GUIDE FOR THE CLASSIFICATION NOTATION

THRUSTER-ASSISTED MOORING (TAM, TAM-R, TAM (Manual)) FOR MOBILE MOORING SYSTEMS

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Foreword *(1 December 2015)*

Due to the increased incorporation of thruster-assisted mooring (TAM) capability in the design of mooring systems for mobile offshore units, there is a desire in the offshore industry for optional classification notations for TAM systems. This Guide is developed and issued in response to that desire. The evaluation procedure and technical requirements are to be used for verifying the eligibility of a TAM system (for mobile offshore units) for the optional notations **TAM** (Automatic position control system), **TAM-R** (Automatic position control system with redundancy), and **TAM (Manual)** (Manual position control system). It is anticipated that after publication of the subject Guide, industry will have established criteria for TAM, thereby allowing verification of the arrangements and potentially increasing the overall level of safety.

This Guide becomes effective on 15 January 2013.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of this Guide is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

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SECTION 1 Introduction

1 General

Thrusters may be used to assist the mooring system by reducing the mean environmental forces, controlling the offshore unit's heading, damping low frequency motions, or a combination of these functions. Thruster-assisted mooring (TAM) systems can be broadly categorized into manual and automatic position control, depending on the type of thrust assist (TA) system fitted on the unit.

3 Application

(1 December 2015) The provisions of this Guide apply to mobile offshore units operating with TAM systems. Sections 2 and 3 of the Guide provide the technical requirements and survey requirements for the optional notations: **TAM** (Automatic position control system), **TAM-R** (Automatic position control system with redundancy), and **TAM (Manual)** (Manual position control system) for mobile offshore units. At the request of the Owners, the TAM system may be verified for compliance with the provisions of Sections 2 and 3, with the appropriate class notation assigned.

This Guide may be used in tandem with Appendix 3-4-A1, "Guide for Position Mooring Systems" of the ABS *Rules for Building and Classing Mobile Offshore Drilling Units (MODU Rules)*.

3.1 Class Notations *(1 December 2015)*

The requirements for conditions of Classification for the entire drilling units and offshore structures are contained in the ABS *Rules for Conditions of Classification – Offshore Units and Structures (Part 1)*. Additional requirements specific to thruster-assisted mooring systems are contained in this Guide.

For TAM systems, which are fitted with a TA system that is capable of automatically maintaining the position and heading of the unit under specified maximum environmental conditions having an independent centralized manual position control with automatic heading control that have been built, installed and commissioned to the satisfaction of the ABS Surveyors to the full requirements of this Guide, where approved by the Committee for service for the specified design environmental conditions, will be classed and distinguished in the ABS *Record* by the notation ✠ **TAM**.

For TAM systems, which are fitted with a TA system that is capable of automatically maintaining the position and heading of the unit under specified maximum environmental conditions with redundancy as determined by failure mode and effects analysis (FMEA) having an independent centralized manual position control with automatic heading control that have been built, installed and commissioned to the satisfaction of the ABS Surveyors to the full requirements of this Guide, where approved by the Committee for service for the specified design environmental conditions, will be classed and distinguished in the ABS *Record* by the notation ✠ **TAM-R**.

For TAM systems, which are fitted with a TA system with centralized manual position control and automatic heading control to maintain the position and heading under specified maximum environmental conditions that have been built, installed and commissioned to the satisfaction of the ABS Surveyors to the full requirements of this Guide, where approved by the Committee for service for the specified design environmental conditions, will be classed and distinguished in the ABS *Record* by the notation ✠ **TAM (Manual)**. This notation assumes continuous attention of a TA operator.

The symbol "✠" (Maltese-Cross) signifies that the system was built, installed and commissioned to the satisfaction of the ABS Surveyors. TAM systems that have not been built under survey to ABS, but which are submitted for Classification, will be subjected to special consideration. Where found satisfactory and thereafter approved by the Committee, it will be classed and distinguished in the *Record* by the notation described above, but the symbol "✠" signifying survey during construction will be omitted.

5 Definitions

Thrusters. Thrusters are devices capable of delivering side thrust or thrusts through 360º to improve the vessel's maneuverability, particularly in confined waters. For more details, refer to 4-3-5/1.5 of the ABS *Rules for Building and Classing Steel Vessels (Steel Vessel Rules).*

Thrust Assist (TA) System. Thrust assist system is a hydro-dynamic system which utilizes thrusters and dynamic positioning capability to assist the mooring system in controlling or maintaining the position and heading of the vessel by centralized manual control or by automatic response to the variations of the environmental conditions within the specified limits.

