mounted inside a 85 m long caisson. This pipe stack consists of one oil pipe section placed inside a water pipe section.

As mentioned before the water section is leading the seawater to the top side, while the oil pipe is leading non conductive oil down to the pump unit. Inside the oil pipe section it is located three copper conductors which is providing the electrical motor with power. Inside this section we also find a return line for the oil, leading the oil back to the topside. Reasons for supplying oil to the pump unit are:

- Lubricate the mechanical seals and the bearing system.
- Cool the electrical motor.
- Keep an overpressure in the oil pipe section, to avoid seawater inflow to the electrical conductors.
- Electrical insulation condition monitoring.

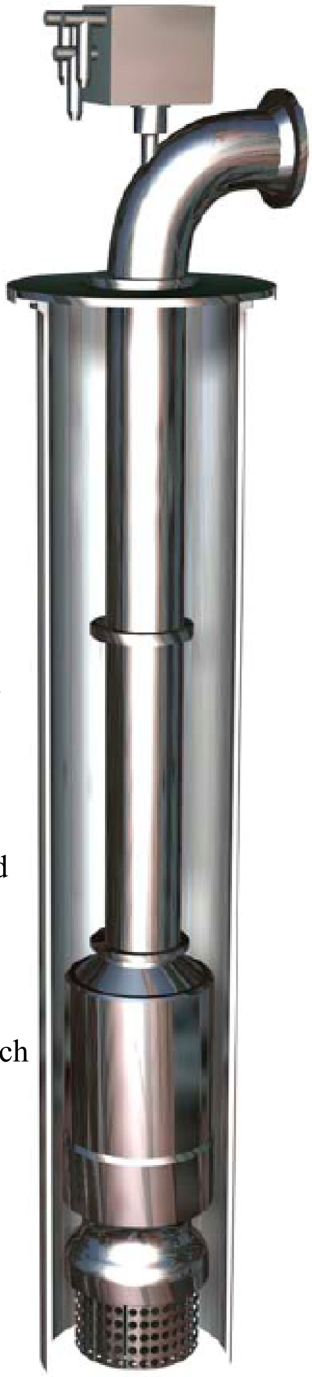


FIG. 3.2.2.1 FRANK MOHN ESP

The pump/motor unit is supported through the pipe stack, with a roller bearing for radial support on the non-drive end, and a combined radial and thrust bearing on the drive end. The seal system protects the electrical motor against inflow of seawater, and consists of a mechanical seal riding on a sleeve. The spring, forcing the seal rings towards each other is placed inside the electrical motor casing, so that sealing plates are lubricated and cooled by the forced oil circulation system.

On the topside, the water section of the pipe stack is going out through a 90 degree bend, while the power conductor is going further up to the top plate arrangement where the junction box is located. In this box the electric power supply is placed, as well as the adapters for the pressure and return side of circulation oil.

The utility system associated with the pump, is the oil circulation unit. It consists of an atmospheric oil reservoir, a positive displacement pump to keep up the pressure on the circulation loop, an accumulator, a closed circulation loop and a pump to circulate the oil from the pressure side and back to the return side. The positive displacement pump is installed to compensate for the small loss of circulation oil through the mechanical seal.

Technical data:

Performance diagram			
Imp. diam:	**575 mm**	**Medium:**	**Seawater**
Speed:	**1780 rpm**	**Density:**	**1030 kg/m^3**
Imp. stages:	**1**	**Visc:**	**1,2 cSt**
		Temp:	**14 deg C**

TABLE 3.2.2.1 PERFORMANCE DIAGRAM 84-PX-9102A/B

Rated point	
Flow [m^3/h]	**900**
Head [mlc]	**132.1**
NPSHr [mlc]	**14.5**
Power [kW]	**435**

TABLE 3.2.2.2 RATED POINT 84-PX-9102A/B

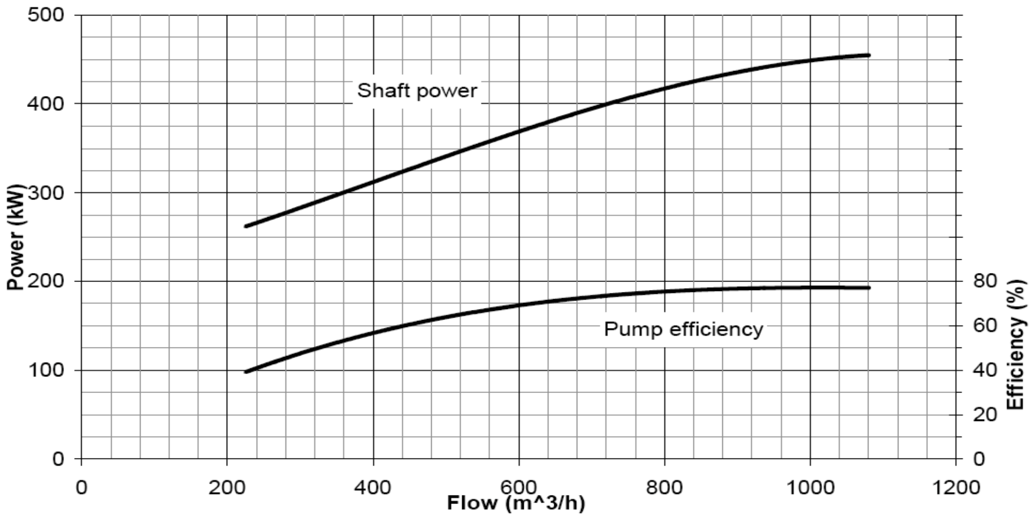


FIG. 3.2.2.2 PUMP CHARACTERISTIC 84-PX-9102A/B

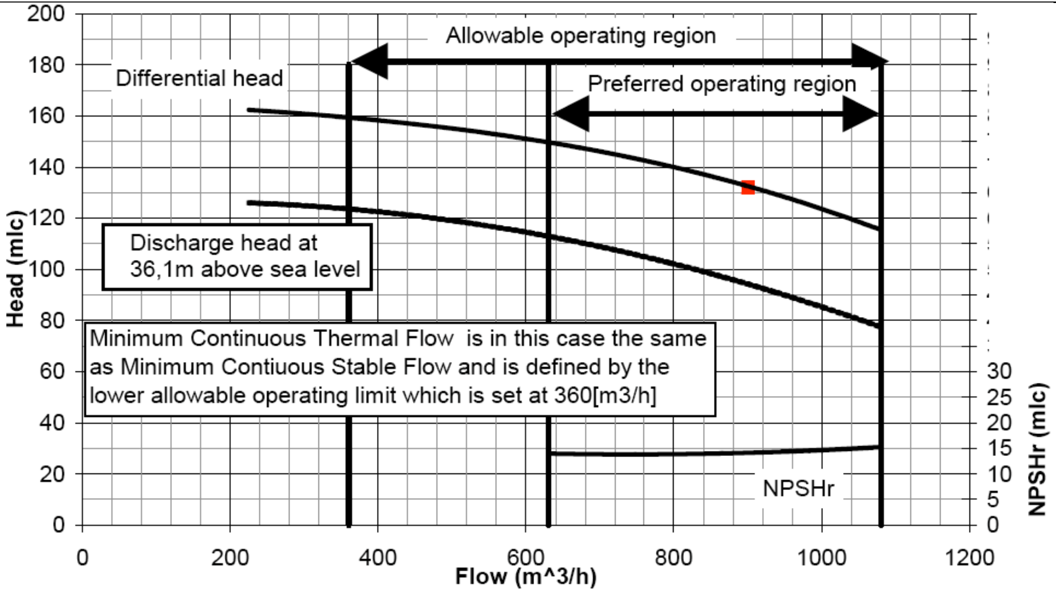


FIG. 3.2.2.3 PUMP CHARACTERISTIC 84-PX-9102A/B

Material selection:

As for the material chosen for the HP seawater lift pumps, 25 Cr. Duplex is used for most of the equipment. This includes pump/motor casing, impeller and pipe stack with sleeves, studs and nuts. The shaft between the motor and the impeller is made of 32CrNiMo6, while the caisson is made of carbon steel.
Reasons for choosing 25 Cr. Duplex, also called super duplex, for the seawater system is that this is a material with exceptional strength and high corrosion resistance.

Maintenance:

Maintenance regimes vary between start-up and regular operation, because of run in phase and abnormal situation.
However, in normal operation, the provider of the pump, Frank Mohn, is recommending the following maintenance program for the pump:

Maintenance program for HP seawater lift pumps (84-PX-9102A/B)	
Maintenance activity	**Intervals**
Check for functionality of air release trap.	Annually.
Check the ambient conditions (air circulation, humidity) and seal integrity of the process connections. Also check cable connectors and cover screws, functional reliability of the voltage supply, the grounds and the lightening protection.	Annually.
Check the pump performance, and compare the data against the predicted performance curves given by Frank Mohn. Ref doc no PH-14034-R-4710023. (In the appendices)	Annually.
Perform particle counting and water analysis of circulation oil.	Once a month.
Take full oil analysis. The oil is to be replaced if the viscosity or if the oxidation stabilizing elements are below minimum limits.	Annually, and after major overhaul and maintenance.
Drain the oil circulation tank for condensation of water.	Once a month.
Change oil filter elements.	Once a year in operation, or if the

	differential pressure is too high by pop-up indicator. Also if it is too large particle containments in the circulation oil.
Measure the consummation of circulation oil. This to give a figure of the mechanical seal leakage.	Continually.
Change the air breather.	If air breather with silica gel is installed, change when the color changes. If water block breather is installed, change annually.
Check pre-charge pressure on the accumulator.	Annually.
Major maintenance, requiring retrieval of the electric submerged pump and full inspection with replacement. This is a program the service engineer from Frank Mohn is called out to do.	Every 5th year, 40 000 running hours or upon failures.

TABLE 3.2.2.3 MAINTENANCE PROGRAM FOR HP SEAWATER LIFT PUMPS (84-PX-9102A/B)

3.2.3 Seawater Coarse Filter

The seawater coarse filters for both the LP and HP seawater systems are provided by GFSA. The filters consist of a large number of standing wedge wire filters, which are open at both ends. A housing made of titanium surrounds the filter assembly. Each of the wedge wire filters has got a filter mesh, designed to filter out every particle above 500 µm ($5x10^{-4}$ m)

The normal flow through the filter is guided into the filter from both ends, and then forced to flow through the wedge wire filter on the way out. By this, the particle contaminants will end up in the inner face of the filter elements.

The filters are designed to provide their own backflushing sequence. This regeneration sequence consists of an electrical motor that rotates a backflushing-arm assembly and a control valve that opens a dump line to the seawater dump caissons.

The backflushing-arm assembly is designed in the way that the wedge wire filter is closed off and sealed at both ends, the assembly now opens a path to the drain system in sequence with opening the control valve. Because of the differential pressure, the already filtrated water will now be forced into the dirty wedge wire filter, with a high velocity going in the opposite direction of the normal path. The wedge wire filter is now being backflushed, and the particle lying in the inner face of the filter elements are being flushed away.

This regeneration operation can be controlled by a timer or by a differential pressure measure over the filter, as well as manually.

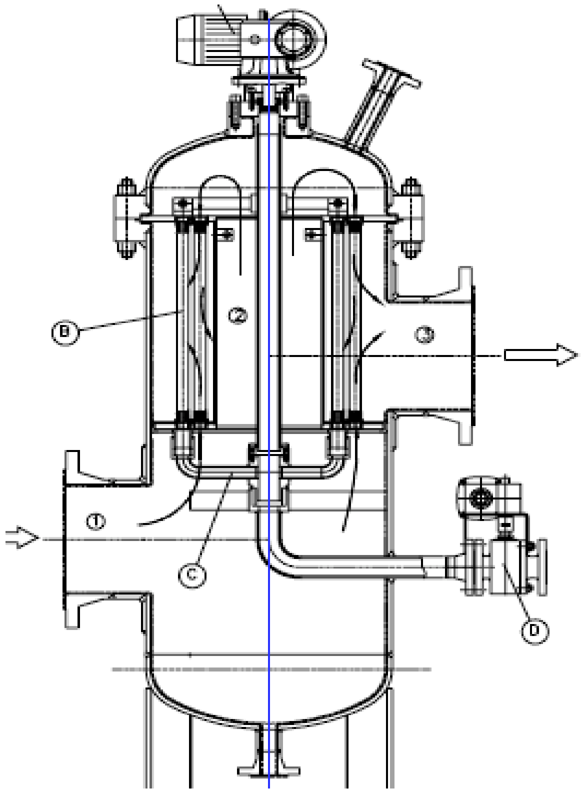


FIG. 3.2.3.1 NORMAL FILTRATION PHASE

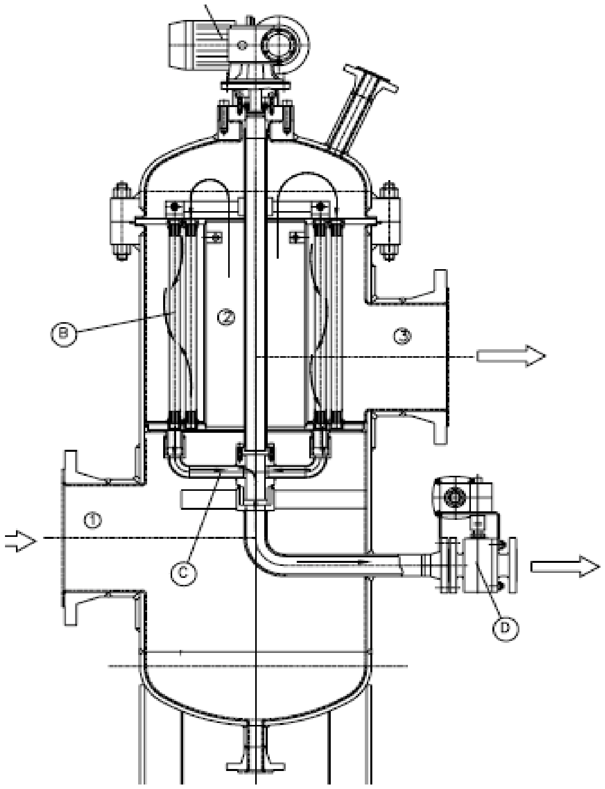


FIG. 3.2.3.2 BACKFLUSHING PHASE

3.2.4 Electro Chlorination Generator

The electro chlorinator generator is supplied to prevent bio fouling on the seawater lift pumps and associated piping systems and filter. The purpose of this generator is to take a small amount of the seawater flow and use this to generate sodium hypochlorite and free copper ions, which are later injected to the seawater caissons.

The process of making sodium hypochlorite and copper ions is done in two different electrolysis processes, which are designed to dose a seawater flow of 4200 m^3/h.

First the seawater flow is split in two, regulating 25 m^3/h through the copper-adding vessel and 0,6 m^3/h through the electro chlorination cell.

The copper-adding vessel consists of one copper anode to which an alternating current is applied. The copper anode will function as a positive pole (anode) and the surrounding vessel will function as a negative pole (cathode), resulting in oxidation of the copper element. The copper ions will therefore be released into the seawater flow. This means that the copper anode is consumed over time, and has to be replaced.

The reaction will be:

$$Cu_2 \rightarrow 2Cu^+ + 2e^-$$

The electro chlorination cell consists of one anode chamber, where the positive electrode is located, and one cathode chamber where the negative electrode is located. The electro chlorination panel now puts a direct current through the electrolyte, sending electrons through the seawater, from the anode to the cathode. By this process, the molecules in the seawater attempt to reach their original elements. Two reactions will occur; the anode will attract the negative charged ions while the cathode will attract the positive charged ions. At the cathode, the ions are receiving electrons while the ions are giving off electrons at the anode.

At the anode:

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

At the cathode:

$$2Na^+ + 2H_2O \rightarrow 2Na^+ + 2OH^- + H_2 + 2e^-$$

The elements resulting from the electrolysis is now separated in the two chambers, but is soon to be mixed together again and new chemical reactions will occur.

The total reaction will then be:

$$Cl_2 + 2Na^+ + 2OH^- \rightarrow 2NaOCl + H_2O$$

This is the reaction where the sodium hypochlorite is being made.

This is then mixed in with the rest of the seawater not participating in the reaction, and is later injected to the seawater caissons along with the flow coming from the copper-adding vessel.

3.3 Potential Root Causes

3.3.1 Water hammer (Surge)

A common problem encountered in seawater systems is surge, or water hammer. This is a phenomenon that occurs due to a sudden change in the liquid velocity. Water hammer usually occurs when a transfer system is quickly started, stopped or is forced to make a rapid change in direction (Sharp and Sharp, 1996). A typical system which is exposed to this, such as a seawater system, often consists of quick closing valves, lots of vertical pipe runs and large pumps with high flow rate. The danger with this phenomenon is extremely high pressure peaks, up to as much as 5 times the system working pressure, which can result in blown diaphragms, ruptured discs, seals and gaskets, as well as burst pipes.

Water is an incompressible medium meaning that every input of energy is transmitted instantly. When a sudden change occurs in a system, as a force like a quick opening valve or a pump start, the energy becomes dynamic and will result in a high velocity change in the medium. This sudden change in velocity will result in a high acoustic sound in the system, causing a pressure spike. This acoustic sound will rapidly accelerate to the speed of sound (in liquid), causing the pressure spike (Webb, Gould and Hardie, 1978).

A way to prevent water hammering is to install a pulsation dampener. This is a tank that is connected to the water system, which is equipped with a gas volume on top to be compressed when the water pressure increases. Gas is a compressible medium and will therefore decrease in volume when the water pressure increases.

Another way to prevent water hammer is install actuators that are acting with slow movements, such that valves are not suddenly closing or opening.

3.3.2 Pulsation

Much like surge, a phenomenon called pulsation also exists. Pulsation occurs in a system that produces pulses with high amplitude, typically displacement pumps. This high amplitude pulse occurs when liquid is being accelerated and decelerated (velocity change), as a result of starting/stopping pumps and quick operating of valves. The uncontrolled energy results in pressure spikes.

The common pump used for seawater systems are therefore centrifugal pumps that are normally producing non-damaging high frequency but low-amplitude pulses, but also here it might appear (Sharp and Sharp, 1996).

3.3.3 Vibration

The technical literature in this section is taken from; Eisenmann and Eisenmann, 2005; Hongyun and Hanwei, 2009, where vibration is briefly described.

Historically, vibration has caused a lot of problems for an operational seawater system. One reason for this is that the main drivers for such systems often are pumps of the kind with a dry mounted electrical motor, converting energy down to a submersible impeller wheel via a long shaft. With an incorrect balancing of the pump shaft the shaft will start vibrating, and increase the mechanical wear on the bearings that stabilize the shaft and the rotor. To help us deal with equipment breakdown caused by vibration it is desirable to install vibration sensors to stop minor failures to escalate.

The vibratory motion is measured by finding the amplitude of the dynamic signal. Meaning that large amplitudes are directly related to high level of vibration, again related to a mechanical problem. In general, the amplitude of vibration relates to the size of the vibratory movement, the speed of the movements, and the force/energy associated with the movement. Amplitude could be defined from a sine wave in the time domain, such in Fig. 3.3.3.

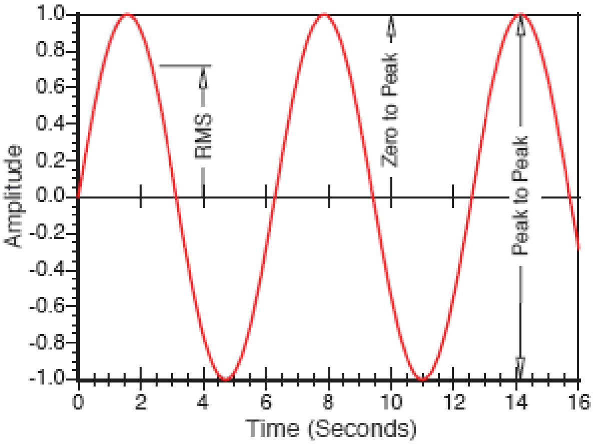


FIG. 3.3.3 VIBRATION MOTION (SINE WAVE)

In this diagram three different types of amplitude measurements are identified. The total magnitude is represented by the peak-to-peak value of the amplitude, and measures from the lowest portion of the dynamic signal (bottom peak) to the highest portion of the signal (top peak). Peak-to-peak amplitude therefore equals to the total signal height, and is an indication of the highest speed achieved.

The zero to peak value represents the middle of the dynamic signal to the highest portion of the signal. For simple voltage signal, the relationship between peak to peak and zero-to-peak could be expressed as: $\text{Amp}_{\text{peak to peak}} = 2 \text{ x } \text{Amp}_{\text{zero to peak}}$

RMS (Root Mean Square) is another measure of the amplitude, and is lower than the zero to peak value. For a pure sine wave, the actual amplitude value reduction from zero to peak equals to $2^{0,5}/2$, which gives the numerical value of 0,7071.

This gives these relations to the other amplitude measurements in a voltage signal:

$$\text{Amp}_{\text{rms}} = 0{,}7071 \text{ x } \text{Amp}_{\text{zero to peak}}$$
$$\text{Amp}_{\text{rms}} = 0{,}3536 \text{ x } \text{Amp}_{\text{peak to peak}}$$

RMS amplitude is an indication of the amount of vibration energy in the machine. The unit used to express RMS is given in mm/s.

There are three different methods of measuring vibration motion:

Displacement sensors, used to measure internal clearances between bearing and shaft, as well as shaft motions. This distance is measured in peak-to-peak difference in the amplitude, means the distance between the positive and negative peak, also known as the magnitude. These are non-contacting transducers that are mounted on a reasonable stationary mechanical structure, observing static and dynamic displacement of the moving machinery.

A typically probe used for measuring displacement is the proximity probe.

The unit for displacement is in ISO standards expressed in µm (10^{-6} m), while it is measured in mils (1^{-6} inch) in the API standards.

Acceleration sensors measure the acceleration of the amplitude by detecting changes in the force resulting from vibration. The most common acceleration transducer is the Piezoelectric Accelerometer, which is a fully contacting probe that is mounted directly on the mechanical element (e.g., bearing housing). The probe consists of a piezoelectric material that produces an electrical charge when being squeezed. This charge is proportional to the force, meaning

that it will increase with increasing motions and vibration. Since the mass is constant, the electrical charge will also be proportional to the acceleration.
Velocity sensors measure the velocity of the amplitude from zero to peak-point. The most used transducer is the Velomitor, which is working after the same principles as the accelerometer. Only difference is that Velomitor measures the speed instead of acceleration.

As for the pumps chosen for the LP and HP seawater systems at PH, vertically suspended centrifugal pumps are selected. For these kinds of pumps it is very important to design it according to API 610, where the pumps are designed with balancing degree. Meaning that the vibration is in relation to the speed of the pump. Also an important issue while selecting pump is to choose a pump with minimum robustness that can handle the environment the pump is set to operate in.
In appendix D, the vibration limits for vertically suspended centrifugal pumps is found. This table is taken from the API 610, standard for centrifugal pumps, and gives vibration limits in peak-to-peak and RMS inside the preferred operating area. The table also shows allowable increase in vibration at flows outside the preferred operating region, inside the allowable operating region.

4 Performance Test of the Seawater Systems

BP, as one of the biggest energy companies' world wide, has many internal objectives and requirements to follow. These are rules outlined through the company's strategy and goals. In BP's internal goals, some key success factors that related to the start-up phase of a facility are found.

Key success factors:

- BP Operations accountable and lead the start-up of facilities. Means that BP run their own start-up strategy, lead by internal personnel that is familiar with BP's requirements.
- Commissioning manager appointed to project in Define. Meaning that the company needs to define the Commissioning Manager of the project.
- Start-Up Manager appointed and small, dedicated Start-Up Team initiated in define.
- Use of start-up execution manual. Means that the project needs to follow BP's "tailor-made" manuals on how to execute a start-up of a facility.
- Rigorous Go/No-go process. This is a common process in BP, means that the company's management needs to approve the phase changes of a project.

There is also outlined a few internal requirements related to a plant performance test.

Plant performance testing:

a. If plant performance tests are required only for internal BP requirements, commissioning and operating authorities shall jointly prepare plant performance test procedures to check that design complies with equipment guarantee points for systems that are critical in achieving rated production.
b. Operating authority should complete performance test procedures within 6 months of start-up.
c. If successful plant performance test form part of contractual delivery by an external design contractor, design engineering contractor should prepare plant performance test procedures based on project SoR.
d. If plant performance is satisfactory, results shall be provided to plant manager for information.
e. If plant performance is unsatisfactory, under BP direction, contractor shall investigate root cause of problem and solve technical issues.

4.1 LP Seawater System

Before the LP seawater system is ready to be tested, the commissioning phase has to be verified and completed. The commissioning phase includes pressure/leak tests as well as functionality tests of the different equipment to be sure that the system will be able to operate after design criteria.

When looking at the whole system, the interfaces also have to be considered along with the subsystems and the start-up sequence. These are systems like electrical- and hydraulic power, PCS (Process Control System), instrument air etc.

Other recommended checks required before start-up, include the line up and general equipment status. It is recommended to go over the entire system, and follow the normal flow path through the system to check that all valves are in correct position for start-up. Use the following P&ID's for going through the system: PH-ME-P-0258-001, PH-ME-P-0259-001 & PH-ME-P-0264-001.

Critical equipment for this system is the vacuum breakers/air release traps and pressure relief valves. Locate these devices and verify that they're correctly installed and NOT blocked.

- 84-PH-S-1000, Air release trap at LP Seawater Lift Pump A.
- 84-PH-S-1001, Air release trap at LP Seawater Lift Pump B.
- 84-PH-S-1011, Air release trap at LP Seawater manifold.
- 84-PH-S-1004, Air release trap downstream Cooling Medium Coolers, placed at the cellar deck.
- 84-PSV-93224A, Relief valve upstream LP Coarse Filter.
- 84-PSV-93291A, Relief valve downstream Cooling Medium Cooler A.
- 84-PSV-93291B, Relief valve downstream Cooling Medium Cooler B.

Before starting with the functionality and performance tests on the different equipment involved in the LP distribution system, there are some main components that have to work.

- Review the flow regulation loop (84-FIC-93294), downstream the cooling medium coolers and record the tuning parameters. The maximum flow through both of the two coolers should not exceed 2400 m^3/h. (Table 6.1)
- Record the tuning parameters for the temperature regulation at the cooling medium coolers, 84-TIC-93286A/B. (Table 6.2/6.3)

When this is verified it is desirable to test each of the main components in the LP seawater distribution systems, starting with the main drivers.

4.1.1 LP Seawater Lift Pumps (84-PX-9101A/B)

The purpose of these tests is to gather pump performance and conditioning monitoring data. Recommended tests for the LP seawater lift pumps:

- Functionality test
- Performance test to verify the pump curves
- Verification of bearing temperatures, winding temperatures and vibration

Method:
Since the minimum-flow valve is dimensioned to handle flow up to 1030 m^3/h (Appendix C), it is recommended to use this line to verify the first two points of the pump characteristic. This is even if the seawater distribution system is in service or not. If the seawater system is in service, it is desirable to start testing the stand-by pump, and then operate both of the pumps simultaneously before changeover and stopping the pump in duty mode to verify the whole length of the pump characteristic of the stand-by pump. The provider of the pump used 1027 kg/m^3 as the seawater density, which is also recommended to use in this test.

Pre-phase:
References relevant for the tests are P&ID's: PH-ME-P-0258-001, PH-ME-P-0107-004 & PH-ME-P-0107-005.
Before the tests are ready to be executed, it is desirable to verify that the instruments used during the tests are in good shape and that correct alarm settings are given. To be sure the data is correct, it is recommended to calibrate the most critical instruments. Local indicators can also be accepted as reference.
Critical instruments are:

- 84-FT-93207A/B. Alarm limits: L=770 m^3/h
- 84-PT-93207A/B. Alarm limits: H=6,8 barg, L=2,8 barg

It is also necessary to verify that the pumps are supplied with electrical power and that the PCS is updated and in service. Instruments necessary for the conditioning monitoring of the pump and the electrical motor needs to be verified correctly installed along with instrumentation and alarm settings.
Following instruments needs to be verified:

- 84-FI-93201A/B. Alarm limits: L=5,5 m^3/h
- 84-YI-95500A/B. Alarm limits: HH=7,1 mm/s, H=4,5 mm/s
- 84-YI-95501A/B. Alarm limits: HH=7,1 mm/s, H=4,5 mm/s
- 84-YI-95510A/B. Alarm limits: HH=8 mm/s, H=5 mm/s
- 84-YI-95511A/B. Alarm limits: HH=8 mm/s, H=5 mm/s
- 84-TI-95500A/B. Alarm limits: HH=120°C, H=110°C
- 84-TI-95502A/B. Alarm limits: HH=145°C, H=135°C
- 84-TI-95505A/B. Alarm limits: HH=145°C, H=135°C
- 84-TI-95508A/B. Alarm limits: HH=145°C, H=135°C
- 84-TI-95511A/B. Alarm limits: HH=120°C, H=110°C

General Procedure:
Use Table 6.4/6.5 to record the data.

- ➢ Measure the distance between the cellar deck and the sea level to be sure of the suction pressure of the pump. This is used in the head calculations later. The total length from the submerged pump to the cellar deck is 44,7 m. The distance from the cellar deck to the discharge level is 0,3 m.
- ➢ Start testing the stand-by pump. (If the system is in service, if not it's optional).
- ➢ Record the relevant XV open/close times and leave the valves in auto.
- ➢ Record the tuning parameters of the minimum-flow valve (84-FIC-93207A/B) and leave the flow regulation in auto. Verify that the set point is put to 1400-1500 m^3/h.
- ➢ Verify that the lube oil levels are acceptable.
- ➢ Start the stand-by pump using the start-up sequence and let it run for 2 hrs to stabilize winding temperatures at the motor, if not recently started.
- ➢ Use the minimum-flow valve on manual to regulate the flow. It is recommended to start verifying the left hand side of the pump characteristic. Start by closing the outlet valve (84-XV-93212A/B). Operate the minimum-flow regulation in manual and decrease the flow to 770 m^3/h, verify that the low-flow alarm activates.
  Record the flow and outlet pressure at this point, which will be the first of six desirable points.
  Other desirable recordings are the speed, temperatures and vibrations.
- ➢ Visually go over the system to localize abnormal vibrations or leakages. This should be repeated for every flow.
- ➢ Make 5 more recordings of flow, outlet pressure, temperatures and vibrations. For flow above 1050 m^3/h the outlet valve (84-XV-93212A/B) needs to be opened, meaning that the distribution system needs to be available. Operate the minimum-flow regulation in manual to help reaching the desirable points.
  Desirable recordings of the flow: 1030, 1600, 2100, 2400, 3100 m^3/h.
  It is recommended to stop the parallel pump when the total flow though the system exceeds 2400 m^3/h.
  2400 m^3/h represent the rated point of the pump; at this point the differential head should be between 78,5 – 84 mlc (meter liquid column), while the power should not exceed 684 kW. This is according to API 610 (appendices E).

3100 m^3/h represents the maximum flow through the pump. However, this flow is above the max capacity of the seawater coarse filter, it is therefore recommended to operate the minimum-flow valve in manual again to achieve the highest flow through the pump.

After the test, the results should be plotted into the original pump characteristic (Fig. 3.2.1.2).

Approximate Duration:
The different tests of one single pump are estimated to take around 3 hrs. This time however, could be reduced if some of the desirable data has been collected during the offshore commissioning phase. These tests can be carried out at any time, also after the system is put in service.

4.1.2 LP Seawater Lift Pump Changeover and Trip Test

The objective for these tests is to verify that changeover between the two pumps is possible when the seawater system is online. The test is desirable to carry out when one of the pumps is in operation. The test requires start-up of the second pump and a simultaneous operation for a while. It is also desirable to test the trip function of each of the pumps at low flow. However, at the writing moment the trip limit is not specified yet. This is something that needs to be implemented before start-up.

General Procedure:

- Verify that the trip limit at low flow is set on both of the pumps.
- Verify that one of the pump is in operation, refer to this pump as the duty pump. Record the flow through the pump:______m^3/h.
- Start the stand-by pump.
- Let the two pumps run simultaneously for a few minutes.
- Duty pump: Verify that the minimum-flow regulation is in auto, and close the outlet valve (84-XV-93212A/B).
    - Put the minimum-flow regulation in manual, and decrease the flow by closing the minimum-flow valve. It is desirable to decrease the flow to the trip level of the pump.
    - Put the minimum flow-regulation back to auto.
- Record the flow through the stand-by pump:______m^3/h.
- Start the duty pump again.
- Let the two pumps run simultaneously for a few minutes.
- Stand-by pump: Verify that the minimum-flow regulation is in auto, and close the outlet valve (84-XV-93212A/B).
    - Put the minimum-flow regulation in manual, and decrease the discharge flow by operating the minimum-flow valve. It is desirable to decrease the flow to the trip level of the pump.
    - Put the minimum-flow regulation back to auto.
- When the pressure and flow has stabilized again, the system can be put into normal operation.

Approximate Duration:
The pump changeover and trip test is estimated to take ½ hr, but is depending on what is done during the commissioning phase. The test is able to carry out at any time after the commissioning phase of the system.

4.1.3 LP Seawater Coarse Filter

The purpose of these tests is to verify that the LP seawater coarse filter is properly installed and is functioning after design. It is also desirable to verify the functionality of critical instruments installed in the package.
Before the LP seawater coarse filter is ready to be tested for functionality, it is necessary to have the LP seawater distribution system in operation to have actual flow through the filter.
Desirable tests to carry out are:

- Functionality test of the backflushing sequence
- Verification of essential instrumentation

References relevant for the tests are P&ID: PH-ME-P-0259-001.

General procedure for functionality test of LP seawater coarse filter:

- ➢ Verify that the motor (84-CA-9119-M01) is supplied with electrical power, and that the PCS is updated with operational functions.
- ➢ Verify that the drain valve (84-XV-93229A) is supplied with electrical power and is acting on demand from the PCS.
- ➢ Verify that the differential pressure instrument (84-PDC-93221) is properly installed and is communicating with the PCS.
  Also check that the correct alarm limit is implemented, set at 0,5 barg.
- ➢ Put the pressure differential controller (84-PDC-93221) in auto, along with the drain valve (84-XV-93229A).
- ➢ Verify that the backflushing sequence is being activated at the set point (0,5 barg), by waiting for the differential pressure to increase or by manipulating the differential pressure from the PCS.

General procedure for verification of essential instrumentation:

- ➢ Verify that the following instruments are properly installed and that the PCS is updated with alarm limits.
  - 84-TI-93225.
  - 84-AI-93223. Alarm limits: L=0,2 ppm.
  - 84-PI-93223. Alarm limits: L=2,5 barg.
- ➢ Verify that 84-PI-93224, is properly installed and that the PSD is updated with trip limit, LL=2,0 barg. This trip will activate PSD 1 after 60 seconds.
  - Temporarily override the output signal to avoid PSD 1. Block the transmitter and drain it. Verify that the low-low alarm activates. Put the system back to original status.

Approximate Duration:

The different tests corresponding to the LP seawater coarse filter is estimated to take ½ hr, and is suitable to be carried out when ever the LP seawater distribution system is in service.

4.1.4 Final tuning of LP seawater distribution system

When the different tests around the LP seawater distribution system are finished, it is time to do the final tuning around the regulation loops at the cooling medium coolers (45-HB-9101A/B). This involves the flow regulation (84-FIC-93294) and the temperature regulation (84-TIC-93286A/B).

To do this, the LP seawater distribution system has to be in service along with the cooling medium system. Make sure that one of the two coolers is being tuned at a time. Record the final settings in Table 6.1/6.2/6.3.

4.2 HP Seawater System

Before the HP seawater system is ready to be tested, the commissioning phase has to be verified and completed. When looking at the whole system, the interfaces also have to be considered along with the subsystems and the start-up sequence. These are systems like electrical- and hydraulic power, PCS, instrument air etc.

Other devices that it is preferable to check before start-up are the line up of valves and equipment. It is recommended to go over the entire system, and follow the normal flow path through the system to check that all valves are in the correct position for start-up.

Use the following P&ID's for going through the system: PH-ME-P-0259-002, PH-ME-P-0259-003, PH-ME-P-0259-004, PH-ME-P-0259-005, PH-ME-P-0260-001 & PH-LP-P-4353-001.

Critical equipment for this system is the vacuum breakers/air release traps and pressure relief valves. Locate these devices and verify that they're correctly installed and NOT blocked / isolated.

- 84-PH-S-1002, Air release trap at HP Seawater Lift Pump A.
- 84-PH-S-1003, Air release trap at HP Seawater Lift Pump B.
- 84-PH-S-8002, Air release trap upstream IGBT Heat Exchangers.
- 84-PH-S-8003, Air release trap upstream AHU Cooling Coil.
- 84-PH-S-8004, Air release trap downstream AHU Cooling Coil.
- 84-PH-S-8005, Air release trap downstream IGBT Heat Exchangers.
- 84-PSV-93494A, Relief valve upstream HP Coarse Filter.
- 84-PSV-93487 / 84-PSV-93488, Relief valve on the essential users.
- 84-PSV-93237, Relief valve on Emergency Generator Cooler A.
- 84-PSV-93238, Relief valve on Emergency Generator Cooler B.

Before starting with the functionality and performance tests on the different equipment involved in the HP distribution system, there are some main components that have to work.

- Review the temperature regulation loop (84-TIC-93233), downstream the VSD cooler and record the tuning parameters. (Table 6.6)
- Review the temperature regulation loop (84-TIC-91771A/B), downstream the AHU cooling coils and record the tuning parameters. (Table 6.7/6.8)

When this is verified it is desirable to test each of the main components in the HP seawater distribution systems, starting with the main drivers.

4.2.1 HP Seawater Lift Pumps (84-PX-9102A/B)

The HP seawater lift pumps are to be tested after the commissioning phase and initial start-up is completed. This includes start-up of the oil circulation unit, and that the electrical motor is mounted and verified ready for test.
Recommended tests for the HP seawater lift pumps:

- Functionality test of the oil circulation unit
- Functionality test of the pump and electrical motor
- Performance test to verify the pump curves

Method:
If the seawater system is in service, it is desirable to start testing the stand-by pump and operate both of the pumps simultaneously before changeover and stopping the pump in duty mode, to verify the whole length of the pump characteristic of the stand-by pump.
The minimum-flow valve is dimensioned to handle flow up to 380 m^3/h, which is right above the minimum continuous flow through the pump at 360 m^3/h. It is therefore recommended to use this line to verify the first point of the pump characteristic, even if the seawater system is in service or not. The provider of the pump used 1030 kg/m^3 as the seawater density, which is also recommended to use in this test.

Pre-phase:
References relevant for the tests are P&ID's: PH-ME-P-0104-006, PH-ME-P-0259-002, PH-ME-P-0259-003, PH-ME-P-0259-004, PH-ME-P-0259-005, PH-ME-P-0260-001 & PH-LP-P-4353-001.
Before the tests are ready to be executed, it is desirable to verify that the instruments used during the tests are in good shape and suitable for reading the preferred data. To be sure the data is correct, it is therefore recommended to calibrate the most critical instruments. Local indicators can also be accepted as reference.
Critical instruments are:

- 84-FT-93477A/B. L=396 m^3/h.
- 84-PT-93477A/B. H=12,3 barg, L=8,2 barg.
- 84-TT-93477A/B.

It is also necessary to verify that the main motor, and the pressurizing and circulation pumps for the oil circulation unit are supplied with electrical power. The PCS needs to be verified updated and functionality tested.

General Procedure Oil Circulation Unit:

- ➢ Check that the following instruments are properly installed and that the PCS is updated with alarm limits:
  - 84-PI-95555A/B. HH=24 barg, H=22 barg, L=12,1 barg, LL=10,1 barg.
  - 84-PIC-95556A/B. Start=16,4 barg, Stop=14,4 barg.
  - 84-FI-95554A/B. L=80 l/min, LL=40 l/min.
  - 84-TI-95553A/B. HH=70°C, H=65°C.
  - 84-PDI-95556A/B. H=2,5 barg.
  - 84-LI-95551A/B. H=82,9 %, L=51,2 %, LL=39,6 %.
- ➢ Verify that the circulation oil level is acceptable.
- ➢ Review the circulation system and line it up for operation.
- ➢ Start the pressurizing pump (84-PS-9101A/B).

- When the pressure has stabilized, start the circulation pump (84-PG-9102A/B).
- Review the system visually, and look for leakages.
- Use the PCS to make trends of the instruments mentioned in the first point. This to verify that the conditions are acceptable before start-up of the submersed pump.

General Procedure Pump/Electrical Motor:

Use Table 6.9/6.10 to record the data.

- Measure the distance between the cellar deck and the sea level to be sure of the suction pressure of the pump. This is used in the head calculations later. The total length from the submerged pump to the cellar deck is 45,5 m. The distance from the cellar deck to the discharge level is 1,1 m.
- Start testing the stand-by pump. (If the system is in service, if not it's optional).
- Measure and record the relevant XV open/close times and leave the valves in auto.
- Record the tuning parameters of the minimum-flow valve (84-FIC-93477A/B) and leave the flow regulation in auto. Verify that the set point is put to 440 m^3/h.
- Start the stand-by pump using the start-up sequence and let it run for 15-20 min to stabilize temperatures, if not recently started.
- Use the minimum-flow valve to regulate the flow. It is recommended to start verifying the left hand side of the pump characteristic. Reduce the flow to the minimum by closing the outlet valve (84-XV-93482A/B). Operate the minimum-flow regulation in manual and decrease the flow to 380 m^3/h, verify that the low-flow alarm activates. Record the flow and outlet pressure at this point, which will be the first of six desirable points.
- Visually go over the system to locate abnormal vibrations or leakages. This should be repeated for every flow.
- For flow above 380 m^3/h the outlet valve (84-XV-93482A/B) needs to be opened, which means the distribution system needs to be available. Operate the minimum-flow regulation in manual to help reach the desirable points.
  Desirable recordings are 380, 650, 800, 900, 1050 m^3/h.
  It is recommended to stop the parallel pump when the total flow though the system exceeds 900 m^3/h.
  900 m^3/h also represent the rated point of the pump; at this point the differential head should be between 129,5 – 139 mlc, while the power should not exceed 452 kW. This is according to API 610 (appendices E).

After the test, the results should be plotted into the original pump characteristic (Fig. 3.2.2.3).

Approximate Duration:

The different tests of one single pump are estimated to take around 1-2 hrs. This time however, could be reduced if some of the desirable data has been collected during the offshore commissioning phase. These tests can be carried out at any time, also after the system is put in service.

4.2.2 HP Seawater Lift Pump Changeover and Trip Test

The objective for this test is to verify that changeover between the two pumps is possible when the seawater system is in service. The test is desirable to carry out when one of the pumps is in operation. The test requires start-up of the second pump and simultaneous operation for a while. It is also desirable to test the trip function at low flow for each of the pumps. However, at the writing moment the trip limit is not specified yet. This is something that needs to be implemented before start-up.

General Procedure:

- Verify that the trip limit at low flow is set on both of the pumps.
- Verify that one of the pump is in operation, refer to this pump as the duty pump. Record the flow through the pump:______m^3/h.
- Start the stand-by pump.
- Let the two pumps run simultaneously for a few minutes.
- Duty pump: Verify that the minimum-flow regulation is in auto, and close the outlet valve (84-XV-93482A/B).
  - Put the minimum-flow regulation in manual, and decrease the flow by closing the minimum-flow valve. It is desirable to decrease the flow to trip level of the pump.
  - Put the minimum-flow regulation back to auto.
- Record the flow through the stand-by pump:______m^3/h.
- Start the duty pump again.
- Let the two pumps run simultaneously for a few minutes.
- Stand-by pump: Verify that the minimum-flow regulation is in auto, and close the outlet valve (84-XV-93482A/B).
  - Put the minimum-flow regulation in manual, and decrease the discharge flow by closing the minimum-flow valve. It is desirable to decrease the flow to the trip level of the pump.
  - Put the minimum-flow regulation back to auto.
- When the pressure and flow has stabilized again, the system can be put into normal operation.

Approximate Duration:

The pump changeover and trip test is estimated to take ½ hr, but is depending on what is done during the commissioning phase. The test is able to carry out at any time after the commissioning phase of the system.

4.2.3 HP Seawater Coarse Filter

The purpose of these tests is to verify that the HP seawater coarse filter is properly installed and is functioning after design. It is also desirable to verify the functionality of critical instruments installed in the package.

Before the HP seawater coarse filter is ready to be tested for functionality, it is necessary to have the HP seawater distribution system in operation to have actual flow through the filter. Desirable tests to carry out are:

- Functionality test of the backflushing sequence
- Verification of essential instrumentation

Reference relevant for the test is P&ID: PH-ME-P-0259-005.

General Procedure, Functionality Test:

- Verify that the motor (84-CA-9129-M01) is supplied with electrical power, and that the PCS is updated with operational functions.
- Verify that the drain valve (84-XV-93499A) is supplied with electrical power and is acting on demand from the PCS.
- Verify that the differential pressure instrument (84-PDC-93491) is properly installed and is communicating with the PCS.
  Also check that the correct alarm limit is implemented, set at 0,5 barg.
- Put the pressure differential controller (84-PDC-93491) in auto, along with the drain valve (84-XV-93499A).
- Verify that the backflushing sequence is being activated at the set point (0,5 barg), by waiting for the differential pressure to increase or by manipulating the differential pressure in PCS.

General Procedure, Verification of Essential Instrumentation:

- Verify that the following instruments are properly installed and that the PCS is updated with alarm limits.
    - 84-TI-93495.
    - 84-AI-93493. L=0,2 ppm.
    - 84-PI-93493. L=7,5 bar.
- Verify that 84-PI-93494, is properly installed and that the PSD is updated with trip limit, LL=6,0 bar. This trip will activate PSD 1 after 60 seconds.
    - Temporarily override the output signal to avoid PSD 1. Block the transmitter and drain it. Verify that the low-low alarm activates. Put the system back to original status.

Approximate Duration:
The different tests corresponding to the HP seawater coarse filter is estimated to take ½ hr.

4.2.4 Electro Chlorination Generation

The electro chlorination generation consists of two vessels, the electro chlorination cell and the copper-adding vessel. The purpose of this test is to line these two vessels up in parallel and adjust the flow running through the package. Also the instrumentation and trip function will be function tested. The HP seawater distribution system needs to be in service before starting these tests.
Desirable tests to carry out are:

- Capacity test
- Functionality test

Reference relevant for the test is P&ID: PH-ME-P-0260-001.

General Procedure:

- Verify that 84-PSV-96072 is correctly mounted and is set at 10 barg.
- Verify that the UCP (Unit Control Panel) is correctly mounted and supplied with electrical power.
- Check 84-PCV-96073 for functionality, should be set at 7,5 barg.

- Verify that the following instruments are properly installed and that the PCS is updated with alarm limits:
    - 84-PI-96071. L=6,5 barg.
    - 84-FI-96069. LL=22 m^3/h.
    - 84-FI-96070. LL=0,48 m^3/h.
    - 84-II-96062. L=15 A.
    - 84-EI-96063. H=120 V.
    - 84-II-96064. L=5 A.
    - 84-EI-96065. H=13 V.
- Line the system up ready for operation.
- Verify that the control valves for hypochlorite to the seawater lift pumps in operation are open (84-XV-93472A/B and 84-XV-93202A/B).
- Adjust the flow through the electro chlorinator cell (84-CX-9107) by regulating the outlet valve, 84-V-94004. The flow should be left at 25 m^3/h.
- Adjust the flow through the copper-adding vessel (84-VX-9108) by regulating the outlet valve, 84-V-94006. The flow should be set at 0,6 m^3/h.
- Activate the electro chlorinator generator with 84-HS-96061.
- Adjust the current at the UCP according to the analyzers, 84-AI-93223 on the LP seawater distribution system and 84-AI-93493 on the HP seawater distribution system.
- Distribute the hypochlorite to the two systems by regulating on the valves upstream 84-XV-93202A/B (LP system) and 84-XV-93472A/B (HP system). The flow should be set to 18,5 l/h at the LP system and 7 l/h in the HP system.
- Make the same adjustments for the stand-by pumps.

Approximate Duration:
The test should take about 1 hr to complete, including correct flow adjustment.

4.2.5 Final tuning of HP seawater distribution system

When the different tests around the HP seawater distribution system are finished, it is time to do the final tuning around the temperature regulation loops. This involves the temperature regulation at the VSD cooler (84-TIC-93233) and at the AHU cooling coils (84-TIC-91771A/B). To do this, the HP seawater distribution system has to be in service along with the coolers and containing utility systems. Record the final settings in Table 6.6/6.7/6.8.

5 Performance Test Rotational Equipment

5.1 Cooling Medium Pumps (45-PA-9106A/B)

Before the test is ready to be executed it needs to be verified that the commissioning phase is completed and the LP seawater system is in operation, as well as the cooling medium system is ready for operation. The recycle line is designed to handle a maximum flow of 680 m^3/h, which is also the minimum continuous flow through the pump. The first point to be verified on the flow will therefore be just above 680 m^3/h.
Reference relevant for the test is P&ID: PH-ME-P-0263-001.

General Procedure
Use Table 6.11/6.12 to record the data.

- Take a density sample of the medium and send to lab for analysis.
- Start testing the stand-by pump. (If the system is in service, if not it's optional).
- Measure and record the relevant XV open/close times and leave the valves in auto.
- Record the tuning parameters of the minimum-flow valve (45-FIC-93267A/B) and leave the flow regulation in auto.
- Start the stand-by pump using the start-up sequence and let it run for 15-20 min to stabilize temperatures, if not recently started.
- Use the minimum-flow valve to regulate the flow. It is recommended to start verifying the left hand side of the pump characteristic. Start reducing the flow towards the minimum continuous flow, by regulating the manual outlet valve 45-V-91245/6. The first desirable point will be at 700 m^3/h, verify that the low-flow alarm activates. Record the flow, pressures and temperatures at this point, which will be the first of six points.
- Visually go over the system to look for abnormal vibrations or leakages. This should be repeated for every flow.
- Slowly operate the manual outlet valve again, and increase the flow through the pump. Operate the minimum-flow regulation in manual to help reaching the desirable points. Use the table and record the parameters. Desirable recordings are 1000, 1200, 1550, 1750, 2000 m^3/h. It is recommended to stop the parallel pump when the total flow though the system exceeds 1550 m^3/h.
  1550 m^3/h represent the rated point of the pump; at this point the differential head should be between 73,5 – 79 mlc, while the power should not exceed 213 kW. This is according to API 610 (appendices E).

After the test, the results should be plotted into the original pump characteristic (appendix K).

Approximate Duration:
The different tests of one single pump are estimated to take around 1-2 hrs. This time however, could be reduced if some of the desirable data has been collected during the offshore commissioning phase. These tests can be carried out at any time, also after the system is put in service.

5.2 Firewater Pumps (48-XD-9107A/B)

Before the test is ready to be executed it needs to be verified that the commissioning phase is completed. A manual dump valve will adjust the firewater flow while the outlet valve of the pump will be closed. The provider of the pump used 1026 kg/m^3 as the seawater density, which is also recommendable to use in this test. It is desirable to test one of the two pumps at a time, means that only one firewater pump is stand-by in an emergency situation. Therefore the test has to be well coordinated along with other critical operations at the platform. References relevant for the test are P&ID's: PH-ME-P-0290-001 & PH-ME-P-0291-001.

General Procedure

Use Table 6.13/6.14 to record the data.

- Measure the distance between the cellar deck and the sea level to be sure of the suction pressure of the pump. This is used in the head calculations later. The total length from the submerged pump to the cellar deck is 49,5 m. The distance from the cellar deck to the discharge level is 1,3 m.
- Start testing one of the pumps, while the other one is in auto-mode.
- Verify that the start-mode selector is switched to auto and press the "TEST START" button. Let it run for 2 hrs to stabilize temperatures.
  It is recommended to start verifying the right hand side of the pump characteristic. Start by opening the manual dump valve a few percent (48-HV-93544A/B), close the outlet valve (48-HV-93547A/B) before opening the dump valve entirely. Record the flow, pressures and temperatures at this point, which will be the first of six desirable points. The approximated flow though the pump at this time should be around 2300 m^3/h. This flow represent the rated point of the pump; at this point the differential head should be between 173,5 – 182 mlc. This is according to API 610 (appendix E).
- Visually go over the system to look for abnormal vibrations or leakages. This should be repeated for every flow.
- Slowly operate the manually dump valve towards closed to adjust the flow through the pump. Use the table and record the parameters.
  Desirable recordings are 2100, 1750, 1550, 1200, 1000 m^3/h.
- Stop the pump by switching the start-mode selector to manual, and press the "STOP Diesel Engine" button.
- Close the manual dump valve (48-HV-93544A/B).
- Open the outlet valve (48-HV-93547A/B).
- Switch the start-mode selector back to auto, and acknowledge alarms.

After the test, the results should be plotted into the original pump characteristic (appendix L).

Approximate Duration:

The different tests of one single pump are estimated to take around 3 hrs. This time however, could be reduced if some of the desirable data has been collected during the offshore commissioning phase. These tests can be carried out at any time, also after the system is put in service.

5.3 Oil Booster Pumps (11-PA-9101A/B)

Before the test is ready to be executed it needs to be verified that the commissioning phase is completed and the oil train is in operation. The recycle line is designed to handle a maximum flow of 320 m^3/h, which is also the minimum continuous flow through the pump. The first point to be verified on the flow will therefore be just above 320 m^3/h. Use the metering station for export oil to verify the density of the oil.
References relevant for the test are P&ID: PH-ME-P-0132-001.

General Procedure
Use Table 6.15/6.16 to record the data.

- Start testing the stand-by pump.
- Measure and record the relevant XV open/close times and leave the valves in auto.
- Record the tuning parameters of the minimum-flow valve (11-FIC-92347A/B) and leave the flow regulation in auto.
- Start the stand-by pump using the start-up sequence and let it run for 15-20 min to stabilize temperatures, if not recently started.
- Use the minimum-flow valve to regulate the flow. It is recommended to start verifying the left hand side of the pump characteristic. Start reducing the flow towards the minimum continuous flow, by regulating the outlet valve 11-V-90245/9. The first desirable point will be at 340 m^3/h, verify that the low-flow alarm activates.
  Record the flow, pressures, speed and temperatures at this point, which will be the first of six points.
- Visually go over the system to look for abnormal vibrations or leakages. This should be repeated for every flow.
- Slowly operate the outlet valve to increase the flow through the pump. Operate the minimum-flow regulation in manual to help reaching the desirable points.
  Use the table and record the parameters. Desirable recordings are 450, 550, 790, 900, 950 m^3/h. It is recommended to stop the parallel pump when the total flow though the system exceeds 790 m^3/h.
  790 m^3/h represent the rated point of the pump; at this point the differential head should be between 79 – 84,5 mlc, while the power should not exceed 182 kW. This is according to API 610 (appendices E).

After the test, the results should be plotted into the original pump characteristic (appendix M).

Approximate Duration:
The different tests of one single pump are estimated to take around 1-2 hrs. This time however, could be reduced if some of the desirable data has been collected during the offshore commissioning phase. These tests can be carried out at any time, also after the system is put in service.

5.4 Oil Export Pumps (11-PA-9102A/B)

Before the test is ready to be executed it needs to be verified that the commissioning phase is completed and the oil train is in operation. The recycle line is designed to handle a maximum flow of 360 m^3/h, which is also the minimum continuous flow through the pump. The first point to be verified on the flow will therefore be just above 360 m^3/h. Use the metering station for export oil to verify the density of the oil.
References relevant for the test are P&ID: PH-ME-P-0133-001.

General Procedure
Use Table 6.17/6.18 to record the data.

- Start testing the stand-by pump.
- Measure and record the relevant XV open/close times and leave the valves in auto.
- Record the tuning parameters of the minimum-flow valve (11-FIC-92367A/B) and leave the flow-regulation in auto.
- Start the 2nd Booster Pump. This to make sure the export pumps got enough NPSH.
- Start the stand-by pump using the start-up sequence and let it run for 15-20 min to stabilize temperatures, if not recently started.
- Use the minimum-flow valve to regulate the flow. It is recommended to start verifying the left hand side of the pump characteristic. Start reducing the flow towards the minimum continuous flow, by regulating 11-LIC-92264. The first desirable point will be at 380 m^3/h, verify that the low-flow alarm activates.
  Record the flow, pressures and temperatures at this point, which will be the first of six points.
- Visually go over the system to look for abnormal vibrations or leakages. This should be repeated for every flow.
- Slowly operate 11-LIC-92264, and increase the flow through the pump. Operate the minimum-flow regulation in manual to help reaching the desirable points. NB! Do not forget to observe the oil level in the 2nd oil separator during this operation, and keep the level inside the boundaries. Use the table and record the parameters. Desirable recordings are 500, 650, 795, 900, 1050 m^3/h. It is recommended to stop the parallel pump when the total flow though the system exceeds 795 m^3/h.
  795 m^3/h represent the rated point of the pump; at this point the differential head should be between 789 – 821 mlc, while the power should not exceed 1872 kW. This is according to API 610 (appendices E).

After the test, the results should be plotted into the original pump characteristic (appendix N).

Approximate Duration:
The different tests of one single pump are estimated to take around 1-2 hrs. This time however, could be reduced if some of the desirable data has been collected during the offshore commissioning phase. These tests can be carried out at any time, also after the system is put in service.

5.5 1st Stage Gas Compressor (23-KA-9101)

Technical literature used to define the performance test of the centrifugal compressors is taken from; Ford, 2007.

Before the test is ready to be executed it needs to be verified that the commissioning phase is completed and the surge line is properly implemented. The recycle line is designed to handle a flow up to 54 000 m^3/h with a differential pressure of 7,4 bar, which means that the recycle line can almost handle the maximum flow of the compressor. However, by running gas on recycle this will affect the molecular weight (i.e. become leaner), it is therefore recommended to let the compressor operate under normal conditions as far as possible.

Since there is not installed any sampler for measuring molecular weight, there is a problem related to the sampling operation. For a centrifugal compressor it is recommended to take three different gas samples related to the anti-surge valve position. However, since the amount of gas that is being produced at Valhall is significantly below the designed capacity of the new compressors, it is assumed that the anti-surge valve position may never be entirely closed. With this information it is only required two gas samples during the test.

The sampling operation, however, is a critical operation where the operator has to couple a sample bottle up to a high-pressure hydrocarbon system. It is therefore important to be aware of the hazard this can lead to, and that the operation has to be well planed. The sample will be sent to shore to be analyzed.

References relevant for the test are P&ID's: PH-ME-P-0151-001, PH-ME-P-0152-001, PH-ME-P-0153-001 & PH-ME-P-0160-001.

General Procedure

Use Table 6.19 to record the data.

- ➢ Record the relevant XV open/close times. NB! This has to be collected during offshore commissioning, or in a start-up sequence.
- ➢ Record the final ASC (Anti-Surge Control) tuning parameters (23-FIC-92543).
- ➢ Start the compressor using the start-up sequence and bring the compressor up to load.
- ➢ Ensure that the compressor suction temperature (23-TI-92533) and pressure (23-PI-92532) are in normal operating range (approximately 40^{o}C and 3,5 barg).
- ➢ Ensure the compressor discharge cooler (23-TIC-92604) is operating in the normal operating range.
- ➢ Put the anti-surge valve (23-FIC-92543) into manual, and slowly increase the output signal to 100 % (fully opened). The first desirable flow recording is at 58 000 m^3/h (around 187 t/h), locate this parameter at the CCP (Compressor Control Panel) if not available in PCS.
- ➢ Visually go over the compressor to verify that everything is working according to design.
- ➢ Take a gas sample for molar weight analysis. It is recommended to use the isokinetic sample valve (23-AE-92527-S2), located downstream 1st stage suction scrubber.
- ➢ Record the following data:
  - The speed, only relevant to record it once since it is fixed speed
  - The flow
  - The recycle valve position
  - The inlet and outlet temperature
  - The inlet and outlet pressure
  - Bearing temperatures

- Vibrations

- ➢ Operate the anti-surge valve towards zero, and make 5 more recordings of the parameters listed above. NB! Confirm that ASC will automatically switch back to auto-mode on detection of surge.
  Desirable flow recordings are 56 000, 53 000, 50 000, 45 000, 40 000 m^3/h.
  It is desirable to take a gas sample when the recycle flow is at minimum.
  53 000 m^3/h represent the rated point of the compressor; at this point the differential head should be between 142 – 149 kj/kg, while the power should not exceed 10,08 MW (API 617, 2002).
  To operate the compressor at lower flow, it may be desirable to close the outlet valve (23-ESDV-92551A) to obtain high pressure and low flow. But, make sure the compressor does not reach the region of surge and that the hot-gas recycle valve (23-FV-92542) is held closed. Visually go over the compressor for each flow recording.

Approximate Duration

The performance test of the 1st stage gas compressor should take about 3-4 hrs. However if data is collected during offshore commissioning, particularly during the set up of the anti-surge controller, then this time may be reduced. This test can be carried out at any stage after the compressor is available by operating it on recycle.

5.6 2nd Stage Gas Compressor (23-KA-9102)

Before the test is ready to be executed it needs to be verified that the commissioning phase is completed and the surge line is properly implemented. The recycle line is designed to handle a flow up to 18 650 m^3/h with a differential pressure of 20,9 bar, which means that the recycle line can almost handle the maximum flow of the compressor.
It is recommended to take two gas samples during the test, all related to the anti-surge valve position. The sampling operation, however, is a critical operation where the operator has to couple a sample bottle up to a high-pressure hydrocarbon system. It is therefore important to be aware of the hazard this can lead to, and that the operation has to be well planed. The sample will be sent to shore for analyzing.
References relevant for the test are P&ID's: PH-ME-P-0160-001, PH-ME-P-0161-001, PH-ME-P-0162-001, PH-ME-P-0170-001 & PH-ME-P-0170-002.

