Designation: F 1878 – 98 (Reapproved 2004)

An American National Standard

# Standard Guide for Escort Vessel Evaluation and Selection[1]

This standard is issued under the fixed designation F 1878; 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.

## 2. Referenced Documents

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

33 CFR Part 168—Escort Vessels for Certain Tankers, Final Rule

2.2 *IMO Resolutions:*[3]

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

IMO Resolution A.751(18)—Interim Standards for Ship Maneuverability

2.3 *Marine Safety Committee Circulars:*[3]

MSC Circular 389/Interim Guidelines for Estimating Maneuvering Performance in Ship Design

MSC Circular 644/Explanatory Notes to the Interim Standards for Ship Maneuverability

## 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.

[1] This guide is under the jurisdiction of Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.06 on Marine Environmental Protection.

Current edition approved May 1, 2004. Published May 2004. Originally approved in 1998. Last previous edition approved in 1998 as F 1878 - 98.

[2] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[3] Available from the International Maritime Organization, 4 Albert Embankment, London, SE1 7SR U.K.

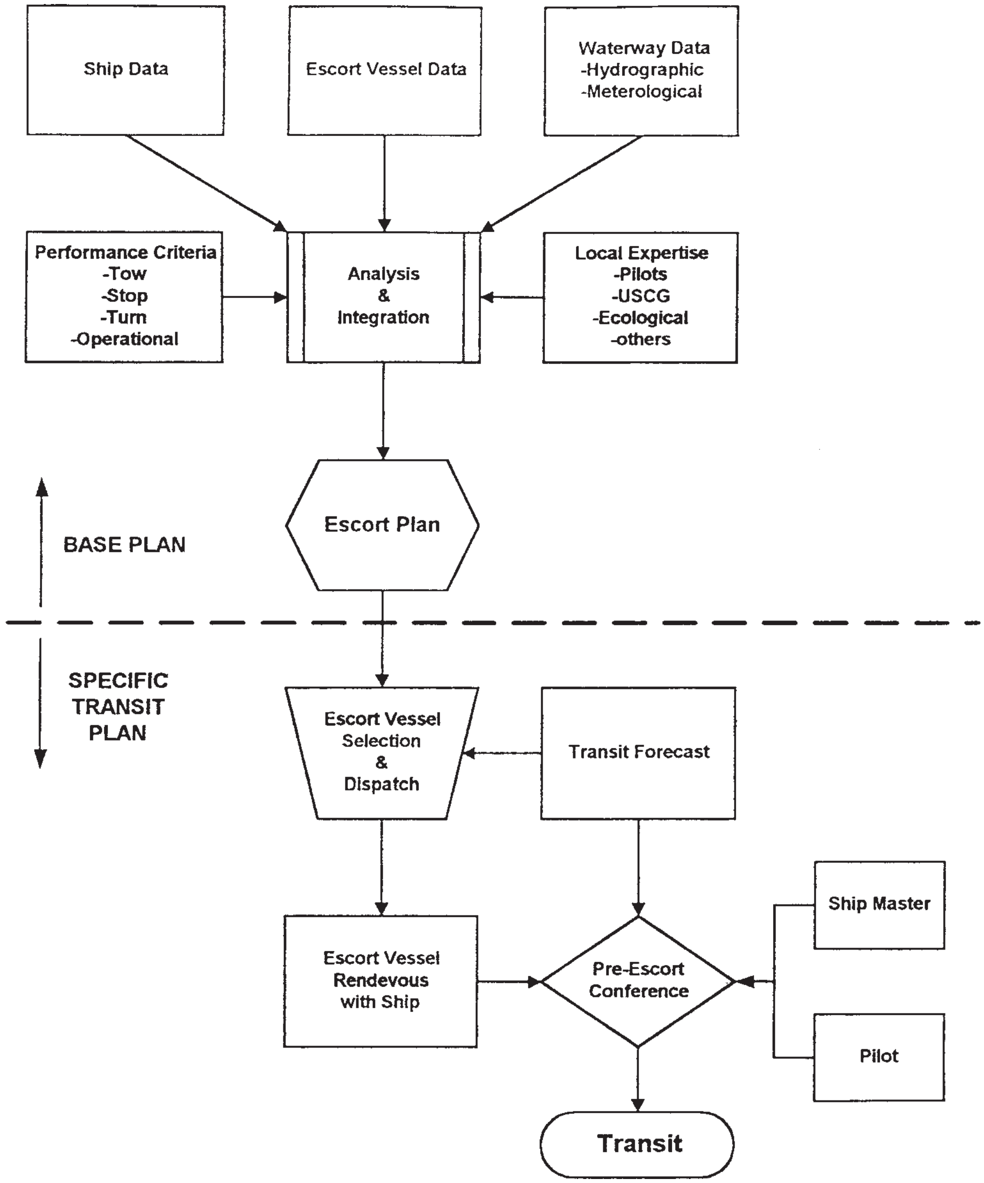



**FIG. 1 Flowchart of the Overall Process for Developing and Implementing an Escort Plan**

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 "omni-directional 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 644, Section 2.2.

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 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 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.

Ship's name ______________________ Date ____________

Call sign ________ Deadweight ________ tonnes Year built ________

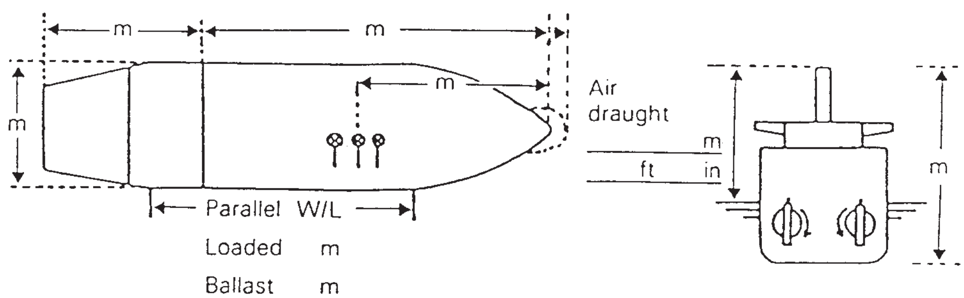
Draught aft _____m/____ft ____in, Forward _____m/____ft ____in, Displacement ______tonnes

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 | 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)*

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 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.

