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Shuttle Tanker and Offloading Operations at FPSO/FSU's

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Shuttle Tanker and Offloading Operations at FPSO/FSU's

A report produced by the Health and Safety Executive (Offshore Safety Division)

February 1998

Contents

1 Introduction

During 1997, the Offshore Safety Division (OSD) of the UK Health and Safety Executive (HSE) initiated a study into the marine risks associated with the operation of shuttle tankers at offshore export facilities and in the vicinity of offshore installations. The study was aimed at obtaining substantive information on the nature and scope of the marine risks and the conclusions in report form (Ref. 1 - 'Close Proximity Study') were made widely available to the Offshore Industry through UKOOA or IMCA.

The specific objective of the 'Close Proximity Study' was to assess the risks of collision during close proximity operations involving shuttle tankers at offshore locations. The secondary objective was to identify suitable standards of control and mitigation so that the risks of collision are reduced to as low as reasonably practicable (ALARP).

The concerns arising out of the 'Close Proximity Study' combined with a number of contact incidents occurring during 1997 involving shuttle tankers and FPSO/FSU's during offloading operations prompted the OSD to draw their concerns to the attention of the Offshore Operators of FPSO/FSU's and particularly the UKOOA FPSO Workgroup.

In addition, the OSD commenced collating information concerning the Offloading systems installed on the FPSO/FSU's including the nominal separation distance between the shuttle bow and the FPSO/FSU stern during the offloading operation. These data are reproduced in Appendix A - 'Offloading Systems: Mooring Hawser/Hose/Separation Data'.

Prompted by the good reaction from a UKOOA FPSO Workgroup meeting on the 25 November 1997 attended by the OSD, the formation of a specific OSD Workgroup was expedited. The Work Group was composed of personnel who were in the best position to contribute to the OSD collation of the concerns covering the whole spectrum of Shuttle Tanker and Offloading operations.

Subsequent internal discussions indicated that a simple categorisation of the concerns would have only 'Hardware' and 'People' concerns listed - which is the presentation format adopted within this report.

The information and advice contained in this report was aimed at assisting the UKOOA FPSO Work Group in assessing the risks associated with activities connected with shuttle tanker and offloading operations at FPSO/FSU's.
How the OSD concerns can best be taken forward for resolution by the UKOOA FPSO Workgroup is not addressed in this report. However, it is suggested that the methodology could follow a similar approach as described in the UKOOA document (Ref. 2 - 'Guidelines for Fire and Explosion Hazard Management'). These Guidelines outline a particular structured approach to the integrated management of risks and the development of performance standards for safety critical elements.

2 Objectives

The objectives of this Report can best be separated into two parts and summarised, as follows:-

1) To review and collate the HSE concerns regarding Shuttle Tanker and Offloading Operations within the categories of 'Hardware' and 'People' concerns, and

2) To relay the reported concerns to the UKOOA FPSO Work Group for their review and resolution.

3 Concerns

3.1 HARDWARE CONCERNS

3.1.1 Equipment Performance Standards

In an FPSO/FSU - offtake tanker export system, there will always be at least one 'physical' connection between the FPSO/FSU and the shuttle tanker - the export hose, carrying the hydrocarbons to the tanker. In some cases there may also be a 'return' path, conveying bunkers from the shuttle tanker to the FPSO/FSU.

There are various safety considerations which apply to the export hose, for example the:

- Maximum and minimum length of hose catenary, which therefore define the maximum and minimum separation distances between FPSO/FSU (stern), and tanker (bow);
- Limiting values on tension loads in hose, and actions of weak link/breakaway section, (and valves therein), of hose;
- Limiting values on export hose operating pressures, (and of less concern), temperatures;
- Method of hose deployment, and connection/disconnection to/from the tanker in normal, conditions, e.g. whether hoses are 'hung' off a crane boom, or stored on 'active' hose reels or chutes;
- Method of 'pulling in' the hose, and connection to the tanker inlet manifold;
- Manner in which the hose is disconnected from the tanker in emergency situations.

