Designation: F1878 – 21

An American National Standard

Standard Guide for Escort Vessel Evaluation and Selection[1]

This standard is issued under the fixed designation F1878; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers the evaluation and selection of escort vessels that are to be used to escort ships transiting confined waters. The purpose of the escort vessel is to limit the uncontrolled movement of a ship disabled by loss of propulsion or steering to within the navigational constraints of the waterway. The various factors addressed in this guide also can be integrated into a plan for escorting a given ship in a given waterway. The selection of equipment also is addressed in this guide.

1.2 This guide can be used in performance-based analyses to evaluate:

1.2.1 The control requirement of a disabled ship,

1.2.2 The performance capabilities of escort vessels,

1.2.3 The navigational limits and fixed obstacles of a waterway,

1.2.4 The ambient conditions (wind and sea) that will impact the escort response, and

1.2.5 The maneuvering characteristics of combined disabled ship/escort vessel(s).

1.3 This guide outlines how these various factors can be integrated to form an escort plan for a specific ship or a specific waterway. It also outlines training programs and the selection of equipment for escort-related activities.

1.4 A flowchart of the overall process for developing and implementing an escort plan is shown in Fig. 1. The process begins with the collection of appropriate data, which are analyzed with respect to the performance criteria and in consultation with individuals having local specialized knowledge (such as pilots, waterway authorities, interest groups, or public/private organizations, and so forth). This yields escort vessel performance requirements for various transit speeds and conditions; these are embodied in the ship's escort plan. When the time comes to prepare for the actual transit, the plan is consulted in conjunction with forecast conditions and desired transit speed to select and dispatch the appropriate escort vessel (or combination of vessels). A pre-escort conference is conducted to ensure that all principal persons (ship master, pilot, and escort vessel masters) have a good understanding of how to make a safe transit and interact in the event of an emergency.

1.5 This guide addresses various aspects of escorting, including several performance criteria and methodologies for analyzing the criteria, as well as training, outfitting, and other escort-related considerations. This guide can be expanded as appropriate to add new criteria, incorporate "lessons learned" as more escorting experience is gained in the industry, or to include alternative methodologies for analyzing the criteria.

1.6 This guide addresses physical control of the disabled ship with the assistance of the escort vessel(s). Other possible functions, such as firefighting, piloting, or navigational redundancy, are outside the scope of this guide. Also, this guide was developed for application to oceangoing ships in coastal waterways; it is not suitable for application to barge strings in riverine environments.

1.7 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *Code of Federal Regulations Document:*[2]

33 CFR Part 168 Escort Vessels for Certain Tankers

2.2 *IMO Resolutions:*[3]

IMO Resolution A.601(15) Provision and Display of Maneuvering Information on Board Ships

IMO Resolution MSC.137(76) Standards for Ship Maneuverability

2.3 *Marine Safety Committee Circulars:*[3]

MSC Circular 1053 Explanatory Notes to the Standards for Ship Maneuverability

[1] This guide is under the jurisdiction of Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.01 on Structures.

Current edition approved Oct. 1, 2021. Published November 2021. Originally approved in 1998. Last previous edition approved in 2015 as F1878 – 98 (2015). DOI: 10.1520/F1878-21.

[2] Available from U.S. Government Publishing Office (GPO), 732 N. Capitol St., NW, Washington, DC 20401, http://www.gpo.gov.

[3] Available from the International Maritime Organization (IMO), 4, Albert Embankment, London, SE1 7SR, UK, http://www.imo.org.