General Procedure

Use Table 6.20 to record the data.

- ➢ Record the relevant XV open/close times. NB! This has to be collected during offshore commissioning, or in a start-up sequence.
- ➢ Record the final ASC tuning parameters (23-FIC-92643).
- ➢ Start the compressor using the start-up sequence and bring the compressor up to load.
- ➢ Ensure that the compressor suction temperature (23-TI-92633) and pressure (23-PI-92632) are in normal operating range (approximately 24°C and 11 barg).
- ➢ Ensure the compressor discharge cooler (24-TIC-92774) is operating in the normal operating range.
- ➢ Put the anti-surge valve (23-FIC-92643) into manual, and slowly increase the output signal to 100 % (fully opened). The first desirable flow recording is at 20 000 m^3/h (around 220 t/h), locate this parameter at the CCP if not available in PCS.

- Visually go over the compressor to verify that everything is working according to design.
- Take a gas sample for molar weight analysis. It is recommended to use the isokinetic sample valve (23-AE-92627-S2), located downstream 2nd stage suction scrubber.
- Record the following data:
  - The speed, only relevant to record it once since it is fixed speed
  - The flow
  - The recycle valve position
  - The inlet and outlet temperature
  - The inlet and outlet pressure
  - Bearing temperatures
  - Vibrations
- Operate the anti-surge valve towards zero, and make 5 more recordings of the parameters listed above. NB! Confirm that ASC will automatically switch back to auto-mode on detection of surge.

  Desirable flow recordings are 19 500, 18 700, 17 200, 16 000, 14 000 m^3/h.
  It is desirable to take a gas sample when the recycle flow is at minimum.
  17 200 m^3/h represent the rated point of the compressor; at this point the differential head should be between 133 – 140 kj/kg, while the power should not exceed 10,00 MW (API 617, 2002).
  To operate the compressor at lower flow, it may be desirable to close the outlet valve (23-ESDV-92651A) to obtain high pressure and low flow. But, make sure the compressor does not reach the region of surge and that the hot-gas recycle valve (23-FV-92642) is held closed. Visually go over the compressor for each flow recording.

Approximate Duration

The performance test of the 2nd stage gas compressor should take about 3-4 hrs. However if data is collected during offshore commissioning, particularly during the set up of the anti-surge controller, then this time may be reduced. This test can be carried out at any stage after the compressor is available by operating it on recycle.

5.7 3rd Stage Gas Compressor (23-KA-9103)

Before the test is ready to be executed it needs to be verified that the commissioning phase is completed and the surge line is properly implemented. The recycle line is designed to handle a flow up to 9 160 m^3/h with a differential pressure of 32,3 bar, which means that the recycle line can almost handle the maximum flow of the compressor.
It is recommended to take two different samples during the test, all related to the anti-surge valve position. The sampling operation, however, is a critical operation where the operator has to couple a sample bottle up to a high-pressure hydrocarbon system. It is therefore important to be aware of the hazard this can lead to, and that the operation has to be well planed. The sample will be sent to shore for analyzing.
References relevant for the test are P&ID's: PH-ME-P-0170-003, PH-ME-P-0171-001, PH-ME-P-0172-001 & PH-ME-P-0180-001.

General Procedure

Use Table 6.21 to record the data.

- Record the relevant XV open/close times. NB! This has to be collected during offshore commissioning, or in a start-up sequence.
- Record the final ASC tuning parameters (24-FIC-92743).
- Start the compressor using the start-up sequence and bring the compressor up to load.
- Ensure that the compressor suction temperature (23-TI-92733) and pressure (23-PI-92732) are in normal operating range (approximately 18°C and 33 barg).
- Ensure the compressor discharge cooler (23-TIC-92704) is operating in the normal operating range.
- Put the anti-surge valve (24-FIC-92743) into manual, and slowly increase the output signal to 100 % (fully opened). The first desirable flow recording is at 10 500 m^3/h (around 420 t/h), locate this parameter at the CCP if not available in PCS.
- Visually go over the compressor to verify that everything is working according to design.
- Take a gas sample for molar weight analysis. It is recommended to use the isokinetic sample valve (23-AE-92727-S2), located downstream 3rd stage suction scrubber.
- Record the following data:
    - The speed, only relevant to record it once since it is fixed speed
    - The flow
    - The recycle valve position
    - The inlet and outlet temperature
    - The inlet and outlet pressure
    - Bearing temperatures
    - Vibrations
- Operate the anti-surge valve towards zero, and make 5 more recordings of the parameters listed above. NB! Confirm that ASC will automatically switch back to auto-mode on detection of surge.

  Desirable flow recordings are 10 000, 9 150, 8 150, 7 300, 6 300 m^3/h.

  It is desirable to take a gas sample when the recycle flow is at minimum.

  8 150 m^3/h represent the rated point of the compressor; at this point the differential head should be between 68 – 71,5 kj/kg, while the power should not exceed 8 560 kW (API 617, 2002).

  To operate the compressor at lower flow, it may be desirable to close the outlet valve (24-ESDV-92751A) to obtain high pressure and low flow. But, make sure the compressor does not reach the region of surge and that the hot-gas recycle valve (23-FV-92742) is held closed. Visually go over the compressor for each flow recording.

Approximate Duration

The performance test of the 3rd stage gas compressor should take about 3-4 hrs. However if data is collected during offshore commissioning, particularly during the set up of the anti-surge controller, then this time may be reduced. This test can be carried out at any stage after the compressor is available by operating it on recycle.

5.8 4th Stage Gas Compressor (27-KA-9104)

Before the test is ready to be executed it needs to be verified that the commissioning phase is completed and the surge line is properly implemented. The recycle line is designed to handle a flow up to 3 500 m^3/h with a differential pressure of 67,3 bar, which means that the recycle line can almost handle the maximum flow of the compressor. However, by running gas on recycle this will affect the molecular weight (i.e. become leaner), it is therefore recommended to let the compressor operate under normal conditions as far as possible.
References relevant for the test are P&ID's: PH-ME-P-0195-004, PH-ME-P-0195-005, PH-ME-P-0199-001 & PH-ME-P-0205-002.

General Procedure
Use Table 6.22 to record the data.

- Record the relevant XV open/close times. NB! This has to be done when the compressor is stopped, or in a start-up sequence.
- Record the final ASC tuning parameters (27-FIC-92943).
- Start the compressor using the start-up sequence and bring the compressor up to load.
- Ensure that the compressor suction temperature (27-TI-92933) and pressure (23-PI-92932) are in normal operating range (approximately 16°C and 47 barg).
- Ensure the compressor discharge cooler (27-TIC-93004) is operating in the normal operating range.
- Put the anti-surge valve (27-FIC-92943) into manual, and slowly increase the output signal to 100 % (fully opened). The first desirable flow recording is at 4 200 m^3/h (around 167 t/h), locate this parameter at the CCP if not available in PCS.
  Visually go over the compressor to verify that everything is working according to design.
  Record the following data:
  - The speed, only relevant to record it once since it is fixed speed
  - The flow
  - The recycle valve position
  - The inlet and outlet temperature
  - The inlet and outlet pressure
  - The molar weight
  - Bearing temperatures
  - Vibrations
- Operate the anti-surge valve towards zero, and make 5 more recordings of the parameters listed above. NB! Confirm that ASC will automatically switch back to auto-mode on detection of surge.
  Desirable flow recordings are 3 800, 3 500, 3 050, 2 700, 2 400 m^3/h.
  3 050 m^3/h represent the rated point of the compressor; at this point the differential head should be between 127 – 133,5 kj/kg, while the power should not exceed 6 750 kW (API 617, 2002).
  To operate the compressor at lower flow, it may be desirable to close the outlet valve (27-ESDV-93019A) to obtain high pressure and low flow. But, make sure the compressor does not reach the region of surge and that the hot-gas recycle valve (27-FV-92942) is held closed. Visually go over the compressor for each flow recording.

Approximate Duration

The performance test of the 4th stage gas compressor should take about 3-4 hrs. However if data is collected during offshore commissioning, particularly during the set up of the anti-surge controller, then this time may be reduced. This test can be carried out at any stage after the compressor is available by operating it on recycle.

6 Calculation

For the rotational equipment it is desirable to verify that the characteristic is the same as it was during the FAT. This is done in order to verify that the purchaser gets the product he paid for. The characteristic is verified through head versus flow, and is plotted against the curves given from the manufacture. For units related to the following calculations please check *Units* at page 7.

Centrifugal pumps:

For centrifugal pumps, the formula used to calculate total dynamic head is given by:

$$H_d = \frac{p_o - p_i}{\rho \cdot g} + \frac{v_o^2 - v_i^2}{2 \cdot g}$$

(GPSA, 2004)

Where v_i and v_o expresses the inlet and outlet velocity, measured in m/s.

In relation, most flow versus head characteristics is given in m^3/h of flow.

Example:

$Q = 2400 m^3 / h$

$p_i = 1{,}27 bar(g) = 127000 Pa$ $\qquad$ $\rho = 1030 kg / m^3$

$p_o = 9{,}29 bar(g) = 929000 Pa$ $\qquad$ $g = 9{,}81 m / s^2$

First the liquid velocity in and out of the pump flanges needs to be calculated.

$$d_i = 35" = \frac{35 \cdot 25{,}4}{1000} = 0{,}889 m \qquad d_o = 18" = \frac{18 \cdot 25{,}4}{1000} = 0{,}4572 m$$

$$A_i = \frac{\pi \cdot d_i^2}{4} = \frac{\pi \cdot (0{,}889)^2}{4} = 0{,}621 m^2 \qquad A_o = \frac{\pi \cdot d_o^2}{4} = \frac{\pi \cdot (0{,}4572)^2}{4} = 0{,}164 m^2$$

$$Q = 2400 m^3 / h = \frac{2400}{3600} = 0{,}667 m^3 / s$$

$$v_i = \frac{Q}{A_i} = \frac{0{,}667 m^3 / s}{0{,}621 m^2} = 1{,}07 m / s \qquad v_o = \frac{Q}{A_o} = \frac{0{,}667 m^3 / s}{0{,}164 m^2} = 4{,}07 m / s$$

The total dynamic head of the pump is then calculated, and in relation to the flow, plotted and compared with the characteristic given by the provider of the centrifugal pump:

$$H_d = \frac{929000 Pa - 127000 Pa}{1030 kg / m^3 \cdot 9{,}81 m / s^2} + \frac{(4{,}07 m / s)^2 - (1{,}07 m / s)^2}{2 \cdot 9{,}81 m / s^2} = \underline{80{,}16 mlc}$$

Centrifugal compressors:

For centrifugal gas compressors, the formula used to calculate flow and polytrophic head is given by:

$$Q=\frac{w\cdot R\cdot T_i\cdot Z_i}{M\cdot p_i}$$ (GPSA, 2004)

$$H_p=\frac{Z_{avg}\cdot R\cdot T_i}{M\cdot\frac{(n-1)}{n}}\left[\left(\frac{p_o}{p_i}\right)^{\frac{(n-1)}{n}}-1\right]$$ (GPSA, 2004)

Where:

$$Z_{avg}=\frac{Z_i+Z_o}{2}$$

$$\frac{T_o}{T_i}=\left(\frac{p_o}{p_i}\right)^{\frac{(n-1)}{n}}\Rightarrow\frac{(n-1)}{n}=\frac{\ln\left(\frac{T_o}{T_i}\right)}{\ln\left(\frac{p_o}{p_i}\right)}$$

(GPSA, 2004)

Example:

$w=150000kg/h$

$T_o=120^oC=393{,}15K$ $\quad T_i=15^oC=288{,}15K$

$p_i=3{,}36bar(g)=336kPa$ $\quad p_o=10{,}75bar(g)=1075kPa$

$M=22{,}572kg/Kmol$

$Z_i=0{,}983$,*found in compressibility charts (appendices)*

$Z_o=0{,}932$,*found in compressibility charts (appendices)*

$$Z_{avg}=\frac{0{,}983+0{,}932}{2}=0{,}958$$

$$\frac{(n-1)}{n}=\frac{\ln\left(\frac{393{,}15K}{288{,}15K}\right)}{\ln\left(\frac{1075kPa}{336kPa}\right)}=0{,}267$$

The volumetric flow is then calculated:

$$Q=\frac{150000kg/h\cdot 8{,}314\cdot 288{,}15K\cdot 0{,}983}{22{,}572kg/Kmol\cdot 336kPa}=\underline{46576m^3/h}$$

The polytrophic head is then calculated, and in relation to the flow, plotted and compared with the characteristic given by the provider of the centrifugal compressor:

$$H_p=\frac{0{,}958\cdot 8{,}314\cdot 288{,}15K}{22{,}572kg/kmol\cdot 0{,}267}\left[\left(\frac{1075kPa}{336kPa}\right)^{0{,}267}-1\right]=\underline{138{,}7kJ/kg}$$

7 Discussion

When the objectives for the submission were first introduced there were a few discussions relating to the contents of the thesis. This was resolved in a tidy way, where the involved parties introduced their opinion on what the report should contain. It was in this process where it was selected to have main focus on one particular system, the seawater system. Along with this system it was decided to describe a verification program for other chosen rotational items of equipment. Afterthoughts and discussions has revealed that this might have been solved out in a better and more effectively way. This is particularly relevant to the performance verification program of the many items of rotational equipment, where it has been suggested that a more effectively way would be to describe the method of one centrifugal pump and one centrifugal compressor instead of describing all the rotational equipment along with tag numbers and specific data. The reason for this is that Chapter 5, performance test rotational equipment, might seem a bit repetitive, especially as it contains a large number of equipment items. It was, however, during the project accepted to avoid some of the rotational equipment mentioned in the submission of the thesis, this was equipment like the HP/LP knock-out drum pumps and jet water pumps. The reason for this decision was that these pumps were deemed less critical and of a more minor scale and size, compared with the larger pumps and compressors.

During the thesis, some aspects have been highlighted as possible root causes for potential errors and gaps in the performance testing results. These are summarized below.
Relating to the submersed pumps, such as firewater, LP and HP seawater lift, there has been revealed a problem of measuring the suction pressure. The reason for this issue is that the pumps are submersed into the seawater beneath the platform and therefore not equipped with pressure gauges at the suction side. This problem is solved by finding the exact length of the pump unit from the submerged rotational impeller and up to the outlet flange. By measuring the differential level from the sea level to the outlet flange, the submersed length of the pump can be determined. This depth is used to calculate the inlet pressure to the pumps. However, this method could lead to a few errors, especially if the sea is upset and large waves are introduced.

Another parameter that might lead to errors or mismatches when calculating the performance of equipment is the density of the medium running through it. Density is a parameter that changes marginally with temperature deviations. It was therefore decided for majority of equipment to measure the density during the performance test to be sure. However, because the changes are relatively low, the same value as used for the factory acceptances test shall be used for all the equipment involving seawater. In other rotational equipment the density is measured, either by analyzing a sample in the lab or by an online sampling station.

The main problem relating to the gas compressors is associated with the molar weight of the gas running through them. The P&ID’s revealed that only the 4th stage had installed gas chromatograph to sample the molar weight. As stated in the report, the gas that is forced to flow through the recycle loop of the compressor shall get progressively leaner over time. This implies the molar weight shall reduce proportionally with closure of the anti-surge valve position. This would have given a mismatch according to the head calculation if a simulated value for the molar weight had been used. First it was suggested to take three gas samples for each of the compressor stages, everyone at different anti-surge valve position. But, since one of the samples was recommended to be taken when the anti-surge valve is closed, something

that is very hard to achieve because of the small amount of produced gas at Valhall, it was decided to only take two gas samples for each of the compressor stages. This will give a more realistic molar weight and hence picture of the gas compressor performance. However, this method introduces a high risk relating to the sampling operation, where the sampling bottles need to be connected to high-pressure hydrocarbon systems. It is stated that due care needs to be exercised when performing this operation.
A problem has also occurred when defining the inlet and outlet compressibility factors for the compressors. To define the exact compressibility factors a comprehensive calculation needs to be carried out. A much less comprehensive way to define this value is to use pre-made compressibility charts of natural gases (with leaner molar weight than 40 kg/kmol). The problem is first that the charts do not include every single molar weight, and second that the exact molar weight is hard to define. By interpolating between two nearby charts, the suspected compressibility factors are found. This might lead to some mismatches in the calculation part. The charts are attached to this report.

Another issue related to this thesis and the literature, is the use of sources found in the VRD-project's internal database, ShareCat, where each equipment supplier deposits important information relating to their product. This is a database that only project personnel can access, and could therefore lead to some misinterpretation for external personnel not having this access. By attaching all the relevant literature, the report can be read and understood by external personnel. There will also be engaged an internal BP employee to assist the evaluation part of the report.

At the time of writing this document there has been discussion in the VRD-project regarding the alarm settings in the new process modules. When searching the documentation given by the many providers, a lot of vendor recommended alarm limits were found. But, when studying the alarm limits set by the responsible personnel in the VRD-project, there was found a mismatch between the settings. This is particularly relevant to vibration and temperature limits, where it is observed that the VRD-project has specified more conservative alarm and trip limits compared to vendor recommendation. This report refers to the alarm settings given by the project, due to this conservatism. As the alarm settings are likely to change (through a managed change process) throughout start-up, the "final" limits have not been specified. Where relevant the test sheets identify this uncertainty, reminding the executing personnel that these limits were not decided at the time of writing.

Hence although there are uncertainties and potential errors relating to the performance testing results, the submitted verification program still is suitable for defining whether the equipment is performing according to the guarantee point or not. But following this procedure it is hoped that the VRD project and ultimately BP Norway Valhall asset will obtain some valuable information regarding the performance of some key equipment.

8 Conclusion

The objective for this master thesis was to outline a program on how to test the performance of chosen equipment on the new field centre (PH) at Valhall. The system that was decided to review in detail was the seawater system, and in particular the LP and HP seawater systems. Along with these systems it was decided to outline a less comprehensive performance verification program for other rotational equipment. The method selected for the verification was to record some of the conditioning monitoring parameters, such as suction and discharge pressure, and thereby calculate the head of the rotational equipment. In relation to the flow through the equipment, the head versus flow points can be plotted against the original characteristic given by the provider. By use of this method, the performance of the equipment can be measured and reviewed for acceptability. The aim of the performance test is to verify that the design complies with the equipment guarantee points and is therefore capable of achieving rated production. The candidate recommends the submitted program as a tool to verify the performance of the tested equipment.

References

Misra, K.B. (2008), *Handbook of Performability Engineering.* Springer-Verlag London Limited, United kingdom.

Bjørge Eureka AS (2009), *Eureka Seawater Lift Pumps.* Compendium.

Frank Mohn Flatøy (2006), *Technical Description Electrical Submersible Pump.* Compendium

Girdhar, P. and Moniz, O. (2005), *Practical centrifugal pumps: design, operation and maintenance*. Elsevier, Amsterdam, Holland.

Palgrave, R. (2003), *Troubleshooting Centrifugal Pumps and Their Systems.* Elsevier, Oxford, United Kingdom.

Carstensen, C. (2009), *Process Plants For Oil And Gas.* Rev. 1 C, University of Stavanger, Norway.

Odland, J. (2000), *Offshore Field Development.* Compendium, University of Stavanger, Norway.

Sharp, D.B. and Sharp B.B. (1996), *Water Hammer: Practical Solutions*. New York, Halsted Press, USA.

T H Webb, T.H., Gould, B.W., Hardie, J. (1978), *Water Hammer.* Kensington, New South Wales University Press, USA.

DNV (2001), *Qualification Procedures for New Technology, DNV-RP-A203.*

API Standard 610 (2004), *Centrifugal Pumps for Petroleum, Petrochemicals and Natural Gas Industries.* 10th Edition. API Publishing Services, Washington D.C., USA.

API Standard 617 (2002), *Axial and Centrifugal Compressors and Expander-compressors for Petroleum, Chemical and Gas Industry Services. 7th Edition.* API Publishing Services, Washington D.C., USA.

ISS International (2006), *Commissioning & Start-Up Directory.* Compendium.

Fisher (2005), *Control Valve Handbook.* 4th Edition. Fisher Controls International Inc, Marshalltown, Iowa, USA.

Riveland, M. (1985), *Fundamental of Valve Sizing for Liquids.* Fisher Controls International, Inc, Marshalltown, Iowa, USA.

Nergaard, A. (2009), *Basics Hydraulic System Design.* University of Stavanger, Norway.

Crane Co. (1979), *Flow of Fluids Through Valves, Fittings and Pipes*. 2nd printing, Crane Co, New York, USA.

McCabe, W.L., Smith, J.C., Harriot, P. (1993) *Unit Operations in Chemical Engineering.* 5th Edition. The McGraw-Hill Companies, New Jersey, USA.

Bird, R.B., Stewart, W.E., Lightfoot, E.N. (2007), *Transport Phenomena.* 2nd edition. John Wiley & Sons LTD, West Sussex, England

Eisenmann, R.C. and Eisenmann R.C. Jr. (2005), *Machinery Malfunctions Diagnosis and Correction.* Prentice Hall, New Jersey, USA.

Hongyun, L. and Hanwei, L. (2009), *Analysis of Centrifugal Pump Vibration and Solutions.* Petroleum refinery engineering, 39, Part 6.

Gas Processors Suppliers Association (2004), *Engineering Data Book.* 12th edition. Tulsa, Oklahoma, USA.

Ford K.R. (2007), *Uncertainty in Centrifugal Compressor Performance Field Testing.* Ohio State University, USA.

Test Sheets

84-FIC-93249								
FIC tuning parameters, Start	Date		Gain		Integr.		Derv.	
FIC tuning parameters, Final	Date		Gain		Integr.		Derv.	

TABLE 6.1 TUNING PARAMETRS 84-FIC-93294

84-TIC-93286A								
TIC tuning parameters, Start	Date		Gain		Integr.		Derv.	
TIC tuning parameters, Final	Date		Gain		Integr.		Derv.	

TABLE 6.2 TUNING PARAMETRS 84-TIC-93286A

84-TIC-93286B								
TIC tuning parameters, Start	Date		Gain		Integr.		Derv.	
TIC tuning parameters, Final	Date		Gain		Integr.		Derv.	

TABLE 6.3 TUNING PARAMETRS 84-TIC-93286B

LP Seawater Lift Pump A (84-PX-9101A)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (84-FIC-93207A) [m^3/h]	2400	-	3100						
Distance from cellar deck to sea level [m]	34	-	-		-	-	-	-	-
Discharge pressure (84-PI-93207A)[Barg]	3,5	6,8	14						
Discharge temp. (84-TI-93207A) [°C]	6	-	50						
Power (84-PX-9101A) [kW]	667	-	730						
Speed (84-NI-95500A) [rpm]	1180	-	1192		-	-	-	-	-
Min flow position (84-FV-93207A) [%]	0	-	100						
Tuning parameters (84-FIC-93207A)	-	-	-	Gain		Integr.		Derv.	
Vib. NDE motor (84-YI-95500A) [mm/s]	3	4,5	7,1						
Vib. DE motor (84-YI-95501A) [mm/s]	3	4,5	7,1						
Vib. Shaft (84-YI-95510A) [mm/s]	3	5	8						
Vib. Shaft (84-YI-95511A) [mm/s]	3	5	8						
Temp. NDE motor (84-TI-95500A) [°C]	70	110	120						
Temp. windings (84-TI-95502A) [°C]	70	135	145						
Temp. windings (84-TI-95505A) [°C]	70	135	145						
Temp. windings (84-TI-95508A) [°C]	70	135	145						
Temp. DE motor (84-TI-95511A) [°C]	70	110	120						
Open / Close time (84-XV-93212A) [s]	6	-	18	Opening			Closing		
Open / Close time (84-XV-93202A) [s]	1	-	4	Opening			Closing		

TABLE 6.4 LP SEAWATER LIFT PUMP A

LP Seawater Lift Pump B (84-PX-9101B)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (84-FIC-93207B) [m^3/h]	2400	-	3100						
Distance from cellar deck to sea level [m]	34	-	-		-	-	-	-	-
Discharge pressure (84-PI-93207B)[Barg]	3,5	6,8	14						
Discharge temp. (84-TI-93207B) [°C]	6	-	50						
Power (84-PX-9101B) [kW]	667	-	730						
Speed (84-NI-95500B) [rpm]	1180	-	1192		-	-	-	-	-
Min flow position (84-FV-93207B) [%]	0	-	100						
Tuning parameters (84-FIC-93207B)	-	-	-	Gain		Integr.		Derv.	
Vib. NDE motor (84-YI-95500B) [mm/s]	3	4,5	7,1						
Vib. DE motor (84-YI-95501B) [mm/s]	3	4,5	7,1						
Vib. Shaft (84-YI-95510B) [mm/s]	3	5	8						
Vib. Shaft (84-YI-95511B) [mm/s]	3	5	8						
Temp. NDE motor (84-TI-95500B) [°C]	70	110	120						
Temp. windings (84-TI-95502B) [°C]	70	135	145						
Temp. windings (84-TI-95505B) [°C]	70	135	145						
Temp. windings (84-TI-95508B) [°C]	70	135	145						
Temp. DE motor (84-TI-95511B) [°C]	70	110	120						
Open / Close time (84-XV-93212B) [s]	6	-	18	Opening			Closing		
Open / Close time (84-XV-93202B) [s]	2	-	4	Opening			Closing		

TABLE 6.5 LP SEAWATER LIFT PUMP B

84-TIC-93233								
TIC tuning parameters, Start	Date		Gain		Integr.		Derv.	
TIC tuning parameters, Final	Date		Gain		Integr.		Derv.	

TABLE 6.6 TUNING PARAMETRS 84-FIC-93233

84-TIC-91771A								
TIC tuning parameters, Start	Date		Gain		Integr.		Derv.	
TIC tuning parameters, Final	Date		Gain		Integr.		Derv.	

TABLE 6.7 TUNING PARAMETRS 84-TIC-91771A

84-TIC-91771B								
TIC tuning parameters, Start	Date		Gain		Integr.		Derv.	
TIC tuning parameters, Final	Date		Gain		Integr.		Derv.	

TABLE 6.8 TUNING PARAMETRS 84-TIC-91771B

HP Seawater Lift Pump A (84-PX-9102A)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (84-FIC-93477A) [m^3/h]	900	-	1050						
Distance from cellar deck to sea level [m]	32	-	-		-	-	-	-	-
Discharge pressure (84-PI-93477A)[Barg]	9,7	12,3	14						
Discharge temp. (84-TI-93477A) [°C]	6	-	50						
Power (84-PX-9102A) [kW]	435	-	500						
Min flow position (84-FV-93477A) [%]	0	-	100						
FIC tuning parameters	-	-	-	Gain		Integr.		Derv.	
Open / Close time (84-XV-93212A) [s]	5	-	14	Opening			Closing		
Open / Close time (84-XV-93202A) [s]	2	-	4	Opening			Closing		

TABLE 6.9 HP SEAWATER LIFT PUMP A

HP Seawater Lift Pump B (84-PX-9102B)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (84-FIC-93477B) [m^3/h]	900	-	1050						
Distance from cellar deck to sea level [m]	32	-	-		-	-	-	-	-
Discharge pressure (84-PI-93477B)[Barg]	9,7	12,3	14						
Discharge temp. (84-TI-93477B) [°C]	6	-	50						
Power (84-PX-9102B) [kW]	435	-	500						
Min flow position (84-FV-93477B) [%]	0	-	100						
Tuning parameters (84-FIC-93477B)	-	-	-	Gain		Integr.		Derv.	
Open / Close time (84-XV-93212B) [s]	5	-	14	Opening			Closing		
Open / Close time (84-XV-93202B) [s]	2	-	4	Opening			Closing		

TABLE 6.10 HP SEAWATER LIFT PUMP B

Cooling Medium Circulation Pump A (45-PA-9106A)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (45-FIC-93267A) $[m^3/h]$	1550	-	2040						
Density $[kg/m^3]$	1003	-	-						
Suction pressure (45-PI-93264A) [Barg]	4	-	-						
Suction temperature (45-TI-93262A) $[^oC]$	50	-	127						
Discharge pressure (45-PI-93267A)[Barg]	11,5	-	13,7						
Discharge temp. (45-TI-93267A) $[^oC]$	50	60	127						
Power (45-PA-9106A) [kW]	323	-	450						
Min flow position (45-FV-93267A) [%]	0	-	100						
Tuning parameters (45-FIC-93267A)	-	-	-	Gain		Integr.		Derv.	
Open / Close time (45-XV-93272A) [s]	8	-	32	Opening			Closing		
Open / Close time (45-XV-93267A) [s]	7	-	20	Opening			Closing		

TABLE 6.11 COOLING MEDIUM CIRCULATION PUMP A

Cooling Medium Circulation Pump B (45-PA-9106B)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (45-FIC-93267B) $[m^3/h]$	1550	-	2040						
Suction pressure (45-PI-93264B) [Barg]	4	-	-						
Suction temp. (45-TI-93262B) $[^oC]$	50	-	127						
Discharge pressure (45-PI-93267B)[Barg]	11,5	-	13,7						
Discharge temp. (45-TI-93267B) $[^oC]$	50	60	127						
Power (45-PA-9106B) [kW]	323	-	450						
Min flow position (45-FV-93267B) [%]	0	-	100						
Tuning parameters (45-FIC-93267B)	-	-	-	Gain		Integr.		Derv.	
Open / Close time (45-XV-93272B) [s]	8	-	32	Opening			Closing		
Open / Close time (45-XV-93267B) [s]	7	-	20	Opening			Closing		

TABLE 6.12 COOLING MEDIUM CIRCULATION PUMP B

Firewater Pump A (48-XD-9107A)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (48-FI-93544A) $[m^3/h]$	2300	-	3425						
Distance from cellar deck to sea level [m]	35	-	-		-	-	-	-	-
Interstage pressure (48-PI-93543A) [Barg]	2,98	-	4,93						
Discharge pressure (48-PI-93544A)[Barg]	14,0	-	16,2						
Speed engine (48-SI-95400A) [rpm]	1850	-	2070		-	-	-	-	-

TABLE 6.13 FIREWATER PUMP A

Firewater Pump B (48-XD-9107B)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (48-FI-93544B) $[m^3/h]$	2300	-	3425						
Distance from cellar deck to sea level [m]	35	-	-		-	-	-	-	-
Interstage pressure (48-PI-93543B) [Barg]	2,98	-	4,93						
Discharge pressure (48-PI-93544B)[Barg]	14,0	-	16,2						
Speed engine (48-SI-95400B) [rpm]	1850	-	2070		-	-	-	-	-

TABLE 6.14 FIREWATER PUMP B

Oil Booster Pump A (11-PA-9101A)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (11-FIC-92347A-01) $[m^3/h]$	790	950	960						
Oil density at metering station $[kg/m^3]$	0,786	-	-						
Suction pressure (11-PI-92344A) [Barg]	1,8	-	-						
Suction temperature (11-TI-92342A) [°C]	60	-	-						
Discharge pressure (11-PI-92347A)[Barg]	8	9,2	-						
Discharge temp. (11-TI-92347A) [°C]	60	70	-						
Power engine [kW]	173	-	200						
Min flow position (11-FV-92347A) [%]	0	-	100						
Tuning parameters (11-FIC-92347A)	-	-	-	Gain		Integr.		Derv.	
Open / Close time (11-ESDV-92352A) [s]	8	-	28	Opening			Closing		
Open / Close time (11-ESDV-92349A) [s]	5	-	16	Opening			Closing		

Table 6.15 Oil Booster Pump A

Oil Booster Pump B (11-PA-9101B)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (11-FIC-92347B-01) $[m^3/h]$	790	950	960						
Oil density at metering station $[kg/m^3]$	0,786	-	-						
Suction pressure (11-PI-92344B) [Barg]	1,8	-	-						
Suction temperature (11-TI-92342B) [°C]	60	-	-						
Discharge pressure (11-PI-92347B)[Barg]	8	9,2	-						
Discharge temp. (11-TI-92347B) [°C]	60	70	-						
Power engine [kW]	173	-	200						
Min flow position (11-FV-92347B) [%]	0	-	100						
Tuning parameters (11-FIC-92347B)	-	-	-	Gain		Integr.		Derv.	
Open / Close time (11-ESDV-92352B) [s]	8	-	28	Opening			Closing		
Open / Close time (11-ESDV-92349B) [s]	5	-	16	Opening			Closing		

Table 6.16 Oil Booster Pump B

Oil Export Pump A (11-PA-9102A)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (11-FIC-92367A-01) $[m^3/h]$	790	-	1070						
Oil density at metering station $[kg/m^3]$	0,786	-	-						
Suction pressure (11-PI-92364A) [Barg]	6,5	-	-						
Suction temperature (11-TI-92362A) [°C]	60	-	-						
Discharge pressure (11-PI-92367A)[Barg]	38	43,5	87						
Discharge temp. (11-TI-92367A) [°C]	60	75	-						
Power engine [kW]	860	-	1950						
Speed engine (11-NI-95099A) [rpm]	3560	-	3596		-	-	-	-	-
Min flow position (11-FV-92367A) [%]	0	-	100						
Tuning parameters (11-LIC-92264)	-	-	-	Gain		Integr.		Derv.	
Tuning parameters (11-FIC-92367A)	-	-	-	Gain		Integr.		Derv.	
Open / Close time (11-XV-92372A) [s]	8	-	28	Opening			Closing		
Open / Close time (11-XV-92369A) [s]	5	-	16	Opening			Closing		

Table 6.17 Oil Export Pump A

Oil Export Pump B (11-PA-9102B)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (11-FIC-92367B-01) [m^3/h]	790	-	1070						
Oil density at metering station [kg/m^3]	0,786	-	-						
Suction pressure (11-PI-92364B) [Barg]	6,5	-	-						
Suction temperature (11-TI-92362B) [°C]	60	-	-						
Discharge pressure (11-PI-92367B)[Barg]	38	43,5	87						
Discharge temp. (11-TI-92367B) [°C]	60	75	-						
Power engine [kW]	860	-	1950						
Speed engine (11-NI-95099B) [rpm]	3560	-	3596		-	-	-	-	-
Min flow position (11-FV-92367B) [%]	0	-	100						
Tuning parameters (11-FIC-92367B)	-	-	-	Gain		Integr.		Derv.	
Open / Close time (11-XV-92372B) [s]	8	-	28	Opening			Closing		
Open / Close time (11-XV-92369B) [s]	5	-	16	Opening			Closing		

TABLE 6.18 OIL EXPORT PUMP B

1st Stage Gas Compressor (23-KA-9101)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (23-FI-92537-01) [10^3 m^3/h]	49,8	-	58,2						
Inlet pressure (23-PI-92532) [Barg]	3,4	6	7,75						
Outlet pressure (23-PI-92539) [Barg]	11	15	15,8						
Inlet temperature (23-TI-92533) [°C]	40	50	-						
Discharge temp. (23-TI-92539) [°C]	120	150	154						
Power engine [MW]	9,4	-	11,0						
Speed engine (23-NI-96144) [rpm]	1784	-	1802		-	-	-	-	-
Recycle valve pos. (23-ZI-92543) [%]	30	-	100						
FIC tuning param. (23-FIC-92543)	-	-	-	Gain		Integr.		Derv.	
Vib. DE (23-YI-96105-01) [µm]	30	55	101						
Vib. DE (23-YI-96105-02) [µm]	30	55	101						
Vib. NDE (23-YI-96106-01) [µm]	30	55	101						
Vib. NDE (23-YI-96106-02) [µm]	30	55	101						
Vib. NDE (23-ZI-96107) [µm]	+0,2	+0,3	+0,5						
Temp. DE (23-TI-96101-01) [°C]	50	60	65						
Temp. DE (23-TI-96101-03) [°C]	50	60	65						
Temp. NDE (23-TI-96102-01) [°C]	50	60	65						
Temp. NDE (23-TI-96102-03) [°C]	50	60	65						
Temp. NDE (23-TI-96103-01) [°C]	50	70	85						
Temp. NDE (23-TI-96104-01) [°C]	50	70	85						
Open/Close time (23-ESDV-92501A)	20	-	60	Opening			Closing		
Open/Close time (23-ESDV-92501B)	2	-	4	Opening			Closing		

TABLE 6.19 1ST STAGE GAS COMPRESSOR

2^{nd} Stage Gas Compressor (23-KA-9102)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (23-FI-92633-01) [10^3 m^3/h]	17,2	-	20,5						
Inlet pressure (23-PI-92632) [Barg]	10,8	15,8	17,5						
Outlet pressure (23-PI-92639) [Barg]	35	43	46,2						
Inlet temp. (23-TI-92633) [°C]	24	35	-						
Outlet temp. (23-TI-92638) [°C]	110	135	140						
Power engine [MW]	9,3	-	11,0						
Speed engine (23-NI-96244) [rpm]	1784	-	1802		-	-	-	-	-
Recycle position (23-ZT-92643) [%]	30	-	100						
FIC tuning param. (23-FIC-92643)	-	-	-	Gain		Integr.		Derv.	
Vib. DE (23-YI-96205-01) [µm]	30	57	82						
Vib. DE (23-YI-96205-02) [µm]	30	57	82						
Vib. NDE (23-YI-96206-01) [µm]	30	57	82						
Vib. NDE (23-YI-96206-02) [µm]	30	57	82						
Vib. NDE (23-ZI-96207) [µm]	+0,2	+0,5	+0,75						
Temp. DE (23-TI-96201-01) [°C]	50	60	65						
Temp. DE (23-TI-96201-03) [°C]	50	60	65						
Temp. NDE (23-TI-96202-01) [°C]	50	60	65						
Temp. NDE (23-TI-96202-03) [°C]	50	60	65						
Temp. NDE (23-TI-96203-01) [°C]	50	70	85						
Temp. NDE (23-TI-96204-01) [°C]	50	70	85						
Open/Close time (23-ESDV-92551A)	22	-	48	Opening			Closing		
Open/Close time (23-ESDV-92551B)	2	-	4	Opening			Closing		
Open/Close time (23-ESDV-92651A)	30	-	62	Opening			Closing		
Open/Close time (23-ESDV-92651B)	3	-	6	Opening			Closing		

TABLE 6.20 2^{ND} STAGE GAS COMPRESSOR

3rd Stage Gas Compressor (23-KA-9103)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (23-FI-92733-02) [10^3 m^3/h]	81,5	-	107						
Inlet pressure (23-PI-92732) [Barg]	33,3	40	44,75						
Outlet pressure (23-PI-92739) [Barg]	61	89	94						
Inlet temp. (23-TI-92733) [^{o}C]	18,1	30	-						
Discharge temp. (23-TI-92739) [^{o}C]	110	125	140						
Power engine [MW]	7,9	-	11,0						
Speed engine (23-NI-96344) [rpm]	1784	-	1802		-	-	-	-	-
Recycle position (24-ZT-92743) [%]	30	-	100						
FIC tuning param. (24-FIC-92743)	-	-	-	Gain		Integr.		Derv.	
Vib. DE (23-YI-96305-01) [µm]	30	57	82						
Vib. DE (23-YI-96305-02) [µm]	30	57	82						
Vib. NDE (23-YI-96306-01) [µm]	30	57	82						
Vib. NDE (23-YI-96306-02) [µm]	30	57	82						
Vib. NDE (23-ZI-96307) [µm]	+0,2	+0,5	+0,75						
Temp. DE (23-TI-96301-01) [^{o}C]	50	60	65						
Temp. DE (23-TI-96301-03) [^{o}C]	50	60	65						
Temp. NDE (23-TI-96302-01) [^{o}C]	50	60	65						
Temp. NDE (23-TI-96302-03) [^{o}C]	50	60	65						
Temp. NDE (23-TI-96303-01) [^{o}C]	50	70	85						
Temp. NDE (23-TI-96304-01) [^{o}C]	50	70	85						
Open/Close time (24-ESDV-92939A)	8	-	32	Opening			Closing		
Open/Close time (24-ESDV-92939B)	3	-	6	Opening			Closing		
Open/Close time (25-XV-92861A)	7	-	24	Opening			Closing		
Open/Close time (25-XV-92861B)	3	-	6	Opening			Closing		

TABLE 6.21 3RD STAGE GAS COMPRESSOR

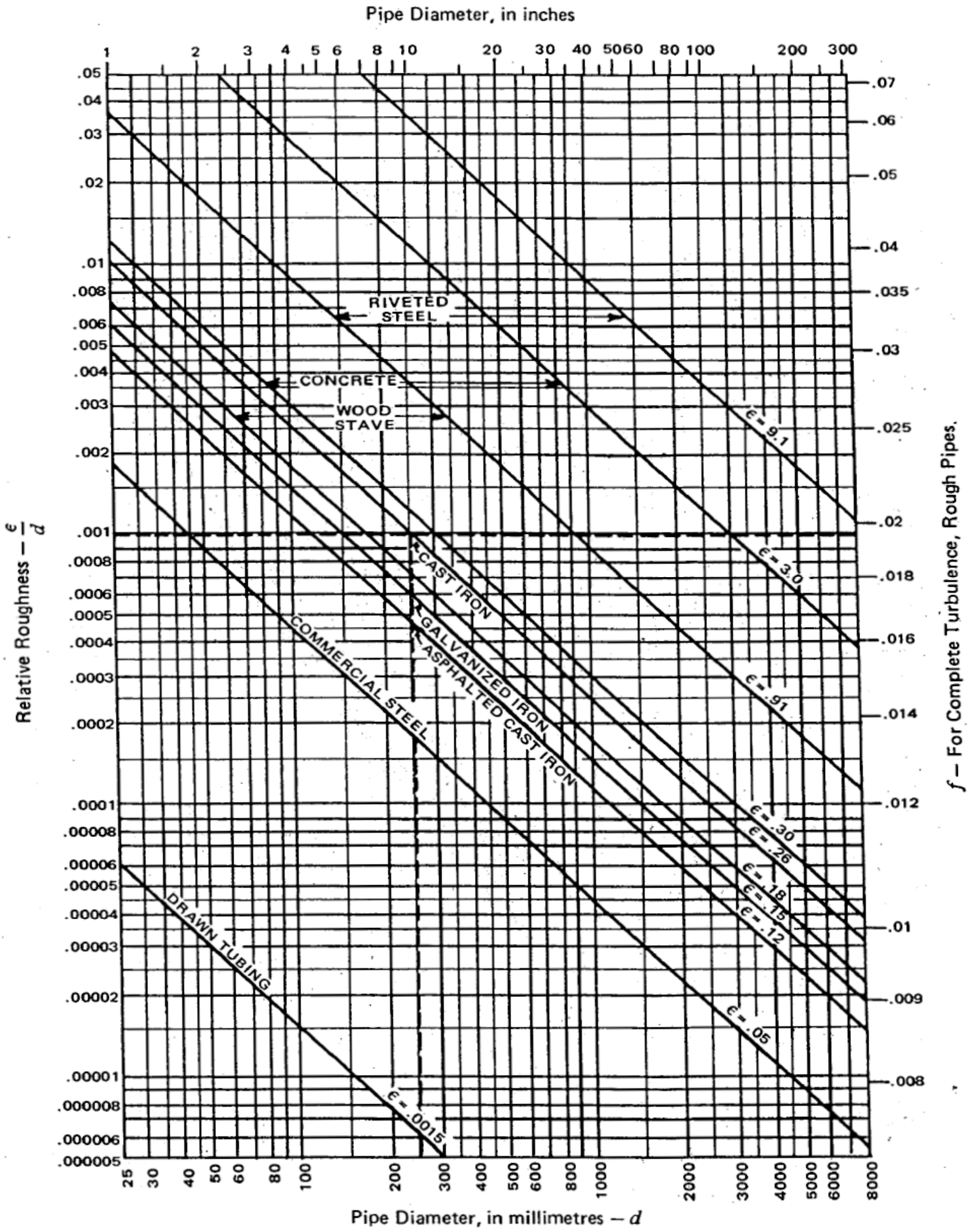
4th Stage Gas Compressor (27-KA-9104)									
Date and time	-	-	-						
	Norm	Alarm	Max	1	2	3	4	5	6
Flowrate (27-FI-92933) $[10^3\ m^3/h]$	30,5	-	42,3						
Molar weig. (27-AI-93022) [kg/kmol]	18,39	-	-						
Inlet pressure (27-PI-92932) [Barg]	47,5	55	58,2						
Outlet pressure (27-PI-92940) [Barg]	105	130	135						
Inlet temperature (27-TI-92933) [°C]	16,1	25	-						
Outlet temp. (27-TI-92938) [°C]	100	120	125						
Power engine [MW]	6,3	-	11,0						
Speed engine (27-NI-96444) [rpm]	1784	-	1802		-	-	-	-	-
Recycle position (27-ZT-92943) [%]	20	-	100						
FIC tuning param. (27-FIC-92943)	-	-	-	Gain		Integr.		Derv.	
Vib. DE (27-YI-96405-01) [µm]	30	57	72						
Vib. DE (27-YI-96405-02) [µm]	30	57	72						
Vib. NDE (27-YI-96406-01) [µm]	30	57	72						
Vib. NDE (27-YI-96406-02) [µm]	30	57	72						
Vib. NDE (27-ZI-96407) [µm]	+0,2	+0,5	+0,75						
Temp. DE (27-TI-96401-01) [°C]	50	60	65						
Temp. DE (27-TI-96401-03) [°C]	50	60	65						
Temp. NDE (27-TI-96402-01) [°C]	50	60	65						
Temp. NDE (27-TI-96402-03) [°C]	50	60	65						
Temp. NDE (27-TI-96403-01) [°C]	50	70	85						
Temp. NDE (27-TI-96404-01) [°C]	50	70	85						
Open/Close time (27-ESDV-92876A)	7	-	28	Opening			Closing		
Open/Close time (27-ESDV-92876B)	3	-	6	Opening			Closing		
Open/Close time (27-ESDV-93019A)	6	-	24	Opening			Closing		
Open/Close time (27-ESDV-93019B)	3	-	6	Opening			Closing		

TABLE 6.22 4TH STAGE GAS COMPRESSOR

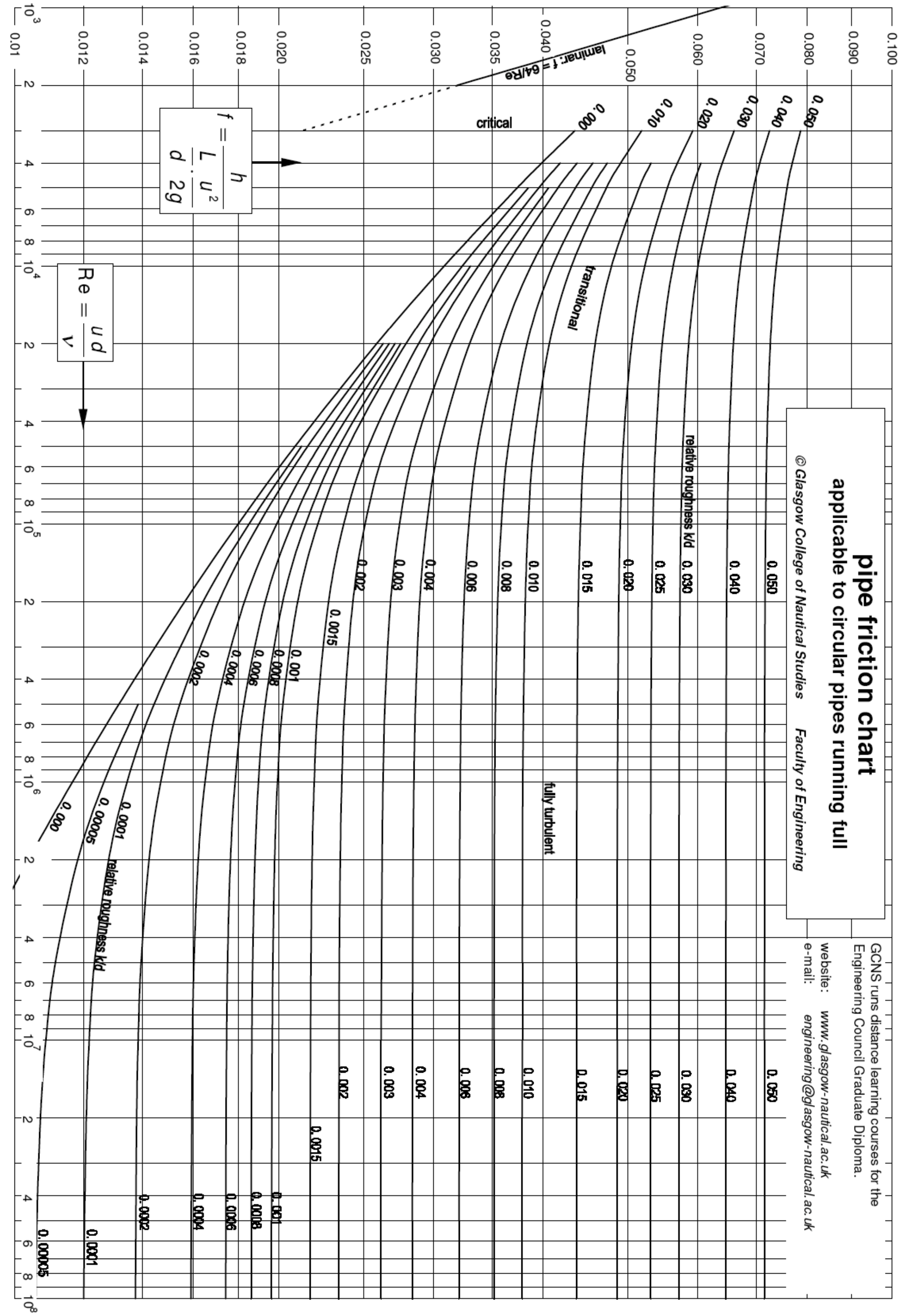
Appendices:

Relative Roughness of Pipe Materials and Friction Factors

For Complete Turbulence



Appendix A. Relative roughness and friction factors



Appendix B. Moody diagram

Appendix C:
This is an example of how to calculate pressure loss in a pipe. In this example it is made references to appendix A and B. For units related to the following calculations, please check *Units* at page 7.

According to the data sheet from the flow valve, the following data is stated:

- The valve has got 10” inlet/outlet size with 8” nominal port size.
- The port area of the valve is A_p=0,03243 m^2.
- The valve has got a C_v= 924 at 100% opening.
- The valve has an equal percentage characteristic.

According to the pump data:

- The pump head is tested to be, H=105 lmc, with a flow of 1000 m^3/h.
- The minimum submerged length of the pump is 10 m.
- The vertical length from the seawater level to the cellar deck is 35 m.
- The vertical length from the cellar deck to the flow valve is 0,8 m.

The piping characteristic of the seawater flow, going trough the flow valve, starts going through the inlet strainer upstream of the pump. On the discharge side of the pump, seawater is flowing horizontally for 4 m, then turns 90^o vertically in a tee and takes the last turn upstream the flow valve through a 90^o bend.
Downstream the flow valve, the pipe is going vertically upwards for 10 m before turning around and gets dumped to the seawater caisson, which contains atmospheric pressure.

$$\text{Density of seawater} = 1027 kg/m^3$$

$$\text{Kinematic viscosity seawater at } 5^oC = 1{,}519\cdot 10^{-6} m^2\cdot s^{-1}$$

Maximum differential pressure over the pump at 1000m^3/h:

$$H_1 = 105 lmc = 105 m\cdot 1027 kg/m^3\cdot 9{,}81 m/s^2 = \underline{1057861 Pa}$$

The maximum static pressure up streams the flow valve:

$$H_2 = 35m + 0{,}8m = 35{,}8m \Rightarrow 35{,}8\cdot 1027 kg/m^3\cdot 9{,}81 = \underline{360680 Pa}$$

Pressure loss in pipe, assuming flow of 1000 m^3/h:

$$\Delta p = f\cdot\frac{l}{d}\cdot\frac{v^2\cdot\rho}{2}$$

(Bird, 2007)

$$\text{Re} = \frac{v\cdot d}{\nu},\ \text{Re} \geq 2600\ \text{(Turbulence)},\ \text{Re} \leq 2599\ \text{(Laminar)}$$

(Bird, 2007)

$$Laminar: f = \frac{64}{\text{Re}} = \frac{64\cdot\nu}{v\cdot d}$$

$$Turbulence: f = Moodydiagram$$

$\Delta p_1(strainer):$

$$d_1 = 24'' = 0{,}6096m \Rightarrow v_1 = \frac{Q}{A_1} = \frac{\frac{1000m^3/h}{3600s}}{\frac{\pi\cdot(0{,}6096m)^2}{4}} = \frac{0{,}278m^3/s}{0{,}2919m^2} = 0{,}952m/s$$

(McCabe, 1993)

$$\mathrm{Re} = \frac{0{,}952m/s\cdot 0{,}6096m}{1{,}519\cdot 10^{-6}m^2/s^{-1}} = 388053 \Rightarrow Turbulence$$

$$\text{Relative roughness} = \frac{\varepsilon}{d} = \frac{0{,}05}{609{,}6mm} = 8{,}2\cdot 10^{-5}$$

$$\text{Moody diagram} \Rightarrow f_1 = 0{,}022$$

Equivalent length of the strainer is found from Nergaard, 2009, and is given as:

$$\frac{l}{d} = 170 \Rightarrow l_1 = 0{,}6096m\cdot 170 = 103{,}6m$$

$$\Delta p_1 = f_1\cdot\frac{l_1}{d_1}\cdot\frac{v_1^2\cdot\rho}{2} = 0{,}022\cdot\frac{103{,}6m}{0{,}6096}\cdot\frac{(0{,}952m/s)^2\cdot 1027kg/m^3}{2} = \underline{1740Pa}$$

$\Delta p_2(18''pipe):$

$$d_2 = 18'' = 0{,}4572m \Rightarrow v_2 = \frac{Q}{A_2} = \frac{0{,}278m^3/s}{\frac{\pi\cdot(0{,}4572m)^2}{4}} = 1{,}693m/s$$

$$\mathrm{Re} = \frac{v_2\cdot d_2}{\nu} = \frac{1{,}693m/s\cdot 0{,}4572m}{1{,}519\cdot 10^{-6}m^2/s^{-1}} = 509571 \Rightarrow Turbulence$$

$$\text{Relative roughness} = \frac{\varepsilon}{d} = \frac{0{,}05}{457{,}2mm} = 1{,}09\cdot 10^{-4}$$

$$\text{Moody diagram} \Rightarrow f_2 = 0{,}0215$$

$$l_2 = 4m$$

$$\Delta p_2 = f_2\cdot\frac{l_2}{d_2}\cdot\frac{v_2^2\cdot\rho}{2} = 0{,}0215\cdot\frac{4m}{0{,}4572m}\cdot\frac{(1{,}693m/s)^2\cdot 1027kg/m^3}{2} = \underline{177Pa}$$

$\Delta p_3(12''Tee + 90^o bend):$

$$d_3 = 12'' = 0{,}3048m \Rightarrow v_3 = \frac{Q}{A_3} = \frac{0{,}278m^3/s}{\frac{\pi\cdot(0{,}3048m)^2}{4}} = 3{,}81m/s$$

$$\mathrm{Re} = \frac{3{,}81m/s\cdot 0{,}3048m}{1{,}519\cdot 10^{-6}m^2/s^{-1}} = 764508 \Rightarrow Turbulence$$

$$\text{Relative roughness} = \frac{\varepsilon}{d} = \frac{0{,}05}{304{,}8mm} = 1{,}64\cdot 10^{-4}$$

$$\text{Moody diagram} \Rightarrow f_3 = 0{,}0198$$

The equivalent length of the tee is found in Crane Co, 1979, and is given as:
$l_3 \Rightarrow 12"$ gives a length of: $11{,}2m$

The equivalent length of the bend is found in Crane Co, 1979, and is given as:
$l_4 \Rightarrow 12"$ gives a length of: $5{,}1m$

$$\Delta p_3 = f_3 \cdot \frac{(l_3 + l_4)}{d_3} \cdot \frac{v_3^2 \cdot \rho}{2} = 0{,}0198 \cdot \frac{(11{,}2 + 5{,}1)m}{0{,}3048m} \cdot \frac{(3{,}81m/s)^2 \cdot 1027kg/m^3}{2} = \underline{7893Pa}$$

$$H_3 = \Delta p_{tot} = 1740Pa + 177Pa + 7893Pa = \underline{9810Pa}$$

The inlet pressure of the flow valve (pressure upstream) will therefore be:
$p_i = H_1 - H_2 - H_3 = 1057861Pa - 360680Pa - 9810Pa = \underline{687371Pa}$

The outlet pressure of the valve (pressure downstream) will be affected by a 9 m water column, as will function as a backpressure. The seawater is later being dumped into an atmospherically seawater caisson.
The outlet pressure of the valve is assumed to be:
$p_o = \rho \cdot g \cdot h = 1027kg/m^3 \cdot 9{,}81m/s^2 \cdot 9m = \underline{90673Pa}$

We can now calculate the maximum flow through the flow valve:

$$Q = C_V \cdot A \cdot \sqrt{\frac{\Delta p \cdot 2}{\rho}}$$

(Fisher, 2005)

$$Q = 924 \cdot 0{,}03243m^2 \cdot \sqrt{\frac{(687371 - 90673)Pa \cdot 2}{1027kg/m^3}} = \underline{\underline{1022m^3/h}}$$

The result we get is a slight lower than expected, but still means that we can use the minimum flow-valve to verify the first points of the left hand side of the characteristics of the pump.

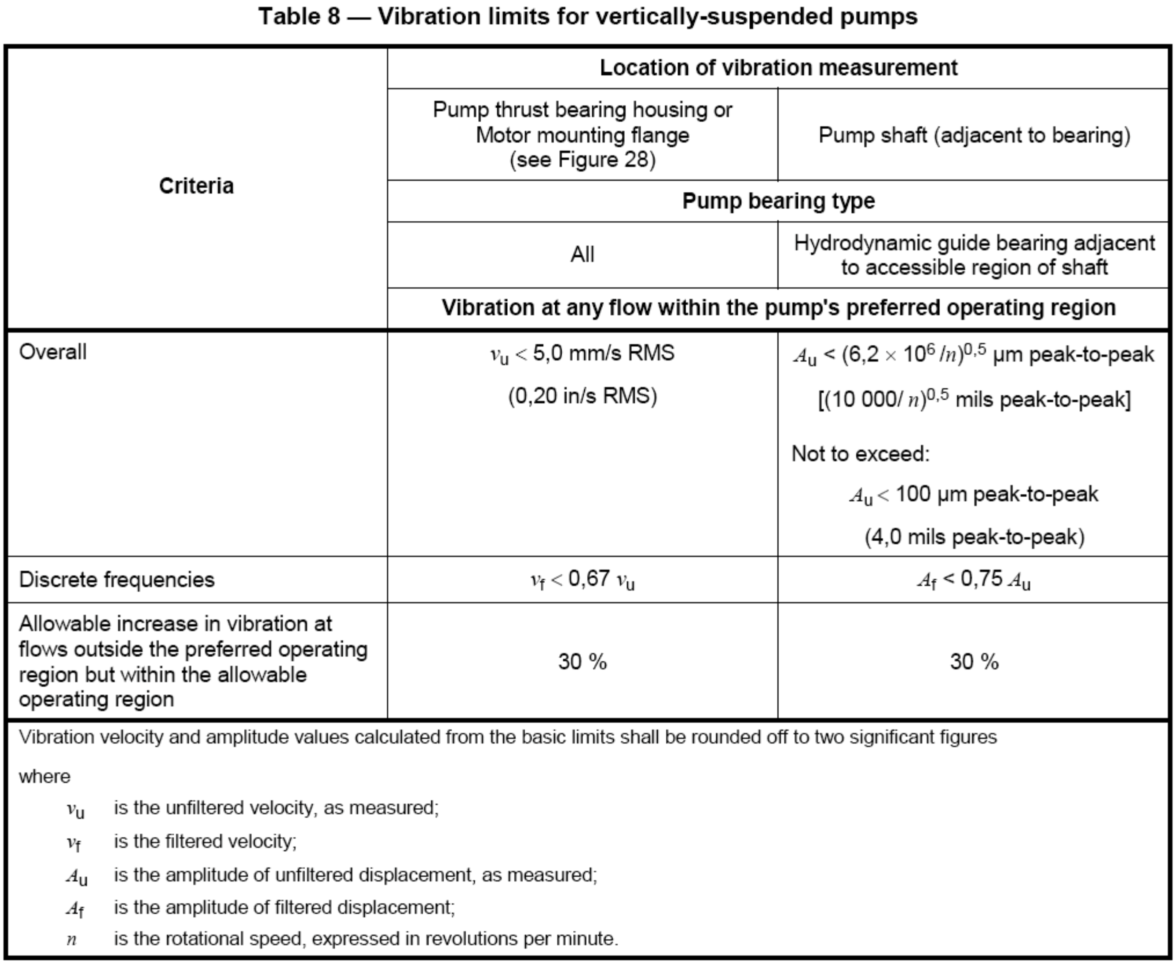


Table 8 — Vibration limits for vertically-suspended pumps

Criteria	Location of vibration measurement	
	Pump thrust bearing housing or Motor mounting flange (see Figure 28)	Pump shaft (adjacent to bearing)
	Pump bearing type	
	All	Hydrodynamic guide bearing adjacent to accessible region of shaft
	Vibration at any flow within the pump's preferred operating region	
Overall	$v_u < 5,0$ mm/s RMS (0,20 in/s RMS)	$A_u < (6,2 \times 10^6 / n)^{0,5}$ µm peak-to-peak $[(10\ 000/ n)^{0,5}$ mils peak-to-peak] Not to exceed: $A_u < 100$ µm peak-to-peak (4,0 mils peak-to-peak)
Discrete frequencies	$v_f < 0,67\ v_u$	$A_f < 0,75\ A_u$
Allowable increase in vibration at flows outside the preferred operating region but within the allowable operating region	30 %	30 %

Vibration velocity and amplitude values calculated from the basic limits shall be rounded off to two significant figures

where

v_u is the unfiltered velocity, as measured;
v_f is the filtered velocity;
A_u is the amplitude of unfiltered displacement, as measured;
A_f is the amplitude of filtered displacement;
n is the rotational speed, expressed in revolutions per minute.

