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The Hibernia Development Project

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ABSTRACT

The Hibernia platform in Grand Banks, Newfoundland and Labrador (NL) is recognized as the world's largest platform, and owns the most productive oil wells in Canada. However, because of the surge, icebergs, storms, and heavy fogs in that sea area, the Hibernia platform needs to be designed to adapt to the harsh weather.

The discovery of the oil field in Grand Banks can be traced back to 1878, when the first geotechnical report for that area was published. Multiple oil companies were involved in the development of the Hibernia oilfield after the discovery. The Hibernia development project was operated by the Hibernia Management and Development Company (HMDC), which formed in December 21, 1988.

The construction of the Hibernia platform started in 1990. Considering the environmental circumstance, the final platform consists of Topsides, Gravity Base Structure (GBS) and Offshore Loading System (OLS). Four departments included shore-base facility, heliport facility, warehouse facility and transhipment terminal work together and maintain the operation of the platform.

This article will briefly introduce the Hibernia development project. In addition, it will give a discussion about the Hibernia platform design methods, the environmental impact, and lessons learned from its successes and failures.

1 INTRODUCTION OF HIBERNIA OIL FIELD

The Hibernia oilfield was discovered in 1979, and is recognized as the fifth largest oil field in Canada. As shown in Figure 1, the Hibernia oil field is located in Jeanne d'Arc Basin, which is appxomately 315 kilometers southeast from St. John's, NL. The local water depth is nearly 80 meters. The oil field consists of two reservoirs: Hibernia reservoirs (3,7000 meters deep) and Nevis-Avalon reservoirs (2400 meters deep).

Figure 1: Hibernia Oilfield Location (“The large Hebron provider”, 2013)

The development of the Hibernia oilfield can be traced back to the 1950’s when the first geophysical survey of the Hibernia oil field was published. This discovery attracted the first few investors of oil exploitation, including Mobil Oil Canada, Gulf, Suncor, Chevron, and Columbia Gas. During the long lasting development of the Hibernia oil field, the Columbia Gas and Gulf had sold their shares. On December 22, 1988, HMDC was formed to manage the development of the Hibernia Platform. Currently, the shareholder of HMDC is shown in Table 1.

Table 1 HMDC Shareholders (“About Hibernia”, n.d.)

Shareholders	Shareholding percentage (%)
ExxonMobio	33.125
Chevron Canada Resources	26.875
Suncor Energy	20
Canada Hibernia Holding Corporation	8.5
Murphy Oil	6.5
Statoil Canada Ltd	5

2 HIBERNIA PLATFORM STRUCTURE

As shown in Figure 2, the Hibernia platform consists of the Topside, GBS, and OLS. The Topside and GBS were fabricated and assembled in Bull Arm, Trinity Bay, NL, and towed to the Hibernia oil field.

Figure 2: Hibernia Platform (“Hibernia”, 2009)

2.1 Topside

The Topside is where the staff on the platform works and lives. As shown in Figure 3, there are five modules mounted to the Topside, including M10 Process, M20 Wellhead, M30 Mud, M40 Utilities, and M50 Accommodations.

Figure 5: Topside, Hibernia Platform (“Hibernia, Canada”, 2012)

The M10 Process module processes the recovered oil. The recovered fluid from a well has different compositions in different stages of exploitation. At the starting stage, the fluid mainly consists of crude oil and natural gas. When the oil recovery is nearly drained, the fluid will contain a significant amount of water and natural gas besides the oil. In order to ensure the purity of the crude oil, the water and natural gas need to be removed. The M10 module will separate the water, gas and crude oil using three pressure separators. After the separation, the crude oil will be stored in the CBS, the water and gas will be treated by removing the oil residues in them. The processed water will be rejected to the ocean or injected back to the reservoir. The majority of the natural gas is going to be pressurized and rejected to the reservoir. A small portion will be used as the fuel in the platform.

The M20 Wellhead module controls the drilling process. Two mobile drill derricks are mounted in the M20 module, thus two wells can be drilled simultaneously.

The M30 Mud module provides the drill mud. The drill mud is used to cool the drill bit, clean the cuttings and support the excavated hole in the drilling process.

The M40 Utilities module controls the utility supplies for power, heating, ventilation, and water.

The M50 Accommodations module contains conference rooms, accommodations, cafeterias, living rooms, and gyms. In addition, a temporary safety refuge and a lifeboat station are also located in this module.