In addition to the export hose connection, there may well be other 'physical' connections, e.g. mooring hawsers and messenger lines etc. Some of the safety considerations concerning hoses will also apply to these other physical connections, e.g. maximum allowable tensions in mooring hawsers; normal/emergency connect and disconnect actions for hawsers and chains; environmental limits for chain or hawser connection/disconnection; consequences of dynamic positioning (DP) failure upon hoses, chains etc.

The selection, design, operation and management of all physical connections between FPSO/FSU and offtake tankers requires careful consideration in order to ensure that risks from such connections are ALARP. The various safety/risk analysis methodologies may be employed in the various processes of the design and operation cycle, (e.g. comparison of Hazard Identification (HAZID's) for differing proposed offload system options), Failure Mode, Effects and Criticality Analysis (FMECA) for

ESD systems, (e.g. effect of telemetry link failure, or hydraulic pressure loss etc.); Hazard and Operability (HAZOP) studies, (e.g. 'too much flow, too high a pressure' etc.) for hose design parameters, (e.g. 'too high a tension in mooring hawser' etc.).

The direct 'physical' connections between FPSO/FSU, and offtake tanker, are the most immediately obvious interfaces between the vessels, but there are additionally other interfaces which also require consideration from a safety viewpoint.

There will usually be a radio based telemetry system between the two vessels, which will pass across ESD signals, process variables, hawser tension loads etc. The safe and reliable operation of such a system is normally a pre-requisite for any offload operation.

In addition to the telemetry system, DP position reference systems may also be interfaced between the two vessels, as well as 'normal' inter-installation communications systems, e.g. VHF radios etc. Proper operation of the DP system is entirely dependent on input from the position referring source and erroneous position data may lead to fluctuations in the unit/shuttle tanker separation distance, or in extreme cases, to "drive off" with potential catastrophic consequences. Further, any spurious loss of telemetry signal for a certain length of time for example, may initiate an ESD sequence, which may shut down export pumps on the FPSO/FSU, shut valves on both the vessels, and release export hoses, and mooring hawsers etc.

As a final safety measure consideration should be given to the provision of a close proximity alarm, being separate and distinct from the position referencing systems; supplemented as appropriate, by a bow watch on the shuttle tanker.

All these 'physical' and 'latent' interfaces need to be evaluated via suitable qualitative and/or quantitative risk analysis; there must also be suitable management controls and operating procedures, to deliver an ALARP solution for the offtake system concept, and its constituent sub-systems.

Summary:
At present there are no minimum Equipment Performance Standards for shuttle tanker offloading systems. These should be developed based on suitable qualitative risk assessments of the various system components to ensure a minimum standard of equipment is available and to increase confidence in the systems as a whole.

3.1.2 Equipment Redundancy

The level of equipment redundancy on shuttle tankers is of concern to OSD, both with regard to DP and non-DP shuttle tankers. To establish an appropriate level of redundancy on a vessel requires a FMECA, or similar study to ascertain the effect of vessel controllability when individual items, or systems of equipment fail to operate as required, (such studies should include DP position referencing systems, as well as propulsion, power generation, and their auxiliary systems). For example, failure of a pneumatic air supply to a controllable pitch propeller can result in full ahead pitch regardless of the DP or manual control input. Similarly hydraulic actuators if stuck can have a similar effect. If such hazards can not be removed, there may be sufficient reason to consider shuttle tankers having redundancy in their propulsion arrangements.

Some years ago an annual trials procedure was developed via the DP Vessel Owners Association (DPVOA) and UKOOA, to test DP vessels and validate the results of their FMECA's. This procedure effectively reduced the overall amount of testing whilst it ensured vessels were audited on a like for like basis. The DPVOA/UKOOA procedure has been useful in testing diver support vessels (DSV's), and other more common types of DP vessel, but it is not clear that these annual trials procedures have been extended to cover DP shuttle tankers. An integral part of an FMECA study is to verify the results via a trials procedure, and ensure any hardware or software modifications undertaken throughout the lifetime of the vessel are adequately tested. Included in such tests should be a blackout trial, to ensure that in the event of a blackout (which is a very real possibility) both crew and procedures are in place to re-apply power in the shortest time possible.

