Hibernia Development Project

Abstract

In the early 1980s the Hibernia Management and Development Company (HMDC) decided to develop the Hibernia oilfield which lies 300 km east of Newfoundland, Canada by means of a Gravity Based Structure (GBS). To withstand the harsh environmental conditions on the Grand Banks the platform was to be ballasted after offshore installation with 411,000 tonnes of iron ore magnetite. The difficult task of ballasting the Hibernia platform was awarded to HAM, dredging and marine contractors.

This article gives an overview of the work executed for the ballasting in which the iron ore magnetite was transported to the offshore location in three self-unloading bulk carriers. Each carrier unloaded the dry cargo using hydraulic transport by mixing the iron ore with water and pumping the mixture to the platform.

Introduction

Only decades after the Titanic sunk there, a consortium of five oil companies decided to develop the Hibernia oilfield in the notoriously rough seas some 300 km east of Newfoundland, Canada (see Figure 1).

Owing to environmental conditions, a water depth of 80 metres, and a sailing distance of 540 nautical miles, the decision was taken to develop the Hibernia field by means of a Gravity Based Structure (GBS). However, the design for this concrete platform had to be different from existing GBSs as it was to be placed on the Grand Banks and had to be able to withstand the adverse environmental forces of storms and icebergs. The final design of the Hibernia platform resulted in a star-shaped concrete base with double walls (see Figure 2). The concrete platform base is 85 m high and has a diameter of 100 m.

It was envisaged that, after offshore installation, 411,000 tonnes of ballasting material had to be placed between the outer “ice” wall and the inner wall to give the platform enough weight to ensure stability in the case of a one-million-tonne iceberg collision, severe storms or hurricanes.

The consortium developing the Hibernia field was named Hibernia Management and Development Company (HMDC). HMDC comprised the following participating oil companies: Mobil Oil Canada, Chevron Canada, Murphy Atlantic, Petro Canada, and Canada Hibernia Holding.

Based on the time required for design and construction, HMDC set the “hit oil” target date as December 1997. To meet that target, the construction schedule for the Hibernia platform was such that the platform had to be ready for tow-out from its construction site “Bull Arm” in Newfoundland and transport to its final offshore destination by the end of May 1997.

The offshore ballasting works were to start directly after installation in order to safeguard the stability of the platform as quickly as possible. Only after the ballasting work had been completed could the drilling operations commence. Ballasting works were thus a critical part of the project.
Ballasting the Hibernia Platform

As mentioned above, for stability reasons an additional 411,000 tonnes of ballast material was to be placed in the concrete platform base after final installation offshore. The design specified iron ore magnetite as the ballast material. It is a material with a high volume weight, and it is readily available on Newfoundland. Though other GBS platforms have been successfully ballasted in the past, the following aspects made the Hibernia project unique:

– the difficult environmental conditions;
– the long sailing distance from the loading facility;
– the properties of the ballasting material (coarse-grained iron ore magnetite);
– the filling method; and
– the tight time schedule.

Looking at the environmental conditions it is clear that even during the most favourable weather window there is a fair chance of iceberg presence, a high risk of dense fog and, later in the window, a considerable probability of hurricane or storm occurrence. The sailing distance of 540 nautical miles from the site to the loading facility complicated finding both technically and economically feasible working methods as well as suitable equipment for the task.

The hydraulic transport of ballast material with a high volume weight (4.3 t/m³) and large-sized particles ($D_{10} \geq 2.5 \text{ mm and } D_{100} \leq 50 \text{ mm}$) was beyond the generally accepted theory and experience. There was no previous experience pumping coarse-grained heavy material on such a large scale. For this reason HMDC performed extensive full-scale tests. The results of the tests were used to design the actual hydraulic distribution system on the vessels and platform.

Needless to say, all these factors made the project complicated and challenging. Well-thought-out working methods and thorough preparation were absolutely indispensable. The three phases of ballasting the Hibernia platform are described below.


HMDC asked HAM to conduct an engineering study for the design of the offshore hydraulic ballasting system of the Hibernia Platform because of the company’s previous experience. This included ballasting platforms on projects such as Ekofisk and F3 in the Norwegian and Dutch sectors of the North Sea and on Moliqpak in the Canadian Beaufort Sea. The F3 platform was ballasted hydraulically using a fine-grained iron ore. Owing to weight restrictions, a somewhat different solution was chosen than what was originally advised.

