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Comparison of the Operational Performance of Different Cargo Offshore Loading Systems, in Particular the Bow Loading System (BLS), the Stern Discharge System (SDS), Submerged Turret Loading (STL) and the Conventional Midship Cargo Manifold (MCM) used on Flex Shuttle Tanker

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ABSTRACT: The purpose of this paper is to describe the characteristics of offshore loading/discharging systems used on Flex Shuttle Tankers (Flex ST) at open sea, in particular the Bow Loading System (BLS), the Stern Discharge System (SDS), Submerged Turret Loading (STL) and the conventional Midship Cargo Manifold (MCM) and to make comparison between them with reference to their operational efficiency, reliability, safety and weather condition operational limits. All types of tankers are always designed to load/unload cargo through a conventional midship cargo manifold (MCM). Most modern shuttle tankers are equipped with BLS used on terminals such as SAL, OLS, SPM, FPSO, FSO. Some specialized shuttle tankers are also adapted to conduct storage and transshipment operations at STL installations offshore. These ships are then equipped with submerged turret mooring and offshore loading system (STL) and sometimes also, but rather rarely with additional stern discharging system (SDS). Tankers equipped with all the above-mentioned systems (BLS, SDS, STL and MCM) are called Flex Shuttle Tanker (Flex ST) and they are used for transshipment of crude oil and gas offshore.

1 INTRODUCTION

Offshore, in gas and/or oil fields, there are many different types of terminals that are considered unique, such as Submerged Turret Loading (STL) [1, 2], Single Anchor Loading (SAL) [2, 4, 6, 11], Ugland Kongsberg Offshore Loading System (UK OLS) [2, 8], Single Buoy Mooring (SBM) or Multi Buoy Mooring (MBM) offshore terminals with floating or submersible cargo hoses [11], Hiload unit [10,13] or any other floating production and/or storage and offloading units (FPSO, FSO, FSU) used offshore to exploit subsea oil & gas resources. These units are currently serviced by a fleet of specialized shuttle tankers (ST) equipped with various offshore mooring, loading & discharging systems. The purpose and scope of this paper is to describe the characteristics of different loading/discharging systems in particular the Bow Loading System (BLS), the Stern Discharge System (SDS), Submerged Turret Loading (STL) and the conventional Midship Cargo Manifold (MCM) used on Shuttle Tankers (ST) at open sea and to make comparison between them with reference to their operational efficiency, reliability, safety and weather condition operational limits.

All types of tankers, including shuttle tankers (ST), are always designed to load/unload liquid cargo by using a conventional midship cargo manifold (MCM) [6, 11, 13].

Most modern shuttle tankers are DP class vessels (DP ST) and are also equipped with BLS used on terminals such as SAL, OLS, SPM, FPSO, FSO. Some specialized DP class 2 shuttle tankers are also adapted to conduct storage and transshipment operations at STL installations offshore [12]. These ships are then

equipped with submerged turret mooring and offshore loading system (STL) and sometimes also, but rather rarely with additional stern discharging system (SDS). Tankers equipped with all the above-mentioned systems (BLS, SDS, STL and MCM) are called Flex Shuttle Tanker (Flex ST) and they are used in the offshore sector for transshipment of crude oil and gas [1, 3, 4, 8, 13, 14, 15].

2 METHODOLOGY

All items described in this paper are based on the common requirements covered by the specified oil field offshore operation manuals (e.g. [3, 5, 9, 12, 16, 18]), installation makers operational manuals [6, 7, 17, 19, 20], ship's operator manuals [15] and the authors own experience and observation collected on shuttle tanker fleet in offshore industry since 1997 (e.g. [2, 10, 11, 13]).