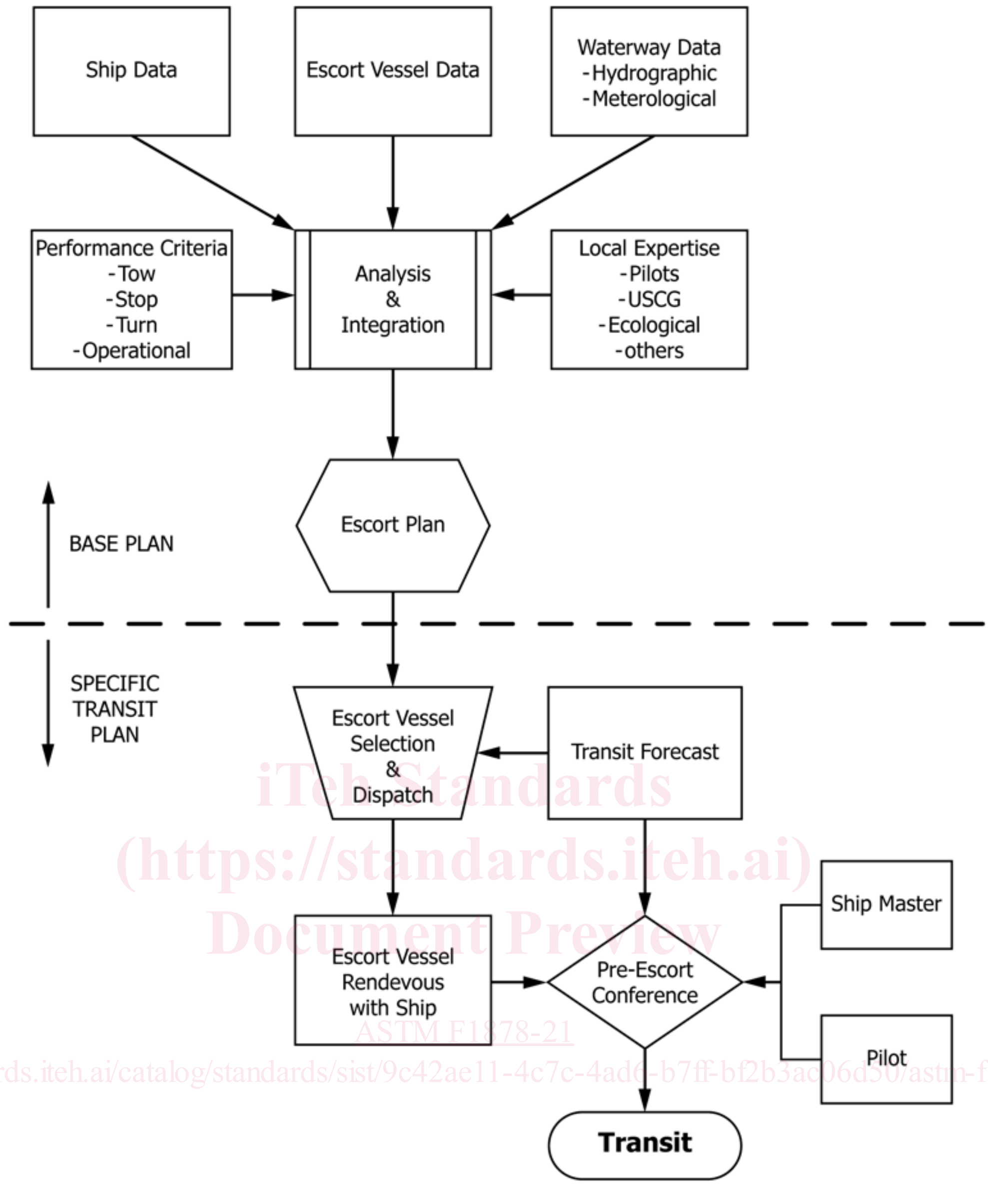


FIG. 1 Flowchart of the Overall Process for Developing and Implementing an Escort Plan

3. Terminology

3.1 For purposes of clarity within this guide, the vessel being escorted is referred to as the "ship" or "disabled ship." The vessel accompanying the ship as its escort is referred to as the "escort vessel."

3.2 The escorting measures addressed in this guide are based on performance.

3.2.1 The term "performance measure" refers to performance capabilities that must be possessed by the escort vessel(s) in controlling the disabled ship within a particular waterway. This requires a holistic analysis of the combined maneuvering dynamics of the escort vessel(s) and ship within the waterway in ambient weather and sea conditions. Performance-based requirements involve extensive preplanning and analyses, but offer greater assurance that the escort vessel(s) actually will be effective. The methodologies and processes presented in this guide can be used in determining the performance envelope of an escort vessel at different transit speeds and under a range of weather and sea conditions.

3.3 The terms "conventional propulsion" and "omnidirectional propulsion" refer to propulsion systems of the escort vessel.

3.3.1 *Conventional Propulsion System*—The propulsive thrust is fixed in a fore/aft direction.

3.3.2 *Omni-Directional Propulsion System*—The propulsive thrust is steerable in any direction (360°) around the hull. Examples are the azimuthing *Z*-drive screw propeller system and the vertical axis cycloidal system.

3.4 The terms "direct mode" and "indirect mode" refer to two towing modes for exerting control forces on a disabled ship via towline from the escort vessel.

3.4.1 *Direct Mode*—The towline force is derived directly from the escort vessel's propulsion system. In general, the towline orientation is over the bow or over the stern of the escort vessel, and only the propulsive thrust vector parallel to the towline axis is effective on the disabled ship.

3.4.2 *Indirect Mode*—The towline force is derived from the escort vessel's hull drag as it is pulled along behind the disabled ship (similar to a drag chute). High-performance escort vessels should have sufficient stability so that they can turn approximately sideways to the towline without capsizing (tripping), thereby substantially increasing their hull drag and, consequently, increasing their towline force. The propulsion system of these escort vessels is used indirectly to maintain an over-the-side towline orientation (rather than pull directly on the towline itself). In the indirect mode, specially designed escort vessels can kite off to one side or the other of the disabled ship's stern, thereby imposing substantial steering forces on the ship as well as retarding forces to slow it down.

