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Accident
Investigation Board
Norway

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REPORT Marine 2018/06

REPORT ON WORK ACCIDENT ON BOARD THE NORMAND MAXIMUS OFF THE COAST OF BRAZIL ON 21 FEBRUARY 2017

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This report has been translated into English and published by the Accident Investigation Board Norway (AIBN) to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photo of ferry on the Norwegian west coast: Bente Amandussen

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NOTIFICATION OF THE ACCIDENT

On 21 February 2017, the Accident Investigation Board Norway (AIBN) was notified by the Norwegian Maritime Authority (NMA) of a work accident on board the construction service vessel Normand Maximus off the coast of Brazil. One person died in the accident. The NMA's notification was based on an accident report from the shipping company Solstad Offshore AS.

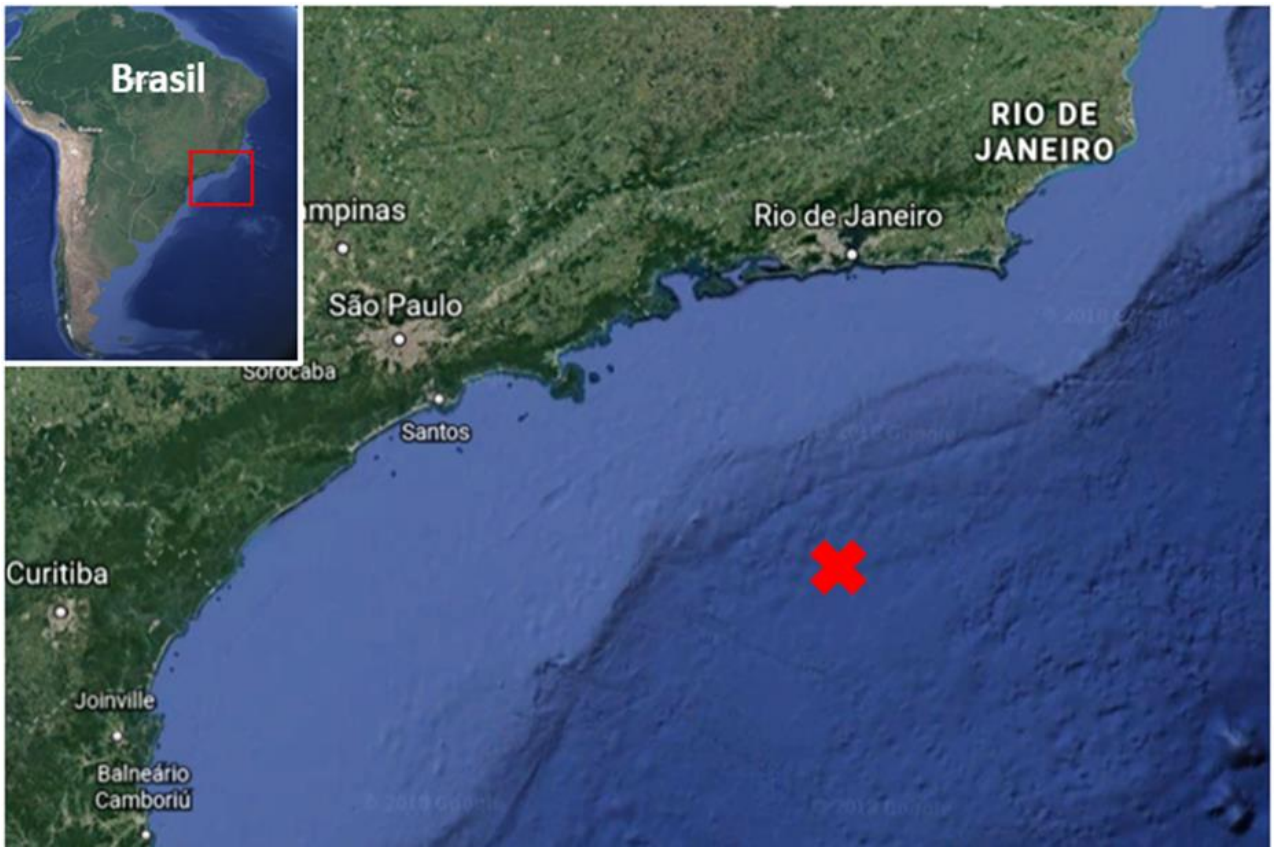

Figure 1: The map section shows Normand Maximus's location on the Lula field off Rio de Janeiro at the time of the accident. Source: Google Maps

On 22 February 2017, the AIBN decided to investigate the accident. The investigation was conducted in cooperation with the Department of Inquiries and Investigations of Navigation Accidents, which is the Brazilian accident investigation authority for marine accidents. The department is subordinate to the Brazilian Navy's Directorate of Ports and Coasts.

The Brazilian Navy's investigation focused on the main activity/activities that led to the accident. The report from the Brazilian Navy's investigation is enclosed (see Annex A). The AIBN conducted a limited investigation focusing on the procedures of the shipping company/vessel and procedures in relation to the third party that hired the vessel to carry out temporary activities on board.

SUMMARY

The construction service vessel (CSV) Normand Maximus was hired by the oil industry service company Saipem and was to function as a platform at sea for this assignment. In cooperation with the oil industry service company Baker Hughes, Saipem was to carry out pre-commissioning (tests to verify that all equipment and components are in accordance with the requirements stipulated) for the oil company Petrobras on the oil field Lula.

Baker Hughes was conducting pressure testing of the oilfield's gas flow system when the accident happened. The pressure testing operation took place in a cordoned off area on the CSV Normand Maximus's open aft deck. A permit to work (PTW) system was used to identify hazards and ensure that safety measures were implemented.

At 06.15 on Tuesday 21 February 2017, in connection with recovery/depressurisation of the MEG[1] system, at a pressure of 215 bar, the compressed mixture of air and MEG exploded, which resulted in several blowouts and breaks in the system of pipes and valves on the open deck. A Baker Hughes employee who was working in front of a manual pipe valve was hit by the valve's handwheel thrown out by the explosion and died as a result of the injuries he sustained. In addition, one seriously injured person and three persons with minor injuries were found on the deck.

The CSV Normand Maximus is deemed to have been a vessel when it was hired and used by Saipem in the pre-commissioning operation. Therefore, the regulatory framework governing ships applied to the CSV Normand Maximus during this operation.

No independent party checked or approved whether the functionality of the completed installation was satisfactory for use on board the vessel after the equipment had been installed on deck and was ready for use on the oil field. The AIBN is of the opinion that an independent check and approval by an external party would have constituted a further barrier that would probably have contributed to the shipping company/vessel being more confident in the performance of their duties as the party responsible for safety on board the vessel. AIBN submits a safety recommendation to the Norwegian Maritime Authority (NMA) on this point.

[1] MEG = mono-ethylene glycol. Injecting large quantities of MEG is an effective way of preventing hydrate formation in order to maintain gas flow through a pipe system. Source: CCR Technologies Ltd.

1. FACTUAL INFORMATION

1.1 Introduction

The factual information is based on interviews with three employees of the oil service company Baker Hughes, relevant crew members from Solstad Offshore AS, interviews with and relevant documentation from the shipping company and from the oil service companies Saipem and Baker Hughes, and relevant information from the Brazilian accident investigation authority.

Local times are used in the description of the sequence of events. Local time corresponds to UTC (Coordinated Universal Time) -4 hours.

1.2 Sequence of events

Figure 2: Construction service vessel (CSV) Normand Maximus. Photo: Harald M Valderhaug

1.2.1 The assignment

The oil service company Saipem had been commissioned by the Brazilian state oil company Petrobras to carry out pre-commissioning (tests to verify that all equipment and components are in accordance with the requirements stipulated) on the oil field Lula. This field is located approximately 90 nm off the coast of Brazil, in what is known as the pre-salt area, between Rio de Janeiro and Santos.

The CSV Normand Maximus was hired by Saipem and was to function as a platform at sea for this assignment. The newly built vessel arrived in Rio de Janeiro in late December 2016 and shortly thereafter proceeded to Saipem' base near Santos to be equipped and prepared for the assignment.

Figure 3: The system installed for use in the pre-commissioning assignment consisted of a number of components placed on the open aft deck of the CSV Normand Maximus. The accident site is marked with a red circle. Photo: The Brazilian Navy

Saipem was responsible for installing and preparing the equipment to be used during the pre-commissioning work on board the CSV Normand Maximus. The technical operation was to take place on the open aft deck. The whole aft deck was filled with different components connected by pipes, hoses and valves. Many of the valves and individual components had been certified by classification societies, but the system as a whole had not been approved or certified by an external party.

Saipem was the main responsibility for the pre-commissioning work taking place on the open deck. The shipping company/vessel was responsible for all vessel-specific matters, such as stability and sea-fastening of all equipment, establishing and maintaining satisfactory escape routes, and permit to work (PWT) approval for all work operations carried out on board the vessel.

Figure 4: Pipes, hoses and valves placed between components on the open deck. Photo: The Brazilian Navy

The pipeline that was to be tested, and that Saipem had laid on the seabed (at a depth of 2,170 metres) before the operation, consisted of pipes with a diameter of 18 inches and was 14.5 kilometres long (including the riser[2] system).