Tendering Phase (1996)

In the course of 1996 HMDC invited several contractors to bid for the Hibernia ballasting works. In October 1996 the contract for the ballasting of Hibernia platform was awarded to HAM, dredging and marine contractors, based on HAM’s technical and commercial proposal. The following paragraphs discuss the works then undertaken, covering the total project execution.

Execution Phase (October 1996-August 1997)

The execution phase can be subdivided in two periods:

I. the preparatory works, from October 1996 through May 1997;
II. the ballasting operations, from May through August 1997.
During the preparatory works, detailed working methods and safety and contingency plans were made. Concurrently, the necessary modifications of the bulk carriers were designed and prefabricated, and preparations were made for the final on-board installation of the extra equipment in May 1997. The actual work cycle and methods are described below under the heading “Ballast operations”.

I. Preparation Works, October 1996-May 1997

Scope of work
- Transport 411,000 tonnes of iron ore magnetite from Flintcote Wharf, Stephenville, Newfoundland, Canada, to the Hibernia platform;
- Hydraulic discharging of 411,000 tonnes iron ore magnetite through a floating pipeline into the mobile distribution unit (MDU) on the platform base;
- Characteristics of ballasting material:
  - \( D_{10} \geq 2.5 \text{ mm} \) and \( D_{100} \leq 50 \text{ mm} \)
  - \( D_{10}/D_{100} \geq 6 \)
  - specific gravity 4.2-4.7 ton/m\(^3\)
- Ballasting period, June-July 1997; deadline, 1 September 1997.

Working method
In order to transport the iron ore at this long sailing distance within the required time frame and budget, large capacity ships were needed. To be able to meet the critical deadline, three 35,000 tonnes self-unloading bulk carriers owned by Canada Steamship Lines (CSL) were used. The working method proposed to ballast the Hibernia platform was novel because:
- the bulk carriers were moored to the concrete platform (as shown in Figure 3); the working method and cycle are further described under “Ballast operations”.
- a slurryfication unit was installed on each vessel to enable hydraulic unloading.

The slurryfication discharge system
This describes the system of dry unloading to hydraulic unloading via a floating pipeline to the platform. To be able to fill the Hibernia platform by means of hydraulic transport a complete “slurryfication” set was installed aboard the carriers as the CSL unloading system was designed for dry unloading. In this system conveyor belts transport the load from the cargo holds to deck level and from there over a boom conveyor to the

Figure 2. Artist impression of Hibernia platform.

Figure 3. Bulk carrier moored to Hibernia platform.
shore. A system was designed to redirect the flow to the slurryfication set and thus enable hydraulic discharge to the platform.

The entire unloading system is as follows, where (1) denotes the existing system and (2) the modifications:

(1) The conveyor belt below the cargo hold collects the ballast material, carefully released through the cargo hold doors. From there the material is moved towards the bow of the vessel and transported in vertical direction by means of a double conveyor belt squeezing, and thus transporting the material upwards. Subsequently, the material is deposited on the horizontal boom conveyor from where it falls into a hopper.

(2) The hopper regulates the outflow of material falling on the conveyor belt (on deck level) which runs to the slurryfication unit. The ballast material flow in the system is controlled by a feeder from where it is released into a water-filled hopper. The water/iron ore magnetite mixture is pumped up by the dredge pump and discharged under pressure through the floating pipeline to the Mobile Distribution Unit (MDU) on the platform. The MDU distributes the material to 5 cells in each of 16 positions in order to fill the 80 platform cells to the required level. The design of the MDU, the level and sequence of filling were controlled by HMDC.

In Figure 4a, b it can be seen that the boom of the existing self-unloading system links the existing unloading system via the on-deck conveyor belts to the custom-made slurryfication unit which enables hydraulic discharge.

**Equipment of subcontractors and required conversions**

The following describes the spread required to enable offshore mooring and hydraulic unloading, after giving a general overview of the equipment used by subcontractors (see also Table I).

