INTERNATIONAL STANDARD

ISO 8847

Third edition
2021-06

Small craft — Steering gear — Cable over pulley systems

Petits navires — Appareils à gouverner — Systèmes à câble sur poulie

Reference number
ISO 8847:2021(E)

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Published in Switzerland

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 188, *Small craft*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 464, *Small craft*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 8847:2004), which has been technically revised.

The main changes compared to the previous edition are as follows:

— update of the scope to clarify application on small craft with and without propulsion engine(s);

— addition to the scope of small craft with outboard engines up to and including 37 kW total power;

— update of the definitions;

— update of requirements to meet state of the art;

— addition of informative Annexes A and B.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Small craft — Steering gear — Cable over pulley systems

1 Scope

This document specifies the requirements for the design, installation and testing of cable over pulley steering systems on small craft with or without a propulsion engine(s), and on small craft with outboard engine(s) up to and including 37 kW total power.

It specifies the requirements for the design and testing of all components of a cable over pulley steering system, from the steering mechanism to the mechanical interface with the rudder shaft or the outboard engine. It applies to cable over pulley steering systems, whether for pedestal or bulkhead types.

This document does not address emergency means of steering the craft.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2408:2017, *Steel wire ropes — Requirements*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
accessible
capable of being reached for operation, inspection or maintenance without removal of permanent structure of the craft

3.2
cable
flexible mechanical means of transmitting tension forces from one location to another

Note 1 to entry: This cable can be metallic or non-metallic.

3.3
cable drum
circular feature of the *steering mechanism* (3.10) over which the steering *cable* (3.2) is routed to provide the required cable travel

3.4
cable over pulley steering system
steering system in which rotation of the steering wheel transmits movement to either the steering arm quadrant fastened to the rudder shaft, or to the outboard engine steering arm, by mechanical means including flexible cable over pulleys mounted to the structure of the craft

3.5
cable load
force applied to the *cable* (3.2) providing the necessary torque to move either the rudder through the rudder shaft/steering arm or the outboard engine while the craft is underway

3.6
cable-in conduit-steering system
steering system in which rotation of the steering wheel transmits movement to either the steering arm quadrant fastened to the rudder shaft, or to the outboard engine steering arm, by mechanical means including flexible *cable* (3.2) and conduits with or without use of pulleys

3.7
fairlead
ring, eye or loop that guides a *cable* (3.2) in the desired direction

Note 1 to entry: A pulley can also perform the function of a fairlead.

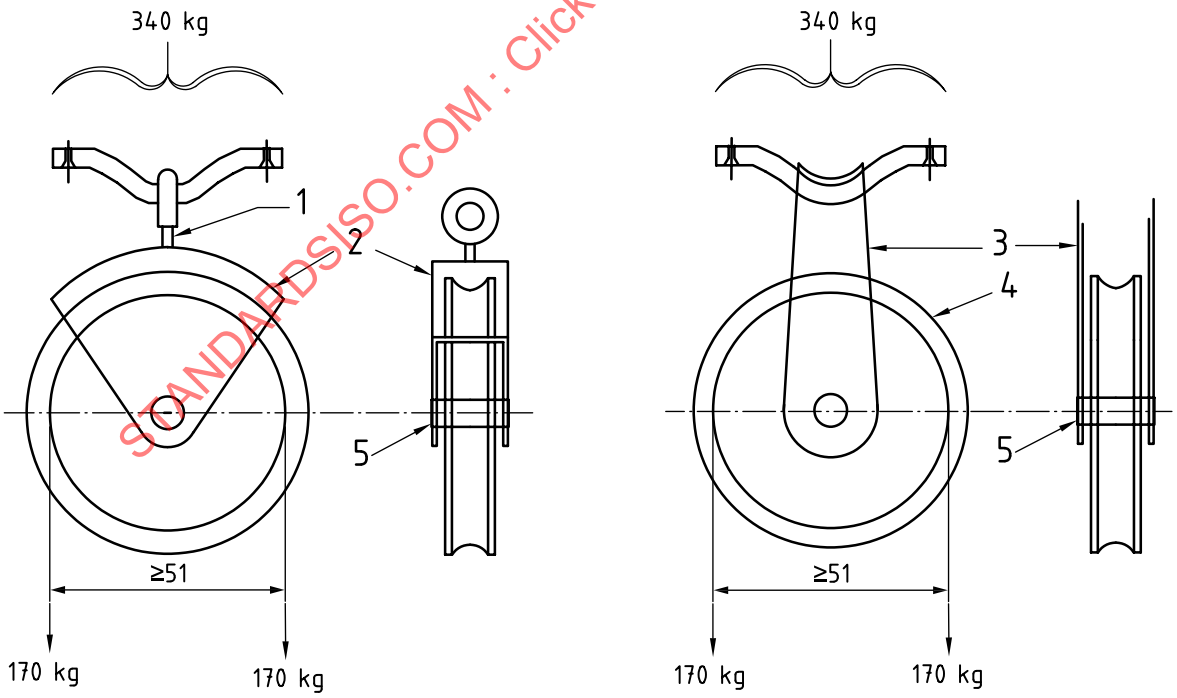
3.8
swivel pulley
pulley whose attachment feature is designed to allow the pulley to rotate freely about the swivel centreline