Appendix D. Vibration limits, vertically-suspended pumps

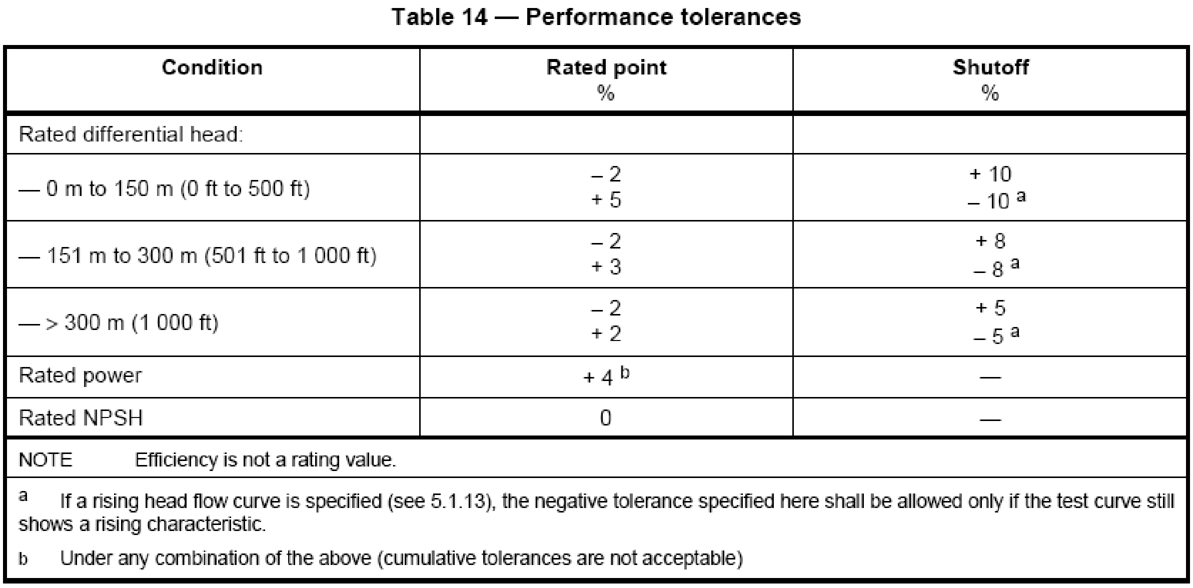


Table 14 — Performance tolerances

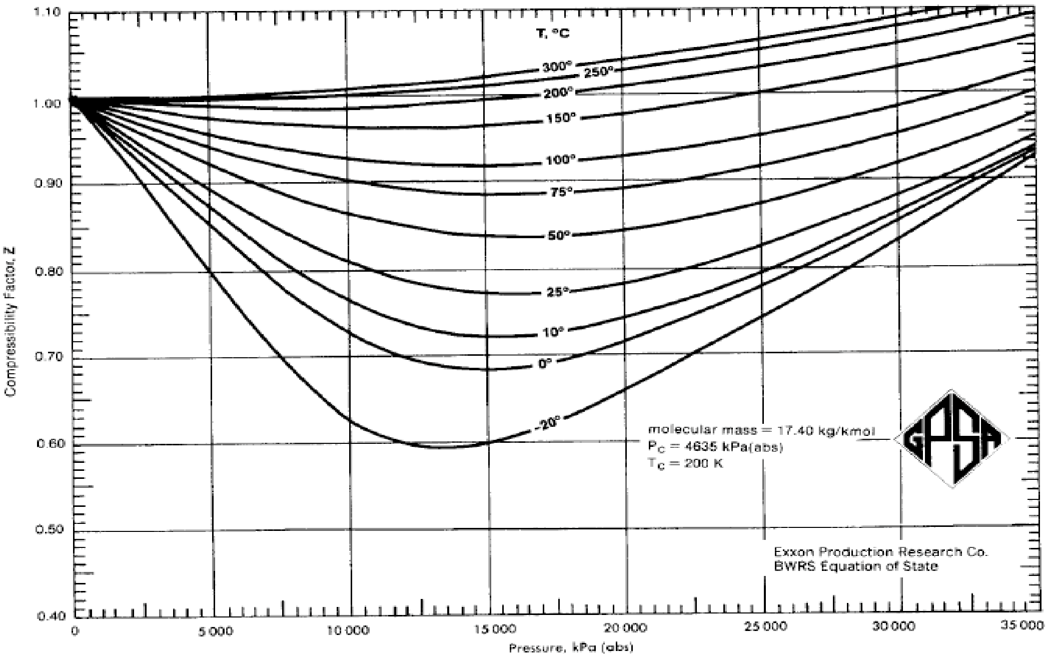
Condition	Rated point %	Shutoff %
Rated differential head:		
— 0 m to 150 m (0 ft to 500 ft)	– 2 + 5	+ 10 – 10 [a]
— 151 m to 300 m (501 ft to 1 000 ft)	– 2 + 3	+ 8 – 8 [a]
— > 300 m (1 000 ft)	– 2 + 2	+ 5 – 5 [a]
Rated power	+ 4 [b]	—
Rated NPSH	0	—

NOTE Efficiency is not a rating value.

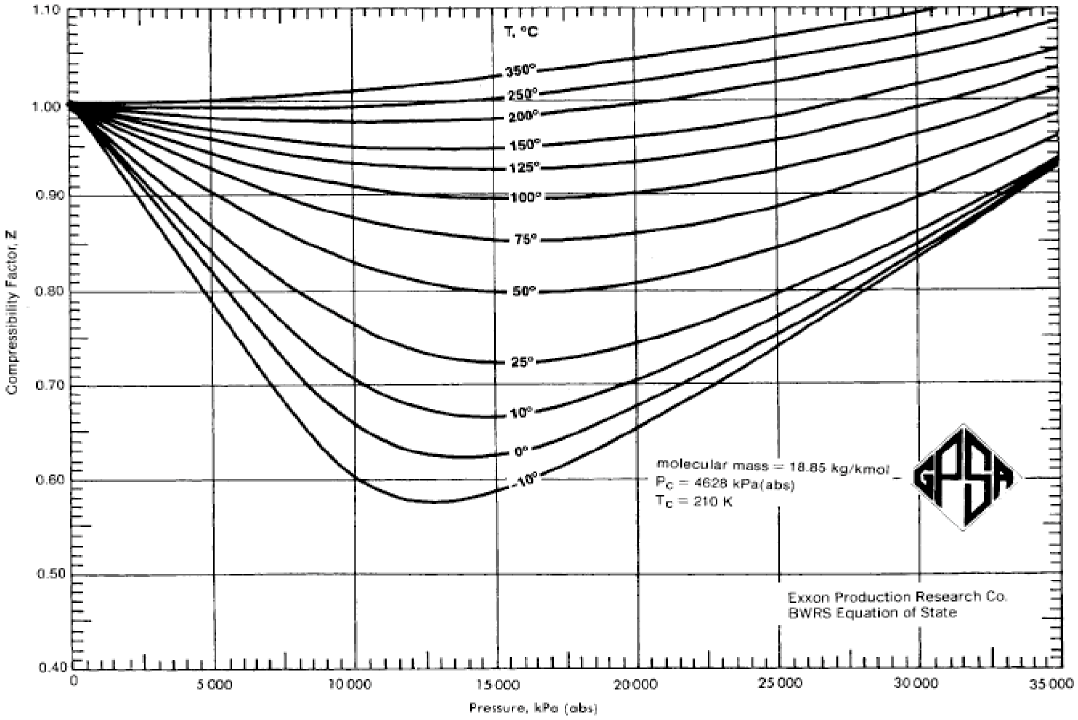
[a] If a rising head flow curve is specified (see 5.1.13), the negative tolerance specified here shall be allowed only if the test curve still shows a rising characteristic.

[b] Under any combination of the above (cumulative tolerances are not acceptable)

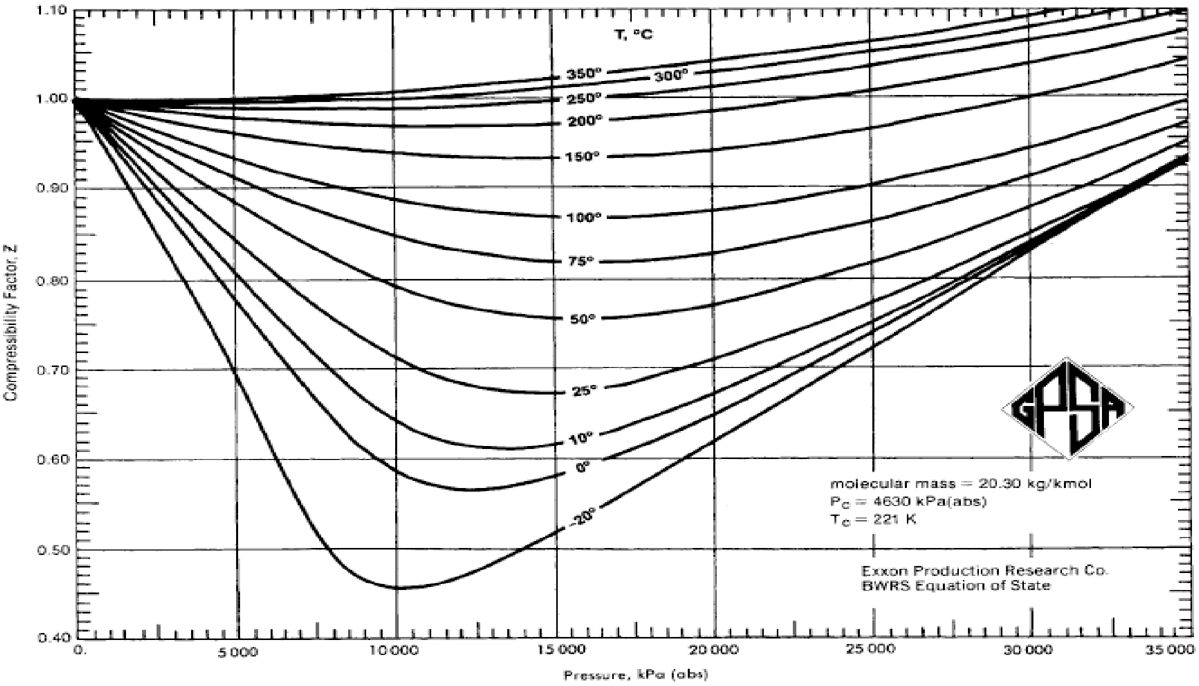
Appendix E. Performance tolerances, centrifugal pumps



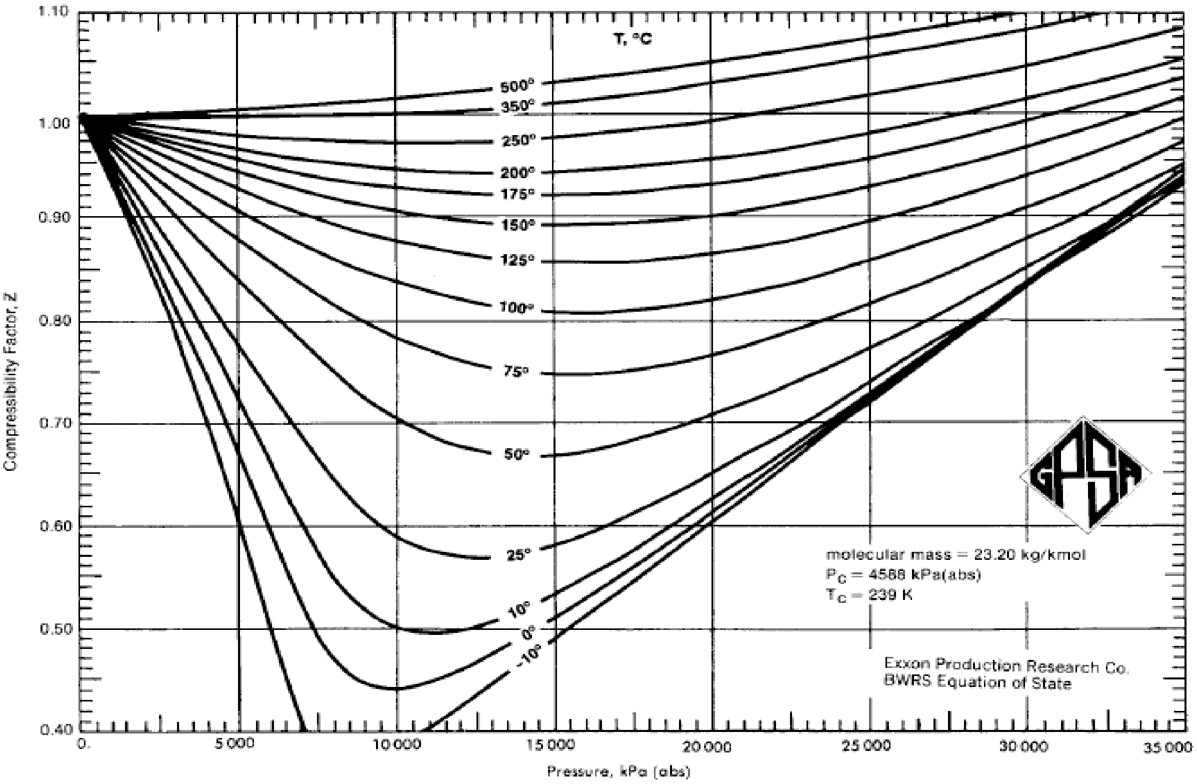
Appendix F. Compressibility factors, natural gases (17,40 kg/kmol)



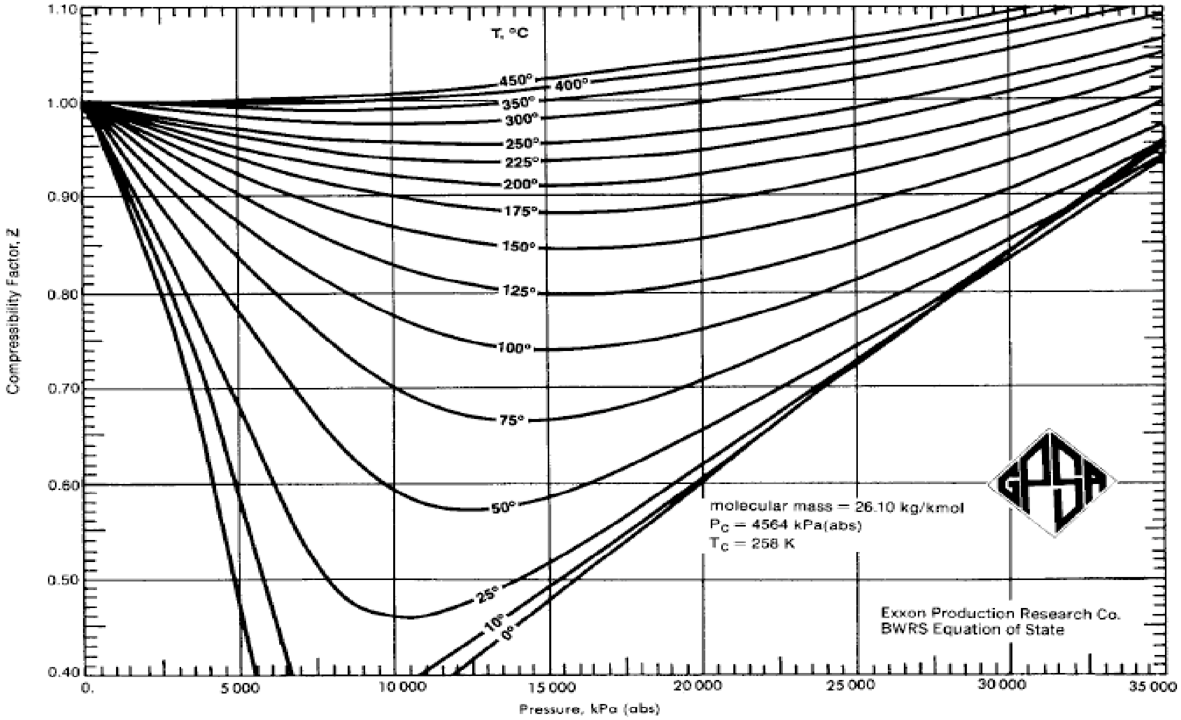
Appendix G. Compressibility factors, natural gases (18,85 kg/kmol)



Appendix H. Compressibility factors, natural gases (20,30 kg/kmol)

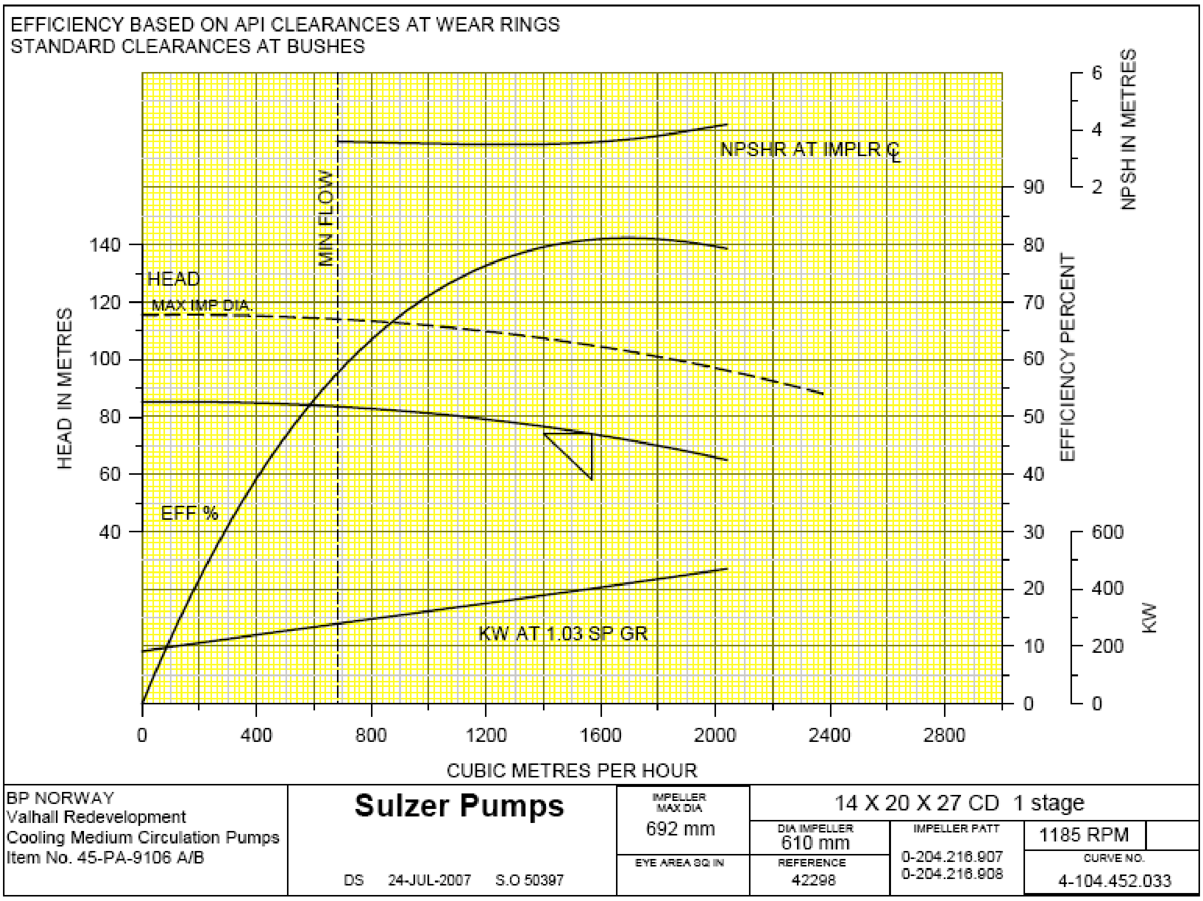


Appendix I. Compressibility factors, natural gases (23,20 kg/kmol)

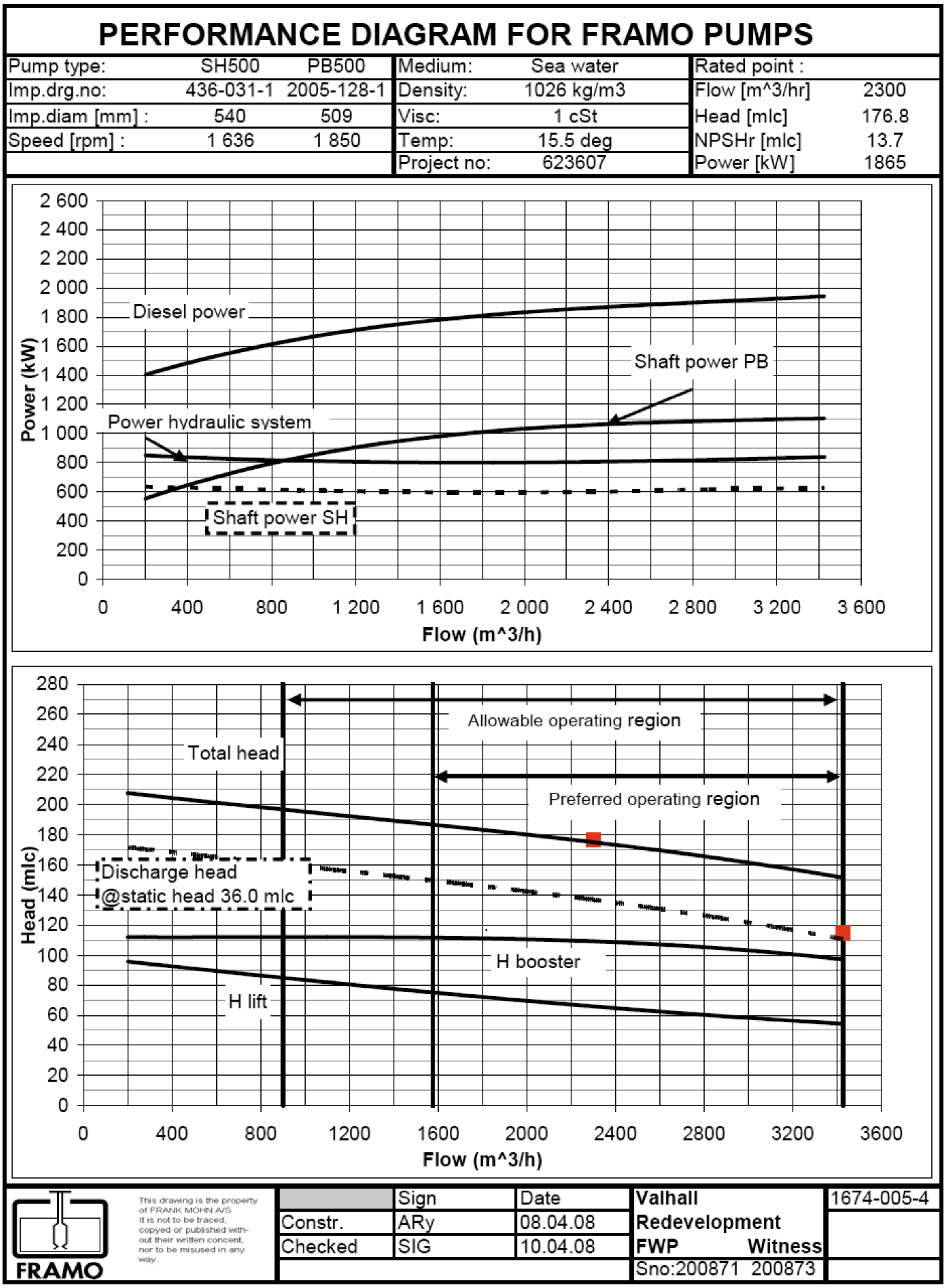


Appendix J. Compressibility factors, natural gases (26,10 kg/kmol)

Appendix K, Cooling Medium Pumps:



Appendix L, Firewater Pumps:



PERFORMANCE DIAGRAM FOR FRAMO PUMPS

Pump type:	SH500	PB500	Medium:	Sea water	Rated point :	
Imp.drg.no:	436-031-1	2005-128-1	Density:	1026 kg/m3	Flow [m^3/hr]	2300
Imp.diam [mm] :	540	509	Visc:	1 cSt	Head [mlc]	176.8
Speed [rpm] :	1 636	1 850	Temp:	15.5 deg	NPSHr [mlc]	13.7
			Project no:	623607	Power [kW]	1865

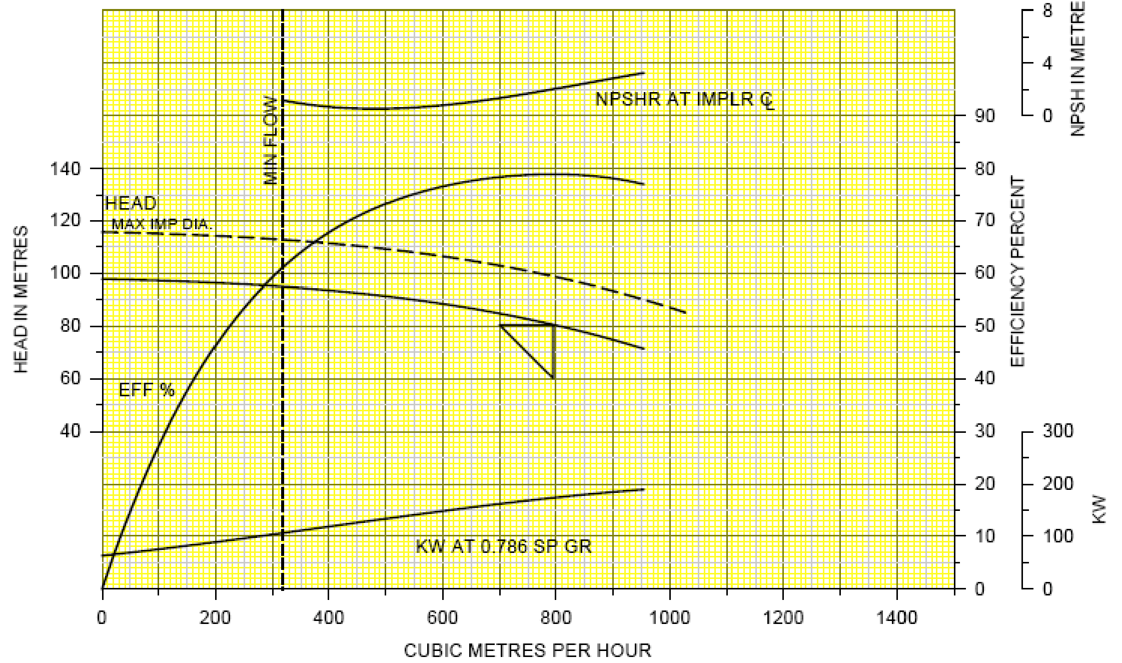
FRAMO

This drawing is the property of FRANK MOHN A/S It is not to be traced, copied or published without their written concent, nor to be misused in any way.

	Sign	Date	**Valhall Redevelopment**	1674-005-4
Constr.	ARy	08.04.08		
Checked	SIG	10.04.08	**FWP Witness**	
			Sno:200871 200873	

Appendix M, Oil Booster Pumps:

EFFICIENCY BASED ON API CLEARANCES AT WEAR RINGS
STANDARD CLEARANCES AT BUSHES



BP VALHALL
Oil Booster Pumps
Item No. 11-PA-9101 A/B

Sulzer Pumps

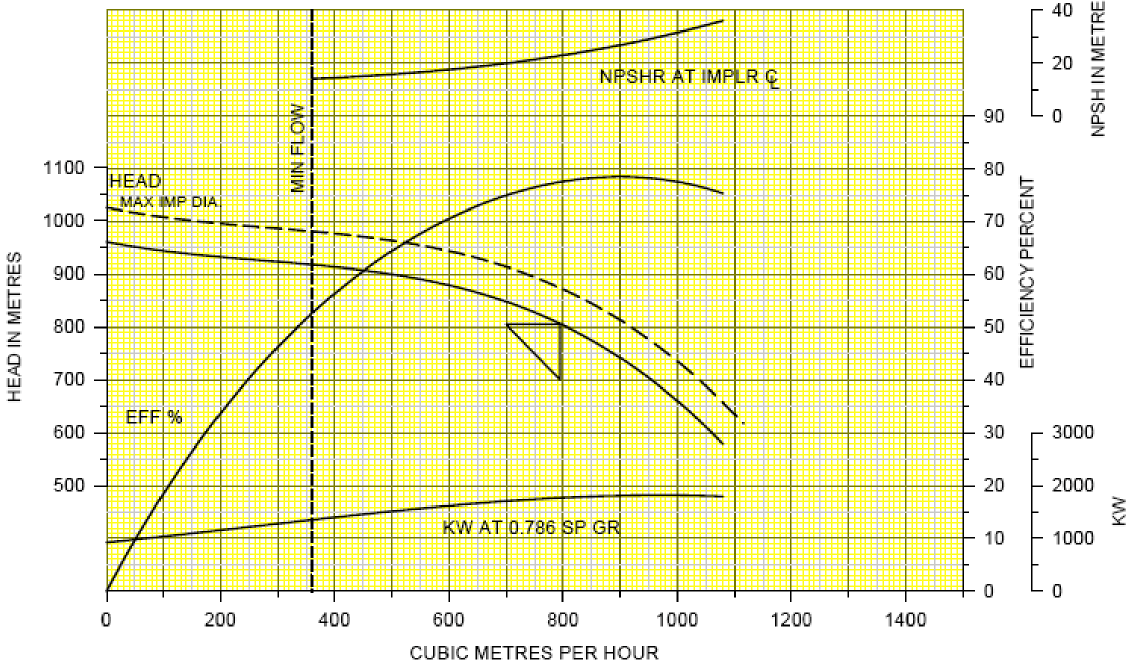
DS 20-FEB-2007 LDS 07_1556A

IMPELLER MAX DIA 686 mm
EYE AREA SQ IN
10 X 12 X 27A CD
DIA IMPELLER 640 mm
REFERENCE T-4B340
IMPELLER PATT 1013CD-12
1175 RPM
CURVE NO. 4-104.451.601

Appendix N, Oil Export Pumps:

EFFICIENCY BASED ON API CLEARANCES AT WEAR RINGS
STANDARD CLEARANCES AT BUSHES

REPLACES 4-104.451.831



BP VALHALL
Crude Oil Export Pumps
Item No. 11-PA-9102 B

Sulzer Pumps

DS 17-AUG-2007 S.O 50493

IMPELLER MAX DIA 355 mm
EYE AREA SQ IN
HPcp 300-355 4 stage
DIA IMPELLER 345 mm
REFERENCE
IMPELLER PATT
3560 RPM
CURVE NO. 4-104.452.081

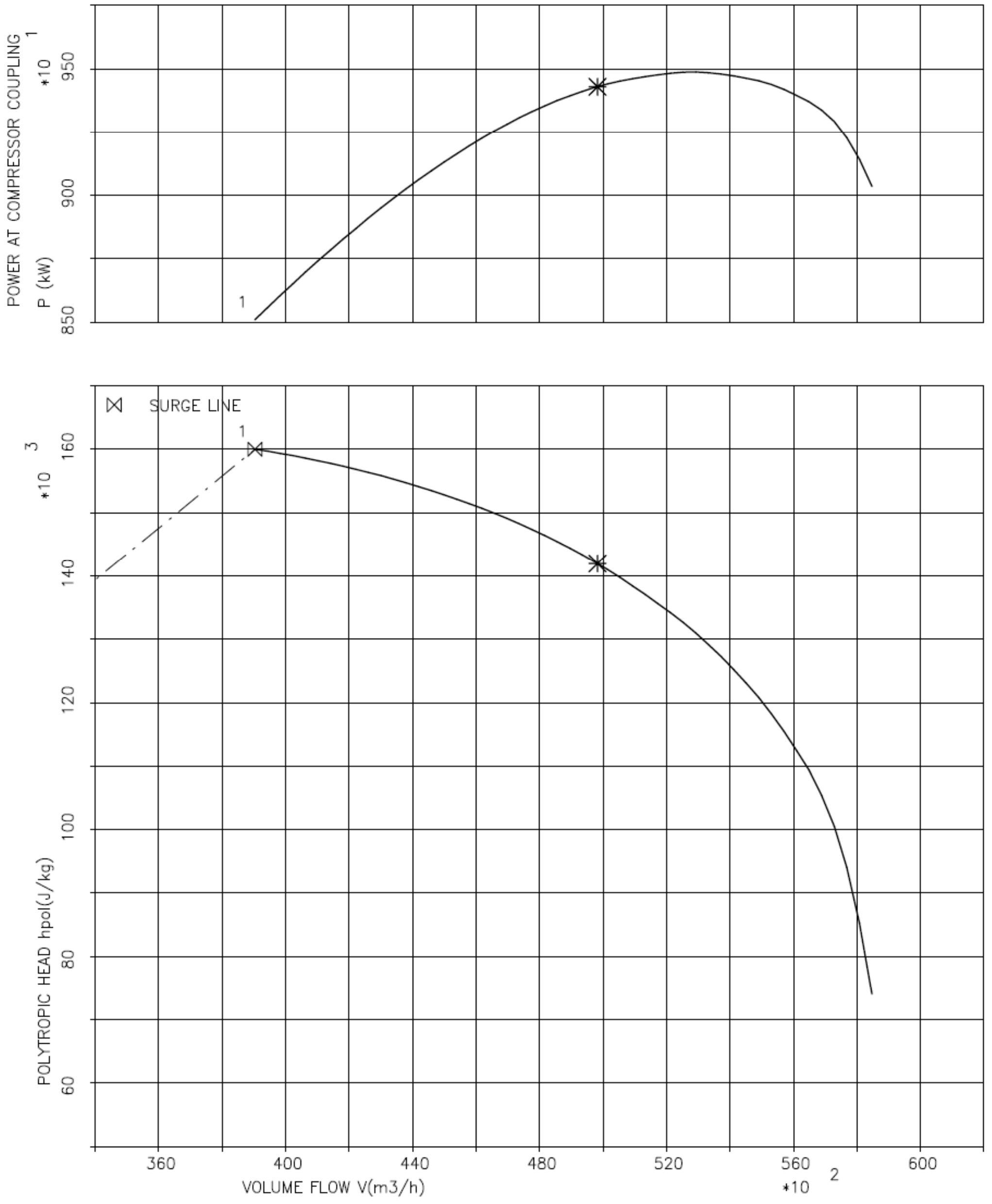
Appendix O, 1st Stage Gas Compressor:

The copyright of these drawings and of all annexes which are entrusted to a person's care always remain the property of our firm. They must not be copied or duplicated nor shown to or placed at the disposal of third persons without our written consent.

BP Valhall VRD RB71-5

REFERENCE No	CURVE (1/min)	1
		6273

CURVE	p1 (bara)	T1 (°C)	R.H.	MW	TW1	N/No	ANGLE (°)
1	4.370	40.0		22.572		1.00	



MAN TURBO

Dept. SC-6	Name A.Louie	Date 16-OCT-07	Page 1 of
RB71-5 Stage 1		MAN No H7800005.78	Client No
Title Predicted Performance Curves			Document No 4-837048811 | Rev 2

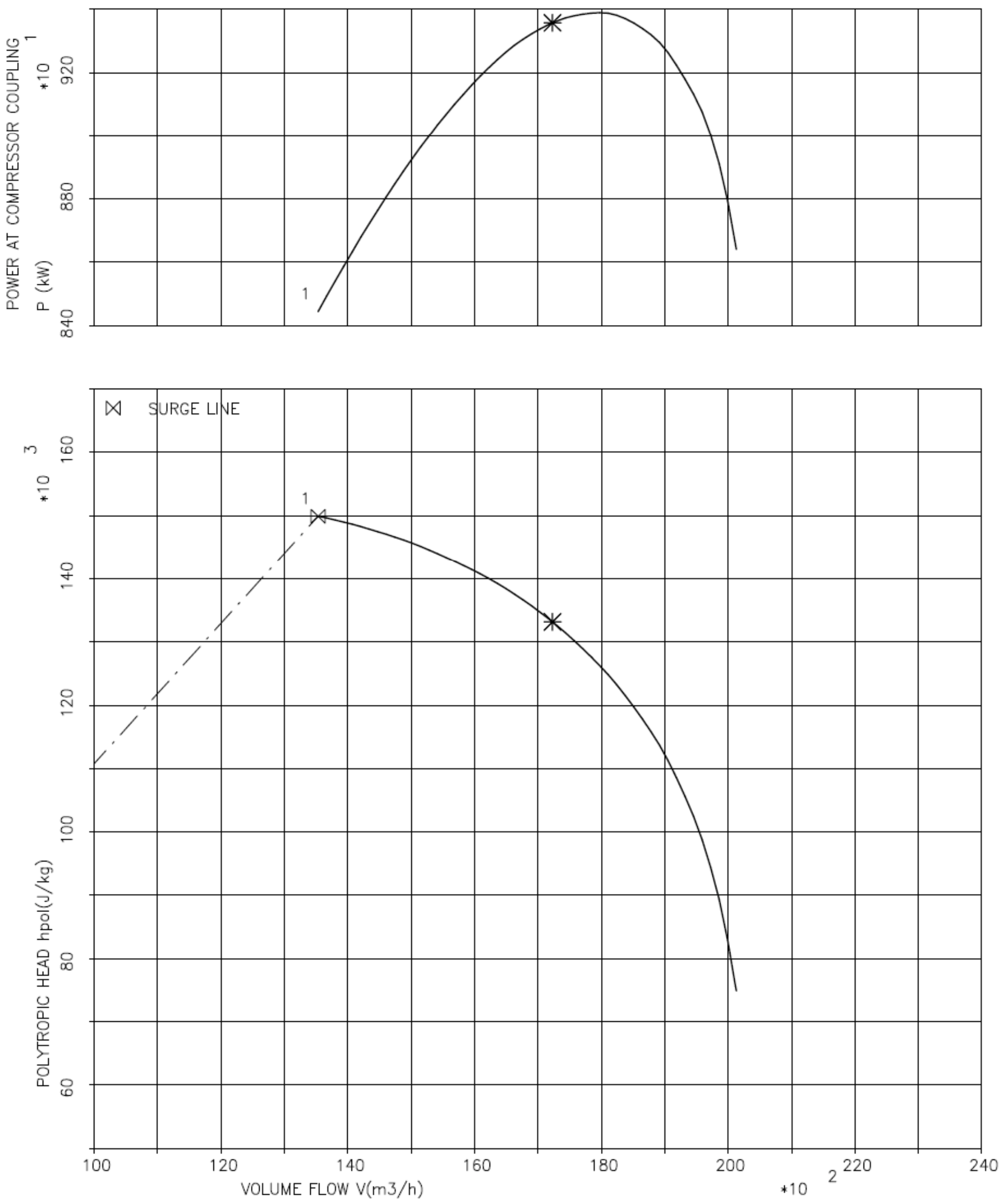
Classification
☐ MAN only ☐ Project
☒ Client ☒ Contract
☐ free Distribution

Appendix P, 2nd Stage Gas Compressor:

BP Valhall VRD RB45-5

REFERENCE CURVE No	(1/min)
1	9562

CURVE	p1 (bara)	T1 (°C)	R.H.	MW	TW1	N/No	ANGLE (°)
1	11.88	24.0		22.839		1.00	



The copyright of these drawings and of all annexes which are entrusted to a person's care always remain the property of our firm. They must not be copied or duplicated nor shown to or placed at the disposal of third persons without our written consent.

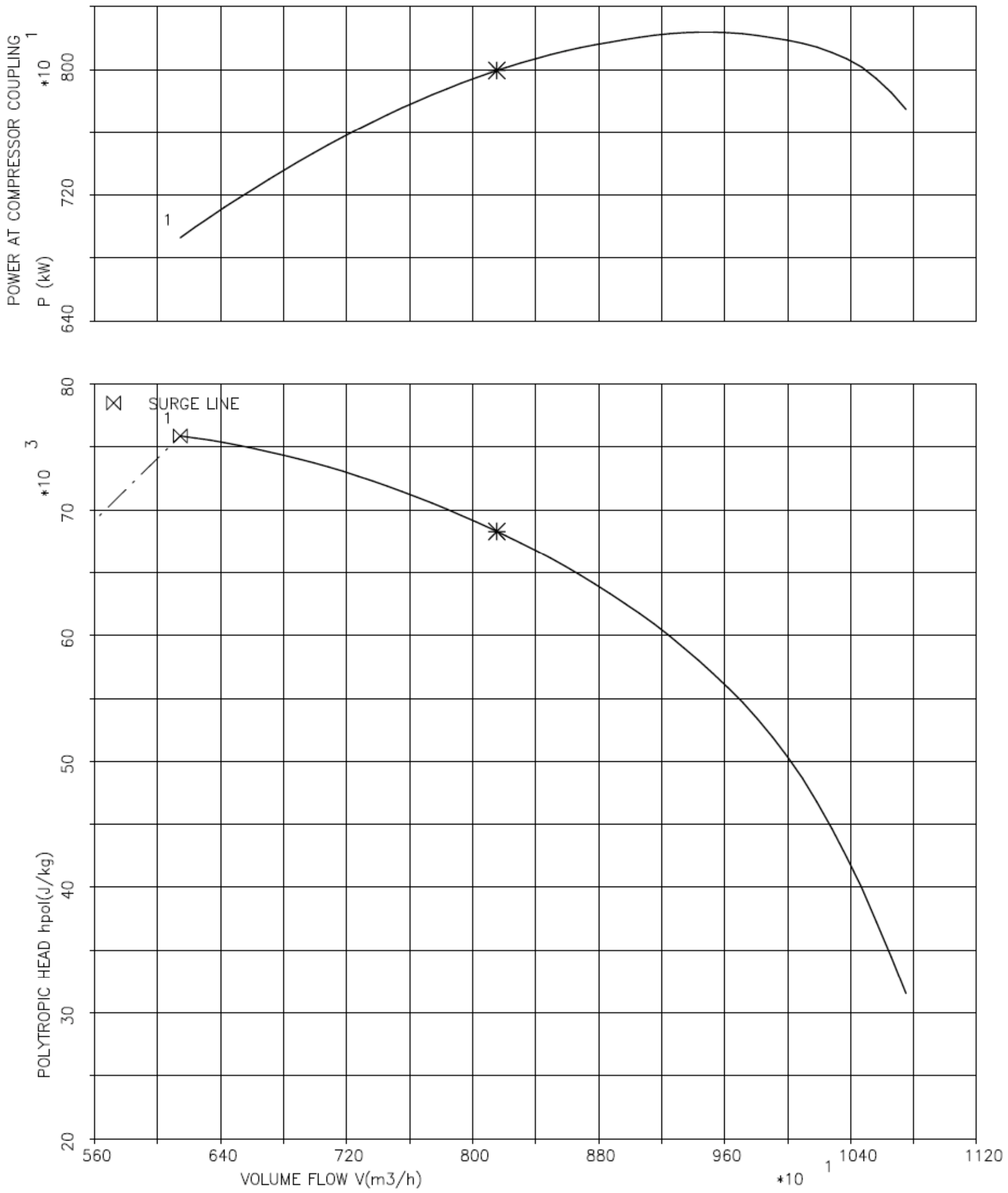
MAN TURBO	Dept. SC-6	Name A.Louie	Date 16-OCT-07	Page 3 of
Classification ☐ MAN only ☐ Project ☒ Client ☒ Contract ☐ free Distribution	RB45-5 Stage 2		MAN No H7800005.78	Client No
	Title Predicted Performance Curves			Document No 4-837048811
				Rev 2

Appendix Q, 3rd Stage Gas Compressor:

BP Valhall VRD RB45−3

REFERENCE No	CURVE (1/min)
1	9562

CURVE	p1 (bara)	T1 (°C)	R.H.	MW	TW1	N/No	ANGLE (°)
1	34.28	18.1		23.857		1.00	



The copyright of these drawings and of all annexes which are entrusted to a person's care always remain the property of our firm. They must not be copied or duplicated nor shown to or placed at the disposal of third persons without our written consent.

MAN TURBO	Dept. SC−6	Name A.Louie	Date 16−OCT−07	Page 5 of	
Classification ☐ MAN only ☐ Project ☒ Client ☒ Contract ☐ free Distribution	RB45−3 Stage 3		MAN No H7800005.78	Client No	
	Title Predicted Performance Curves			Document No 4−837048811	Rev 2

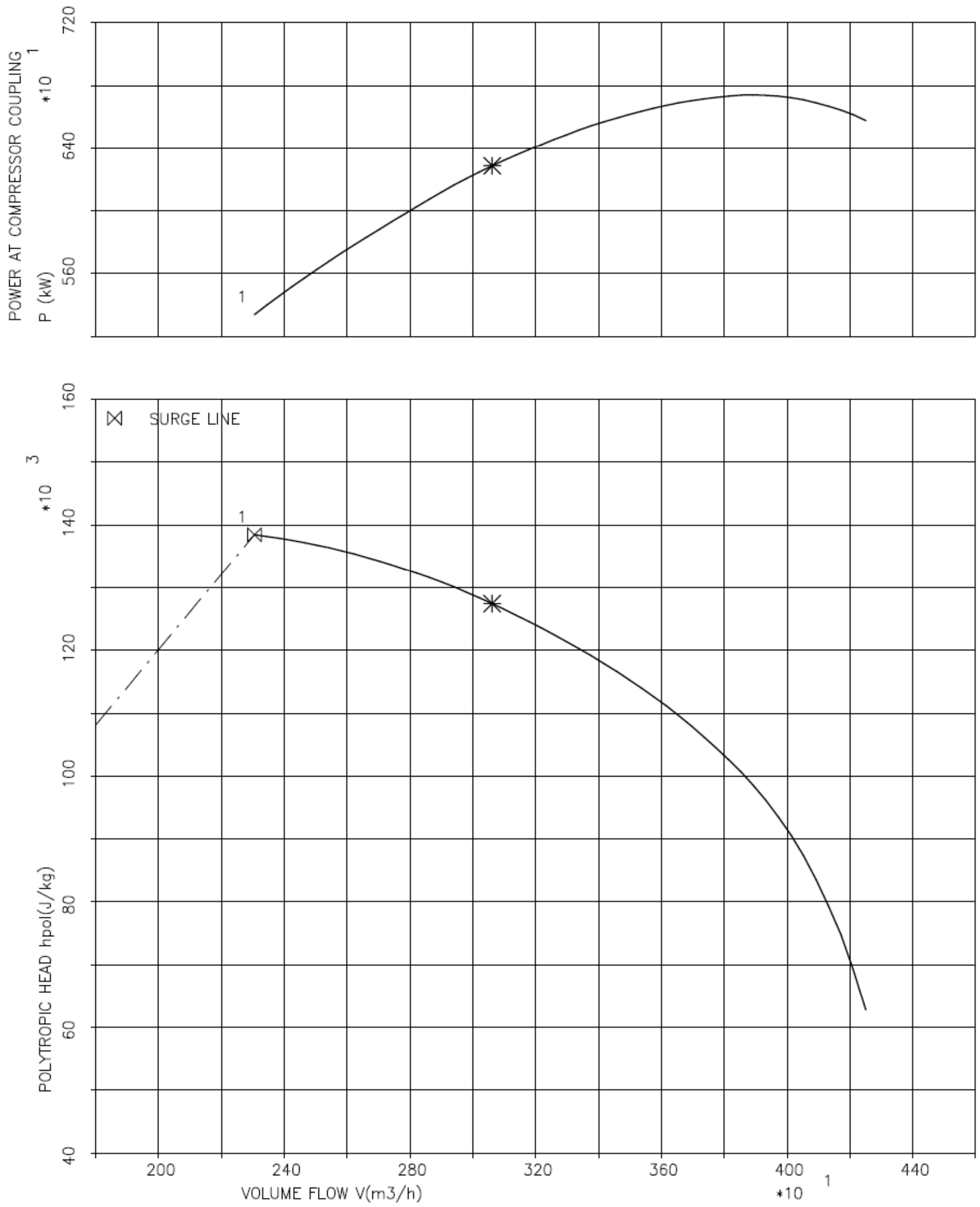
Appendix R, 4th Stage Gas Compressor:

The copyright of these drawings and of all annexes which are entrusted to a person's care always remain the property of our firm. They must not be copied or duplicated nor shown to or placed at the disposal of third persons without our written consent.

BP Valhall VRD RB35–5

REFERENCE CURVE No	(1/min)
1	11934

CURVE	p1 (bara)	T1 (°C)	R.H.	MW	TW1	N/No	ANGLE (°)
1	48.80	16.1		18.390		1.00	



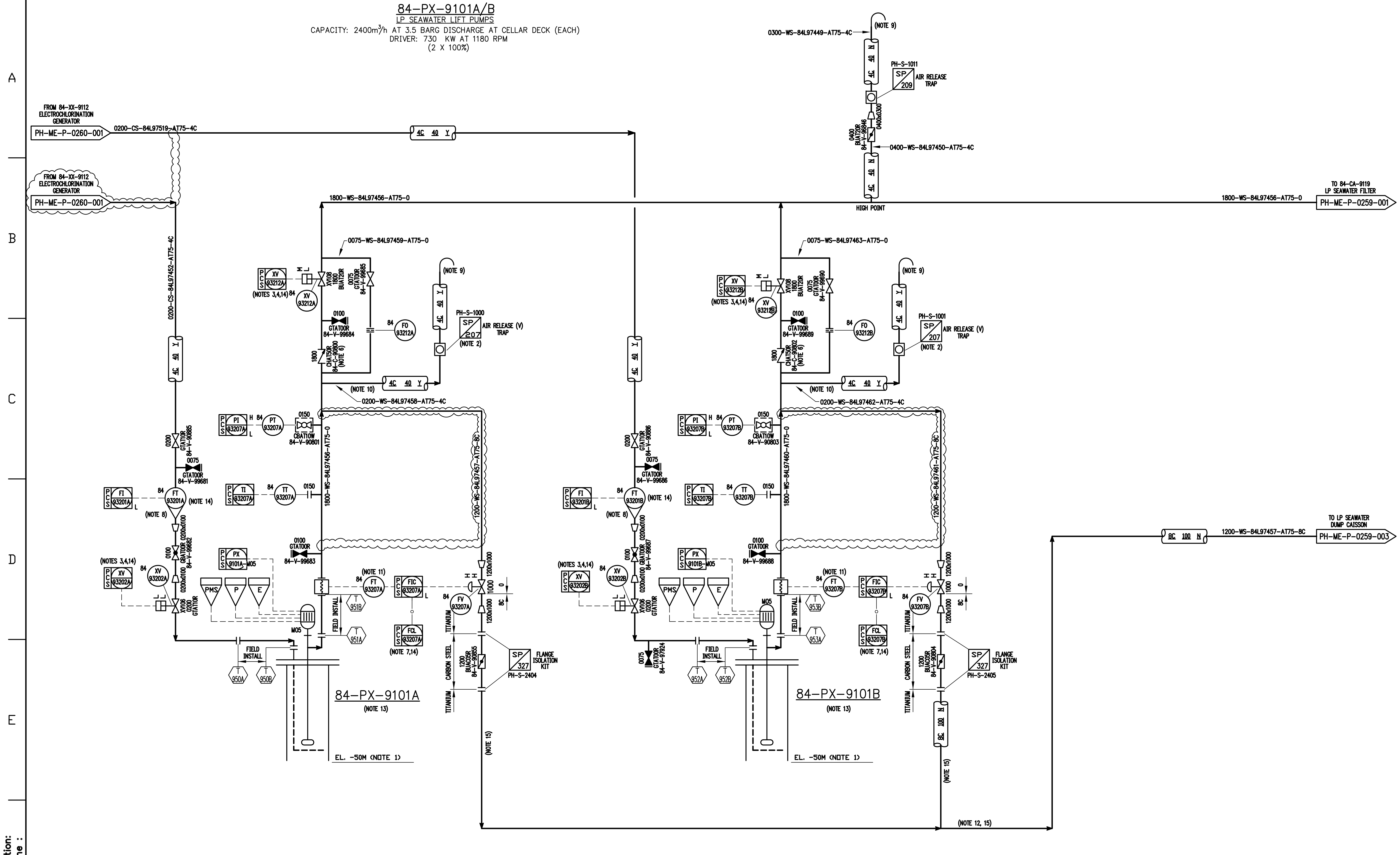
MAN TURBO	Dept. SC–6	Name A.Louie	Date 16–OCT–07	Page 7 of
Classification ☐ MAN only ☐ Project ☒ Client ☒ Contract ☐ free Distribution	RB35–5 Stage 4		MAN No H7800005.78	Client No
	Title Predicted Performance Curves			Document No 4–837048811 Rev 2

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0258-001.DWG 09SEP09 0834 SF 25.40 IMP J1KELLE

84-PX-9101A/B

LP SEAWATER LIFT PUMPS

CAPACITY: 2400m³/h AT 3.5 BARG DISCHARGE AT CELLAR DECK (EACH)
DRIVER: 730 KW AT 1180 RPM
(2 X 100%)


FROM 84-XX-9112
ELECTROCHLORINATION
GENERATOR
PH-ME-P-0260-001
0200-CS-84L97519-AT75-4C
4C 40 Y
FROM 84-XX-9112
ELECTROCHLORINATION
GENERATOR
PH-ME-P-0260-001
0200-CS-84L97452-AT75-4C
1800-WS-84L97456-AT75-0
0075-WS-84L97459-AT75-0
XV 93212A
(NOTES 3,4,14)
XV108 1800 BUAT20R
0075 GTAT00R 84-V-99685
0100 GTAT00R 84-V-99684
1800 CHAT50R 84-C-90800 (NOTE 6)
FO 93212A
(NOTE 9)
PH-S-1000
SP 207
AIR RELEASE (V) TRAP
(NOTE 2)
(NOTE 10)
0200-WS-84L97458-AT75-4C
PI 93207A
PT 93207A
0150 CBAT10W 84-V-90801
1800-WS-84L97456-AT75-0
1200-WS-84L97457-AT75-8C
0200 GTAT10R 84-V-90885
0075 GTAT00R 84-V-99681
FI 93201A
FT 93201A
(NOTE 14)
(NOTE 8)
TI 93207A
TT 93207A
0150
0100 GTAT00R 84-V-99683
0100 GBAT00R 84-V-99682
0200x0100
XV 93202A
XV106 0200 GTAT10R
PX 9101A-M05
PMS
P
E
M05
FT 93207A
(NOTE 11)
FIC 93207A
FCL 93207A
(NOTE 7,14)
FV 93207A
1200x1000
1000
0
8C
FIELD INSTALL
T 951B
T 951A
T 950A
T 950B
TITANIUM
CARBON STEEL
TITANIUM
1200 BUAC05R 84-V-90855
SP 327
FLANGE ISOLATION KIT
PH-S-2404
84-PX-9101A
(NOTE 13)
EL. -50M (NOTE 1)
(NOTE 15)
0300-WS-84L97449-AT75-4C
4C 40 N
PH-S-1011
SP 209
AIR RELEASE TRAP
0400 BUAT20R 84-V-96846
0400x0300
0400-WS-84L97450-AT75-4C
HIGH POINT
TO 84-CA-9119
LP SEAWATER FILTER
PH-ME-P-0259-001
0075-WS-84L97463-AT75-0
XV 93212B
XV108 1800 BUAT20R
0075 GTAT00R 84-V-99690
0100 GTAT00R 84-V-99689
1800 CHAT50R 84-C-90802 (NOTE 6)
FO 93212B
PH-S-1001
SP 207
AIR RELEASE (V) TRAP
0200-WS-84L97462-AT75-4C
PI 93207B
PT 93207B
0150 CBAT10W 84-V-90803
1800-WS-84L97460-AT75-0
1200-WS-84L97461-AT75-8C
0200 GTAT10R 84-V-90886
0075 GTAT00R 84-V-99686
FI 93201B
FT 93201B
TI 93207B
TT 93207B
0100 GTAT00R 84-V-99688
0100 GBAT00R 84-V-99687
XV 93202B
XV106 0200 GTAT10R
0075 GTAT00R 84-V-97924
PX 9101B-M05
FT 93207B
FIC 93207B
FCL 93207B
FV 93207B
T 953B
T 953A
T 952A
T 952B
1200 BUAC05R 84-V-90804
PH-S-2405
84-PX-9101B
8C 100 N
(NOTE 12, 15)
1200-WS-84L97457-AT75-8C
TO LP SEAWATER
DUMP CAISSON
PH-ME-P-0259-003

NOTES:
1. SEAWATER LIFT PUMPS CAISSON TERMINATING AT 50M BELOW L.A.T.
2. AIR RELEASE VALVE / VACUUM BREAKER 2", VENDOR SUPPLY, TO BE MOUNTED VERTICALLY.
3. VALVE TO CLOSE IF CORRESPONDING SEAWATER LIFT PUMPS STOPS.
4. VALVE TO OPEN AUTOMATICALLY AFTER START-UP OF CORRESPONDING SEAWATER LIFT PUMP.
5. DELETED.
6. NON / SLAM CHECK VALVES.
7. INDIVIDUAL TRIP ON CORRESPONDING PUMP IF FLOW LESS THAN FCL. ATER PUMP STARTUP SEQUENCE.
8. FLOW DIRECTION TO BE VERTICAL UP. PROVIDE 10D UPSTREAM AND 5D DOWNSTREAM.
9. ROUTE TO SAFE LOCATION.
10. AIR RELEASE VALVE/VACUUM BREAKER SHALL BE LOCATED AT THE HIGHEST POSSIBLE LOCATION AND AS CLOSE TO THE DISCHARGE BLOCK VALVE AS POSSIBLE.
11. MAGMETER. PROVIDE 5D UPSTREAM AND 2D DOWNSTREAM.
12. PIPE WORK TO RISE TO HIGH POINT MINIMUM 5M ABOVE FV-93207A/B.
13. FOR CONDITION MONITORING INSTRUMENTATION, SEE DWG. PH-ME-P-0107-004/005.
14. REFER TO DOCUMENT VRD-ME-P-0042 FOR OPERATING DETAILS.
15. PIPING DOWNSTREAM OF 84-V-90855/90804 TO BE SCH 40S MINIMUM FOR A MINIMUM DISTANCE OF 10 DIAMETERS.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
5	08SEP09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
4	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
3	03DEC08	CDB	RE-ISSUED FOR CONSTRUCTION	SRK	RK/PS/JL	DR	
2	28APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/PS	SVS	
1	15APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/JB	RB	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SRK	JC/ES/JB	SVS	

WOOD GROUP
Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

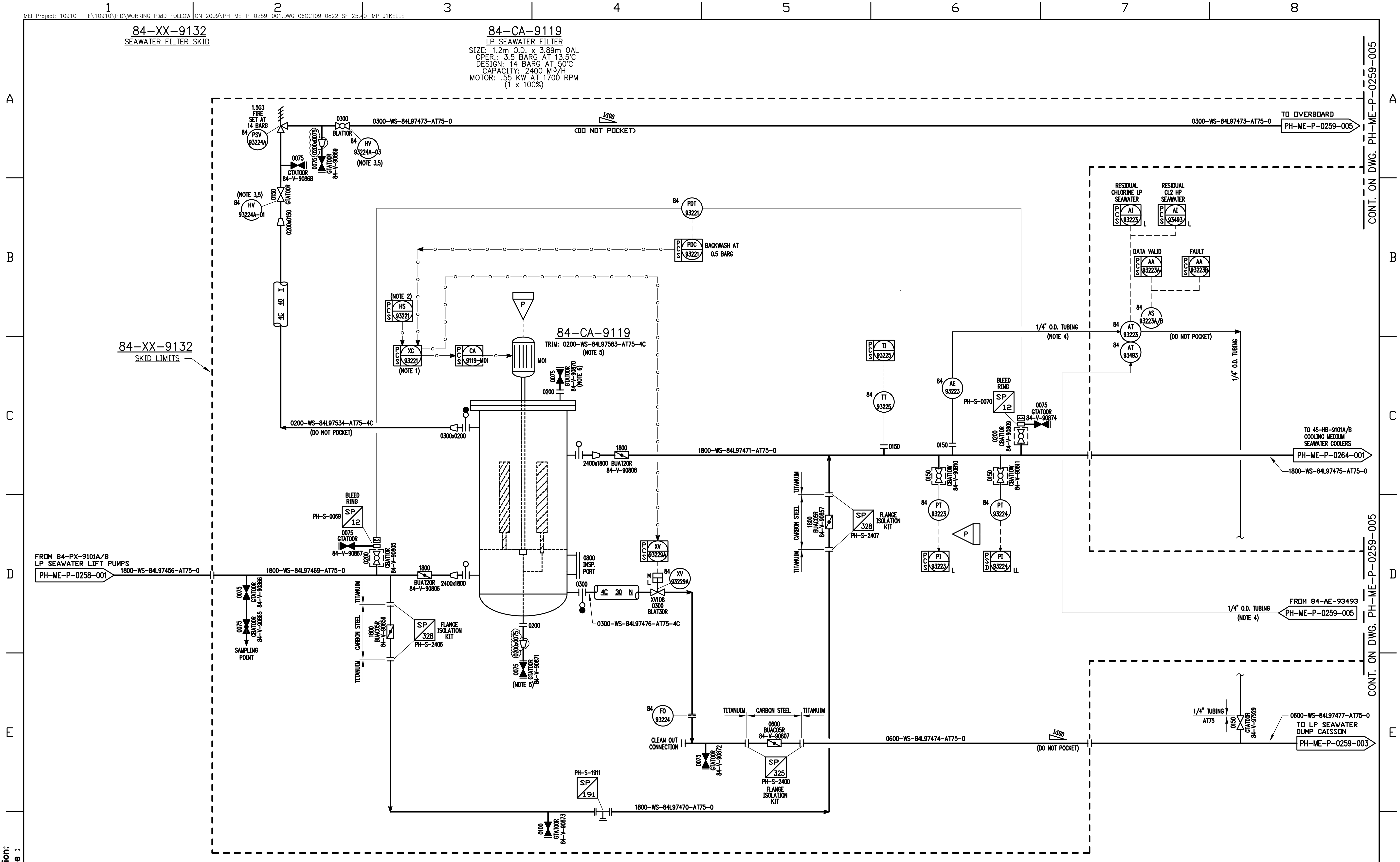
VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
LP SEAWATER LIFT PUMPS

