Section 3.14: Single Point Mooring Provisions and Procedures

TERMPOL Surveys and Studies

ENBRIDGE NORTHERN GATEWAY PROJECT

FINAL - REV. 0

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1 Objectives

The objective of Termpol 3.14 is to determine the suitability of any proposed single point mooring (SPM) for the design ships intending to use it. Since the Northern Gateway terminal does not use any SPMs, preparation of a comprehensive study on this topic is not warranted. Nonetheless, it was recognized that some of the regulatory authorities may wish to consider SPMs as part of a comprehensive review of project alternatives. This document therefore provides some background on SPM technology and some of the rationale as to why the concept was not selected for the Northern Gateway project. The scope of this document is not intended to reflect the terms of reference provided in the Termpol Review Process Section 3.14 (TP743e, 2001).
2 Single Point Mooring Description

2.1 Introduction

Single Point Moorings (SPMs) are a type of offshore mooring where the vessel is not tied to a fixed pier, but rather swings freely around a buoy. Such moorings are generally used where a suitable land-based site is not available and/or where the seafloor is gently sloping and the cost to dredge and maintain a channel or build a long jetty from shore is prohibitively expensive.

The potential use of one or more SPMs for the Northern Gateway marine terminal was reviewed at an earlier stage of the project. It was concluded that SPMs were feasible, but not preferred for a variety of technical, practical and economic reasons. The preferred solution was to develop two fixed berths on the shore, as described in Termpol 3.10.

2.2 SPM Description

A Single Point Mooring terminal involves a cylindrical steel mooring buoy secured to the seabed with chains and anchors (or chain-wire combinations in deep water). A diagram of a typical SPM buoy installation is shown in Figure 2-1 below, while a photograph is shown in Figure 2-2. This particular type of buoy is also called a CALM (Catenary Anchor Leg Mooring) buoy, which refers to the curved catenary shape of the anchor legs. Compared to simple mooring buoys, SPMs are highly specialized pieces of equipment, generally designed and fabricated by a limited number of specialist suppliers.

Normally one to six anchor legs are used to secure a SPM depending on the specific geometry required, ship size, and environmental loads. Cast steel drag embedment anchors are most frequently used, however in areas where embedment anchors are not feasible, piled anchors may be required. A thorough geotechnical and geophysical investigation of the seabed is generally needed to determine the type of anchors required.

The buoy has a mooring hook which allows the vessel to secure its mooring lines. Fuel is offloaded by connecting the ship’s cargo manifold (connection point) to a floating hose. The hose in turn connects to the buoy, and then to a flexible pipe riser leading to the seabed. At the seabed, a device known as a Pipeline End Manifold or PLEM connects the flexible riser to a subsea pipeline which runs to the shore. Loading rates for larger SPM’s can be up to 100,000 bbls per hour, depending on the number and size of floating hoses, distance to shore, and the total hydraulic head to overcome.
Arriving vessels first secure their mooring lines to the buoy, and then connect the floating fuel hose(s) to the vessel’s cargo manifold. Once all the operational checks are complete (e.g., verifying that all connections and seals are in place) the cargo transfer begins.
During the fuel transfer operation, the vessel is free to “weathervane” or rotate around the buoy according to changes in the direction of the winds, waves, and currents. As the vessel moves about the buoy, it describes an arc known as the “mooring circle” or “watch circle”, which is centered about the buoy. The mooring line and fuel hose connection points are usually mounted on a rotating turntable, allowing them to move with the vessel. The buoy itself remains essentially stationary, held in place by the chains and anchors.

![Typical CALM Buoy Note Two Mooring Hawsers Leading to Bow of Vessel and Floating Fuel Hose (Source: SBM Offshore)](image)

**Figure 2-2** Typical CALM Buoy Note Two Mooring Hawsers Leading to Bow of Vessel and Floating Fuel Hose (Source: SBM Offshore)

### 2.3 SPM Location and Water Depth

The amount of space required to safely operate a single point mooring is quite large. A fixed jetty keeps the vessel in a fixed position whereas the SPM allows the vessel to weather vane around the buoy into prevailing metocean conditions (wind or current). For the Northern Gateway project, the largest vessel being considered is a VLCC-class tanker, with an overall length of up to approximately 345 metres.

The approximate watch circle radius for the design VLCC can therefore estimated as follows:

- Buoy Radius = 10 metres;
- Buoy Motion (rule of thumb about 10 percent of water depth) = 20 metres;
Hawser Length = 100 metres;

Hawser Stretch = 15 metres;

Tanker Length = 345 metres;

Additional Clearance = 20 metres; and,

TOTAL CIRCLE RADIUS: Approximately 510 meters (1020 metres diameter).

This is similar to the recommendations of Transport Canada in TP743e, where for planning purposes, a mooring circle with a diameter of 3 times the length of the largest vessel should be assumed. This results in a recommended watch circle of 1035 metres in diameter for the largest VLCC.