Note 1 to entry: See Figure 1, left side.

3.9
fixed strap pulley
pulley whose attachment is designed for minimum, if any, rotation of the pulley assembly about the fixed strap axis

Note 1 to entry: See Figure 1, right side.

Dimensions in millimetres



Key

1 swivel
2 cheek strap
3 fixed strap
4 sheave
5 pulley pin

Figure 1 — Swivel and fixed strap pulleys cable over pulley systems

3.10
steering mechanism
device to which a *control element* (3.20) is attached for manual application of a controlling force, and by which the controlling force is fed into a *steering system* (3.14)

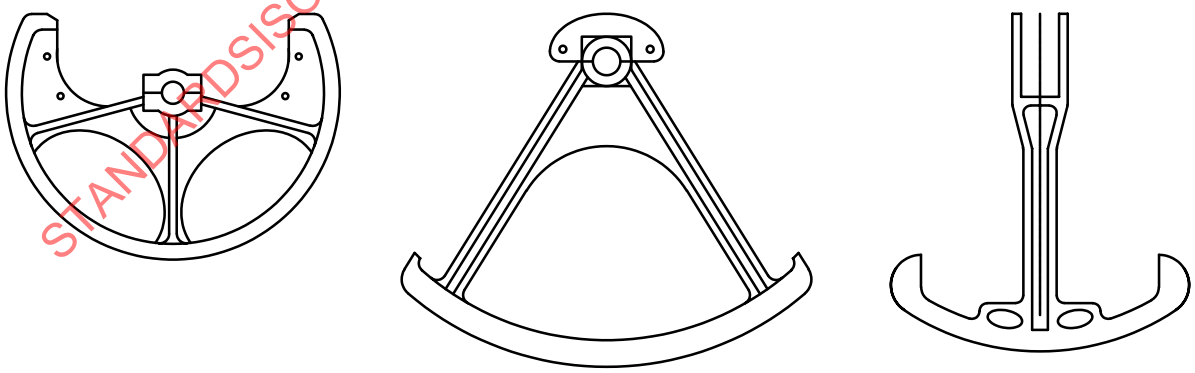
3.11
helm station
location from which steering, propulsion and thrust can be controlled

3.12
minimum retained system performance
system capability after test(s) such that at least 90 % of the outboard engine steering arm travel normally available each side of the mid-position can be attained by exertion of no more than 27 Nm of torque at the helm through the *steering mechanism* (3.10), through the *control element* (3.20)

Note 1 to entry: These limits are not intended to define a condition under which a craft can or cannot be safely operated but are intended to provide quantitative limits for design and testing purposes.

3.13
steering arm
component fixed to the rudder shaft with at least one groove for the *cable* (3.2) concentric to the shaft centre or for outboard engines, the portion of the outboard engine that the steering system makes *mechanical interface* (3.21) with

Note 1 to entry: The steering arm can be a wheel quadrant (see Figure 2a), a quadrant (see Figure 2b) or a tiller quadrant (see Figure 2c).



a) Wheel quadrant **b) Quadrant** **c) Tiller quadrant**

Figure 2 — Examples of steering arm types

3.14
steering system
assembly including all components necessary to transmit remote manual effort to the rudder blade steering arm quadrant or to the outboard engine steering arm

3.15
total steering loss
complete loss of the ability to steer the craft from the *helm station* (3.11) by application of manual effort to the *control element* (3.20)

3.16
steering wheel
mechanical means for applying manual steering effort to the helm, normally a circular configuration with a continuous loop at the distal end of support spokes with the *steering mechanism* (3.10) connected at the rotational axis

3.17
steering wheel diameter
actual diameter
D_a
diameter of the circle formed by the outermost sections of the *steering wheel* (3.16)

Note 1 to entry: See Figure 3.