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
U12-02	84	XB	PH	ME	P	0258	001	REV. 5

A1

Field for file specification:
Field for date and time :

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0259-001.DWG 06OCT09 0822 SF 25.40 IMP J1KELLE


1 2 3 4 5 6 7 8
A B C D E F
84-XX-9132
SEAWATER FILTER SKID
84-CA-9119
LP SEAWATER FILTER
SIZE: 1.2m O.D. x 3.89m OAL
OPER.: 3.5 BARG AT 13.5°C
DESIGN: 14 BARG AT 50°C
CAPACITY: 2400 M3/H
MOTOR: .55 KW AT 1700 RPM
(1 x 100%)
1.5G3
FIRE
SET AT
14 BARG
84 PSV 93224A
0300 BLAT10R
0300-WS-84L97473-AT75-0
1:100
(DO NOT POCKET)
TO OVERBOARD
PH-ME-P-0259-005
(0200x0075)
0075 GTATOOR 84-V-90869
84 HV 93224A-03
(NOTE 3,5)
0075 GTATOOR 84-V-90868
(NOTE 3,5)
84 HV 93224A-01
0150 GTATOOR
0200x0150
4C 40 Y
84 PDT 93221
PCS PDC 93221
BACKWASH AT 0.5 BARG
(NOTE 2)
PCS HS 93221
PCS XC 93221
(NOTE 1)
PCS CA 9119-M01
P
M01
84-CA-9119
TRIM: 0200-WS-84L97583-AT75-4C
(NOTE 5)
0075 GTATOOR 84-V-90870 (NOTE 6)
0200
84-XX-9132
SKID LIMITS
0200-WS-84L97534-AT75-4C
(DO NOT POCKET)
0300x0200
1800
2400x1800 BUAT20R 84-V-90808
1800-WS-84L97471-AT75-0
PCS TI 93225
84 TT 93225
0150
84 AE 93223
BLEED RING
PH-S-0070
SP 12
0075 GTATOOR 84-V-90874
0200 CBATIOR 84-V-90809
0150 CBATIOW 84-V-90810
0150 CBATIOW 84-V-90811
84 PT 93223
84 PT 93224
P
PCS PI 93223 L
PSD PI 93224 LL
RESIDUAL CHLORINE LP SEAWATER
PCS AI 93223 L
RESIDUAL CL2 HP SEAWATER
PCS AI 93493 L
DATA VALID
PCS AA 93223A
FAULT
PCS AA 93223B
84 AS 93223A/B
84 AT 93223
84 AT 93493
1/4" O.D. TUBING
(NOTE 4)
(DO NOT POCKET)
1/4" O.D. TUBING
TO 45-HB-9101A/B
COOLING MEDIUM
SEAWATER COOLERS
PH-ME-P-0264-001
1800-WS-84L97475-AT75-0
FROM 84-AE-93493
PH-ME-P-0259-005
1/4" O.D. TUBING
(NOTE 4)
CONT. ON DWG. PH-ME-P-0259-005
CONT. ON DWG. PH-ME-P-0259-005
FROM 84-PX-9101A/B
LP SEAWATER LIFT PUMPS
PH-ME-P-0258-001
1800-WS-84L97456-AT75-0
1800-WS-84L97469-AT75-0
0075 GTATOOR 84-V-90866
0075 GBATOOR 84-V-90865
SAMPLING POINT
BLEED RING
PH-S-0069
SP 12
0075 GTATOOR 84-V-90867
0200 CBATIOR 84-V-90805
1800 BUAT20R 84-V-90806
2400x1800
TITANUIM
CARBON STEEL
TITANUIM
1800 BUAC05R 84-V-90856
SP 328
FLANGE ISOLATION KIT
PH-S-2406
0800 INSP. PORT
0300
4C 30 N
M L
84 XV 93229A
PCS XV 93229A
XV108 0300 BLAT30R
0300-WS-84L97476-AT75-4C
0200
(0200x0075)
0075 GTATOOR 84-V-90871
(NOTE 5)
TITANUIM
CARBON STEEL
TITANUIM
1800 BUAC05R 84-V-90857
SP 328
FLANGE ISOLATION KIT
PH-S-2407
84 FO 93224
CLEAN OUT CONNECTION
0075 GTATOOR 84-V-90872
TITANUIM
CARBON STEEL
TITANUIM
0600 BUAC05R 84-V-90807
SP 325
PH-S-2400
FLANGE ISOLATION KIT
0600-WS-84L97474-AT75-0
1:100
(DO NOT POCKET)
PH-S-1911
SP 191
1800-WS-84L97470-AT75-0
0100 GTATOOR 84-V-90873
1/4" TUBING
AT75
0150 GTATOOR 84-V-97929
0600-WS-84L97477-AT75-0
TO LP SEAWATER
DUMP CAISSON
PH-ME-P-0259-003

Field for file specification:
Field for date and time :

NOTES:
1. AUTOMATIC BACKFLUSHING TO BE INITIATED AT HIGH DIFFERENTIAL PRESSURE OR TRIGGERED BY A TIMER.
2. MANUAL INITIATION OF BACKFLUSH.
3. KEY INTERLOCKED VALVE.
4. TUBING PURCHASED WITH PRE-FITTED INSULATION AND HEAT TRACING.
5. FILTER 84-CA-9119 TO BE DRAINED OF WATER BEFORE ISOLATION OF 84-PSV-93224A.
6. VENT VALVE TO BE INSULATED BUT NOT ELECTRIC TRACED.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
5	06OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
4	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
3	01OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/PS/JL	SVS	
2	28APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/PS	SVS	
1	15APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/JB	RB	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SRK	JC/ES/JB	SVS	

**Wood Group Engineering
(North Sea) Ltd.**

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

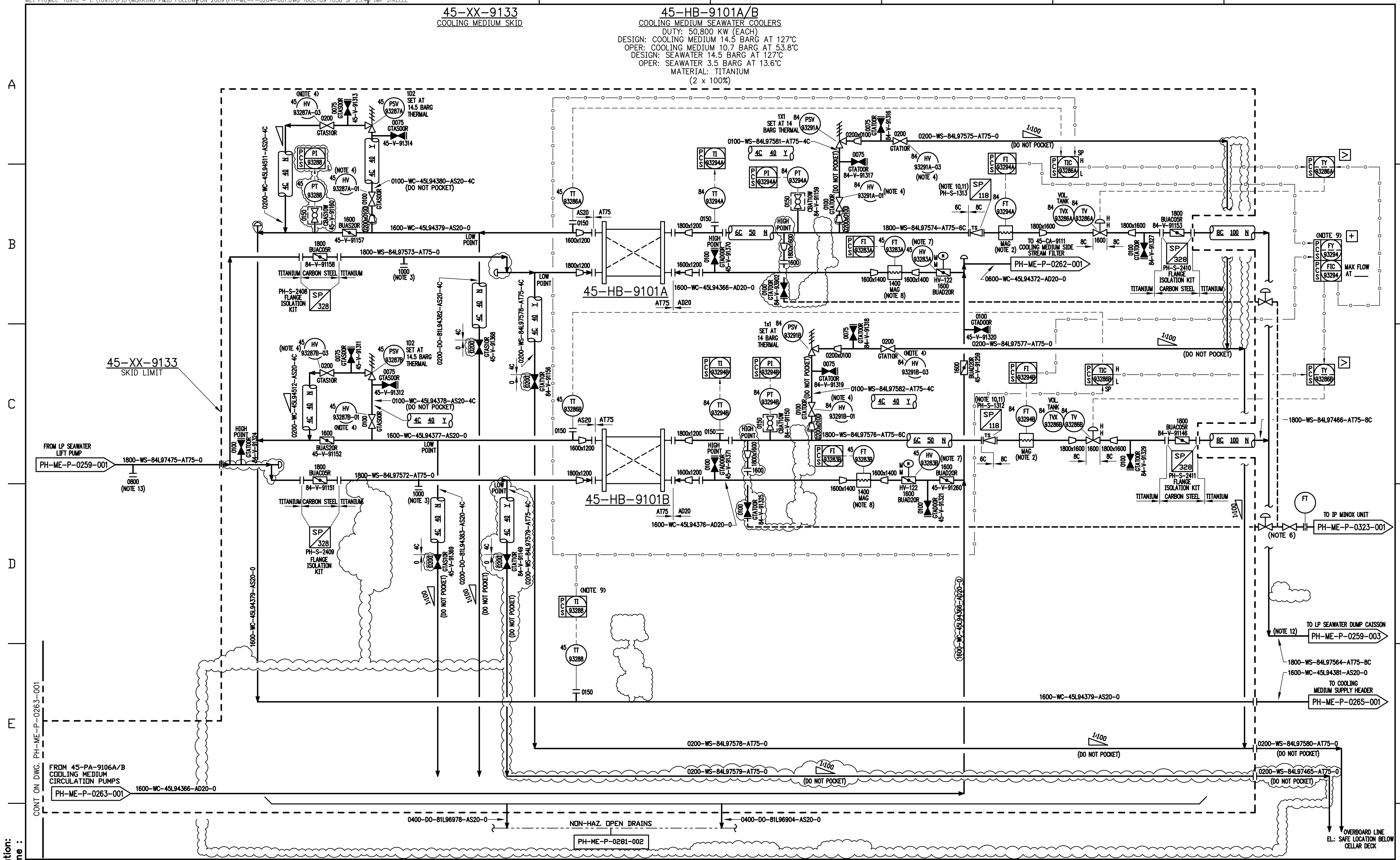
VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
LP SEAWATER FILTER

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
U12-02	84	XB	PH	ME	P	0259	001	REV. 5

A1

Field for file specification:
Field for date and time :

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0264-001.DWG 16OCT09 1056 SF 25.40 IMP J1KELLE


45-XX-9133
COOLING MEDIUM SKID
45-HB-9101A/B
COOLING MEDIUM SEAWATER COOLERS
DUTY: 50,800 KW (EACH)
DESIGN: COOLING MEDIUM 14.5 BARG AT 127°C
OPER: COOLING MEDIUM 10.7 BARG AT 53.8°C
DESIGN: SEAWATER 14.5 BARG AT 127°C
OPER: SEAWATER 3.5 BARG AT 13.6°C
MATERIAL: TITANIUM
(2 x 100%)
45-XX-9133
SKID LIMIT
FROM LP SEAWATER
LIFT PUMP
PH-ME-P-0259-001
1800-WS-84L97475-AT75-0
0800
(NOTE 13)
HIGH POINT
0100 GTATOOR 84-V-91324
1600-WC-45L94379-AS20-0
0200-WC-45L94511-AS20-4C
0200-WC-45L94512-AS20-4C
4C 40 N
4C 40 Y
(NOTE 4)
45 HV 93287A-03
45 HV 93287B-03
45 PSV 93287A
45 PSV 93287B
1D2 SET AT 14.5 BARG THERMAL
0075 GTAS00R
45-V-91313
45-V-91314
45-V-91311
45-V-91312
0200 GTAS10R
PI 93288
PT 93288
CBAS10W 45-V-91160
45 HV 93287A-01
45 HV 93287B-01
0100-WC-45L94380-AS20-4C
0100-WC-45L94378-AS20-4C
(DO NOT POCKET)
1600 BUAS20R 45-V-91157
1600 BUAS20R 45-V-91152
LOW POINT
1800 BUAC05R 84-V-91158
1800 BUAC05R 84-V-91151
1800-WS-84L97573-AT75-0
1800-WS-84L97572-AT75-0
1000 (NOTE 3)
TITANIUM CARBON STEEL TITANIUM
PH-S-2408 FLANGE ISOLATION KIT
PH-S-2409 FLANGE ISOLATION KIT
SP 328
0200-DO-81L94382-AS20-4C
0200-DO-81L94383-AS20-4C
0200 GTAS10R 45-V-91368
0200 GTAS10R 45-V-91369
0200-WS-84L97578-AT75-4C
0200-WS-84L97579-AT75-4C
0200 GTAT10R 84-V-91156
0200 GTAT10R 84-V-91149
1:100
45 TT 93286A
45 TT 93286B
0150
AS20 AT75
1600x1200
1800x1200
45-HB-9101A
45-HB-9101B
AT75 AD20
1600-WC-45L94366-AD20-0
1600-WC-45L94376-AD20-0
84 TT 93294A
84 TT 93294B
TI 93294A
TI 93294B
HIGH POINT
0100 GTADOOR 45-V-91370
0100 GTADOOR 45-V-91371
6C 50 N
PI 93294A
PT 93294A
PI 93294B
PT 93294B
CBAT10W 84-V-91159
CBAT10W 84-V-91150
1X1 84 PSV 93291A
SET AT 14 BARG THERMAL
84 PSV 93291B
0100-WS-84L97581-AT75-4C
0100-WS-84L97582-AT75-4C
0200x0100
0075 GTATOOR 84-V-91317
0075 GTATOOR 84-V-91319
84 HV 93291A-01
84 HV 93291B-01
84 HV 93291A-03
84 HV 93291B-03
0075 GTATOOR 84-V-91316
0075 GTATOOR 84-V-91318
0200 GTAT10R
0200-WS-84L97575-AT75-0
0200-WS-84L97577-AT75-0
1800-WS-84L97574-AT75-6C
1800-WS-84L97576-AT75-6C
0100 GTATOOR 84-V-93902
0100 GTATOOR 84-V-91325
1800x1600
FI 93283A
FT 93283A
FI 93283B
FT 93283B
45 HV 93283A
45 HV 93283B
(NOTE 7)
1600x1400
1400 MAG (NOTE 8)
HV-122
1600 BUAD20R
45-V-91260
0100 GTADOOR 45-V-91321
PH-ME-P-0262-001
0600-WC-45L94372-AD20-0
0100 GTADOOR 45-V-91320
1600 BUAD20R 45-V-91259
(NOTE 10,11)
PH-S-1313
PH-S-1312
SP 118
6C 8C
TS
FI 93294A
FT 93294A
FI 93294B
FT 93294B
MAG (NOTE 2)
TO 45-CA-9111
COOLING MEDIUM SIDE
STREAM FILTER
VOL. TANK
84 TVX 93286A
84 TV 93286A
84 TVX 93286B
84 TV 93286B
TIC 93286A
TIC 93286B
SP H L
1800x1600
1600
0100 GTATOOR 84-V-91327
0100 GTATOOR 84-V-91329
1800 BUAC05R 84-V-91153
1800 BUAC05R 84-V-91146
PH-S-2410 FLANGE ISOLATION KIT
PH-S-2411 FLANGE ISOLATION KIT
8C 100 N
TY 93286A
TY 93286B
(NOTE 9)
FY 93294
FIC 93294
MAX FLOW AT ___
1800-WS-84L97466-AT75-8C
FT
(NOTE 6)
TO IP MINOX UNIT
PH-ME-P-0323-001
TI 93288
45 TT 93288
(NOTE 9)
1600-WC-45L94366-AD20-0
TO LP SEAWATER DUMP CAISSON
(NOTE 12)
PH-ME-P-0259-003
1800-WS-84L97564-AT75-8C
1600-WC-45L94381-AS20-0
TO COOLING MEDIUM SUPPLY HEADER
PH-ME-P-0265-001
1600-WC-45L94379-AS20-0
0200-WS-84L97578-AT75-0
0200-WS-84L97579-AT75-0
0200-WS-84L97580-AT75-0
0200-WS-84L97465-AT75-0
OVERBOARD LINE
EL.: SAFE LOCATION BELOW CELLAR DECK
CONT ON DWG. PH-ME-P-0263-001
FROM 45-PA-9106A/B
COOLING MEDIUM
CIRCULATION PUMPS
PH-ME-P-0263-001
1600-WC-45L94366-AD20-0
0400-DO-81L96978-AS20-0
0400-DO-81L96904-AS20-0
NON-HAZ. OPEN DRAINS
PH-ME-P-0281-002

NOTES:
1. DELETED.
2. PROVIDE 5D UPSTREAM & 2D DOWNSTREAM.
3. CONNECTION PROVIDED TO ALLOW THE DISCHARGE OF REVERSE FLOW SEAWATER THROUGH OFFLINE COOLER FOR CLEANING PURPOSES.
4. KEY INTERLOCKED VALVES.
5. DELETED.
6. TEMPERATURE CONTROL AND SYSTEM OPERATION TO BE DEVELOPED IN THE FUTURE.
7. ACTUATION GEARING TO BE NO FASTER THAN 2.0 MINUTES STROKE TIME.
8. MAGNETIC FLOWMETERS DOWNSTREAM OF CONCENTRIC REDUCERS. PROVIDE STRAIGHT RUN OF 0D UPSTREAM AND 0D DOWNSTREAM.
9. TI-93288 AND FIC-93294 PROVIDE COMMON HEADER TEMP CONTROL AND MAX FLOW CONTROL DURING EXHCANGER CHANGEOVER.
10. STRAINER FOR CONTROL VALVE TRIM MUST BE REMOVED AFTER FULL FLOW COMMISSIONING.
11. PIPE SPOOL TO INCLUDE LIFTING LUGS PENETRATING INSULATION.
12. PIPEWORK TO RISE TO HIGH POINT MINIMUM 4500mm ABOVE 84-TV-93286A/B.
13. CONNECTIONS FOR FUTURE OIL EXPORT COOLER (11-HA-9104) AT 6353 Kw RATING.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
5	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/MR	GMK	
4	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
3	01OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/PS/JL	SVS	
2	28APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/PS	SVS	
1	15APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/JB	RB	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SRK	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

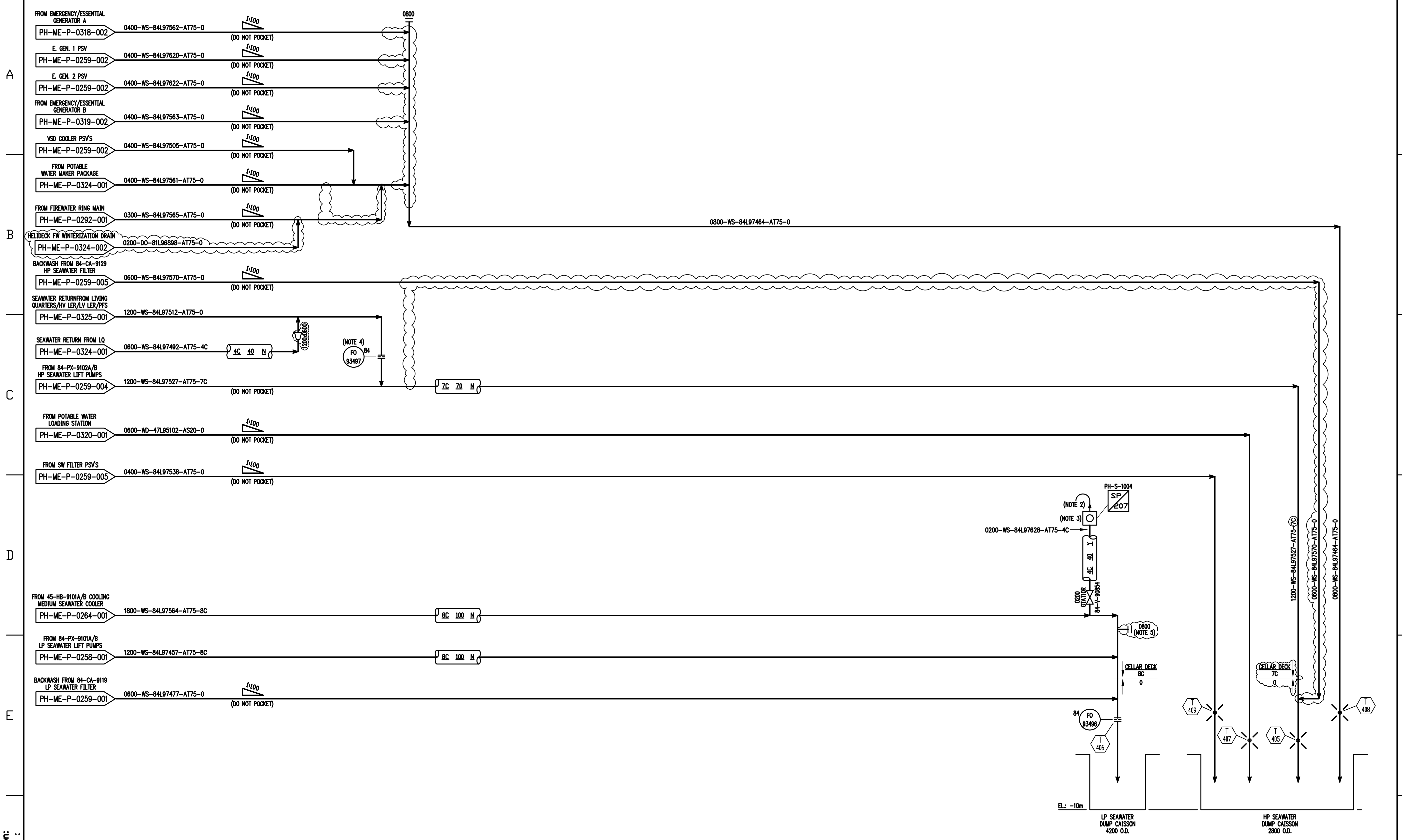
PROJECT NO. 10910

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
COOLING MEDIUM SEAWATER COOLERS

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
U12-02	45	XB	PH	ME	P	0264	001	REV. 5

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0259-003.DWG 12OCT09 1605 SF 25.40 IMP J1KELLE


FROM EMERGENCY/ESSENTIAL GENERATOR A
PH-ME-P-0318-002
0400-WS-84L97562-AT75-0
E. GEN. 1 PSV
PH-ME-P-0259-002
0400-WS-84L97620-AT75-0
E. GEN. 2 PSV
PH-ME-P-0259-002
0400-WS-84L97622-AT75-0
FROM EMERGENCY/ESSENTIAL GENERATOR B
PH-ME-P-0319-002
0400-WS-84L97563-AT75-0
VSD COOLER PSV'S
PH-ME-P-0259-002
0400-WS-84L97505-AT75-0
FROM POTABLE WATER MAKER PACKAGE
PH-ME-P-0324-001
0400-WS-84L97561-AT75-0
FROM FIREWATER RING MAIN
PH-ME-P-0292-001
0300-WS-84L97565-AT75-0
HELIDECK FW WINTERIZATION DRAIN
PH-ME-P-0324-002
0200-DO-81L96898-AT75-0
BACKWASH FROM 84-CA-9129 HP SEAWATER FILTER
PH-ME-P-0259-005
0600-WS-84L97570-AT75-0
SEAWATER RETURNFROM LIVING QUARTERS/HV LER/LV LER/PFS
PH-ME-P-0325-001
1200-WS-84L97512-AT75-0
SEAWATER RETURN FROM LQ
PH-ME-P-0324-001
0600-WS-84L97492-AT75-4C
4C 40 N
1200x0600
(NOTE 4)
84
FO
93497
FROM 84-PX-9102A/B HP SEAWATER LIFT PUMPS
PH-ME-P-0259-004
1200-WS-84L97527-AT75-7C
7C 70 N
FROM POTABLE WATER LOADING STATION
PH-ME-P-0320-001
0600-WD-47L95102-AS20-0
FROM SW FILTER PSV'S
PH-ME-P-0259-005
0400-WS-84L97538-AT75-0
FROM 45-HB-9101A/B COOLING MEDIUM SEAWATER COOLER
PH-ME-P-0264-001
1800-WS-84L97564-AT75-8C
8C 100 N
FROM 84-PX-9101A/B LP SEAWATER LIFT PUMPS
PH-ME-P-0258-001
1200-WS-84L97457-AT75-8C
8C 100 N
BACKWASH FROM 84-CA-9119 LP SEAWATER FILTER
PH-ME-P-0259-001
0600-WS-84L97477-AT75-0
1:100
(DO NOT POCKET)
0800
0800-WS-84L97464-AT75-0
PH-S-1004
SP
207
(NOTE 2)
(NOTE 3)
0200-WS-84L97628-AT75-4C
4C 40 Y
0200
GTATIOR
84-V-90854
0800
(NOTE 5)
CELLAR DECK
8C
0
84
FO
93496
T
406
1200-WS-84L97527-AT75-7C
0600-WS-84L97570-AT75-0
0800-WS-84L97464-AT75-0
CELLAR DECK
7C
0
T
409
T
407
T
405
T
408
EL.: -10m
LP SEAWATER DUMP CAISSON 4200 O.D.
HP SEAWATER DUMP CAISSON 2800 O.D.

NOTES:

1. DELETED.
2. VENT TO SAFE LOCATION.
3. AIR RELEASE/VAC BREAKER AT HIGH POINT.
4. LOCATE 84-FO-93497 AT MINIMUM ELEVATION.
5. CONNECTION FOR FUTURE OIL EXPORT COOLER (11-HA-9104) AT 6853 KW RATING.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
5	13OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
4	22MAY09	JS	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
3	14NOV08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JL/PS	SVS	
2	28APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/PS	SVS	
1	15APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/JB	RB	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SRK	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
OVERBOARD

REGISTRATION CODES

AREA	SYSTEM	TYPE
T	84	XB

DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0259	003

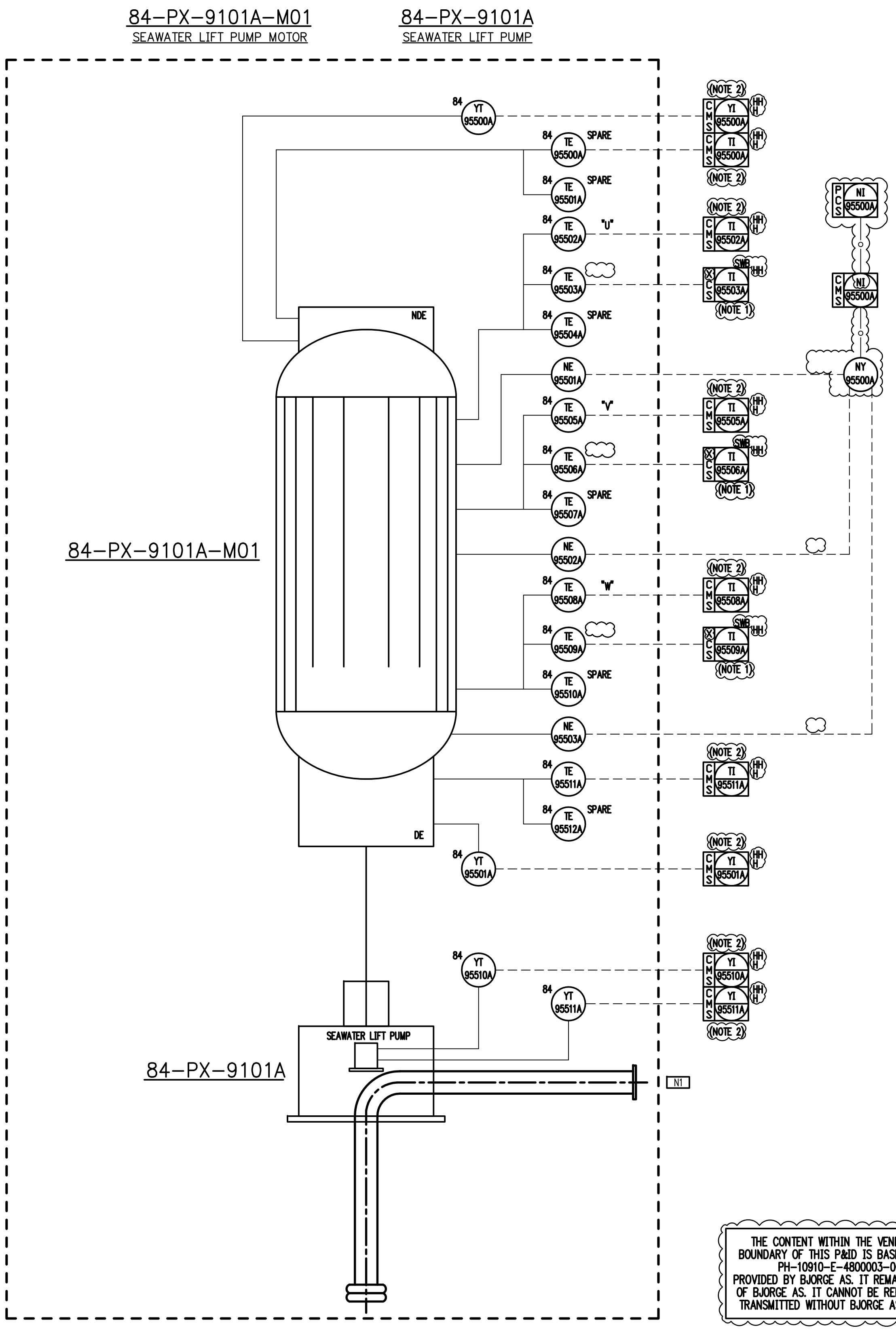
SCALE NONE

REV. 5

Field for file specification:
Field for date and time :

A1

MEI Project: 10910 – I:\10910\PID\MAY 2009 FROZEN\PH-ME-P-0107-004.DWG 26MAY09 0748 SF 25.40 IMP J1KELLE


84-PX-9101A-M01
SEAWATER LIFT PUMP MOTOR
84-PX-9101A
SEAWATER LIFT PUMP
84-PX-9101A-M01
NDE
DE
84-PX-9101A
SEAWATER LIFT PUMP
N1
84 YT 95500A
84 TE 95500A SPARE
84 TE 95501A SPARE
84 TE 95502A "U"
84 TE 95503A
84 TE 95504A SPARE
NE 95501A
84 TE 95505A "V"
84 TE 95506A
84 TE 95507A SPARE
NE 95502A
84 TE 95508A "W"
84 TE 95509A
84 TE 95510A SPARE
NE 95503A
84 TE 95511A
84 TE 95512A SPARE
84 YT 95501A
84 YT 95510A
84 YT 95511A
(NOTE 2)
CMS YI 95500A HH H
CMS TI 95500A HH H
(NOTE 2)
(NOTE 2)
CMS TI 95502A HH H
XCS TI 95503A SWB HH
(NOTE 1)
(NOTE 2)
CMS TI 95505A HH H
XCS TI 95506A SWB HH
(NOTE 1)
(NOTE 2)
CMS TI 95508A HH H
XCS TI 95509A SWB HH
(NOTE 1)
(NOTE 2)
CMS TI 95511A HH H
(NOTE 2)
CMS YI 95501A HH H
(NOTE 2)
CMS YI 95510A HH H
CMS YI 95511A HH H
(NOTE 2)
PCS NI 95500A
CMS NI 95500A
NY 95500A

THE CONTENT WITHIN THE VENDOR SKID LIMIT
BOUNDARY OF THIS P&ID IS BASED ON DOCUMENT:
PH-10910-E-4800003-001 REV. A
PROVIDED BY BJORGE AS. IT REMAINS THE PROPERTY
OF BJORGE AS. IT CANNOT BE REPRODUCED AND/OR
TRANSMITTED WITHOUT BJORGE AS AUTHORIZATION.

NOZZLE	DESCRIPTION	SIZE	STANDARD
N1	PUMP DISCHARGE	18"	ANSI B16.5/150# FF

Field for file specification:
Field for date and time :

NOTES:
1. TO BE CONNECTED TO SWITCHGEAR PROTECTIVE RELAY.
2. SUMMARIZED TRIP SIGNAL (84-NXO-95501A) TO SHUTDOWN PUMP UNIT IS SENT FROM CMS TO PSD.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
1	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
0	10OCT08	JDK	ISSUED FOR CONSTRUCTION	SRK	RK/JL/PS	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
LP SW LIFT PUMP A CONDITION MONITORING

REGISTRATION CODES

AREA	SYSTEM	TYPE
U12-02	84	XB

DRAWING NO.

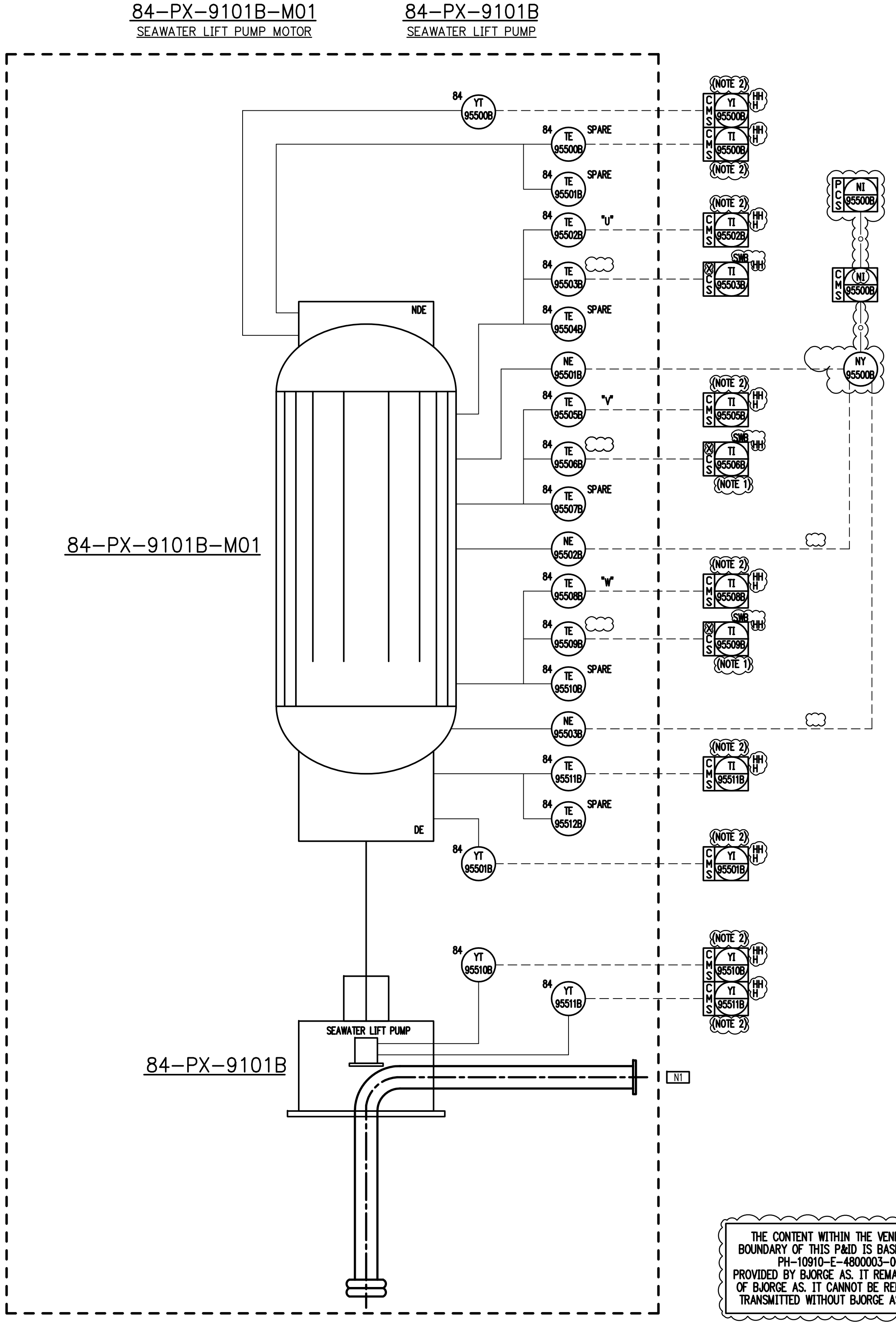
FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0107	004

SCALE NONE

REV. 1

A1

MEI Project: 10910 – I:\10910\PID\MAY 2009 FROZEN\PH-ME-P-0107-005.DWG 26MAY09 0747 SF 25.40 IMP J1KELLE


84–PX–9101B–M01
SEAWATER LIFT PUMP MOTOR
84–PX–9101B
SEAWATER LIFT PUMP
84–PX–9101B–M01
NDE
DE
84–PX–9101B
SEAWATER LIFT PUMP
N1
84 YT 95500B
84 TE 95500B SPARE
84 TE 95501B SPARE
84 TE 95502B "U"
84 TE 95503B
84 TE 95504B SPARE
NE 95501B
84 TE 95505B "V"
84 TE 95506B
84 TE 95507B SPARE
NE 95502B
84 TE 95508B "W"
84 TE 95509B
84 TE 95510B SPARE
NE 95503B
84 TE 95511B
84 TE 95512B SPARE
84 YT 95501B
84 YT 95510B
84 YT 95511B
(NOTE 2)
CMS YI 95500B HH H
CMS TI 95500B HH H
(NOTE 2)
(NOTE 2)
CMS TI 95502B HH H
SWB
CS TI 95503B HH
(NOTE 2)
CMS TI 95505B HH H
SWB
CS TI 95506B HH
(NOTE 1)
(NOTE 2)
CMS TI 95508B HH H
SWB
CS TI 95509B HH
(NOTE 1)
(NOTE 2)
CMS TI 95511B HH H
(NOTE 2)
CMS YI 95501B HH H
(NOTE 2)
CMS YI 95510B HH H
CMS YI 95511B HH H
(NOTE 2)
PCS NI 95500B
CMS NI 95500B
NY 95500B

NOZZLE	DESCRIPTION	SIZE	STANDARD
N1	PUMP DISCHARGE	18"	ANSI B16.5/150# FF

THE CONTENT WITHIN THE VENDOR SKID LIMIT
BOUNDARY OF THIS P&ID IS BASED ON DOCUMENT:
PH-10910-E-4800003-001 REV. A
PROVIDED BY BJORGE AS. IT REMAINS THE PROPERTY
OF BJORGE AS. IT CANNOT BE REPRODUCED AND/OR
TRANSMITTED WITHOUT BJORGE AS AUTHORIZATION.

Field for file specification:
Field for date and time :

NOTES:
1. TO BE CONNECTED TO SWITCHGEAR PROTECTIVE RELAY.
2. SUMMARIZED TRIP SIGNAL (84-NXO-95501B) TO SHUTDOWN PUMP UNIT IS SENT FROM CMS TO PSD.

A1

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
1	22MAY09	JDK	RE–ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
0	10OCT08	CDB	ISSUED FOR CONSTRUCTION	SRK	RK/JL/PS	SVS	

Wood Group Engineering (North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

VALHALL
RE–DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
LP SW LIFT PUMP B CONDITION MONITORING

REGISTRATION CODES

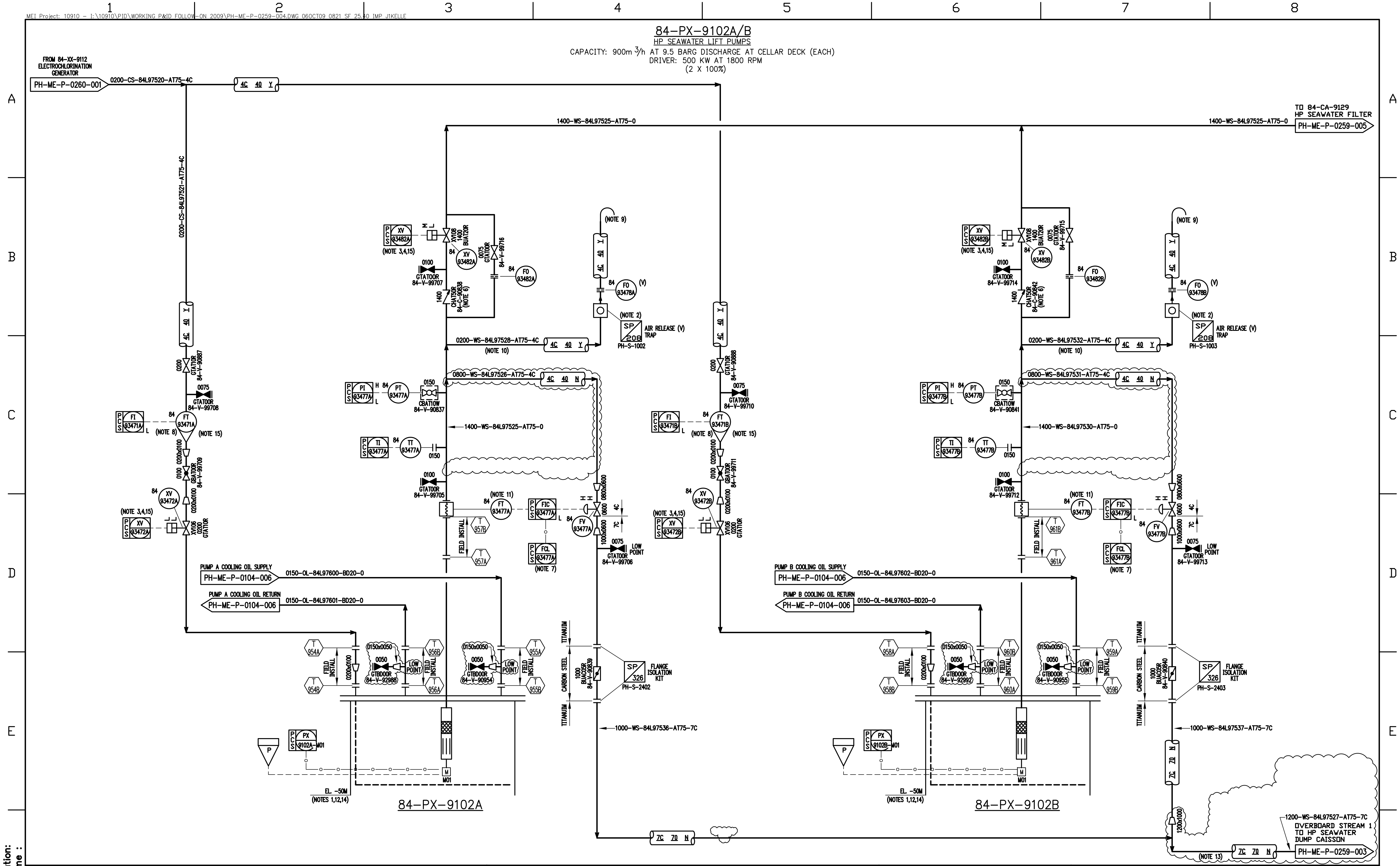
AREA	SYSTEM	TYPE
U12–02	84	XB

DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0107	005

SCALE NONE
REV. 1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW–ON 2009\PH–ME–P–0259–004.DWG 06OCT09 0821 SF 25.40 IMP J1KELLE


84–PX–9102A/B
HP SEAWATER LIFT PUMPS
CAPACITY: 900m 3/h AT 9.5 BARG DISCHARGE AT CELLAR DECK (EACH)
DRIVER: 500 KW AT 1800 RPM
(2 X 100%)
FROM 84-XX-9112 ELECTROCHLORINATION GENERATOR
PH-ME-P-0260-001
0200-CS-84L97520-AT75-4C
0200-CS-84L97521-AT75-4C
4C 40 Y
1400-WS-84L97525-AT75-0
TO 84-CA-9129 HP SEAWATER FILTER
PH-ME-P-0259-005
XV 93482A
(NOTE 3,4,15)
XV108 1400 BUAT20R
0075 GTATOOR 84-V-99716
FO 93482A
0100 GTATOOR 84-V-99707
1400 CHAT50R 84-C-90838 (NOTE 6)
(NOTE 9)
FO 93478A (V)
(NOTE 2)
SP 208 AIR RELEASE (V) TRAP
PH-S-1002
0200-WS-84L97528-AT75-4C
(NOTE 10)
0800-WS-84L97526-AT75-4C
4C 40 N
PI 93477A
PT 93477A
0150 CBAT10W 84-V-90837
1400-WS-84L97525-AT75-0
TI 93477A
TT 93477A
0150
0100 GTATOOR 84-V-99705
(NOTE 11)
FT 93477A
FIC 93477A
FCL 93477A
(NOTE 7)
FV 93477A
0800x0600
1000x0600
0600
4C
7C
0075 GTATOOR 84-V-99706
LOW POINT
FIELD INSTALL
957A
957B
0200 GTAT10R 84-V-90887
0075 GTATOOR 84-V-99708
FI 93471A
FT 93471A
(NOTE 8)
(NOTE 15)
0200x0100
0100 GBATOOR 84-V-99709
XV 93472A
XV106 0200 GTAT10R
PUMP A COOLING OIL SUPPLY
PH-ME-P-0104-006
0150-OL-84L97600-BD20-0
PUMP A COOLING OIL RETURN
PH-ME-P-0104-006
0150-OL-84L97601-BD20-0
954A
954B
955A
955B
956A
956B
0150x0050
0050 GTBDOOR 84-V-92988
0050 GTBDOOR 84-V-90954
0200x0100
TITANUIM
CARBON STEEL
1000 BUAC05R 84-V-90839
SP 326 FLANGE ISOLATION KIT
PH-S-2402
1000-WS-84L97536-AT75-7C
7C 70 N
PX 9102A-M01
P
M
M01
EL. -50M
(NOTES 1,12,14)
84–PX–9102A
XV 93482B
XV108 1400 BUAT20R
0075 GTATOOR 84-V-99715
FO 93482B
0100 GTATOOR 84-V-99714
1400 CHAT50R 84-C-90842 (NOTE 6)
FO 93478B (V)
SP 208 AIR RELEASE (V) TRAP
PH-S-1003
0200-WS-84L97532-AT75-4C
0800-WS-84L97531-AT75-4C
PI 93477B
PT 93477B
0150 CBAT10W 84-V-90841
1400-WS-84L97530-AT75-0
TI 93477B
TT 93477B
0100 GTATOOR 84-V-99712
FT 93477B
FIC 93477B
FCL 93477B
FV 93477B
0075 GTATOOR 84-V-99713
961A
961B
0200 GTAT10R 84-V-90888
0075 GTATOOR 84-V-99710
FI 93471B
FT 93471B
0100 GBATOOR 84-V-99711
XV 93472B
PUMP B COOLING OIL SUPPLY
PH-ME-P-0104-006
0150-OL-84L97602-BD20-0
PUMP B COOLING OIL RETURN
PH-ME-P-0104-006
0150-OL-84L97603-BD20-0
958A
958B
959A
959B
960A
960B
0050 GTBDOOR 84-V-92992
0050 GTBDOOR 84-V-90955
1000 BUAC05R 84-V-90840
SP 326 FLANGE ISOLATION KIT
PH-S-2403
1000-WS-84L97537-AT75-7C
PX 9102B-M01
84–PX–9102B
1200x1000
(NOTE 13)
1200-WS-84L97527-AT75-7C
OVERBOARD STREAM 1 TO HP SEAWATER DUMP CAISSON
PH-ME-P-0259-003

Field for file specification:
Field for date and time :

NOTES:
1. SEAWATER LIFT PUMPS CAISSON TERMINATING AT 50M BELOW L.A.T.
2. AIR RELEASE VALVE / VACUUM BREAKER 2" VENDOR SUPPLY, TO BE MOUNTED VERTICALLY.
3. VALVE TO CLOSE IF CORRESPONDING SEAWATER LIFT PUMPS STOPS.
4. VALVE TO OPEN AUTOMATICALLY AFTER START-UP OF CORRESPONDING SEAWATER LIFT PUMP.
5. DELETED.
6. NON / SLAM CHECK VALVES.
7. INDIVIDUAL TRIP ON CORRESP. PUMP IF FLOW LESS THAN FCL. ATER PUMP STARTUP SEQUENCE.
8. FLOW DIRECTION TO BE VERTICAL UP. PROVIDE 10D UPSTREAM AND 5D DOWNSTREAM.
9. ROUTE TO SAFE LOCATION.
10. AIR RELEASE VALVE/VACUUM BREAKER SHALL BE LOCATED AT THE HIGHEST POSSIBLE LOCATION AND AS CLOSE TO THE DISCHARGE BLOCK VALVE AS POSSIBLE.
11. MAGMETER. PROVIDE 5D UPSTREAM AND 2D DOWNSTREAM.
12. SLOTTED AREA FOR WATER INLET ELEVATION FOR PUMPS A AND B TO BE -50M.
13. PIPEWORK TO RISE TO HIGH POINT MINIMUM 10M ABOVE FV-93477A/B.
14. FOR COOLING OIL PUMP SYSTEM INFORMATION SEE DWG. PH-ME-P-0104-006.
15. REFER TO DOCUMENT VRD-ME-P-0042 FOR OPERATING DETAILS.

A1

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
5	06OCT09	JDK	RE–ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
4	22MAY09	JDK	RE–ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
3	14NOV08	JDK	RE–ISSUED FOR CONSTRUCTION	SRK	RK/JL/PS	SVS	
2	28APR08	JDK	RE–ISSUED FOR CONSTRUCTION	SRK	JC/JL/PS	SVS	
1	15APR08	JDK	RE–ISSUED FOR CONSTRUCTION	SRK	JC/JL/JB	RB	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SRK	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. JH

VALHALL
RE–DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
HP SEAWATER LIFT PUMPS

REGISTRATION CODES

AREA	SYSTEM	TYPE
U12–02	84	XB

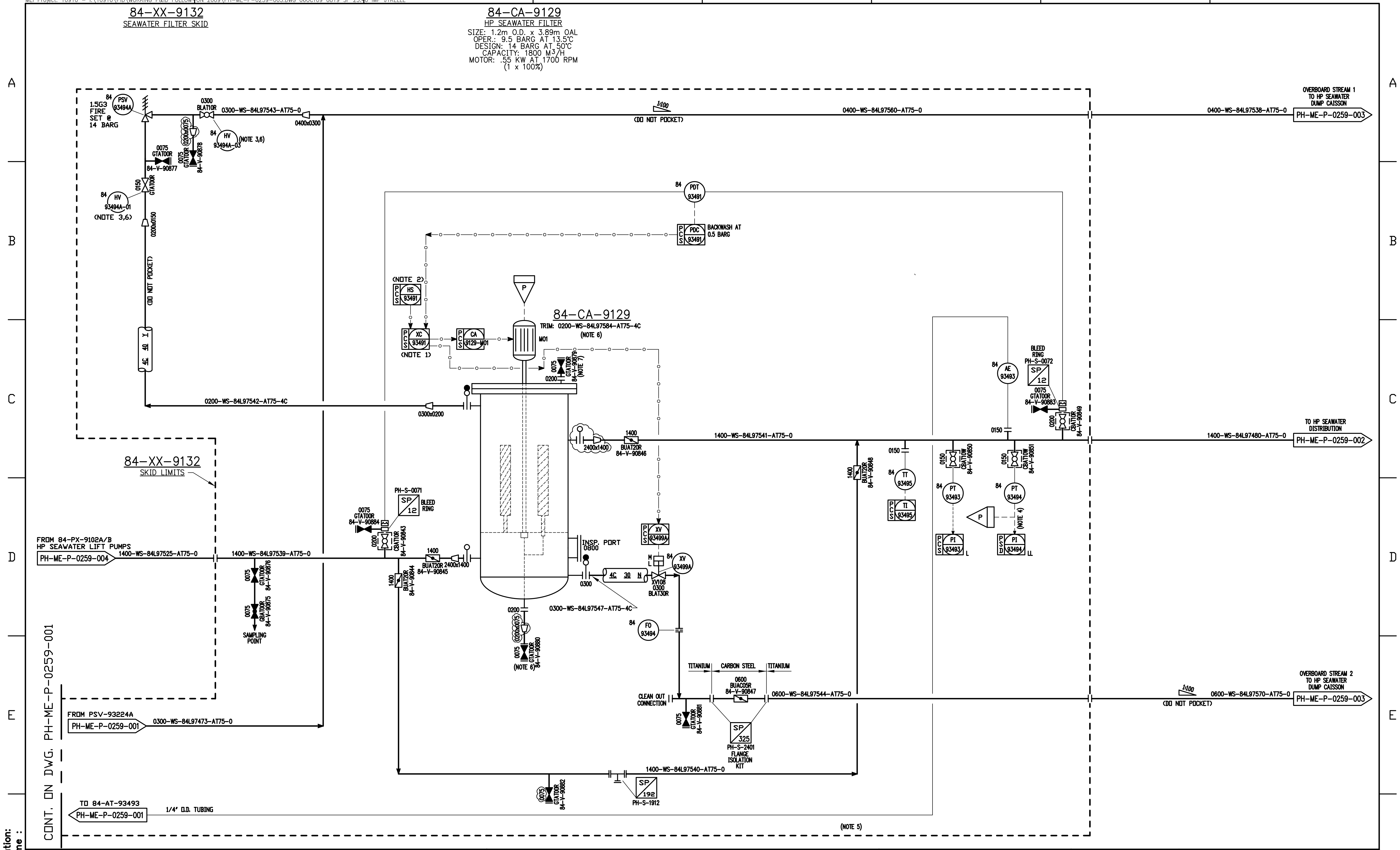
DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0259	004

SCALE NONE

REV. 5

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0259-005.DWG 06OCT09 0819 SF 25.40 IMP J1KELLE


84-XX-9132
SEAWATER FILTER SKID
84-CA-9129
HP SEAWATER FILTER
SIZE: 1.2m O.D. x 3.89m OAL
OPER.: 9.5 BARG AT 13.5°C
DESIGN: 14 BARG AT 50°C
CAPACITY: 1800 M³/H
MOTOR: .55 KW AT 1700 RPM
(1 x 100%)
84 PSV 93494A
1.5G3 FIRE SET @ 14 BARG
0300 BLATIOR
0300-WS-84L97543-AT75-0
0400x0300
84 HV 93494A-03 (NOTE 3,6)
0075 GTATOOR 84-V-90877
0075 GTATOOR 84-V-90878
0200x0075
84 HV 93494A-01 (NOTE 3,6)
0150 GTATOOR
0200x0150
(DO NOT POCKET)
4C 40 Y
1:100
0400-WS-84L97560-AT75-0
0400-WS-84L97538-AT75-0
OVERBOARD STREAM 1 TO HP SEAWATER DUMP CAISSON
PH-ME-P-0259-003
84 PDT 93491
PDC 93491
BACKWASH AT 0.5 BARG
(NOTE 2)
HS 93491
XC 93491
(NOTE 1)
CA 9129-M01
P
M01
84-CA-9129
TRIM: 0200-WS-84L97584-AT75-4C
(NOTE 6)
0075 GTATOOR 84-V-90879 (NOTE 7)
0200
0200-WS-84L97542-AT75-4C
0300x0200
84-XX-9132
SKID LIMITS
2400x1400
1400 BUAT20R 84-V-90846
1400-WS-84L97541-AT75-0
1400-WS-84L97480-AT75-0
TO HP SEAWATER DISTRIBUTION
PH-ME-P-0259-002
84 AE 93493
BLEED RING PH-S-0072
SP 12
0075 GTATOOR 84-V-90883
0200 CBATIOR 84-V-90849
0150
0150 CBATIOW 84-V-90850
0150 CBATIOW 84-V-90851
84 TT 93495
TI 93495
84 PT 93493
84 PT 93494
(NOTE 4)
PI 93493 L
PI 93494 LL
1400 BUAT20R 84-V-90848
PH-S-0071
SP 12
BLEED RING
0075 GTATOOR 84-V-90884
0200 CBATIOR 84-V-90843
FROM 84-PX-9102A/B HP SEAWATER LIFT PUMPS
PH-ME-P-0259-004
1400-WS-84L97525-AT75-0
1400-WS-84L97539-AT75-0
0075 GTATOOR 84-V-90876
0075 GBATOOR 84-V-90875
SAMPLING POINT
1400 BUAT20R 84-V-90845
2400x1400
1400 BUAT20R 84-V-90844
INSP. PORT 0800
0300
4C 30 N
XV 93499A
84 XV 93499A
XV108 0300 BLAT30R
0300-WS-84L97547-AT75-4C
84 FO 93494
0200
0200x0075
0075 GTATOOR 84-V-90880
(NOTE 6)
TITANIUM
CARBON STEEL
TITANIUM
0600 BUAC05R 84-V-90847
CLEAN OUT CONNECTION
0075 GTATOOR 84-V-90881
SP 325
PH-S-2401 FLANGE ISOLATION KIT
0600-WS-84L97544-AT75-0
0600-WS-84L97570-AT75-0
OVERBOARD STREAM 2 TO HP SEAWATER DUMP CAISSON
PH-ME-P-0259-003
1400-WS-84L97540-AT75-0
SP 192
PH-S-1912
0075 GTATOOR 84-V-90882
FROM PSV-93224A
PH-ME-P-0259-001
0300-WS-84L97473-AT75-0
TO 84-AT-93493
PH-ME-P-0259-001
1/4" O.D. TUBING
(NOTE 5)
CONT. ON DWG. PH-ME-P-0259-001

Field for file specification:
Field for date and time :

NOTES:

1. AUTOMATIC BACKFLUSHING TO BE INITIATED AT HIGH DIFFERENTIAL PRESSURE OR TRIGGERED BY A TIMER.
2. MANUAL INITIATION OF BACKFLUSH.
3. KEY INTERLOCKED VALVE.
4. ADJUSTABLE TIME DELAY T1 TO ALLOW STANDBY PUMP TO START AND ATTEMPT PRESSURE RECOVERY. PSLL-93494 TO ACTIVATE PSDO, VALHALL FIELD COMPLETE SHUTDOWN. REFER TO DOCUMENT VRD-ME-P-0042 FOR OPERATION DETAILS.
5. TUBING PURCHASED WITH PRE-FITTED INSULATION AND HEAT TREATING.
6. FILTER 84-CA-9129 TO BE DRAINED OF WATER BEFORE ISOLATION OF 84-PSV-93494A.
7. VENT VALVE TO BE INSULATED BUT NOT ELECTRIC TRACED.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
5	06OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/AJ/PS	GMK	
4	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JB/AJ	GMK	
3	01OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/PS/AJ	SVS	
2	28APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/AJ/PS	SVS	
1	15APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/AJ/JB	RB	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SRK	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

REGISTRATION CODES

AREA	SYSTEM	TYPE
U12-02	84	XB

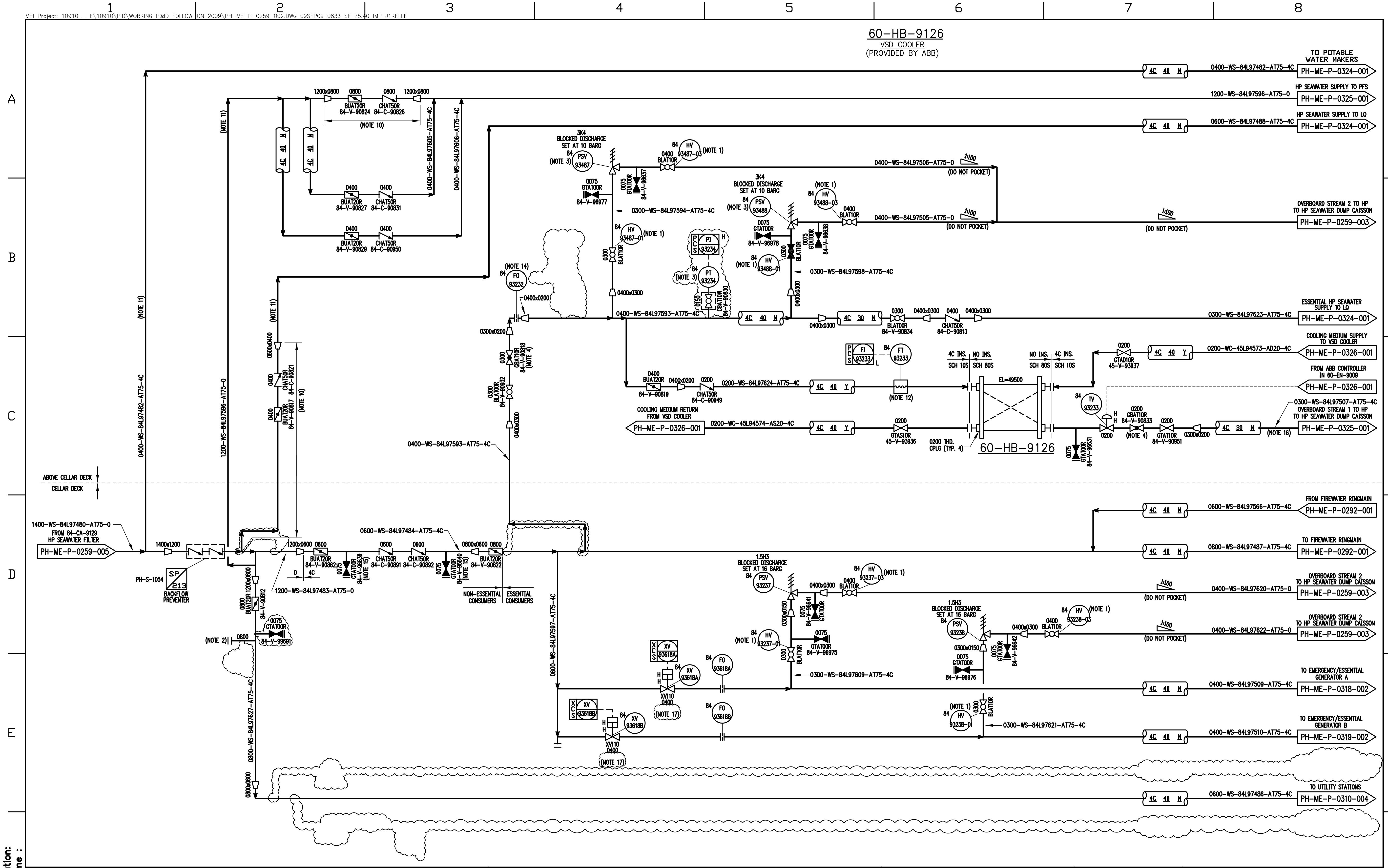
VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
HP SEAWATER FILTER

DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	SCALE
PH	ME	P	0259	005	NONE
					REV. 5

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0259-002.DWG 09SEP09 0833 SF 25.40 IMP J1KELLE


60–HB–9126
VSD COOLER
(PROVIDED BY ABB)
TO POTABLE WATER MAKERS
0400–WS–84L97482–AT75–4C
PH–ME–P–0324–001
HP SEAWATER SUPPLY TO PFS
1200–WS–84L97596–AT75–0
PH–ME–P–0325–001
HP SEAWATER SUPPLY TO LQ
0600–WS–84L97488–AT75–4C
PH–ME–P–0324–001
OVERBOARD STREAM 2 TO HP TO HP SEAWATER DUMP CAISSON
PH–ME–P–0259–003
(DO NOT POCKET)
ESSENTIAL HP SEAWATER SUPPLY TO LQ
0300–WS–84L97623–AT75–4C
PH–ME–P–0324–001
COOLING MEDIUM SUPPLY TO VSD COOLER
0200–WC–45L94573–AD20–4C
PH–ME–P–0326–001
FROM ABB CONTROLLER IN 60–EN–9009
PH–ME–P–0326–001
0300–WS–84L97507–AT75–4C
OVERBOARD STREAM 1 TO HP TO HP SEAWATER DUMP CAISSON
PH–ME–P–0325–001
(NOTE 16)
COOLING MEDIUM RETURN FROM VSD COOLER
PH–ME–P–0326–001
0200–WC–45L94574–AS20–4C
0200–WS–84L97624–AT75–4C
0400–WS–84L97593–AT75–4C
0400–WS–84L97594–AT75–4C
0300–WS–84L97598–AT75–4C
0400–WS–84L97506–AT75–0
0400–WS–84L97505–AT75–0
0400–WS–84L97605–AT75–4C
0400–WS–84L97606–AT75–4C
3K4 BLOCKED DISCHARGE SET AT 10 BARG
PSV 93487
PSV 93488
HV 93487–03
HV 93487–01
HV 93488–03
HV 93488–01
PI 93234
PT 93234
FO 93232
FI 93233
FT 93233
TV 93233
(NOTE 12)
EL=49500
4C INS. SCH 10S
NO INS. SCH 80S
0200 THD. CPLG (TYP. 4)
ABOVE CELLAR DECK
CELLAR DECK
1400–WS–84L97480–AT75–0
FROM 84–CA–9129 HP SEAWATER FILTER
PH–ME–P–0259–005
SP 213 BACKFLOW PREVENTER
PH–S–1054
1200–WS–84L97483–AT75–0
0600–WS–84L97484–AT75–4C
NON–ESSENTIAL CONSUMERS
ESSENTIAL CONSUMERS
0600–WS–84L97597–AT75–4C
0800–WS–84L97627–AT75–4C
(NOTE 2)
(NOTE 10)
(NOTE 11)
(NOTE 14)
(NOTE 15)
(NOTE 17)
FROM FIREWATER RINGMAIN
0600–WS–84L97566–AT75–4C
PH–ME–P–0292–001
TO FIREWATER RINGMAIN
0800–WS–84L97487–AT75–4C
PH–ME–P–0292–001
OVERBOARD STREAM 2 TO HP SEAWATER DUMP CAISSON
0400–WS–84L97620–AT75–0
PH–ME–P–0259–003
OVERBOARD STREAM 2 TO HP SEAWATER DUMP CAISSON
0400–WS–84L97622–AT75–0
PH–ME–P–0259–003
1.5H3 BLOCKED DISCHARGE SET AT 16 BARG
PSV 93237
PSV 93238
HV 93237–03
HV 93237–01
HV 93238–03
HV 93238–01
XV 93618A
XV 93618B
FO 93618A
FO 93618B
0300–WS–84L97609–AT75–4C
0300–WS–84L97621–AT75–4C
TO EMERGENCY/ESSENTIAL GENERATOR A
0400–WS–84L97509–AT75–4C
PH–ME–P–0318–002
TO EMERGENCY/ESSENTIAL GENERATOR B
0400–WS–84L97510–AT75–4C
PH–ME–P–0319–002
TO UTILITY STATIONS
0600–WS–84L97486–AT75–4C
PH–ME–P–0310–004

NOTES:
1. KEY INTERLOCKED VALVES.
2. COMMISSIONING TIE–IN CONNECTIONS.
3. 84–PSV–93487/93488 AND 84–PT–93234 TO BE LOCATED AT SAME ELEVATION AS VSDCOOLER (EL. 49500mm).
4. GLOBE VALVE TO BE SET ON COMMISSIONING AND TO REMAIN IN POSITION WITH HANDWHEEL REMOVED.
5. DELETED.
6. DELETED.
7. DELETED.
8. DELETED.
9. DELETED.
10. MINIMIZE LENGTH.
11. VERTICAL RISE TO HIGH POINT. DO NOT POCKET.
12. MAGMETER. PROVIDE 5D UPSTREAM AND 2D DOWNSTREAM.
13. DELETED.
14. 84–FO–93232 IS A SAFETY REGISTER DEVICE.
15. FOR CHECK VALVE INTEGRITY TESTING.
16. LINE TO RISE MIN. 5M ABOVE 60–HB–9126 BEFORE TIE–IN.
17. 2507 SUPER DUPLEX VALVE.