[2] Riser = a pipe that connects a floating production storage and offloading (FPSO) unit or a drilling rig to a subsea system for the purpose of production of or drilling for oil or gas. Source: www.tenaris.com

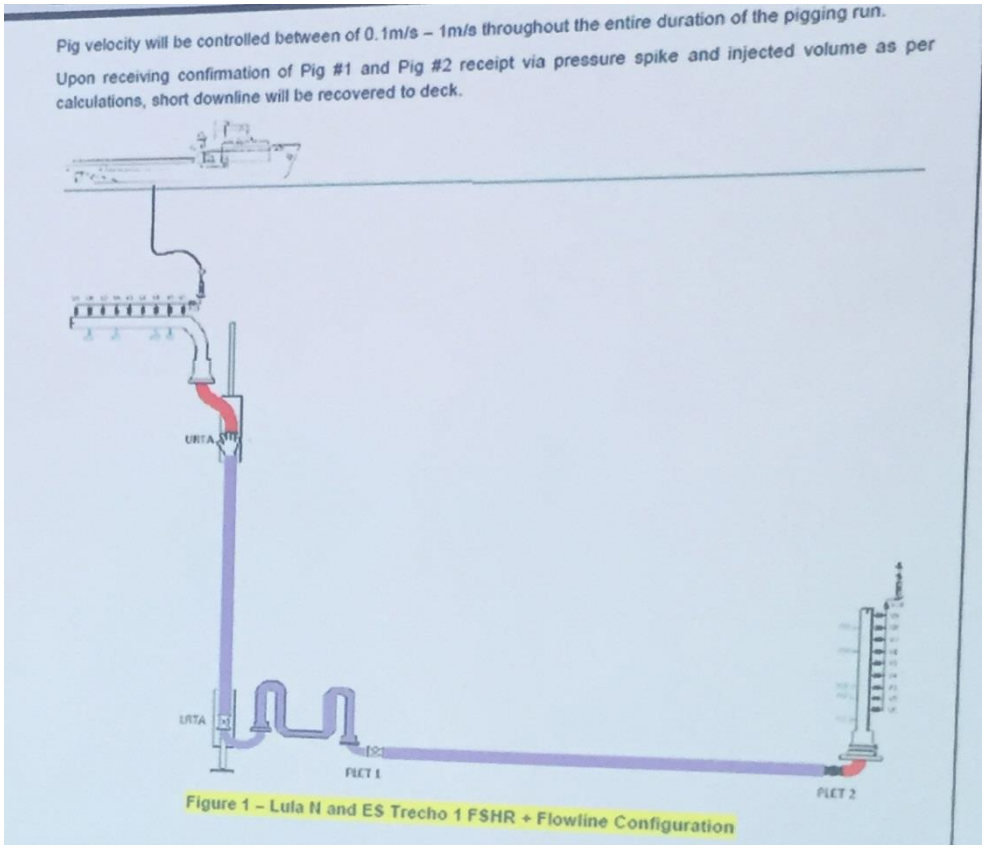

Figure 5: Schematic drawing of the pipeline arrangement placed at a depth of 2,170 metres that was to be pressure-tested using the system installed on the deck of the CSV Normand Maximus. Source: The Brazilian Navy

Saipem had also hired the oil service company Baker Hughes for the project. Baker Hughes was to conduct the pressure testing, a type of operation that the company had carried out before in similar projects.

The Brazilian authorities do not permit MEG[3] emissions, and the contract for this operation therefore required residues of the MEG used in the operation to be collected in tanks placed on the open deck of the CSV Normand Maximus.

On the oil field, work on board went on around the clock, with shifts of twelve hours on and twelve hours off. Saipem and Baker Hughes cooperated on job planning, risk analyses and safe job analyses. A permit to work (PTW) system (see 1.6.2) was used to identify hazards and ensure that safety measures were implemented.

Special handover/pre-shift meetings were held before each work shift began. The mate and crane driver usually attended these meetings as the vessel's representatives. Provided that the conclusions from such meetings were in accordance with Saipem's and Baker Hughes' own risk assessment requirements, the CSV Normand Maximus's shipboard management issued a permit to work (PTW).

[3] MEG = mono-ethylene glycol. Injecting large quantities of MEG is an effective way of preventing hydrate formation in order to maintain gas flow through a pipe system. Source: CCR Technologies Ltd.

1.2.2 The accident

Baker Hughes was conducting pressure testing of the oilfield's gas flow system when the accident happened. The five-person team from Baker Hughes that was working in the area around the MEG system started their twelve-hour shift at 23.00 on Monday 20 February 2017. The system was placed in a cordoned off area on the open aft deck of the CSV Normand Maximus.

A PTW valid for 12 hours had been issued for this work at the handover meeting held at 23.00 on 20 February. It was signed by the person in charge of the work operation to be carried out (Baker Hughes), the person with overall responsibility for the whole operation (Saipem) and the shipboard management of the CSV Normand Maximus.

The chief mate and third mate were on watch on the bridge from midnight on Tuesday 21 February. Their watch was to last until 12.00, but because it was a crew changeover day and the chief mate was one of the people going ashore, the captain came up to relieve the chief mate at 06.00.

At 06.15 on Tuesday 21 February 2017, in connection with recovery/depressurisation of the MEG system, at a pressure of 215 bar, the compressed mixture of air and MEG exploded, which resulted in several blowouts and breaks in the system of pipes and valves on the open deck. A Baker Hughes employee who was working in front of a manual pipe valve was hit by the valve's handwheel thrown out by the explosion and died as a result of the injuries he sustained.

See the report from the investigation conducted by the Brazilian Navy (Annex A) for more information about the main activities that lead to the accident.

1.3 Personal injuries

At 06.17, crew members arrived at the scene of the accident with a stretcher. At 06.40, the doctor on board determined that one person had died, a 35-year-old Baker Hughes employee. In addition, one person was seriously injured and three others sustained minor injuries on the open deck. At 09.33, a helicopter transported the four survivors ashore. The deceased person was transported in a separate helicopter the following evening.

1.4 The vessel

The CSV Normand Maximus is 177.9 metres long and 33 metres in breadth. The vessel can accommodate a total of 180 persons on board in 132 cabins. The vessels had a deck area of 2,500 square metres and was equipped with a crane with a maximum lifting capacity of 900 tonnes.

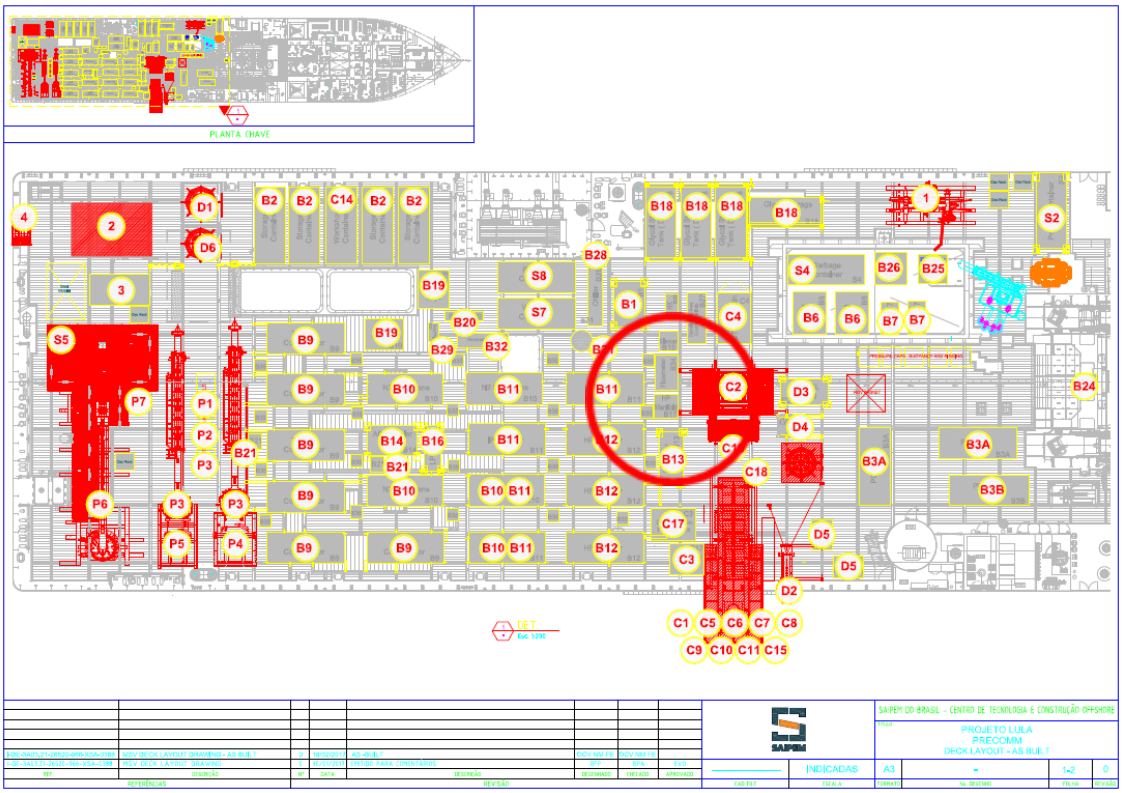

Figure 6: The layout of the main deck with all the components used during the operation. The accident site is marked with a red circle. Source: Solstad Offshore AS

1.5 Persons on board (POB)

There were a total of 173 persons on board the CSV Normand Maximus at the time of the accident. The operating crew (the ship's crew) consisted of 27 people plus catering staff. The rest of the persons on board, other than the catering staff, worked on the pre-commissioning operation headed by Saipem.