3 TANKER RAIL HOSES ON MIDSHIP CARGO MANIFOLD (MCM)

During offshore cargo handling operations using conventional tankers and sometimes also shuttle tankers (ST), the midship cargo manifold (MCM) is used to handle liquid cargoes such as oil and gas using flexible and submersible tanker rail hoses that are lifted from the seabed (e.g. MBM Aracaju terminal, selected SPM and SAL offshore installations [1, 11]) or floating hoses lifted from the water level (e.g. SPM Sao Francisco do Sul terminal, SPM Tramandai in Brazil) or optionally cargo rail hoses transferred directly from Stern Discharg System (SDS) located on FPSO/FSO (e.g. FPSO Campos Basin P-31, FPSO P-38, FPSO P47 [6, 11, 13]).

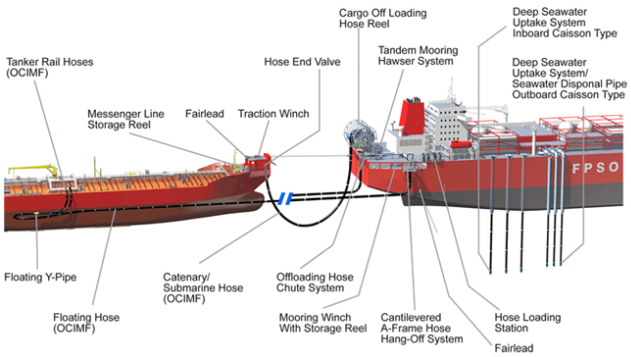

Figure 1. Schematic diagram of Floating Rail Hoses connecting Stern Discharg System (SDS) on FPSO with Midship Cargo Manifold (MCM) on Shuttle Tanker according to OCIMF guidelines. SDS on FPSO may include optionally Hose Reel system, Contilevered A-Frame Hose Hang-Off System or Offloading Hose Chute System. Source: Own researches based on [16, 21].

Schematic diagram of Floating Rail Hoses connecting Stern Discharg System (SDS) on FPSO with Midship Cargo Manifold (MCM) on Shuttle Tanker according to OCIMF guidelines [21] is shown in Figure 1. Tanker rail hose can be delivered to MCM on Shuttle tanker from FPSO/FSO Stern Discharge System (SDS) by using Hose Reel system, Contilevered A-Frame Hose Hang-Off System or Offloading Hose Chute System (See Fig.1) [16,21].

Tanker rail floating hose is being used in calm sea contitions (max. wave height 1 m, max. wind speed 30 kn (≈15 m/s). Calm sea in required to avoid hose vertical jumps during connection/ disconnection and hose handling crane overweight while keeping hose weight on crane hook. Offloading hose has at least 250 m in length and has tipically 16", 20" or 24". Offloading hose is taken alongside tanker midship hauled by standby vessel and picked-up by tanker hose handling crane and secured over tanker rail to the midship manifold. Experienced deck crew need to carried out hose securing, bending over tanker rail and connect offload hose to tanker manifold. Precautions needs to be taken to perform that safely and avoid hose snap forward or aft while hose secured to rail and bended for end flange disconnection and connection hose to the vessel cargo system.

Shuttle tanker/conventional tanker shall use tug fast center lead aft before final arrival to FPSO for mooring. Tug shall be connected aft and ready for use at least 2 Nm (≈3.7 km) from FPSO/FSO. Shuttle tanker shall take great caution do not take by thrust hose messenger into bow thruster while cargo hose is being hauled by stand-by vessel to ship manifold and do not take hose messenger into main propeller when hose messenger incidentally released by stand-by vessel. Start bringing cargo hose alongside can take place when vessel is safely moored and assisting tug used for hawser tension. Fairleads with hose suspending chain at ships manifold area shall be greased after hose connection to protect hose chains on fearlead holding vertically hose from parting.

When cargo loading is taken via midship manifold cargo max. loading rate depends on piping max. loading capacity through single tanker manifold usually not exceed 2500-3000 m3/h. During loading max. wind speed is 40 kn (≈21 m/s) and max. waves 2-2.5m. Connection and disconnection of cargo hose shall take place during daylight and with wave height not exceeding 1 m in height. When cargo hose is lowered to the water surface during hose disconnection, hose weight on hook is reduced by its boyancy and hose suspending chain is released from the crane hook by quick release to free hose handling crane from floating hose weighting during hose ballancing on waves while hose drifting off ships side. When loading is completed and sea state is not adequate for hose disconnection than its reasonable to wait for wave height reduction to 1 m. Connection and disconnection cargo hose is risky operation and risk mitigation must be taken to prevent incident/accident occurance. In case wave is too high, quick release of cargo hose can be tricky, expecially when quick release messenger could not release crane hook due to loads created by hose dancing on waves on crane hook via suspension chain.