In 1994 the International Maritime Organisation (IMO) produced the DP Equipment Guidelines (IMO MSC Circ. 645(1994)) 'Guidelines for Vessels with Dynamic Positioning Systems'. This document outlines three levels of redundancy for DP vessels, section 2.1 states:

'*... The equipment class of vessel required for a particular operation should be agreed between the owner of the vessel and the customer, based on a risk analysis of the consequence of a loss of position.*'

To fulfil this advice the shuttle tanker operators need to assess the consequences of loss of position, including collision and possible escalation events such as fire, explosion, effect on stability etc. for every loading scenario and ensure a level of DP equipment commensurate with the risks involved. For example, the number and type of position references installed should be adequate for the shuttle tanker and offloading operation. A minimum of two independent position references will be necessary for most operations, but three may enable greater utilisation of the shuttle tanker. Correct installation and optimum locations for 'line of sight' and satellite antennae should reduce downtime and minimise erroneous data through reflections etc.

The IMO guidelines have been adopted by the majority of conventional DP vessels operating on the UKCS as a means of demonstrating the ALARP principle. Furthermore, industry developed guidance (IMCA: Guidelines for the Design and Operation of Dynamically Positioned Vessels) follows these principles. This guidance requires the total offloading arrangement to be considered including such factors as separation distance, weather limits, flare location, GOR, etc.

Summary:
Duty Holders need to establish an appropriate level of equipment redundancy. For example, the FMECA method, which can be verified from annual trials, is one approach. Also, the IMO/IMCA DP Equipment Guidelines offer performance standards for adoption in shuttle tankers.

3.1.3 Equipment Ergonomics/Control Location

In general, the layout of DP operating consoles is not 'user friendly'. Manufacturers of these systems should ensure that the operator/system interface complies with accepted "best practice" for console design by the use of mimic boards and a standardised method of data display and control system operation.

The selection of personnel to operate the DP system, should be subsequent to a task analysis whereby individuals are chosen who "fit the task and the hardware" rather than the other way round.

Careful consideration should be given to the siting of the DP control rooms, i.e. whether at the shuttle tanker bow, or further aft. Whichever location is chosen it should be considered holistically against the vessel's hardware and management systems, including those in place to cover an emergency situation.

Summary:
The siting of the DP control rooms and the layout of DP operating consoles should be viewed and carefully assessed against the vessel as a whole. Adequate management systems should be put in place to operate the system in accordance with procedures and to reduce risks associated with its operation to ALARP.

3.1.4 Use of Dynamic Positioning

The first consideration regarding the safe operation of shuttle tankers in close proximity to FPSO/FSU's concerns station-keeping, and whether or not to utilise DP. Shuttle tankers may suffer electrical/mechanical failures and possibly leading to blackout. The decision process to use DP or not must include a holistic view of the shuttle tanker and offloading operations, including weather limitations, loading arrangements, time on location, hawser length, consequences of collision etc. Non-DP shuttle tankers should have sufficient integrity in the propulsion system to minimise failure and the possibility of collision. DP shuttle tankers should have at least equal integrity in their propulsion system.

For installations fitted with drag chain moorings the shuttle tanker heading may not be optimum for shuttle operations, however, without thruster assist it may be difficult for the shuttle tanker to maintain heading. This raises the question as to whether DP is an essential requirement for controlling a shuttle tanker position and heading, but more importantly, highlights the need for operators to consider the totality of the installation and the offloading vessel when seeking to reduce risks to ALARP.

Operators utilising shuttle tankers have sought to demonstrate risks are ALARP through the use of quantified risk assessment (QRA). Since there is a limited amount of data available to cover shuttle tanker and offloading operational risks, such data should be treated with caution. Safety Cases so far presented would appear to have underestimated the risks of shuttle tanker collision when compared to reality in the field.