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<br>Minimum rpm ____ ____knots | | |
| Slow astern | | Time limit astern ____min<br>Time limit at min revs ____min | | |
| Half astern | | Emergency full ahead to full astern ____s<br>Stop to full astern ____s | | |
| Full astern | | Astern power ____% ahead<br>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

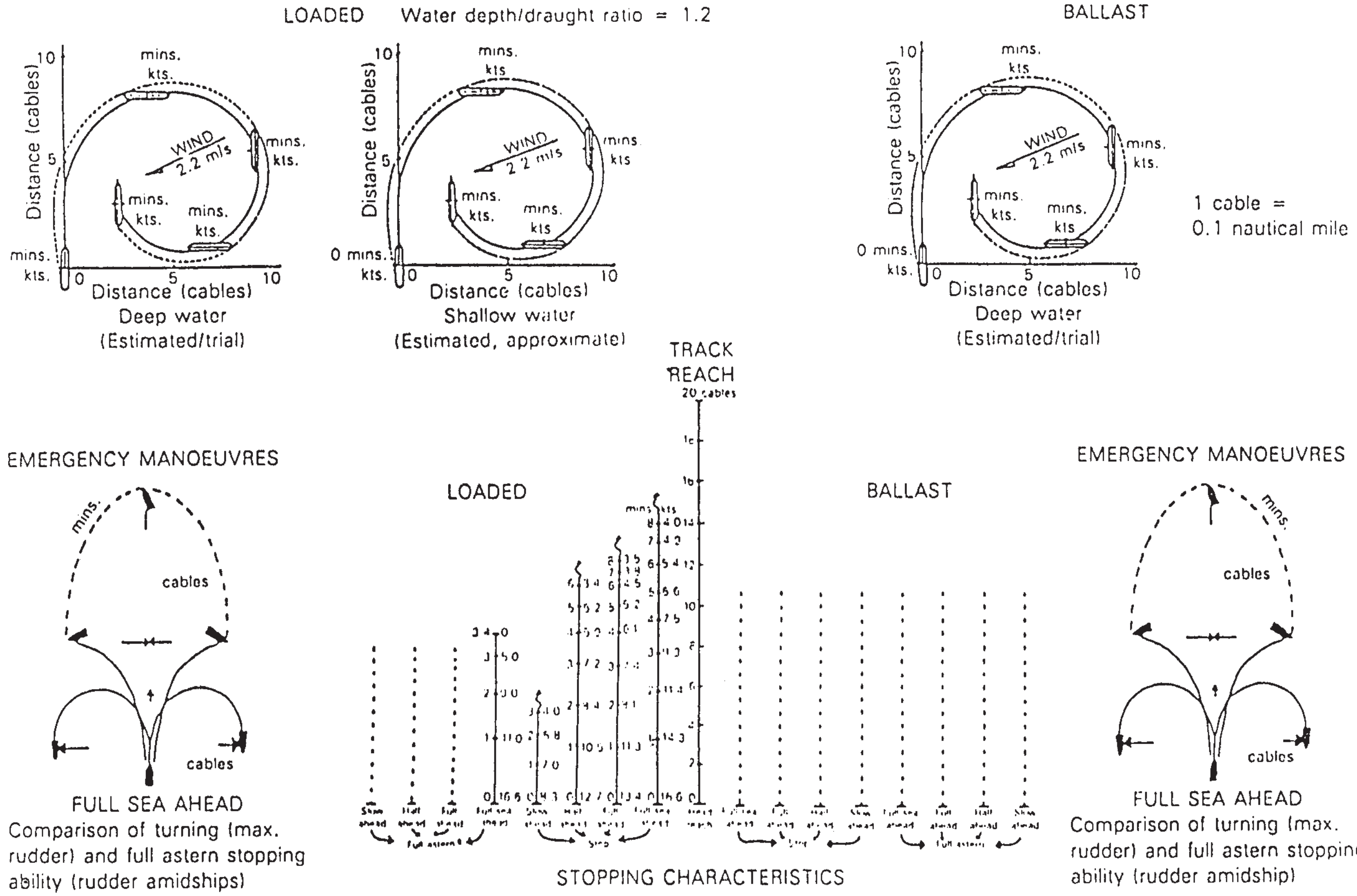
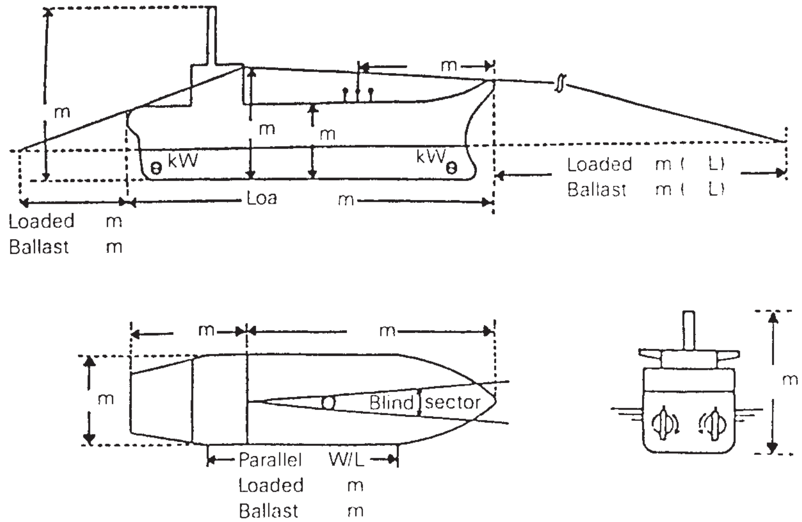



FIG. 4 Turning Circles at Maximum Rudder Angle




**MAN OVERBOARD RESCUE MANOEUVRE**

SEQUENCE OF ACTIONS TO BE TAKEN.

- TO CAST A LIFEBUOY
- TO GIVE THE HELM ORDER
- TO SOUND THE ALARM
- TO KEEP THE LOOK-OUT

Insert a recommended turn

Prepared by ____________________

Date ____________________

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**

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 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),

| | |
|---|---|
| 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**

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.

6.3.6 Estimates should be based on experience, full-scale trials, commentary from experienced masters, and other reliable available data.

6.3.7 *Type of Assistance*:

6.3.7.1 An escort vessel must be capable of providing assistance in towing, stopping, and steering. The way in which this assistance is provided will depend on the nature of the ship's casualty, its speed, navigational constraints, escort vessel type, escort position, and escort mode (whether tethered or untethered).

6.3.7.2 The towline forces for steering and braking assist can be substantially higher than the loads that the bitts and chocks of many existing ships have been designed to accommodate. The braking and steering assist forces above the safe limits of the ship's fittings should not be considered in an operational analysis.

6.3.7.3 The capability limits of escort vessel fittings should be evaluated. Assist forces above the safe limits of the escort vessel fittings should not be considered in an operational analysis.

6.3.7.4 The use of the disabled ship's astern thrust and the deployment of its anchors to complement the action of the escort vessel(s) or other actions should be considered.

6.3.8 *Navigational Constraints*:

| | |
|---|---|
| Rudder Type: (Flat Plate, Trailing Edge Wedge, NACA, High Lift, other) | |
| Maximum Rudder Angle | |
| Chord | |
| Span | |
| Aspect Ratio | |
| Rudder Area | |
| ENGINES: | |
| Number | |
| Manufacturer and Type | |
| Maximum RPM | |
| Rated RPM | |
| BHP at Rated RPM | |
| Gear Ratio | |
| Gear Efficiency | |
| Shaft Efficiency | |
| PROPELLERS | |
| Type: open wheel, nozzle, steerable nozzle, azimuthing, cycloidal, other | |
| Four quadrant Kt vs Beta curves | |
| Propeller Interaction Effects | |
| Longitudinal Coordinate of Center of Thrust for Propellers | |
| Transverse Coordinate of Center of Thrust for Propellers | |
| Vertical Coordinate of Center of Thrust for Propellers | |
| FENDERING | |
| Description (Type, materials, etc.) | |
| Dimensions (Vertical Extent at Bow, Length along side, Depth from hull) | |
| Locations (Bow, midship, stern, etc.) | |

**FIG. 7 Escort Vessel Additional Data Form** *(continued)*

6.3.8.1 A quantitative definition of the navigational constraints for each escort zone in terms of an allowable reach and an allowable transfer must be determined. The analysis is to include distances to point constraints such as bridges, rocks, and islands, as well as to bottom contours. In evaluating the navigational constraint, consideration can be made between grounding on hard bottom, which may potentially open the hull, and on soft bottom, such as mud, which may not.