4 BOW LOADING SYSTEM (BLS)

Most DP shuttle tankers (DP ST) are equipped with a Bow Loading System (BLS) which has two parts. One on top platform is designed for vessel mooring to offshore terminals such as SAL, OLS, SPM, FPSO/FSO, and second part inside BLS for connection offloading hose to BLS cargo manifold using the hose handling winch to pick-up a cargo hose end flange to BLS manifold shown at Fig. 2.

When shuttle tanker is loading from FSO/FPSO, operation is called tandem operation. In the North Sea the distance between the loading point-base (stern of the FPSO) and the shuttle tanker bow is typically between 70 m and 100 m, while in Brazil distance is typically between 145 m to150 m. Some FPSOs have active heading control using thrusters while others are passive, meaning that they are weather-vaning on the turret. In case wind and current direction changing rapidly than heading of FPSO is changing rapidly to creating challenge for shuttle tanker to follow FPSO heading. For instance, FSU Alba in British Sector was usually liable to sudden heading changes due to environmental forces changes.

In Brazil weather vaning FPSO are seldom in use. Prevailing FPSO ' s are Spread-Moored FPSO ' s, which have fix heading e.g. 210° moored by anchor chains to sea bottom. Approaching to FPSO starts from 10 Nm zone (≈18.5 km from FPSO) and shuttle tanker shall follow oil field operational procedures with regards to offtake tanker speed limits and weather limitations for approach and loading [13,15]. BLS tests/checklists shall be carried out by shuttle tanker personel before arrival 10 Nm zone, and shuttle tanker shall not have any defects in regards to propulsion, thrusters, DP system, BLS system and cooling systems [2]. Average time from arrival 10 Nm zone to commence loading take arround 5-6 hrs, while time period of competion loading, disconnection and passing 10 Nm zone takes around 3,5-4 hrs.

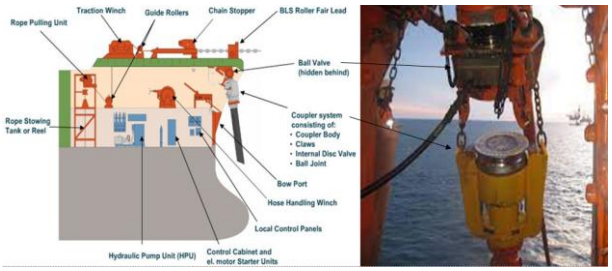

Figure 2. Shuttle tanker Bow Loading System overview. Source: Own research based on [4, 7, 20].

Shuttle tanker speed limits when approaching an offshore installation (e.g. FPSO, FSO, SPM, OLS, SAL) within 10 Nm (≈18.5 km) zone from the loading position for DP ST are presented in table 1.

Table 1. Shuttle tanker DP ST speed limits during approaching to installation offshore

Operational Zones	Speed limits
Outside 10 Nm (distance ⩾18.5 km)	Safe cruising speed full ahead
10 Nm to 3 Nm (18.5 km to 5.5 km)	Slowly reduce speed to max 5.0 knots (≈2.6 m/s) at 3 Nm zone
3000 m to 900 m	Max. 3.0 knots (≈1.5 m/s)
900 m to 500 m	Max. 1.2 knots (≈0.6 m/s)
500 m to 150 m	Max. 0.6 knots (≈0.3 m/s)
150 m to loading position	Max. 0.4 knots (≈0.2 m/s)

Source: Teekay reqirements for Offshore Loading Operations (Shuttle Tankers). Doc No SP0978, [15].