3.18
steering wheel dish
distance between the two parallel planes formed by the aft rim surface and the forward hub surface of a *steering wheel* (3.16)

Note 1 to entry: see Figure 3.

3.19
craft
small craft
recreational boat, and other watercraft using similar equipment, of up to 24 m length of hull (L_H)

Note 1 to entry: The measurement methodology for the length of hull is defined in ISO 8666.

[SOURCE: ISO 8666:2020, 3.15, modified – Note 1 to entry has been added.]

3.20
control element
device connected to the *steering mechanism* (3.10) that allows the operator to apply manual steering effort to *the steering system* (3.14)

3.21
mechanical interface
interface where force and motion are transmitted mechanically

3.22
sailing boat
craft (3.19) for which the primary means of propulsion is by wind power, having reference sail area (A_S) ≥ 0,07 $(m_{LDC})^{2/3}$

[SOURCE: ISO 8666:2020, 3.11]

4 General requirements

4.1 Components of the steering system shall be fastened securely to the structure of the craft, reinforced where necessary, especially at the steering mechanism bulkhead/pedestal mounting and at pulleys.

4.2 On a sailing boat, the steering arm connection to the rudder shaft shall be capable of transmitting the required steering torque to the rudder.

NOTE Rudder requirements are addressed in ISO 12215-8.

4.3 Cable over pulley steering systems designed to meet the requirements of this document shall not be used to steer craft having outboard engine(s) in excess of 37 kW total power.

4.4 All threaded fasteners whose integrity affects safe operation of the steering system so that separation or loss of the fasteners can cause total steering loss without warning shall be provided with a locking means.

4.4.1 Threaded fasteners that can be expected to be disturbed by installation or adjustment procedures shall be referenced by instructions for correct assembly and:

a) shall be locked by a device whose presence is determined by visual inspection or by feel following assembly, or

b) shall incorporate an integral locking means, provided the fastener cannot be omitted or substituted without making the steering system inoperable.

NOTE Self-locking nuts with plastic inserts that create mechanical plastic interference meet the above stated requirements.

4.5 Loose lock washers, distorted thread nuts or separately applied adhesives shall not be used.

4.6 Plain threaded jam nuts may be used to permit adjustments and shall be designed so that total separation of parts or other complete loss of steering will not occur should they loosen.

4.7 Plastics and elastomers shall be designed to resist degradation from ultraviolet radiation, salt water, hydrocarbons and ozone.

4.8 Components of the steering system shall be resistant to corrosion, either by virtue of material or coating thereof, and shall be galvanically compatible with adjoining components.

4.9 Components of the steering system shall be sized to prevent derailing or jamming of the cable.

4.10 Components of the steering system shall be accessible for inspection and maintenance.

4.11 Compass interference — Materials used in the various components of the steering system as supplied shall not affect the accuracy and reliability of a compass mounted on the pedestal, if used, whatever steering angle is used.

5 Steering system requirements

5.1 Steering stops for the outboard engine shall permit at least 30° of angular movement either side of centre. Stops for the rudder blade steering arm quadrant shall be set by the sailing boat manufacturer.

5.2 When used with an outboard engine, the cable over pulley steering system attachment to the engine shall be designed so that with any combination of engine turn and tilt, there will be no damaging interference between the engine, its accessories, the steering system and the craft.