1.6 The shipping company

1.6.1 General information

The head office of Solstad Offshore AS is located in Skudeneshavn. The shipping company's activities primarily target the offshore oil industry. The company's fleet comprise 61 vessels in the following categories: platform supply vessels (PSV), anchor-handling vessels (AHTS) and construction service vessels (CSV). Since its formation in 1964, Solstad Offshore AS has grown into a global player.

1.6.2 The permit to work (PTW) system

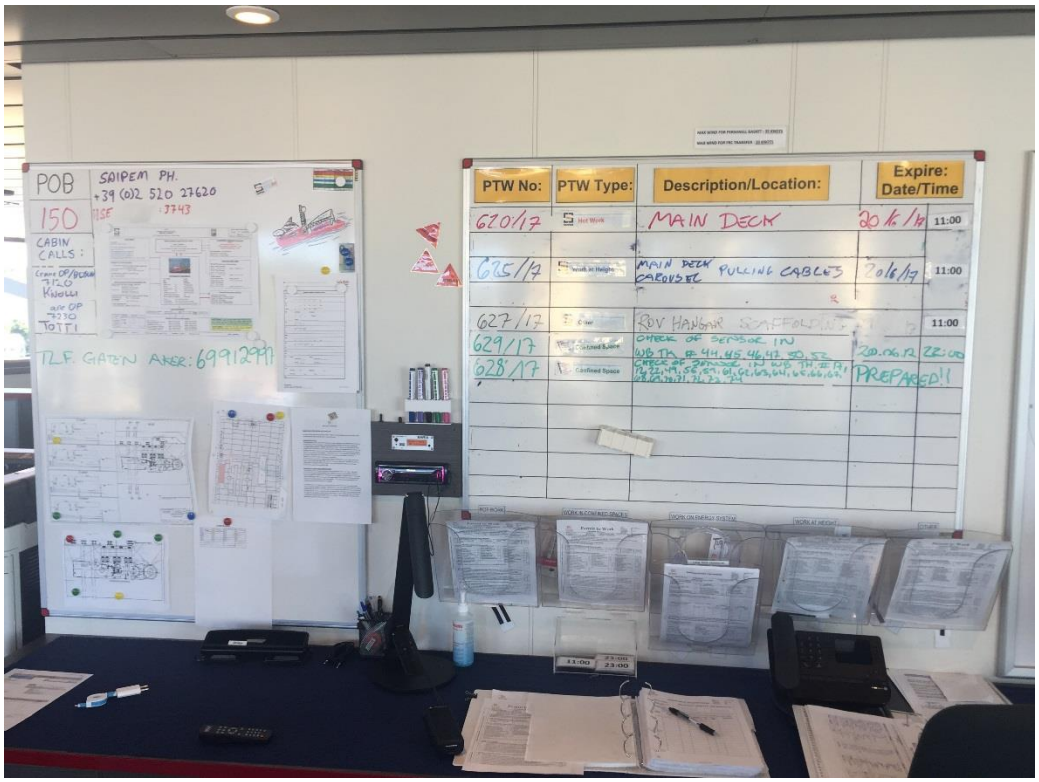

Figure 7: The photo shows the area on the bridge of the CSV Normand Maximus dedicated to handling the permit to work system. This photo was taken in June 2017 and shows entries and notes from another project that has nothing to do with the accident in February 2017. Photo: AIBN

The objective of Solstad's permit to work (PTW) system:

- *PTW is a mechanism intended to ensure that the increased hazards involved are identified and that all necessary control measures are put in place.*
- *By using the PTW system we ensure compliance with our requirements for risk evaluation.*

The shipboard management, represented by the captain, chief mate and first mate, was authorised to provide final signature of PTW forms (issuing authority). The function of the shipboard management was not to approve the job as such, but to verify that the relevant procedures and checklists in Baker Hughes' and Saipem's management systems had been observed.

The bridging document described the practical arrangements between Saipem and Solstad Offshore for how the PTW system was intended to function. It is stated in section 5.2.9 of the original document of 19 May 2016 that all activities on board the CSV Normand Maximus shall be carried out in accordance with Solstad's permit to work system.

A modification was made with effect from 10 February 2017 at the request of Saipem. A new bridging document (DVES-TOOL-2643) was prepared, in which section 5.2.9 had been modified to state that all activities on board Normand Maximus shall be in accordance with both Solstad's PTW system and Saipem's PTW system. This entailed a change to the procedure that leads up to the final approval of a PTW.

Previously, it was the person in charge of the work operation to be carried out (Baker Hughes) who obtained final approval from the shipboard management in the handover meetings. After the change, it was the manager responsible for the whole operation (Saipem) who came to the bridge to obtain the shipboard management's final approval.

1.7 Supervision by regulatory bodies

1.7.1 The Norwegian Maritime Authority

The NMA is the supervisory authority for the work to protect life, health, the environment and material assets on board vessels sailing under the Norwegian flag and foreign vessels in Norwegian waters.

1.7.2 The Petroleum Safety Authority Norway

The Petroleum Safety Authority Norway (PSA) is responsible for establishing parameters for the petroleum industry on the Norwegian continental shelf and supervising that activities in this sector are pursued in a prudent manner.

The PSA has supervisory responsibility for petroleum activities on the whole Norwegian continental shelf, in addition to eight onshore facilities and associated pipeline systems. The supervisory responsibility covers operators, licensees, contractors and shipowners.

1.8 Relevant rules and regulations

1.8.1 The Ship Safety and Security Act

The Ship Safety and Security Act (Act No 65 of 19 June) Section 6, General duties of the company:

> *The company has an overall duty to see to that the construction and operation of the ship is in accordance with the rules laid down in or pursuant to this Act, including that the master and other persons working on board comply with the legislation.*
>
> *The company shall ensure that the statutory requirements are fulfilled, except for cases when the master by law is given an independent duty to ensure this. The company shall take steps to ensure that all the persons working on board have the opportunity to fulfil their obligations under the law.*
>
> *The Ministry may issue regulations containing further provisions relating to the obligations of the company pursuant to this provision.*

1.8.2 Regulation of multipurpose vessels on the Norwegian continental shelf

The PSA has, on assignment from the Ministry of Labour and Social Affairs, mapped trends in petroleum activities and the use of what is known as multipurpose vessels on the Norwegian continental shelf. The report was published in 2016 and shows, among other things, that there has been a considerable increase in the use of such vessels in recent years, while the number of available vessels has not increased to the same extent.

The report does not take into account waters outside the Norwegian continental shelf, but is nevertheless deemed to be relevant to the regulatory framework relating to this accident. The following sections are quoted from the report:

10.1 The Petroleum Activities Act

The Petroleum Activities Act and pertaining regulations apply to facilities on the continental shelf when they are used for petroleum activity. Petroleum activity can include survey activities, exploration drilling, production, transportation, utilisation and decommissioning, including planning of such activities, cf. the Petroleum Activities Act Section 1-4 and the definition in the Petroleum Activities Act Section 1-6 letter c). The legislation applies to the facility as such and to the activities that take place there.

…

Although supply and support vessels are not facilities, the petroleum activities carried out from these vessels are nevertheless covered by the Petroleum Activities Act, see the definition of 'petroleum activity' in the Petroleum Activities Act Section 1-6 letter c). This is elaborated on in Proposition No 43 to the Odelsting (1995–1996).

…

The decisive factor when determining whether a unit is a supply or support vessel is not what the unit in question was built for, but what it is used for. By 'support vessel' is meant what is known in the industry as 'offshore service vessels'. This includes vessels used as: standby vessels, anchor-handling vessels, construction, commissioning, repair and maintenance vessels, diving vessels, cable-laying and pipe-laying vessels, geological and seismic vessels, other units engaged in geological surveys during the survey phase, towing vessels, and aircraft. The building of such vessels and other mobile offshore units is regulated by maritime legislation. Ships that transport petroleum in bulk are exempt from the scope of the Act.

To the extent that petroleum activities are carried out from mobile units, these units must be considered facilities in the sense of the Act if they perform core petroleum activities or are otherwise in direct contact with well or processing facilities. This means that units engaged in exploration drilling, production, including test production, processing, well testing and workovers, are considered facilities in the sense of the Act. To the extent that a mobile unit carries out well stimulation, mud treatment, water injection or uses equipment that is directly connected to a well, such units will also be considered facilities under the Act. Units that are used to perform a type of activity that will be necessary for the whole or most of the production period and that seem to be a prerequisite for or an integral part of the production activities, for example flotels, must be considered facilities. This must apply even if a specific flotel is only used for a short period of time. Offloading installations (loading buoys, tanks etc.) connected to production are covered by the term 'facility'.

…

The guidelines to Section 3 state that the main distinction is whether the unit has primary control of the wells' block valve and well stream and uses equipment entering the well, or whether the activity is carried out from or on the outside, and another facility handles primary control of the well stream. In the latter case, the activities in question are vessel activities.

Based on the above, the CSV Normand Maximus would have been considered a support vessel had it carried out a corresponding operation on the Norwegian continental shelf. Based on the fact that the vessel did not have control of the well, it would not be considered a facility, and only rules and regulations issued pursuant to the Ship Safety and Security Act would apply.