**Table I. Facts and figures on bulk carriers, supplier and tugs.**

<table>
<thead>
<tr>
<th>Type of Vessel</th>
<th>Details</th>
</tr>
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<tbody>
<tr>
<td>Self-unloading bulk carriers</td>
<td>- Owned by Canada Steamship Lines</td>
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<tr>
<td></td>
<td>- Loading capacity: 35,000 tonnes</td>
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<tr>
<td></td>
<td>- Length: 220 metres</td>
</tr>
<tr>
<td></td>
<td>- Width: 23 metres</td>
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<tr>
<td></td>
<td>- Sailing speed: 12 knots</td>
</tr>
<tr>
<td>Z-drive tugs</td>
<td>- Owned by Canada Steamship Lines</td>
</tr>
<tr>
<td></td>
<td>- Bullard pull: 50 tonnes</td>
</tr>
<tr>
<td></td>
<td>- Length: 28 metres</td>
</tr>
<tr>
<td></td>
<td>- Beam: 11 metres</td>
</tr>
<tr>
<td></td>
<td>- Propulsion: 4000 HP</td>
</tr>
<tr>
<td>Supplier vessel</td>
<td>- Owned by Groupe Ocean</td>
</tr>
<tr>
<td></td>
<td>- Bullard pull: 50 tonnes</td>
</tr>
<tr>
<td></td>
<td>- Length: 56 metres</td>
</tr>
<tr>
<td></td>
<td>- Beam: 11.8 metres</td>
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<tr>
<td></td>
<td>- Propulsion: 5200 HP</td>
</tr>
</tbody>
</table>
**Subcontractors’ equipment**

The main subcontractors during this project were CSL, ATL and Groupe Ocean:
- Canada Steamship Lines (CSL) for the joint exploitation of the three bulk carriers;
- Atlantic Towing Ltd. (ATL) for two seagoing highly manoeuvrable Z-drive tugs;
- Groupe Ocean for the supplier vessel.

**Prefabrication and installation of mooring and discharge equipment**

The CSL carriers had to undergo extensive modifications to enable mooring of the vessels to the Hibernia platform and the hydraulic discharging of iron ore magnetite. In order not to lose time during installations it was decided to prefabricate modules which could then be installed quickly. In the relatively short period of only eight months, the systems shown in Table II were designed, prefabricated and installed under the supervision of HAM.

**Organisation**

To manage these conversion works and to make the necessary preparations for the offshore ballasting operations a project management team of six was assigned to the job. The team comprised a Project Director, a Works Manager, a Project Engineer and a Technical Engineer all based in The Netherlands during the project preparation. A Technical Engineer and a Project Controller were based in Canada.

The physical separation of the team clearly formed one of the management challenges of this project, in which communication proved to be very important. This structure, however, was chosen deliberately to make use of relevant experience, to address financial issues efficiently, and to save time.

The writing of the project plan and the design of the hydraulic discharge system were mainly done in the Netherlands as most of the knowledge and experience was available there. The fabrication of the two new boosters (which formed an important part of the prefabricated discharge system) was also supervised from the head office in The Netherlands as existing contacts with reliable suppliers could guarantee timely delivery of high quality products.

After assembling the prefab modules, they were tested at the HAM shipyard in The Netherlands. Upon approval, the components were shipped in a chartered vessel to Canada for installation aboard the self-unloading carriers.

The conveyor sections and feeding mechanism that link the CSL carrier dry discharging systems to the pump set were simultaneously designed and prefabricated in Canada, and preparations were made for final module installation on board the CSL vessels.

**Quality and safety**

During a short operation period there is little time for learning, whilst working offshore adds to the risk of the operations. For these reasons quality and safety were important issues, and communication and education played a key role in the project’s preparation, both to minimise the total operational time and to reduce the number of unsafe acts.

The following courses were developed to train the crew involved:
- Offshore safety training for all personnel;
- Process training to minimise start-up delays and blockage of the discharge system for operators;
- Nautical training for mooring and hook-up exercise to decrease delays and unsafe working conditions for the nautical staffs of HAM, CSL, Groupe Ocean and ATL.

The offshore safety course was held to teach basic offshore survival skills to all personnel involved in the ballasting operations. The course compulsory for the platform-based team was an extensive full-week course organised by HMDC. It included firefighting, helicopter escape and a real offshore exercise. The process training was conducted at HAM’s head office in the Netherlands. Here, all operators were trained with the help of a computer system controlling and simulating the different stages and difficulties of the hydraulic discharge process. The systems used were the actual automation installations used during the operations.

The nautical training was conducted in the virtual ship simulator of the Maritime Institute in St. Johns, Newfoundland. The crew of the CLS vessels, supplier and tugboats simulated mooring the carriers under all imaginable circumstances to the GBS.