Field for file specification:
Field for date and time :

A1

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
5	08SEP09	JDK	RE–ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
4	22MAY09	JS	RE–ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
3	14NOV08	JDK	RE–ISSUED FOR CONSTRUCTION	SRK	RK/JL/PS	SVS	
2	28APR08	JDK	RE–ISSUED FOR CONSTRUCTION	SRK	JC/JL/PS	SVS	
1	15APR08	JDK	RE–ISSUED FOR CONSTRUCTION	SRK	JC/JL/JB	RB	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SRK	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE–DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
SEAWATER DISTRIBUTION

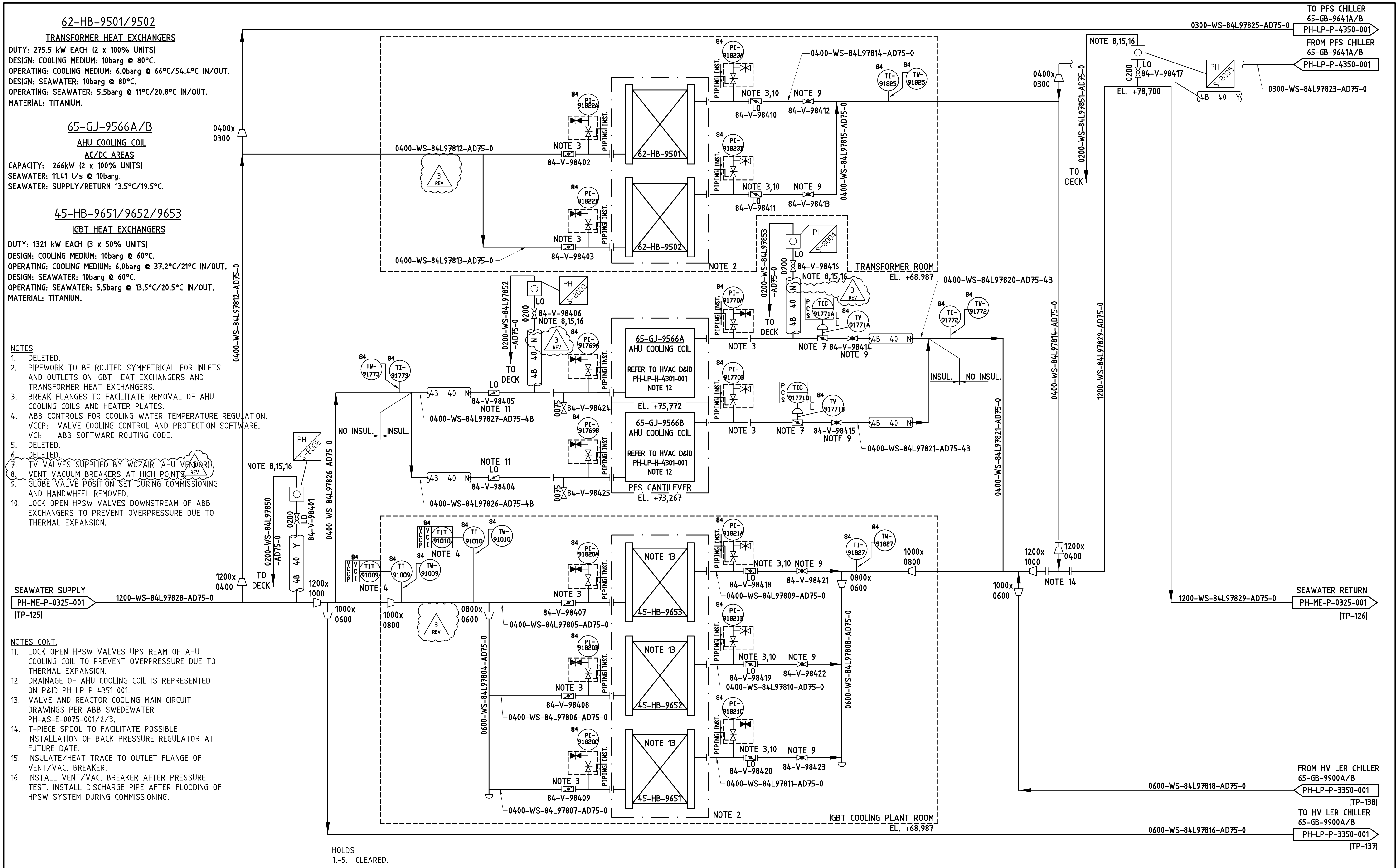
REGISTRATION CODES

AREA	SYSTEM	TYPE
T	84	XB

DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0259	002

SCALE NONE
REV. 5


0300-WS-84L97825-AD75-0
TO PFS CHILLER
65-GB-9641A/B
PH-LP-P-4350-001
FROM PFS CHILLER
65-GB-9641A/B
PH-LP-P-4350-001
0300-WS-84L97823-AD75-0
NOTE 8,15,16
0200
LO
84-V-98417
PH
S-8005
4B 40 Y
EL. +78,700
0400x
0300
0200-WS-84L97851-AD75-0
TO DECK
0400-WS-84L97814-AD75-0
1200-WS-84L97829-AD75-0
0400-WS-84L97812-AD75-0
0400-WS-84L97813-AD75-0
0400-WS-84L97814-AD75-0
0400-WS-84L97815-AD75-0
84
PI-
91822A
91822B
91823A
91823B
TI-
91825
TW-
91825
NOTE 3
84-V-98402
84-V-98403
PIPING INST.
62-HB-9501
62-HB-9502
NOTE 3,10
LO
84-V-98410
84-V-98411
NOTE 9
84-V-98412
84-V-98413
NOTE 2
TRANSFORMER ROOM
EL. +68.987
3
REV
0200-WS-84L97853
-AD75-0
PH
S-8004
84-V-98416
NOTE 8,15,16
TO DECK
4B 40 N
0400-WS-84L97820-AD75-4B
PI-
91770A
91770B
P C S
TIC
91771A
91771B
TV
91771A
91771B
NOTE 7
84-V-98414
84-V-98415
TI-
91772
TW-
91772
INSUL.
NO INSUL.
0400-WS-84L97821-AD75-4B
65-GJ-9566A
AHU COOLING COIL
REFER TO HVAC D&ID
PH-LP-H-4301-001
NOTE 12
EL. +75,772
65-GJ-9566B
AHU COOLING COIL
REFER TO HVAC D&ID
PH-LP-H-4301-001
NOTE 12
PFS CANTILEVER
EL. +73,267
PI-
91769A
91769B
0075
84-V-98424
84-V-98425
0200-WS-84L97852
-AD75-0
PH
S-8003
84-V-98406
NOTE 8,15,16
TO DECK
LO
84-V-98405
NOTE 11
84-V-98404
0400-WS-84L97827-AD75-4B
0400-WS-84L97826-AD75-4B
TW-
91773
TI-
91773
NO INSUL.
INSUL.
0400-WS-84L97826-AD75-0
PH
S-8002
NOTE 8,15,16
0200-WS-84L97850
-AD75-0
0200
LO
84-V-98401
4B 40 Y
TO DECK
1200x
0400
1200x
1000
SEAWATER SUPPLY
PH-ME-P-0325-001
(TP-125)
1200-WS-84L97828-AD75-0
1000x
0600
1000x
0800
V C C P
V C I
TIT
91009
91010
TT
91009
91010
TW-
91009
91010
NOTE 4
0800x
0600
0600-WS-84L97804-AD75-0
0400-WS-84L97805-AD75-0
0400-WS-84L97806-AD75-0
0400-WS-84L97807-AD75-0
PI-
91820A
91820B
91820C
NOTE 3
84-V-98407
84-V-98408
84-V-98409
NOTE 13
45-HB-9653
45-HB-9652
45-HB-9651
PI-
91821A
91821B
91821C
NOTE 3,10
NOTE 9
84-V-98418
84-V-98419
84-V-98420
84-V-98421
84-V-98422
84-V-98423
0400-WS-84L97809-AD75-0
0400-WS-84L97810-AD75-0
0400-WS-84L97811-AD75-0
0600-WS-84L97808-AD75-0
TI-
91827
TW-
91827
1000x
0800
0800x
0600
NOTE 2
IGBT COOLING PLANT ROOM
EL. +68.987
1200x
1000
1200x
0400
1000x
0600
NOTE 14
SEAWATER RETURN
PH-ME-P-0325-001
(TP-126)
FROM HV LER CHILLER
65-GB-9900A/B
PH-LP-P-3350-001
(TP-138)
0600-WS-84L97818-AD75-0
TO HV LER CHILLER
65-GB-9900A/B
PH-LP-P-3350-001
(TP-137)
0600-WS-84L97816-AD75-0

62-HB-9501/9502

TRANSFORMER HEAT EXCHANGERS

DUTY: 275.5 kW EACH (2 x 100% UNITS)
DESIGN: COOLING MEDIUM: 10barg @ 80°C.
OPERATING: COOLING MEDIUM: 6.0barg @ 66°C/54.4°C IN/OUT.
DESIGN: SEAWATER: 10barg @ 80°C.
OPERATING: SEAWATER: 5.5barg @ 11°C/20.8°C IN/OUT.
MATERIAL: TITANIUM.

65-GJ-9566A/B

AHU COOLING COIL

AC/DC AREAS

CAPACITY: 266kW (2 x 100% UNITS)
SEAWATER: 11.41 l/s @ 10barg.
SEAWATER: SUPPLY/RETURN 13.5°C/19.5°C.

45-HB-9651/9652/9653

IGBT HEAT EXCHANGERS

DUTY: 1321 kW EACH (3 x 50% UNITS)
DESIGN: COOLING MEDIUM: 10barg @ 60°C.
OPERATING: COOLING MEDIUM: 6.0barg @ 37.2°C/21°C IN/OUT.
DESIGN: SEAWATER: 10barg @ 60°C.
OPERATING: SEAWATER: 5.5barg @ 13.5°C/20.5°C IN/OUT.
MATERIAL: TITANIUM.

NOTES

1. DELETED.
2. PIPEWORK TO BE ROUTED SYMMETRICAL FOR INLETS AND OUTLETS ON IGBT HEAT EXCHANGERS AND TRANSFORMER HEAT EXCHANGERS.
3. BREAK FLANGES TO FACILITATE REMOVAL OF AHU COOLING COILS AND HEATER PLATES.
4. ABB CONTROLS FOR COOLING WATER TEMPERATURE REGULATION.
   VCCP: VALVE COOLING CONTROL AND PROTECTION SOFTWARE.
   VCI: ABB SOFTWARE ROUTING CODE.
5. DELETED.
6. DELETED.
7. TV VALVES SUPPLIED BY WOZAIR (AHU VENDOR).
8. VENT VACUUM BREAKERS AT HIGH POINTS.
9. GLOBE VALVE POSITION SET DURING COMMISSIONING AND HANDWHEEL REMOVED.
10. LOCK OPEN HPSW VALVES DOWNSTREAM OF ABB EXCHANGERS TO PREVENT OVERPRESSURE DUE TO THERMAL EXPANSION.

3
REV

NOTES CONT.

11. LOCK OPEN HPSW VALVES UPSTREAM OF AHU COOLING COIL TO PREVENT OVERPRESSURE DUE TO THERMAL EXPANSION.
12. DRAINAGE OF AHU COOLING COIL IS REPRESENTED ON P&ID PH-LP-P-4351-001.
13. VALVE AND REACTOR COOLING MAIN CIRCUIT DRAWINGS PER ABB SWEDEWATER PH-AS-E-0075-001/2/3.
14. T-PIECE SPOOL TO FACILITATE POSSIBLE INSTALLATION OF BACK PRESSURE REGULATOR AT FUTURE DATE.
15. INSULATE/HEAT TRACE TO OUTLET FLANGE OF VENT/VAC. BREAKER.
16. INSTALL VENT/VAC. BREAKER AFTER PRESSURE TEST. INSTALL DISCHARGE PIPE AFTER FLOODING OF HPSW SYSTEM DURING COMMISSIONING.

HOLDS

1.-5. CLEARED.

REV. No.	DESCRIPTION OF REVISION	ISSUE DATE	MADE BY	CHK'D BY	DISC. APPR.	PROJ APPR.	CLIENT APPR.	REV. No.	DESCRIPTION OF REVISION	ISSUE DATE	MADE BY	CHK'D BY	DISC. APPR.	PROJ APPR.	CLIENT APPR.
1	REISSUED FOR CONSTRUCTION	27.07.09	SW	JR	RJ	DED									
0	ISSUED FOR CONSTRUCTION	30.04.09	SW	JR	DED	AM									
D	REISSUED FOR AFD/CLIENT REVIEW (DCP-0720-P-760)	24.03.09	SW	JR	TOD	RW									
C	REISSUED FOR AFD/CLIENT REVIEW	19/01/09	SW	JR	TOD	RW									
B	ISSUED FOR AFD/CLIENT REVIEW (FOR HAZOP)	23/09/08	SW	RC	TOD	RD		3	REISSUED FOR CONSTRUCTION (DCP-0720-L-1871)	03/02/10	GO	RC	DED	AD	
A	ISSUED FOR IDC	02/07/08	LM	JM				2	REISSUED FOR CONSTRUCTION (DCP-0720-P-1362)	12.08.09	SW	RWJ	DED	DED	

VALHALL RE-DEVELOPMENT
PROJECT No. C06106

SLP ENGINEERING LTD
HAMILTON ROAD
LOWESTOFT
SUFFOLK, NR32 1XF

REFERENCE DRAWINGS:	DRAWING TITLE:
PH-ME-P-0101-001/2/3	PH LEGEND AND GENERAL SYMBOLS
PH-ME-P-0259-002	P & ID SEAWATER DISTRIBUTION
PH-LP-P-4350-001	P & ID PFS CHILLER PLANT
PH-LP-P-3350-001	P & ID HV LER CHILLER PLANT

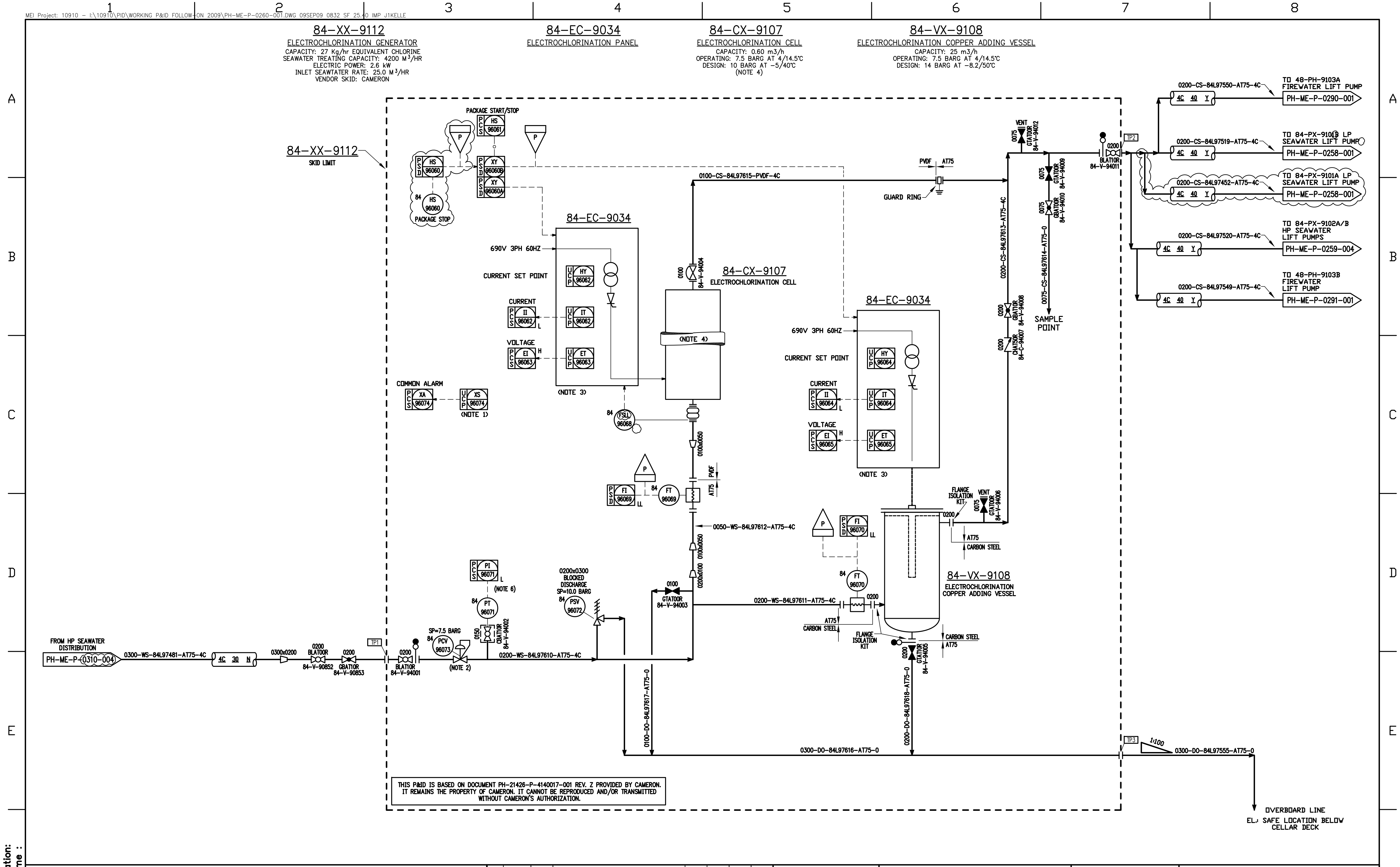
bp

P & ID
PFS SEA WATER COOLING

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	REV.
M	84	XB	PH	LP	P	4353	001	3

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0260-001.DWG 09SEP09 0832 SF 25.40 IMP J1KELLE


84-XX-9112
ELECTROCHLORINATION GENERATOR
CAPACITY: 27 Kg/hr EQUIVALENT CHLORINE
SEAWATER TREATING CAPACITY: 4200 M3/HR
ELECTRIC POWER: 2.6 kW
INLET SEAWTATER RATE: 25.0 M3/HR
VENDOR SKID: CAMERON
84-EC-9034
ELECTROCHLORINATION PANEL
84-CX-9107
ELECTROCHLORINATION CELL
CAPACITY: 0.60 m3/h
OPERATING: 7.5 BARG AT 4/14.5°C
DESIGN: 10 BARG AT -5/40°C
(NOTE 4)
84-VX-9108
ELECTROCHLORINATION COPPER ADDING VESSEL
CAPACITY: 25 m3/h
OPERATING: 7.5 BARG AT 4/14.5°C
DESIGN: 14 BARG AT -8.2/50°C
84-XX-9112
SKID LIMIT
PACKAGE START/STOP
HS 96061
HS 96060
84 HS 96060
PACKAGE STOP
XY 96060B
XY 96060A
P
84-EC-9034
690V 3PH 60HZ
CURRENT SET POINT
HY 96062
CURRENT
II 96062
IT 96062
VOLTAGE
EI 96063
ET 96063
(NOTE 3)
COMMON ALARM
XA 96074
XS 96074
(NOTE 1)
84-CX-9107
ELECTROCHLORINATION CELL
(NOTE 4)
0100 84-V-94004
0100-CS-84L97615-PVDF-4C
84 FSLL 96068
0100x0050
FI 96069
84 FT 96069
PVDF
AT75
0050-WS-84L97612-AT75-4C
0200x0100
0100x0050
84-EC-9034
690V 3PH 60HZ
CURRENT SET POINT
HY 96064
CURRENT
II 96064
IT 96064
VOLTAGE
EI 96065
ET 96065
(NOTE 3)
FI 96070
84 FT 96070
FLANGE ISOLATION KIT
VENT
0075 GTATOOR 84-V-94006
0200
AT75
CARBON STEEL
84-VX-9108
ELECTROCHLORINATION COPPER ADDING VESSEL
0200-WS-84L97611-AT75-4C
FLANGE ISOLATION KIT
0200 GTATIOR 84-V-94005
0200-DO-84L97618-AT75-0
GUARD RING
PVDF
AT75
VENT
0075 GTATOOR 84-V-94012
0075 GTATOOR 84-V-94009
0075 GBATOOR 84-V-94010
0075-CS-84L97614-AT75-0
SAMPLE POINT
0200-CS-84L97613-AT75-4C
0200 GBATIOR 84-V-94008
0200 CHATSOR 84-C-94007
0200 BLATIOR 84-V-94011
TP2
0200-CS-84L97550-AT75-4C
4C 40 Y
TO 48-PH-9103A FIREWATER LIFT PUMP
PH-ME-P-0290-001
0200-CS-84L97519-AT75-4C
TO 84-PX-9101B LP SEAWATER LIFT PUMP
PH-ME-P-0258-001
0200-CS-84L97452-AT75-4C
TO 84-PX-9101A LP SEAWATER LIFT PUMP
PH-ME-P-0258-001
0200-CS-84L97520-AT75-4C
TO 84-PX-9102A/B HP SEAWATER LIFT PUMPS
PH-ME-P-0259-004
0200-CS-84L97549-AT75-4C
TO 48-PH-9103B FIREWATER LIFT PUMP
PH-ME-P-0291-001
FROM HP SEAWATER DISTRIBUTION
PH-ME-P-0310-004
0300-WS-84L97481-AT75-4C
4C 30 N
0300x0200
0200 BLATOOR 84-V-90852
0200 GBATIOR 84-V-90853
TP1
0200 BLATIOR 84-V-94001
SP=7.5 BARG
84 PCV 96073
(NOTE 2)
PI 96071
(NOTE 6)
84 PT 96071
0150 CBATIOR 84-V-94002
0200-WS-84L97610-AT75-4C
0200x0300 BLOCKED DISCHARGE SP=10.0 BARG
84 PSV 96072
0100 GTATOOR 84-V-94003
0200x0100
0100-DO-84L97617-AT75-0
0300-DO-84L97616-AT75-0
TP3
1:100
0300-DO-84L97555-AT75-0
OVERBOARD LINE
EL: SAFE LOCATION BELOW CELLAR DECK
THIS P&ID IS BASED ON DOCUMENT PH-21426-P-4140017-001 REV. Z PROVIDED BY CAMERON. IT REMAINS THE PROPERTY OF CAMERON. IT CANNOT BE REPRODUCED AND/OR TRANSMITTED WITHOUT CAMERON'S AUTHORIZATION.

NOTES:

1. COMMON ALARM FROM UNIT CONTROL PANEL.
2. HASTELLOY.
3. UNIT CONTROL PANEL LOCATED IN ELECTRICAL EQUIPMENT ROOM.
4. SUITABLE FOR OPERATION AT -8.2 CELSIUS WITH INSULATION JACKET.
5. ALL ITEMS IN SKID BOUNDARY SUPPLIED BY VENDOR.
6. LOW PRESSURE ALARM 84-PAL-96071 WILL ALSO CLOSE POSING VALVES 84-XV-93202A/B, 84-XV-93472A/B & 48-XV-93541A/B. AUTO RESET OF POSING VALVES TO NORMAL CONTROL FUNCTION ON RE-ESTABLISHMENT OF NORMAL PRESSURE.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
5	08SEP09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
4	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
3	15OCT08	CDB	RE-ISSUED FOR CONSTRUCTION	SRK	RK/PS/JL	RAB	
2	28APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/PS	SVS	
1	15APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/JB	RB	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SRK	JC/ES/JB	SVS	

Field for file specification:
Field for date and time :

A1

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
ELECTROCHLORINATION GENERATOR

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
T	84	XB	PH	ME	P	0260	001	REV. 5

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0104-006.DWG 06OCT09 0830 SF 25.40 IMP J1KELLE

84-CS-9102A/B
HP SEAWATER LIFT PUMP
LUBE OIL COOLING UNITS

84-CB-9126A/B
FILLING FILTERS
GRADE: 7β≥1000μm REF. ISO16889

84-CB-9127A/B
DUPLEX FILTERS
GRADE: 12β≥1000μm REF. ISO16889

84-VX-9109A/B
ACCUMULATORS
VOLUME: 12 L
PRECHARGE PRESS.: 11 bar
DESIGN PRESSURE: 50 bar

84-PS-9101A/B
OIL CIRC. PUMPS
DIFF. PRESS.: 5 BAR
FLOW: 128 L/MIN.

84-PS-9101A/B-M01
OIL CIRC. PUMP MOTORS
VOLTAGE: 3 X 690 V / 60 Hz
RATING: 11 kW

84-PG-9102A/B
OIL PRESSURE PUMPS
FLOW RATE: 3.5 l/min.
PRESSURE: 15 barg

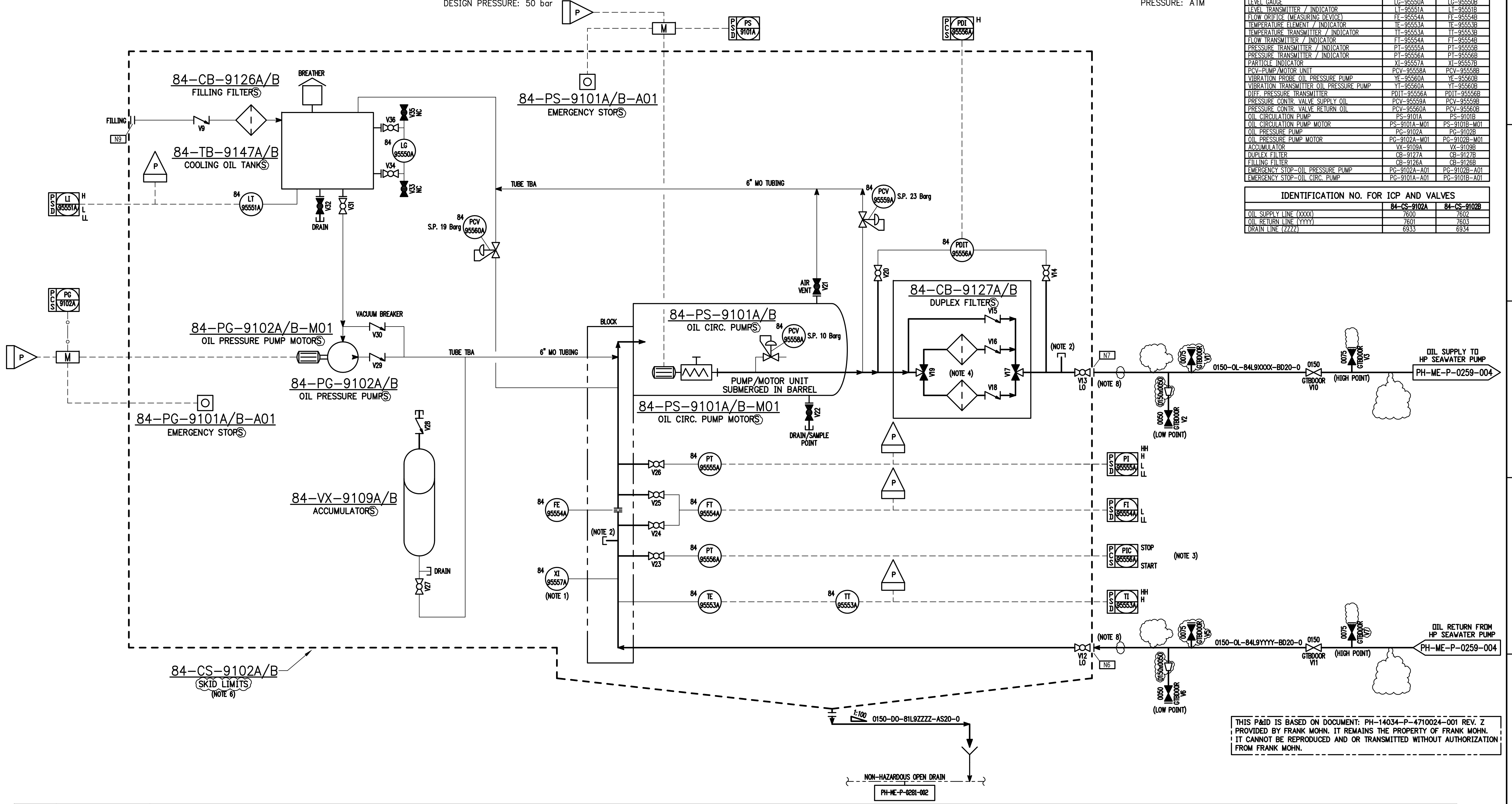
84-PG-9102A/B-M01
OIL PRESSURE. PUMP MOTORS
VOLTAGE: 3 X 690 V / 60 Hz
RATING: 0.9 kW

84-TB-9147A/B
COOLING OIL TANKS
TOTAL VOLUME: 165 L
OPER. VOLUME: 100 L
PRESSURE: ATM

(NOTE 6)

TAG NO. FOR ALL OIL CIRCULATION UNITS LISTED BELOW		
	TAG NUMBERS	TAG NUMBERS
OIL CIRCULATION UNIT	TAG NO. CS9102A	TAG NO. CS9102B
COOLING OIL TANK	TB-9147A	TB-9147B
LEVEL GAUGE	LG-95550A	LG-95550B
LEVEL TRANSMITTER / INDICATOR	LT-95551A	LT-95551B
FLOW ORIFICE (MEASURING DEVICE)	FE-95554A	FE-95554B
TEMPERATURE ELEMENT / INDICATOR	TE-95553A	TE-95553B
TEMPERATURE TRANSMITTER / INDICATOR	TT-95553A	TT-95553B
FLOW TRANSMITTER / INDICATOR	FT-95554A	FT-95554B
PRESSURE TRANSMITTER / INDICATOR	PT-95555A	PT-95555B
PRESSURE TRANSMITTER / INDICATOR	PT-95556A	PT-95556B
PARTICLE INDICATOR	XI-95557A	XI-95557B
PCV-PUMP/MOTOR UNIT	PCV-95558A	PCV-95558B
VIBRATION PROBE OIL PRESSURE PUMP	YE-95560A	YE-95560B
VIBRATION TRANSMITTER OIL PRESSURE PUMP	YT-95560A	YT-95560B
DIFF. PRESSURE TRANSMITTER	PDIT-95556A	PDIT-95556B
PRESSURE CONTR. VALVE SUPPLY OIL	PCV-95559A	PCV-95559B
PRESSURE CONTR. VALVE RETURN OIL	PCV-95560A	PCV-95560B
OIL CIRCULATION PUMP	PS-9101A	PS-9101B
OIL CIRCULATION PUMP MOTOR	PS-9101A-M01	PS-9101B-M01
OIL PRESSURE PUMP	PG-9102A	PG-9102B
OIL PRESSURE PUMP MOTOR	PG-9102A-M01	PG-9102B-M01
ACCUMULATOR	VX-9109A	VX-9109B
DUPLEX FILTER	CB-9127A	CB-9127B
FILLING FILTER	CB-9126A	CB-9126B
EMERGENCY STOP-OIL PRESSURE PUMP	PG-9102A-A01	PG-9102B-A01
EMERGENCY STOP-OIL CIRC. PUMP	PG-9101A-A01	PG-9101B-A01

IDENTIFICATION NO. FOR ICP AND VALVES		
	84-CS-9102A	84-CS-9102B
OIL SUPPLY LINE (XXXX)	7600	7602
OIL RETURN LINE (YYYY)	7601	7603
DRAIN LINE (ZZZZ)	6933	6934


P
M
PS 9101A
PDI 95556A
H
84-PS-9101A/B-A01
EMERGENCY STOPS
84-CB-9126A/B
FILLING FILTERS
BREATHER
FILLING
N9
V9
84-TB-9147A/B
COOLING OIL TANKS
V36
V35 NC
84 LG 95550A
V34
V33 NC
P
LI 95551A
H
L
LL
84 LT 95551A
V32
DRAIN
V31
TUBE TBA
84 PCV 95560A
S.P. 19 Barg
6" MO TUBING
84 PCV 95559A
S.P. 23 Barg
84 PDIT 95556A
V20
V14
PG 9102A
VACUUM BREAKER
V30
84-PG-9102A/B-M01
OIL PRESSURE PUMP MOTORS
V29
TUBE TBA
6" MO TUBING
BLOCK
84-PG-9102A/B
OIL PRESSURE PUMPS
84-PG-9101A/B-A01
EMERGENCY STOPS
AIR VENT
V21
84-PS-9101A/B
OIL CIRC. PUMPS
84 PCV 95558A
S.P. 10 Barg
PUMP/MOTOR UNIT SUBMERGED IN BARREL
84-PS-9101A/B-M01
OIL CIRC. PUMP MOTORS
V22
DRAIN/SAMPLE POINT
84-CB-9127A/B
DUPLEX FILTERS
V15
V16
V19
(NOTE 4)
V17
V18
(NOTE 2)
N7
V13 LO
(NOTE 8)
0075 GTBDOOR V1
0150-OL-84L9XXXX-BD20-0
0150 GTBDOOR V10
0075 GTBDOOR V3
(HIGH POINT)
OIL SUPPLY TO HP SEAWATER PUMP
PH-ME-P-0259-004
(0150x0050)
0050 GTBDOOR V2
(LOW POINT)
V28
84-VX-9109A/B
ACCUMULATORS
DRAIN
V27
V26
84 PT 95555A
P
PI 95555A
HH
H
L
LL
84 FE 95554A
V25
84 FT 95554A
P
FI 95554A
L
LL
V24
(NOTE 2)
V23
84 PT 95556A
PIC 95556A
STOP
START
(NOTE 3)
84 XI 95557A
(NOTE 1)
P
84 TE 95553A
84 TT 95553A
TI 95553A
HH
H
V12 LO
N6
(NOTE 8)
0075 GTBDOOR V5
0150-OL-84L9YYYY-BD20-0
0150 GTBDOOR V11
0075 GTBDOOR V7
(HIGH POINT)
OIL RETURN FROM HP SEAWATER PUMP
PH-ME-P-0259-004
(0150x0050)
0050 GTBDOOR V6
(LOW POINT)
84-CS-9102A/B
SKID LIMITS
(NOTE 6)
1:100
0150-DO-81L9ZZZZ-AS20-0
NON-HAZARDOUS OPEN DRAIN
PH-ME-P-0281-002

THIS P&ID IS BASED ON DOCUMENT: PH-14034-P-4710024-001 REV. Z PROVIDED BY FRANK MOHN. IT REMAINS THE PROPERTY OF FRANK MOHN. IT CANNOT BE REPRODUCED AND OR TRANSMITTED WITHOUT AUTHORIZATION FROM FRANK MOHN.

EQUIPMENT NO.	DESCRIPTION	MANUAL VALVES																																			
		V1	V2	V3	-	V5	V6	V7	-	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25	V26	V27	V28	V29	V30	V31	V32	V33	V34	V35	V36
84-CS-9102A	HP SW COOLING OIL PUMP SYSTEM	84-V-90956	84-V-90952	84-V-92994	-	84-V-92985	84-V-92986	84-V-92987	-	84-C-96583	84-V-97874	84-V-97876	84-V-96558	84-V-96559	84-V-96560	84-C-96561	84-C-96562	84-V-96563	84-C-96564	84-V-96565	84-V-96566	84-V-96567	81-V-96568	84-V-96569	84-V-96570	84-V-96571	84-V-96572	84-V-96573	84-C-96574	84-C-96575	84-C-96576	84-V-96577	81-V-96578	84-V-96579	84-V-96580	84-V-96581	84-V-96582
84-CS-9102B	HP SW COOLING OIL PUMP SYSTEM	84-V-90957	84-V-90953	84-V-92995	-	84-V-92989	84-V-92990	84-V-92991	-	84-C-97319	84-V-97875	84-V-97877	84-V-96584	84-V-96585	84-V-96586	84-C-96587	84-C-96588	84-V-96589	84-C-96590	84-V-96591	84-V-96592	84-V-96593	81-V-96594	84-V-96595	84-V-96596	84-V-96597	84-V-96598	84-V-96599	84-C-97310	84-C-97311	84-C-97312	84-V-97313	81-V-97314	84-V-97315	84-V-97316	84-V-97317	84-V-97318

NOTES:
1. MAGNETIC PARTICLE DETECTOR. CAN BE CHECKED IN RUNNING CONDITION. LOCAL INDICATION ONLY.
2. T "MINIMESS" TEST CONNECTION.
3. START/STOP OF OIL PRESSURE PUMP 84-PG-9102 A/B MOTOR.
4. FILTER ELEMENT CAN BE CHANGED IN STAND BY AND RUNNING MODE.
5. DELETED.
6. INSTRUMENT TAGS SHOWN ARE FOR PUMP A ONLY. FOR PUMP B TAGS HAVE SUFFIX "B".
7. DELETED.
8. SAE 3000 PSI MATING FLANGES, PROVIDED BY VENDOR.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
2	06OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
1	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
0	30OCT08	JDK	ISSUED FOR CONSTRUCTION	SRK	RK/JL/PS	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
HP SW COOLING OIL PUMP SYSTEM

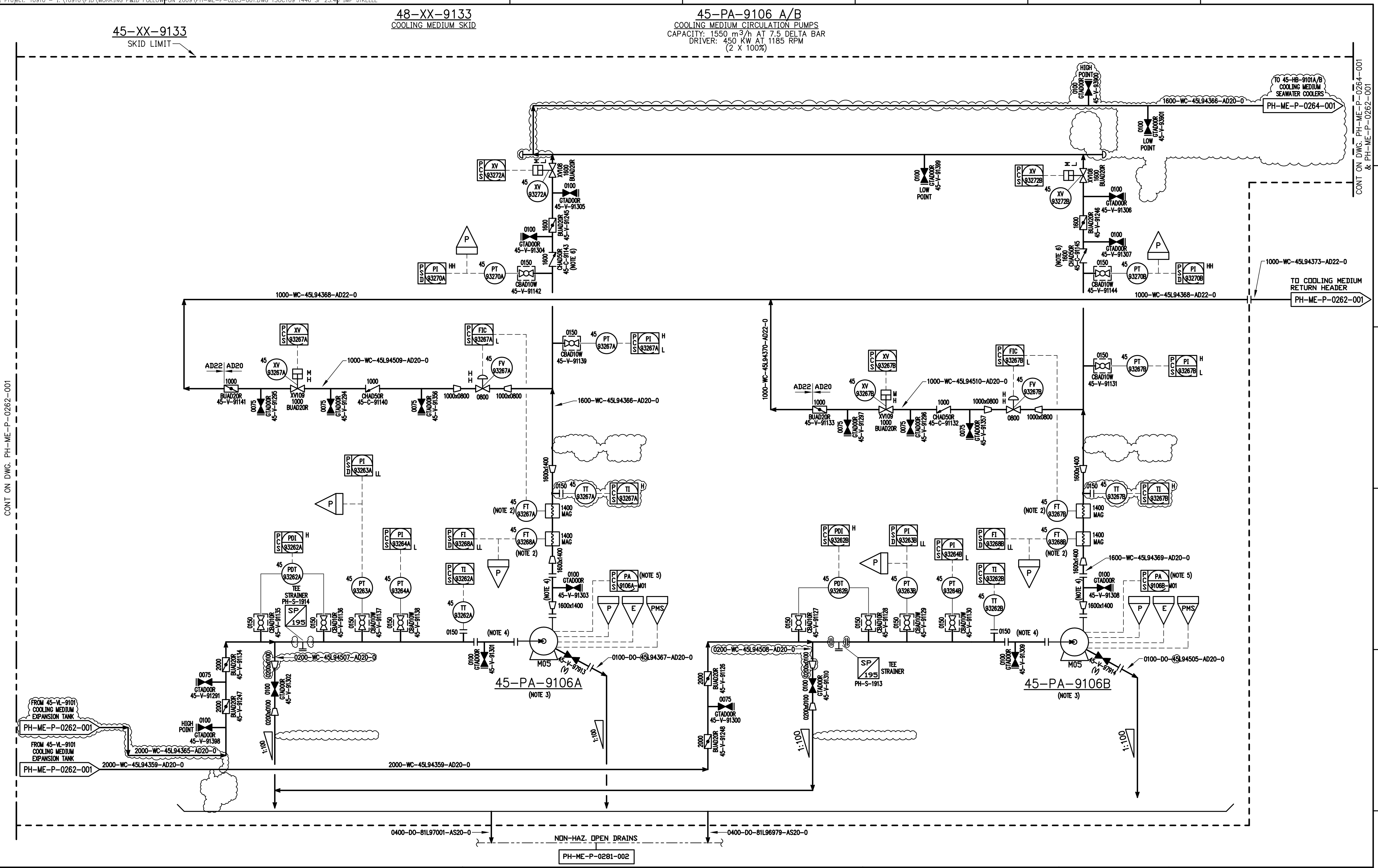
REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
U12-02	84	XB	PH	ME	P	0104	006	REV. 2

Field for file specification:
Field for date and time :

A1

Field for file specification:
Field for date and time :

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0263-001.DWG 15OCT09 1446 SF 25.40 IMP JIKELLE


45-XX-9133
SKID LIMIT
48-XX-9133
COOLING MEDIUM SKID
45-PA-9106 A/B
COOLING MEDIUM CIRCULATION PUMPS
CAPACITY: 1550 m³/h AT 7.5 DELTA BAR
DRIVER: 450 KW AT 1185 RPM
(2 X 100%)
CONT ON DWG. PH-ME-P-0262-001
CONT ON DWG. PH-ME-P-0264-001 & PH-ME-P-0262-001
TO 45-HB-9101A/B COOLING MEDIUM SEAWATER COOLERS
PH-ME-P-0264-001
1600-WC-45L94366-AD20-0
TO COOLING MEDIUM RETURN HEADER
PH-ME-P-0262-001
1000-WC-45L94373-AD22-0
1000-WC-45L94368-AD22-0
1000-WC-45L94370-AD22-0
1000-WC-45L94509-AD20-0
1000-WC-45L94510-AD20-0
1600-WC-45L94366-AD20-0
1600-WC-45L94369-AD20-0
FROM 45-VL-9101 COOLING MEDIUM EXPANSION TANK
PH-ME-P-0262-001
2000-WC-45L94365-AD20-0
2000-WC-45L94359-AD20-0
0200-WC-45L94507-AD20-0
0200-WC-45L94508-AD20-0
0100-DO-45L94367-AD20-0
0100-DO-45L94505-AD20-0
0400-DO-81L97001-AS20-0
0400-DO-81L96979-AS20-0
NON-HAZ. OPEN DRAINS
PH-ME-P-0281-002
45-PA-9106A
(NOTE 3)
45-PA-9106B
(NOTE 3)
M05
TEE STRAINER PH-S-1914
TEE STRAINER PH-S-1913
XV 93272A
XV 93272B
XV 93267A
XV 93267B
FIC 93267A
FIC 93267B
FV 93267A
FV 93267B
FT 93267A
FT 93267B
FT 93268A
FT 93268B
TI 93267A
TI 93267B
TI 93262A
TI 93262B
PI 93270A HH
PI 93270B HH
PI 93267A
PI 93267B
PI 93263A LL
PI 93263B LL
PI 93264A L
PI 93264B L
PDI 93262A H
PDI 93262B H
FI 93268A LL
FI 93268B LL
PA 9106A-M01 (NOTE 5)
PA 9106B-M01 (NOTE 5)
P
E
PMS
1400 MAG
(NOTE 2)
(NOTE 4)
(NOTE 6)
HIGH POINT
LOW POINT
1:100
45-V-91134
45-V-91247
45-V-91291
45-V-91398
45-V-91302
45-V-91135
45-V-91136
45-V-91137
45-V-91138
45-V-91301
45-V-91303
45-V-91141
45-V-91295
45-V-91294
45-C-91140
45-V-91356
45-V-91139
45-V-91142
45-V-91304
45-C-91143
45-V-91245
45-V-91305
45-V-91399
45-V-93900
45-V-93901
45-V-91126
45-V-91300
45-V-91248
45-V-91310
45-V-91127
45-V-91128
45-V-91129
45-V-91130
45-V-91309
45-V-91308
45-V-91133
45-V-91297
45-V-91296
45-C-91132
45-V-91357
45-V-91131
45-V-91144
45-C-91145
45-V-91307
45-V-91246
45-V-91306
45-V-97913
45-V-97914

NOTES:

1. TEMPORARY TOTE CONNECTION FOR DRAINING COOLING MEDIUM.
2. ELECTROMAGNETIC FLOWMETERS BETWEEN CONCENTRIC REDUCERS. PROVIDE STRAIGHT RUN OF 0D/0D PIPE DIAMETERS.
3. FOR CONDITION MONITORING INSTRUMENTATION SEE DRAWING PH-ME-P-0107-002/003.
4. REMOVABLE MAINENANCE SPOOL.
5. STANDBY PUMP TO START AUTOMATICALLY UPON MAIN PUMP FAILURE.
6. NON-SLAM CHECK VALVE.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
2	01OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/PS/JK	SVS	
1	15APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/JB	RB	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SRK	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
COOLING MEDIUM CIRC. PUMPS

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
U12-02	45	XB	PH	ME	P	0263	001	REV. 4

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0290-001.DWG 09SEP09 0818 SF 25.40 IMP J1KELLE

48-HB-9106A
FWP HYDR. OIL / JACKET WATER HEAT EXCHANGER

	HOT SIDE	COLD SIDE	HOT SIDE
MEDIUM	HYDR. OIL ISO VG32	SEA WATER	FRESH WATER
DUTY (KW)	213	1583	1370
TEMP. (°C)	55	16	95
DESIGN PRESS.	16	16	16
FLOW Kg/S	24	14	13.9

48-PH-9103A
FIREWATER LIFT PUMP

DUTY RATING: 628 kW
DUTY FLOW: 2300 m^3/h
DIFF. HEAD: 67 m

48-DD-9101A
FIREWATER PUMP DIESEL ENGINE

RATING: 2105 kW
TYPE: MTU 16V4000
SPEED (RPM): 1850

48-VL-9105A
FWP SURGE TANK

VOLUME: 352 L
DESIGN PRESS.: 19 barg

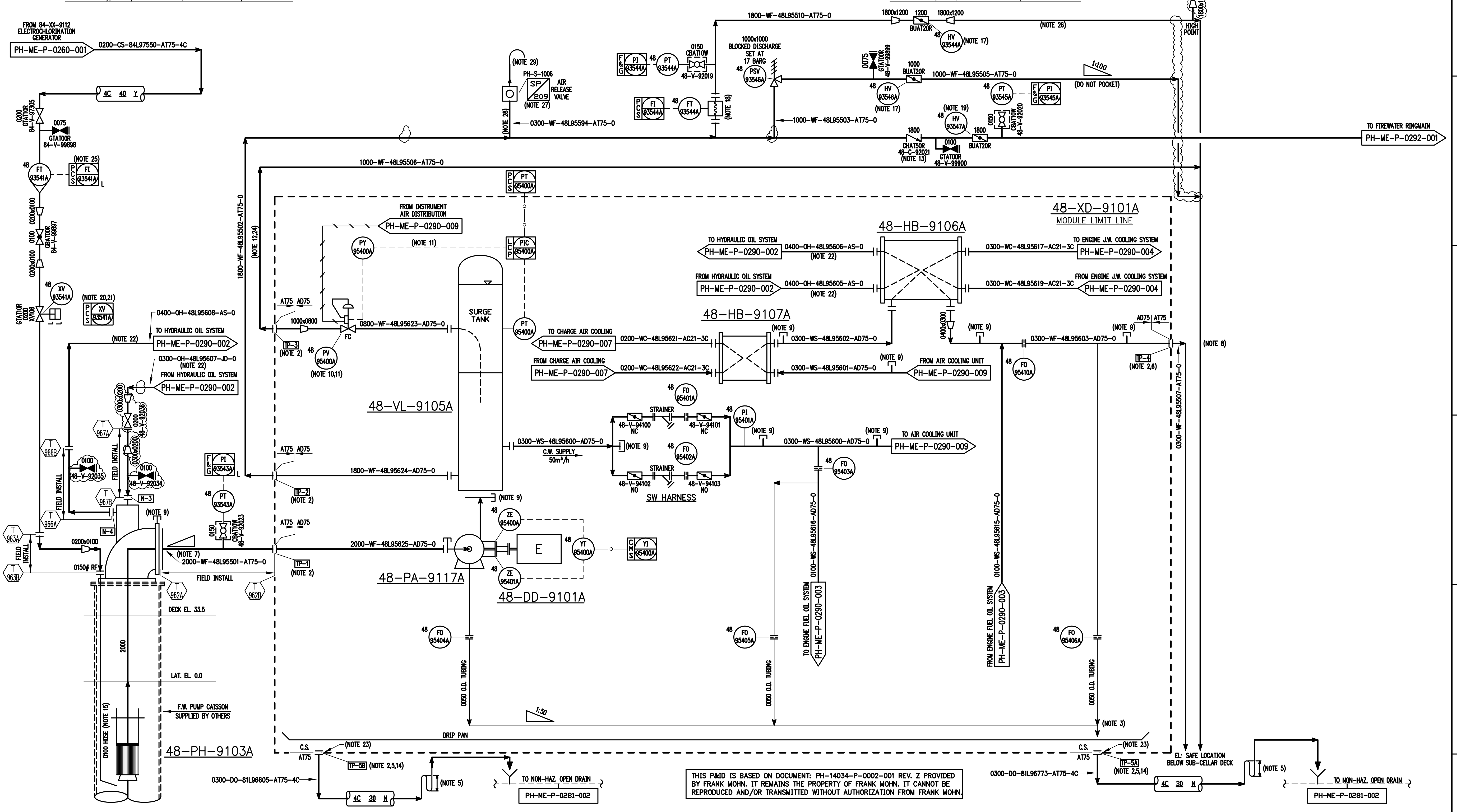
48-PA-9117A
FIREWATER BOOSTER PUMP

DUTY RATING: 1109 kW
DUTY FLOW: 2300 m^3/h
DIFF. HEAD: 110 m

48-HB-9107A
FWP CHARGE AIR HEAT EXCHANGER

	COLD SIDE	HOT SIDE
MEDIUM	SEA WATER	FRESH WATER
DUTY (KW)	380	380
TEMP. (°C)	16	95
DESIGN PRESS.	16	16
FLOW m^3/h	13	37

48-XD-9101A
FIREWATER PUMP PACKAGE A


FROM 84-XX-9112 ELECTROCHLORINATION GENERATOR
PH-ME-P-0260-001
0200-CS-84L97550-AT75-4C
4C 40 Y
0200 GTATIOR 84-V-97305
0075 GTATOOR 84-V-99898
FT 93541A
FI 93541A
(NOTE 25)
0200x0100
0100 GBATOOR 84-V-99897
XV 93541A
(NOTE 20,21)
GTATIOR 0200 XV106
0400-OH-48L95608-AS-0
TO HYDRAULIC OIL SYSTEM
PH-ME-P-0290-002
(NOTE 22)
0300-OH-48L95607-JD-0
FROM HYDRAULIC OIL SYSTEM
PH-ME-P-0290-002
0300x0200
0200 48-V-92036
0100 48-V-92035
0100 48-V-92034
T 967A
T 966B
T 967B
T 966A
T 963A
T 963B
T 962A
T 962B
N-3
N-4
FIELD INSTALL
0150# RF
(NOTE 7)
2000-WF-48L95501-AT75-0
(NOTE 9)
PI 93543A
PT 93543A
0150 CBATIOW 48-V-92023
DECK EL. 33.5
LAT. EL. 0.0
2000
0100 HOSE (NOTE 15)
F.W. PUMP CAISSON SUPPLIED BY OTHERS
48-PH-9103A
1800-WF-48L95502-AT75-0
(NOTE 12,24)
1000-WF-48L95506-AT75-0
0300-WF-48L95594-AT75-0
(NOTE 28)
(NOTE 29)
PH-S-1006
SP 209
AIR RELEASE VALVE
(NOTE 27)
PI 93544A
PT 93544A
0150 CBATIOW 48-V-92019
FI 93544A
FT 93544A
(NOTE 18)
1800-WF-48L95510-AT75-0
1000x1000 BLOCKED DISCHARGE SET AT 17 BARG
PSV 93546A
1000-WF-48L95503-AT75-0
0075 GTATOOR 48-V-99899
1000 BUAT20R
1000-WF-48L95505-AT75-0
HV 93546A
(NOTE 17)
1800x1200
1200 BUAT20R
HV 93544A
(NOTE 26)
1:100
(DO NOT POCKET)
PT 93545A
PI 93545A
0150 CBATIOW 48-V-92020
HV 93547A
(NOTE 19)
1800 CHAT50R 48-C-92021 (NOTE 13)
0100 GTATOOR 48-V-99900
1800 BUAT20R
HIGH POINT
1800x1000
1000-VA-48L95511-AT75-0
TO FIREWATER RINGMAIN
PH-ME-P-0292-001
FROM INSTRUMENT AIR DISTRIBUTION
PH-ME-P-0290-009
PY 95400A
(NOTE 11)
PT 95400A
PIC 95400A
AT75 AD75
1000x0800
TP-3
(NOTE 2)
PV 95400A
(NOTE 10,11)
FC
0800-WF-48L95623-AD75-0
SURGE TANK
48-VL-9105A
1800-WF-48L95624-AD75-0
TP-2
2000-WF-48L95625-AD75-0
TP-1
48-PA-9117A
ZE 95400A
ZE 95401A
E
YT 95400A
YI 95400A
48-DD-9101A
48-XD-9101A
MODULE LIMIT LINE
48-HB-9106A
TO HYDRAULIC OIL SYSTEM
0400-OH-48L95606-AS-0
FROM HYDRAULIC OIL SYSTEM
0400-OH-48L95605-AS-0
TO ENGINE J.W. COOLING SYSTEM
0300-WC-48L95617-AC21-3C
PH-ME-P-0290-004
FROM ENGINE J.W. COOLING SYSTEM
0300-WC-48L95619-AC21-3C
48-HB-9107A
TO CHARGE AIR COOLING
PH-ME-P-0290-007
0200-WC-48L95621-AC21-3C
FROM CHARGE AIR COOLING
0200-WC-48L95622-AC21-3C
0300-WS-48L95602-AD75-0
0300-WS-48L95601-AD75-0
FROM AIR COOLING UNIT
0400x0300
0300-WF-48L95603-AD75-0
FO 95410A
TP-4
(NOTE 2,6)
(NOTE 8)
0300-WF-48L95507-AT75-0
0300-WS-48L95600-AD75-0
C.W. SUPPLY 50m³/h
STRAINER
48-V-94100 NC
48-V-94101 NC
48-V-94102 NO
48-V-94103 NO
FO 95401A
FO 95402A
PI 95401A
SW HARNESS
TO AIR COOLING UNIT
FO 95403A
TO ENGINE FUEL OIL SYSTEM
PH-ME-P-0290-003
0100-WS-48L95616-AD75-0
FROM ENGINE FUEL OIL SYSTEM
0100-WS-48L95615-AD75-0
FO 95404A
FO 95405A
FO 95406A
0050 O.D. TUBING
1:50
DRIP PAN
(NOTE 3)
C.S. AT75
(NOTE 23)
TP-5B
(NOTE 2,5,14)
0300-DO-81L96605-AT75-4C
4C 30 N
(NOTE 5)
TO NON-HAZ. OPEN DRAIN
PH-ME-P-0281-002
TP-5A
0300-DO-81L96773-AT75-4C
EL: SAFE LOCATION BELOW SUB-CELLAR DECK

THIS P&ID IS BASED ON DOCUMENT: PH-14034-P-0002-001 REV. Z PROVIDED BY FRANK MOHN. IT REMAINS THE PROPERTY OF FRANK MOHN. IT CANNOT BE REPRODUCED AND/OR TRANSMITTED WITHOUT AUTHORIZATION FROM FRANK MOHN.