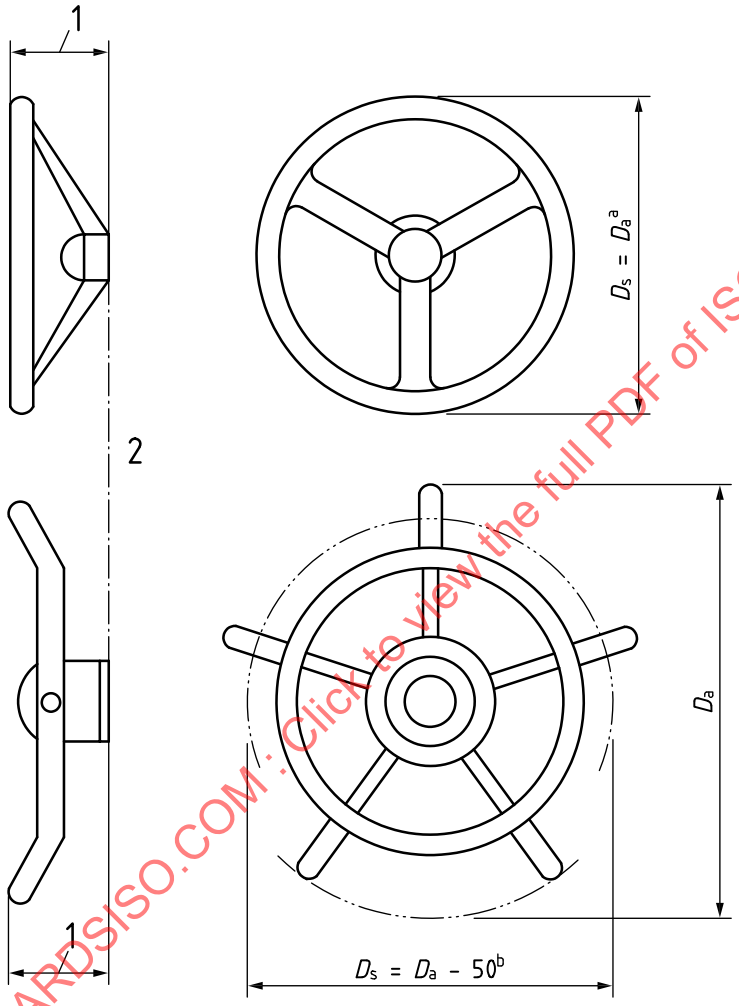
5.3 Steering wheels and helm shafts shall be selected to fit each other. See Annex A, Figure A.1 a), b), c).

NOTE Steering wheel requirements are addressed in ISO 23411.

5.3.1 The largest diameter D_s and deepest dish steering wheel information shall be permanently marked by the component manufacturer on the steering mechanism so as to be visible with the steering mechanism installed, and the wheel removed. See Figure 3.

5.3.2 When equipped with the largest diameter D_s and deepest dish steering wheel for which the helm is rated, all steering components shall be of sufficient strength to successfully pass the testing requirements of Clause 7.

Dimensions in millimetres



Key

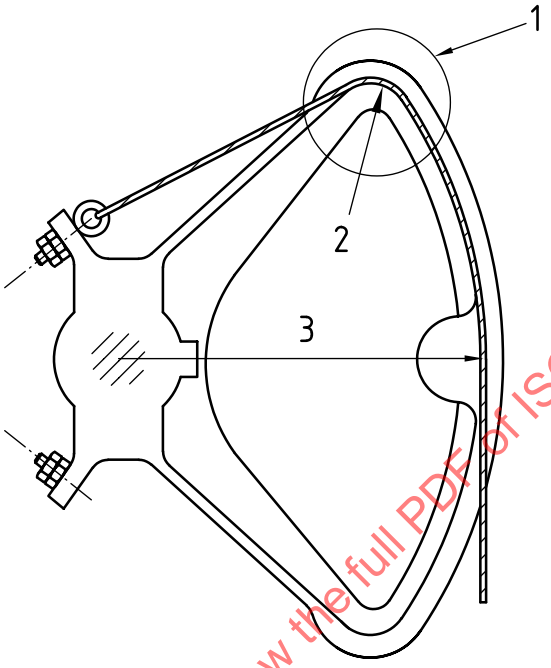
1 steering wheel dish
2 forward hub surface
D_a actual diameter
D_s standard diameter for the application of loads
a For steering wheels without handgrips, $D_s = D_a$.
b For external spoke steering wheels, $D_s = D_a - 50$ mm.

NOTE For non-circular steering wheels, D_s is the largest diameter that can be inscribed in the steering wheel shape.

Figure 3 — Steering wheel terms

5.4 Steering arm

The radius of the steering arm and cable diameter shall be chosen so that the cable load is less than 25 % of the cable breaking strength. The arc generated by the steering arm radius shall be concentric with the rudder shaft centre. The radius at the end of the groove where the cable is led out shall be at least 5 times the diameter of the cable used. See Figure 4.