3.5 The terms "parameters" and "constraints" refer to additional conditions that define the escort scenario and response.

3.5.1 *Parameters*—Additional details that are specified as part of the performance criteria to define more fully the performance "problem" that must be solved by the escort vessel(s). Parameters are used to customize the performance criteria to reflect a particular waterway or a specific performance objective. Examples of parameters include an initial ship speed at moment of failure, or winds, currents, and sea state conditions that must be assumed during the escort response.

3.5.2 *Constraints*—Limitations associated with "solving" the performance problem. Examples of constraints include the stability limits of the escort vessel (which limit how much towline heeling moment the escort vessel can tolerate), strength limits of the ship's bollards (which limit how much towline force can be applied), or the navigable limits of the waterway (which limit how much maneuvering room is available).

3.6 *Definitions:*

3.6.1 *allision, n*—a collision with a fixed object.

3.6.2 *allowable reach, n*—the straight line distance forward from the designated ship, parallel to its course direction, to a point at which a grounding of an allision would occur.

3.6.3 *allowable transfer, n*—the straight line distance from the designated ship, perpendicular to its course direction, to a point at which a grounding or an allision would occur.

3.6.4 *assist maneuver, n*—an escort vessel maneuver in which the assisting escort vessel(s) apply maximum steering force to a disabled ship to enhance the turn of the rudder. In this maneuver, the objective is to make the radius of turn of the ship as small as possible.

3.6.5 *emergency scenarios, n*—the complete description of the failure, the navigational situation, and the emergency assist response.

3.6.6 *escort operating area, n*—a subregion of the waterway, harbor, bay, and so forth, that has been identified as the region in which the escort vessel(s) will stand by or accompany the designated ship. The subregion may contain locations that would require timely escort vessel assistance should the ship experience a propulsion or steering failure, or both.

3.6.7 *escort vessel, n*—a vessel that is assigned to stand by or is dedicated to travel in close proximity to a designated ship to provide timely assistance should the ship experience a propulsion or steering failure, or both. The escort vessel has appropriate fendering and towing gear to provide emergency assist capability relative to the demand of the disabled ship.

3.6.8 *grounding, n*—impact of a ship's hull with the sea bottom.

3.6.9 *maneuvering coefficients, n*—a set of numerical coefficients the are used in polynomial representations of the forces acting on a ship in terms of the instantaneous state of the ship.

3.6.10 *oppose maneuver, n*—an escort vessel maneuver in which the assisting escort vessel(s) apply maximum steering force to a disabled ship to turn the ship against its rudder. In this maneuver, the objective is to return the ship to its original heading by opposing the rudder forces.

3.6.11 *propulsion failure, n*—the ship is unable to propel or actively stop itself.

3.6.12 *response times, n*—the sequence of time delays following a disabling failure on a transiting ship before the escort vessel(s) can apply corrective forces.

3.6.13 *rescue tow, n*—a maneuver in which the escort vessel makes up lines and pulls the disabled ship; undertaken after all forward way has come off the disabled ship.

3.6.14 *retard maneuver, n*—an escort vessel maneuver in which the assisting escort vessel(s) apply maximum braking force to a disabled ship. In this maneuver, the objective is to take speed off the ship as quickly as possible by pulling astern. The control of a ship's heading is not an objective. Also referred to as *arrest*.

3.6.15 *rudder failure, n*—the ship's rudder is locked at some angle or it is swinging uncontrollably.

3.6.16 *ship track/course, n*—the path covered by the ship's center of gravity during a voyage, a waterway transit, or a maneuver.

3.6.17 *tactical diameter, n*—the distance, perpendicular to the original course direction, between the ship's center of gravity at the start and at the end of a 180° heading change.

3.6.18 *zigzag maneuver, n*—a test used to measure the effectiveness of the rudder to initiate and check course changes. The maneuver is described in MSC Circular 1053, Section 2.2.1.4.

3.7 *Evaluation and Selection Variables:*

3.7.1 *transit speeds, n*—the speed of the escorted ship measured through the water. The transit speed takes into account tidal and wind-driven currents. Transit speed is not over ground (SOG) as measured by Global Positioning System (GPS), Loran, or radar.

3.7.2 *bollard pull, n*—the maximum sustainable force that the escort vessel is able to develop while pulling on a towline attached to a stationary object. The forward and astern bollard pulls are individually specified.

3.7.3 *dynamic pull (at a particular speed), n*—the maximum sustainable force that the escort vessel is able to develop while moving through the water at a particular speed.

3.7.4 *transfer, n*—the distance perpendicular to the original track that a ship's center of gravity travels in a 90° change in heading.