2. THE ACCIDENT INVESTIGATION BOARD ASSESSMENTS

2.1 Introduction

The AIBN has conducted an investigation of the work accident that happened on board the Norwegian-owned CSV Normand Maximus off the coast of Brazil on 21 February 2017. A person employed by an oil service company died in the accident.

The investigation has focused on the procedures of the shipping company/vessel in relation to the third party that hired the vessel. The AIBN has looked into how work relating to this type of operations was organised on board the ship, and considered potential improvements to requirements and procedures.

2.2 The permit to work (PTW) system

The change made in the PTW system at the request of Saipem entailed changes to the procedure that leads up to the final approval of a PTW. Previously, it was the person who was to carry out the work (Baker Hughes) who submitted to the shipboard management 'checklists and procedures relevant to the work to be carried out'. The function of the shipboard management was not to approve the job as such, but to verify that the submitted procedures and checklists in the system had been observed.

After the change in the PTW system, the person who was to carry out the work (Baker Hughes) submitted 'checklists and procedures relevant to the work to be carried out' to Saipem at the handover meetings, and it was thus Saipem that could understand and discuss relevant details with the persons carrying out the work. Saipem would then describe the work to the shipboard management and receive its final approval.

As a result of the change, safety information was communicated to the shipboard management via an extra level. This meant that the shipboard management lost the direct contact with, and possibility to clarify things with, the people who were to carry out work operations on board (Baker Hughes).

The AIBN has no basis for claiming that the change in the PTW system had any bearing on the accident, but would like to draw attention to how important it is that the PTW issuer should have as close contact as possible with those who will actually be carrying out the work.

2.3 The installation of equipment placed on deck

The MEG system operation was considered a high-risk activity because of the high pressure involved, and the area around the MEG system was therefore cordoned off. Other than the Ship Safety and Security Act Section 6, General duties of the company, the regulatory framework for ships contains no requirements that cover the operation for which the CSV Normand Maximus was used.

The shipboard management will normally have limited ability to fully evaluate a complex technical installation such as the one installed on board the CSV Normand Maximus. Nor did an independent party check or approve whether the functionality of the completed

installation was satisfactory for use on board the vessel after the equipment had been installed on deck and was ready for use on the oil field.

The AIBN is of the opinion that an independent check and approval by an external party would have constituted a further barrier that would probably have contributed to the shipping company/vessel being more confident in the performance of their duties as the party responsible for safety on board the vessel.

AIBN therefore submits a safety recommendation to the Norwegian Maritime Authority (NMA) on this point.

3. SAFETY RECOMMENDATIONS

The investigation of this marine accident has identified one area in which the Accident Investigation Board Norway deems it necessary to submit a safety recommendation for the purpose of improving safety at sea:[4]

Safety recommendation MARINE No. 2018/07T

The explosion on board the CSV Normand Maximus on 21 February 2017 took place off Rio de Janeiro in Brazil. One person died and four were injured to varying degrees in the accident. The ship was used in a pre-commissioning operation on an oil field. The regulatory framework for ships does not contain requirements that cover the type of operation for which Normand Maximus was used.

The Accident Investigation Board Norway recommends that the Norwegian Maritime Authority carry out an assessment of whether the current regulatory framework is sufficient to ensure safety on board offshore vessels engaged in complex national and international operations for the petroleum industry.

Accident Investigation Board Norway

Lillestrøm, 14 December 2018

[4] The investigation report is submitted to the Ministry of Trade, Industry and Fisheries, which will take the necessary steps to ensure that due consideration is given to the safety recommendations.

DETAILS ABOUT THE VESSEL

Vessel	
Name	Normand Maximus
Flag state	Norwegian International Ship Register (NIS)
Classification society	DNVGL
IMO Number/Call signal	9744518/LAVR7
Type	Support vessel (offshore construction)
Build year	2016
Owner	Maximus Ltd.
Operator/Responsible for ISM	Solstad Offshore AS, Norway
Construction material	Steel
Length	177.9 m
Gross tonnage	26,832
The voyage	
Port of departure	Santos, Brazil
Port of arrival	Campo de Lula, Brazil
Type of voyage	Oil-related activities
Cargo	Support vessel
Persons on board	173
Information about the accident	
Date and time	06:15 LT (09.15 UTC) on 21 February 2017
Type of accident	Very serious marine accident
Place/position where the accident occurred	Campo de Lula, Santos Basin, State of Rio de Janeiro, Brazil S25º34.7’ W042º53.8’
Place on board where the accident occurred	Open main deck
Injuries/deaths	4 injured persons, 1 fatality
Damage to vessel/the environment	No damage to the vessel
Vessel operation	Platform for pre-commissioning operation
At what point of the voyage was the vessel	DP position on the oil field

ANNEXES

Annex A: Report from the Brazilian Navy

BRAZILIAN NAVY

DIRECTORATE OF PORTS AND COASTS

MARINE SAFETY SUPERINTENDENCE

DEPARTMENT OF INQUIRIES AND INVESTIGATIONS OF NAVIGATION ACCIDENTS

ACCIDENT WITH PEOPLES ON BOARD THE MARITIME SUPPORT SHIP "NORMAN MAXIMUS"

MARITIME SAFETY INVESTIGATION REPORT

Photo 1: Vessel NORMAND MAXIMUS in photo provided by the owner

Reference: Casualty Investigation Code, of the International Maritime Organization (IMO) – MSC-MEPC.3 / Circ.2, 13 June 2008 / Resolution MSC.255 (84)

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I) LIST OF ABBREVIATIONS:

ABBREVIATIONS	Meaning
Bar	Pressure measurement - bar gauge 1barg = 14.7psi
BHPPS	Baker Hughes Process And Pipelines Services
CPRJ	Captaincy of the Ports of Rio de Janeiro
CTS	Minimum Safe Manning Certificate
DPEM	Personal Injury Caused by Vessels or Cargo Insurance
FISPQ	Material Safety Data Sheets
FLAG	Flag State Control Inspection
ISM CODE	ISM Code - International Safety Management Code
MSC	Maritime Safety Committee
MEG	MONO ETHYLENE GLYCOL
MEG died	MONO ETHYLENE GLYCOL BLUE (died MEG)
OMI	International Maritime Organization
PIG	Designation of substances separators
PLR	*Pig launcher and receiver*
ROV	Remote Operated Vehicle
SCF	Standard Cubic Feet
SCFM	Standard Cubic Feet per Minute
FISQ	Chemical Safety Data Sheets
TAG	Identification packs
UHF	Ultra High Frequency
MSDS	Material Safety Data Sheets (MSDS)

II) Introduction

For the purpose of accomplishing the collection and the analysis of evidences, the identification of the causal factors and the elaboration of the recommendations of safety that are necessary, in order to avoid that in the future occur similar maritime accidents and/or incidents, the Ports Captaincy of Rio de Janeiro (CPRJ) carried out the present Safety Investigation of Marine Accidents and Incidents (ISAIM) in compliance with that laid down in the Casualty Investigation Code of the International Maritime Organization (IMO), adopted by Resolution MSC.255(84).

This Final Report is a technical document that reflects the result obtained by the CPRJ in relation to the circumstances that contributed or may have contributed to unleash the occurrence and does not resort to any procedures of proof for verification of civil or criminal responsibility.

Furthermore, it should be emphasized the importance of protecting the persons responsible for the supplying of information related to the occurrence of the accident, for the use of information included in this report for ends other than the prevention of future similar accidents may lead to erroneous interpretations and conclusions.

III) Synopsis:

At the date of the accident, 02/21/2017, the NORMAND MAXIMUS vessel was sub-contracted by Saipen. Saipen was performing the pre-commissioning of LULA EXTREMO SUL stretch 1 lines, with the cleaning and verification of the integrity of these lines. In the execution of the service, the company Baker Hughes do Brasil Ltda, subcontracted to the pre-commissioning service by Saipen, complied with Procedure I-PR-3A03.21-26520-970-XSA-1425 (Rev.A), an integral document of the Project LULA NORTE, LULA EXTREMO SUL AND LULA SUL, issued by it, and approved by PETROBRAS (client).

At 6:15 p.m. on February 21, 2017, during the MEG recovery process and pressure reduction of the underwater system, an accident occurred at the pre-commissioning facility positioned on the main deck of the vessel, causing one fatality and four injured. The pre-commissioning facility positioned on the main deck of the vessel is a temporary and independent installation.