Whether DP or non-DP fitted shuttle tankers are chosen is a matter for Duty Holders to decide. Whichever system is chosen, the Duty Holder should consider all pertinent factors when determining what the vessel separation distance should be. The basis for making this decision should be transparent and may be the result of carrying out a FMECA to ascertain the consequences of equipment failure.

Summary:
When demonstrating ALARP, the Duty Holder should consider the total combined operating system of the FPSO/FSU, the offloading system, and the shuttle tanker. The QRA output appears to be out of step with reality, e.g., risk of collision.

3.1.5 Position Reference Equipment Complexity

The DP system functions by continuously comparing the vessels known position and heading with the desired values and applying the necessary thruster forces to correct deviations due to external forces, primarily, wind and current. Position monitoring in relation to a fixed point on or attached to the earth's surface is therefore critical to the system performance and is a topic which has been the subject of major change and highly technical development.

Early solutions involved taut wires and sea bed transponders. The next generation of solutions involved line of sight data transmission from fixed structure to the DP vessel (ARTEMIS, FANBEAM etc.). In the interests of accuracy, dependability, availability and rationalisation with other navigational requirements the industry has now acquired satellite navigation systems for DP position referencing (Global Positioning System (GPS), Differential Global Positioning System (DGPS), and Diffstar Absolute Relative Positioning System (DARPS)), encompassing the most up to date technology and very specialised software/hardware.

As a result, the constant development of DP position referencing equipment has led to the deployment of advanced and complex systems in recent years.

In modern systems, very little on-board maintenance or fault-finding can be carried out by the vessel's personnel unless those responsible have the necessary competencies to carry out the task, and are backed-up by an adequate number and array of spare parts. At present, the necessary training to undertake repairs and maintenance to the position referencing system appears to lag behind what is necessary.

Summary:
Experience indicates that new advanced and complex systems initially carry an incipient risk of developing spontaneous, spurious or unpredicted malfunctions or failures.

A brief summary of five reports from the International Marine Contractors Association (IMCA), dealing with DGPS in dynamic positioning applications, is presented for the reader's interest in Appendix C.

3.1.6 Support Vessel Performance Standards

It is accepted practice that some degree of support vessel assistance is desirable when shuttle tankers are approaching and securing to FPSO/FSU's. The extent of assistance may vary from vessel to vessel and depend on factors such as the prevailing environmental conditions, and the method of passing the transfer hose and its connection to the tanker bow manifold.

The suitability of the various support vessels will obviously differ depending on the assistance they are required to provide and on the conditions in which they are required to operate. It is likely that the best support will be provided by highly manoeuvrable supply vessels, however, in recent years it has become the practice for attending standby vessels (SBV), especially those of second or third generation design, to provide some assistance during shuttle tanker operations. Overall, this activity should be viewed against whether the vessel and its crew are adequately trained and equipped to carry out this work, particularly in marginal weather conditions, notwithstanding the fact that their primary duty is one of emergency support.

Currently, no standards exist for the performance for crew and vessel when engaged in shuttle tanker assistance activity. This may lead to the crew and vessel being asked to provide assistance which is beyond their capability and, in the case of SBV, to the greater detriment of their primary function.

Summary:
At present there are no minimum Performance Standards for support vessel and crew when engaged in shuttle tanker assistance activities. These should be developed to take account of the nature of the tasks expected of them and provide guidelines for the limits of environmental conditions under which they should be expected to operate. Where SBV's are concerned the Performance Standards should never lose sight of their primary function to provide support in the event of an emergency.

3.2 PEOPLE CONCERNS

3.2.1 Use of DP, Operator Training and Competency

Operating the DP control system whilst approaching, offloading and departing from an installation is a complex task requiring a management structure that ensures both operator competency and procedures are in place to minimise the risks involved. Personnel operating the DP system should be aware of the limitations of the systems as well as the factors which may effect its accuracy. For example, the implications of aerial position, and the need for the correct application of "offsets" where aerials are not at the bow/stem should be fully understood, particularly where the vessels' position change relative to each other.