3.7.5 *advance, n*—the distance parallel to the original track that a ship's center of gravity travels in a 90° change of heading.

3.7.6 *performance limits, n*—limits of performance measures such that under all circumstances, the use of vessels, equipment, or crew shall not place the life and safety of individuals in jeopardy. No applicable federal or state regulations should be exceeded in determining escort vessel performance capabilities and limits.

4. Significance and Use

4.1 This guide presents some methodologies to predict the forces required to bring a disabled ship under control within the available limits of the waterway, taking into account local influences of wind and sea conditions. Presented are methodologies to determine the control forces that an escort vessel can reasonably be expected to impose on a disabled ship, taking into account the design of the ship, transit speed, winds, currents, and sea conditions. In some instances, this guide presents formulae that can be used directly; in other instances, in which the interaction of various factors is more complicated, it presents analytic processes that can be used in developing computer simulations.

4.2 Unlike the more traditional work of berthing assistance in sheltered harbors or pulling a "dead ship" on the end of a long towline, the escorting mission assumes that the disabled ship will be at transit speed at the time of failure, and that it could be in exposed waters subject to wind, current, and sea conditions.

4.3 The navigational constraints of the channel or waterway might restrict the available maneuvering area within which the disabled ship must be brought under control before it runs aground or collides with fixed objects in the waterway (see *allision*).

4.4 The escort mission requires escort vessel(s) that are capable of responding in timely fashion and that can safely apply substantial control forces to the disabled ship. This entails evaluation of the escort vessel's horsepower, steering and retarding forces at various speeds, maneuverability, stability, and outfitting (towing gear, fendering, and so forth). This guide can be used in developing escort plans for selecting suitable escort vessel(s) for specific ships in specific waterways.

4.5 The methodologies and processes outlined in this guide are for performance-based analyses of escort scenarios. This means that the acceptability of a vessel (or combination of vessels) for escorting is based upon the ability to control the disabled ship in accordance with specified performance criteria. This guide addresses four selected performance measures:

4.5.1 *Towing*—the ability to tow the disabled ship under specified parameters,

4.5.2 *Stopping*—the ability to stop the disabled ship within specified parameters,

4.5.3 *Turning*—the ability to turn the disabled ship within specified parameters, and

4.5.4 *Holding steady*—the ability to hold the disabled ship on a steady course under specified parameters.

4.6 The "specified parameters" are additional details that must be factored into the performance analysis. These parameters might be specified by a regulatory agency imposing the escort requirement, by a study group evaluating the feasibility of escorting in a particular waterway, or by the ship or escort vessel operators themselves to define the performance envelope of their vessels. Some examples of these parameters are:

4.6.1 A ship transit speed (at the moment of failure);

4.6.2 The failure scenario (rudder failure alone, or simultaneous rudder/propulsion failure, degree of failure, and so forth);

4.6.3 Navigational constraint within which the disabled ship must be brought under control (such as allowable advance and transfer, cross-track error, and so forth);

4.6.4 Wind, current, and sea conditions; and

4.6.5 Time delays, failure recognition, decision making, escort vessel notification, escort vessel positioning, achieving full power, and so forth.

4.7 The anticipated users of this guide are:

4.7.1 Ship owners/operators who are required to select escort vessel(s) that meet the performance measures addressed by this guide.

4.7.2 Escort vessel designers/operators who need to evaluate the performance capabilities of their vessels with respect to the measures addressed by this guide.

4.7.3 Regulatory agencies that have imposed the performance measures in this guide in a particular waterway to develop suitable escort vessel matrices for various sized ships in the waterway.

4.7.4 Enforcement agencies can use this guide to confirm/verify compliance with the performance measures (that is, that suitable escort vessel(s) are being selected).

4.7.5 Study groups can use this guide to explore the feasibility and effectiveness of escorting as a means of mitigating risk on a particular waterway.

4.8 This guide does not address the use of escort vessels with barge fleets or barge tows. However, some sections of this guide would be useful if an evaluation of escort vessels with barge shipments were undertaken. Paragraphs 5.4 and 5.5, and all of Section 6 would apply in this type of analysis.

4.9 The methodologies and processes presented in this guide will yield valid solutions to the performance measures. This means that the selected escort vessel(s) can reasonably be expected to control the disabled ship within the specified parameters. However, users are reminded that other circumstances surrounding the disabling incident may still preclude the escorts from safely responding (such as fire).

4.10 The methodologies in this guide are not necessarily the only ones that can be used to find solutions for the performance measures. There may be other analytic approaches that also will yield valid results. It is hoped that as these alternative methods are developed, they will be incorporated into this guide.

5. Data Requirements for Analysis

5.1 This section describes the data required for an escort vessel evaluation and selection analysis. This analysis is part of the development of an escort plan. The data recommended for inclusion in an escort plan document are presented in Section 8.