6.3.8.2 It is not intended that the escort analysis or escort plan define the transit route that ships must take in a particular waterway. It is recognized that tracklines chosen during an actual transit may differ from those used in the preparation of the escort plan. However, the escort plan should be based on the average or most likely route that the ship will take in the waterway. Thus, allowable reach and transfer distances can be based on the average or most likely transit route.

6.3.8.3 The offtrack distances from a disabling failure scenario, including the effects of escort vessel assistance, are to be compared with these allowable distances to determine the adequacy of escort vessel selection. The offtrack distances can be obtained from full-scale trials, model-scale testing, or computer simulations.

6.3.8.4 There are several methods of determining the numerical values of the available reach and transfer distances. The simplest is to choose the absolute minimums as used from a trackline chosen for each ship's purposes. Using this definition, the reach constraint would be the shortest straight-ahead distance from a turn in the transit route to the constraint directly ahead. The minimum transfer distance would be the shortest perpendicular distance to constraints on either side. However, if this approach is adopted, the escort requirement would be based on a single-point exposure to the worst case hazard, which may be too restrictive in relation to the entire transit route.

6.3.8.5 An alternative approach is to define the reach and transfer constraints as a statistical measure of the exposure of the vessel to potential grounding/allision situations. The statistical measure could be the average distance ahead and abeam measured throughout the entire transit in the escort zone of interest. Percentile measures of reach and transfer distances can also be determined. For example, the 95$^{th}$ or 98$^{th}$ percentile levels can be used to define the navigational constraint. The procedure for the calculation of statistically defined constraints begins by measuring the reach and transfer distances from the normal ship track to a constraint. To do this, the transit is divided into evenly spaced segments, and the ahead and abeam distances measured. A histogram of the measurements showing the frequency distribution of reach and transfer is then constructed (Fig. 8). Cumulative frequency distributions are developed and used to determine the percentile reach and transfer for any particular transit. An example calculation is shown in Figs. 9 and 10.

6.3.8.6 Other reasonable methods of determining available reach and transfer distances may be developed.

6.3.9 *Environmental Conditions*—The behavior of a disabled ship and the capability of an escort system are influenced by the environmental conditions. The environmental factors to be considered include wind speeds, direction and duration, wave heights, periods and directions, current velocities, and direction. Seasonal variations in climatological conditions should be considered in escort operations analysis and escort vessel selection.

6.4 *Stability of Escort Vessels*:

6.4.1 Some modes of escorting may result in an escort vessel being subjected to forces, both static and dynamic, that cause heeling moments in excess of those for which the escort vessel was originally designed.

6.4.2 Conventional stability analysis techniques consider the effects of heeling moments only in a static condition. The impact of vessel speed and the resulting hydrodynamic forces acting on the vessel are not considered.

6.4.3 Escort vessels with omni-directional propulsion systems deliberately can be placed abeam to the direction of the tow line to achieve high retarding forces. Such attitudes can result in high heeling angles at higher speeds and, thus, a potentially sudden incidence of deck edge submergence.