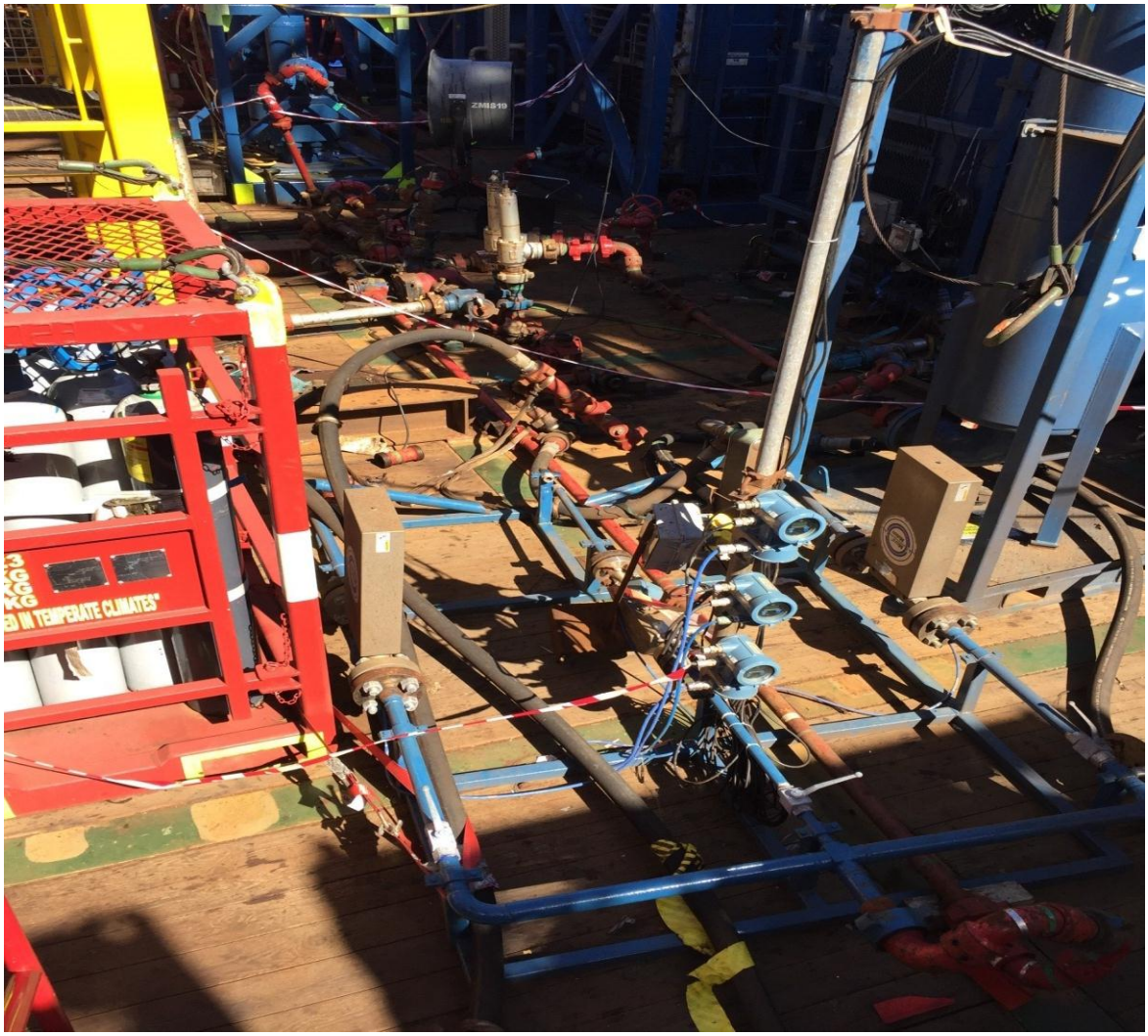
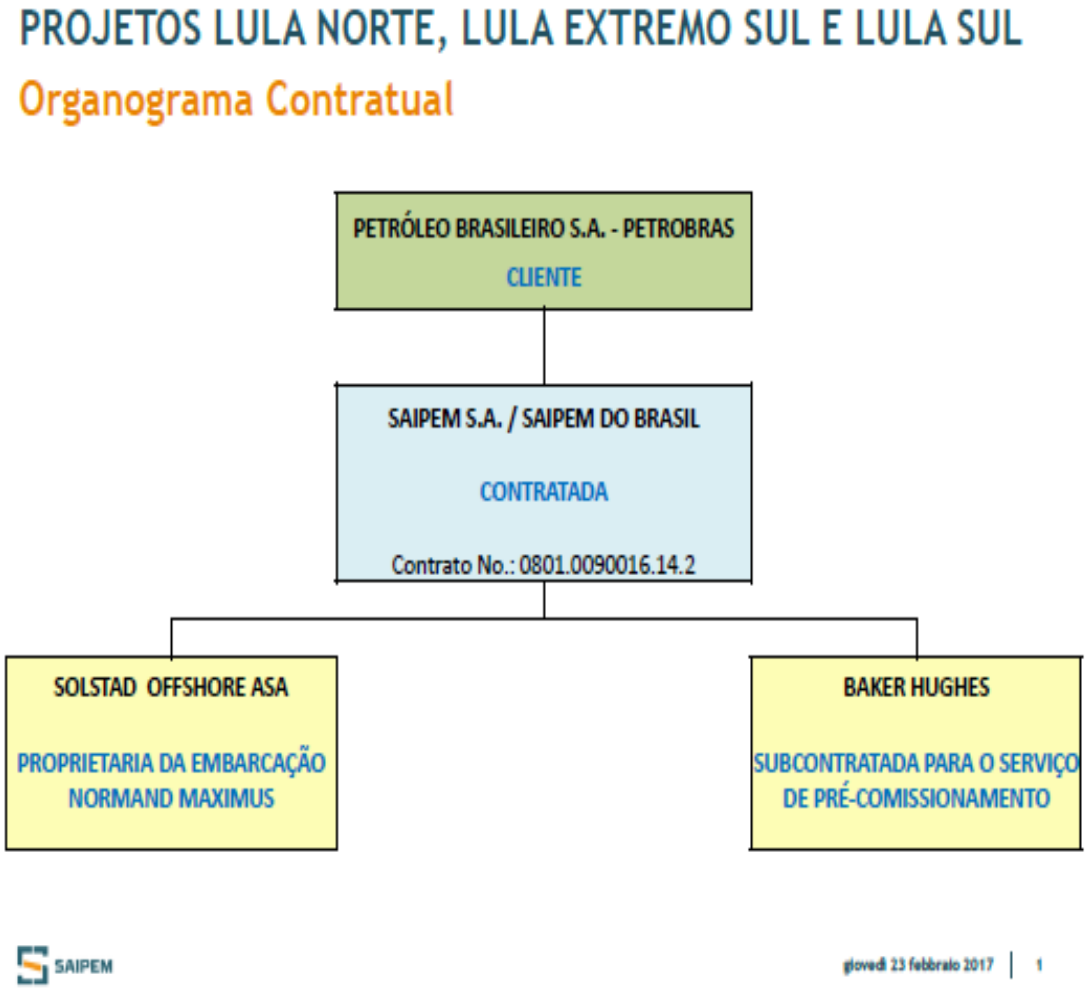


Photo 2: Installation overview

Immediately, the ship's doctor was called, the emergency teams were activated and the procedures of attending the 5 (five) injured were initiated. At 06:25 h was declared the death of one of the victims. At 09:07 h, the aero-medical evacuation helicopter landed aboard, taking off at 09:33 h. with the other injured to continue ground service in a hospital.

At the time of the accident, the deceased employee of the company Baker Hughes was positioned in front of the choke valve, monitoring the installation and complying with the instructions transmitted to him from the control room, by means of UHF equipment.

The activities carried out on board the vessel observed the hierarchy of decisions according to the organization chart below:



On the occasion of the investigation carried out on 23/02/2017, it was verified that the vessel was in good condition. The communication and navigation equipment were in order; the provision of salvage equipment, other systems and organic equipment were operational. In this way, their material integrity was not affected.

However, specifically on the pre-commissioning system installed on board by Saipen and Baker Hugues, the inspection performed by the investigators at the accident site (main deck), pointed out the following evidences:

a) Several material broken and broken steel pipes; faulty locking and relief valves; high pressure hoses (2,500 psi capacity), belonging to the pre-commissioning system, were torn and with broken steel mesh;

Photo 3: Pre-commissioning system equipment

Photo 4: Faulty pre-commissioning system hoses

Photo 5: Pressure and temperature recorders not installed

b) installation was without supports; the structures had no fixation and were loose, as well as pipes, valves and connections belonging to the system presented corrosion on their surfaces; two pressure and temperature loggers, members of the project scope (according to the approved procedure), were positioned on the main deck and not installed;

c) lack of grounding protection, existing recommendation in the Chemical Safety Data Sheets (FISQ) of the suppliers of chemical products to Baker Hughes;

d) lack of traceability of documents or certificates of high pressure piping, fittings and hoses, as well as affixed location identifiers (TAGs);

e) absence of remote control for activation of the system flow control valve; and

f) the existence of residues of oily product already absorbed by the wooden deck, close to the damaged valves.

IV) General information

A) Characteristics of the vessel:

Ship: “Normand Maximus” Flag: Norway
Activity: Marine Support Type: Marine Support Propulsion: Motor
Navigation area: Open sea Gross tonnage: 26,832 Length: 177,9m
Total Power: 29,365KW Depth: 13 m Hull Material: Steel
Owner: Solstad Offshore AS Max Draft: 8.5 m IMO: 9744518
Classification: DNV IRIN: LAVR7 Breadth: 33m
Port of Registry: Skudeneshavn, Norway
Construction Site: Brattvaag, Norway, Vard Brattvaag Shipyard, 2016
Sub-contract by: SAIPEM DO BRASIL SERVIÇOS DE PETRÓLEO LTD

B) Documents of the M/V “NORMAN MAXIMUS

The statutory documents were in order, as presented in the FLAG Inspection Report held on February 23, 2017. The number and qualification of the crew complied with the provisions of the Minimum Safe Manning Certificate issued by the Ports Captaincy of Rio de Janeiro. The DPEM Insurance is no longer required under Cir. Nº 04/2016 of 01/04/2016 of the Directorate of Ports and Coasts.