NOTES:

1. FOR INSTRUMENT LIST REF. VENDOR DWG: PH-14034-I-0001 (1674-002-4).
2. TP-X REFERS TO MODULE GEN. ARR. DWG. PH-14034-R-0004-001 (1674-024-3).
3. FOR DRAINAGE OF COOLING WATER SYSTEM AT STANDBY TO OPEN DRAIN INSIDE ENCLOSURE. WATERLOCK TUBE INSTALLED IN DOWNSTREAM PIPING.
4. MATERIALS: FIREWATER PIPING: UNS-S32750 (25Cr); COOLING WATER PIPING: SUPER DUPLEX (25Cr) UPSTREAM HEAT EXCHANGER/TITANIUM DOWNSTREAM HEAT EXCHANGER; LIFT PUMP: SUPER DUPLEX S.S. (25Cr); BOOSTER PUMP: SUPER DUPLEX (25Cr); SURGE TANK: SUPER DUPLEX (25Cr); DRAIN PIPING: TITANIUM; BUTTERFLY VALVES AND STRAINERS IN S.W. HARNESS: DUCTILE IRON WITH PTFE LINING.
5. WATERLOCK TO BE INCLUDED IN DRAIN PIPING TO MAINTAIN 50 Pa OVERPRESSURE IN THE MODULE.
6. TO NON-HAZARDOUS OVERBOARD DRAIN BACK PRESSURE DESIGN CRITERIA 0,5 BARG.
7. INTERCONNECTING FW PIPE TO BE PREFERABLY SLOPED. WATER TRAP TO BE AVOIDED.
8. PREVENT CONNECTION TO OTHER COOLING WATER SYSTEM TO AVOID BACKFLOW AT STAND-BY.
9. PLUGGED TEST CONNECTION.
10. COMBINED 8" MIN. FLOW AND AIR RELEASE/VACUUM BREAKER VALVE.
11. 48-PV-95400A WILL GO TO A PARTIAL OPEN PRESET POSITION UPON START AND STOP SIGNAL. AT PUMP RUNNING THE PV-VALVE WILL START TO OPEN AT A PRESSURE CORRESPONDING TO REQ. MINIMUM FLOW.
12. ROUTE PIPE TO VENTED DRAIN CASSION. VALVE 48-PV-95400A WILL OPEN AND ACT AS SYSTEM VACUUM BREAKER AT PUMP STOP.
13. CHECK VALVE SHOULD BE LOCATED AS CLOSE AS POSSIBLE TO ENCLOSURE WALL.
14. TO NON-HAZARDOUS OPEN DRAIN.
15. HYPOCLORITE LINE MADE FROM CHEMICAL HOSE WITH TITANIUM NOZZLE AND TOP FLANGE.
16. DELETED.
17. KEY LOCKED VALVE.
18. MAGMETER, PROVIDE STRAIGHT RUN OF 5D UPSTREAM AND 2D DOWNSTREAM.
19. KEY INTERLOCKED VALVE.
20. VALVE XV-93541A TO CLOSE WHEN FIREWATER LIFT PUMP STOPS. VALVE WILL OPEN PERIODICALLY IN AUTOMATIC CONTROL TO ALLOW INJECTION OF HYPOCHLORITE SOLUTION INTO CASSION.
21. VALVE XV-93541A TO OPEN WHEN FIREWATER LIFT PUMP STARTS.
22. HYDRAULIC PIPING IS SUPPLIER'S STANDARD PIPE SPEC. SEE PH-ME-P-0290-002 FOR MORE DETAIL.
23. PACKAGE DRIP PAN DRAIN FLANGES ARE CARBON STEEL.
24. PIPEWORK TO RISE MINIMUM OF 5M ABOVE PV-95400A.
25. REFER TO DOCUMENT VRD-ME-P-0042 FOR OPERATING DETAILS.
26. PIPEWORK TO RISE MINIMUM OF 5M DOWNSTREAM OF HV-93544A.
27. AIR RELEASE VALVE/VACUUM BREAKER TO BE MOUNTED VERTICALLY.
28. LOCATE AT HIGHEST POSSIBLE LOCATION AND AS CLOSE TO THE CHECK VALVE AS POSSIBLE.
29. VENT TO SAFE LOCATION.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
5	08SEP09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
4	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
3	14NOV08	CDB	RE-ISSUED FOR CONSTRUCTION	SRK	RK/JL/PS	SVS	
2	28APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/PS	SVS	
1	15APR08	JDK	RE-ISSUED FOR CONSTRUCTION	SRK	JC/JL/JB	RB	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SRK	JC/ES/JB	SVS	

Wood Group Engineering (North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
FIREWATER & SEAWATER COOLING SYSTEM

REGISTRATION CODES

AREA	SYSTEM	TYPE
U12-02	48	XB

DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	SCALE	REV.
PH	ME	P	0290	001	NONE	5

A1

Field for file specification:
Field for date and time :

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0291-001.DWG 09SEP09 1112 SF 25.40 IMP J1KELLE

48–PH–9103B
FIREWATER LIFT PUMP
DUTY RATING: 628 kW
DUTY FLOW: 2300 m3/h
DIFF. HEAD: 67 m

48–DD–9101B
FIREWATER PUMP DIESEL ENGINE
RATING: 2105 kW
TYPE: MTU 16V4000
SPEED (RPM): 1850

48–PA–9117B
FIREWATER BOOSTER PUMP
DUTY RATING: 1109 kW
DUTY FLOW: 2300 m 3/h
DIFF. HEAD: 110 m

48–VL–9105B
FWP SURGE TANK
VOLUME: 352 L
DESIGN PRESS.: 19 barg

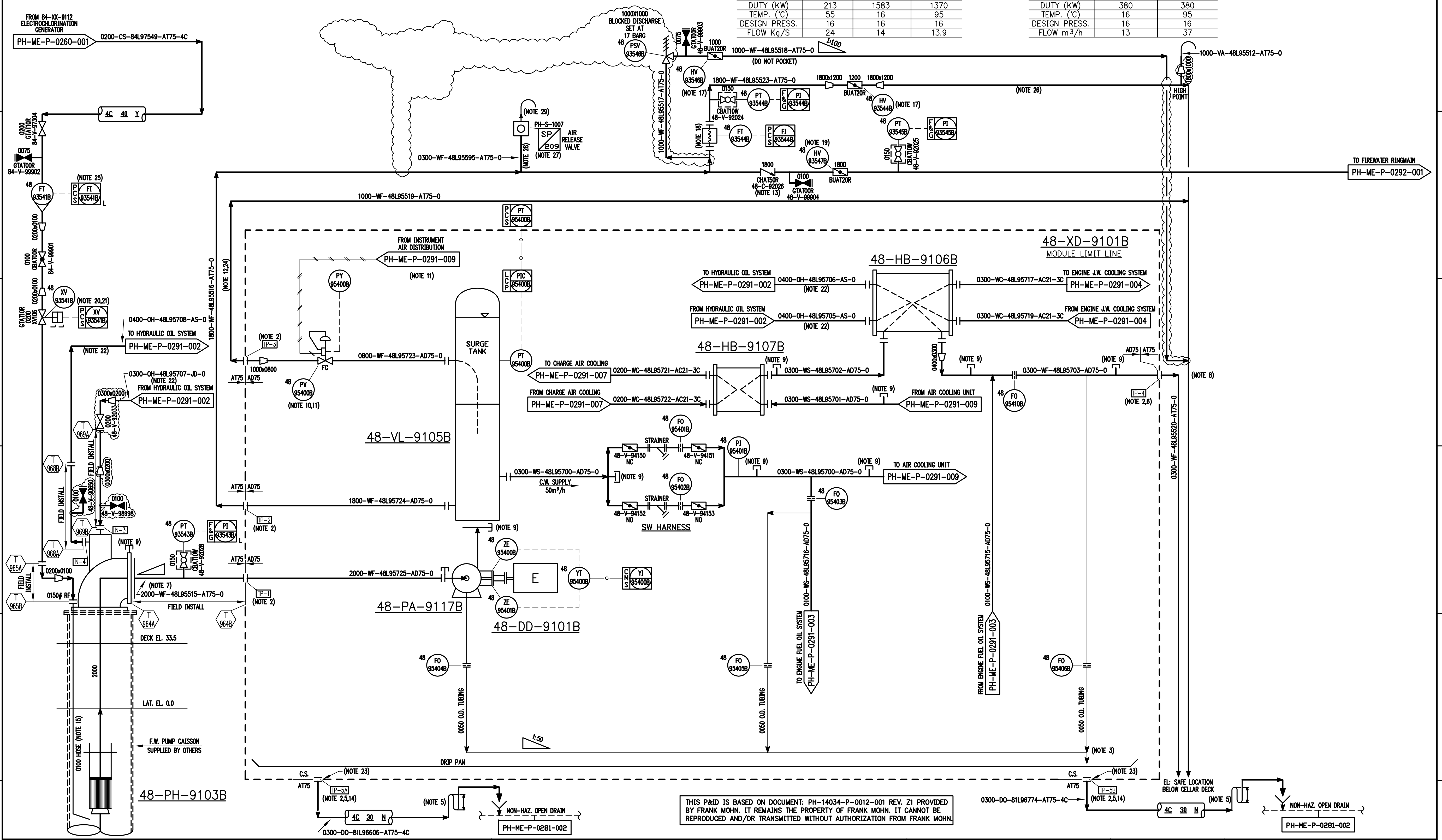
48–HB–9106B
FWP HYDR. OIL / JACKET WATER HEAT EXCHANGER

	HOT SIDE	COLD SIDE	HOT SIDE
MEDIUM	HYDR. OIL ISO VG32	SEA WATER	FRESH WATER
DUTY (KW)	213	1583	1370
TEMP. (°C)	55	16	95
DESIGN PRESS.	16	16	16
FLOW Kg/S	24	14	13.9

48–HB–9107B
FWP CHARGE AIR HEAT EXCHANGER

	COLD SIDE	HOT SIDE
MEDIUM	SEA WATER	FRESH WATER
DUTY (KW)	380	380
TEMP. (°C)	16	95
DESIGN PRESS.	16	16
FLOW m3/h	13	37

48–XD–9101B
FIREWATER PUMP PACKAGE B


1
2
3
4
5
6
7
8
A
B
C
D
E
FROM 84-XX-9112 ELECTROCHLORINATION GENERATOR
PH-ME-P-0260-001
0200-CS-84L97549-AT75-4C
4C 40 Y
0200 GTATIOR 84-V-97304
0075 GTATOOR 84-V-99902
48 FT 93541B
PCS FI 93541B
(NOTE 25)
0200x0100
0100 GBATOOR 84-V-99901
0200x0100
0200 GTATIOR XY106
48 XV 93541B
PCS XV 93541B
(NOTE 20,21)
0400-OH-48L95708-AS-0
TO HYDRAULIC OIL SYSTEM
PH-ME-P-0291-002
(NOTE 22)
0300-OH-48L95707-JD-0
FROM HYDRAULIC OIL SYSTEM
0300x0200
0200 48-V-92033
969A
968B
968A
969B
FIELD INSTALL
0100 48-V-90650
0100 48-V-99998
N-3
N-4
965A
965B
0200x0100
0150 RF
964A
964B
(NOTE 7)
2000-WF-48L95515-AT75-0
(NOTE 9)
48 PT 93543B
FG PI 93543B
0150 CBATIOW 48-V-92028
DECK EL. 33.5
LAT. EL. 0.0
2000
0100 HOSE (NOTE 15)
F.W. PUMP CAISSON SUPPLIED BY OTHERS
48–PH–9103B
1800-WF-48L95516-AT75-0
(NOTE 12,24)
1000-WF-48L95519-AT75-0
0300-WF-48L95595-AT75-0
1000X1000 BLOCKED DISCHARGE SET AT 17 BARG
48 PSV 93546B
(NOTE 29)
PH-S-1007
SP 209
AIR RELEASE VALVE
(NOTE 28)
(NOTE 27)
0075 GTATOOR 48-V-99903
1000 BUAT20R
1000-WF-48L95518-AT75-0
(DO NOT POCKET)
1:100
48 HV 93546B
(NOTE 17)
1800-WF-48L95523-AT75-0
1000-WF-48L95517-AT75-0
0150 CBATIOW 48-V-92024
48 PT 93544B
FG PI 93544B
(NOTE 18)
48 FT 93544B
PCS FI 93544B
1800x1200
1200 BUAT20R
1800x1200
48 HV 93544B
48 PT 93545B
FG PI 93545B
0150 CBATIOW 48-V-92025
(NOTE 19)
48 HV 93547B
1800 CHAT50R 48-C-92026 (NOTE 13)
0100 GTATOOR 48-V-99904
1800 BUAT20R
(NOTE 26)
1000-VA-48L95512-AT75-0
1800x1000
HIGH POINT
TO FIREWATER RINGMAIN
PH-ME-P-0292-001
PCS PT 95400B
FROM INSTRUMENT AIR DISTRIBUTION
PH-ME-P-0291-009
PY 95400B
(NOTE 11)
LCP PIC 95400B
(NOTE 2)
TP-3
1000x0800
AT75 AD75
48 PV 95400B
FC
(NOTE 10,11)
0800-WF-48L95723-AD75-0
SURGE TANK
48 PT 95400B
48–VL–9105B
1800-WF-48L95724-AD75-0
TP-2
(NOTE 2)
AT75 AD75
2000-WF-48L95725-AD75-0
TP-1
(NOTE 2)
(NOTE 9)
48 ZE 95400B
48 ZE 95401B
E
48 YT 95400B
CMS YI 95400B
48–PA–9117B
48–DD–9101B
0300-WS-48L95700-AD75-0
C.W. SUPPLY 50m3/h
48-V-94150 NC
48-V-94151 NC
48-V-94152 NO
48-V-94153 NO
STRAINER
SW HARNESS
48 FO 95401B
48 FO 95402B
48 PI 95401B
TO AIR COOLING UNIT
PH-ME-P-0291-009
48 FO 95403B
TO ENGINE FUEL OIL SYSTEM
PH-ME-P-0291-003
0100-WS-48L95716-AD75-0
FROM ENGINE FUEL OIL SYSTEM
0100-WS-48L95715-AD75-0
TO CHARGE AIR COOLING
PH-ME-P-0291-007
0200-WC-48L95721-AC21-3C
FROM CHARGE AIR COOLING
0200-WC-48L95722-AC21-3C
48–HB–9107B
0300-WS-48L95702-AD75-0
0300-WS-48L95701-AD75-0
FROM AIR COOLING UNIT
TO HYDRAULIC OIL SYSTEM
0400-OH-48L95706-AS-0
FROM HYDRAULIC OIL SYSTEM
0400-OH-48L95705-AS-0
48–HB–9106B
TO ENGINE J.W. COOLING SYSTEM
PH-ME-P-0291-004
0300-WC-48L95717-AC21-3C
FROM ENGINE J.W. COOLING SYSTEM
0300-WC-48L95719-AC21-3C
48–XD–9101B
MODULE LIMIT LINE
0400x0300
0300-WF-48L95703-AD75-0
48 FO 95410B
TP-4
(NOTE 2,6)
AD75 AT75
(NOTE 8)
0300-WF-48L95520-AT75-0
48 FO 95404B
48 FO 95405B
48 FO 95406B
0050 O.D. TUBING
1:50
DRIP PAN
(NOTE 3)
C.S.
AT75
(NOTE 23)
TP-5A
(NOTE 2,5,14)
4C 30 N
0300-DO-81L96606-AT75-4C
(NOTE 5)
NON-HAZ. OPEN DRAIN
PH-ME-P-0281-002
TP-5B
0300-DO-81L96774-AT75-4C
EL: SAFE LOCATION BELOW CELLAR DECK

THIS P&ID IS BASED ON DOCUMENT: PH-14034-P-0012-001 REV. Z1 PROVIDED BY FRANK MOHN. IT REMAINS THE PROPERTY OF FRANK MOHN. IT CANNOT BE REPRODUCED AND/OR TRANSMITTED WITHOUT AUTHORIZATION FROM FRANK MOHN.

Field for file specification:
Field for date and time :

NOTES:

1. FOR INSTRUMENT LIST REF VENDOR DWG: PH-14034-I-0001 (1674-002-4).
2. TP-X REFERS TO MODULE GEN. ARR. DWG. PH-14034-R-0030-001 (1674-114-1).
3. FOR DRAINAGE OF COOLING WATER SYSTEM AT STANDBY TO OPEN DRAIN INSIDE ENCLOSURE. WATERLOCK TUBE INSTALLED IN DOWNSTREAM PIPING.
4. MATERIALS: FIREWATER PIPING: UNS-S32750 (25Cr); COOLING WATER PIPING: SUPER DUPLEX (25Cr) UPSTREAM HEAT EXCHANGER/TITANIUM DOWNSTREAM HEAT EXCHANGER; LIFT PUMP: SUPER DUPLEX S.S. (25Cr); BOOSTER PUMP: SUPER DUPLEX (25Cr); SURGE TANK: SUPER DUPLEX (25Cr); DRAIN PIPING: TITANIUM; BUTTERFLY VALVES AND STRAINERS IN S.W. HARNESS: DUCTILE IRON WITH PTFE LINING.
5. WATERLOCK TO BE INCLUDED IN DRAIN PIPING TO MAINTAIN 50 Pa. OVERPRESSURE IN THE MODULE.
6. TO NON-HAZARDOUS OVERBOARD DRAIN BACK PRESSURE DESIGN CRITERIA 0,5 BARG.
7. INTERCONNECTING FW PIPE TO BE PREFERABLY SLOPED. WATER TRAP TO BE AVOIDED.
8. PREVENT CONNECTION TO OTHER COOLING WATER SYSTEM TO AVOID BACKFLOW AT STAND-BY.
9. PLUGGED TEST CONNECTION.
10. COMBINED 8" MIN. FLOW AND AIR RELEASE/VACUUM BREAKER VALVE.
11. 48-PV-95400B WILL GO TO A PARTIAL OPEN PRESET POSITION UPON START AND STOP SIGNAL. AT PUMP RUNNING THE PV-VALVE WILL START TO OPEN AT A PRESSURE CORRESPONDING TO REQ. MINIMUM FLOW.
12. ROUTE PIPE TO VENTED DRAIN CASSION. VALVE 48-PV-95400B WILL OPEN AND ACT AS SYSTEM VACUUM BREAKER AT PUMP STOP.
13. CHECK VALVE SHOULD BE LOCATED AS CLOSE AS POSSIBLE TO ENCLOSURE WALL.
14. TO NON-HAZARDOUS OPEN DRAIN.
15. HYPOCLORITE LINE MADE FROM CHEMICAL HOSE WITH TITANIUM NOZZLE AND TOP FLANGE.
16. DELETED.
17. KEY LOCKED VALVE.
18. MAGMETER, PROVIDE STRAIGHT RUN OF 5D UPSTREAM AND 2D DOWNSTREAM.
19. KEY INTERLOCKED VALVE.
20. VALVE XV-93541A TO CLOSE WHEN FIREWATER LIFT PUMP STOPS. VALVE WILL OPEN PERIODICALLY IN AUTOMATIC CONTROL TO ALLOW INJECTION OF HYPOCHLORITE SOLUTION INTO CASSION.
21. VALVE XV-93541A TO OPEN WHEN FIREWATER LIFT PUMP STARTS.
22. HYDRAULIC PIPING IS SUPPLIER'S STANDARD PIPE SPEC. SEE PH-ME-P-0290-002 FOR MORE DETAIL.
23. PACKAGE DRIP PAN DRAIN FLANGES ARE CARBON STEEL.
24. PIPEWORK TO RISE MINIMUM OF 5M ABOVE PV-95400A.
25. REFER TO DOCUMENT VRD-ME-P-0042 FOR OPERATING DETAILS.
26. PIPEWORK TO RISE MINIMUM OF 5M DOWNSTREAM OF HV-93544A.
27. AIR RELEASE VALVE/VACUUM BREAKER TO BE MOUNTED VERTICALLY.
28. LOCATE AT HIGHEST POSSIBLE LOCATION AND AS CLOSE TO THE CHECK VALVE AS POSSIBLE.
29. VENT TO SAFE LOCATION.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
5	08SEP09	JDK	RE–ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
4	22MAY09	JDK	RE–ISSUED FOR CONSTRUCTION	SRK	RK/JB/JL	GMK	
3	14NOV08	CDB	RE–ISSUED FOR CONSTRUCTION	SRK	RK/JL/PS	SVS	
2	28APR08	JDK	RE–ISSUED FOR CONSTRUCTION	SRK	JC/JL/PS	SVS	
1	15APR08	JDK	RE–ISSUED FOR CONSTRUCTION	SRK	JC/JL/JB	RB	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SRK	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

VALHALL
RE–DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
FIREWATER & SEAWATER COOLING SYSTEM

REGISTRATION CODES

AREA	SYSTEM	TYPE
U12-02	48	XB

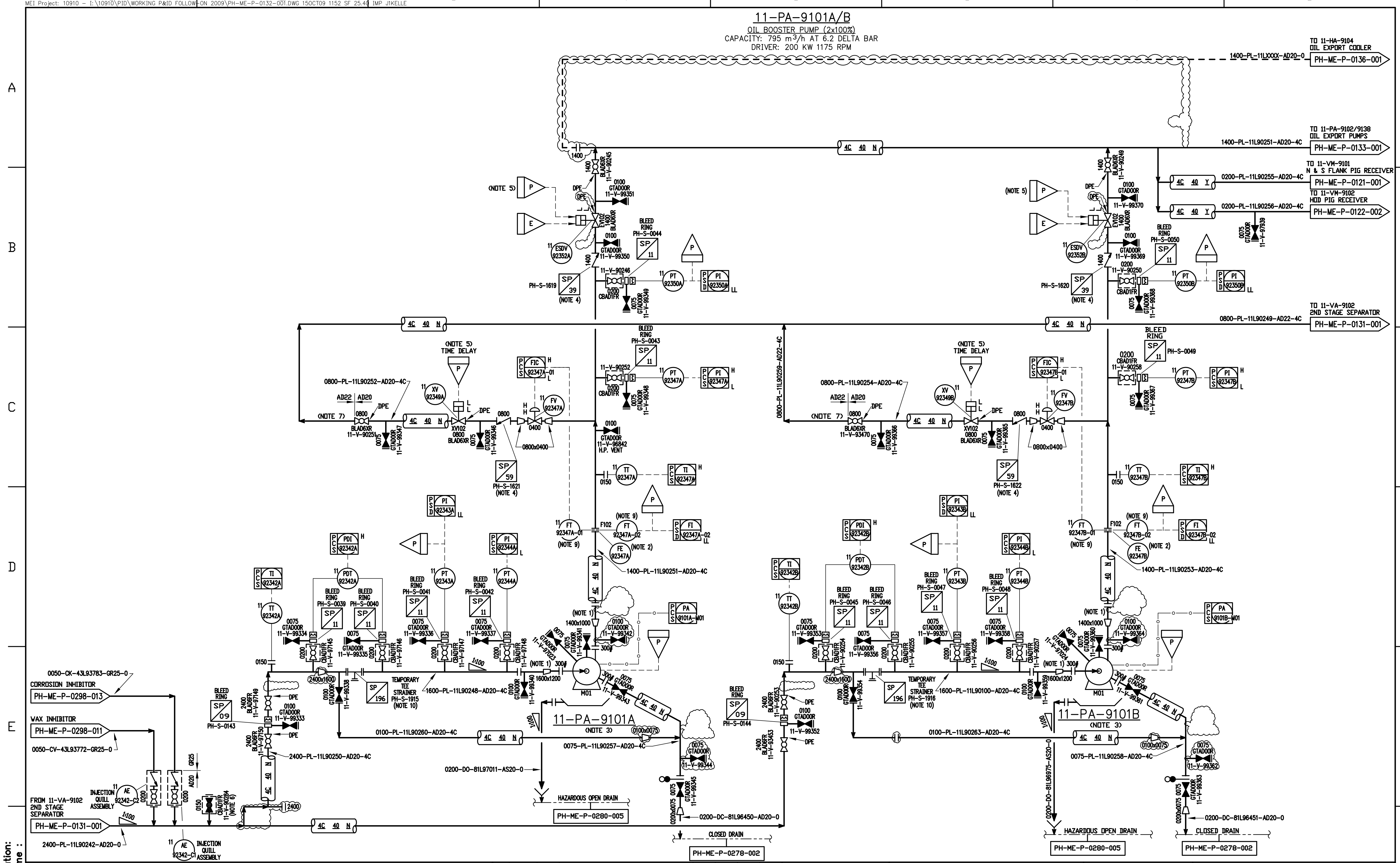
DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0291	001

SCALE NONE
REV. 5

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0132-001.DWG 15OCT09 1152 SF 25.40 IMP J1KELLE


11-PA-9101A/B
OIL BOOSTER PUMP (2x100%)
CAPACITY: 795 m3/h AT 6.2 DELTA BAR
DRIVER: 200 KW 1175 RPM
TO 11-HA-9104
OIL EXPORT COOLER
1400-PL-11LXXXX-AD20-0
PH-ME-P-0136-001
TO 11-PA-9102/9138
OIL EXPORT PUMPS
1400-PL-11L90251-AD20-4C
PH-ME-P-0133-001
TO 11-VM-9101
N & S FLANK PIG RECEIVER
0200-PL-11L90255-AD20-4C
PH-ME-P-0121-001
TO 11-VM-9102
HOD PIG RECEIVER
0200-PL-11L90256-AD20-4C
PH-ME-P-0122-002
TO 11-VA-9102
2ND STAGE SEPARATOR
0800-PL-11L90249-AD22-4C
PH-ME-P-0131-001
ESDV 92352A
ESDV 92352B
EV102
PT 92350A
PT 92350B
PI 92350A
PI 92350B
XV 92349A
XV 92349B
FIC 92347A-01
FIC 92347B-01
FV 92347A
FV 92347B
PT 92347A
PT 92347B
TT 92347A
TT 92347B
FT 92347A-01
FT 92347A-02
FT 92347B-01
FT 92347B-02
FE 92347A
FE 92347B
0800-PL-11L90252-AD20-4C
0800-PL-11L90254-AD20-4C
0800-PL-11L90259-AD22-4C
1400-PL-11L90251-AD20-4C
1400-PL-11L90253-AD20-4C
(NOTE 5) TIME DELAY
(NOTE 7)
H.P. VENT
PDT 92342A
PDT 92342B
PT 92343A
PT 92343B
PT 92344A
PT 92344B
TT 92342A
TT 92342B
PA 9101A-M01
PA 9101B-M01
M01
TEMPORARY TEE STRAINER PH-S-1915 (NOTE 10)
TEMPORARY TEE STRAINER PH-S-1916 (NOTE 10)
1600-PL-11L90248-AD20-4C
1600-PL-11L90100-AD20-4C
0100-PL-11L90260-AD20-4C
0100-PL-11L90263-AD20-4C
0075-PL-11L90257-AD20-4C
0075-PL-11L90258-AD20-4C
11-PA-9101A (NOTE 3)
11-PA-9101B (NOTE 3)
0200-DO-81L97011-AS20-0
0200-DO-81L96975-AS20-0
HAZARDOUS OPEN DRAIN
PH-ME-P-0280-005
0200-DC-81L96450-AD20-0
0200-DC-81L96451-AD20-0
CLOSED DRAIN
PH-ME-P-0278-002
0050-CK-43L93783-GR25-0
CORROSION INHIBITOR
PH-ME-P-0298-013
WAX INHIBITOR
PH-ME-P-0298-011
0050-CV-43L93772-GR25-0
FROM 11-VA-9102
2ND STAGE SEPARATOR
PH-ME-P-0131-001
2400-PL-11L90242-AD20-0
2400-PL-11L90250-AD20-4C
INJECTION QUILL ASSEMBLY
AE 92342-C1
AE 92342-C2
4C 40 N
4C 40 Y

NOTES:
1. REMOVABLE MAINTENANCE SPOOL.
2. CONDITIONING ORIFICE PLATE. PROVIDE STRAIGHT RUN OF 2D UPSTREAM AND 2D DOWNSTREAM. MOUNT IN VERTICAL POSITION, FLOW UP.
3. FOR CONDITION MONITORING INSTRUMENTATION, SEE DWG. PH-ME-P-0107-006 AND PH-ME-P-0107-007.
4. NON-SLAM AXIAL FLOW CHECK VALVE. LOCATE AS CLOSE AS POSSIBLE TO PUMP DISCHARGE.
5. XV-92349A/B AND ESDV-92352A/B TO AUTOMATICALLY CLOSE WHEN CORRESPONDING PUMP STOPS AND TO AUTOMATICALLY OPEN WHEN CORRESPONDING PUMP STARTS.
6. CONNECTION FOR FUTURE TRUE VAPOR PRESSURE ANALYZER RETURN LINE.
7. HEAVY WALL PIPE USED DOWNSTREAM OF CONTROL VALVE 11-FV-92347A/B FOR NOISE ATTENUATION.
8. DELETED.
9. TWO 0050 SIZE FLANGED GATE VALVES, GTADOOR, FOR EACH OF: 11-FT-92347A-01/02, 11-FT-92347B-01/02 (TOTAL 8 VALVES) - BY PIPING (SEE DETAIL F102 ON P&ID PH-ME-P-0102-001).
10. REMOVE THESE TEMPORARY STRAINERS, AS SOON AS PDI'S SHOW NO PRESSURE RISE FOR 30 DAYS, AND STRAINERS HAVE BEEN IN SERVICE FOR 90 DAYS OR MORE. OIL BOOSTER PUMP NPSHA IS OTHERWISE LIMITED.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	CC	RK/JB/JL	GMK	
2	15OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RM	RK/PS/JL	RAB	
1	04APR08	JDK	RE-ISSUED FOR CONSTRUCTION	RM	JC/PS	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SD	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
OIL BOOSTER PUMPS

REGISTRATION CODES

AREA	SYSTEM	TYPE
T13-02	11	XB

DRAWING NO.

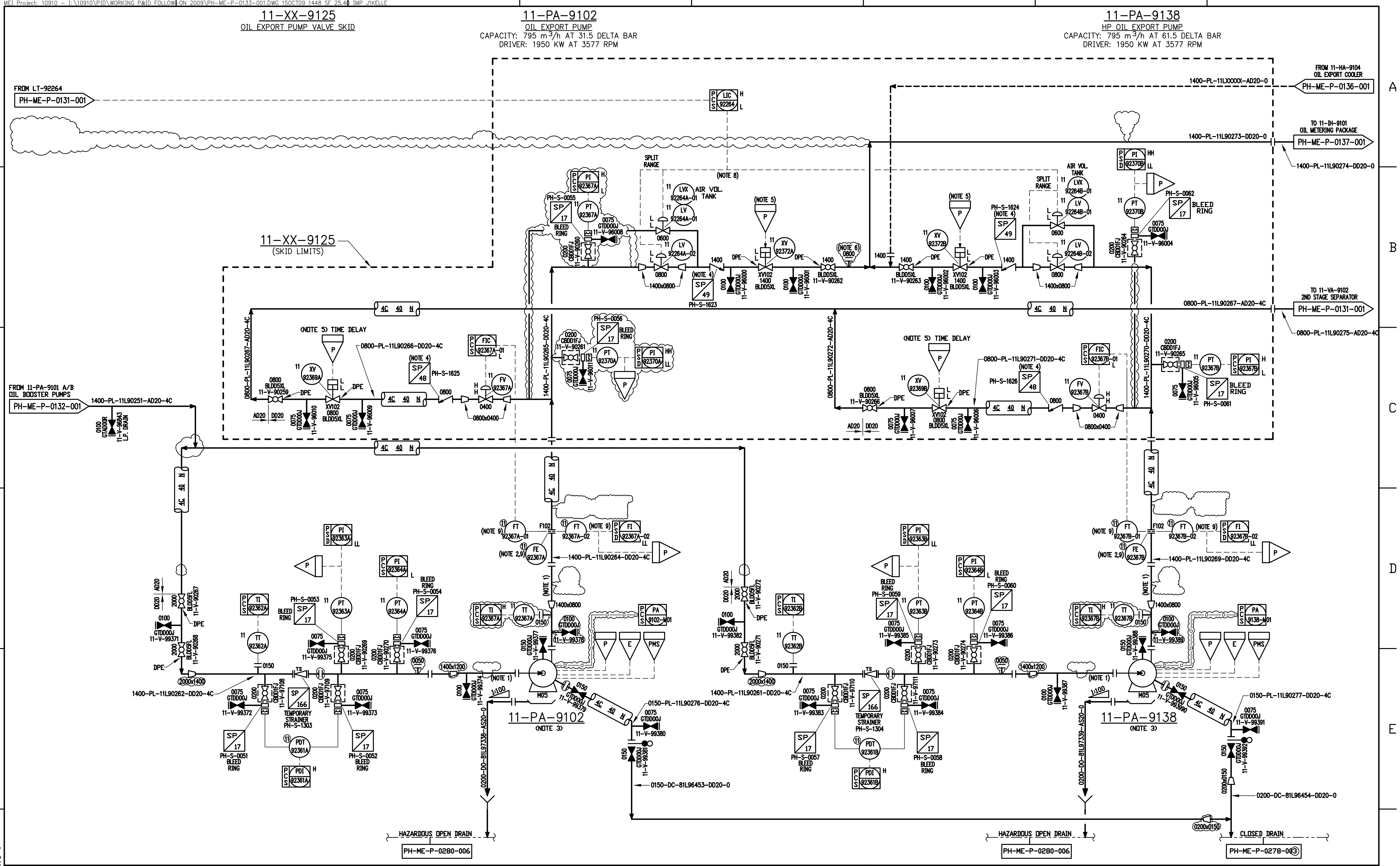
FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	SCALE
PH	ME	P	0132	001	NONE

REV. 4

A1

Field for file specification:
Field for date and time :

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0133-001.DWG 16OCT09 1448 SF 25.40 IMP JIKELLE


11-XX-9125
OIL EXPORT PUMP VALVE SKID
11-PA-9102
OIL EXPORT PUMP
CAPACITY: 795 m³/h AT 31.5 DELTA BAR
DRIVER: 1950 KW AT 3577 RPM
11-PA-9138
HP OIL EXPORT PUMP
CAPACITY: 795 m³/h AT 61.5 DELTA BAR
DRIVER: 1950 KW AT 3577 RPM
FROM LT-92264
PH-ME-P-0131-001
FROM 11-HA-9104
OIL EXPORT COOLER
PH-ME-P-0136-001
1400-PL-11LXXXXX-AD20-0
TO 11-IH-9101
OIL METERING PACKAGE
PH-ME-P-0137-001
1400-PL-11L90273-DD20-0
1400-PL-11L90274-DD20-0
TO 11-VA-9102
2ND STAGE SEPARATOR
PH-ME-P-0131-001
0800-PL-11L90267-AD20-4C
0800-PL-11L90275-AD20-4C
11-XX-9125
(SKID LIMITS)
FROM 11-PA-9101 A/B
OIL BOOSTER PUMPS
PH-ME-P-0132-001
1400-PL-11L90251-AD20-4C
11-V-96843
L.P. DRAIN
SPLIT RANGE
AIR VOL. TANK
(NOTE 5) TIME DELAY
(NOTE 8)
(NOTE 4)
(NOTE 6)
1400-PL-11L90265-DD20-4C
1400-PL-11L90270-DD20-4C
0800-PL-11L90266-DD20-4C
0800-PL-11L90271-DD20-4C
0800-PL-11L90272-AD20-4C
1400-PL-11L90264-DD20-4C
1400-PL-11L90269-DD20-4C
1400-PL-11L90262-DD20-4C
1400-PL-11L90261-DD20-4C
TEMPORARY STRAINER PH-S-1303
TEMPORARY STRAINER PH-S-1304
BLEED RING
11-PA-9102
(NOTE 3)
11-PA-9138
(NOTE 3)
0150-PL-11L90276-DD20-4C
0150-PL-11L90277-DD20-4C
0150-DC-81L96453-DD20-0
0200-DC-81L96454-DD20-0
0200-DO-81L97338-AS20-0
0200-DO-81L97339-AS20-0
HAZARDOUS OPEN DRAIN
PH-ME-P-0280-006
HAZARDOUS OPEN DRAIN
PH-ME-P-0280-006
CLOSED DRAIN
PH-ME-P-0278-00③

Field for file specification:
Field for date and time :

NOTES:

1. REMOVABLE MAINTENANCE SPOOL.
2. CONDITIONING ORIFICE PLATE. PROVIDE STRAIGHT RUN OF 2D UPSTREAM AND 2D DOWNSTREAM. MOUNT IN VERTICAL PIPE, FLOW UP.
3. FOR CONDITION MONITORING INSTRUMENTATION, SEE DWG. PH-ME-P-0107-008 AND PH-ME-P-0107-009.
4. NON-SLAM AXIAL CHECK VALVE. LOCATE AS CLOSE AS POSSIBLE TO PUMP DISCHARGE.
5. XV-92369A/B AND XV-92372A/B TO AUTOMATICALLY CLOSE WHEN CORRESPONDING PUMP SHUTS DOWN, AND TO AUTOMATICALLY OPEN WHEN CORRESPONDING PUMP STARTS.
6. FUTURE PSV CONNECTION.
7. DELETED.
8. A/B VALVE SET TO BE SELECTED BY PUMP RUNNING STATUS.
9. TWO 0050 SIZE FLANGED GATE VALVES, GTDD00J, FOR EACH OF: 11-FT-92367A-01/02, 11-FT-92367B-01/02, (TOTAL 8 VALVES) - BY PIPING. (SEE DETAIL F102 ON P&ID PH-ME-P-0102-001).

A1

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	CC	RK/JB/JL	GMK	
2	15OCT08	JAB	RE-ISSUED FOR CONSTRUCTION	RM	RK/PS/JL	RAB	
1	04APR08	JDK	RE-ISSUED FOR CONSTRUCTION	RM	JC/PS	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	SD	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

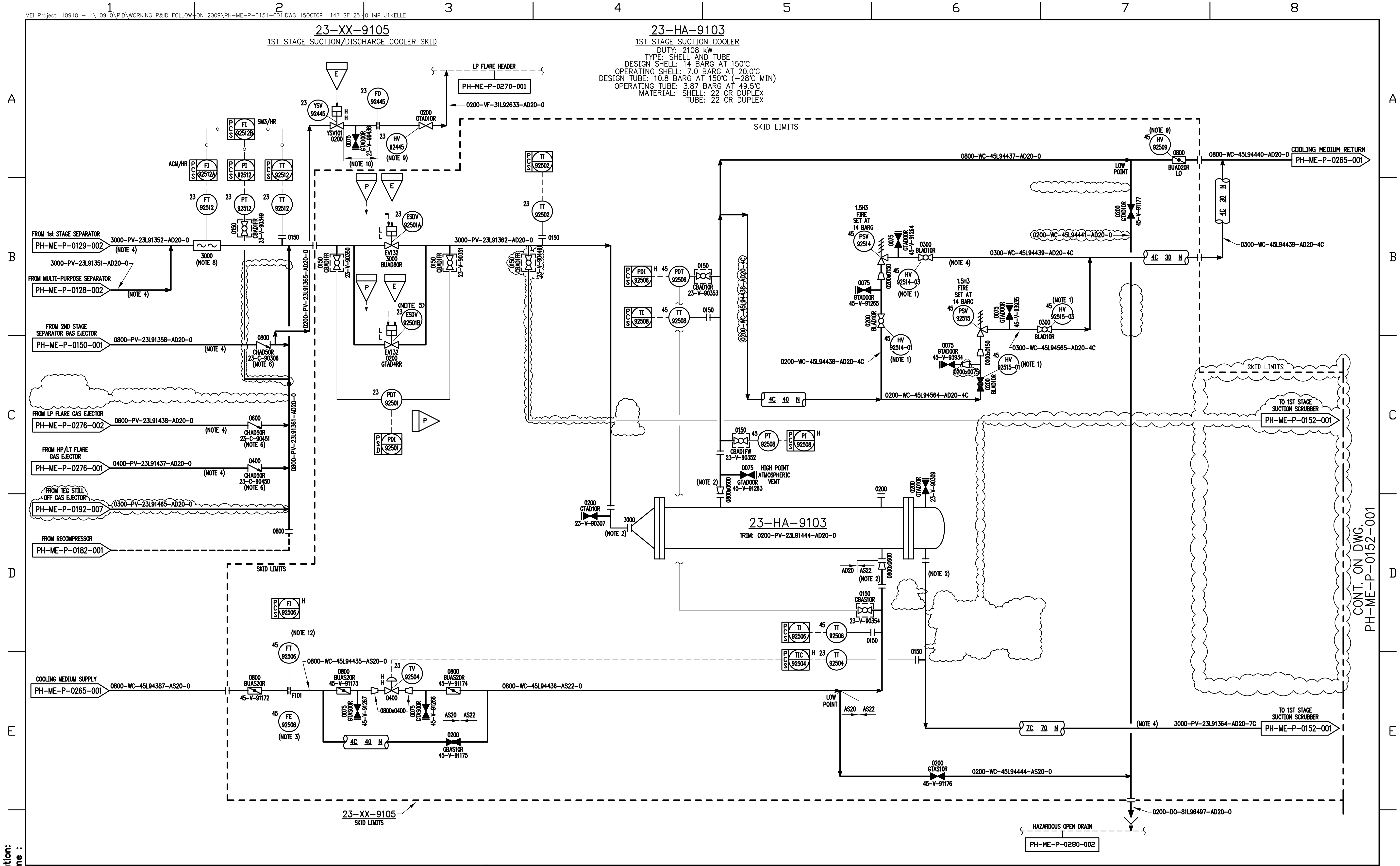
MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
OIL EXPORT PUMPS

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
T34-02	11	XB	PH	ME	P	0133	001	REV. 4

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0151-001.DWG 15OCT09 1147 SF 25.40 IMP J1KELLE


23-XX-9105
1ST STAGE SUCTION/DISCHARGE COOLER SKID
23-HA-9103
1ST STAGE SUCTION COOLER
DUTY: 2108 kW
TYPE: SHELL AND TUBE
DESIGN SHELL: 14 BARG AT 150°C
OPERATING SHELL: 7.0 BARG AT 20.0°C
DESIGN TUBE: 10.8 BARG AT 150°C (–28°C MIN)
OPERATING TUBE: 3.87 BARG AT 49.5°C
MATERIAL: SHELL: 22 CR DUPLEX
TUBE: 22 CR DUPLEX
LP FLARE HEADER
PH-ME-P-0270-001
0200-VF-31L92633-AD20-0
SKID LIMITS
FROM 1st STAGE SEPARATOR
PH-ME-P-0129-002
3000-PV-23L91352-AD20-0
3000-PV-23L91351-AD20-0
FROM MULTI-PURPOSE SEPARATOR
PH-ME-P-0128-002
FROM 2ND STAGE SEPARATOR GAS EJECTOR
PH-ME-P-0150-001
0800-PV-23L91358-AD20-0
FROM LP FLARE GAS EJECTOR
PH-ME-P-0276-002
0600-PV-23L91438-AD20-0
FROM HP/LT FLARE GAS EJECTOR
PH-ME-P-0276-001
0400-PV-23L91437-AD20-0
FROM TEG STILL OFF GAS EJECTOR
PH-ME-P-0192-007
0300-PV-23L91465-AD20-0
FROM RECOMPRESSOR
PH-ME-P-0182-001
0800-PV-23L91361-AD20-0
0200-PV-23L91365-AD20-0
3000-PV-23L91362-AD20-0
FI 92512B
SM3/HR
ACM/HR
FI 92512A
PI 92512
TT 92512
FT 92512
PT 92512
TT 92512
YSV 92445
FO 92445
HV 92445
YSV101 0200
0075 GTAD00R 23-V-99436
0200 GTAD10R
ESDV 92501A
ESDV 92501B
EV132 3000 BUAD80R
EV132 0200 GTAD4RR
PDT 92501
PDI 92501
CHAD50R 23-C-90306
CHAD50R 23-C-90451
CHAD50R 23-C-90450
0150 CBAD1FR 23-V-90349
0150 CBAD1FR 23-V-90350
0150 CBAD1FR 23-V-90351
0150 CBAD1FR 23-V-90449
TI 92502
TT 92502
PDI 92506
PDT 92506
CBAD10R 23-V-90353
TI 92508
TT 92508
PT 92508
PI 92508
CBAD1FW 23-V-90352
HIGH POINT ATMOSPHERIC VENT
GTAD00R 45-V-91263
0200 GTAD10R 23-V-90307
23-HA-9103
TRIM: 0200-PV-23L91444-AD20-0
0200 GTAD10R 23-V-90309
0150 CBAS10R 23-V-90354
TI 92506
TT 92506
TIC 92504
TT 92504
0800-WC-45L94437-AD20-0
0800-WC-45L94440-AD20-0
COOLING MEDIUM RETURN
PH-ME-P-0265-001
HV 92509
0800 BUAD20R LO
LOW POINT
0200 GTAD10R 45-V-91177
0200-WC-45L94441-AD20-0
0300-WC-45L94439-AD20-4C
4C 30 N
1.5H3 FIRE SET AT 14 BARG
PSV 92514
PSV 92515
HV 92514-03
HV 92514-01
HV 92515-03
HV 92515-01
GTAD00R 45-V-91264
GTAD00R 45-V-91265
GTAD00R 45-V-93934
GTAD00R 45-V-93935
0300 BLAD10R
0200-WC-45L94438-AD20-4C
0200-WC-45L94564-AD20-4C
0300-WC-45L94565-AD20-4C
4C 40 N
TO 1ST STAGE SUCTION SCRUBBER
PH-ME-P-0152-001
3000-PV-23L91364-AD20-7C
7C 70 N
CONT. ON DWG. PH-ME-P-0152-001
COOLING MEDIUM SUPPLY
PH-ME-P-0265-001
0800-WC-45L94387-AS20-0
0800 BUAS20R 45-V-91172
FI 92506
FT 92506
FE 92506
F101
0800-WC-45L94435-AS20-0
BUAS20R 45-V-91173
BUAS20R 45-V-91174
TV 92504
0800x0400
GTAS00R 45-V-91267
GTAS00R 45-V-91266
0200 GBAS10R 45-V-91175
0800-WC-45L94436-AS22-0
AS20 AS22
0200 GTAS10R 45-V-91176
0200-WC-45L94444-AS20-0
0200-DO-81L96497-AD20-0
HAZARDOUS OPEN DRAIN
PH-ME-P-0280-002
23-XX-9105 SKID LIMITS

NOTES:
1. KEY INTERLOCKED VALVE.
2. REMOVABLE MAINTENANCE SPOOL.
3. CONDITIONING PLATE. PROVIDE STRAIGHT RUN OF 2D UPSTREAM AND 2D DOWNSTREAM.
4. DO NOT POCKET.
5. 2" EQUALIZATION VALVE PARALLEL TO ESDV VALVE.
6. ANTI-SLAM DESIGN.
7. VALVE WILL BE LOCATED AS CLOSE TO EXCHANGER AS PRACTICAL.
8. GAS ULTRASONIC METER. PROVIDED STRAIGHT RUN OF 7D UPSTREAM AND 3D DOWNSTREAM.
9. KEY LOCKED VALVE.
10 MINIMUM ONE METER SEPARATION.
11. DELETED.
12. TWO 0050 SIZE FLANGED GATE VALVES, GTAS00R, FOR EACH OF: 45-FT-92506 (TOTAL: 2 VALVES) - BY PIPING. SEE DETAIL F101 ON P&ID PH-ME-P-0102-001.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	15OCT08	CDB	RE-ISSUED FOR CONSTRUCTION	RAK	RK/PS/JL	RAB	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Field for file specification:
Field for date and time :

A1

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
1ST STAGE SUCTION COOLER

REGISTRATION CODES

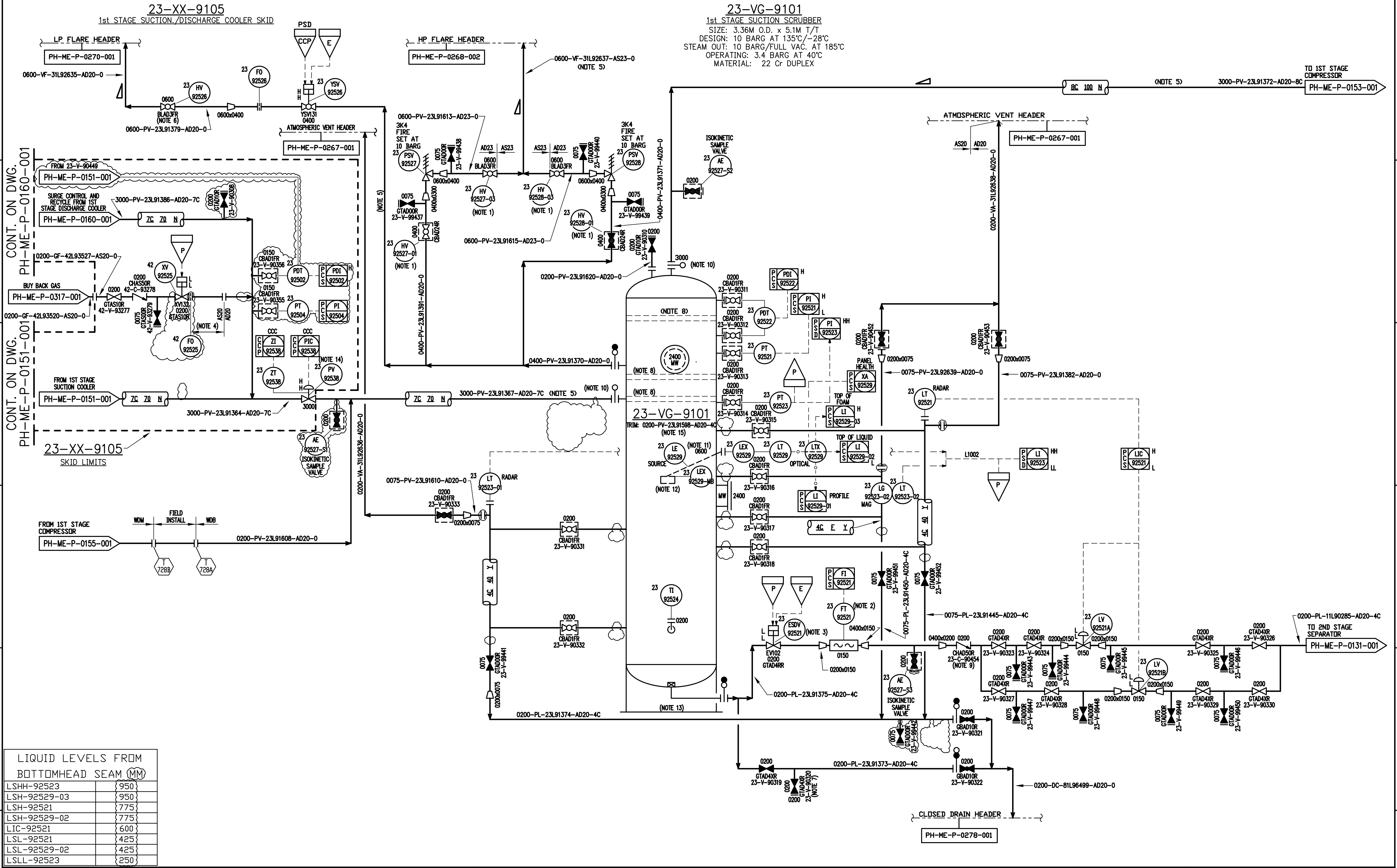
AREA	SYSTEM	TYPE
T33-02	23	XB

DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0151	001

SCALE NONE
REV. 4

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0152-001.DWG 15OCT09 11:46 SF 25.40 IMP J1KELLE


23-XX-9105
1st STAGE SUCTION./DISCHARGE COOLER SKID
LP FLARE HEADER
PH-ME-P-0270-001
0600-VF-31L92635-AD20-0
PSD
CCP
E
HV 92526
FO 92526
YSV 92526
YSV131
0600-PV-23L91379-AD20-0
ATMOSPHERIC VENT HEADER
PH-ME-P-0267-001
HP FLARE HEADER
PH-ME-P-0268-002
0600-VF-31L92637-AS23-0
(NOTE 5)
23-VG-9101
1st STAGE SUCTION SCRUBBER
SIZE: 3.36M O.D. x 5.1M T/T
DESIGN: 10 BARG AT 135°C/-28°C
STEAM OUT: 10 BARG/FULL VAC. AT 185°C
OPERATING: 3.4 BARG AT 40°C
MATERIAL: 22 Cr DUPLEX
TO 1ST STAGE COMPRESSOR
PH-ME-P-0153-001
3000-PV-23L91372-AD20-8C
CONT. ON DWG. PH-ME-P-0160-001
CONT. ON DWG. PH-ME-P-0151-001
FROM 23-V-90449
PH-ME-P-0151-001
SURGE CONTROL AND RECYCLE FROM 1ST STAGE DISCHARGE COOLER
PH-ME-P-0160-001
3000-PV-23L91386-AD20-7C
BUY BACK GAS
PH-ME-P-0317-001
0200-GF-42L93527-AS20-0
0200-GF-42L93520-AS20-0
XV 92525
FO 92525
PDT 92502
PDI 92502
PT 92504
PI 92504
ZI 92538
PIC 92538
ZT 92538
PV 92538
(NOTE 14)
FROM 1ST STAGE SUCTION COOLER
PH-ME-P-0151-001
3000-PV-23L91364-AD20-7C
23-XX-9105
SKID LIMITS
AE 92527-S1
ISOKINETIC SAMPLE VALVE
FROM 1ST STAGE COMPRESSOR
PH-ME-P-0155-001
FIELD INSTALL
0200-PV-23L91608-AD20-0
728B
728A
3K4 FIRE SET AT 10 BARG
PSV 92527
PSV 92528
HV 92527-01
HV 92527-03
HV 92528-03
HV 92528-01
0600-PV-23L91613-AD23-0
0600-PV-23L91615-AD23-0
0400-PV-23L91391-AD20-0
0400-PV-23L91370-AD20-0
0400-PV-23L91371-AD20-0
0200-PV-23L91620-AD20-0
3000-PV-23L91367-AD20-7C
0200-VA-31L92636-AD20-0
0075-PV-23L91610-AD20-0
LT 92523-01
RADAR
AE 92527-S2
ISOKINETIC SAMPLE VALVE
23-VG-9101
TRIM: 0200-PV-23L91598-AD20-4C
2400 MW
LE 92529
LEX 92529
LT 92529
LTX 92529
LI 92529-02
LI 92529-01
LI 92529-03
TOP OF LIQUID
TOP OF FOAM
PROFILE
OPTICAL
SOURCE
LG 92523-02
LT 92523-02
MAG
TI 92524
PDI 92522
PDT 92522
PI 92521
PT 92521
PI 92523
PT 92523
XA 92529
PANEL HEALTH
LT 92521
LI 92523
LIC 92521
L1002
0075-PV-23L92639-AD20-0
0075-PV-23L91382-AD20-0
0200-VA-31L92638-AD20-0
ATMOSPHERIC VENT HEADER
PH-ME-P-0267-001
FI 92521
FT 92521
ESDV 92521
EV102
AE 92527-S3
ISOKINETIC SAMPLE VALVE
LV 92521A
LV 92521B
0075-PL-23L91450-AD20-4C
0075-PL-23L91445-AD20-4C
0200-PL-23L91375-AD20-4C
0200-PL-23L91374-AD20-4C
0200-PL-23L91373-AD20-4C
0200-PL-11L90285-AD20-4C
TO 2ND STAGE SEPARATOR
PH-ME-P-0131-001
0200-DC-81L96499-AD20-0
CLOSED DRAIN HEADER
PH-ME-P-0278-001

LIQUID LEVELS FROM BOTTOMHEAD SEAM (MM)	
LSHH-92523	950
LSH-92529-03	950
LSH-92521	775
LSH-92529-02	775
LIC-92521	600
LSL-92521	425
LSL-92529-02	425
LSLL-92523	250

NOTES:

1. KEY INTERLOCKED VALVE.
2. LIQUID ULTRASONIC METER. PROVIDE STRAIGHT RUN OF 10D UPSTREAM AND 5D DOWNSTREAM.
3. LOCATE AS CLOSE TO THE VESSEL AS PRACTICAL.
4. MINIMUM I METER SEPARATION.
5. DO NOT POCKET.
6. KEY LOCKED VALVE.
7. N2 AND STEAM INJECTION AT 2" DRAIN VALVE.
8. INTERNALS.
9. ANTISLAM DESIGN.
10. SPADE & SPACER TYPE. PROVIDE SPADE STAND AT EACH LOCATION TO PREVENT MISPLACING SPADE.
11. 6" NOZZLE FOR PROFILER TO DETECT FOAMING. MOUNT NOZZLE 45° FROM THE VERTICAL.
12. SUPPORT DETAILS BY VESSEL VENDOR.
13. VESSEL SKIRT.
14. ACTUATOR TO HAVE TRAVEL STOP SET AT A POSITION EQUIVALENT TO CV=1500 (TO LIMIT CLOSURE).
15. 4C INSULATION IS NOT REQUIRED ON TRIM IN VAPOR SERVICE.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	15OCT08	CDB	RE-ISSUED FOR CONSTRUCTION	RAK	RK/PS/JL	RAB	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

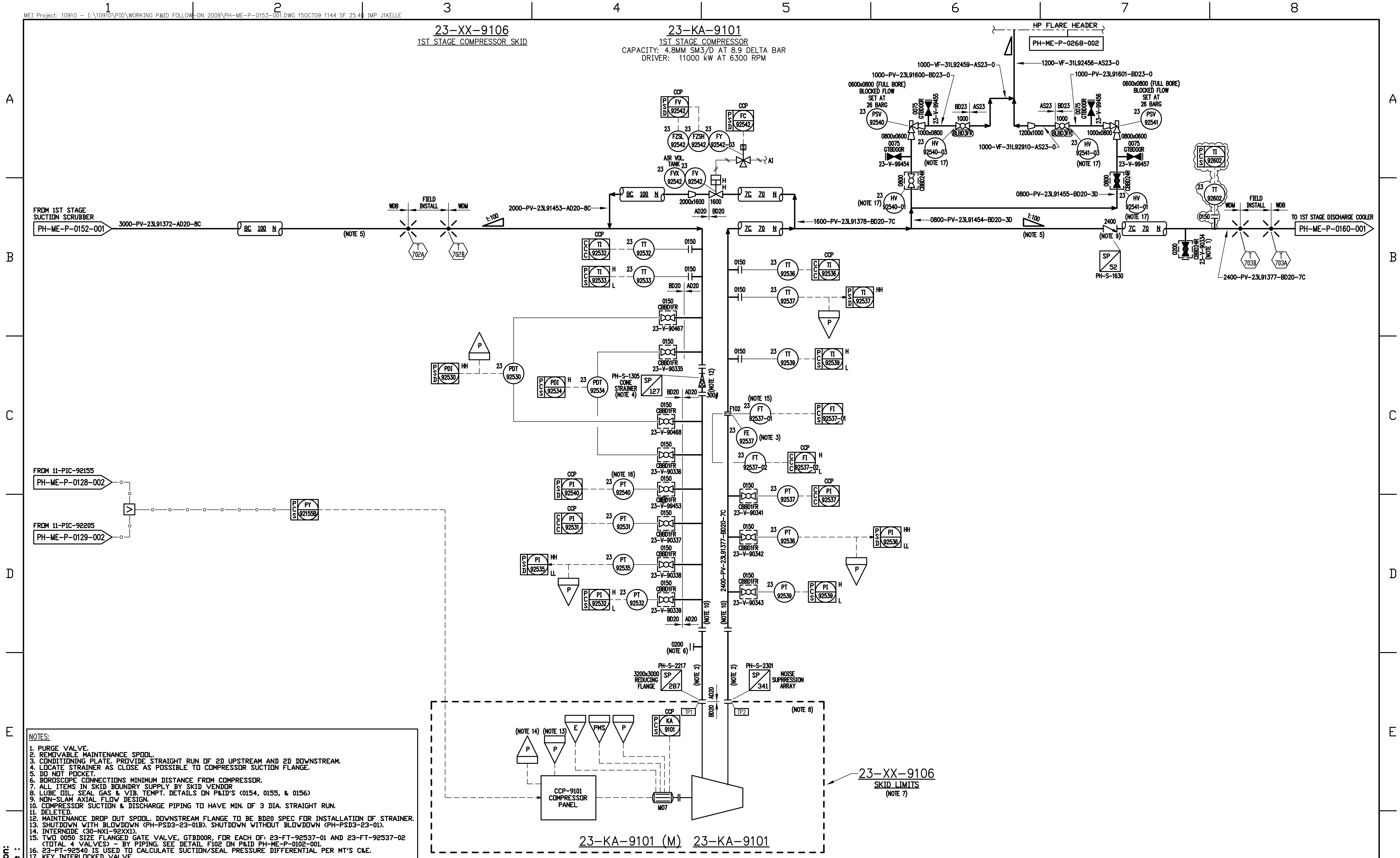
VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
1ST STAGE SUCTION SCRUBBER

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
T33-02	23	XB	PH	ME	P	0152	001	REV. 4

Field for file specification:
Field for date and time :

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0153-001.DWG 15OCT09 1144 SF 25.40 IMP J1KELLE


23-XX-9106
1ST STAGE COMPRESSOR SKID
23-KA-9101
1ST STAGE COMPRESSOR
CAPACITY: 4.8MM SM3/D AT 8.9 DELTA BAR
DRIVER: 11000 kW AT 6300 RPM
HP FLARE HEADER
PH-ME-P-0268-002
1000-VF-31L92459-AS23-0
1200-VF-31L92456-AS23-0
1000-PV-23L91600-BD23-0
1000-PV-23L91601-BD23-0
0600x0800 (FULL BORE) BLOCKED FLOW SET AT 26 BARG
PSV 92540
PSV 92541
1000-VF-31L92910-AS23-0
HV 92540-03 (NOTE 17)
HV 92541-03 (NOTE 17)
HV 92540-01 (NOTE 17)
HV 92541-01 (NOTE 17)
23-V-99454
23-V-99455
23-V-99456
23-V-99457
GTBD00R
CBBD24R
BLBD3FR
0800-PV-23L91455-BD20-3D
0800-PV-23L91454-BD20-3D
1600-PV-23L91378-BD20-7C
2400-PV-23L91377-BD20-7C
1:100
(NOTE 5)
(NOTE 9)
SP 52 PH-S-1630
TI 92602
TT 92602
23-V-90334 (NOTE 1)
FIELD INSTALL
WDM
WDB
T 703A
T 703B
T 702A
T 702B
TO 1ST STAGE DISCHARGE COOLER
PH-ME-P-0160-001
FROM 1ST STAGE SUCTION SCRUBBER
PH-ME-P-0152-001
3000-PV-23L91372-AD20-8C
2000-PV-23L91453-AD20-8C
8C 100 N
7C 70 N
FV 92542
FC 92542
FZSL 92542
FZSH 92542
FY 92542-03
AIR VOL. TANK
FVX 92542
FV 92542
AI
2000x1600
1600
AD20
BD20
CCP
TI 92532
TT 92532
TI 92533
TT 92533
TT 92536
TI 92536
TT 92537
TI 92537
TT 92539
TI 92539
PDI 92530
PDT 92530
PDI 92534
PDT 92534
PH-S-1305 CONE STRAINER (NOTE 4)
SP 127
(NOTE 12)
23-V-90467
23-V-90335
23-V-90468
23-V-90336
23-V-99453
23-V-90337
23-V-90338
23-V-90339
23-V-90341
23-V-90342
23-V-90343
CBBD1FR
F102
FT 92537-01
FI 92537-01
FE 92537 (NOTE 3)
FT 92537-02
FI 92537-02
(NOTE 15)
PT 92540
PI 92540
(NOTE 16)
PT 92531
PI 92531
PT 92535
PI 92535
PT 92532
PI 92532
PT 92537
PI 92537
PT 92536
PI 92536
PT 92539
PI 92539
2400-PV-23L91377-BD20-7C
(NOTE 10)
0200 (NOTE 6)
PH-S-2217
3200x3000 REDUCING FLANGE
SP 287
(NOTE 2)
PH-S-2301
SP 341
NOISE SUPPRESSION ARRAY
TP1
TP2
(NOTE 8)
FROM 11-PIC-92155
PH-ME-P-0128-002
FROM 11-PIC-92205
PH-ME-P-0129-002
PY 92155B
KA 9101
(NOTE 14)
(NOTE 13)
E
PMS
P
CCP-9101 COMPRESSOR PANEL
M07
23-KA-9101 (M)
23-KA-9101
23-XX-9106
SKID LIMITS
(NOTE 7)

NOTES:

1. PURGE VALVE.
2. REMOVABLE MAINTENANCE SPOOL.
3. CONDITIONING PLATE. PROVIDE STRAIGHT RUN OF 2D UPSTREAM AND 2D DOWNSTREAM.
4. LOCATE STRAINER AS CLOSE AS POSSIBLE TO COMPRESSOR SUCTION FLANGE.
5. DO NOT POCKET.
6. BOROSCOPE CONNECTIONS MINIMUM DISTANCE FROM COMPRESSOR.
7. ALL ITEMS IN SKID BOUNDRY SUPPLY BY SKID VENDOR
8. LUBE OIL, SEAL GAS & VIB. TEMPT. DETAILS ON P&ID'S (0154, 0155, & 0156)
9. NON-SLAM AXIAL FLOW DESIGN.
10. COMPRESSOR SUCTION & DISCHARGE PIPING TO HAVE MIN. OF 3 DIA. STRAIGHT RUN.
11. DELETED.
12. MAINTENANCE DROP OUT SPOOL. DOWNSTREAM FLANGE TO BE BD20 SPEC FOR INSTALLATION OF STRAINER.
13. SHUTDOWN WITH BLOWDOWN (PH-PSD3-23-01B). SHUTDOWN WITHOUT BLOWDOWN (PH-PSD3-23-01).
14. INTERNODE (30-NX1-92XX1).
15. TWO 0050 SIZE FLANGED GATE VALVE, GTBD00R, FOR EACH OF: 23-FT-92537-01 AND 23-FT-92537-02 (TOTAL 4 VALVES) - BY PIPING. SEE DETAIL F102 ON P&ID PH-ME-P-0102-001.
16. 23-PT-92540 IS USED TO CALCULATE SUCTION/SEAL PRESSURE DIFFERENTIAL PER MT'S C&E.
17. KEY INTERLOCKED VALVE.