Operator error has been the greatest single cause of accidents involving shuttle tankers in the North Sea to date. For this reason it is essential that Industry participate fully in establishing suitable courses, or training schemes to ensure competency of operators.

IMO established a training scheme for operators of DP vessels in 1995 (IMO MSC Circ. 738), this in turn was derived from courses administered via the Nautical Institute in the UK and NMD in Norway. Both courses being mutually recognised. With the advent of shuttle tanker operations, facilities that provide DP training in Lowestoft, Aberdeen, Kongsberg, Haugersand, and Trondheim introduced simulator based training schemes featuring DP shuttle tankers. There are now several facilities offering a range of shuttle tanker training from bridge resource management, and manoeuvring skills to specific simulator based DP training. Additionally some operators have established their own specific training schemes, i.e. BP.

The IMO scheme of training, validated by the Nautical Institute, was originally developed from training suitable for DP operators onboard DSV's and other such vessels. This training may not be entirely suitable or practical for shuttle tankers, particularly regarding the time required to gain suitable experience in the use of DP. The IMO scheme can and should be modified if a more appropriate competency standard is required. Industry need to assess matters of training and competence for shuttle tanker operations and ensure such training is available. The Nautical Institute scheme could be the best starting point.

Industry also need to address the question of shuttle tanker vessel management, including cultural differences that may exist between typical DP vessels (i.e. DSV's), and shuttle tankers. The offshore DP fleet has, over a number of years developed structures and methods of working suitable to the role of the vessel, i.e. DP operators controlling station keeping instead of the vessel Master. These methods may not have been adopted by shuttle tanker operators.

Summary:
Industry responded positively in dealing with the management of risks on dive support vessels such that there is now an industry wide accepted approach with standards. OSD considers that a similar approach is required to deal with the risks associated with DP shuttle tanker operations due to the possible high consequence of a vessel failing to maintain position.

3.2.2 Shuttle Tanker Personnel Fatigue

Shuttle tanker offtake from an FPSO/FSU may take many hours and it is not unknown for the Master of a shuttle tanker to operate the DP system continuously. DSV's and other conventional DP vessels have attempted to minimise operator error induced by fatigue by relieving operators, with typical periods of only one to two hours at the DP control console.

Summary:
Industry should address the problem of shuttle tanker personnel fatigue during offloading operations and recommend the minimum manning levels for DP operators, and the limiting continuous duty period at the DP control console.

3.2.3 Guidelines for Operating DP Shuttle Tankers

Guidelines for operating DP shuttle tankers have been developed by IMCA, OCIMF, and are currently being considered by INTERTANKO. Each attempt has been based around an individual operators best estimate of how such operations should be undertaken. For UKCS operations any industry guidance should first satisfy statutory requirements, such as those embodied within the Safety Case Regulations, reducing risks to ALARP etc., and be in accordance with IMO guidelines. It would be useful and beneficial for all interested parties to develop or agree upon suitable guidance incorporating all types of shuttle offloading.

IMCA have agreed to revise their existing guidelines concerning how to perform risk analysis prior to commencing DP operations. This revision should be undertaken during 1998 and it may be appropriate for UKOOA to participate with this initiative.

Summary:
There is a lack of comprehensive operating guidelines.

3.2.4 PFEER Implications

There is a concern that hazards imposed by the possibility of shuttle tanker collision are not always fully considered in the context of the various PFEER Regulations. The following are illustrations only by some of the specific hazards that may not have been properly considered under these regulations:-

(i) Regulations 5 - Summary.
Has the assessment taken full cognisance of the possible secondary effects of shuttle tanker collision, flooding, fire/explosion etc.?

(ii) Regulations 6 - Preparation for Emergencies.
Has specific emergency training for damage control, prevention of flooding etc. been considered?