DP Shuttle tankers use BLS to receive crude oil from FPSO via FPSO stern discharge system (SDS) to shuttle tanker BLS manifold through FPSO hose end valve. Hose end valve is opened by BLS coulper valve while vessel being safely moored to FPSO and having cargo hose connected to BLS manifold. Loading though tanker midship manifold Rail Hoses are taking place when FPSO using Hose Hang-Off System or Hose Chute System.

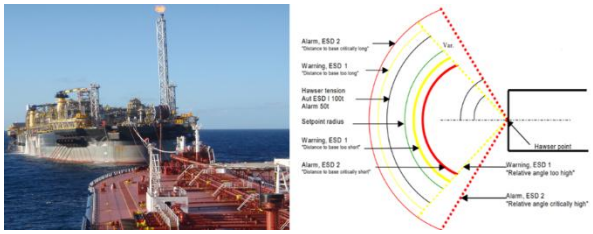

Figure 3. Shuttle tanker during bow loading via BLS on FPSO P-57 and DP ST operational limit. Source: Own research based on [7, 13,15].

Loading take place around 15-18 hrs for 100000 DWT tanker, and around 24-30 hrs for 150000 DWT tanker. Time of loading depends on FPSO cargo pumps capacity, but in real time rates 6000-6500 m3/h are possible. Shuttle tanker shall have balast pumps fully operational to manage discharge ballast during such fast-loading rates. When weather is touching operational limits shuttle tanker master shall terminate loading operation and disconnect from FPSO. Shuttle Tankers are equipped with telemetry system integrated with DP system which monitor bow-base distance safety limits and heading difference between shutte tanker and FPSO/FSO and also Hawser Tension. See Fig. 3 for reference.

In case shuttle tanker touch 'yellow limits' ESD1-emergency shut down class 1 – stops pumps on FPSO/FSO and closes manifold valves while ESD2 'red limits' – additionally activates fire fighting water deluge over the BLS area and after water deluge activation release cargo hose and finally FPSO/FSO chafing chain from top platform to the water. Before loading commencement cargo hose and mooring chaffing chain shall be ready for emergency release, when activated by telemetry or manually from BLS accumulators in case of drive-off from DP positioning or shuttle tanker blackout [13,15]. Steering cabinet for BLS manifold at righthand side. Ones loading hose is connected to BLS manifold hold by coulpler claws, hose messenger shall be released and manifold set to free wheel. BLS is slightly ballansing with hose weight gravity. Cargo Hose messenger must be disconnected from cargo hose and cargo hose bridles taken out of bow loading structure. Chafing chain messenger line on top platform shall be diconnected and shackle shall be removed from the end of chafing chane. Thus, system is ready for emergency release into the sea. Shuttle Tanker must perform DP Failure Mode and Effect Analysis (FMEA) to have proven that all BLS and DP features are working properly. Shuttle tanker stay on DP during FPSO approach, mooring, cargo hose connection, loading. Shuttle tanker weather vaning behind FPSO during loading using thrusters and propellers.

Weather operational limits for tandem operations with DP: for mooring, wave heights 4,5 m; wave period max. 15 s, wind speed 40 kn (≈21 m/s), for loading: wave heights 5,5 m, wave period max.15 s, wind speed 50 kn (≈ 26 m/s). Weather operational limits for tandem operations in Taut Hawser (Non-DP): for mooring, wave heights 3,5 m; wave period max. 15 s, wind speed 40 kn (≈21 m/s), for loading: wave heights 4,5 m, wave period max.15 s, wind speed 50 kn (≈26 m/s).