2.2 Gravity Based Structure

Gravity Based Structure (GBS) is used to support the topside, and to store the recovered crude oil. It is a 111 meters tall concrete structure with a storage capacity of 1.3 million barrels of crude oil. The GBS is designed to resist the ice impact of six million tons, which has a one in ten thousand chance to occur estimated from the water depth in Hibernia oil field. The GBS was constructed in Bull Arm, Trinity Bay, Newfoundland. After the construction, the Topside was mounted to the GBS, and the whole structure was towed to the Hibernia oil field, and placed on the ocean floor.

Figure 3: Gravity Base Structure (CBS), Hibernia Platform (“Hibernia, Canada”, 2012)

2.3 Offshore Loading System

The OLS is a crude oil transmission system, which transfers the crude oil from the GBS to the ice resisting tankers. The tankers are used to transfer oil to the transhipment terminal or the market. The OLS is made of a series of oil-transmitting pipelines on the ocean floor. In order to prevent the damage from ice impact, the pipeline is made of thick steel piles and is protected by a concrete cover.

2.4 Supporting Facilities

Various facilities had been built to support the production of the Hibernia platform. Those facilities could be classified as shorebase facilities, warehouse complex, heliport, and transhipment terminal.

The shorebase, located in the St. John’s Harbour, is run by A. Harvey and Company. The company provides ship docking spaces, barrels to transfer materials to the platform, and staffs and equipment to assist the transportation. Asco Warehouse Complex, located in Mount Pearl, provides offshore storage for Hibernia platform. All the materials are stored in the warehouse prior to transporting to the platform. Heliport is the control centre of the air transportation. The heliport services are provided by Cougar Helicopters. The main heliport is located in St. John’s, and in case of poor weather conditions, an alternative heliport is located in Long Pond, Conception Bay South. Transhipment is an optional service for transmitting the recovered crude oil from the GBS to the market. Specially built ice-resisting tankers are used to transmit the crude oil.

3 MAJOR CHALLENGES

There are many challenges for the exploitation of the Hibernia oil field. Some of the major challenges will be discussed in this section. The challenges include:

- The fabrication of the Hibernia platform
- The design the GBS and OLS system against the ice impact
- Personnel safety
- Prevention of potential harms to the environment

3.1 Design and Fabrication of the Topside and GBS

The Hibernia reservoir is located at a depth of 3,700 meters below water surface. A large platform is required to provide efficient drillings, crude oil storage, and living and working spaces for all required personnel. Several designs were carried out at the beginning stage to correspond to such a large demand. The gravity-based structure was eventually selected and designed by Newfoundland Offshore Development Constructors (Nodeco) and Doris Development Canada (DDC) (subcontractor). The major component of the GBS is a 115m tall caisson made with high strength concrete with reinforcement. The caisson is surrounded by ice walls. The total weight of the GBS goes up to 450,000 tons. It is capable of resisting a direct hit of 6,000,000-ton iceberg (1/10,000yrs).

The fabrication of the Topside and GBS was carried out in Bull Arm, Trinity Bay, NL. The choice of where to fabricate a structure with this scale is complicated. As shown in Figure 5, Bull Arm is located around 150 meters away from St. John’s. This location was chosen because the deep channel between Bull Arm and Trinity Bay allowed the transmission of the fabricated platform. In addition, steep hills around Bull Arm provide a suitable environment for the construction.

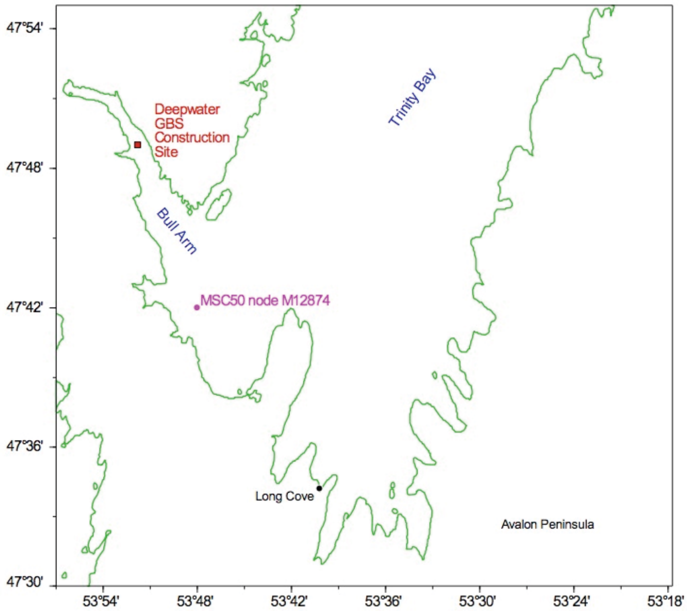

Figure 5: Bull Arm Location ("Hibernia Project Comprehensive Study Report", n.d.)