(iii) Regulation 8 - Emergency Response Plan.
Emergency procedures for different circumstances; are they in place for imminent collision, have they considered pre-emptive blowdown and the possible effect on flare size etc.?

(iv) Regulation 9 - Prevention of Fire and Explosion.
In deciding appropriate measures to comply with this regulation, has thought been given to the possibility of say, ceasing production on FPSO's with stern located flares and HP gas fed equipment during offloading operations?

(v) Regulation 12 - Control of Emergencies.
Have suitable ESD levels been identified and can they be activated from the sites where possible collision will be first detected?

(vi) Regulation 17 - Arrangements for Recovery and Rescue.
Has consideration been given to the possibility that the offload operation could continue in weather conditions when the emergency response arrangements are no longer effective?

Summary:
The industry should ensure that possible shuttle tanker related hazards are given full consideration under the PFEER Regulations.

3.2.5 Reporting of Incidents

In order to identify incidents on attending shuttle tankers and thus to enable investigation and the compilation of a meaningful database a robust reporting regime is required.

The reporting of incidents etc., on a shuttle tanker whilst carrying out activities in connection with an Offshore Installation, or immediately preparatory thereto, are required by the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995.

However as shuttle tanker operators may possibly not be conversant with these requirements, the assistance of the installation duty holder through procedural arrangements etc. with the shuttle tanker operator is needed to ensure the reporting requirements are met.

Summary:
There may be a degree of under-reporting of occurrences with the potential for a collision between shuttle tankers and FPSO/FSU's.

4 Risk Management Strategy Approach

The OSD encourage an integrated and structured approach to the management of offshore risks. The Guidelines described in Ref. 2 is suggested as one approach that could be usefully adopted in addressing the OSD concerns for Shuttle Tanker and FPSO/FSU Offloading operations.

These Guidelines were aimed specifically to promote understanding of hazardous events involving fires and explosions by both designers and operators/owners. However the methodology provided in the Guidelines should be equally useful in understanding the hazardous events surrounding Shuttle Tanker and Offloading operations.

If adopted as a methodology for addressing the Shuttle Tanker and Offloading operations the output should provide :-

- An outline of the management process, the analyses and decisions that need to be taken and the factors to be considered when making these decisions;

- A balanced approach to hazard management by ensuring that the resources provided to manage Shuttle Tanker and Offloading operation are commensurate with the risks of these events;

- A framework whereby everyone, managers, designers, operators/owners, contractors and auditors can work effectively together to understand and manage the hazardous events;

- Enable improvement in the presentation and development of risk management strategies and performance standards for the safety critical elements associated with Shuttle Tankers and Offloading operations.

One sample Outline Generic Risk Management Strategy for the Oil Export Operation is attached to Appendix B. This shows an example of a risk management strategy for the hazard of collision during the Shuttle Tanker/Offloading operations leading to Oil Pollution/Fire and Explosion. The sample tabulation attached to Appendix B indicates where performance standards could be set throughout the hierarchy of the risk control measures of, for example:

- 'Hazard Substitution'
- 'Prevention'
- 'Incident Control'
- 'Incident Mitigation'
- 'Evacuation, Escape and Rescue'

5 References

1. 'Close Proximity Study', Poseidon Maritime (UK) Ltd., HSE Offshore Technology Report - OTO 97 055, October 1997.

2. 'Guidelines for Fire and Explosion Hazard Management' - issue No. 1, UKOOA Report, May 1995.