5 STERN DISCHARGE SYSTEM (SDS)

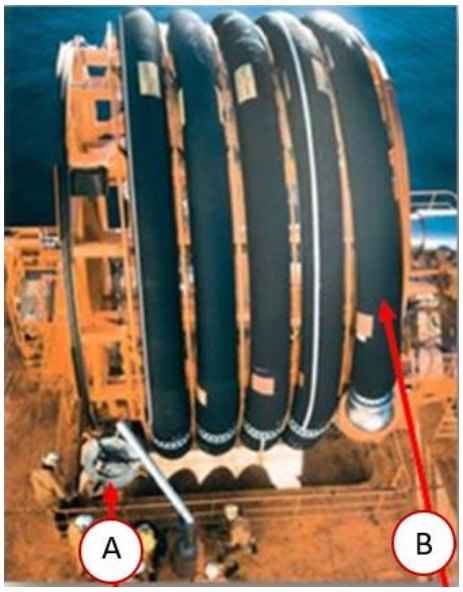

Figure 4. SDS Offloading Hose stored on a Reel. A - Hose end piece with flushing unit. B - Submerged hose.
Source: Photos from the authors' private collections.

Stern Discharge System (SDS) located on FPSO/FSO can include Hose Reel system, Contilevered A-Frame Hose Hang-Off System or Offloading Hose Chute System (See Fig.1, 4 & 5) [16,21].

Many of the modern FPSO's /FSO have Offloading Reel Type SDS system. The hose assembly on the SDS is stored on a dedicated hose reel, enabling rapid and safe deployment. The system also incorporates a vertical drum mooring and hawser handling winch specifically designed for tandem mooring with shuttle tanker. The mooring operation is significantly simplified, with the winch storing chain and rope on the same drum. To avoid wear on the soft mooring hawser, both chafing chains are stored in a special recess at the bottom flange. The vertical drum construction also prevents chain fall-off, a common problem for horizontal drum winches. The SDS contains a ball joint for "moment-free" termination of the loading hose, thus protecting it from excessive strain

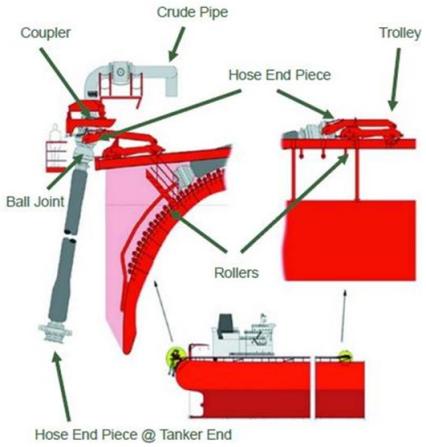

Figure 5. SDS Offloading Chute type.
Source: Based on [4, 6, 11].

SDS Offloading Reel type (See Fig. 4) is most frequently used on FPSO's / FSO's, expecially on new buidings. Cargo hose is paid out from slowly turning hose storage drum while shuttle tanker is heaving cargo hose messenger line with messenger bridles connected to cargo hose end swivel. Its reasonable to keep messenger line tensioned to avoid bridles twisting before final picking -up cargo hose and connection. Offloading hose can be either submerged or floating type. Length and diameter are project specific. Hose end-piece is usually equipped with flashing unit (See Fig. 4A). Submerged hoses used in the North Sea and Canada are typically 120 m of 16" or 20" and are stored in one layer on the reel. Offloading house during cargo operation offshore is connected to Bow Loading system installed on DP shuttle tanker (DP ST). Typical seperation distance between DP ST and FPSO/FSO is 80 m. Floating hoses are typically used in area with 'nice' sea conditions (e.g. Campos Basin Offshore Brazil). Hose length is typically more then 250 m of 20". Floating hoses are stored in two layers on the reel and can be connected also to midship manifold on conventional tanker (See Fig.1).

SDS Offloading chute type (See Fig. 5) is met on older types of FPSO/FSO for instance in Campos Basin in Brasil (Petrobras-43 and Petrobras-48). Chute type SDS require proper maintenance. Horizontaly stowed cargo hose need to be paid out by FPSO hydraulic rollers. Can be the case when shuttle tanker Master is being asked to pull out cargo house using some tension to pull hose out by hose handling winch or combined traction winch used for mooring and later for cargo hose heaving.