5.2 The data required for this analysis must be either an accurate evaluation of ship and escort vessel characteristics or must be based on conservative assumptions regarding those characteristics.

5.3 *Ship Data:*

5.3.1 It is recommended that, as a minimum, the ship information contained on the IMO Resolution A.601(15) defined pilot card and wheelhouse poster be collected for use in developing and verifying an escort vessel analysis. Examples of the pilot card and wheelhouse poster are shown in Figs. 2-5. The completed forms can be made part of an escort plan.

5.3.2 In addition, the following ship-specific characteristics can be used in the development of an escort plan and can be used in the validation of ship-maneuvering simulation computer models:

5.3.2.1 Unpropelled advance and transfer distances starting from an engine stop order with rudder amidships at the

Ship's name ____________________ Date ____________

Call sign ________ Deadweight ________ tonnes Year built ________

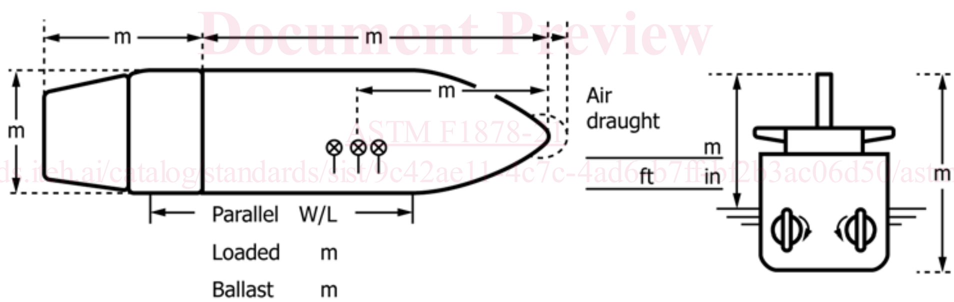
Draught aft ____m/____ft ____in, Forward ____m/____ft ____in, Displacement ____tonnes

SHIP'S PARTICULARS

Length overall____m, Anchor chain: Port ____shackles, Starboard____shackles,

Breadth ____m Stern ____shackles

Bulbous bow Yes/No (1 shackle = ______m/______fathoms)



Type of engine ____________ Maximum power ________kW (________HP)

Manoeuvring engine order	Rpm/pitch	Speed (knots) Loaded	Speed (knots) Ballast
Full ahead			
Half ahead			
Slow ahead			
Dead slow ahead			
Dead slow astern		Time limit astern ________min	
Slow astern		Full ahead to full astern ________s	
Half astern		Max. no. of consec. starts ________	
Full astern		Minimum RPM ________ ________knots	
		Astern power ________% ahead	

FIG. 2 Pilot Card

STEERING PARTICULARS		
Type of rudder ______		Maximum angle ______ °
Hard-over to hard-over ______ s		
Rudder angle for neutral effect ______ °		
Thruster:	Bow ______ kW (______ HP)	Stern ______ kW (______ HP)

CHECKED IF ABOARD AND READY

Anchors ☐		Indicators:
Whistle ☐		Rudder ☐
Radar ☐ 3 cm ☐ 10 cm		Rpm/pitch ☐
ARPA ☐		Rate of turn ☐
Speed log ☐ Doppler: Yes/No		Compass system ☐
Water speed ☐		Constant gyro error ± ______ °
Ground speed ☐		VHF ☐
Dual-axis ☐		Elec. pos. fix. system ☐
Engine telegraphs ☐		Type ______
Steering gear ☐		
Number of power units operating ☐		

OTHER INFORMATION:

FIG. 2 Pilot Card *(continued)*

proposed transit speed until a speed of 1 knot is achieved in calm conditions at level trim in deep water.

5.3.2.2 Crash stop (full engine astern) advance and transfer distances at a speed of 1 knot with port and starboard locked rudder starting from the proposed transit speed in calm conditions at level trim in deep water.

5.3.2.3 Dead ship tow behavior and tow force requirements for a range of wind speeds characteristic of the escort area, including associated wave heights and the effects of vessel trim on towing behavior.

5.3.2.4 Data from full-scale ship-escort vessel trials, if conducted.

5.4 *Escort Vessel Data:*

5.4.1 It is recommended that, as a minimum, the escort vessel information shown in Fig. 6 be obtained.

5.4.2 In addition, the additional information shown in Fig. 7 can be used in the development of an escort plan.

5.4.3 Alternatively, data from scale model testing or instrumented full-scale trials can be used in the development of an escort plan.

5.5 *Waterway Data:*

5.5.1 *Transit Routes and Escort Zones*—Transit route(s) through the escort area must be identified. For routes that pass through distinctly different regions, it may be beneficial to divide the escort area into separate zones based on the environment and the severity of the constraints. This procedure will separate a zone with severe constraints from one that is less restrictive. Different escort vessels can be used in the different zones to satisfy the requirements of this guide.