Specified Maximum Environmental Conditions. The specified maximum environmental conditions are the specified wind speed, current and wave height under which the unit is designed to carry out intended operations.

Specified Operating Envelope. The specified operating envelope is the area within which the unit is required to stay in order to satisfactorily perform the intended operations under the specified maximum environmental conditions.

Damaged Condition. Damaged condition is defined as loss of single mooring line or loss of single thruster or single engine/generator. A failure in the TA system that results in thruster(s) inoperability shall be considered equivalent to damaged condition.

7 Plans and Particulars to be Submitted

The general arrangements of the thruster(s) installation, its location of installation, together with its supporting auxiliary machinery systems, fuel oil tanks, foundations, watertight boundary fittings, etc., are to be submitted. The rated power/rpm and the rated thrust are to be indicated. For azimuthal thrusters, the mechanical and control systems for rotating the thruster assembly or for positioning the direction of thrust are to be submitted. Thruster specifications and calculations for thruster forces and power to counteract environmental forces are to be submitted. In addition, plans of each component and of the systems associated with the thruster are to be submitted.

In addition, plans showing the arrangement and complete details of the anchoring system, including anchors, shackles, anchor lines consisting of chain, wire or rope, together with details of fairleads, windlasses, winches and any other components of the anchoring system and their foundations and attachments to the unit are to be submitted. Mooring analysis describing method of load calculations and analysis of dynamic system to determine the mooring line design loads is to be submitted. Specifications and calculations for all components of the anchoring system are to be submitted. The type and design of anchors are to be submitted for review, together with documentation estimating their holding power in various types of soil.

Model test report when the design loads are based on model tests is to be submitted, if applicable.

9 References

Some of the applicable requirements of the following Rules, Guides, Codes and Standards are referenced in this Guide are listed below:

- ABS *Rules for Building and Classing Mobile Offshore Drilling Units*
- ABS *Rules for Building and Classing Steel Vessels*
- ABS *Guide for the Certification of Offshore Mooring Chain*
- ABS *Guidance Notes on the Application of Fiber Ropes for Offshore Mooring*
- API RP 2SK *Design and Analysis of Stationkeeping Systems for Floating Structures*
- API Spec 9A *Specification for Wire Rope*

SECTION 2 Technical Requirements for Notations

1 General *(1 December 2015)*

In evaluating the capability of the TAM system for mobile offshore units with the intent of assigning the optional notation **TAM**, **TAM-R**, or **TAM (Manual)**, the provisions in this Section are to be complied with as applicable.

3 Analysis Conditions for Thruster-Assisted Mooring (TAM, TAM-R) System *(1 December 2015)*

The TAM or TAM-R system shall be designed for the intact and damaged conditions as defined in Section 2, Tables 1A and 1B.

TABLE 1A
Intact and Damaged TAM Definitions

TAM Definition and Mooring Line Factor of Safety	*Mooring System Condition*	*Thrust Assist (TA) System Condition*
Intact	Intact	Intact
Damaged	Intact	Damaged
Damaged	Damaged	Intact

TABLE 1B
Intact and Damaged TAM-R Definitions *(1 December 2015)*

TAM-R Definition and Mooring Line Factor of Safety	*Mooring System Condition*	*Thrust Assist (TA) System Condition*
Intact	Intact	Intact
Damaged	Intact	Damaged with redundancy as determined by failure mode and effects analysis (FMEA).
Damaged	Damaged	Intact

Damaged condition is defined as loss of a single mooring line or loss of a single thruster or single engine/ generator. A failure in the TA system that results in thruster(s) inoperability shall be considered equivalent to damaged condition.

The *mooring line factor of safety* is specified in Section 2, Table 2. For additional design considerations of the mooring system, refer to Appendix 3-4-A1 of the *MODU Rules*.

TABLE 2
Mooring Line Factor of Safety

Analysis Condition		*Mooring Line Factor of Safety (FOS)*	
		Quasi-Static Analysis	*Dynamic Analysis*
Operating	Intact	2.70	2.25
	Damaged	1.80	1.57
	Transient	1.40	1.22
Severe Storm	Intact	2.00	1.67
	Damaged	1.43	1.25
	Transient	1.18	1.05

5 Mooring System

5.1 Anchoring Systems

5.1.1

An analysis of the anchoring arrangements expected to be utilized in the unit's operation is to be submitted. Among the items to be addressed include:

i) Design environmental conditions of waves, winds, currents, tides and ranges of water depth

ii) Description of analysis methodology

5.1.2

The anchoring system should be designed so that a failure of any single component will not cause progressive failure of the remaining anchoring arrangements.