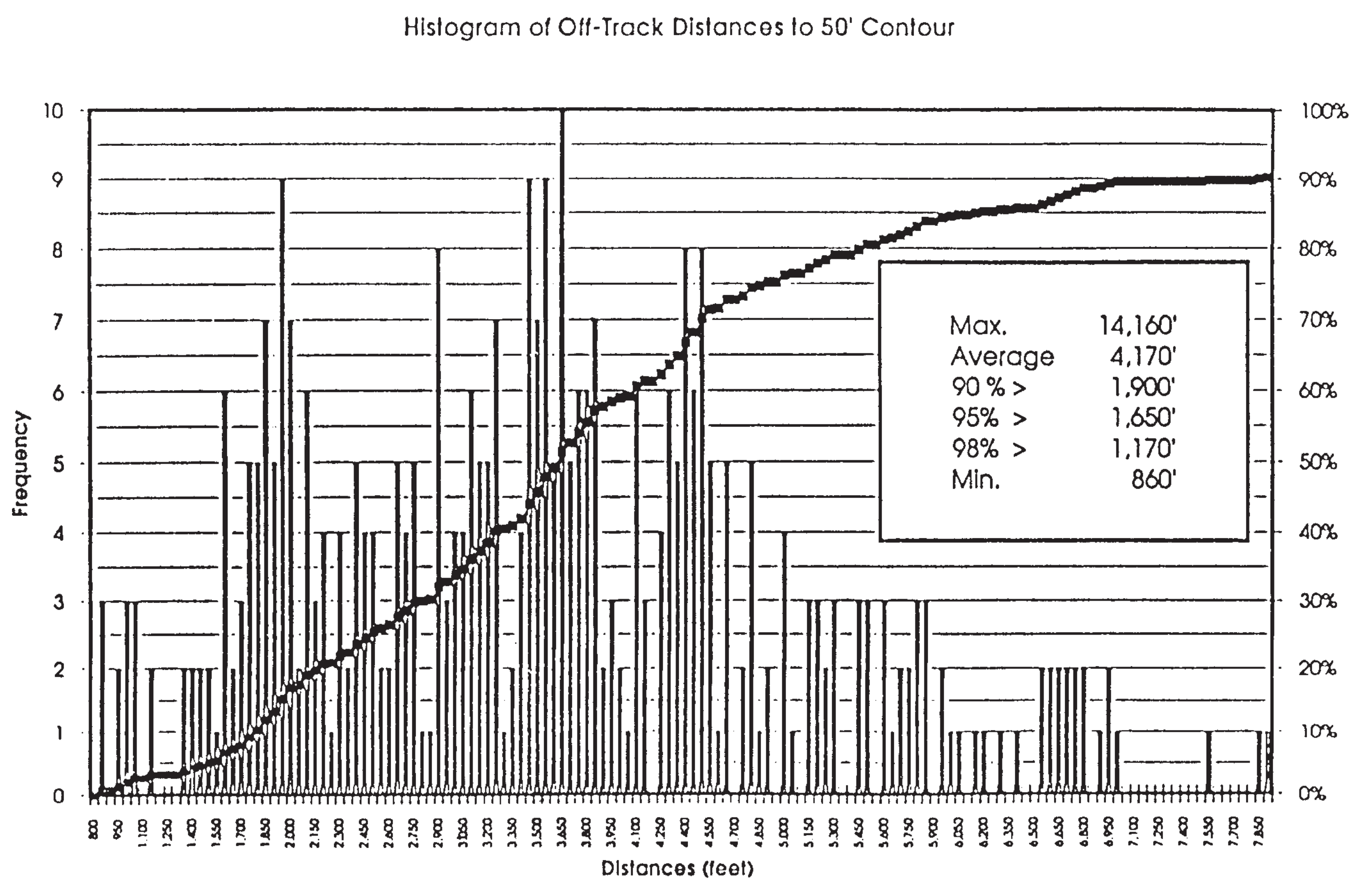



FIG. 8 Histogram of Transfer Distances from Track to 50-ft Depth Contour

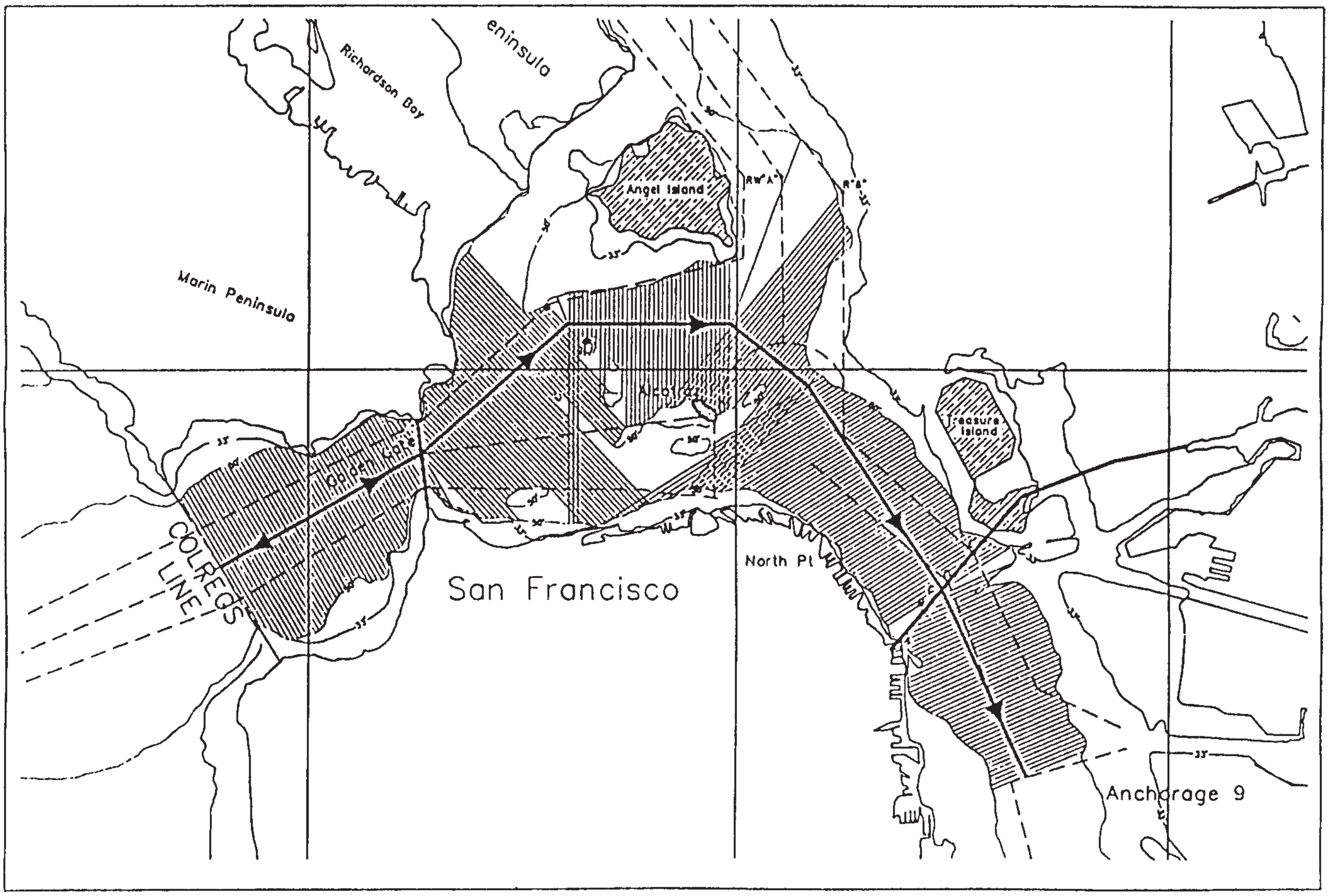



**FIG. 9 Example Calculation of a Statistical Measure of the Navigational Constraint; Transfer Distances from Track to 50-ft Depth Contour**

6.4.4 The stability analysis of escort vessels must consider all potential attitudes of the escort vessel to the direction of line pull, the maximum line pull, and the resultant combination of heel and trim on the escort vessel.

6.4.5 For all escort vessels, a limiting heel angle must be established. This limit might be the geometrical submergence of the main deck, including the loss of freeboard as a result of waves.

6.4.6 The stability analysis must include the effects of fenders, skegs, nozzles, rudders, and any other appendages on both the reserve buoyancy and the lateral resistance of the escort vessel.

6.4.7 The stability analysis must include the contribution to heel and trim of the propulsion system in conjunction with maximum line forces.

6.4.8 The stability analysis must include an evaluation of the reaction of the escort vessel to an instantaneous release of the line forces and the propulsive forces.

6.5 *Procedures for Determination of Escort Vessel Capabilities*:

6.5.1 *Full-Scale Trials*:

6.5.1.1 Full-scale ship-escort vessel trials, wherever they can be properly designed and safely executed, may be used to verify the adequacy of escort vessel(s). These trails should be carefully planned in conjunction with ship owners and escort vessel operators to ensure proper evaluation of escort vessel(s). The differences between the environmental conditions prevailing at the time of the test and the postulated environmental conditions during the actual transit should be accounted for in the analysis.

6.5.1.2 Full-scale ship-escort vessel makeup trials can provide examples of the time taken by an escort vessel to approach a ship and begin to render effective assistance. However, the trials may take place in conditions different from emergency conditions and when the crew is fully prepared for the test. Thus, time delays obtained in these tests will, in most cases, underestimate the time required in a true emergency.

6.5.1.3 The ship's position during the course of the trials is to be continuously recorded. Observers should be stationed on the vessels to monitor the precise sequence of events aboard the ship and the actions taken by the escort vessel(s). The water depth, the ship's loaded condition, the load condition of the escort vessel, and the environmental conditions prevailing at the time of the trials are to be noted.

6.5.1.4 At no point in the course of the trials should the safety of the vessels and their crew be compromised.

6.5.1.5 At the conclusion of the trials, the results are to be analyzed and the ship tracks plotted. Corrections for any currents, wind loads, ship and escort vessel operating condition, and the GPS antenna location on the ship are to be incorporated, if applicable.