5.5.2 *Navigational Constraints*—The geography of the escort area should be evaluated to determine its navigational limits. It is within these constraints that a disabled ship must be stopped or controlled if a grounding is to be prevented. Such limits might be prescribed by a minimum under-keel clearance, a particular depth contour, or a safety distance from a point hazard.

5.5.3 *Environmental Conditions*—The climatology of the escort area, including wind speeds, wind directions, wave heights, wave periods, wave directions, current speeds, and current directions should be assembled. If there are significant seasonal variations in the climatological conditions and if

Ship's name ____________, Call sign ________, Gross tonnage ________, Net tonnage ________

Max. displacement ______ tonnes, and Deadweight ______ tonnes, and Block coefficient ______ at summer full load draught

Draught at which the manoeuvring data were obtained

Loaded	Ballast
Trial/Estimated	Trial/Estimated
___m forward	___m forward
___m aft	___m aft

STEERING PARTICULARS

Type of rudder (s) ____________

Maximum rudder angle ______

Time hard-over to hard over
with one power unit ______ s
with two power units ______ s

Minimum speed to maintain course propeller stopped ____ knots

Rudder angle for neutral effect ______ °

ANCHOR CHAIN		
	No. of shackles	Max. rate of heaving (min/shackle)
Port		
Starboard		
Stern		
(1 shackle = _____m/_____fathoms)		

PROPULSION PARTICULARS

Type of engine ______, ___kW (___HP), Type of propeller ______

Engine order	Rpm/pitch setting	Speed (knots) Loaded	Ballast
Full sea speed			
Full ahead			
Half ahead			
Slow ahead			
Dead slow ahead			
Dead slow astern		Critical revolutions _____ rpm Minimum rpm____ ____ knots	
Slow astern		Time limit astern ___ min Time limit at min revs___ min	
Half astern		Emergency full ahead to full astern ___ s Stop to full astern ___ s	
Full astern		Astern power ___% ahead Max. no. of consecutive starts ___	

THRUSTER EFFECT at trial conditions					
Thruster	kW (HP)	Time delay for full thrust	Turning rate at zero speed	Time delay to reverse full thrust	Not effective above speed
Bow		s	°/min	min s	knots
Stern		s	°/min	min s	knots
Combined		s	°/min	min s	knots

DRAUGHT INCREASE (LOADED)				
Estimated Squat Effect			Heel Effect	
Under keel clearance	Ship's speed (knots)	Max. bow squat estimated (m)	Heel angle (degree)	Draft increase (m)
m			2	
			4	
			8	
m			12	
			16	