Field for file specification:
Field for date and time :

NOTES:

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	15OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/PS/JL	RAB	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
1ST STAGE COMPRESSOR

REGISTRATION CODES

AREA	SYSTEM	TYPE
T43-02	23	XB

DRAWING NO.

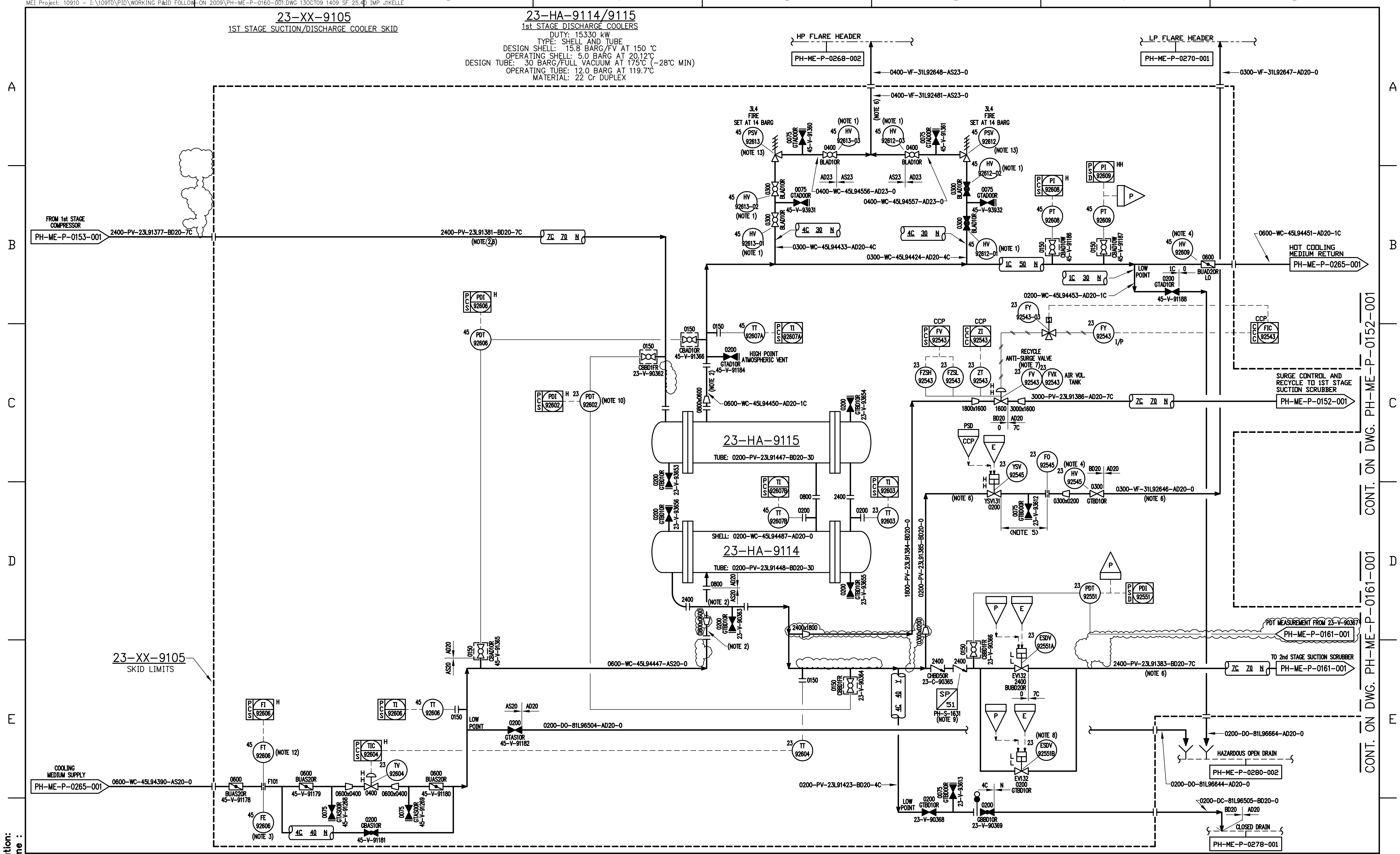
FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0153	001

SCALE NONE

REV. 4

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0160-001.DWG 13OCT09 1409 SF 25.40 IMP J1KELLE


23-XX-9105
1ST STAGE SUCTION/DISCHARGE COOLER SKID
23-HA-9114/9115
1st STAGE DISCHARGE COOLERS
DUTY: 15330 kW
TYPE: SHELL AND TUBE
DESIGN SHELL: 15.8 BARG/FV AT 150 °C
OPERATING SHELL: 5.0 BARG AT 20.12°C
DESIGN TUBE: 30 BARG/FULL VACUUM AT 175°C (–28°C MIN)
OPERATING TUBE: 12.0 BARG AT 119.7°C
MATERIAL: 22 Cr DUPLEX
HP FLARE HEADER
PH-ME-P-0268-002
LP FLARE HEADER
PH-ME-P-0270-001
FROM 1st STAGE COMPRESSOR
PH-ME-P-0153-001
2400-PV-23L91377-BD20-7C
2400-PV-23L91381-BD20-7C
23-HA-9115
TUBE: 0200-PV-23L91447-BD20-3D
23-HA-9114
SHELL: 0200-WC-45L94487-AD20-0
TUBE: 0200-PV-23L91448-BD20-3D
HIGH POINT ATMOSPHERIC VENT
RECYCLE ANTI-SURGE VALVE (NOTE 7)
AIR VOL. TANK
HOT COOLING MEDIUM RETURN
PH-ME-P-0265-001
SURGE CONTROL AND RECYCLE TO 1ST STAGE SUCTION SCRUBBER
PH-ME-P-0152-001
PDT MEASUREMENT FROM 23-V-90367
PH-ME-P-0161-001
TO 2nd STAGE SUCTION SCRUBBER
PH-ME-P-0161-001
HAZARDOUS OPEN DRAIN
PH-ME-P-0280-002
CLOSED DRAIN
PH-ME-P-0278-001
COOLING MEDIUM SUPPLY
PH-ME-P-0265-001
0600-WC-45L94390-AS20-0
23-XX-9105
SKID LIMITS
LOW POINT
CONT. ON DWG. PH-ME-P-0152-001
CONT. ON DWG. PH-ME-P-0161-001

NOTES:
1. KEY INTERLOCKED VALVE.
2. REMOVABLE MAINTANCE SPOOL.
3. CONDITIONING PLATE. PROVIDE STRAIGHT RUN OF 2D UPSTREAM AND 2D DOWNSTREAM.
4. KEY LOCKED VALVE.
5. MINIMUM 1 METER SEPARATION.
6. DO NOT POCKET.
7. LOCATE ANTI-SURGE VALVE AS CLOSE AS PRACTICAL TO TEE.
8. 2" EQUALIZATION VALVE PARALLEL TO SHUTDOWN VALVE.
9. DISSIMILAR CHECK VALVES.
10. TRANSMITTER TO BE MOUNTED OFF SKID ON WEATHER DECK DUE TO THE ELEVATION OF THE PDT TAPS ON SKID.
11. DELETED.
12. TWO 0050 GATE VALVES, GTAS00R, FOR EACH OF: 45-FT-92606 (TOTAL: 2 VALVES) – BY PIPING. SEE DETAIL F101 ON P&ID PH-ME-P-0102-001.
13. FIRE CASE IS THE GOVERNING CASE (EXCEEDS TUBE RUPTURE PROTECTION REQUIREMENT).

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	13OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	15OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/PS/JL	RAB	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering (North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
1st STAGE DISCHARGE COOLER

REGISTRATION CODES

AREA	SYSTEM	TYPE
T33-02	23	XB

DRAWING NO.

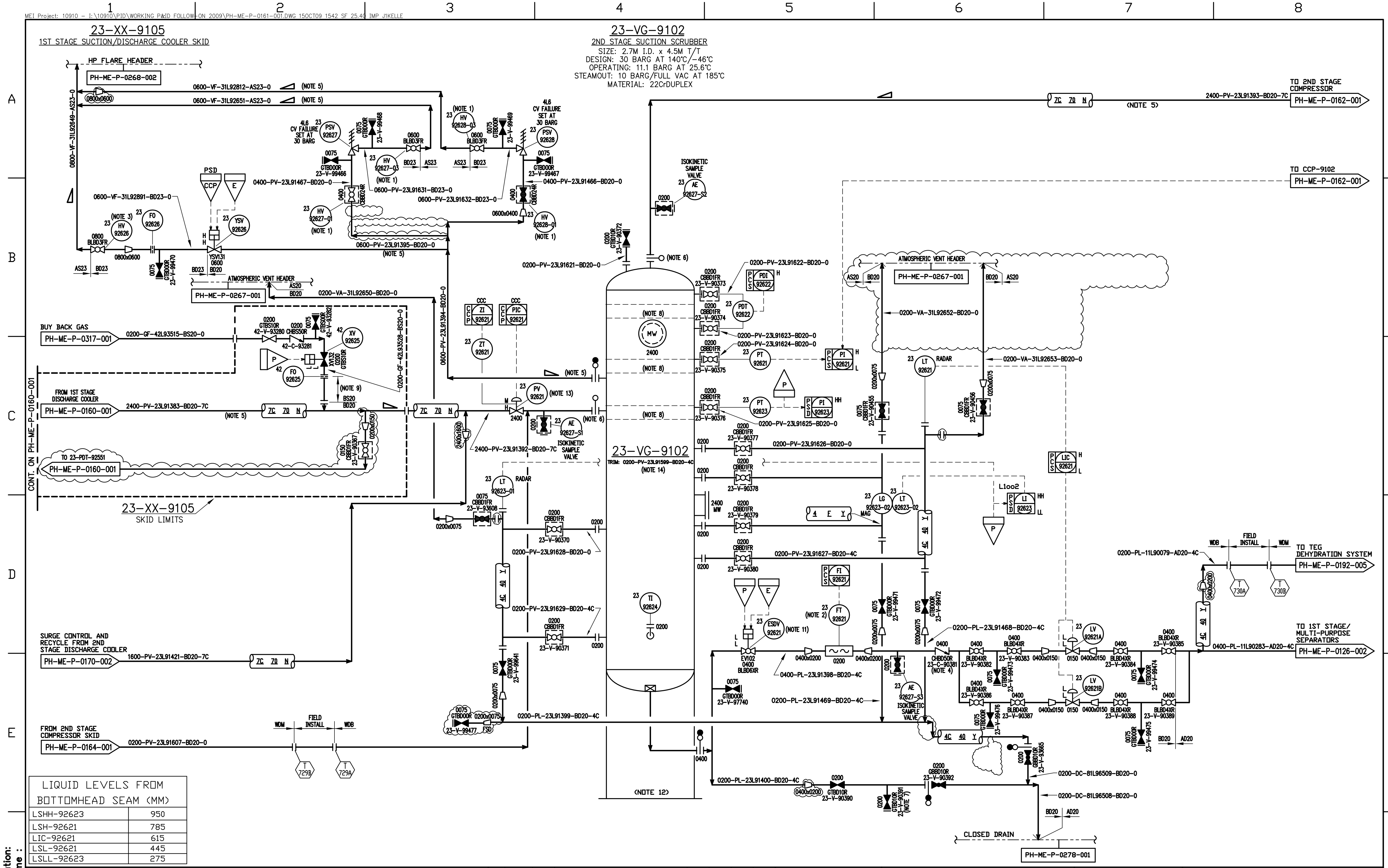
FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	SCALE
PH	ME	P	0160	001	NONE

REV. 4

A1

Field for file specification:
Field for date and time :

MEI Project: 10910 - I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0161-001.DWG 15OCT09 1542 SF 25.40 IMP J1KELLE



23-XX-9105
1ST STAGE SUCTION/DISCHARGE COOLER SKID
HP FLARE HEADER
PH-ME-P-0268-002
0600-VF-31L92812-AS23-0
0600-VF-31L92651-AS23-0
0800-VF-31L92649-AS23-0
0600-VF-31L92891-BD23-0
(NOTE 5)
PSD
CCP
E
YSV 92626
HV 92626
FO 92626
(NOTE 3)
PSV 92627
PSV 92628
CV FAILURE SET AT 30 BARG
HV 92627-01
HV 92627-03
HV 92628-01
HV 92628-03
(NOTE 1)
0400-PV-23L91467-BD20-0
0400-PV-23L91466-BD20-0
0600-PV-23L91631-BD23-0
0600-PV-23L91632-BD23-0
0600-PV-23L91395-BD20-0
ATMOSPHERIC VENT HEADER
PH-ME-P-0267-001
0200-VA-31L92650-BD20-0
BUY BACK GAS
PH-ME-P-0317-001
0200-GF-42L93515-BS20-0
0200-GF-42L93528-BS20-0
XV 92625
FO 92625
XV132
FROM 1ST STAGE DISCHARGE COOLER
PH-ME-P-0160-001
2400-PV-23L91383-BD20-7C
CONT. ON PH-ME-P-0160-001
TO 23-PDT-92551
23-XX-9105
SKID LIMITS
0600-PV-23L91394-BD20-0
2400-PV-23L91392-BD20-7C
PV 92621
(NOTE 13)
AE 92627-S1
ISOKINETIC SAMPLE VALVE
LT 92623-01
RADAR
ZI 92621
PIC 92621
ZT 92621
CCC
SURGE CONTROL AND RECYCLE FROM 2ND STAGE DISCHARGE COOLER
PH-ME-P-0170-002
1600-PV-23L91421-BD20-7C
0200-PV-23L91628-BD20-0
0200-PV-23L91629-BD20-4C
FROM 2ND STAGE COMPRESSOR SKID
PH-ME-P-0164-001
0200-PV-23L91607-BD20-0
FIELD INSTALL
0200-PL-23L91399-BD20-4C
23-VG-9102
2ND STAGE SUCTION SCRUBBER
SIZE: 2.7M I.D. x 4.5M T/T
DESIGN: 30 BARG AT 140°C/-46°C
OPERATING: 11.1 BARG AT 25.6°C
STEAMOUT: 10 BARG/FULL VAC AT 185°C
MATERIAL: 22CrDUPLEX
23-VG-9102
TRIM: 0200-PV-23L91599-BD20-4C
(NOTE 14)
(NOTE 8)
(NOTE 6)
(NOTE 12)
MW 2400
TI 92624
0200-PV-23L91621-BD20-0
AE 92627-S2
ISOKINETIC SAMPLE VALVE
TO 2ND STAGE COMPRESSOR
PH-ME-P-0162-001
2400-PV-23L91393-BD20-7C
TO CCP-9102
PH-ME-P-0162-001
0200-PV-23L91622-BD20-0
0200-PV-23L91623-BD20-0
0200-PV-23L91624-BD20-0
0200-PV-23L91625-BD20-0
0200-PV-23L91626-BD20-0
0200-PV-23L91627-BD20-4C
PDI 92622
PDT 92622
PT 92621
PI 92621
PT 92623
PI 92623
ATMOSPHERIC VENT HEADER
PH-ME-P-0267-001
0200-VA-31L92652-BD20-0
0200-VA-31L92653-BD20-0
LT 92621
RADAR
LG 92623-02
LT 92623-02
LIC 92621
LI 92623
L1oo2
MAG
ESDV 92621
(NOTE 11)
FT 92621
FI 92621
(NOTE 2)
AE 92627-S3
ISOKINETIC SAMPLE VALVE
0400-PL-23L91398-BD20-4C
0200-PL-23L91469-BD20-4C
0200-PL-23L91468-BD20-4C
LV 92621A
LV 92621B
(NOTE 4)
0200-PL-11L90079-AD20-4C
TO TEG DEHYDRATION SYSTEM
PH-ME-P-0192-005
0400-PL-11L90283-AD20-4C
TO 1ST STAGE/ MULTI-PURPOSE SEPARATORS
PH-ME-P-0126-002
0200-PL-23L91400-BD20-4C
(NOTE 7)
0200-DC-81L96509-BD20-0
0200-DC-81L96508-BD20-0
CLOSED DRAIN
PH-ME-P-0278-001

LIQUID LEVELS FROM BOTTOMHEAD SEAM (MM)	
LSHH-92623	950
LSH-92621	785
LIC-92621	615
LSL-92621	445
LSLL-92623	275

NOTES:

1. KEY INTERLOCKED VALVE.
2. LIQUID ULTRASONIC METER. PROVIDE STRAIGHT RUN OF 10D UPSTREAM AND 5D DOWNSTREAM.
3. KEY LOCKED VALVE.
4. ANTI-SLAM DESIGN.
5. DO NOT POCKET.
6. SPADE & SPACER TYPE. PROVIDE SPADE STAND AT EACH LOCATION TO PREVENT MISPLACING SPADE.
7. N2 AND STEAM INJECTION AT 2" DRAIN VALVE.
8. INTERNALS ILLUSTRATED ARE INCOMPLETE AND NOT TO SCALE. REFER TO VENDOR DWG.'S FOR COMPLETE INTERNAL INFORMATION.
9. MINIMUM 3 METER SEPARATION.
10. HEAVY WALL PIPE FOR NOISE ATTENUATION.
11. LOCATE ESDV AS CLOSE TO THE SCRUBBER AS PRACTICAL.
12. VESSEL SKIRT.
13. ACTUATOR TO HAVE TRAVEL STOP SET AT A POSITION EQUIVALENT TO CV=1000 (TO LIMIT CLOSURE).
14. 4C INSULATION IS NOT REQUIRED ON TRIM IN VAPOR SERVICE.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	15OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/PS/JL	RAB	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

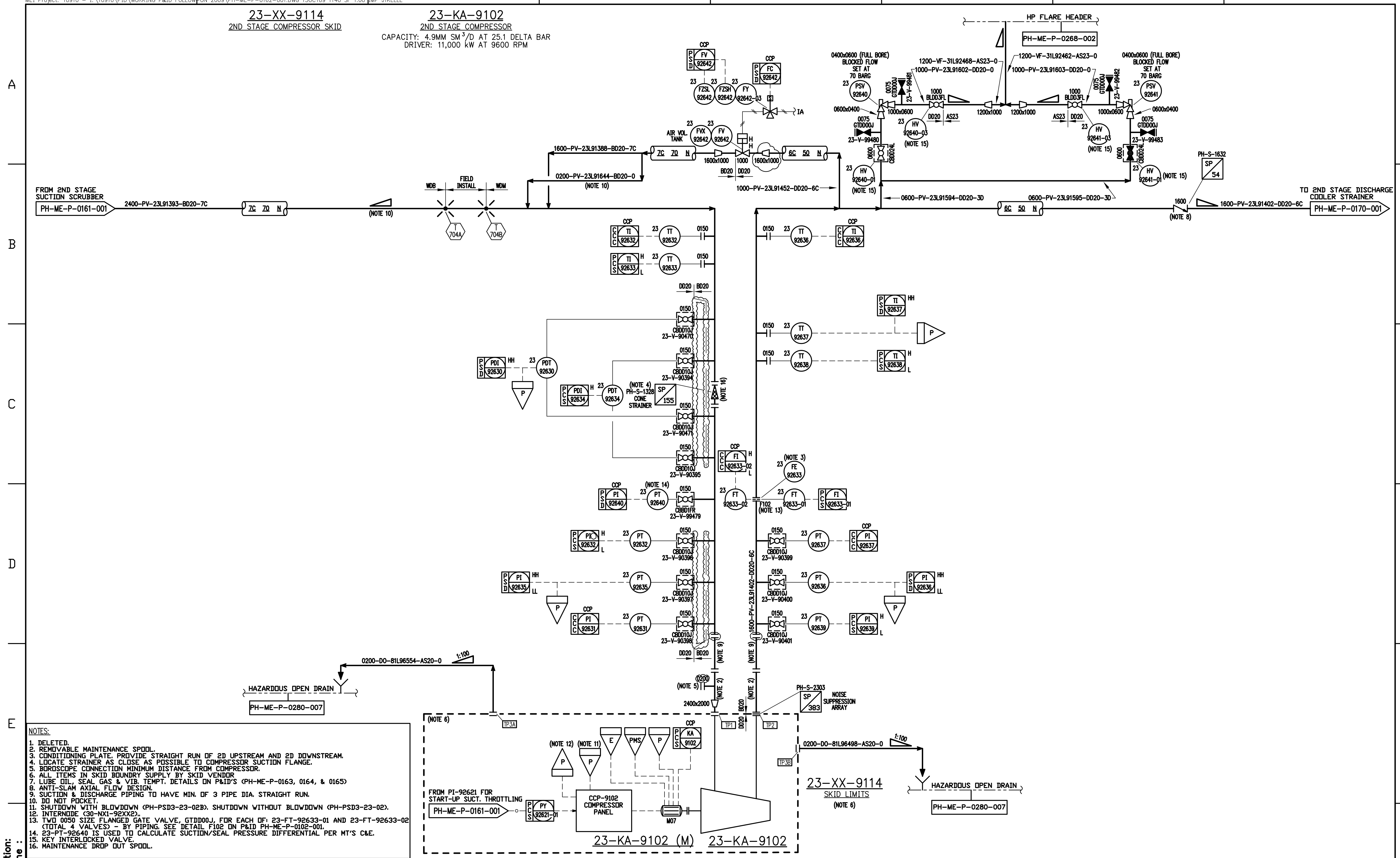
PROJECT NO. 10910

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
2ND STAGE SUCTION SCRUBBER

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
T33-02	23	XB	PH	ME	P	0161	001	REV. 4

Field for file specification:
Field for date and time :

A1


23-XX-9114
2ND STAGE COMPRESSOR SKID
23-KA-9102
2ND STAGE COMPRESSOR
CAPACITY: 4.9MM SM³/D AT 25.1 DELTA BAR
DRIVER: 11,000 kW AT 9600 RPM
FROM 2ND STAGE SUCTION SCRUBBER
PH-ME-P-0161-001
2400-PV-23L91393-BD20-7C
7C 70 N
(NOTE 10)
WDB
FIELD INSTALL
WDM
T 704A
T 704B
1600-PV-23L91388-BD20-7C
0200-PV-23L91644-BD20-0
1000-PV-23L91452-DD20-6C
AIR VOL. TANK
FVX 92642
FV 92642
FZSL 92642
FZSH 92642
FY 92642-03
FC 92642
IA
6C 50 N
HP FLARE HEADER
PH-ME-P-0268-002
1200-VF-31L92468-AS23-0
1000-PV-23L91602-DD20-0
1200-VF-31L92462-AS23-0
1000-PV-23L91603-DD20-0
0400x0600 (FULL BORE) BLOCKED FLOW SET AT 70 BARG
PSV 92640
PSV 92641
23-V-99480
23-V-99481
23-V-99482
23-V-99483
HV 92640-01
HV 92640-03
HV 92641-01
HV 92641-03
(NOTE 15)
0600-PV-23L91594-DD20-3D
0600-PV-23L91595-DD20-3D
PH-S-1632
SP 54
(NOTE 8)
1600-PV-23L91402-DD20-6C
TO 2ND STAGE DISCHARGE COOLER STRAINER
PH-ME-P-0170-001
TT 92632
TT 92633
TT 92636
TT 92637
TT 92638
PDT 92630
PDI 92630
PDT 92634
PDI 92634
(NOTE 4) PH-S-1328 CONE STRAINER
SP 155
(NOTE 16)
23-V-90470
23-V-90394
23-V-90471
23-V-90395
FI 92633-02
FE 92633
(NOTE 3)
FT 92633-02
FT 92633-01
FI 92633-01
F102 (NOTE 13)
PT 92640
(NOTE 14)
23-V-99479
PT 92632
PI 92632
23-V-90396
PT 92635
PI 92635
23-V-90397
PT 92631
PI 92631
23-V-90398
PT 92637
PI 92637
23-V-90399
PT 92636
PI 92636
23-V-90400
PT 92639
PI 92639
23-V-90401
(NOTE 9)
(NOTE 2)
(NOTE 5)
2400x2000
PH-S-2303
SP 383
NOISE SUPPRESSION ARRAY
TP1
TP2
TP3A
TP3B
0200-DO-81L96554-AS20-0
0200-DO-81L96498-AS20-0
1:100
HAZARDOUS OPEN DRAIN
PH-ME-P-0280-007
(NOTE 6)
FROM PI-92621 FOR START-UP SUCT. THROTTLING
PH-ME-P-0161-001
PY 92621-01
(NOTE 12)
(NOTE 11)
E
PMS
P
KA 9102
CCP-9102 COMPRESSOR PANEL
M07
23-KA-9102 (M)
23-KA-9102
23-XX-9114
SKID LIMITS
(NOTE 6)

NOTES:

1. DELETED.
2. REMOVABLE MAINTENANCE SPOOL.
3. CONDITIONING PLATE. PROVIDE STRAIGHT RUN OF 2D UPSTREAM AND 2D DOWNSTREAM.
4. LOCATE STRAINER AS CLOSE AS POSSIBLE TO COMPRESSOR SUCTION FLANGE.
5. BOROSCOPE CONNECTION MINIMUM DISTANCE FROM COMPRESSOR.
6. ALL ITEMS IN SKID BOUNDRY SUPPLY BY SKID VENDOR
7. LUBE OIL, SEAL GAS & VIB. TEMPT. DETAILS ON P&ID'S (PH-ME-P-0163, 0164, & 0165)
8. ANTI-SLAM AXIAL FLOW DESIGN.
9. SUCTION & DISCHARGE PIPING TO HAVE MIN. OF 3 PIPE DIA. STRAIGHT RUN.
10. DO NOT POCKET.
11. SHUTDOWN WITH BLOWDOWN (PH-PSD3-23-02B). SHUTDOWN WITHOUT BLOWDOWN (PH-PSD3-23-02).
12. INTERNODE (30-NX1-92XX2)..
13. TWO 0050 SIZE FLANGED GATE VALVE, GTDD00J, FOR EACH OF: 23-FT-92633-01 AND 23-FT-92633-02 (TOTAL 4 VALVES) - BY PIPING. SEE DETAIL F102 ON P&ID PH-ME-P-0102-001.
14. 23-PT-92640 IS USED TO CALCULATE SUCTION/SEAL PRESSURE DIFFERENTIAL PER MT'S C&E.
15. KEY INTERLOCKED VALVE.
16. MAINTENANCE DROP OUT SPOOL.

NOTES:

Field for file specification:
Field for date and time :

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JS	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	15OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/PS/JL	RAB	
1	16MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering (North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
2ND STAGE COMPRESSOR

REGISTRATION CODES

AREA	SYSTEM	TYPE
T43-02	23	XB

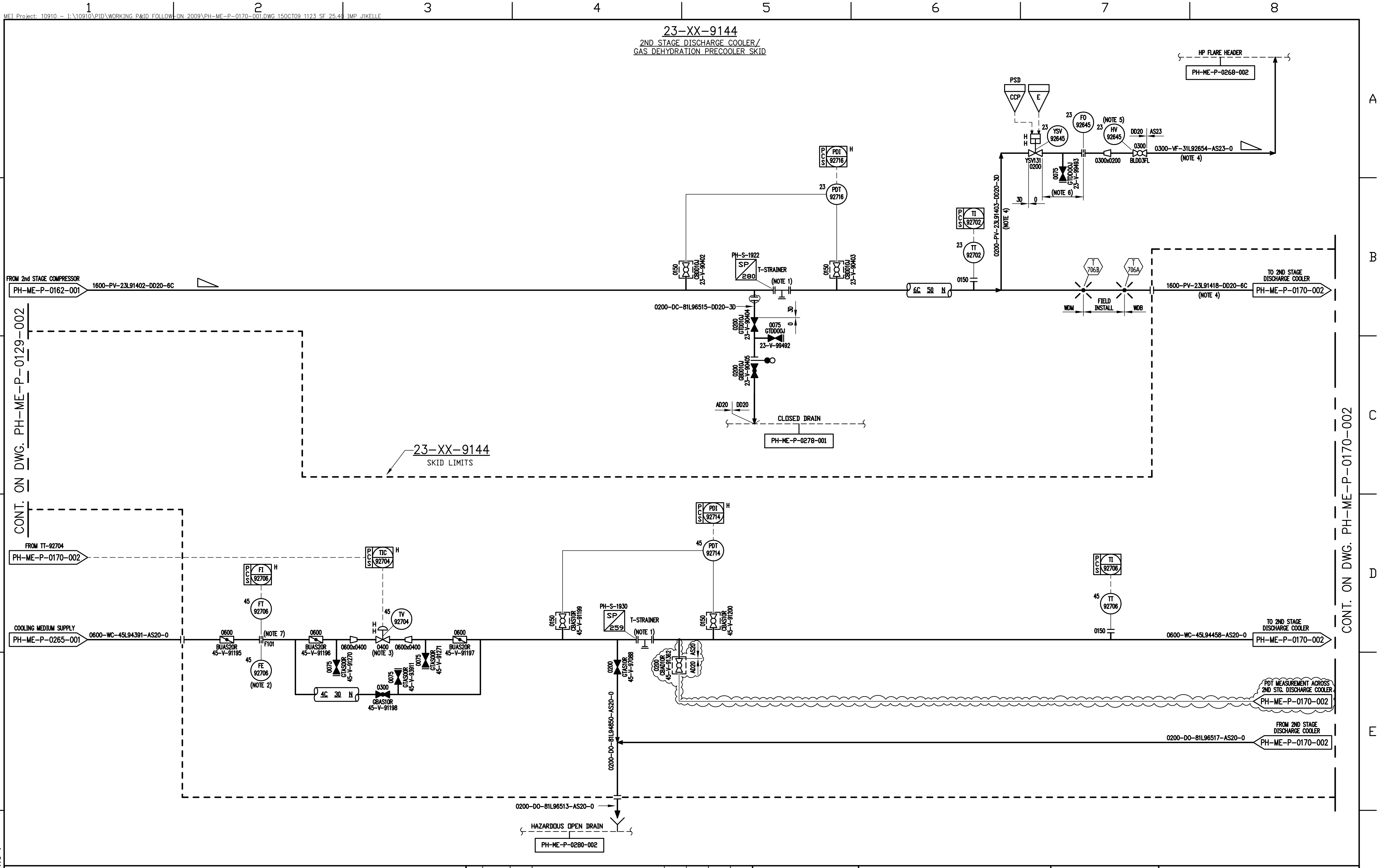
DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0162	001

SCALE NONE
REV. 4

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0170-001.DWG 15OCT09 1123 SF 25.40 IMP J1KELLE



23-XX-9144
2ND STAGE DISCHARGE COOLER/
GAS DEHYDRATION PRECOOLER SKID
HP FLARE HEADER
PH-ME-P-0268-002
PSD
CCP
E
23 YSV 92645
23 FO 92645
(NOTE 5)
23 HV 92645
DD20
AS23
YSV131
0200
0300
BLDD3FL
0300x0200
0300-VF-31L92654-AS23-0
(NOTE 4)
0075
GTDD00J
23-V-99493
(NOTE 6)
3D
0
0200-PV-23L91403-DD20-3D
(NOTE 4)
PCS PDI 92716 H
23 PDT 92716
PCS TI 92702
23 TT 92702
0150
FROM 2nd STAGE COMPRESSOR
PH-ME-P-0162-001
1600-PV-23L91402-DD20-6C
0150
CBDD10J
23-V-90402
PH-S-1922
SP 280
T-STRAINER
(NOTE 1)
0150
CBDD10J
23-V-90403
6C 50 N
T 706B
T 706A
WDM
FIELD INSTALL
WDB
1600-PV-23L91418-DD20-6C
(NOTE 4)
TO 2ND STAGE DISCHARGE COOLER
PH-ME-P-0170-002
0200-DC-81L96515-DD20-3D
0200
GTDD10J
23-V-90404
0075
GTDD00J
23-V-99492
3D
0
0200
GBDD10J
23-V-90405
AD20
DD20
CLOSED DRAIN
PH-ME-P-0278-001
CONT. ON DWG. PH-ME-P-0129-002
23-XX-9144
SKID LIMITS
FROM TT-92704
PH-ME-P-0170-002
PCS TIC 92704 H
PCS FI 92706 H
45 FT 92706
45 FE 92706
(NOTE 2)
COOLING MEDIUM SUPPLY
PH-ME-P-0265-001
0600-WC-45L94391-AS20-0
0600
BUAS20R
45-V-91195
(NOTE 7)
F101
0600
BUAS20R
45-V-91196
0600x0400
H
H
45 TV 92704
0400
(NOTE 3)
0600x0400
0600
BUAS20R
45-V-91197
0075
GTAS00R
45-V-91270
0075
GTAS00R
45-V-93911
0075
GTAS00R
45-V-91271
4C 30 N
0300
GBAS10R
45-V-91198
0150
CBAS10R
45-V-91199
PH-S-1930
SP 259
T-STRAINER
(NOTE 1)
0200
GTAS10R
45-V-97088
0200
CBAD10R
45-V-91362
AS20
AD20
PCS PDI 92714 H
45 PDT 92714
0150
CBAS10R
45-V-91200
PCS TI 92706
45 TT 92706
0150
0600-WC-45L94458-AS20-0
TO 2ND STAGE DISCHARGE COOLER
PH-ME-P-0170-002
PDT MEASUREMENT ACROSS 2ND STG. DISCHARGE COOLER
PH-ME-P-0170-002
FROM 2ND STAGE DISCHARGE COOLER
0200-DO-81L96517-AS20-0
PH-ME-P-0170-002
0200-DO-81L94850-AS20-0
0200-DO-81L96513-AS20-0
HAZARDOUS OPEN DRAIN
PH-ME-P-0280-002
CONT. ON DWG. PH-ME-P-0170-002

Field for file specification:
Field for date and time :

A1

NOTES:

1. T-STRAINERS ARE BUTT WELD.
2. CONDITIONING PLATE. PROVIDE STRAIGHT RUN OF 2 PIPE DIAMETERS UPSTREAM AND 2 PIPE DIAMETERS DOWNSTREAM.
3. VALVE EQUIPPED WITH MINIMUM 10% FLOW MECHANICAL STOP TO PROTECT AGAINST THERMAL SHOCK.
4. DO NOT POCKET.
5. KEY○LOCKED VALVE.
6. MINIMUM 1 METER SEPARATION.
7. TWO 0050 SIZE FLANGED GATE VALVES, GTAS00R, FOR EACH OF: 45-FT-92706 (TOTAL 2 VALVES) - BY PIPING.
   SEE DETAIL F101 ON P&ID PH-ME-P-0102-001.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	15OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/PS/JL	RAB	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
2ND STAGE DISCHARGE COOLER STRAINERS

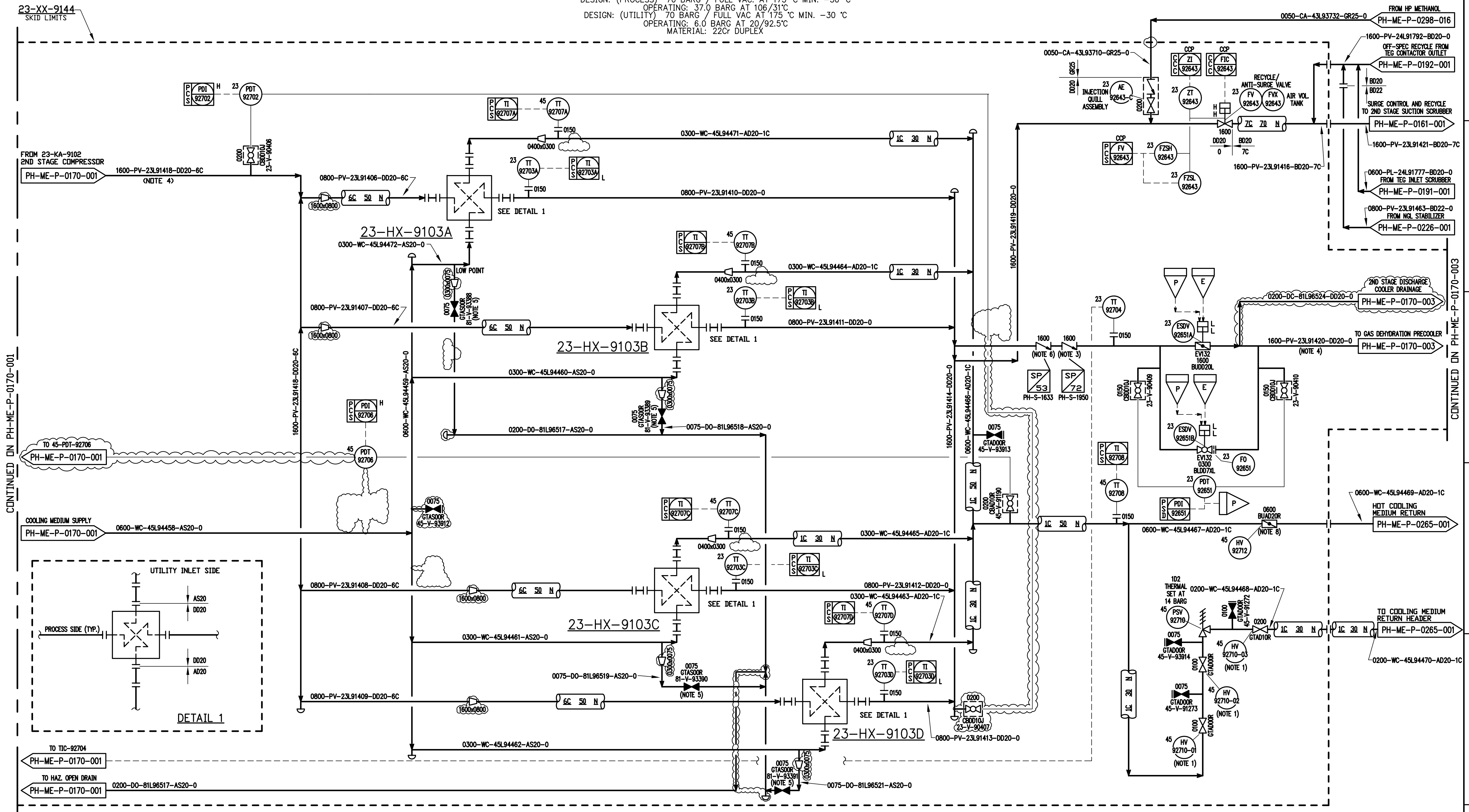
REGISTRATION CODES		
AREA	SYSTEM	TYPE
T33-02	23	XB

DRAWING NO.					SCALE
FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
PH	ME	P	0170	001	REV. 4

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0170-002.DWG 15OCT09 1121 SF 25.40 IMP J1KELLE

23-XX-9144
2nd STAGE DISCHARGE COOLER/
GAS DEHYDRATION PRECOOLER SKID

23-HX-9103 A/B/C/D
2nd STAGE DISCHARGE COOLERS
DUTY: 13430 kW
TYPE: PCHE
DESIGN: (PROCESS) 70 BARG / FULL VAC. AT 175 °C MIN. –30 °C
OPERATING: 37.0 BARG AT 106/31°C
DESIGN: (UTILITY) 70 BARG / FULL VAC AT 175 °C MIN. –30 °C
OPERATING: 6.0 BARG AT 20/92.5°C
MATERIAL: 22Cr DUPLEX


23-XX-9144
SKID LIMITS
CONTINUED ON PH-ME-P-0170-001
CONTINUED ON PH-ME-P-0170-003
FROM 23-KA-9102
2ND STAGE COMPRESSOR
PH-ME-P-0170-001
1600-PV-23L91418-DD20-6C
(NOTE 4)
PDI 92702
PDT 92702
23-V-90406
0800-PV-23L91406-DD20-6C
0800-PV-23L91407-DD20-6C
0800-PV-23L91408-DD20-6C
0800-PV-23L91409-DD20-6C
0800-PV-23L91410-DD20-0
0800-PV-23L91411-DD20-0
0800-PV-23L91412-DD20-0
0800-PV-23L91413-DD20-0
1600-PV-23L91418-DD20-6C
1600-PV-23L91414-DD20-0
1600-PV-23L91419-DD20-0
23-HX-9103A
23-HX-9103B
23-HX-9103C
23-HX-9103D
SEE DETAIL 1
LOW POINT
TT 92707A
TT 92703A
TT 92707B
TT 92703B
TT 92707C
TT 92703C
TT 92707D
TT 92703D
0300-WC-45L94471-AD20-1C
0300-WC-45L94472-AS20-0
0300-WC-45L94464-AD20-1C
0300-WC-45L94460-AS20-0
0300-WC-45L94465-AD20-1C
0300-WC-45L94461-AS20-0
0300-WC-45L94463-AD20-1C
0300-WC-45L94462-AS20-0
0600-WC-45L94459-AS20-0
0600-WC-45L94466-AD20-1C
0200-DO-81L96517-AS20-0
0075-DO-81L96518-AS20-0
0075-DO-81L96519-AS20-0
0075-DO-81L96521-AS20-0
GTASOOR 81-V-93388 (NOTE 5)
GTASOOR 81-V-93389 (NOTE 5)
GTASOOR 81-V-93390 (NOTE 5)
GTASOOR 81-V-93391 (NOTE 5)
GTASOOR 45-V-93912
TO 45-PDT-92706
PH-ME-P-0170-001
PDI 92706
PDT 92706
COOLING MEDIUM SUPPLY
PH-ME-P-0170-001
0600-WC-45L94458-AS20-0
UTILITY INLET SIDE
PROCESS SIDE (TYP.)
AS20
DD20
AD20
DETAIL 1
TO TIC-92704
PH-ME-P-0170-001
TO HAZ. OPEN DRAIN
PH-ME-P-0170-001
0200-DO-81L96517-AS20-0
CBAD10R 45-V-91190
GTADOOR 45-V-93913
CBDD10J 23-V-90407
FROM HP METHANOL
PH-ME-P-0298-016
0050-CA-43L93732-GR25-0
0050-CA-43L93710-GR25-0
INJECTION QUILL ASSEMBLY
AE 92643-C
ZI 92643
FIC 92643
ZT 92643
RECYCLE/ ANTI-SURGE VALVE
FV 92643
FVX 92643
AIR VOL. TANK
FZSH 92643
FZSL 92643
1600-PV-23L91416-BD20-7C
1600-PV-24L91792-BD20-0
OFF-SPEC RECYCLE FROM TEG CONTACTOR OUTLET
PH-ME-P-0192-001
SURGE CONTROL AND RECYCLE TO 2ND STAGE SUCTION SCRUBBER
PH-ME-P-0161-001
1600-PV-23L91421-BD20-7C
0600-PL-24L91777-BD20-0
FROM TEG INLET SCRUBBER
PH-ME-P-0191-001
0800-PV-23L91463-BD22-0
FROM NGL STABILIZER
PH-ME-P-0226-001
2ND STAGE DISCHARGE COOLER DRAINAGE
0200-DC-81L96524-DD20-0
PH-ME-P-0170-003
TO GAS DEHYDRATION PRECOOLER
1600-PV-23L91420-DD20-0
(NOTE 4)
PH-ME-P-0170-003
TT 92704
(NOTE 6)
(NOTE 3)
SP 53 PH-S-1633
SP 72 PH-S-1950
ESDV 92651A
ESDV 92651B
EV132 1600 BUDD20L
EV132 0300 BLDD74L
FO 92651
PDT 92651
PDI 92651
CBDD10J 23-V-90409
CBDD10J 23-V-90410
TT 92708
TI 92708
0600-WC-45L94467-AD20-1C
BUAD20R (NOTE 8)
HV 92712
0600-WC-45L94469-AD20-1C
HOT COOLING MEDIUM RETURN
PH-ME-P-0265-001
THERMAL SET AT 14 BARG
PSV 92710
0200-WC-45L94468-AD20-1C
GTADOOR 45-V-91272
GTADOOR 45-V-93914
GTADOOR 45-V-91273
HV 92710-03 (NOTE 1)
HV 92710-02 (NOTE 1)
HV 92710-01 (NOTE 1)
TO COOLING MEDIUM RETURN HEADER
PH-ME-P-0265-001
0200-WC-45L94470-AD20-1C

NOTES:
1. KEY INTERLOCKED VALVE.
2. DELETED.
3. ANTI-SLAM DESIGN.
4. DO NOT POCKET.
5. COOLING MEDIUM DRAINS TO BE LOCATED ON EITHER THE PIPE OR EQUIPMENT AND SHALL BE AT LOW POINT.
6. DISSIMILAR CHECK VALVES.
7. DELETED.
8. KEY LOCKED VALVE.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	15OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/PS/JL	RAB	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
2ND STAGE DISCHARGE COOLER

REGISTRATION CODES

AREA	SYSTEM	TYPE
T33-02	23	XB

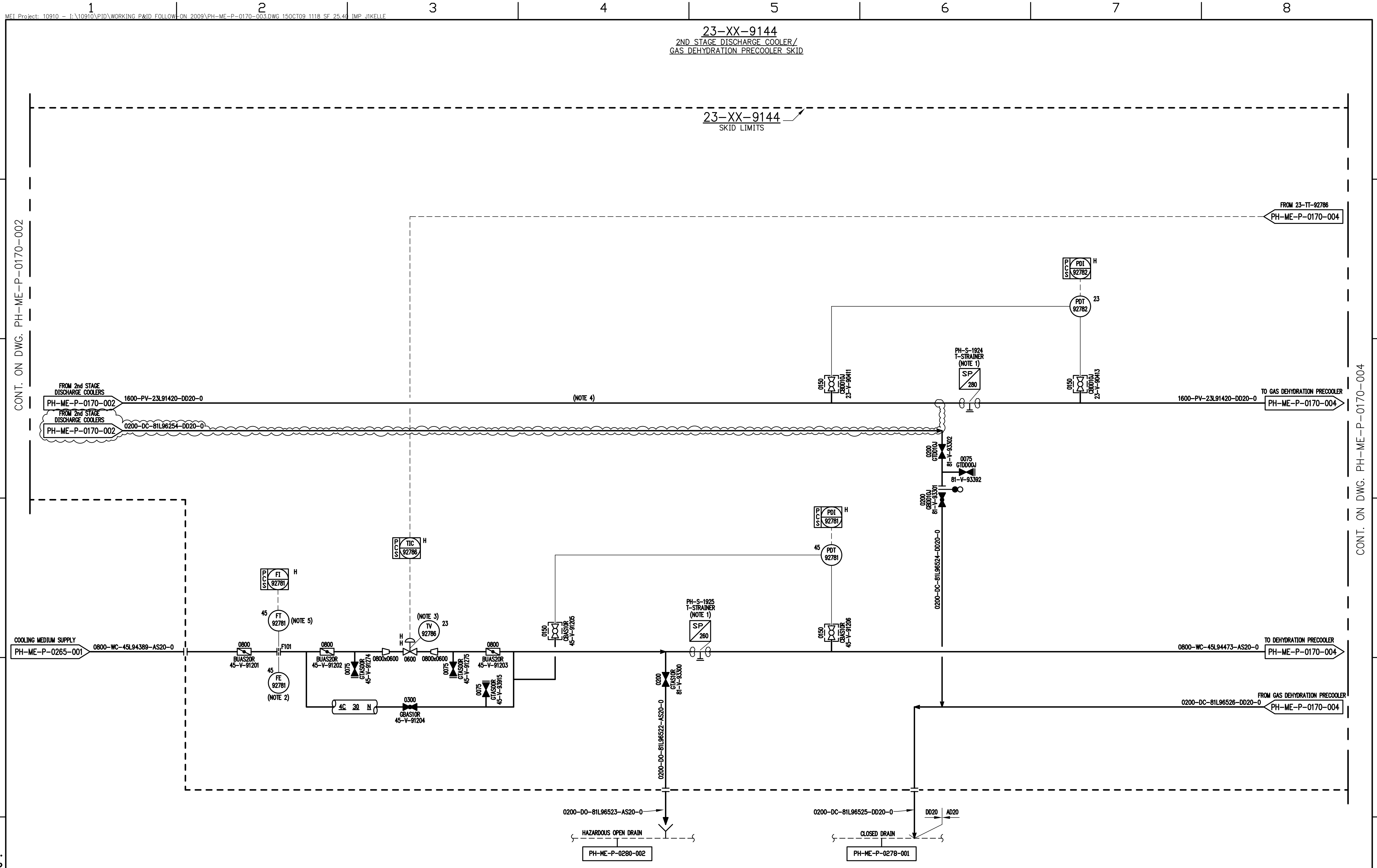
DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0170	002

SCALE NONE
REV. 4

Field for file specification:
Field for date and time :
A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0170-003.DWG 15OCT09 1118 SF 25.40 IMP J1KELLE


23-XX-9144
2ND STAGE DISCHARGE COOLER/
GAS DEHYDRATION PRECOOLER SKID
23-XX-9144
SKID LIMITS
CONT. ON DWG. PH-ME-P-0170-002
CONT. ON DWG. PH-ME-P-0170-004
FROM 23-TT-92786
PH-ME-P-0170-004
FROM 2nd STAGE DISCHARGE COOLERS
PH-ME-P-0170-002
1600-PV-23L91420-DD20-0
FROM 2nd STAGE DISCHARGE COOLERS
PH-ME-P-0170-002
0200-DC-81L96254-DD20-0
(NOTE 4)
PDI 92782 H
PCS
PDT 92782 23
0150 CBDD10J 23-V-90411
0150 CBDD10J 23-V-90413
PH-S-1924
T-STRAINER
(NOTE 1)
SP 280
1600-PV-23L91420-DD20-0
TO GAS DEHYDRATION PRECOOLER
PH-ME-P-0170-004
0200 GTDD10J 81-V-93302
0075 GTDD00J 81-V-93392
0200 GBDD10J 81-V-93301
0200-DC-81L96524-DD20-0
COOLING MEDIUM SUPPLY
PH-ME-P-0265-001
0800-WC-45L94389-AS20-0
0800 BUAS20R 45-V-91201
FI 92781 H
45 FT 92781 (NOTE 5)
F101
45 FE 92781 (NOTE 2)
0800 BUAS20R 45-V-91202
0075 GTAS00R 45-V-91274
0800x0600
TIC 92786 H
H H
0600
(NOTE 3)
TV 92786 23
0800x0600
0075 GTAS00R 45-V-91275
0800 BUAS20R 45-V-91203
0075 GTAS00R 45-V-93915
4C 30 N
0300 GBAS10R 45-V-91204
0150 CBAS10R 45-V-91205
PH-S-1925
T-STRAINER
(NOTE 1)
SP 260
0200 GTAS10R 81-V-93300
PDI 92781 H
45 PDT 92781
0150 CBAS10R 45-V-91206
0800-WC-45L94473-AS20-0
TO DEHYDRATION PRECOOLER
PH-ME-P-0170-004
FROM GAS DEHYDRATION PRECOOLER
0200-DC-81L96526-DD20-0
PH-ME-P-0170-004
0200-DO-81L96522-AS20-0
0200-DO-81L96523-AS20-0
HAZARDOUS OPEN DRAIN
PH-ME-P-0280-002
0200-DC-81L96525-DD20-0
DD20 AD20
CLOSED DRAIN
PH-ME-P-0278-001

Field for file specification:
Field for date and time :

NOTES:

1. T-STRAINERS ARE BUTT WELDED.
2. CONDITIONING PLATE. PROVIDE STRAIGHT RUN OF 2 PIPE DIAMETERS UPSTREAM AND 2 PIPE DIAMETERS DOWNSTREAM.
3. VALVE EQUIPPED WITH MINIMUM 10% FLOW MECHANICAL STOP TO PROTECT AGAINST THERMAL SHOCK.
4. DO NOT POCKET.
5. TWO 0050 SIZE FLANGED GATE VALVES, GTAS00R, FOR EACH OF: 45-FE-92781 (TOTAL: 2 VALVES) - BY PIPING. SEE F101 ON P&ID PH-ME-P-0102-101.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	15OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/PS/JL	RAB	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
GAS DEHYDRATION PRECOOLER STRAINERS

REGISTRATION CODES

AREA	SYSTEM	TYPE
T33-02	23	XB

DRAWING NO.