6.5.2 *Ship Model for Computer Simulation*:

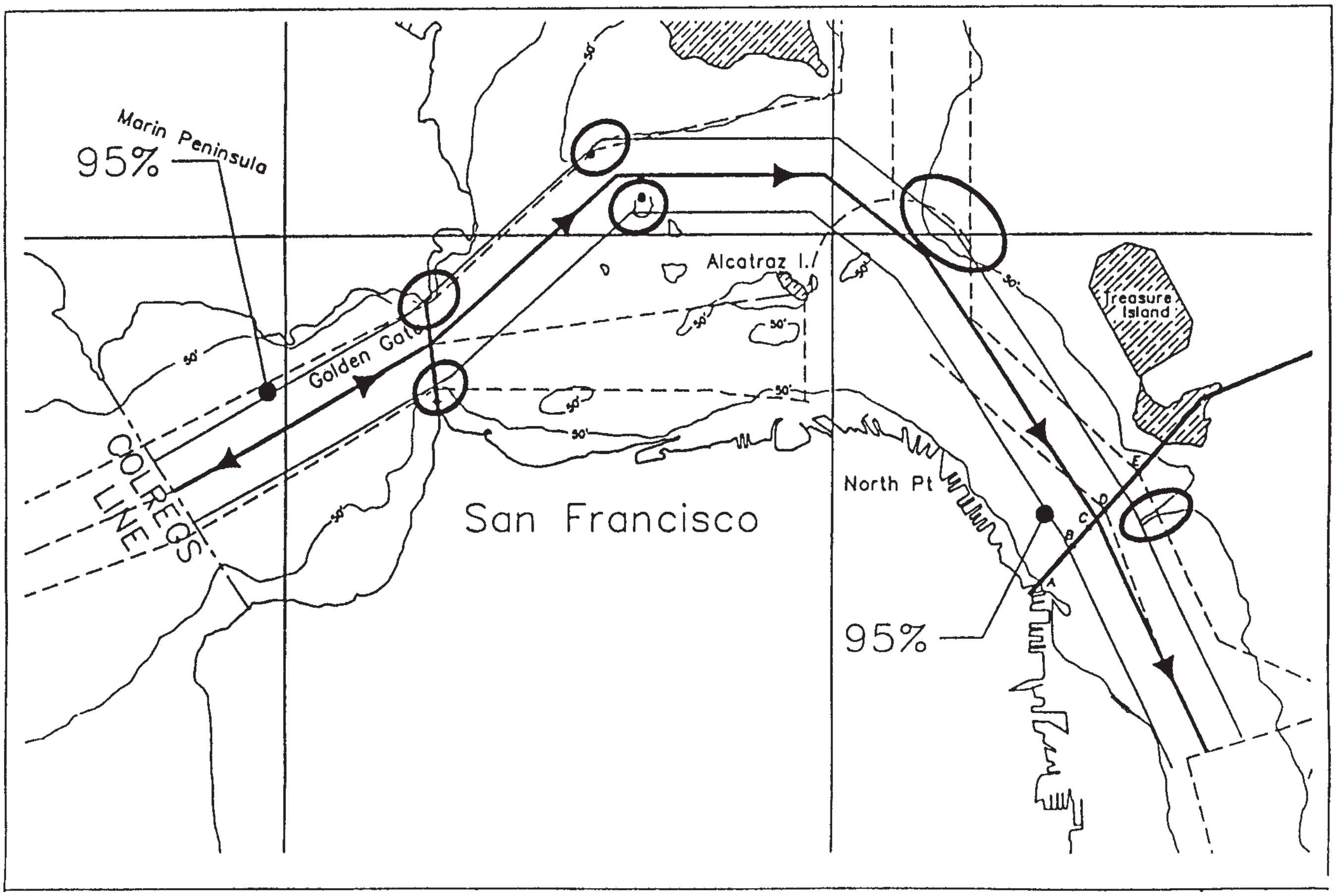



FIG. 10 Example Statistical Transfer Distances

6.5.2.1 As an alternative to full-scale trials, a validated ship-maneuvering simulation program can be used to verify the adequacy of escort vessel(s).

6.5.2.2 The coefficients of the underlying mathematical model of ship maneuvering may be obtained from an appropriate database established by properly conducted physical model tests. The coefficient set shall be suitable for the type of ship and the waterway bathymetry being modeled. Restricted water effects, such as bank suction and shallow water effects on maneuvering, shall be considered. Effects of ship-ship interaction on maneuvering shall be considered where appropriate.

6.5.3 *Escort Vessel Model for Computer Simulation*:

6.5.3.1 The performance of an escort vessel in an emergency maneuver depends on its ability to apply corrective forces to the disabled ship either through a line or through direct contact with the ship's hull. The forces may be applied while the disabled ship is still moving at speeds close to its transit speed, except where sea room is available to allow the disabled ship to slow without escort vessel intervention. Three distinct assist modes are to be evaluated. They are: stopping (also called retarding or arresting), steering, and towing. The assist forces in these modes should be properly evaluated and applied to the ship model as external forces.

6.5.3.2 Conventionally propelled escort vessels apply braking force by backing down on a head line while being dragged through the water by the disabled ship. The braking capability and clutch-in speed of a conventional escort vessel can be calculated using fourth quadrant open water propeller curves for the installed propellers, including the hull-propeller interaction effects, and the drag of the hull. For conventionally propelled escort vessels, the braking force may be assumed to be constant up to the clutch-in speed and equal to that measured in reverse bollard pull trials.

6.5.3.3 The braking force of a vertical axis cycloidal escort vessel (in direct and indirect modes) and the braking force of an azimuthing propelled escort vessel (in reverse, transverse, or indirect modes) can be calculated from open water propeller curves for the installed propellers, including the hull-propeller and propeller-propeller interaction effects, and the lift and drag of the hull at its equilibrium attitude to the flow.

6.5.3.4 Alternatively, the braking force as a function of advance speed can be determined from scale-model testing or instrumented full-scale trials.

6.5.3.5 The emergency assist steering capability of the escort vessels can be quantified by a pair of speed-dependent vector force functions, a maximum steering force together with an associated pushing or braking force. The hydrodynamics of the underwater hull with any skegs, rudders, and appendages, the propeller characteristics and stability, including freeboard and metacentric height, should be considered in the evaluation of these vector force functions. The assumed position of the escort vessel at the bow or stern, or when pushing on the side or transom, or when pulling on a line, is to be properly modeled. When the escort vessel is pushing on the transom or the side of the disabled ship or pulling on a headline, the steering force is accompanied by a longitudinal force which affects the speed of the disabled ship. Likewise, when steering by pulling on a line from the stern of the disabled ship, the steering force is accompanied by a braking force which can affect the speed of the ship.

6.5.3.6 For all escort vessel types, a heel angle limit should be established. This limit can be the geometrical submergence of the main deck edge including the loss of freeboard as a result of waves. Even though it may be possible to submerge a portion of the main deck and produce somewhat larger steering forces, the stability of the escort vessel decreases rapidly.