FIG. 3 Wheelhouse Poster

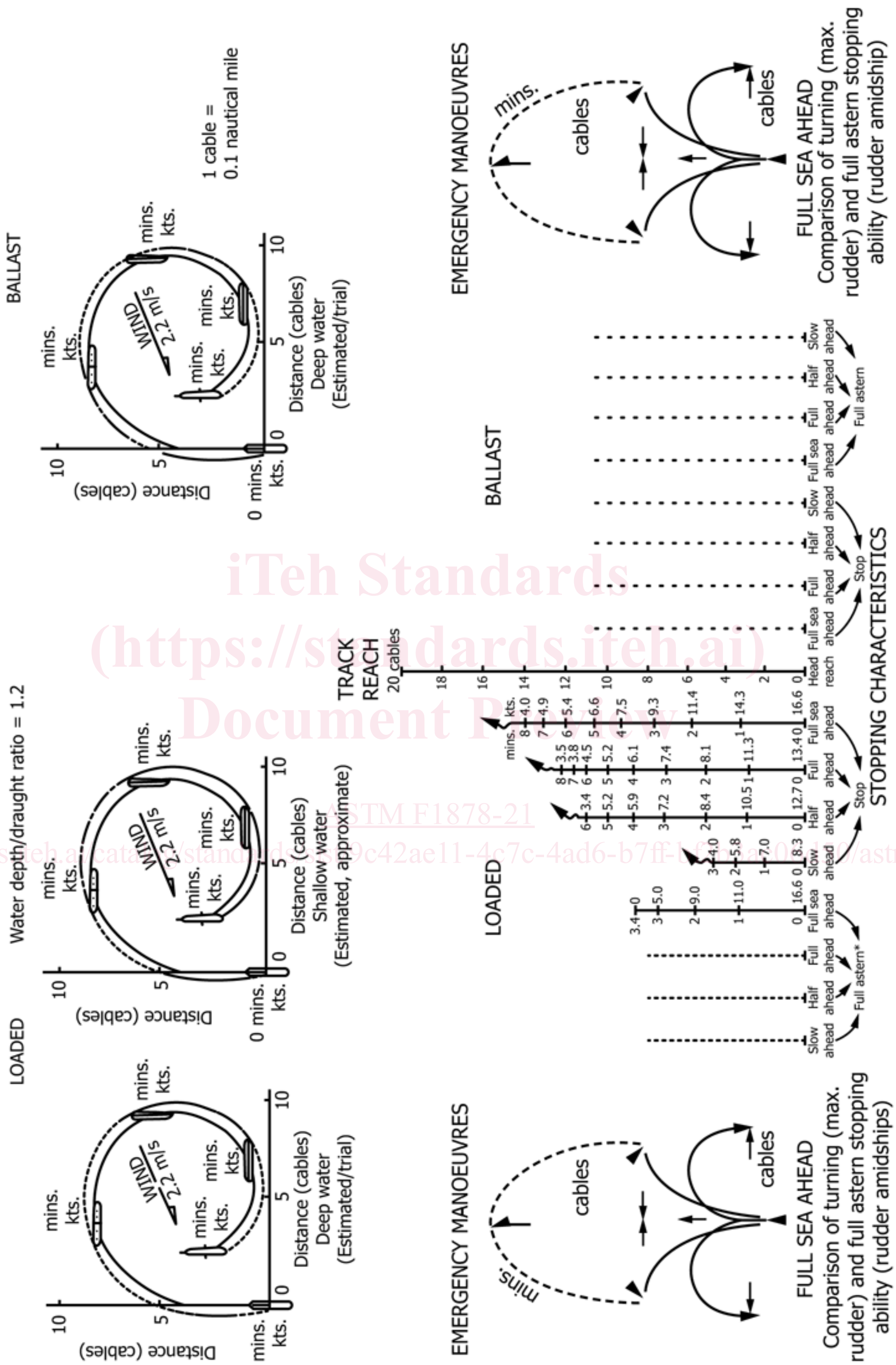
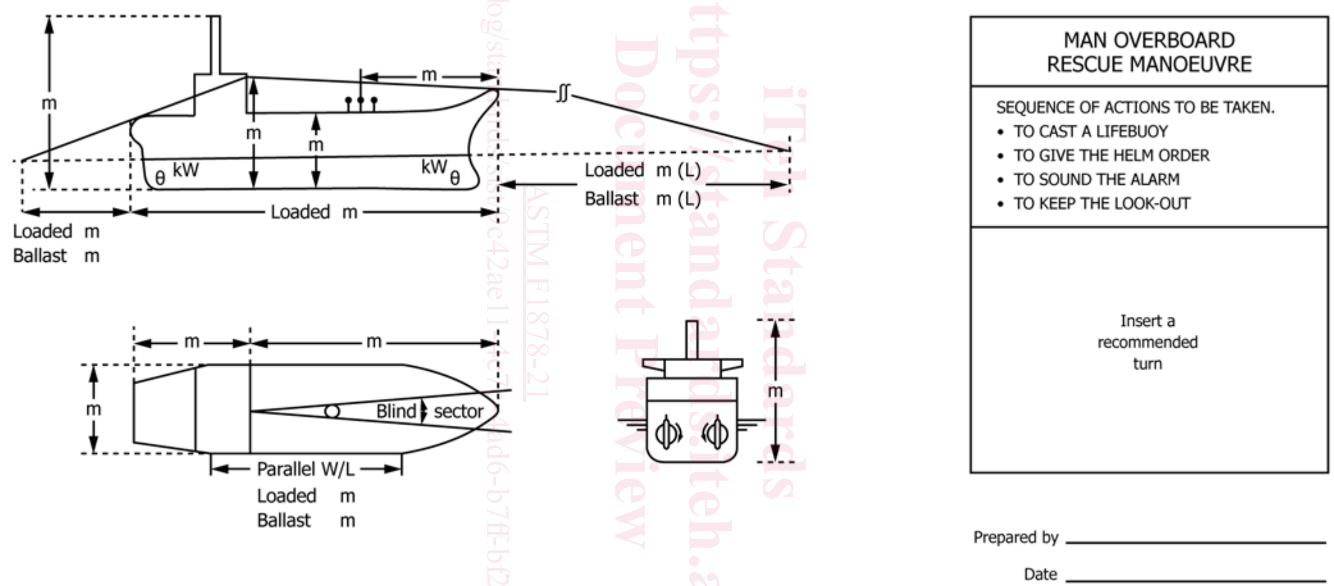


FIG. 4 Turning Circles at Maximum Rudder Angle



NOTE 1—Performance may differ from this record as a result of environmental, hull, and loading conditions.