V) Accident Local Data:

Identification: Latitude 25º 34 '42 "S, Longitude 042º 53' 48" W, in Campo de Lula, Santos Basin, coast of the State of Rio de Janeiro.

Environmental conditions at the moment of occurrence: sea state 4, in the Beaufort scale; wind direction NE, with intensity of 4 knots; ambient temperature 22º C, according to the logbook records.

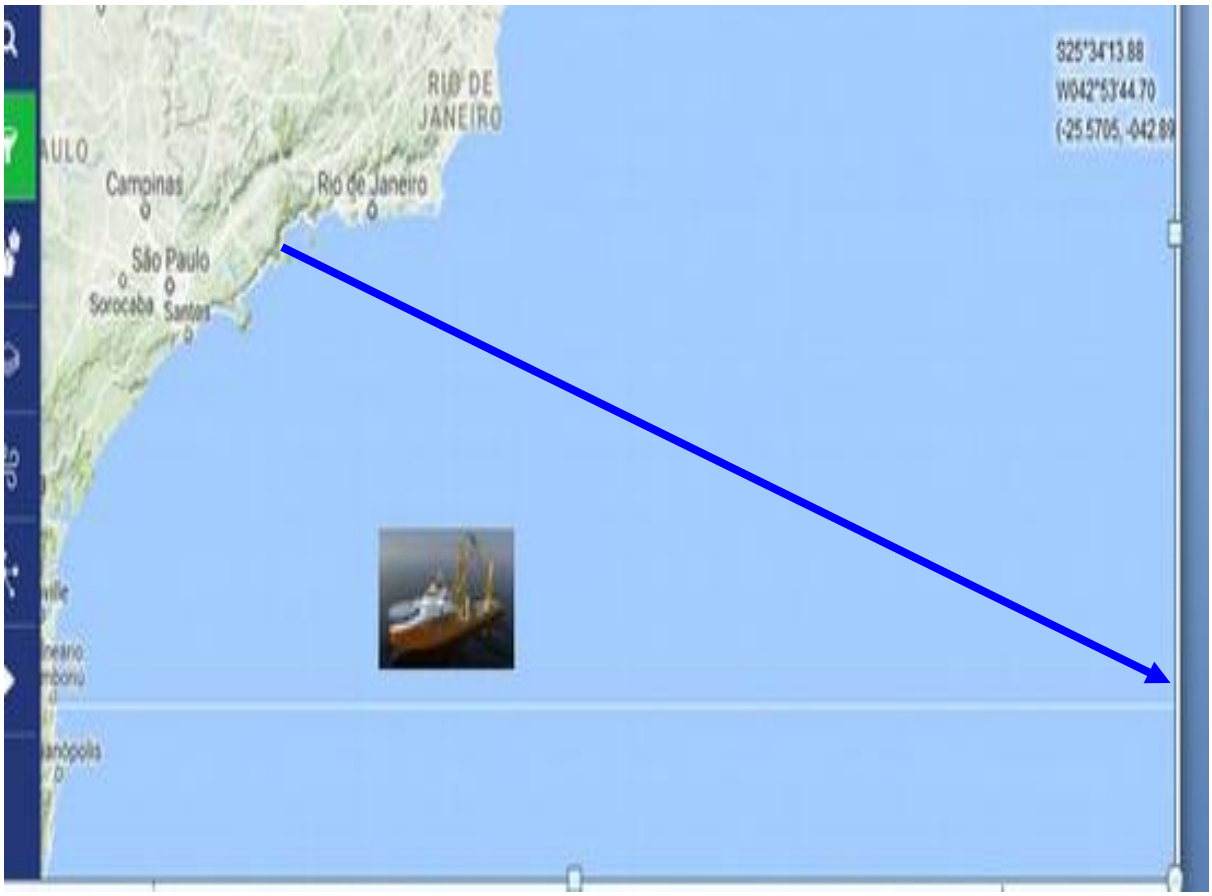


Photo 6: Location of the accident on Google map.

VI) - Human Factors and Crew

Number and qualification of the ship's crew complied with the provisions of the CTS. The crew members had the qualification required by STCW.

Bakers Hughes' top-level employees, training engineers, exercising supervisory duties, had more than 4 years in the company. Other members of the team had diverse service time in the company and had experience in the operation of high pressure systems.

Qualification of crew members, non-crew professionals and engineers:

- Captain - Nationality: Norway. Certificate No. 338267 (issued by the Norwegian Maritime Authority).
- Chief Mate - Nationality: Norway. Certificate No. 220022 (issued by the Norwegian Maritime Authority).
-. Baker Hughes membrane operator - Nationality: Brazil.; injured.
- Baker Hughes Compressor Operator - Nationality: Brazil.-; injured
- Operator of the elevators - Nationality: Brazil; injured.
- Engineer at Baker Hughes do Brasil - Nationality: Brazil.

- Engineer at Baker Hughes do Brasil Ltda - Nationality: Brazil.

Consequences of the accident:

Personal injury:

- GRIMALDO RIBEIRO JÚNIOR, General Supervisor, who died due to multiple injuries; MAYO MELTON CULP- professional injured; ISRAEL RAMOS DE LIMA - professional injured; RICARDO HENRIQUE TEIXEIRA SANTOS - professional injured and BRUNO RODRIGUES DE MELO - professional injured

From what was found, all Baker Hughes employees responsible for assembly and operation of the system were qualified to operate high pressure systems of work included in the Project Manager and the Engineers. As for the other employees, the General Supervisor also had knowledge about the installation, but the operators only operated in the compressors and pressure elevators (peripheral equipment of the process), participating in activities indirectly, without having training (experience) in the specific system.

- Periods of Work versus Rest and Fatigue:

The period of work versus rest was observed in shifts of 12 hours, in the periods of 11h to 23h and 23h to 11h.

- Alcohol, drugs and prescription and over-the-counter medications:

The use of nonprescription drugs, drugs or alcohol consumption on board has not been verified.

- Security Management:

There has been no detailed verification of written Security Management procedures.

As the accident occurred in an inorganic installation to the ship, the verification concentrated on looking for a possible failure in the equipment, or in the procedures pertinent to the pre-commissioning system installed.

It should be noted that the ship has not suffered any material damage, remaining with all systems and equipment on board operational; in the verifications of the statutory documents and other certificates on staff and material were in perfect order.

When the accident occurred, the emergency procedures were completed

immediately and were adequate.

Contributing Factors:

• Human Factor - did not contribute from the bio-psychological point of view.

• Material Factor - contributed to the absence of system protection elements (grounding measures to avoid electrostatic charges as well as remote means of operation of the installation) in addition to several system components mounted on the deck of the vessel without fasteners; and

• Operational Factor - contributed, since the General Supervisor acted directly on the flow control valve, following the guidelines given by the Control Room, whose orders emanated from the SAIPEM Engineer.

VII- Chronological Sequence of Events

The accident occurred at 06:15 p.m. on February 21, 2017. According to the document "Daily Operations Report # 176" provided by SAAKEM subcontractor BAKER HUGHES, the following extract from the event schedule of that day, from the beginning of the depressurising of the system to the occurrence of the accident.

Time	EVENT	OBSERVATION
00:10	BH PPS aligned the valves for rec 9. BH	Baker Hughes PPS - Process and Pipeline Services.
00:12	ROV opened V6.	
00:18	SAIPEM pre-commissioning engineer confirmed: PIG # 5 inside the PLR .	
00:36	SAIPEM pre-commissioning engineer and Petrobras representative testified to Baker Hughes Process Engineer measuring density of MEG sample # 1: 96%.	
00:39	SAIPEM pre-commissioning engineer and Petrobras representative testified to Baker Hughes Process Engineer measuring density of MEG sample # 9: 97%.	
01:25	Baker Hughes Process Engineer confirmed CT pressure for SAIPEM Engineer. Pressure: 135.50 barg. BH PPS still receiving MEG.	BH - Baker Hughes PPS - Process and Pipeline Services.
03:10	Baker Hughes Process Engineer informed the SAIPEM Engineer: receiving 70% air and 30% MEG.	

03:22	Baker Hughes Field Services Coordinator on the deck informs to prepare the Pig Caliber (Caliber Pig) to be deployed.	Caliber Pig - checks the caliber of the ducts
03:35	Cabin (Control) began recirculating MEG Linear Gel that was in the blue tank.	
03:49	SAIPEM's pre-commissioning engineer asked the Cabin (Control) to better control the receipt of MEG. Flow: 2,286 scfm	scfm – s*tandard cubic feet per minute*
03:50	Cab (Control) has closed the throttle valve (choke valve) slightly. Flow: 1,550 (scfm)	
03:59	Baker Hughes Process Engineer confirmed parameters for SAIPEM Pre-commissioning Engineer. Total volume received: 759,885 - 657,669 = 102,216 scf	*scf* – standard cubic feet
04:07	ROV open the valves in the PLR to check the pressures via subsea pressure gauge (spg) spg - underwater pressure gauge	*spg* – underwater pressure gauge
04:13	Crane supporting the Caliber Operator to send the Caliber Pig to the bottom to perform the test.	
04:43	Baker Hughes Process Engineer confirmed to SAIPEM that she was receiving mist (99% air and 1% MEG, approx.)	
05:07	SAIPEM's pre-commissioning engineer asked BH PPS to increase the airflow being received.	
05:24	BH PPS began to increase the airflow being received: flow = 3,265 scfm.	
05:55	Baker Hughes Process Engineer goes to breakfast and leaves Project Coordinator Baker Hughes USA in the cabin.	Cabin / Control Room
06:13	Baker Hughes Process Engineer returns from breakfast.	
06:15	BH PPS MEG and recovered air spread. **Accident.**	
06:30	SAIPEM Engineer informs the Baker Hughes Procedures Coordinator about the accident and also requests to inform the Project Coordinator.	