Appendix A

Offloading Systems; Mooring Hawser/Hose/Separation Data

OFFLOADING SYSTEMS: MOORING HAWSER/HOSE/SEPARATION DATA

	Catenary transfer hose						Mooring hawser						
Installation	Nominal diameter (ins)	Length (m)	Maximum flow (m³/hr)	Breakaway coupling fitted	Automatic shut-down valve fitted	Storage means	Circumference (ins)	Length (m)	Weak link fitted	Load tensioner fitted	Storage means	Approx. stern to shuttle distance (m)	Remarks
"A"	2 x 12		7,000			Suspended from crane boom						45 (B)	
"B"	16	100	5,500	No	Yes	Suspended from deck manifold	21	60		Yes	Winch	50 (T)	Bunker hose reel fitted
"C"	None fitted												
"D"	20	115	3,975			Hose chute	21	80			Winch	80 (T)	
"E"	16	107	5,600	Yes	Yes	Hose reel		75		Yes	Winch	75 (T)	
"F"	16	55	7,000			Hose reel		40			Winch	45 (T)	
"G"	16		4,250	Yes	Yes	Suspended from crane boom				Yes	Chute	45 (B)	
"H"	16	118	3,500	Yes	Yes	Suspended in loop from deck manifold	21	50		Yes	Winch	50 (*)	(*) From helideck edge
"I"	16	245 (**)	4,500	Yes		Suspended overside	21	65		Yes		65 (T)	(**) Double carcass floating hose
"J"	16	106	5,600	Yes	Yes	Hose reel					Winch	75 (T)	
"K"	16	115	2,850	Yes	Yes	Hose chute	30	85			Winch	60 (T)	Hose tension measured
"L"	16	120	5,000	Yes	Yes	Hose reel	21	80	Yes	Yes	Winch	85 (T)	
"M"	16	100	7,200			Hose reel	20	80			Winch		Shuttle used 10% field life
"N"	16		5,000			Hose reel	20				Winch	55 (T)	Bunker hose reel fitted
"O"	16	66	5,600	Yes	Yes	Hose reel	20	40	Yes	Yes	Winch	40 (T)	Bunker (6") hose reel fitted
"P"	20		5,600			Hose reel							
"Q"	None fitted: 2 x Tripod catenary mooring systems installed 1.6 km distant												
"R"	16		5,000			Hose reel					Winch		
"S"	16/20	106	6,000/8,000	Yes	Yes	Hose reel					Winch	80 (T)	
"T"													

SEPARATION DISTANCES TO BOW OF SHUTTLE TANKER FROM INSTALLATION TRANSOM (T) ; FROM BOOM TIP (B)

Appendix B

Outline Generic Risk Management Strategy for Oil Export Operation (Sample Only)

OUTLINE GENERIC RISK MANAGEMENT STRATEGY FOR OIL EXPORT OPERATION

HAZARD No. 1A: - COLLISION DURING SHUTTLE TANKER/OFFLOADING OPERATIONS

LEADING TO OIL POLLUTION/FIRE & EXPLOSION

HAZARD SUBSTITUTION	PREVENTION (Hazard avoidance)	INCIDENT CONTROL	INCIDENT MITIGATION	EVACUATION, ESCAPE AND RESCUE
Export oil via an offshore oil terminal	**Design of installation & offloading system**	**Design of installation & offloading system**	**Installation structural integrity**	**Helicopter**
	- structural/marine integrity	- CO/WB subdivision		- landing capability
	- intact stability capability	- damage stability capability	**Installation position monitoring & heading control**	
	- mooring integrity	- position monitoring		**TEMPSC & liferafts**
Export oil onshore by pipeline		- thrust-assist heading control	**Inert gas blanket in CO tanks**	- launch capability
	Design of shuttle tanker & import system			
	- position/maneouvring integrity	**Installation inclination and flooding detection systems**	**Emergency procedures**	**Personnel protective equipment**
				- survival suits & life jackets
	Pre-mooring planning (SMS)	**Fire fighting and F&G detection systems**		
	- operational/contingency procedures			**Rescue arrangements**
	- competency audit	**Emergency procedures**		
	- communications	- emergency disconnect		**Emergency procedures**
	- weather forecasting			
	- support vessel duties			

NOTE: THE ABOVE IS BY WAY OF EXAMPLE ONLY

Appendix C

Summarised DGPS Reports of the International Marine Contractors Association (IMCA)

The following reports have been produced by the International Marine Contractors Association (IMCA), and deal with Differential GPS in dynamic positioning applications. Their content is summarised below:

Differential GPS Reliability Study
9/94

This report reviews DGPS for DP applications, (around the time that DGPS came to prominence as a suitable DP position reference system). The report identifies problems with DGPS using practical experience from 'Semi 2', 'Lorelay', 'Polyclipper', and 'Stena Wellservicer' as well as system suppliers and providers of differential correction signals.