SDS Offloading hose is usually submerged type and is stored on a chute. Length and diameter are project specific. Submerged hoses used in North Sea are typically 120 m length and 20" diameter, in Brazil 250 m of 20". Typical separation distance between vessels is 80 m to 150 m. SDS offloading hose can be connected to BLS on DP ST or conventional tanker MCM. The chute is equipped with rollers to enable pull-in and pay-out of the offloading hose. For enabling connection of the offloading hose to the coupler, a trolley with a lifting mechanism is used. The trolley also ensures that the hose end piece is free from the rollers.

SDS of Reel Type and SDS of Chute Type are used to be connected to shuttle tanker BLS system. Thus, the same procedures against weather limitations are used for shuttle tanker loading via BLS described in previous chapter. On Spread-Moored FPSO sometimes 2 offloading stations are available Depending on direction of environmental forces shuttle tanker master decide which station he is going for use. For shuttle tanker approach heading 210° (e.g. to the stern of FPSO P50) or approach heading 030° (to the bow of FPSO P50). We can add one to two extra hours in comparision to the North Sea FPSO's mooring operations due too longer mooring system and cargo hose system in Brasil FPSO's infrastucture. During loading telemetry system is being used. In case of cargo green line failure cargo pumps are tripped on FPSO by telemetry system. After cargo hose connection to BLS, Shut Down Class I shall be tested against SDS before loading commencement take place.

6 SUBMERGED TURRET LOADING (STL)

Submerged turret loading (STL) is underwater instalation designated for DP class 2 Shuttle Tanker equipped with STL manifold at forward bottom part of tanker. The STL buoy known as STL system incorporates a turret spread-moored to the sea floor and to the riser (see Fig.6). The buoy floats in neutral position about 30 m to 50 m below water surface. The buoy is pulled into the keel pool for STL system on shuttle tanker. The turret is free to rotate inside the buoy, thus it allows shuttle tanker to bias against weather within STL base point while STL buoy is connected to shuttle tanker STL manifold. All STLs are based on standardized mating cone geometry in the vessel keel.

DP ST arrives oil field and pick-up STL buoy by STL pool messenger line connected with STL buoy messenger line and finally enable to connect STL buoy to STL manifold, perform loading operation and disconnecting STL buoy when loading is completed. STL system with a submerged STL buoy that connects through a cone-shaped mating cone in the keel of the shuttle tanker or FSO tanker. STL is also currently used on LNG STL tankers. STL is best suited for loading in areas of high sea states.

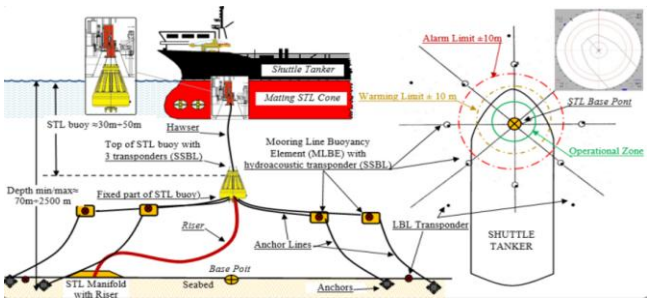

Figure 6. Shuttle tanker SDS overview. Source: Own research based on [2, 7, 13].

As an example of loading with extreme weather conditions experienced at Aasgard C FSO Storage Tanker. Åsgard is located at Haltenbanken in the Norwegian Sea, about 200 kilometres from the Trøndelag coast and 50 kilometres south of the Heidrun field. Water depth in the area is 240-310 metres [5, 12, 15]. STL require technology, experience and reliable equipment.

Field specific limits are programmed into the DP software (buoy selection). Specific limits and configuration differ from one type of loading installation to another. For Kongsberg supplied DP systems the following alarm wording is used: 'yellow limits' (Distance to base too long. ESD I shall be activated if this limit is exceeded); 'red limits' (Distance to base critically long. ESD II shall be activated if this limit is exceeded). Teekay reqirements [15] for Offshore Loading Operations (Shuttle Tankers- Doc No SP0978) are as follow: For STL connection max. significant wave height 4,5 m; max. wave period 15 s. For STL loading: max. significant wave height 10 m. Telemetry shut down loading, when shuttle tanker touches yellow limits. However, it must be noted that ESD II was not applicable for shuttle tanker STL loading at Heidrun oil field.