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**Table II. Systems to enable offshore mooring and hydraulic discharge by self-unloading bulk carriers.**

<table>
<thead>
<tr>
<th>System</th>
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<tbody>
<tr>
<td>Mooring system</td>
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<tr>
<td>Stern mooring hook with quick release</td>
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<tr>
<td>Aft mooring hook</td>
</tr>
<tr>
<td>Floating hose coupling system</td>
</tr>
<tr>
<td>Bow connection</td>
</tr>
<tr>
<td>Bow connection winch</td>
</tr>
<tr>
<td>Discharge system: dry to hydraulic transport</td>
</tr>
<tr>
<td>Conveyor belt system (on deck)</td>
</tr>
<tr>
<td>Slurryfication system (tank and water supply pumps)</td>
</tr>
<tr>
<td>Dredge pump system</td>
</tr>
<tr>
<td>Additional power supply for pumps and winches</td>
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<tr>
<td>Floating hoses</td>
</tr>
</tbody>
</table>
These training sessions facilitated communication before and during the operations.

The project plan and contingency plan functioned as a means of communication as well as to prepare all crew members for their tasks. As part of this plan, a study was made of the movements of the vessel when moored and the forces that would develop in the hawser. Based on that study, the design for the mooring hook was altered and the working method modified in order to increase the safety of the offshore operation. A custom-made Process Automation System was developed to control the critical hydraulic discharging process.

II. Ballast Operation, May-August 1997

Working method and cycle
It took one day to load a bulk carrier with ballast material, supplied by HMDC, in the dry loading facility at Flintcote Wharf. The carrier would then sail approximately 540 nautical miles in two days to the Hibernia field where the vessel was moored to the platform aided by a supplier and two tugs. After the floating pipeline had been coupled to the discharge unit on the platform and to the carrier the load of ballast material was hydraulically discharged into the cells of the GBS base. For the mooring, coupling and discharging operations an estimated two days was allowed. Having off-loaded the ballast material, the vessel was disconnected and sailed back to the loading facility. Each of the three bulk carriers would repeat this seven-day cycle three times in order to deliver the total required 411,000 tonnes of iron ore magnetite.

Mooring and coupling operations
The operations to moor and couple the carriers to the Hibernia platform were thought through in detail during the preparation phase where the knowledge and experience of the nautical staff of both contractor and subcontractor were combined to develop a safe mooring procedure. Well in advance of approaching the platform the CSL vessel would be informed by the platform team of the local weather circumstances. In close co-ordination with the platform team one of the six mooring positions covering 360° around the platform was chosen based on the prevalent wind and wave direction. Two assisting tugs of subcontractor ATL would then prepare the chosen mooring point by attaching a flexible (Deltaflex®) line to the 70 mm steel wire installed on the outer wall of the GBS just above water level. The CSL vessel would then approach the platform from the leeward side, in the meantime connecting to the stern to the supplier vessel used to control her position whilst moored and discharging. One of the assisting ATL tugs would then hand over a runner line to the carrier enabling the crew to haul in the Deltaflex® mooring hawser. After the hawser was attached to the bow of the carrier, the second assisting tug would move in to assist the coupling operation to both the bow-coupling on the carrier and to the MDU on the GBS base. Depending on the vessel’s position with respect to the prescribed discharge location of the MDU, a longer or shorter floating hose was utilised. When repositioning the MDU, the floating hose would be disconnected and reconnected on the platform side only, weather permitting, unless the distance required the other hose to be used.

Wear and Tear
Though many contingencies were considered during the preparation phase, both HAM and HMDC encountered severe wear and tear, greatly in excess of what was expected. This resulted in a delay of operations owing to repair works and installation of three completely new dredge pumps and pipeline sections. As soon as the extensive wear had been discovered, all efforts were focussed on mobilising spare pumps and impellers from all over the world and on setting up mobile workshops for repair and replacement of system sections. The two complete floating pipelines were towed back to St Johns for inspection and some modifications were implemented in order to be able to finish the job with the existing pipelines. The excessive wear and tear continues to be a subject of further study.

Conclusions
The sheer size of ballasting such a large platform as the Hibernia required extensive tests and innovative methods and designs. Severe weather conditions off the coast of Newfoundland, Canada as well as the extremely long sailing distance from the harbour to the offshore site added special problems, and detailed safety training were part of the programmes put in place for the crews. In addition, owing to unexpected wear and tear, offshore operations took double the estimated duration. Studies concerning wear and tear continue. Even so, with careful management and clear communication, the deadline for the ballasting works of the Hibernia platform was met and HMDC hit oil even ahead of schedule, at the end of November of 1997.

References
HMDC Contract #4352.
Solid ballast operations, Project Plan and archive.
de Bruijn, Mrs VMPJ, KIVI presentation material.