The report provides a useful discussion on DGPS together with a description of the installed equipment, and information available via DGPS monitors. The report explains many of the early problems experienced when DGPS became generally available. Those vessels reviewed, and to a certain extent most 'conventional' DP vessels, i.e. DSV's, cable/pipe layers, etc. have overcome these initial problems either by experience or training; these problems may, however, be particularly applicable to shuttle tanker operators that are new to DP. The main problems identified included monitoring of the DGPS data, changes in the satellite constellation causing position 'jumps', installation of the satellite antenna to avoid reflections, and a general lack of operator training/vessel procedures.

QRA for the Use of a Dual DGPS System for Dynamic Positioning
2/95

The report attempts to estimate the probability that on a DP vessel with two independent DGPS''s both will fail (lost as position inputs to the DP system) at the same time. This is important for vessels such as "Iolair" which has two DGPS's and no other position references; and it will also be applicable for deep water drilling when other position references may be limited.

The report summarises common mode failure mechanisms, and uses the experience of two MODU's, and other vessels, to estimate the loss of two DGPS's. It concludes that the probability of two separate faults occurring, affecting both systems is between $8.9x10^{-6}$ and $1x10^{-5}$, depending on satellite geometry, and availability of the differential correction signal. Operator error is not taken into account.

Guidelines on the Use of DGPS as a Position Reference in a DP Control System
10/97

The document describes DGPS, and relative GPS (where two satellite receivers are used to provide a pseudo position reference such as Artemis' range & bearing). Simrad's version goes by the acronym of DARPS and is often used with shuttle tanker operations.

The guidelines provide information to users and purchasers of DGPS, and include specifications for equipment and its installation, types of correction signals, power supplies, testing, and interfacing to a DP system. The document also describes the use of a quality control parameter displayed on the DGPS monitor which is a measure of how 'good' the position fix is. This QC parameter includes the number of satellites in the constellation, geometry, correction data, etc., and can be used by the DPO as a means of checking data prior to selecting into the DP system.

The guidelines go on to propose suitable training in the use of DGPS, including classroom and vessel specific training. Both Aberdeen College and Lowestoft college now offer two day courses on the use of DGPS in DP applications, these courses may be particularly suitable for shuttle tanker operators.

Position Reference Reliability Study
11/97

The report investigates the reliability of various common position reference systems. Reliability and availability being determined on the basis of time working between failures; a failures being repaired onboard or requiring the attention of a specialist from the system supplier. Data for this study was collected from 51 vessels, no distinction was made between suppliers of equipment so it is not possible to tell if one manufacturer is better than another. The results for availability were:

- Taut Wire 99.6%
- Acoustics 99.4%
- DGPS 99.6%
- Artemis 99.3%
- Fanbeam 94.5%

IMCA Station Keeping Seminar
12/97

The forth paper at this seminar related the experiences on "Iolair" of operating two independent DGPS's. The systems were installed in 1995 and are the only position references onboard. Experiences were generally good, and the author noted communication between system suppliers and DP operators, as well as training for the DPO's as being key features in making the system work reliably.

Conclusions

DGPS is as reliable as any other position reference.

Training undertaken at all DP training colleges emphasises that any position reference can be expected to 'drop out' of the DP system from time to time, which is why several position references are used at the same time. A DP operator must ensure that sufficient position references are on-line depending on the criticality of the DP operation, and that position data is checked prior to selecting into the DP system.

Suitable guidance and information on DGPS is available in the above publications, and DP specific training is available at Aberdeen and Lowestoft.

Shuttle tanker operators will probably have less experience with DGPS than conventional DP vessels. Training is vital if shuttle tankers are not to experience the early problems that the rest of the industry experienced and has since dealt with.