On STL buoy only DP class 2 shuttle tankers are used for operation. The following DP modes are being used [5, 12, 15]: DP Approach Mode (from 1500 m to 5 m off STL terminal base point), DP Connect Mode and Go to Base/Buoy (during connection/disconnection STL buoy to/from ST) are used.

On DP2 minimum two position reference systems (PRS) are required to be in use by the DP system on the shuttle tanker and usually there are as follow: one Hydroacoustic Position Reference system (HPR) and one (absolute) Differential Global Navigational Satellite System (DGNSS/DGPS). When DP is prepared the following apply: Between 3000 m and 1200 m from the STL base, the pickup line on the ST shall be lowered trough the mating cone with a sandbag and a floating element. The ST shall stop and thrust sideways by 0.5 knots (≈0.3 m/s). The sandbag will be hydrostatically released, and the floating element rise to the surface. It shall be picked up by the crew and made fast on the port side, forward. The vessel shall continue its approach. On 300 meters zone DPO shall select Heidrun1 or Heidrun 2 on HPR, interrogate LBL transponders on seabed. When stable HPR, position drop-out, select HPR as reference origin, select DGPS as PRS 2. Select Approach mode and continue towards shooting position, speed 0.4 knots (≈0.2 m/s). When passing 200 meters zone DPO shall stop vessel in shooting position. Pick up the messenger line. Continue towards STL base while picking up slack on the messenger line. At 50 meters zone DPO shall activate STL buoy transponders by selecting auto scan. The system will select the best transponder automatically. The depth of the STL buoy on Heidrun oil field was 40 to 45 meters. Shuttle tanker speed limit was set up to ≈ 0.15 m/s. At 5 meters zone to STL buoy DPO proceeded towards STL centre if sway and heading was stable. If not, he shall wait in 'DP Approach Mode' until stable and then select 'DP Connect Mode'. DPO shall select 'DP Go to Base' mode and pull STL buoy. Then buoy is locked, it's displayed on the DP 'STL Buoy in Position'.

When the vessel is in 'Base/Buoy position' than it's ready to hoist the buoy into the mating cone and when STL buoy is in locked position, a signal is sent to the DP. The DPO should then select 'DP Loading Mode'. In good weather conditions it is most common to stay in 'Loading Mode' with no thruster active and only DGPS as reference system. When loading is completed, the vessel shall disconnect from the STL more or less opposite way of how the vessel connects to the buoy. The DPO shall select 'Connect' and 'Go to Base'. The STL shall be disconnected and lowered to its normal depth. The DP shall be set to the 'Approach mode', and the vessel shall move astern while slacking away on the messenger line until the marker buoy is in the water. According to field operator [12, 5] and APL manufacturer for most of the STL systems [4, 7], connection can be done in sea states between 5 m to 7 m of significant wave height. Loading is weather independent, and further disconnection can be undertaken in any sea state.

7 COMPARISON SUMMARY

A summary comparision between Midship Cargo Manifold (MCM) used for tanker rail hose loading, bow loading system (BLS), stern discharge system (SDS) and submerged turret loading (STL), considering

operational limits, time needed for approach, mooring, hose connection, loading, hose disconnection and unmooring had been taken into consideration. With regards to weather conditions limits STL is the most realible and sophisticated offshore loading system, BLS and SDS system are interlocking with each other and are commongly used by DP Shuttle Tankers allowing smooth approach, connection, loading and disconnection when weather window opens. Tanker Rail Hose manifold loading is uniwersal loading system for all types of crude oil tankers but mooring chafing chain via Panama Fairlead and manifold hose connection require crew experience, proper planning and carefull tracking of weather forecast. A summary comparison between BLS, SDS, STL and Tanker Rail Hose loading were presented in table 2.

Table 2. A summary comparison between BLS, SDS, STL & MCM hose rail loding.