FIG. 5 Man Overboard Rescue Maneuver

Escort vessel Name	
Type	
Owner	
Builder	
Year Built	

Basic Performance Data	
Horsepower (BHP)	
Ahead Bollard Pull	
Astern Bollard Pull	

Hull Data	
LOA	
Beam (Main Deck)	
Draft (operating)	
Freeboard (operating)	

Engine Data	
Make/Model:	
Number of Engines	
Maximum RPM	

Propeller Data	
Propulsion Type	
Number of Shafts and Props	
Prop. Type (No. Blades, etc.)	
Prop. Diameter	
Prop. Pitch	
Nozzle (Type)	
Nozzle Diameter	
Nozzle Length	

Deck and Escort Equipment	
Tow winch (make/model)	
Winch brake capacity	
Quick release features	
Towline (type/size)	
Breaking strength	
Bow winches and lines	
Firefighting Equipment	

Rudder Data	
Number of Rudders	
Rudder Shapes (flat, faired, etc.)	
Maximum Rudder Angles	
Flanking Rudders (yes/no)	

FIG. 6 Escort Vessel Data Form

seasonally varying escort plans are to be prepared, then the climatological data for each season should be assembled.

5.5.4 *Particular Hazards*—A list of points of particular hazard along the transit route should be compiled.

6. Determination of Escort Vessel Capability

6.1 Two different approaches to escort vessel performance measures are presented. Paragraph 6.2 discusses selected performance measures. Paragraph 6.3 discusses operational performance measures. Operational performance measures differ from selected performance measures in both definition and methodology for determination of adequacy.

6.2 *Selected Performance Measures:*

6.2.1 Selected performance measures can be thought of as the ship demand for escort vessel capability. These measures can be chosen by regulatory bodies at either the state or national level, or they can be chosen by vessel operators as a means of setting minimum performance standards for their own evaluation and selection of escort vessel(s). These measures can be specified so as to be waterway and weather independent. They would not require consideration of such operational issues as time delays for the application of escort vessel force and procedures for applying those forces.

6.2.2 Example performance measures are presented in Appendix X1.

6.3 *Operational Performance Measures:*

6.3.1 Operational performance measures are ship, waterway, and season specific. An example of this type of performance measure is contained in 33 CFR 168.50 Part (a). It reads, in part: "... at all times during the escort transit each tanker to which this part applies: ...(2) Must have the escort vessels positioned relative to the tanker such that timely response to a propulsion or steering failure can be effected. (3) Must not exceed a speed beyond which the escort vessels can reasonably be expected to safely bring the tanker under control within the navigational limits of the waterway, taking into consideration ambient sea and weather conditions, surrounding vessel traffic, hazards, and other factors that may reduce the

Name:	
HULL:	
LWL	
Beam	
Draft	
Freeboard	
Displacement	
Wetted Surface	
GM(corrected)	
KG	
Vertical Coordinate of Center of Bow Fenders	
Vertical Coordinate of Line in Bow Staple	
Vertical Coordinate of Line in Towing Staple	
Underwater Lateral Area of Hull	
Longitudinal Coordinate of Center of Pressure for Hull	
Vertical Coordinate of Center of Pressure for Hull	
Bow Entrance Angle	
SKEG (if fitted)	
Aspect Ratio of Skeg	
Lateral Area of Skeg	
Longitudinal Coordinate of Center of Pressure for Skeg	
Vertical Coordinate of Center of Pressure for Skeg	
RUDDERS (if fitted)	
Number of Rudders	

FIG. 7 Escort Vessel Additional Data Form

available sea room." An operational analysis needs to consider transit speed, time delays, sea and weather conditions, navigational constraints, failure modes, type of assistance used, ship fitting, and other factors.

6.3.2 The adequacy of the escort under this section can be demonstrated through computer simulations, model-scale or full-scale trials, or a combination of both.

6.3.3 *Failure Modes*—Failure modes for an operational analysis are to be defined. Possible failure modes include propulsion failure, steering failure, or steering failure without the use of ship propulsion. The escort requirements differ significantly, depending on the failure scenario.

6.3.4 *Time Delays*—Time delays for an operational analysis are to be defined. Actual time delays can vary significantly as a result of differences in human performance, weather conditions, nature of casualty, ship speed, escort vessel type, escort position, escort mode, emergency assist procedures, and equipment. The time delay chain of events should include each of the following, if applicable.

6.3.4.1 Time delay for failure recognition aboard the transiting ship (consideration can be given to on-board failure alarm systems),

6.3.4.2 Time delay to consider options and cures and notify escort vessel(s),

6.3.4.3 Time required to maneuver escort vessel(s) from its escort position to the ship,

6.3.4.4 Time required to connect any lines, and

6.3.4.5 Time required to stream lines and develop tension.

6.3.5 The possibility that an emergency assist might be required under adverse conditions, such as storms, darkness, times of poor visibility, conditions with ice on the decks, or difficult communications caused by winds and darkness, is to be considered.