According to the above table of events and information obtained from interviews with Baker Hughes employees, the system pressure at the start of the depressurising at 00:10 hours was 3,200 psi.

The Process Engineer, starting her work shift in the control room at 03:10 hours, controlled the compressor output pressure and monitored compliance with the

operating procedures. At that time, the operation was in the last phase of depressurising the pre-commissioning line, when it received 70% (seventy percent) of compressed air and 30% (thirty percent) of MEG. In the control room were monitored the compressor output pressure, the inlet / outlet on the membrane and the outlet / inlet of the intermediate and also the compliance with the operating procedures.

Temperature control was not performed because it was not included in the operating procedures, as mentioned in the documentation presented by the company.

At 4:43 p.m., the Process Engineer in the control room confirms to the SAIPEM official, in control of the ROV, that the facility was receiving FOG (a mixture of 99% air and 1% MEG, approximately).

At 05:07 hours the SAIPEM representative asked the control room to increase the flow of air (flow).

At 5:24 a.m. the control room began to increase the flow rate to 3265 scfm (standard cubic feet per minute).

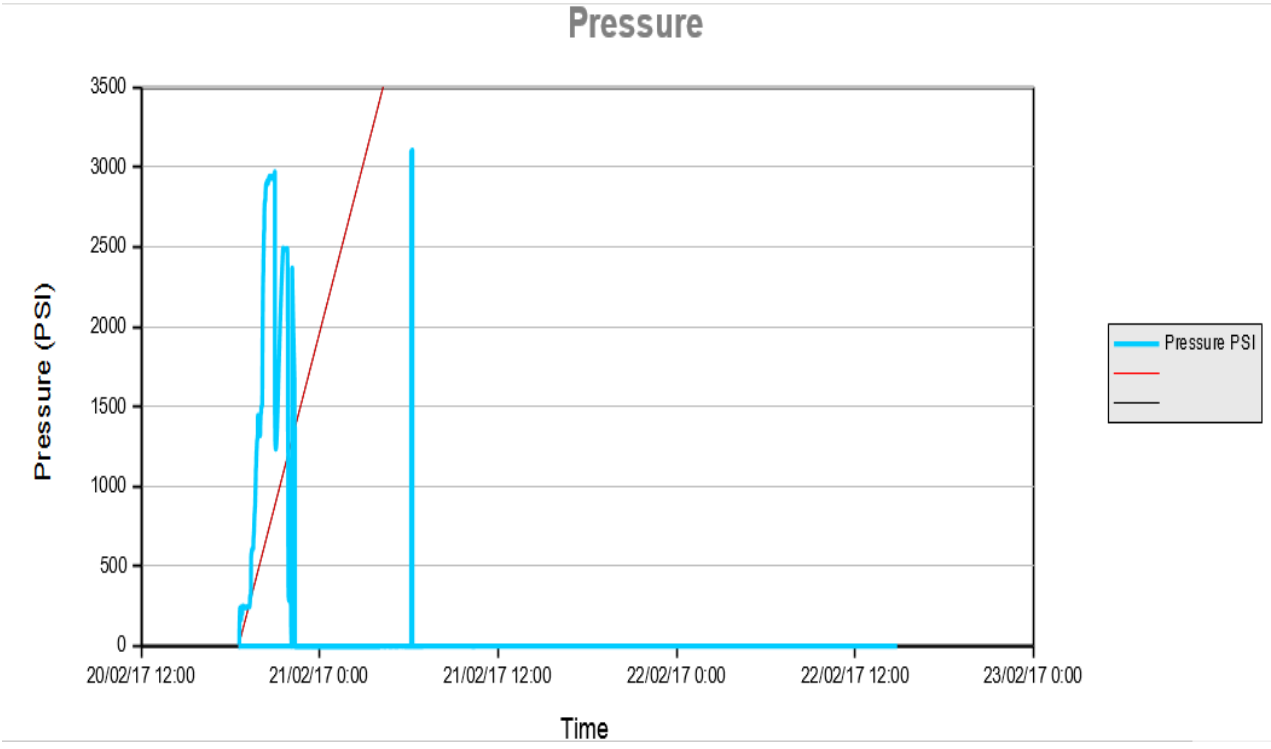


Photo 7: Diagram Pressure (PSI) X time

At 6:14 p.m. the control room informs that the recovered air (compressed air drawn from the piping, - 99% air mixture and 1% MEG) spreads (moment of explosion). The General Supervisor, who was in front position to the valve, was directly hit by the steering wheel of the equipment fatally. From that moment, emergency procedures and care of the injured are adopted.

The process of recovering MEG and depressurising the underwater system was monitored by the Test Cabin, located in a container on the Main Deck, equipped with electrical panels, electronics and a computer.

The control room monitored the conditions of operation and the launch / arrival of the pigs to the deck. The General Supervisor ("Senior Supervisor"), guided by the Control Room, manually depressurized the deck by means of valves. The network operated at local pressure up to 3,916 psi (270 bar). At the time of the accident the system operated at a pressure of 3,188 psi (215 bar).

The operation of the system was performed by the General Supervisor, manually, through valves, starting with the local pressure of the order of 3,916 psi (270 Bar). The Process Engineer, positioned in the Control Room, monitored the pressures and flows, guiding the actions to be taken.

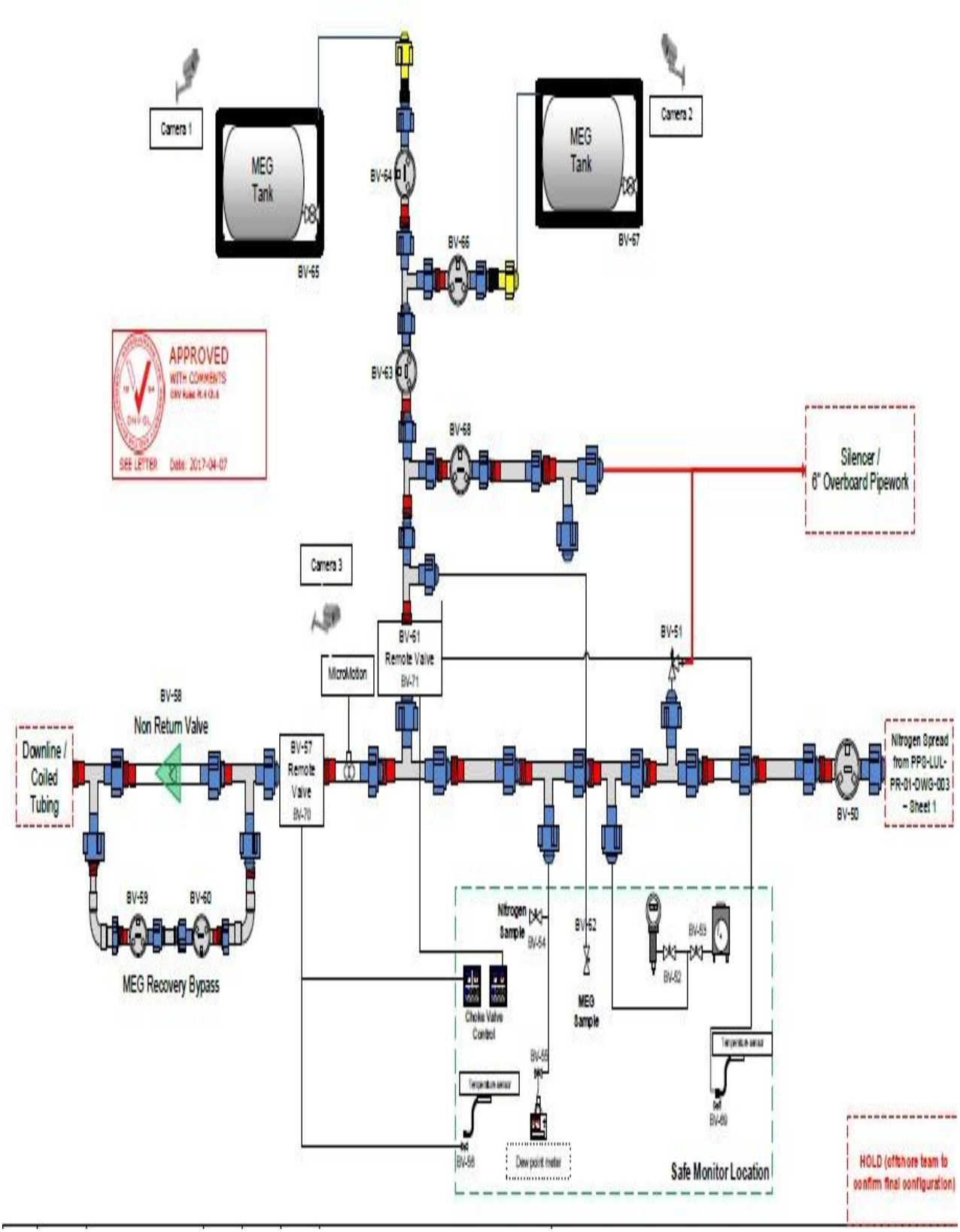


Photo 8: Installation diagram.