Bow Loading System (BLS)	SDS Stern Discharge System	Submerged Turret Loading (STL)	Midship Cargo Manifold (MCM) hose rail loding
1. Approach to FPSO or FSO or FSU// N.A //STL buoy//FPSO or FSO or FSU			
DP Approach mode (DP ST) or manual approach (Taut Hauser)	Waiting for ST or conventional tanker	DP Approach mode on (DP2 ST)	Manual approach with tugboat fast aft
2.Time for approach			
10 Nm till mooring psn at 150 m Off FPSO in Brazil and 80 m Off FPSO in the North Sea: 4 h		1.5-2 hrs on DP2 ST	10 Nm till mooring line pick-up abt 400 m off FPSO/ FSO: 2-2.5 hrs
3. Tug connection with tugline paying out around 600 m of towline for tow connection: 30 min			
N/A			ST:1000 m from FPSO; Conv.tanker: 2 Nm from FPSO
4. Type of mooring			
chain stopper on BLS with chaffing chain and hawser	STP-submerged turret production anchored to seabed or Spread-Moored FPSO in Brasil	STL buoy anchored to seabed	Chain stoper on ST or chafing chain via panama fairlead on conventional tanker
5. Time for mooring			
From time of shooting psn till chain stoper closed: 30 min to 1 hour	From start of mooring Messenger paying out till chafing chain paid out from mooring drum: 30 min to 1 hour	30 min to 1-hour Vsl at STL base picking up STL buoy to ST hull mating cone	Mooring tug bringing mooring messenger: 380 m from FPSO till chafing chain received via panama fairlead – 2.5 hrs
6. Time for cargo hose connection			
Heaving and picking up cargo hose – 30 min in the North Sea, 1-1.5 hrs in Brazil	Cargo Hose pay out from Cargo Hose Rai or from horizontal chute system 1-2 hrs in Brazil; 30 min in North Sea	STL buoy turret manifold connection to vls manifold by actuators: 15 min	Hose brought by stand-by tug alongside midship manifold: 1-1.5 hrs (wave max. 1 m); Daylight
7. Time for loading			
15-18 hrs - 100000 DWT 24-30 hrs - 150000 DWT	24 hrs-100000-130000 DWT	48 h-60 h	
8. Time for hose disconnection			
15 min in the North Sea, 30 min in Brazil		10 min, can be performed in any weather condition	40 min- 1 hrs, daylight
9. Time for unmooring/mooring disconnection			
15-20 min			1-1.5 hrs
10. Weather limits – for mooring and hose connection			
On DP: wave heights 4,5 m; wave period max. 15 s, wind speed 40 kn, On Taut Hawser mooring: wave heights 3,5 m; wave period max. 15 s, wind speed 40 kn	Same as for offtake tanker via BLS beside	Teekay SP0978 doc max. sign. wave height: 4,5m; max. wave per.:15 s, as per APLsign. wave height: 5-7m	max. wave height 1 m, max. wind speed 30 kn,
11. Weather limits – for loading			
On DP: wave heights 5,5 m, wave period max.15 s, wind speed 50 kn, On Taut Hawser: for loading: wave heights 4,5 m, wave period max.15 s, wind speed 50 kn	Same as for offtake tanker via BLS beside Same as for offtake tanker via BLS beside	Teekay SP0978: max. sign. wave height: 10 m; APL-weather independent offshore loading	max. wind speed 40 kn and max. waves 2-2.5m
12. Weather limits for hose disconnection and unmooring			
On DP: wave heights 4,5 m; wave period max. 15 s, wind speed 40 kn, On Taut Hawser mooring: wave heights 3,5 m; wave period max. 15 s, wind speed 40 kn	Same as for offtake tanker via BLS besides, Same as for offtake tanker via BLS beside	Teekay SP0978: disconnection with DP Mode: Hs=10m; APL maker: in any weather conditions	Daylight, wave height not exceeding 1 m, max. wind speed 30 kts

Source: Authors Own researches.

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