Transport Canada also recommends that the mooring circle should be placed such that the closest point on its circumference is no less than 300 metres from the requisite minimum depth contour. The minimum required water depth is based on the draft of the largest vessel, plus an allowance for under-keel clearance, wave action, etc. For this project, a minimum water depth of approximately 30 metres is required. Given the steepness of the shore contours, deep water is within 30-40m of the shore, so Transport Canada recommendations would put the edge of the watch circle approximately 340 metres from shore, with the center of the circle approximately 850 metres from shore as shown in Figure 2-3.

Referring to the nautical charts for Douglas channel, water depths in the vicinity of the buoy would be over 100 fathoms (more than 200 metres). This is very deep for an SPM - typical water depths are in the range of 30 to 40 meters for these types of vessels. Although SPM vendors say that this depth is within the operational limits, the technical challenges and costs of installing, inspecting and maintaining the subsea pipeline, end manifold (PLEM), anchors and subsea hoses would be significant.
Figure 2-3 Possible SPM Locations (Source – CHS Chart # 3743. Copyright Canadian Hydrographic Services – Not for Navigation)

2.4 Operational Issues

Cargo transfer to and/or from a SPM may be done using a combination of gravity, ships on-board pumps, and shore based pumps. For loading bitumen, the hydraulic head differential between the storage tanks on shore and buoy may be sufficient to allow loading by gravity, although this would need to be confirmed through hydraulic analysis. For condensate offloading, the vessels on-board pumps may require assistance from shore-based pumps to lift the cargo up to the elevation of the storage tanks. The time required for discharging the cargo is generally similar to that for a shore-based terminal, although it may take slightly longer depending on the length of pipeline between the buoy and the storage tanks.

At this time no hydraulic calculations have been performed to verify pump requirements and cargo transfer rates.
Compared to a fixed on-shore jetty, there is greater operational risk associated with SPMs since hose handling and mooring require transfers of lines and hoses using a launch boat and the ship’s crane. These operations can become hazardous and put personnel at risk during inclement weather, which is certainly to be expected during the winter months in Kitimat. SPMs also typically have more downtime for inspection and maintenance. Given the water depth in which these buoys would be installed, inspection and repair of the subsea components would take more time and effort than a typical installation, requiring specialist deep-sea divers and equipment. To avoid unexpected operational delays, the Northern Gateway terminal would likely need to make provision to mobilize such specialist crews and equipment on short notice, e.g., by providing such equipment at the terminal or contracting with a service provider to be available on-site within a certain number of hours.

Since there are currently no SPM systems in British Columbia, these systems would require additional training for pilots, tug operators, line handlers, and shore crews.

### 2.5 Standards and Specifications

The following preliminary design criteria were used for the feasibility assessment and for preparing initial order-of-magnitude cost estimates. Since SPMs are not the preferred cargo handling method for the Northern Gateway terminal, a complete list of relevant codes and standards has not been prepared.

**Location:** 850 metres offshore from the Northern Gateway terminal in about 200 meters of water;

**Standards:** OCIMF; API; ASME; etc as appropriate;

**Capacity:** VLCC up to 320,000 DWT;

**Fluids:** Bitumen and Condensate (assume no heating is required or any special metallurgy);

**Paths:** Assume 2 fluid paths, say 24” diameter, top quality double seals;

**Topsides:** Hydraulically actuated ball valves;

Power pack and recharging facilities (Wind and Solar);

Chain tension monitoring;

Navigational Aids;

**Hoses:** Subsea and floating hoses the double carcass type, 2 hose string;

**PLEM:** Hydraulically operated ball values for normal operation and diver operated valves for hose change out;

**Subsea Pipeline:** Approximately 850 meters to shore;

**Anchor leg:** Assume array of 6 chain anchor legs;

**Anchors:** Assume drilled and grouted pile anchor points for estimating purposes;

**Controls:** Radio linked to pilot and shore side; and,
2.6 Costs

The estimated cost for a single SPM in this location which meets the above specifications is on the order of $35 to $40 million. This is somewhat favourable compared to the cost of a fixed jetty structure, but does not provide the same level of operational flexibility, reliability, serviceability, or convenience. Therefore the two alternatives (fixed jetty vs. SPM) cannot be considered to be equivalent projects.
3 Conclusion

Installation of an SPM at the Kitimat site appears to be technically feasible and potentially less expensive than a single product fixed jetty. However, a SPM terminal has significant operational and risk disadvantages compared to the fixed jetty, and so a choice should not be made on the basis of least initial cost alone. Any potential cost savings would likely be small within the context of the overall Northern Gateway project. Given the importance of this facility to the operations of the Northern Gateway project, and the added operational and maintenance difficulties associated with a SPM, it was concluded that a land-based fixed terminal was the preferred solution for the marine terminal.
4 References

1. Fisheries and Oceans Canada, Canadian Hydrographic Services Chart #3743
2. SBM Offshore website, http://www.sbmoffshore.com