Key

1 end of groove
2 radius ≥ 5 × cable diameter
3 steering arm radius

Figure 4 — Steering arm terms

5.5 Cables

5.5.1 Cables used on sailing boat steering systems with or without a propulsion engine(s) shall meet the following requirements a) to e):

a) the cables shall be of flexible construction;

b) the wire rope characteristics shall meet the specifications given in ISO 2408:2017;

c) the wire rope tension shall be adjustable by means of an appropriate tensioner (e.g. a rigging screw) to tension the system initially and when the craft is not in use;

d) the cable shall be aligned with the grooves when leaving a steering arm;

e) the cable termination shall be appropriate to transfer the cable loads.

EXAMPLE Wire rope thimble and two cable clamps; swaged terminals; splicing with thimble.

5.5.2 Cables used on steering systems of craft with outboard engine(s) shall meet the requirements of 7.1.2, a) and b).

5.6 Pulleys

5.6.1 Pulleys used on sailing boat steering systems with or without a propulsion engine(s) shall meet the following requirements a) to c):

a) the pulley tread diameter and groove width shall be suitable for the cable used or recommended;

NOTE 1 The generally accepted minimum pulley tread diameter is 16 times the diameter of a 7 × 19 cable.

NOTE 2 The 7 x 19 reference refers to the braid of the cable within the wire rope. There are seven twisted stands, each made up of 19 wires.

b) a means to secure the swivel pulley in the correct position shall be provided;

c) the pulleys shall be fitted with a means to guide the cables into and out of the sheaves to prevent the cable from jamming between the sheave and pulley frame.

5.6.2 Pulleys used on steering systems of craft with outboard engine(s) shall meet the following requirements a) to d):

a) the steering cable pulleys shall be located so that the cable comes off the steering cable drum at 90° ± 5° to the steering axis at the centre of travel. Clear space shall be provided behind the dash or pedestal to route the steering cables to pulleys;

b) the angle formed between the pulley pin axis and the axis of both cables shall be 90° ± 5°;

c) all pulleys, mounting and cable straps shall be through bolted or may be solid riveted to withstand a minimum force of 3 340 N without permanent deformation;

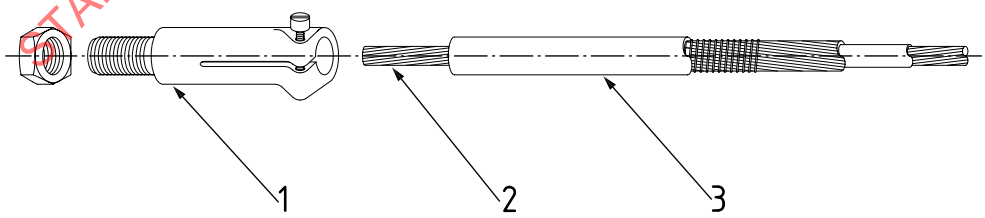
d) swivel pulleys shall not be used at the outboard engine connection or where the pulley changes the cable direction more than 135°.

5.7 Conduit

The conduit used on sailing boat steering systems with or without a propulsion engine(s) shall meet the following requirements a) and b):

a) the conduit shall be of sufficient flexibility to permit a minimum bend radius of 50 times the smallest diameter of cable specified for use;

b) the conduit shall be finished at each end with a conduit fitting which provides a method of clamping the conduit securely and permitting the assembly to be locked onto a plate, pulley of terminal unit which connects the cable onto a chain assembly, intermediate sheave or steering arm; see Figures 5 and 6.