6.5.3.7 The emergency assist steering capability of the escort vessel can be calculated by solving the equilibrium free body problems for a hull in a free stream. The solution corresponds to a quasi-steady state condition in which the horizontal-plane forces and moments are in balance. The dynamic fluctuations in the forcing functions can be assumed to be negligible with respect to the time rate of change of ship momentum, and small with respect to the average force capability of the escort vessel. The analysis should include the hydrodynamic forces on the escort vessel hull, skeg, and other appendages and fenders; the lift and drag forces acting on the rudders (if present); and the thrust of the propellers. The analysis should include flow modifications, such as the flow straightening and wake effects of the hull on the flow entering the propellers, and modifications to the direction and magnitude of the velocity field acting on the rudders (if present) as a result of the propeller slipstream. In addition to the hydrodynamic forces on the underwater hull, the equilibrium is affected by all lines and escort vessel-ship contact. The components of a complete quasi-steady state analysis are summarized in Appendix X2. Effects of escort vessel motions on freeboard can be ignored. These are time-dependent dynamic processes and can be assumed not to affect significantly the quasi-steady state solution.

6.5.3.8 Alternatively, the emergency assist steering force as a function of advance speed can be determined from scale-model testing or instrumented full-scale trials.

6.5.3.9 Towing capability can be determined by the thrust and torque characteristics of the propeller and the resistance of the escort vessel, towed vessel, and towline at speed. The calculation should use an accurate model of the escort vessel's propulsion system. The solution of thrust, torque, RPM, and required power should be checked for propeller cavitation, RPM limitations, and engine capacity. The towing capability predicted in calm water should be modified for sea conditions by reducing the RPM of the engines and adding steady wave forces and wind loads to the escort vessel hull.

6.5.3.10 *Capability Reductions Because of Vessel Condition*—Towing performance is reduced as the engines, shafting, and propellers deviate from design specifications. Accountability should be made for significant changes in capability caused by any change in escort vessel condition. The performance of a selected escort vessel can change as a result of the degradation of equipment or stability characteristics over time. The capability of the selected escort vessel(s) should be reassessed periodically to ensure the performance is adequate to meet the needs of the escort plan.

6.6 *Escort Vessel Equipment*:

6.6.1 The fittings and equipment installed in an escort vessel must be capable of, and suitable for, the safe transmission of forces and loads between the escort vessel and the designated ship. Both the equipment and the manner in which it is connected to the structure of the escort vessel must be designed in recognition of the maximum loads anticipated during emergency maneuvers.

6.6.2 *Towline Winch*—Winches designed for installation on board escort vessels shall be designed and constructed in accordance with the following specifications:

6.6.2.1 The winch foundation, drum, and ancillary structures shall be designed to accept the maximum anticipated dynamic and static loads with appropriate factors of safety.

6.6.2.2 Winch performance shall be commensurate with the operator's requirements for safe operations. Performance criteria of light line speed, static line pull, and brake capacity of the winch should be considered when evaluating the escort vessel's suitability. Other tow winch features that should be considered are a fail-safe and properly located abort mechanism, load tension devices, and a method to spool the towline to prevent burying under severe tension.

6.6.3 *Towlines*:

6.6.3.1 The towline between the escort vessel and ship is critical to any successful escort maneuver, but should be designed as the weak link in the system. The towline should fail before any mechanical or structural component on the escort vessel. If the strength of the towing connection on a designated ship is unknown or suspect, the escort vessel operator may consider operational restrictions that would reduce the potential for high line loads.

6.6.3.2 Towlines for escort service should be sized to the mission and capabilities of the escort vessel, with consideration of the appropriate safety factor of the type of line used.

6.6.3.3 Towlines for escort duty must be routinely inspected for proper condition.

6.6.4 *Towline Connectors*—Instead of a line winch and towline stored aboard and controlled by the escort vessel, the connection between the escort vessel and ship may be made by using a towline stored aboard the designated ship. In this case, the escort vessel must be equipped with a device capable of the following:

6.6.4.1 Rapidly and safely securing the line to the escort vessel,

6.6.4.2 Rapidly and safely disconnecting the line from the escort vessel, and

6.6.4.3 Sustaining the highest anticipated loads experienced during the escort maneuvers.

6.6.5 *Ground Tackle*—Escort vessels should be equipped with ground tackle (anchors, cables, and so forth) in compliance with classification society requirements for ocean service.

6.6.6 *Fendering*:

6.6.6.1 Escort vessels shall be fully fendered to preclude damage in the event of contact between the escort vessel and the designated ship.

6.6.6.2 Fender type and geometry shall be arranged to provide a resilient contact zone between the escort vessel and ship, such that when the maximum static bollard pull of the escort vessel is applied, the structural limits of the ship's side or stern are not exceeded, and the fender system is not stressed beyond its design limits.

6.6.7 A line-throwing apparatus is required to facilitate rapid connection between the escort vessel and the ship.

## 7. Methodology for Escort Vessel Selection

7.1 The methodologies presented in this section provide the user with three alternatives for analyzing an escort situation and can be used as guidance in the selection of an escort vessel. The different approaches are: (1) a ship-specific analysis using computer simulation of specific escort vessel(s) in a matrix of operating conditions; (2) a parametric study of the trends in the results of escort vessel-assisted maneuvers using a number of ships, escort vessel(s), and operating conditions; and (3) a demand versus capability study.

7.2 Other methodologies may be developed for escort vessel selection, but must be validated with literature citations, scale-model testing, or full-scale testing.

7.3 *Simulation Matrices*:

7.3.1 The use of a matrix of scenarios to identify escort requirements is based on an analysis of individual or representative ships matched with specific escort vessel(s). This method requires using ship-specific and escort vessel-specific information.

7.3.2 A matrix of simulation cases is to be defined so that acceptable escort solutions can be identified for each escort area and transit condition. The matrix should include appropriate combinations covering all relevant geographic regions, climatic conditions, navigational conditions, operating speeds, failure modes, escort deployments, time delays, and types of assistance.

7.3.3 A computer simulation of the escort vessel acting on the disabled ship should be carried out for each combination in the matrix. The resulting ship trackline should be plotted and then compared with the navigational constraints of the waterway. Based on this process, acceptable escorts are identified for all applicable geographic regions, climatic conditions, navigational conditions, and transit speeds.

7.3.4 Computer simulation of disabled ship maneuvers with escort vessel assist requires a validated computer model. This can be accomplished using the ship and escort vessel information discussed in 5.1, 5.2, and Section 6. Additional validation can come from full-scale trials.

7.4 *Parametric Studies*:

7.4.1 A parametric study is an extension of the matrix of simulation cases presented in 7.3. However, unlike the matrix of cases described in 7.3, which evaluated specific climatic conditions and transit speeds, this approach uses a matrix of scenarios based on parametric variations in climatic conditions, operating speeds, and time delays. Each scenario in the matrix is analyzed using a particular ship and escort vessel.