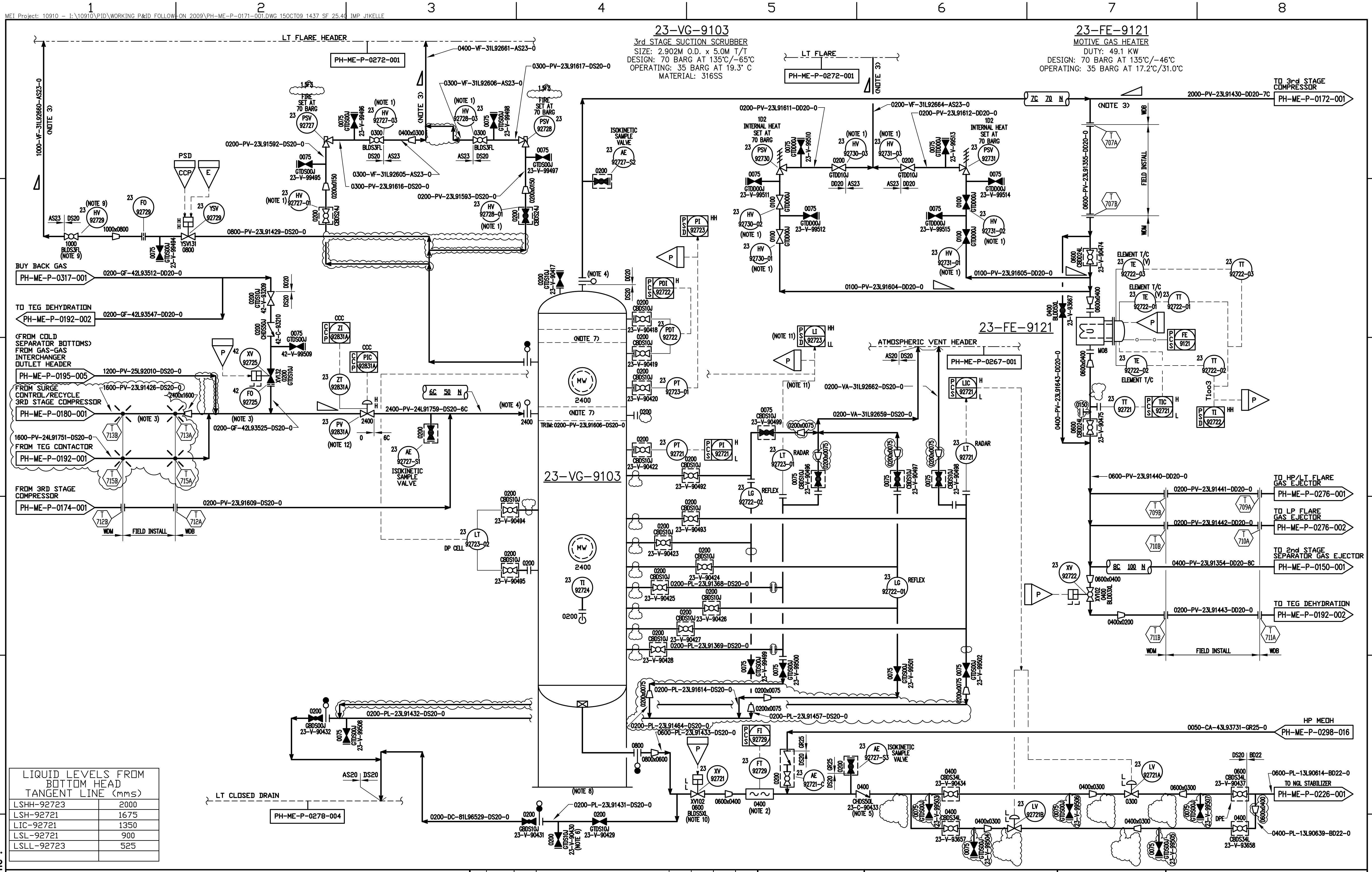
FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0170	003

SCALE NONE
REV. 4

A1

Field for file specification:
Field for date and time :

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0171-001.DWG 15OCT09 1437 SF 25.40 IMP J1KELLE


LT FLARE HEADER
PH-ME-P-0272-001
1000-VF-31L92660-AS23-0
0400-VF-31L92661-AS23-0
0300-PV-23L91617-DS20-0
0300-VF-31L92606-AS23-0
0300-VF-31L92605-AS23-0
0300-PV-23L91616-DS20-0
0200-PV-23L91592-DS20-0
0200-PV-23L91593-DS20-0
PSV 92727
PSV 92728
HV 92729
FO 92729
YSV 92729
PSD
CCP
E
YSV131
0800-PV-23L91429-DS20-0
BUY BACK GAS
PH-ME-P-0317-001
0200-GF-42L93512-DD20-0
TO TEG DEHYDRATION
PH-ME-P-0192-002
0200-GF-42L93547-DD20-0
(FROM COLD SEPARATOR BOTTOMS) FROM GAS-GAS INTERCHANGER OUTLET HEADER
PH-ME-P-0195-005
1200-PV-25L92010-DS20-0
FROM SURGE CONTROL/RECYCLE 3RD STAGE COMPRESSOR
PH-ME-P-0180-001
1600-PV-23L91426-DS20-0
1600-PV-24L91751-DS20-0
FROM TEG CONTACTOR
PH-ME-P-0192-001
FROM 3RD STAGE COMPRESSOR
PH-ME-P-0174-001
0200-PV-23L91609-DS20-0
0200-GF-42L93525-DS20-0
XV 92725
FO 92725
XV132
ZI 92831A
PIC 92831A
ZT 92831A
PV 92831A
2400-PV-24L91759-DS20-6C
6C 50 N
AE 92727-S1
ISOKINETIC SAMPLE VALVE
LT 92723-02
DP CELL
23-VG-9103
MW 2400
TI 92724
TRIM: 0200-PV-23L91606-DS20-0
AE 92727-S2
PI 92723
PDI 92722
PDT 92722
PT 92723-01
PT 92721
PI 92721
LI 92723
LG 92722-02
LT 92723-01
RADAR
LT 92721
LG 92722-01
REFLEX
LIC 92721
ATMOSPHERIC VENT HEADER
PH-ME-P-0267-001
0200-VA-31L92662-DS20-0
0200-VA-31L92659-DS20-0
0200-PV-23L91611-DD20-0
0200-VF-31L92664-AS23-0
0200-PV-23L91612-DD20-0
PSV 92730
PSV 92731
LT FLARE
0100-PV-23L91604-DD20-0
0100-PV-23L91605-DD20-0
23-FE-9121
7C 70 N
2000-PV-23L91430-DD20-7C
TO 3rd STAGE COMPRESSOR
PH-ME-P-0172-001
0600-PV-23L91355-DD20-0
FIELD INSTALL
0400-PV-23L91643-DD20-0
TE 92722-03
TE 92722-01
TT 92722-03
TT 92722-01
FE 9121
TE 92722-02
TT 92722-02
TT 92721
TIC 92721
TI 92722
T1oo3
ELEMENT T/C
0600-PV-23L91440-DD20-0
TO HP/LT FLARE GAS EJECTOR
PH-ME-P-0276-001
0200-PV-23L91441-DD20-0
TO LP FLARE GAS EJECTOR
PH-ME-P-0276-002
0200-PV-23L91442-DD20-0
TO 2nd STAGE SEPARATOR GAS EJECTOR
PH-ME-P-0150-001
8C 100 N
0400-PV-23L91354-DD20-8C
XV 92722
XV102
TO TEG DEHYDRATION
PH-ME-P-0192-002
0200-PV-23L91443-DD20-0
HP MEOH
PH-ME-P-0298-016
0050-CA-43L93731-GR25-0
0200-PL-23L91614-DS20-0
0200-PL-23L91457-DS20-0
0200-PL-23L91464-DS20-0
0600-PL-23L91433-DS20-0
0200-PL-23L91432-DS20-0
0200-PL-23L91431-DS20-0
0200-PL-23L91368-DS20-0
0200-PL-23L91369-DS20-0
FI 92729
FT 92729
XV 92721
AE 92721-C
AE 92727-S3
LV 92721A
LV 92721B
TO NGL STABILIZER
PH-ME-P-0226-001
0600-PL-13L90614-BD22-0
0400-PL-13L90639-BD22-0
LT CLOSED DRAIN
PH-ME-P-0278-004
0200-DC-81L96529-DS20-0
AS20
DS20

23-VG-9103
3rd STAGE SUCTION SCRUBBER
SIZE: 2.902M O.D. x 5.0M T/T
DESIGN: 70 BARG AT 135°C/–65°C
OPERATING: 35 BARG AT 19.3° C
MATERIAL: 316SS

23-FE-9121
MOTIVE GAS HEATER
DUTY: 49.1 KW
DESIGN: 70 BARG AT 135°C/–46°C
OPERATING: 35 BARG AT 17.2°C/31.0°C

LIQUID LEVELS FROM BOTTOM HEAD TANGENT LINE (mms)	
LSHH-92723	2000
LSH-92721	1675
LIC-92721	1350
LSL-92721	900
LSLL-92723	525

NOTES:
1. KEY INTERLOCKED VALVE.
2. LIQUID ULTRASONIC METER. PROVIDE STRAIGHT RUN OF 7 PIPE DIAMETERS UPSTREAM AND 3 PIPE DIAMETERS DOWNSTREAM.
3. DO NOT POCKET.
4. SPADE & SPACER TYPE. PROVIDE SPADE STAND AT EACH LOCATION TO PREVENT MISPLACING SPADE.
5. ANTISLAM DESIGN.
6. N2 INJECTION AT 2" DRAIN VALVE.
7. INTERNALS ILLUSTRATED ARE INCOMPLETE AND NOT TO SCALE. REFER TO VENDOR DWG.'S FOR COMPLETE DETAILS AND ACCURATE INTERNAL INFORMATION.
8. VESSEL SKIRT.
9. KEY LOCKED VALVE.
10. LOCATE THE XV AS NEAR THE SCRUBBER AS PRACTICLE.
11. 1oo2 VOTING ONLY ON LSHH USING 23-LT-92723-01/02. 1oo1 VOTING ON LSLL USING LEVEL TRANSMITTER 23-LT-92723-01.
12. ACTUATOR TO HAVE TRAVEL STOP SET AT A POSITION EQUIVALENT TO CV=510 (TO LIMIT CLOSURE).

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	03DEC08	CDB	RE-ISSUED FOR CONSTRUCTION	RM	RK/PS/JL	DR	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

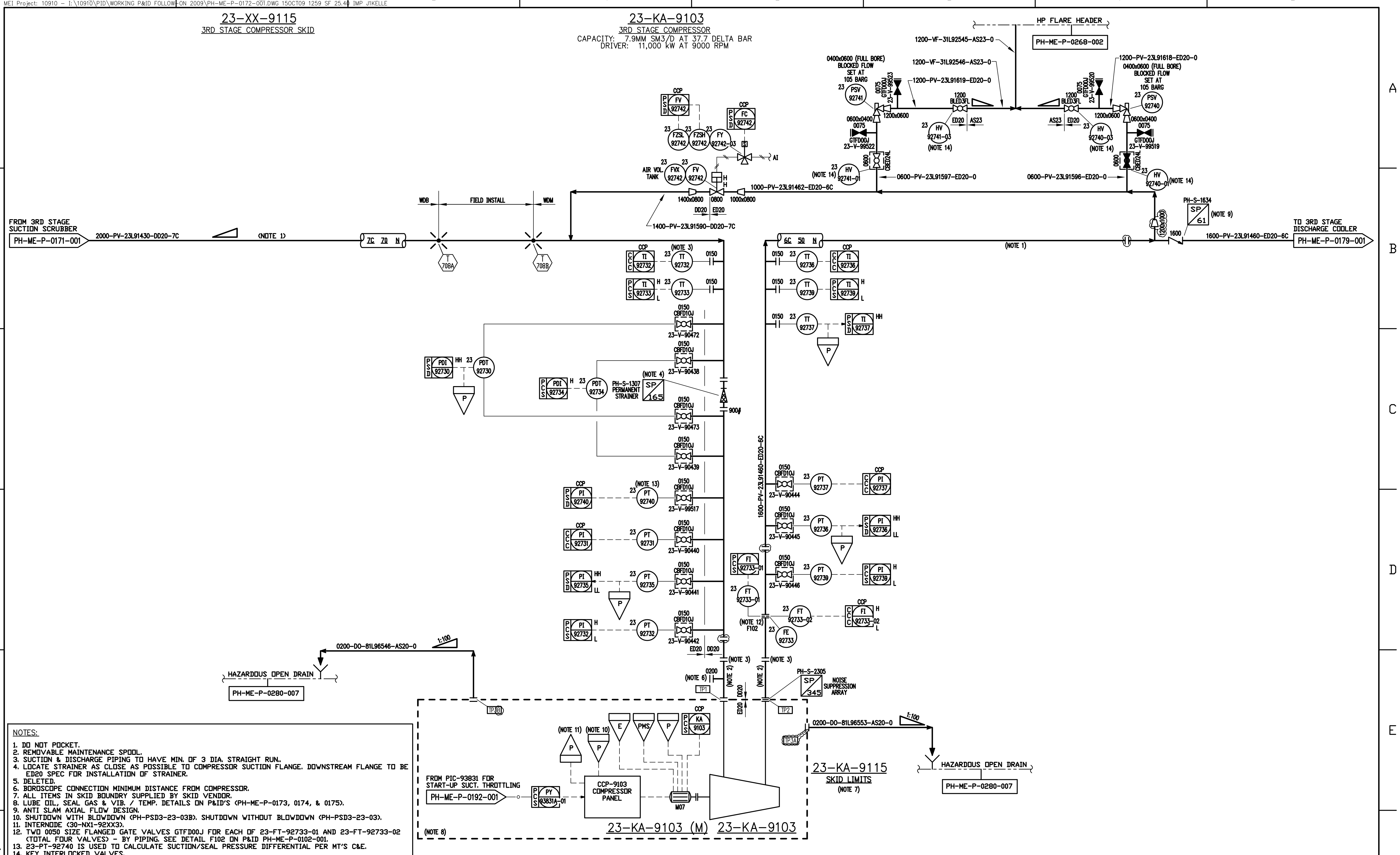
PROJECT NO. 10910

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
3RD STAGE SUCTION SCRUBBER

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
T33-02	23	XB	PH	ME	P	0171	001	REV. 4

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0172-001.DWG 15OCT09 1259 SF 25.40 IMP J1KELLE


1
2
3
4
5
6
7
8
A
B
C
D
E
F
23-XX-9115
3RD STAGE COMPRESSOR SKID
23-KA-9103
3RD STAGE COMPRESSOR
CAPACITY: 7.9MM SM3/D AT 37.7 DELTA BAR
DRIVER: 11,000 kW AT 9000 RPM
HP FLARE HEADER
PH-ME-P-0268-002
1200-VF-31L92545-AS23-0
1200-VF-31L92546-AS23-0
1200-PV-23L91619-ED20-0
1200-PV-23L91618-ED20-0
0400x0600 (FULL BORE) BLOCKED FLOW SET AT 105 BARG
PSV 92741
PSV 92740
0075 GTFD00J 23-V-99523
0075 GTFD00J 23-V-99520
1200 BLED3FL
ED20
AS23
HV 92741-03 (NOTE 14)
HV 92740-03 (NOTE 14)
1200x0600
0600x0400
0075 GTFD00J 23-V-99522
0075 GTFD00J 23-V-99519
0600 CBED24L
HV 92741-01 (NOTE 14)
HV 92740-01 (NOTE 14)
0600-PV-23L91597-ED20-0
0600-PV-23L91596-ED20-0
CCP
FV 92742
FC 92742
FZSL 92742
FZSH 92742
FY 92742-03
AI
AIR VOL. TANK
FVX 92742
FV 92742
1400x0800
0800
1000x0800
DD20
ED20
1000-PV-23L91462-ED20-6C
1400-PV-23L91590-DD20-7C
FROM 3RD STAGE SUCTION SCRUBBER
PH-ME-P-0171-001
2000-PV-23L91430-DD20-7C
(NOTE 1)
7C 70 N
WDB
FIELD INSTALL
WDM
T 708A
T 708B
TI 92732
TT 92732
(NOTE 3)
0150
TI 92733
TT 92733
H
L
HH
LL
0150 CBFD10J
23-V-90472
23-V-90438
23-V-90473
23-V-90439
23-V-99517
23-V-90440
23-V-90441
23-V-90442
PDI 92730
PDT 92730
PDI 92734
PDT 92734
PH-S-1307 PERMANENT STRAINER
SP 165
(NOTE 4)
900#
P
PI 92740
PT 92740
(NOTE 13)
PI 92731
PT 92731
PI 92735
PT 92735
PI 92732
PT 92732
ED20
DD20
(NOTE 3)
0200
(NOTE 6)
(NOTE 2)
TP1
TP2
TP3B
TP3A
6C 50 N
TT 92736
TI 92736
TT 92739
TI 92739
TT 92737
TI 92737
1600-PV-23L91460-ED20-6C
23-V-90444
PT 92737
PI 92737
23-V-90445
PT 92736
PI 92736
23-V-90446
PT 92739
PI 92739
FI 92733-01
FT 92733-01
FT 92733-02
FI 92733-02
(NOTE 12) F102
FE 92733
PH-S-2305
SP 345
NOISE SUPPRESSION ARRAY
(NOTE 1)
1200x1000
1600
PH-S-1634
SP 61
(NOTE 9)
TO 3RD STAGE DISCHARGE COOLER
PH-ME-P-0179-001
1600-PV-23L91460-ED20-6C
0200-DO-81L96546-AS20-0
1:100
HAZARDOUS OPEN DRAIN
PH-ME-P-0280-007
0200-DO-81L96553-AS20-0
1:100
HAZARDOUS OPEN DRAIN
PH-ME-P-0280-007
23-KA-9115
SKID LIMITS
(NOTE 7)
(NOTE 11)
(NOTE 10)
E
PMS
KA 9103
FROM PIC-93831 FOR START-UP SUCT. THROTTLING
PH-ME-P-0192-001
PY 93831A-01
CCP-9103 COMPRESSOR PANEL
M07
(NOTE 8)
23-KA-9103 (M)
23-KA-9103
P S D
P C S
C C C
23

NOTES:

1. DO NOT POCKET.
2. REMOVABLE MAINTENANCE SPOOL.
3. SUCTION & DISCHARGE PIPING TO HAVE MIN. OF 3 DIA. STRAIGHT RUN..
4. LOCATE STRAINER AS CLOSE AS POSSIBLE TO COMPRESSOR SUCTION FLANGE. DOWNSTREAM FLANGE TO BE ED20 SPEC FOR INSTALLATION OF STRAINER.
5. DELETED.
6. BOROSCOPE CONNECTION MINIMUM DISTANCE FROM COMPRESSOR.
7. ALL ITEMS IN SKID BOUNDRY SUPPLIED BY SKID VENDOR.
8. LUBE OIL, SEAL GAS & VIB. / TEMP. DETAILS ON P&ID'S (PH-ME-P-0173, 0174, & 0175).
9. ANTI SLAM AXIAL FLOW DESIGN.
10. SHUTDOWN WITH BLOWDOWN (PH-PSD3-23-03B). SHUTDOWN WITHOUT BLOWDOWN (PH-PSD3-23-03).
11. INTERNODE (30-NX1-92XX3).
12. TWO 0050 SIZE FLANGED GATE VALVES GTFD00J FOR EACH OF 23-FT-92733-01 AND 23-FT-92733-02 (TOTAL FOUR VALVES) - BY PIPING. SEE DETAIL F102 ON P&ID PH-ME-P-0102-001.
13. 23-PT-92740 IS USED TO CALCULATE SUCTION/SEAL PRESSURE DIFFERENTIAL PER MT'S C&E.
14. KEY INTERLOCKED VALVES.

Field for file specification:
Field for date and time :

NOTES:

4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTOIN	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	30OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	SVS	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	
REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
3RD STAGE COMPRESSOR

REGISTRATION CODES

AREA	SYSTEM	TYPE
T44-02	23	XB

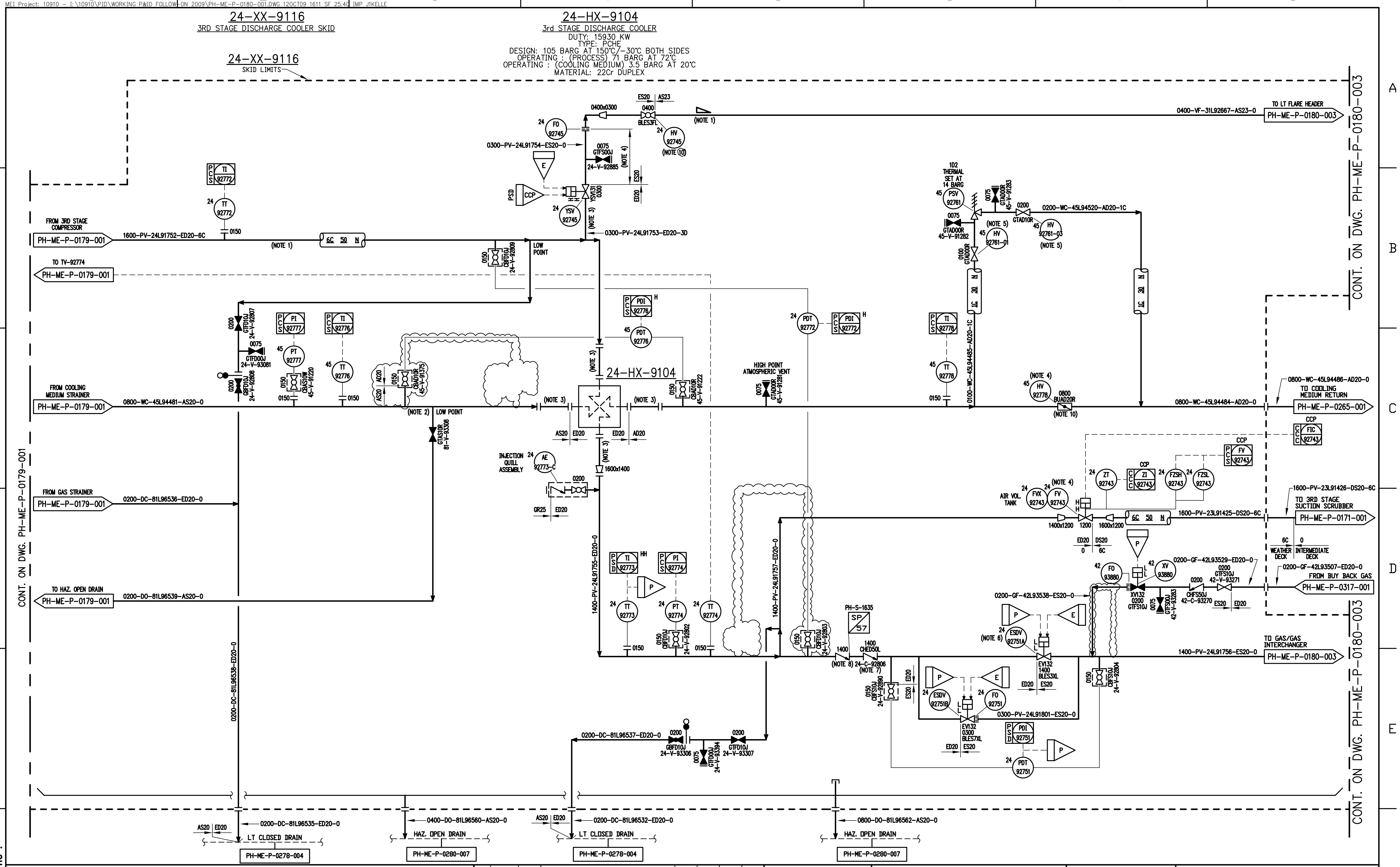
DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0172	001

SCALE NONE
REV. 4

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0180-001.DWG 12OCT09 1611 SF 25.40 IMP J1KELLE


24-XX-9116
3RD STAGE DISCHARGE COOLER SKID
24-HX-9104
3rd STAGE DISCHARGE COOLER
DUTY: 15930 KW
TYPE: PCHE
DESIGN: 105 BARG AT 150°C/-30°C BOTH SIDES
OPERATING : (PROCESS) 71 BARG AT 72°C
OPERATING : (COOLING MEDIUM) 3.5 BARG AT 20°C
MATERIAL: 22Cr DUPLEX
24-XX-9116
SKID LIMITS
FROM 3RD STAGE COMPRESSOR
PH-ME-P-0179-001
1600-PV-24L91752-ED20-6C
TO TV-92774
PH-ME-P-0179-001
FROM COOLING MEDIUM STRAINER
PH-ME-P-0179-001
0800-WC-45L94481-AS20-0
FROM GAS STRAINER
PH-ME-P-0179-001
0200-DC-81L96536-ED20-0
TO HAZ. OPEN DRAIN
PH-ME-P-0179-001
0200-DO-81L96539-AS20-0
CONT. ON DWG. PH-ME-P-0179-001
0400-VF-31L92667-AS23-0
TO LT FLARE HEADER
PH-ME-P-0180-003
0300-PV-24L91754-ES20-0
0300-PV-24L91753-ED20-3D
0200-WC-45L94520-AD20-1C
0100-WC-45L94485-AD20-1C
0800-WC-45L94484-AD20-0
0800-WC-45L94486-AD20-0
TO COOLING MEDIUM RETURN
PH-ME-P-0265-001
1600-PV-23L91426-DS20-6C
1600-PV-23L91425-DS20-6C
TO 3RD STAGE SUCTION SCRUBBER
PH-ME-P-0171-001
0200-GF-42L93529-ED20-0
0200-GF-42L93507-ED20-0
FROM BUY BACK GAS
PH-ME-P-0317-001
0200-GF-42L93538-ES20-0
1400-PV-24L91756-ES20-0
TO GAS/GAS INTERCHANGER
PH-ME-P-0180-003
1400-PV-24L91755-ED20-0
1400-PV-24L91757-ED20-0
0300-PV-24L91801-ES20-0
0200-DC-81L96537-ED20-0
0200-DC-81L96538-ED20-0
0200-DC-81L96535-ED20-0
0400-DO-81L96560-AS20-0
0200-DC-81L96532-ED20-0
0800-DO-81L96562-AS20-0
LT CLOSED DRAIN
PH-ME-P-0278-004
HAZ. OPEN DRAIN
PH-ME-P-0280-007
LT CLOSED DRAIN
PH-ME-P-0278-004
HAZ. OPEN DRAIN
PH-ME-P-0280-007
CONT. ON DWG. PH-ME-P-0180-003
CONT. ON DWG. PH-ME-P-0180-003
24-HX-9104
LOW POINT
HIGH POINT ATMOSPHERIC VENT
INJECTION QUILL ASSEMBLY
AIR VOL TANK
1D2 THERMAL SET AT 14 BARG
PH-S-1635
SP 57
WEATHER DECK
INTERMEDIATE DECK
TI 92772
TT 92772
PI 92777
PT 92777
TI 92776
TT 92776
PDI 92776
PDT 92776
PDT 92772
PDI 92772
TI 92778
TT 92778
FO 92745
HV 92745
YSV 92745
YSV131
PSV 92761
HV 92761-01
HV 92761-03
HV 92778
AE 92773-C
TI 92773
TT 92773
PI 92774
PT 92774
TT 92774
FIC 92743
FV 92743
FVX 92743
ZT 92743
ZI 92743
FZSH 92743
FZSL 92743
FO 93880
XV 93880
ESDV 92751A
ESDV 92751B
FO 92751
PDI 92751
PDT 92751
CCP
PSD
(NOTE 1)
(NOTE 2)
(NOTE 3)
(NOTE 4)
(NOTE 5)
(NOTE 6)
(NOTE 7)
(NOTE 8)
(NOTE 10)

NOTES:
1. DO NOT POCKET.
2. COOLING MEDIUM DRAINS TO BE LOCATED EITHER ON PIPE OR EQUIPMENT AND SHALL BE AT LOW POINT.
3. MAINTENANCE DROP OUT SPOOL.
4. LOCATE VALVE AS CLOSE AS PRACTICAL TO TEE. PROVIDE APPROX. 1 METER OF DOWNSTREAM STRAIGHT RUN.
5. KEY INTERLOCKED VALVE.
6. MINIMIZE DISTANCE BETWEEN ESDV AND UPSTREAM CHECK VALVE.
7. ANTI-SLAM DESIGN.
8. DISSIMULAR CHECK VALVE.
9. DELETED.
10. KEY LOCKED VALVE.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	13OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	30OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	SVS	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

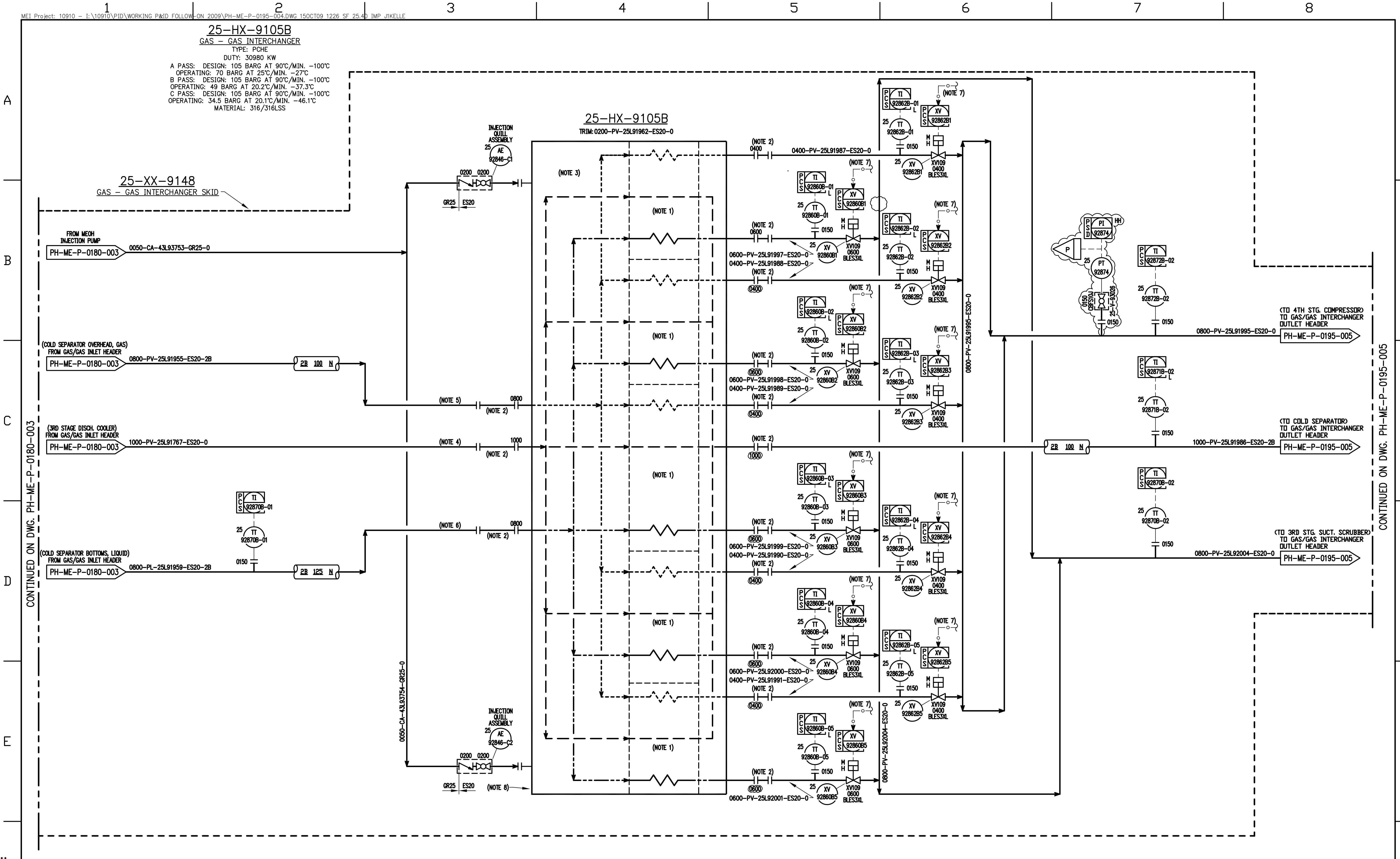
VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
3RD STAGE DISCHARGE COOLER

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
T44-02	24	XB	PH	ME	P	0180	001	REV. 4

Field for file specification:
Field for date and time :

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0195-004.DWG 15OCT09 1226 SF 25.40 IMP J1KELLE


25-HX-9105B
GAS – GAS INTERCHANGER
TYPE: PCHE
DUTY: 30980 KW
A PASS: DESIGN: 105 BARG AT 90°C/MIN. -100°C
OPERATING: 70 BARG AT 25°C/MIN. -27°C
B PASS: DESIGN: 105 BARG AT 90°C/MIN. -100°C
OPERATING: 49 BARG AT 20.2°C/MIN. -37.3°C
C PASS: DESIGN: 105 BARG AT 90°C/MIN. -100°C
OPERATING: 34.5 BARG AT 20.1°C/MIN. -46.1°C
MATERIAL: 316/316LSS
25-XX-9148
GAS – GAS INTERCHANGER SKID
CONTINUED ON DWG. PH-ME-P-0180-003
FROM MEOH INJECTION PUMP
PH-ME-P-0180-003
0050-CA-43L93753-GR25-0
(COLD SEPARATOR OVERHEAD, GAS) FROM GAS/GAS INLET HEADER
PH-ME-P-0180-003
0800-PV-25L91955-ES20-2B
2B 100 N
(3RD STAGE DISCH. COOLER) FROM GAS/GAS INLET HEADER
PH-ME-P-0180-003
1000-PV-25L91767-ES20-0
(COLD SEPARATOR BOTTOMS, LIQUID) FROM GAS/GAS INLET HEADER
PH-ME-P-0180-003
0800-PL-25L91959-ES20-2B
2B 125 N
TI 92870B-01
TT 92870B-01
0150
0050-CA-43L93754-GR25-0
INJECTION QUILL ASSEMBLY
AE 92846-C1
AE 92846-C2
0200 0200
GR25 ES20
(NOTE 8)
(NOTE 5)
(NOTE 4)
(NOTE 6)
(NOTE 2)
0800
1000
25-HX-9105B
TRIM:0200-PV-25L91962-ES20-0
(NOTE 3)
(NOTE 1)
0400-PV-25L91987-ES20-0
0600-PV-25L91997-ES20-0
0400-PV-25L91988-ES20-0
0600-PV-25L91998-ES20-0
0400-PV-25L91989-ES20-0
0600-PV-25L91999-ES20-0
0400-PV-25L91990-ES20-0
0600-PV-25L92000-ES20-0
0400-PV-25L91991-ES20-0
0600-PV-25L92001-ES20-0
0400
0600
(NOTE 7)
PCS TI 92860B-01
TT 92860B-01
PCS XV 92860B1
XV 92860B1
XV109 0600 BLES3XL
TI 92860B-02
TT 92860B-02
XV 92860B2
TI 92860B-03
TT 92860B-03
XV 92860B3
TI 92860B-04
TT 92860B-04
XV 92860B4
TI 92860B-05
TT 92860B-05
XV 92860B5
PCS TI 92862B-01
TT 92862B-01
PCS XV 92862B1
XV 92862B1
XV109 0400 BLES3XL
TI 92862B-02
TT 92862B-02
XV 92862B2
TI 92862B-03
TT 92862B-03
XV 92862B3
TI 92862B-04
TT 92862B-04
XV 92862B4
TI 92862B-05
TT 92862B-05
XV 92862B5
M H
0150
0800-PV-25L91995-ES20-0
0800-PV-25L92004-ES20-0
PSD PI 92874 HH
P
PT 92874
0150 CBFS10J 25-V-93026
PCS TI 92872B-02
TT 92872B-02
PCS TI 92871B-02
TT 92871B-02
PCS TI 92870B-02
TT 92870B-02
(TO 4TH STG. COMPRESSOR) TO GAS/GAS INTERCHANGER OUTLET HEADER
PH-ME-P-0195-005
0800-PV-25L91995-ES20-0
(TO COLD SEPARATOR) TO GAS/GAS INTERCHANGER OUTLET HEADER
PH-ME-P-0195-005
1000-PV-25L91986-ES20-2B
(TO 3RD STG. SUCT. SCRUBBER) TO GAS/GAS INTERCHANGER OUTLET HEADER
PH-ME-P-0195-005
0800-PV-25L92004-ES20-0
CONTINUED ON DWG. PH-ME-P-0195-005
1 2 3 4 5 6 7 8
A B C D E F

NOTES:

1. FIVE SEPARATE CELLS INTERNALLY.
2. MAINTENANCE DROP OUT SPOOLS.
3. PROCESS FLOW STREAMLINES REMAIN SEPARATED IN THE INLET CHAMBER.
4. "A" PASS.
5. "B" PASS.
6. "C" PASS.
7. DATA HWY. TIES THE PDI'S TO THE XV'S.
8. THIS BOUNDARY REPRESENTATION IS ACTUALLY MULTIPLE CHAMBERS (i.e. ONE FOR EACH STREAM LINE).

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	30OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	SVS	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

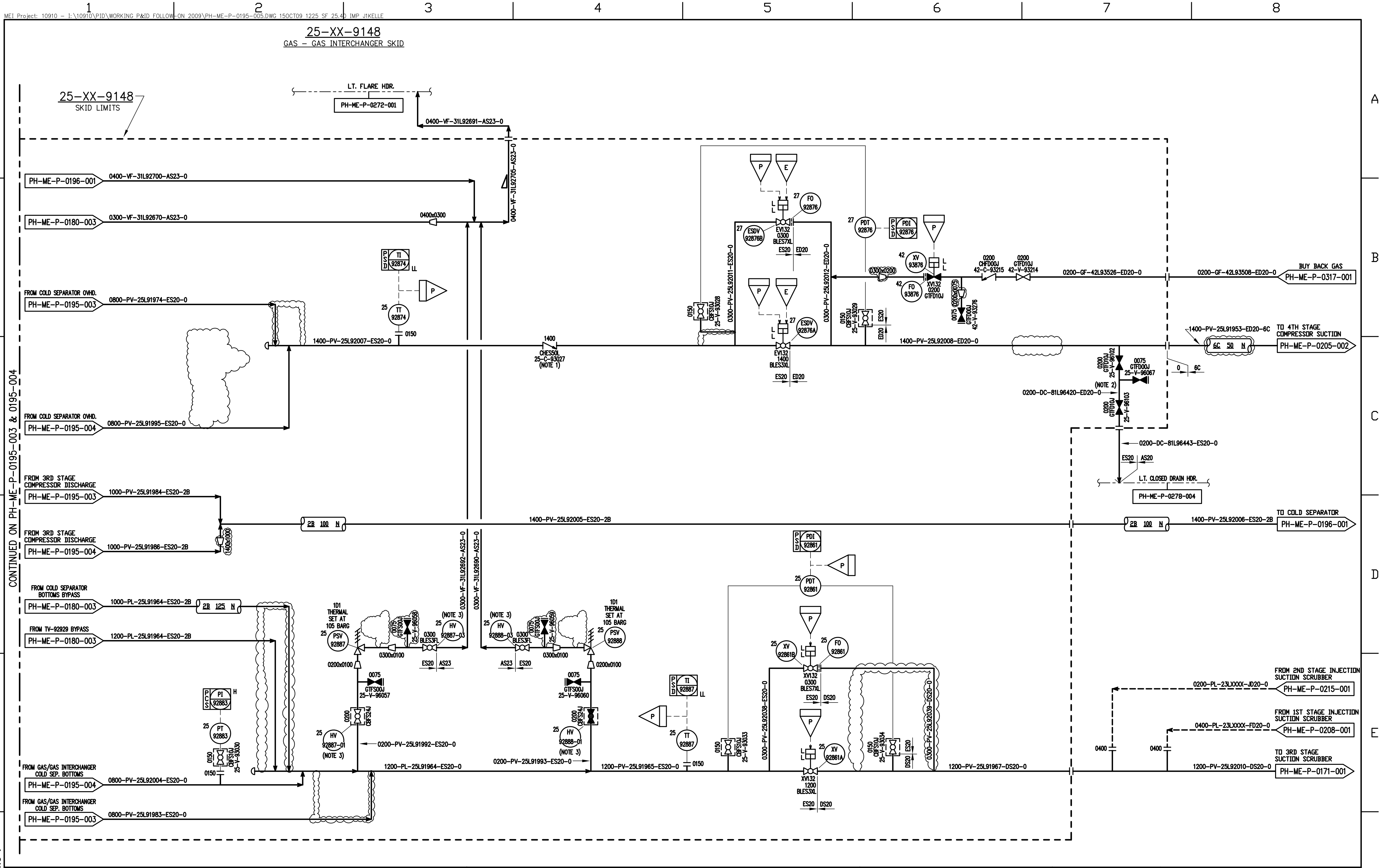
VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
GAS-GAS INTERCHANGER "B"

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
T34-02	25	XB	PH	ME	P	0195	004	REV. 4

Field for file specification:
Field for date and time :

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0195-005.DWG 15OCT09 1225 SF 25.40 IMP J1KELLE


25-XX-9148
GAS – GAS INTERCHANGER SKID
25-XX-9148
SKID LIMITS
LT. FLARE HDR.
PH-ME-P-0272-001
0400-VF-31L92691-AS23-0
0400-VF-31L92705-AS23-0
PH-ME-P-0196-001
0400-VF-31L92700-AS23-0
PH-ME-P-0180-003
0300-VF-31L92670-AS23-0
0400x0300
FROM COLD SEPARATOR OVHD.
PH-ME-P-0195-003
0800-PV-25L91974-ES20-0
FROM COLD SEPARATOR OVHD.
PH-ME-P-0195-004
0800-PV-25L91995-ES20-0
1400-PV-25L92007-ES20-0
TI 92874 LL
PSD
P
TT 92874
25
0150
1400
CHES50L
25-C-93027
(NOTE 1)
CONTINUED ON PH-ME-P-0195-003 & 0195-004
0150
CBFS10J
25-V-93028
0300-PV-25L92011-ES20-0
0300-PV-25L92012-ED20-0
P
E
27
FO 92876
ESDV 92876B
EV132
0300
BLES7XL
ES20
ED20
ESDV 92876A
EV132
1400
BLES3XL
27
PDT 92876
PDI 92876
0150
CBFS10J
25-V-93029
42
XV 93876
FO 93876
XV132
0200
GTFD10J
0300x0200
0200x0075
0075
GTFD00J
42-V-93276
0200
CHFD00J
42-C-93215
0200
GTFD10J
42-V-93214
0200-GF-42L93526-ED20-0
0200-GF-42L93508-ED20-0
BUY BACK GAS
PH-ME-P-0317-001
1400-PV-25L92008-ED20-0
1400-PV-25L91953-ED20-6C
6C 50 N
TO 4TH STAGE
COMPRESSOR SUCTION
PH-ME-P-0205-002
0
6C
0200
GTFD10J
25-V-96102
0075
GTFD00J
25-V-96067
(NOTE 2)
0200-DC-81L96420-ED20-0
0200
GTFD10J
25-V-96103
0200-DC-81L96443-ES20-0
AS20
L.T. CLOSED DRAIN HDR.
PH-ME-P-0278-004
FROM 3RD STAGE
COMPRESSOR DISCHARGE
PH-ME-P-0195-003
1000-PV-25L91984-ES20-2B
FROM 3RD STAGE
COMPRESSOR DISCHARGE
PH-ME-P-0195-004
1000-PV-25L91986-ES20-2B
1400x1000
2B 100 N
1400-PV-25L92005-ES20-2B
1400-PV-25L92006-ES20-2B
TO COLD SEPARATOR
PH-ME-P-0196-001
FROM COLD SEPARATOR
BOTTOMS BYPASS
PH-ME-P-0180-003
1000-PL-25L91964-ES20-2B
2B 125 N
FROM TV-92929 BYPASS
PH-ME-P-0180-003
1200-PL-25L91964-ES20-2B
0300-VF-31L92692-AS23-0
0300-VF-31L92690-AS23-0
1D1
THERMAL
SET AT
105 BARG
PSV 92887
PSV 92888
0075
GTFS00J
25-V-96058
25-V-96059
0300
BLES3FL
HV 92887-03
HV 92888-03
(NOTE 3)
0300x0100
0200x0100
AS23
GTFS00J
25-V-96057
25-V-96060
0200
CBFS24J
HV 92887-01
HV 92888-01
0200-PV-25L91992-ES20-0
0200-PV-25L91993-ES20-0
1200-PL-25L91964-ES20-0
1200-PV-25L91965-ES20-0
PI 92883 H
PCS
PT 92883
0150
CBFS10J
25-V-93030
TI 92887 LL
TT 92887
FROM GAS/GAS INTERCHANGER
COLD SEP. BOTTOMS
PH-ME-P-0195-004
0800-PV-25L92004-ES20-0
FROM GAS/GAS INTERCHANGER
COLD SEP. BOTTOMS
PH-ME-P-0195-003
0800-PV-25L91983-ES20-0
PDI 92861
PDT 92861
XV 92861B
FO 92861
XV132
0300
BLES7XL
DS20
XV 92861A
XV132
1200
BLES3XL
0150
CBFS10J
25-V-93033
0300-PV-25L92038-ES20-0
0150
CBFS10J
25-V-93034
0300-PV-25L92039-DS20-0
1200-PV-25L91967-DS20-0
FROM 2ND STAGE INJECTION
SUCTION SCRUBBER
PH-ME-P-0215-001
0200-PL-23LXXXX-JD20-0
FROM 1ST STAGE INJECTION
SUCTION SCRUBBER
PH-ME-P-0208-001
0400-PL-23LXXXX-FD20-0
0400
TO 3RD STAGE
SUCTION SCRUBBER
PH-ME-P-0171-001
1200-PV-25L92010-DS20-0

Field for file specification:
Field for date and time :

A1

NOTES:
1. ANTI-SLAM DESIGN.
2. DRAIN AND PURGE POINT.
3. KEY INTERLOCKED VALVE.

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	03DEC08	CDB	RE-ISSUED FOR CONSTRUCTION	RAK	RK/PS/JL	DR	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
GAS-GAS INTERCHANGER OUTLET HDR.

REGISTRATION CODES

AREA	SYSTEM	TYPE
T34-02	25	XB

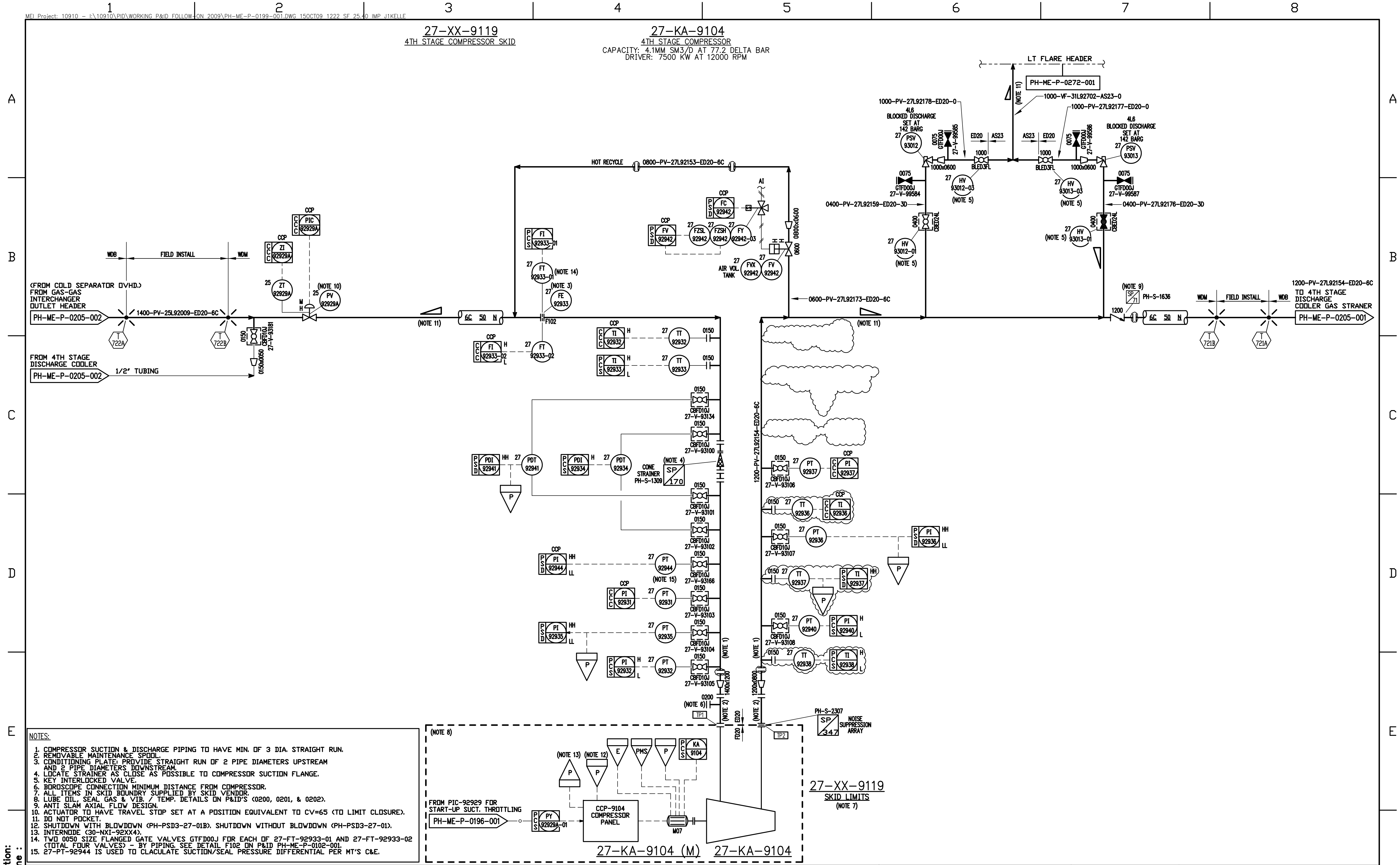
DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0195	005

SCALE NONE

REV. 4

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0199-001.DWG 15OCT09 1222 SF 25.40 IMP J1KELLE


27-XX-9119
4TH STAGE COMPRESSOR SKID
27-KA-9104
4TH STAGE COMPRESSOR
CAPACITY: 4.1MM SM3/D AT 77.2 DELTA BAR
DRIVER: 7500 KW AT 12000 RPM
LT FLARE HEADER
PH-ME-P-0272-001
1000-PV-27L92178-ED20-0
1000-VF-31L92702-AS23-0
1000-PV-27L92177-ED20-0
BLOCKED DISCHARGE SET AT 142 BARG
PSV 93012
PSV 93013
HV 93012-01
HV 93012-03
HV 93013-01
HV 93013-03
0400-PV-27L92159-ED20-3D
0400-PV-27L92176-ED20-3D
HOT RECYCLE
0800-PV-27L92153-ED20-6C
0600-PV-27L92173-ED20-6C
1200-PV-27L92154-ED20-6C
TO 4TH STAGE DISCHARGE COOLER GAS STRANER
PH-ME-P-0205-001
(FROM COLD SEPARATOR OVHD.)
FROM GAS-GAS INTERCHANGER OUTLET HEADER
PH-ME-P-0205-002
1400-PV-25L92009-ED20-6C
FIELD INSTALL
FROM 4TH STAGE DISCHARGE COOLER
1/2" TUBING
PIC 92929A
ZI 92929A
ZT 92929A
PV 92929A
FT 92933-01
FT 92933-02
FE 92933
F102
FC 92942
FV 92942
FZSL 92942
FZSH 92942
FY 92942-03
FVX 92942
AIR VOL. TANK
CONE STRAINER PH-S-1309
PDT 92941
PDT 92934
PT 92944
PT 92931
PT 92935
PT 92932
PT 92937
PT 92936
PT 92940
TT 92936
TT 92937
TT 92938
NOISE SUPPRESSION ARRAY
PH-S-2307
PH-S-1636
FROM PIC-92929 FOR START-UP SUCT. THROTTLING
PH-ME-P-0196-001
CCP-9104 COMPRESSOR PANEL
M07
27-KA-9104 (M)
27-KA-9104
27-XX-9119
SKID LIMITS
(NOTE 7)

NOTES:

1. COMPRESSOR SUCTION & DISCHARGE PIPING TO HAVE MIN. OF 3 DIA. STRAIGHT RUN.
2. REMOVABLE MAINTENANCE SPOOL.
3. CONDITIONING PLATE: PROVIDE STRAIGHT RUN OF 2 PIPE DIAMETERS UPSTREAM AND 2 PIPE DIAMETERS DOWNSTREAM.
4. LOCATE STRAINER AS CLOSE AS POSSIBLE TO COMPRESSOR SUCTION FLANGE.
5. KEY INTERLOCKED VALVE.
6. BOROSCOPE CONNECTION MINIMUM DISTANCE FROM COMPRESSOR.
7. ALL ITEMS IN SKID BOUNDRY SUPPLIED BY SKID VENDOR.
8. LUBE OIL, SEAL GAS & VIB. / TEMP. DETAILS ON P&ID'S (0200, 0201, & 0202).
9. ANTI SLAM AXIAL FLOW DESIGN.
10. ACTUATOR TO HAVE TRAVEL STOP SET AT A POSITION EQUIVALENT TO CV=65 (TO LIMIT CLOSURE).
11. DO NOT POCKET.
12. SHUTDOWN WITH BLOWDOWN (PH-PSD3-27-01B). SHUTDOWN WITHOUT BLOWDOWN (PH-PSD3-27-01).
13. INTERNODE (30-NXI-92XX4).
14. TWO 0050 SIZE FLANGED GATE VALVES GTFD00J FOR EACH OF 27-FT-92933-01 AND 27-FT-92933-02 (TOTAL FOUR VALVES) – BY PIPING. SEE DETAIL F102 ON P&ID PH-ME-P-0102-001.
15. 27-PT-92944 IS USED TO CLACULATE SUCTION/SEAL PRESSURE DIFFERENTIAL PER MT'S C&E.

NOTES:

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	30OCT08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	SVS	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
4TH STAGE COMPRESSOR

REGISTRATION CODES

AREA	SYSTEM	TYPE
T44-02	27	XB

DRAWING NO.

FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET
PH	ME	P	0199	001

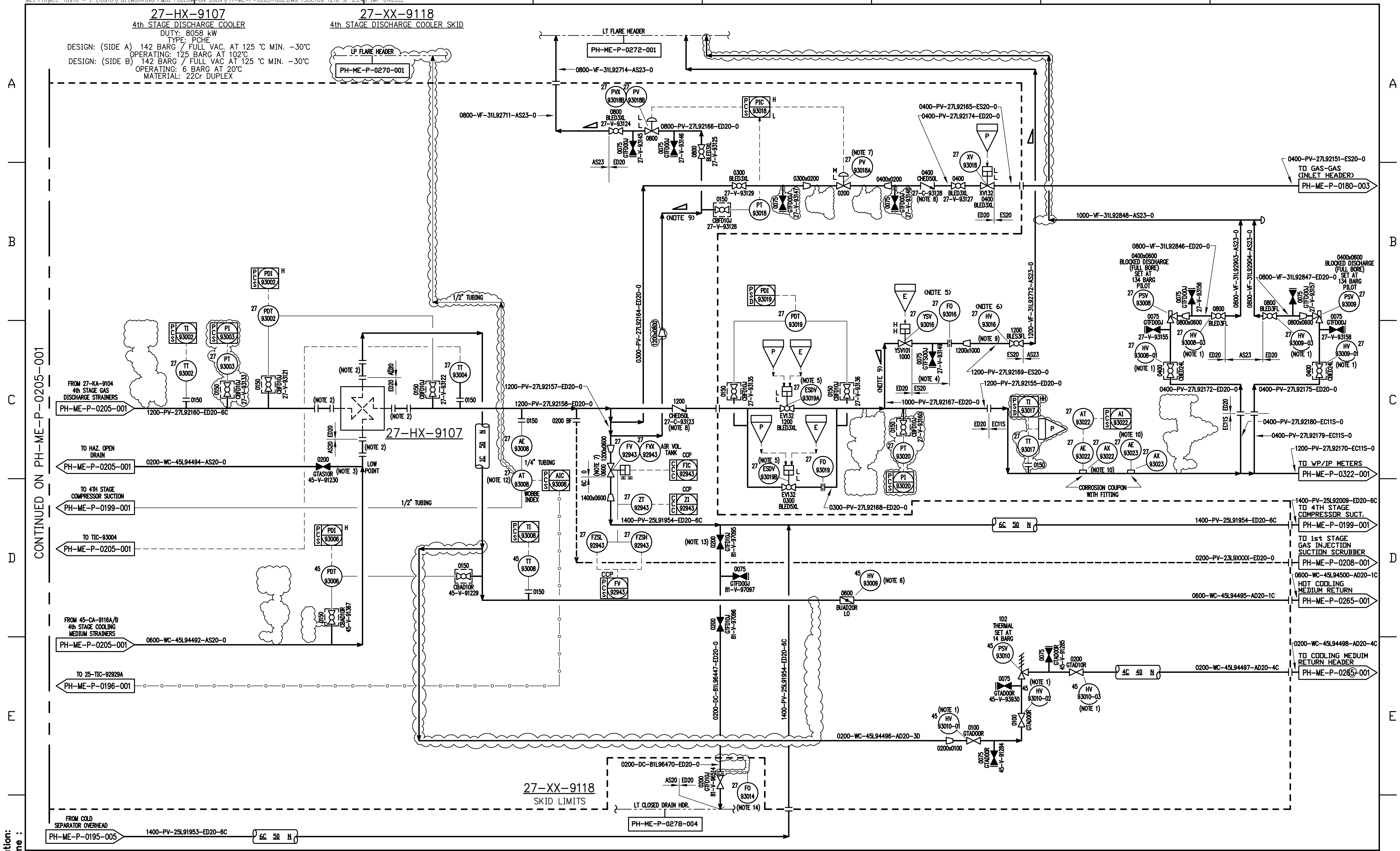
SCALE NONE

REV. 4

Field for file specification:
Field for date and time :

A1

MEI Project: 10910 – I:\10910\PID\WORKING P&ID FOLLOW-ON 2009\PH-ME-P-0205-002.DWG 15OCT09 1216 SF 25.40 IMP J1KELLE


27-HX-9107
4th STAGE DISCHARGE COOLER
DUTY: 8058 kW
TYPE: PCHE
DESIGN: (SIDE A) 142 BARG / FULL VAC. AT 125 °C MIN. -30°C
OPERATING: 125 BARG AT 102°C
DESIGN: (SIDE B) 142 BARG / FULL VAC AT 125 °C MIN. -30°C
OPERATING: 6 BARG AT 20°C
MATERIAL: 22Cr DUPLEX
27-XX-9118
4th STAGE DISCHARGE COOLER SKID
LP FLARE HEADER
PH-ME-P-0270-001
LT FLARE HEADER
PH-ME-P-0272-001
0800-VF-31L92714-AS23-0
0800-VF-31L92711-AS23-0
CONTINUED ON PH-ME-P-0205-001
FROM 27-KA-9104 4th STAGE GAS DISCHARGE STRAINERS
PH-ME-P-0205-001
1200-PV-27L92160-ED20-6C
TO HAZ. OPEN DRAIN
PH-ME-P-0205-001
0200-WC-45L94494-AS20-0
TO 4TH STAGE COMPRESSOR SUCTION
PH-ME-P-0199-001
TO TIC-93004
PH-ME-P-0205-001
FROM 45-CA-9116A/B 4th STAGE COOLING MEDIUM STRAINERS
PH-ME-P-0205-001
0600-WC-45L94492-AS20-0
TO 25-TIC-92929A
PH-ME-P-0196-001
FROM COLD SEPARATOR OVERHEAD
PH-ME-P-0195-005
1400-PV-25L91953-ED20-6C
6C 50 N
27-HX-9107
1/2" TUBING
1/4" TUBING
WOBBE INDEX
LOW POINT
1200-PV-27L92157-ED20-0
1200-PV-27L92158-ED20-0
0300-PV-27L92164-ED20-0
0800-PV-27L92166-ED20-0
0300-PV-27L92168-ED20-0
1400-PV-25L91954-ED20-6C
1000-PV-27L92167-ED20-0
1200-PV-27L92169-ES20-0
1200-PV-27L92155-ED20-0
1200-VF-31L92712-AS23-0
1000-VF-31L92848-AS23-0
0400-PV-27L92165-ES20-0
0400-PV-27L92174-ED20-0
0400-PV-27L92151-ES20-0
TO GAS-GAS (INLET HEADER)
PH-ME-P-0180-003
0800-VF-31L92846-ED20-0
0800-VF-31L92847-ED20-0
0800-VF-31L92903-AS23-0
0800-VF-31L92904-AS23-0
0400x0600 BLOCKED DISCHARGE (FULL BORE) SET AT 134 BARG PILOT
0400-PV-27L92172-ED20-0
0400-PV-27L92175-ED20-0
0400-PV-27L92180-EC11S-0
0400-PV-27L92179-EC11S-0
1200-PV-27L92170-EC11S-0
TO WP/IP METERS
PH-ME-P-0322-001
CORROSION COUPON WITH FITTING
1400-PV-25L92009-ED20-6C
TO 4TH STAGE COMPRESSOR SUCT.
PH-ME-P-0199-001
TO 1st STAGE GAS INJECTION SUCTION SCRUBBER
0200-PV-23L9XXXX-ED20-0
PH-ME-P-0208-001
0600-WC-45L94500-AD20-1C
HOT COOLING MEDIUM RETURN
0600-WC-45L94495-AD20-1C
PH-ME-P-0265-001
0200-WC-45L94498-AD20-4C
TO COOLING MEDIUM RETURN HEADER
0200-WC-45L94497-AD20-4C
PH-ME-P-0265-001
4C 40 N
102 THERMAL SET AT 14 BARG
0200-WC-45L94496-AD20-3D
0200-DC-81L96447-ED20-0
0200-DC-81L96470-ED20-0
LT CLOSED DRAIN HDR.
PH-ME-P-0278-004
27-XX-9118
SKID LIMITS
PDI 93002
PDT 93002
TI 93002
TT 93002
PI 93003
PT 93003
TT 93004
PDI 93006
PDT 93006
AE 93008
AT 93008
AIC 93008
TI 93008
TT 93008
FV 92943
FVX 92943
AIR VOL. TANK
FIC 92943
ZT 92943
ZI 92943
FZSL 92943
FZSH 92943
FV 92943
PVX 93018B
PV 93018B
PIC 93018
PT 93018
PV 93018A
XV 93018
PDI 93019
PDT 93019
ESDV 93019A
ESDV 93019B
FO 93019
PT 93020
PI 93020
YSV 93016
FO 93016
HV 93016
TI 93017
TT 93017
AT 93022
AI 93022
AE 93022
AX 93022
AE 93023
AX 93023
PSV 93008
HV 93008-01
HV 93008-03
PSV 93009
HV 93009-01
HV 93009-03
HV 93009
PSV 93010
HV 93010-01
HV 93010-02
HV 93010-03
FO 93014
(NOTE 1)
(NOTE 2)
(NOTE 3)
(NOTE 4)
(NOTE 5)
(NOTE 6)
(NOTE 7)
(NOTE 8)
(NOTE 9)
(NOTE 10)
(NOTE 12)
(NOTE 13)
(NOTE 14)

NOTES:
1. KEY INTERLOCKED VALVE.
2. MAINTENANCE DROP OUT SPOOLS.
3. COOLING MEDIUM DRAINS TO BE LOCATED EITHER ON PIPING OR EQUIPMENT AND SHALL BE AT LOW POINT.
4. MINIMUM DISTANCE 1 METER.
5. LOCATE ESDV93019A/B AND YSV93016 AS NEAR THE BRIDGE INTERFACE AS PRACTICAL.
6. KEY LOCKED VALVE.
7. LOCATE VALVE AS CLOSE AS POSSIBLE TO TEE AND PROVIDE 1 METER OF STRAIGHT RUN DOWNSTREAM.
8. ANTI SLAM DESIGN.
9. DO NOT POCKET.
10. A MINIMUM OF FREE SPACE OF 2M ABOVE & 300MM AROUND THE CENTERLINE OF THE FITTING IS REQUIRED FOR HYDRAULIC RETRIEVAL TOOL.
11. DELETED.
12. 27-AT-93008 (GC SHELTER) MOUNTED OFF SKID.
13. DRAIN AND PURGE POINT.
14. RESTRICTION ORIFICE TO LIMIT FLOW AND PREVENT OVERPRESSURE OF 'A' CLASS DRAIN HEADER.

Field for file specification:
Field for date and time :

REV	DATE	BY	DESCRIPTION	CHK	ENGR	APPR	CLIENT
4	16OCT09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	GMK	
3	22MAY09	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JB/JL	GMK	
2	14NOV08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	RK/JL/PS	SVS	
1	09MAY08	JDK	RE-ISSUED FOR CONSTRUCTION	RAK	JC/PS/JL	SVS	
0	01OCT07	JDK	ISSUED FOR CONSTRUCTION	JTG	JC/ES/JB	SVS	

Wood Group Engineering
(North Sea) Ltd.

MUSTANG INTERNATIONAL, LP
HOUSTON, TEXAS

PROJECT NO. 10910

bp

VALHALL
RE-DEVELOPMENT PROJECT
PIPING & INSTRUMENT DIAGRAM
4TH STAGE DISCHARGE COOLER

REGISTRATION CODES			DRAWING NO.					SCALE
AREA	SYSTEM	TYPE	FACILITY CODE	ORIG.	DISP.	SEQ. No.	SHEET	NONE
T34-01	27	XB	PH	ME	P	0205	002	REV. 4

A1