5.1.3

Anchoring system components should be designed utilizing adequate factors of safety (FOS) (see Section 2, Table 2) and a design methodology suitable to identify the most severe loading condition for each component. In particular, sufficient numbers of heading angles together with the most severe combination of wind, current and wave are to be considered, usually from the same direction, to determine the maximum tension in each mooring line. The effects of the thrust assist (TA) system (see Subsection 2/9) shall be considered.

The owner is to specify the environmental conditions for which the TAM system is to be designed for.

5.1.4

When a quasi-static analysis method is applied, the tension in each anchor line is to be calculated at the maximum excursion for each design condition defined in Section 2, Table 2, combining the following steady state and dynamic responses of the unit:

i) Steady mean offset due to the defined wind, current and steady wave forces.

ii) Maximum surge/sway excursions of the unit due to first-order wave excitations in a storm sea-state of three-hour duration. Significant values of surge/sway excursions due to first-order wave excitations may be used for evaluating transient conditions resulting from the sudden failure of any one anchor line. The effects of second-order wave-induced motions are to be included for units when the magnitudes of such motions are considered to be significant.

5.1.5

Factors of safety (FOS) (see Section 2, Table 2) are dependent on the design conditions of the system (intact, damaged or transient), as well as the level of analyses (Quasi-Static or Dynamic Analysis). The minimum Quasi-Static FOS at the maximum excursion of the unit for a range of headings should be satisfied if the quasi static method outlined in 2/5.1.4 is applied. Otherwise, the minimum Dynamic Analysis FOS should be satisfied, including the effects of line dynamics when these effects are considered significant.

For anchoring systems incorporating fiber ropes, additional requirements are defined in ABS *Guidance Notes on the Application of Fiber Ropes for Offshore Mooring*.

5.1.6

Anchor lines are to be of adequate length to prevent uplift forces on the anchors (unless anchors are specifically design to withstand such forces) under the design conditions specified in Section 2, Table 2. However, only steady wind, wave and current forces need to be applied in evaluating anchor uplift forces in transient conditions.

5.1.7

In general, the maximum surge/sway excursions of the unit due to wave excitation about the steady mean offset should be obtained by means of model tests. Analytical calculations may be acceptable, provided that the proposed method is based on methodologies validated by model tests.

5.1.8

Other analysis methodologies may be acceptable, provided that a level of safety equivalent to that required by 2/5.1.4 and 2/5.1.5 is attained.

5.3 Equipment

5.3.1 Winches and Windlasses.

The design of mooring winches and windlasses is to provide for adequate dynamic braking capacity to control normal combinations of loads from the anchor, anchor line and anchor handling vessel during the deployment of the anchors at the maximum design payout speed of the winch or windlass. Winches and windlass foundations and adjacent hull structures are to be designed to withstand an anchor line load at the winch or windlass at least equal to the rated breaking load of the anchor line.

Each winch or windlass is to be provided with two independent, power operated brakes and each brake is to be capable of holding a static load in the anchor line of at least 50 percent of the anchor line's rated breaking strength. One of the brakes may be replaced by a manually operated brake.

On loss of power to the winches or windlasses, the power operated braking system should be automatically applied and be capable of holding against 50 percent of the total static braking capacity of the windlass.

5.3.2 Fairleads and Sheaves.

Fairleads and sheaves should be designed to prevent excessive bending and wear of the anchor lines. The attachments to the hull or structure are to be such as to withstand the stresses imposed when an anchor line is loaded to its rated breaking strength.

5.5 Anchor Lines

Anchor lines are to be of a type that will satisfy the design conditions of the anchoring system. Details are to be submitted.

Means are to be provided to enable the anchor lines to be released from the unit after loss of main power.

Means are to be provided for measuring anchor line tensions and for initial and periodic calibration of line tension measuring instrumentation.

For anchoring systems which utilize chains, requirements for the mooring chains are defined in accordance to ABS *Guide for the Certification of Offshore Mooring Chain*.

5.7 Anchors

The type and design of anchors are to be submitted for review, together with documentation estimating their holding power in various types of soil.

Suitable anchor stowage arrangements are to be provided to prevent movement of the anchors during transit.