7.4.2 The results of the parametric study can be presented in a graphical form by plotting a measure representing the outcome of the emergency assist (transfer distance) as a function of any of the underlying parameters, while holding the remaining parameters fixed. For example, a plot of the transfer distance as a function of the initial speed will clearly demonstrate the change in the escort vessel's ability to control the ship as transit speed changes. Similarly, a plot of the transfer distance as a function of wind speed or current speed will show the change in the ability of the escort vessel to control a disabled ship in different climatic conditions. In this example, comparing the transfer results with the navigational limits of the waterway will enable the selection of a transit speed or an environmentally imposed operational limit.

7.4.3 Computer simulation of disabled ship maneuvers with escort vessel assist requires a validated computer model. This can be accomplished using the ship and escort vessel information discussed in 5.1, 5.2, and Section 6. Additional validation can come from full-scale trials.

7.5 *Demand Versus Capability Formulation*:

7.5.1 The approach is advantageous when a diverse range of escorted ships and escort vessels are to be considered. It can be used to select a suitable escort system for a given ship at a prescribed displacement and speed, transiting a particular escort area. The ship's "demand" for assist forces is separated from the "capability" of the escort vessel and must not exceed the demand to have an acceptable escort system.

7.5.2 The demands of the ship requiring escort shall be quantified as a function of the displacement, speed, time delays, and the prevailing environment. The "demand" measures generally take on scalar values of force or distance. They should be specific to the failure mode and the escort area. They are to be independent of escort vessel parameters.

7.5.3 The capabilities of a vessel providing escort should be established as a function of the speed and the prevailing environment. They should be independent of ship parameters. The capability measures must have the same measurement units as the demand.

7.5.4 Once the demands and capabilities are established, they should be clearly tabulated. The governing demand can be taken as the maximum demand across all possible failure modes. An escort vessel or escort vessel combinations with a total capability sufficient to meet or exceed the governing demand qualify as acceptable escorts. Alternative escort choices for any given ship at a prescribed displacement and transit speed in any escort area should then be easily identifiable from the tables.

7.5.5 Because of the simplifying assumptions inherent in a demand versus capability formulation, the demand and capability determination of escort vessel selection should be double-checked. This should be done by demonstrating that the selected escort vessel(s) capabilities meet or exceed the demand of a disabled ship, and that they are capable of rendering timely assistance to the disabled ship and bringing it 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 available sea room. The validation should be carried out through full-scale trials or computer simulations and should cover the full range of ship, escort vessel, and environmental parameters.

## 8. Preparation of An Escort Plan

8.1 *Components of an Escort Plan*—This section provides recommendations for developing an escort plan. The plan may be ship- or ship class-specific. It should provide clear and precise instructions regarding the escorted segment of the voyage. Forms are to be developed and included in the plan for presenting the applicable voyage, ship- and escort vessel-specific information. Flowcharts may be developed for the various activities to be performed.

8.2 *Information and Assumptions*:

8.2.1 It is recommended that able ship-maneuvering characteristics be compiled in the form of the maneuvering booklet recommended in IMO Resolution A.601(15). MSC/Circular 389 may be consulted for guidance on estimating maneuvering performance. In addition, escort-specific information, including the current condition of the ship with regard to its loading, propulsion and maneuvering equipment, and so forth, should be available in the form of the pilot card recommended in IMO Resolution A. 601(15).

8.2.2 The plan should include all additional information that is useful for understanding the ship's behavior and how it affects emergency assist requirements. If this information is not available, the escort plan should indicate that it is not available. Data from full-scale ship-escort vessel trials, if available, are to be assembled and included in the escort plan.

8.2.3 Any assumptions used in the selection of the escort vessel(s) should be documented. These include time delays, failure modes, environmental conditions, and emergency assist maneuvers.

8.2.4 *Particular Hazards*—The escort plan should include a list of points of particular hazard along the escort transit or shall contain a reference to the relevant published compilation of the points of particular hazard, such as the Coast Pilot.

8.2.5 All Coast Guard, VTS, and marine traffic control contacts, radio frequencies, and phone numbers for the escort area should be listed in the escort plan.

8.2.6 The climatology of the escort operating area, including winds, currents, and sea conditions, should be assembled and included in the escort plan. If there are significant seasonal variations in the climatological conditions and if seasonally varying escort plans are to be prepared, then the climatological data for each season should be assembled and included in the escort plan.

8.3 *Equipment and Deployment*:

8.3.1 A stand-alone diagram or flowchart can be included that describes the equipment involved and the methods employed in making an emergency towline connection (if one is required to be made in accordance with the escort plan).

8.3.2 The plan should include the location and load capacities of the bitts, chocks, and hard points to be used in an emergency assist.

8.4 *Escort Selection*:

8.4.1 The escort plan should indicate available escort vessel or vessel combinations capable of providing escort.

8.4.2 The plan should specify where to position the escort vessel(s). In this section, consideration should be given to the safety of the escort vessel(s) and to the time it takes for the escort vessel(s) to provide the emergency assistance.

8.4.3 The plan should specify whether the escort vessel(s) will be tethered or not and, if tethered, whether it will be tethered during all or a portion of the transit.

8.4.4 If any portion of the escort transit is untethered, then the plan should define if and how the escort vessel(s) will tether during an emergency.

8.5 *Escort Transit Speed*:

8.5.1 The speed for a specific transit should be determined in compliance with 33 CFR 168. This speed might depend on the anticipated environmental conditions (winds, currents, and sea conditions) and the capability of the escort vessel(s).

8.5.2 The intended speed for each portion of the transit should be clearly indicated on the escort plan.

8.5.3 The plan should contain a notice that the speeds written are "through the water" speeds and that they differ from speeds "over ground" by the amount of the current.

8.6 The plan should contain documentation of the results of all proposed emergency assist maneuvers. The predicted outcome of the emergency assist maneuvers should be shown on the escort plan at key points along the route.

8.7 *Alternatives to Primary Plan*—The escort plan should clearly spell out alternative procedures for controlling the disabled ship if the primary plan cannot be executed.

8.8 *Pre-Escort Planning and Conference*—The plan should contain a procedure and a form (a sample format is given in Table 1) to use when conducting a pre-escort conference. The condition of the environment in which the escort is to take place, including winds, currents, and sea conditions and the consequences for escort vessel selection, should be discussed.