3.2 Design of resistance to ice impact

Ice impact is considered to be one of the major issues for the Hibernia platform. The water depth in the Hibernia platform is only around 80 meters, which gives a low chance of having large-scale icebergs. However, since ice could cause serious damage to the GBS and OLS systems and consequently lead to oil leaking, which will cause severe harm to the environment, the series of iceberg detecting and intervention systems are installed on the platform.


Figure 6: drag an iceberg (National Geographic, n.d.)

In addition to the state of art ice detection and prevention system, the GBS and OLS system are also designed to resist ice impacts. CBS is designed to resist 1,000,000 tons of iceberg impact without damage, and resist 6,000,000 (1/10,000 yrs) tons of iceberg impact with repairable damage. The OLS system is made of thick steel and encased in concrete to prevent the damage of icebergs flooring. An extra set of the OLS system is also installed as an alternative system and operates in case of the original OLS system suffering any damage.

3.3 Personal Safety

Insurance of personal safety is the most crucial tasks during a operation. A variety of precautions have been taken to prevent accidents from happening on the Hibernia platform. Proper safety training and proper safety gears are mandatory for all the personnel. All personnel have the responsibility to recognize, respond, and report to any hazards, or potential hazards. Fire and smoke detection system are used in the platform and are located in a short distance. The triggers of two or more alarms will turn off the production. The helicopter uses the GPS technology and de-icing system, which allow the helicopter to fly safely in cold and foggy weather.

In case of an unavoidable accident, the platform is equipped with rescue instruments to ensure the safety. A TSR is located in the M50 accommodation module in the topside. The TSR is designed against fire, smoke, and gas, and can provide power, radio communication and medical kit in case of an emergency. The lifeboat and liferafts are two evacuation systems in the platform. Lifeboat is designed to protect against heat and fire. Two lifeboat stations are located in the platform. Four liferafts with a capacity of 25 people each are located in the four escaping chutes in the platform. In addition, two sets of immersion suits are provided for each personnel in the platform. One is located in their lifeboat station and the other one is available at individual cabins.

3.4 Environmental Safety

Without strict management, oil exploitation could cause significant damage to the local sea area in both short term and long term.

The most significant issue will be oil spill. Oil spill could happen either during the drilling or during the storage or transportation. Two preventive measures are carried out for oil spill during the drilling, which are the heavy dust blow out preventer and platform drain system. If the oil spilled out during drilling, it will flow through the platform drain system, which will separate the oil and water, and transfer the oil to an oil storage tank. In order to prevent the oil spill during storage and transmission, the GBS, OLS and transmitting vessel are designed for iceberg impact with a high safety factor. The Hibernia platform also has some reactive methods for oil spill. In case of spill, the single vessel side sweep system will be used to clean the spilled oil. If the spill scale is large, then an emergency support group will be contacted to assist the cleaning. In addition, agreement has been made with nearby platforms to share the resources in case of large scale of oil spills.

The exploitation could also cause damage to the local marine lives. In order to monitor the local ocean environment, water, sediment and biological samples are taken in the nearby area, analyzed and compared with control points. According to the data from Hibernia website, there are no significant influences that have been detected up to now.

Further potential damage, which will be discussed here, is the influence on the pressure in the reservoir. Since oil, water and gas are extracted from the reservoir, the pressure decreases. In order to compensate for the loss of pressure, the Hibernia platform pressurizes the majority of collected gas and re-injects them into the reservoir.

4 LESSONS LEARNED FROM THE SUCCESS AND FAILURE

Hibernia is one of the major oil exploitation projects in Canada. Abundant geophysical and geological studies, detailed designs, and strong safety plans have made the project successful. This has proved that a detailed preparation is the key to success.

Even with safety plans, the Hibernia platform still has had several accidents. Those accidents could have been prevented with more careful inspections. Although the advanced equipment could increase the safety on the platform, a more important component of a safety net is the careful attitude towards safety.

5 CONCLUSION

The Hibernia platform was designed to have safe and profitable oil exploitation. Comprehensive preparation plans were carried out before developing the Hibernia project, detailed construction strategies were derived to ensure the quality of the platform, and systematic managements were implemented for enhancing the efficiency of the production. Those features make the Hibernia development project a representative for projects completed with macroscopic plans, and detail oriented executions.

This article intends to use the Hibernia development project as an example to exhibit the methods for preparing solutions against challenges such as Topside and GBS fabrication and iceberg impaction.

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