5.9 Quality Control

Details of the quality control of the manufacturing process of the individual anchoring system components are to be submitted. Components should be designed, manufactured and tested in accordance with recognized standards insofar as possible and practical. Equipment so tested should, insofar as practical, be legibly and permanently marked with the Surveyor's stamp and delivered with documentation which records the results of the tests.

5.11 Control Stations

A manned central control station is to be provided with means to indicate anchor line tensions and to indicate wind speed and direction.

Reliable means are to be provided to communicate between locations critical to the anchoring operation.

Each winch or windlass should be capable of being controlled from a position which provides a good view of the operation. Means are to be provided at the individual winch or windlass control positions to monitor anchor line tension, winch or windlass power load and to indicate the amount of anchor line paid out.

7 Thrust Capacity

Evaluation of *available thrust* shall take into consideration the efficiency of thrusters and losses due to vessel motions, current, thruster/hull and thruster/thruster interference effects, and any directional restrictions. The determination of *allowable thrust* for automatic and manual thrust assist (TA) systems is specified in Section 2, Table 3.

TABLE 3
Allowable Thrust for Manual and Automatic Thrust Assist (TA) Systems *(1 December 2015)*

		Analysis Condition		*Class Notation*
		Intact	*Damaged*	
Allowable Thrust	Automatic Thrust Assist Systems	Equal to the available thrust or effective bollard pull when the thruster system is operating normally	Equal to the available thrust	**TAM**
			The available thrust shall account for the worst failure as determined by failure mode and effects analyses (FMEA).	**TAM-R**
	Manual Thrust Assist Systems	Equal to the available thrust or effective bollard pull when the thruster system is operating normally multiplied by Reduction Factor of 0.7	Equal to the available thrust multiplied by Reduction Factor of 0.7	**TAM (Manual)**

The allowable thrust used in the mooring analysis shall be verified during the TAM system sea trials. For guidelines on evaluating available thrust, refer to API RP 2SK.

9 Thruster-Assisted Mooring Analysis

Thruster-assisted mooring analysis shall be performed using either the Mean Load Reduction Method (simplified approach) or Time Domain System Dynamic Analysis. For guidelines on the analysis methods, refer to API RP 2SK.

11 System Requirements

The design and performance of thrusters is to be determined by the interaction of multi-disciplinary systems including *thruster system*, *power generation and distribution system*, *control and instrumentation system*, and *environment sensor and position reference system*.

11.1 Thruster System

In general, the thrusters are to comply with the requirements of 4-3-5/3 through 4-3-5/13 of the *Steel Vessel Rules*, as applicable.

Units are to have thrusters in number and of capacity sufficient to meet the minimum thrust output as required for the specified design conditions.

11.3 Power Generation and Distribution System

In general, requirements in Part 4, Chapter 8 of the *Steel Vessel Rules* are to be complied with, as applicable.

For **TAM** notation, an independent uninterruptible power system is to be provided for each independent control system and its associated monitoring and reference system. Each uninterruptible power system is to be capable of supplying power for a minimum 30 minutes after failure of the main power supply.

11.5 Environment Sensor and Position Reference System

For **TAM (Manual)** notation, a position reference system, a wind sensor and a gyro-compass are to be fitted. For **TAM** notation, they are to be provided in duplicate.

11.7 Control and Instrumentation System

11.7.1 Control and Monitoring System Components

In general, control and monitoring (alarms and instrumentation) system components for TAM systems intended to be assigned **TAM** or **TAM (Manual)** notation are to comply with the provisions of Section 4-9-8 of the *Steel Vessel Rules*.

11.7.2 Control Stations

11.7.2(a) Control Station Arrangement. The main TA control station is to be so arranged that the operator is aware of the external environmental conditions and any activities relevant to the TA operation.

11.7.2(b) Emergency Shutdown. An emergency shutdown facility for each thruster is to be provided at the main TA control station. The emergency shutdown facility is to be independent of the automatic control systems (2/11.7.3), manual position control system (2/11.7.4) and manual thruster control system (2/11.7.5). The emergency shutdown facility is to be arranged to shut down each thruster individually.

11.7.3 Position Keeping Control System

*11.7.3(a) Units with **TAM** Notation.* An automatic control system and a manual position control system with automatic heading control are to be fitted. Transfer of control between the two systems is to be initiated manually.

11.7.4 Manual Position Control System

The manual position control system described in 2/11.7.3 is to be independent of the automatic control systems so that it will be operational if the automatic control systems fail. The system is to provide one joystick for manual control of the unit position and is to be provided with the arrangements for automatic heading control.