## 9. Keywords

9.1 disabled ship; escort plan; escort vessel; navigational limit; ship transit

**TABLE 1 Pre-Escort Conference Guide**

NOTE 1—Inbound ships: The pre-escort conference (PEC) should be conducted after safely clearing the pilot boarding area and before entering the escort zone. Outbound ships: The PEC should commence before getting underway.

| USCG Rule | Description |
|---|---|
| Transit: The destination, route, planned speed, other vessel traffic, anticipated weather, tide, and sea conditions, and other navigational considerations | Our destination is _______ via _______ (strait). Transit speed will be _______. Anticipated weather/ sea conditions are _______. The predicted tide is _______. All vessels monitor VTS for traffic. |
| Operational status: The type and operational status of communication, towing, steering, and propulsion equipment on the ship and escort vessels | Vessels should report any unusual equipment specifications, extraordinary handling characteristics, or operational deficiencies at this time. |
| Positioning: The relative positioning and reaction time for the escort vessel(s) to move into assist positions, including, if appropriate, pretethering the escort vessel(s) at crucial points along the route | Escort vessel(s) will be deployed in the following manner. |
| Preparedness: The preparations required on the ship and escort vessel(s), and the methods used in making an emergency towline connection, including stationing of deck crews, preparation of messenger lines, bridles, and other towing gear, and energizing appropriate deck equipment | All vessels will prepare their decks and crews for escort and emergency response for the transit. |
| Emergency response: The manner in which an emergency towline connection would be made (which escort vessel will respond, how messengers and towlines will be passed, and so forth) | In the event of an emergency, the escort vessel(s) will be deployed as necessary, subject to the circumstances at the time. |

# APPENDIXES

**(Nonmandatory Information)**

## X1. SELECTED PERFORMANCE MEASURES

X1.1 Example performance measures in three assist modes are described herein. The demand and capability method described in 7.5 can be used to verify the compliance of an escort with these measures. In this method, the various parameters are first applied to the ship to determine the "demand." The demand in these examples is some measure of performance, such as towing resistance, stopping ability, rudder force, or turning ability. This measure of performance is a function of the ship, its displacement, dimensions, proportions, propulsion system, and rudder system. The example assist modes are:

X1.1.1 *Ability to Tow the Disabled Ship at a Specified Speed in Calm Conditions and Holding It in a Steady Position Against a Specified Head Wind*:

X1.1.1.1 The ship demand in the first case is equal to the calm water resistance of the ship at the specified towing speed. The resistance of a ship may be estimated by the following:

$$R = \frac{4\pi}{1000} C_R \rho \nabla^{2/3} V^2 \quad \text{(X1.1)}$$

where:

$R$ = resistance,
$\rho$ = density of the water,
$\nabla$ = displaced volume, and
$V$ = specified towing speed, in any consistent system of units.

$C_R$ may be taken as 0.65 for a tanker or bulk carrier. Use any consistent set of units.

X1.1.1.2 The ship demand in the second case is equal to the wind load caused by the specified head wind. The load as a result of a head wind can be calculated as follows (loads are not included):

$$F_w = K\rho A_T V_w^2 \quad \text{(X1.2)}$$

where:

$V_w$ = the specified wind speed and
$A_T$ = the equivalent transverse projected area obtained by adding 30 % of the projected transverse main hull area to the projected superstructure area.

$K$ may be taken to be 0.6. Use any consistent set of units.

X1.1.1.3 The escort vessel(s) must have sufficient tow rope pull to match or exceed $R$, the calm water towing resistance at the specified speed, and their bollard pull must match or exceed the wind load, $F_w$. The wind drag resistance of the escort vessel is considered negligible and is ignored.

X1.1.2 *Ability to Hold the Ship on a Steady Course Against a Locked Rudder at a Specified Speed*:

X1.1.2.1 The ship demand in this case is equal to the lift force generated by the rudder in a specified locked position with the propeller free wheeling at the RPM corresponding to the ambient flow.

X1.1.2.2 In maneuvering simulation equations, the lift force generated by the rudder is represented by the following:

$$Y_{Rud} = \frac{1}{2}\rho L^2 U_R^2 [Y'_{\delta r}\delta r] \quad \text{(X1.3)}$$

where:

$Y_{Rud}$ = the lateral force,
$L$ = the length between perpendiculars,
$U_R$ = the assumed flow velocity at the rudder location,
$\delta r$ = the rudder angle in radians, and
$Y'_{\delta r}$ = the nondimensional maneuvering coefficient used to represent the lateral rudder force as a function of the rudder angle and should depend on the effective rudder area.

X1.1.2.3 The escort vessel(s) must be capable of generating counteracting steering forces at the specified speed to match or exceed this demand. The ship can then be held on a steady course, provided the steering force is applied at the transom.

X1.1.2.4 This solution applies only to a single escort vessel applying steering forces at the transom. If multiple escort vessels are used, the moment arms of the rudder steering force and the counteracting steering forces must be determined and matched.

X1.1.3 *Ability to Turn the Ship 90°, Assuming a Free-Swinging Rudder in Deep Water and an Initial Specified Speed, Within a Specified Reach and Transfer Distance*:

X1.1.3.1 When the escort vessel steering force is applied, the ship is assumed to be unpropelled, the rudder is assumed to be ineffective, and the escort vessel assist is to be treated as immediate and without time delay. Deep water is assumed.

X1.1.3.2 The advance and transfer of the able ship may be obtained from the maneuvering card posted in the wheelhouse. Since the advance and transfer are nearly independent of speed, the wheelhouse information for slow speeds can be used in the evaluation at other speeds.

X1.1.3.3 The behavior of the disabled ship with escort vessel assistance has to be assessed through ship-maneuvering simulations, model-scale, or full-scale trials. With the requirement to meet both the reach and transfer constraints simultaneously, the effect of the differences in steering modes between escort vessel types should be properly accounted for in the simulations.

X1.1.4 The selected performance measure "demands" must be matched by the "capabilities" of escort vessel or escort vessel combinations. The ship operator can use these measures to choose any escort vessel combination that has sufficient capability to meet the demand.

X1.1.5 Alternative validated methodologies for the calculation of the selected performance measures can be used.

## X2. COMPONENTS OF A STEADY-STATE ESCORT VESSEL PERFORMANCE ANALYSIS

X2.1 Lift, drag, and center of pressure of hull.

X2.2 Lift, drag, and center of pressure of rudders, based on published flat plate and lifting surface coefficients, including effects of aspect ratio and edge effects (for conventional escort vessels).

X2.3 Lift, drag, and center of pressure of skeg, including effects of aspect ratio.

X2.4 Modification of flow into rudders resulting from hull shape (for conventional tugs).

X2.5 Modification of flow into rudders resulting from momentum changes induced by the propellers (for conventional tugs).

X2.6 Position of rudders with respect to propellers and local rudder angles (for conventional tugs).

X2.7 Cross-flow effects as a result of tug orientation with respect to the free stream.

X2.8 Effects of fendering on hydrodynamic performance of the hull.

X2.9 Propeller performance, including engine, gearbox, and shafting characteristics, command RPM, and propeller geometry.

X2.10 Effects of twin screw control.

X2.11 Lift, drag, and center of pressure of propeller nozzles, if present.

X2.12 Heeling moments caused by contact with ship, bow lines (if rigged), and transverse components of hull, skeg, rudder, nozzle, and propeller forces.

X2.13 Heeling moments caused by tow line tension (for tractor tugs working on a line).

X2.14 Freeboard and GM in the design condition, and the escort condition.

X2.15 Reduction in freeboard as a result of average wave amplitudes.

X2.16 Deck edge submergence.

X2.17 Friction between its fendering and the ship's hull (for tugs working in contact with the disabled ship's hull).

X2.18 Forces in lines.

X2.19 Position of tug on ship, either alongside, on the transom, or on a line.

X2.20 Use of additional thrusters.

X2.21 Actual condition of propellers and rudders, that is, effects of wear or damage.

X2.22 Reductions in available power because of vessel condition and maintenance.