On the main deck would be located pressure monitors and emergency stop buttons, which was not evidenced during the investigation, due to the decharacterization of the scene, as well as there was no remote control for the valves of the installation.

At the time of the accident, at 06:15 hours, the General Supervisor was positioned in front of the flow control valve and depressurising (choke valve), controlling the flow rate.

Photo 9: "Choke valve" failed

The point control of the equipment was carried out on the deck by the Operators (compressor oil pressure, radiator water, local line pressure, etc.) and valve operation was performed by the General Supervisor, with guidance from the Control Room.

During the pre-commissioning of well lines, six (six) pigs (mechanical elements separating substances within the test line) were used, separating the following substances: MEG (Monoethylene Glycol) - a chemical compound hygroscopic, antifreeze and coalescing agent, water, high pressure air-compressed and Nitrogen. The verification of the Material Safety Data Sheets (MSDS) obtained from the chemical suppliers for Baker Hughes indicated the following characteristics of the MEG:

• HAZARDS IDENTIFICATION - is listed as "Physical and Chemical Hazards: burning, although not classified as flammable";

• FIRE PREVENTION AND FIRE FIGHTING MEASURES - presents as one of the "Specific Methods: (...) Grounding equipment when handling. Cool containers exposed to fire ";

• SPILL / LEAK CONTROL MEASURES - recommended when handling "Removal of ignition sources: Eliminate hot and ignition sources".

• HANDLING AND STORAGE - for handling, are listed as "Fire and Explosion Prevention: Dispose of equipment when handling. Do not smoke. Do not handle the product near sources of heat or ignition (...). Take measures against the accumulation of electrostatic charges. Store in clean, well-ventilated areas "(sic); are listed as "Appropriate: Covered, fresh, dry and ventilated area. To avoid: Wet, overcast and unventilated places. "

• PHYSICAL AND CHEMICAL PROPERTIES - Presents "Specific temperatures or ranges of temperatures at which changes in physical state occur: Distillation range: 194 to 199 ° C; Flash Point: 116 ° C "and" Explosion Limits: LEI (lower explosion limit): 3.2% (v) ".

• FIRE-FIGHTING MEASURES - Presents as one of the "Specific Hazards: (...) The commercial product contains a non-volatile oxidation inhibitor. If the product is distilled, its distillate will not contain the inhibitor and be more subject to the formation of peroxides, **which could lead to an explosion hazard**.

VIII - Procedures after the accident:

Immediately following the occurrence of the accident, the medical assistance of the vessel was activated and the vessel emergency team was provided. With the confirmation of the occurrence of a death and other injured non-crew professionals, aero-medical removal was provided for attendance at a hospital onshore.

The inspection carried out by the investigators at the ship's facilities found that the vessel was not structurally damaged, nor were its organ systems damaged. The faults were restricted to the installation of the pre-commissioning system of the LULA EXTREMO SUL stretch 1 well lines, in the section installed provisionally on the main deck, aft section.

IX - Consequences of the accident:

Personal injury:

- GRIMALDO RIBEIRO JÚNIOR, born on 05/02/1981, male, who died due to multiple injuries; MAYO MELTON CULP- professional injured;

ISRAEL RAMOS DE LIMA - professional injured;

RICARDO HENRIQUE TEIXEIRA SANTOS - professional injured; and

BRUNO RODRIGUES DE MELO - professional injured.

Material damage:

- There was no material damage to the vessel, according to the Ship Inspection Report, dated 02/23/2017. However, the pre-commissioning system installations of the LULA EXTREMO SUL stretch well line 1, in the section installed on the main deck, in the stern area, have been damaged.

Pollution - No environmental pollution was found.

Photo 10: Faulty installation (1)

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Photo 11: Faulty installation (2)

X - Expert Examinations:

No physical tests were performed on the defective material.

XI - Analysis and Causal Factors:

From what was found, all Baker Hughes employees responsible for assembly and operation of the system were qualified to operate high pressure systems of work: both the Project Manager and the Engineers. As for the other employees involved in the operation on board, the General Supervisor also had knowledge about the installation, but the operators only operated in the compressors and pressure elevators (peripheral equipment of the process), participating in activities indirectly, without having training (experience) in the specific system.

The process used the following products: water, air-compressed, MEG and Nitrogen. Of these, only the MEG could be explosive if it reached a temperature above its flash point. At the time of the accident and the consequent disruption of the installation on the deck, the General Supervisor was receiving MEG mist (99% air-compressed and 1% MEG, approx.). The Control Room monitored the

values received on a computer screen, passing on the operating orders of the plant (received from the SAIPEM Representative) to the General Supervisor through UHF Radio; the records of the operations were carried out by manually launching the operation in the "Daily Operations Report".

Due to the decharacterization of the area, it was not possible to determine the monitoring points of the pressure and temperature values predicted in the procedure used in the pre-commissioning of the well line. From the information gathered in the interviews with Baker Hughes employees, only the pressure and flow elements in the system were monitored during the process, although MEG suppliers warned in the FISQ about the risk of explosion of this gas when subjected to the special conditions of sources of heat and static electricity.

Thus, the critical monitoring element to be monitored in terms of safety would become the temperature rise, which may occur depending on the process conditions. However, the control of temperature elevation during the process was not evidenced, although the FISQ contained this orientation.

The constituent elements of the pre-commissioning network had calibration certificates; however, it was not possible to track the respective certificates of control elements, pipes, connections, and valves.

Another element of fragility regarding personal security was the lack of individual protection of the operators, especially the General Supervisor, who acted directly on the elements of flow control and flow.

It was concluded, therefore, that the cause of the accident was the explosion of the compressed air-MEG mixture, due to the exposure of the MEG mist to inadequate conditions due to lack of monitoring and control at different points in the system.

XII- Preliminary Lessons Learned and Conclusions:

• The accident with the pre-commissioning system installations of LULA EXTREMO SUL well section 1, in the section installed on the main deck, could have been avoided if there was a monitoring of the temperature of the mixture in the installed pre-commissioning line. Temperature monitoring was not included in Procedure I-PR-3A03.21-26520-970-XSA-1425 (Rev.A), an integral document of the LULA NORTE Project, LULA EXTREMO SUL AND LULA SUL, issued by Baker Hughes, and

approved by PETROBRAS (client). However, in the light of the information contained in the Chemical Safety Information Sheets - MSDS of the chemical suppliers for Baker Hughes, regarding the risk of explosion of this gas when subjected to the special conditions of heat sources, should have been carried out monitoring the temperature. The presence of temperature recorders in the installation area indicates that such equipment should have been installed, otherwise its mere presence on the premises is not justified. This equipment, if installed, would have increased the safety level of the operation.

• Also, the MSDS reported the need to predict ground due to the presence of static electricity, which was also not verified in the installation, thus increasing the risks to the operation.

• The use of a manually actuated flow control and depressurising valve was the determining factor for the death of the General Supervisor, since his positioning in the operation was frontal to the valve and, when it was exploded, it was directly hit by the steering wheel of equipment, so was shown to be inadequate and fatal. For this type of system, equipment with remote actuation must be used in order to increase the individual protection of the operators.

• The pre-commissioning project did not provide for the installation a safety valve in the network of pipelines used for the depressurising of the system. The presence of this equipment would contribute to increase the safety of the operation and, therefore, its use is advisable.

XII - Safety recommendations

(to Saipen, Baker Hugues and other companies engaged in similar activities of pre-commissioning of lines) :

• It is essential to observe the recommendations set out in the Chemical Information Sheet and establish relevant monitoring and control procedures in the projects.

• Due to the MEG manufacturer's recommendations contained in the MSDS, it is necessary to install a cooling system in the pre-commissioning mechanical installations, since the variable "temperature" is of great importance to inhibit changes in the characteristics of the MEG.

• The Preliminary Risk Analysis should include all specific risks for high pressure pre-commissioning activity, as well as measures to prevent area safety and the use of

adequate Personal Protective Equipment (PPE) by deck personnel.

• Valve commands and monitoring of local flow, temperature and pressure variables should be done remotely, in scanned and automatic form, to increase the individual protection of the equipment.

• It is essential that there are safety valves in the pre-commissioning installation, thus avoiding the occurrence of an accident caused by an excessive increase of pressure above the permitted limits.

XIII) ANNEX:

SHIP´S PARTICULARS

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ANEX

SHIP´S PARTICULARS

Ship: “Normand Maximus”	Flag: Norway	
Activity: Marine Support	Type: Marine Support	Propulsion: Motor
Navigation area: Open sea	Gross tonnage: 26,832	Length: 177,9m
Total Power: 29,365KW	Depth: 13 m	Hull Material:
Owner: Solstad Offshore AS	Max Draft: 8.5 m	IMO: 9744518
Classification: DNV	IRIN: LAVR7	Breadth: 33m
Port of Registry: Skudeneshavn, Norway		
Construction Site: Brattvaag, Norway, Vard Brattvaag Shipyard, 2016		
Sub-contract: SAIPEM DO BRASIL SERVIÇOS DE PETRÓLEO LTD		