11.7.5 Manual Thruster Control System

In addition to 2/11.7.3 and 2/11.7.4, a manual thruster control system that can effectively control the thruster from the navigation bridge is to be provided. Control power is to be from the thruster motor controller or directly from the main switchboard. The manual thruster control system is to be independent of the automatic control systems so that it will be operational if the automatic control systems fail. The system is to provide an individual joystick for each thruster.

Any failure in the manual position control system is not to affect the capabilities of the manual thruster control system to individually control each thruster.

11.7.6 Alarms and Instrumentation

The displays, alarms and indicators as specified in Section 2, Table 4 are to be provided at each control station, as applicable.

TABLE 4
Instrumentation at TA Control Station

System	*Monitored Parameters*	*Alarm*	*Display*
Thruster Power System	Engine lubricating oil pressure – low	x	
	Engine coolant temperature – high	x	
	CPP hydraulic oil pressure – low and high	x	
	CPP hydraulic oil temperature – high	x	
	CPP pitch		x
	Thruster RPM		x
	Thrust direction		x
	Thrust motor/semiconductor converter coolant leakage	x	
	Thrust motor semiconductor converter temperature		x
	Thruster motor short circuit		x
	Thruster motor exciter power available		x
	Thruster motor supply power available		x
	Thruster motor overload	x	
	Thruster motor high temperature	x	
Power Distribution System	Status of automatically controlled circuit breakers		x
	Bus bar current and power levels		x
	High power consumers – current levels		x
System Performance	Excursion outside operating envelope	x	
	Control system fault	x	
	Position sensor fault	x	
	Vessels target and present position and heading		x
	Wind speed and direction		x
	Selected reference system		x

11.9 Communications for Units with Thrust Assist Capability

One means of voice communication is to be provided between each TA control position and the navigation bridge, the engine control position, main propulsion control station, the thruster room or any relevant operation control centers associated with TA.

SECTION 3 Survey Requirements for Notations

1 Survey During Construction

Where the unit maintains the optional **TAM** or **TAM (Manual)** notations, position mooring systems and TA systems are to be surveyed in accordance with the requirements of Part 7, Chapter 1 of the *MODU Rules*, as applicable.

1.1 Thrusters and Associated Equipment

Thrusters and associated equipment are to be inspected, tested and certified by ABS in accordance to the following requirements in Part 4 of the *Steel Vessel Rules*, as applicable:

- Diesel engines: Section 4-2-1
- Gas turbines: Section 4-2-3
- Electric motors: Section 4-8-3
- Gears: Section 4-3-1
- Shafting: Section 4-3-2
- Propellers: Section 4-3-3

Upon completion of the installation, performance tests are to be carried out in the presence of a Surveyor in a sea trial. This is to include but not limited to running tests at intermittent or continuous rating, variation through design range of the magnitude and/or direction of thrust, vessel turning tests and vessel maneuvering tests.

1.3 Control and Monitoring System Equipment

Control and monitoring (alarms and instrumentation) system equipment used in a TA system to be assigned with a **TAM** or **TAM (Manual)** notation are to be certified for suitability for marine atmospheres.

Hydraulic and pneumatic piping systems associated with the TA system are to be subjected to pressure tests at 1.5 times the relief-device setting using the service fluid in the hydraulic system and dry air or dry inert gas for pneumatic systems as testing media. The tests are to be carried out in the presence of a Surveyor.

Upon completion and installation of the TA system, complete performance tests are to be carried out to the Surveyor's satisfaction at the sea trials. Where practicable, the test environment is to reflect the limiting design operating conditions.

3 Survey After Construction

Where the unit maintains the optional **TAM** or **TAM (Manual)** notations, thrusters and TA systems are to be surveyed on the basis of "Survey Requirements for Additional Systems and Services" in accordance with the requirements of Section 7-9-6 of the ABS *Rules for Survey After Construction (Part 7)*. In addition, position mooring systems are to be surveyed in accordance with the requirements of Part 7, Chapter 2 of the *MODU Rules*, as applicable.

In cases where testing may interfere with operations, verification of all different operational modes may not be practicable. Operational status of the unit may then be taken into consideration. When any operational mode is not witnessed by the Surveyor, the TA system records are to be examined. The Surveyor is to review the TA system records and examine the performance of the systems throughout the period since the last survey to establish if there has been any abnormal functioning or failures and what corrective measures had been taken to preclude their recurrence.