Key

1 conduit fitting
2 cable
3 conduit

Figure 5 — Example of a conduit fitting

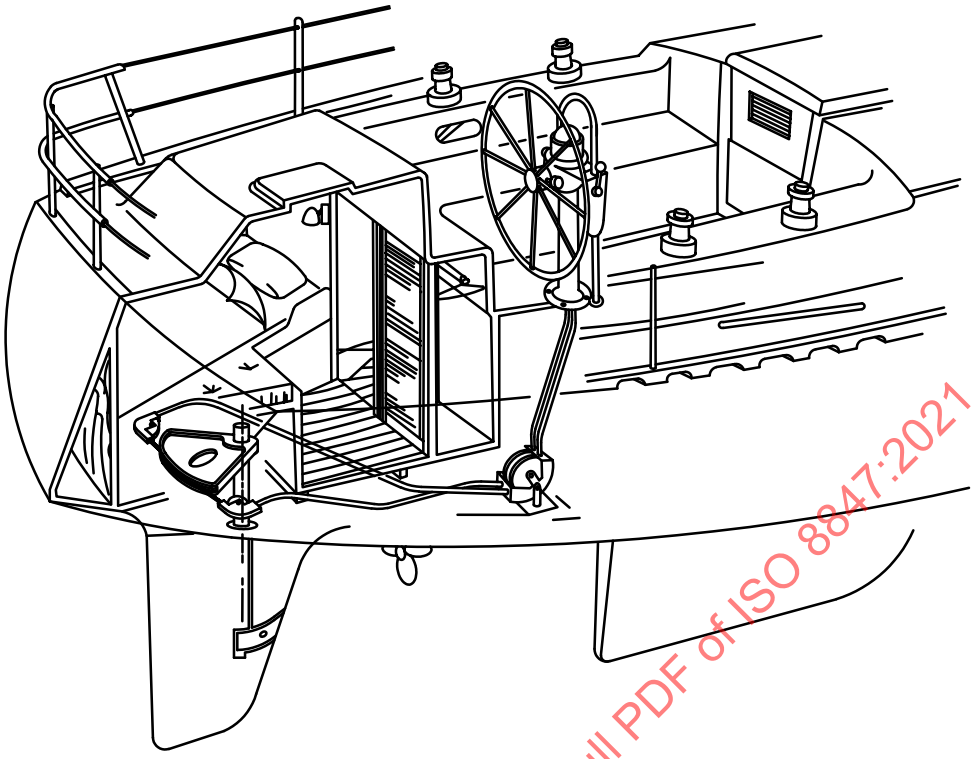


Figure 6 — Example of a cable in the conduit steering system

5.8 Cable drums

Cable drums used on steering systems of craft with outboard engine(s) shall provide a minimum cable travel of 760 mm.

6 Installation

6.1 All cable and pulley steering systems shall meet the following requirements a) to c):

a) anti-chafe protection shall be provided at cable routing openings in the craft structure whose edges can contact the cable during operation;

b) clearance provisions shall be provided for cables, pulleys, fittings and end attachments so that they operate free of interference;

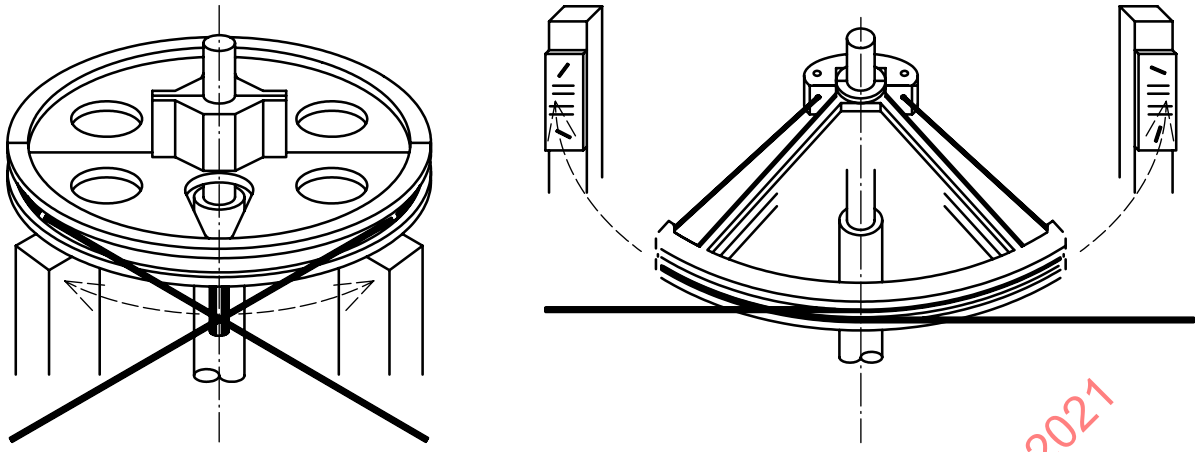
c) open S-hooks shall not be used in pulley over cable steering systems.

6.2 Sailing boat steering applications with or without propulsion engine(s) shall meet the following additional requirements a) to c):

a) steering arm rotation — One or two stops shall be suitably fixed to the structure of the craft to limit over-rotation of the steering arm; see Figure 7;

b) the positioning of the steering stops shall take into consideration the possible dynamic overloading of the system due to shock;

c) no component(s) except the rudder stop(s) shall limit the rotation of the steering system.



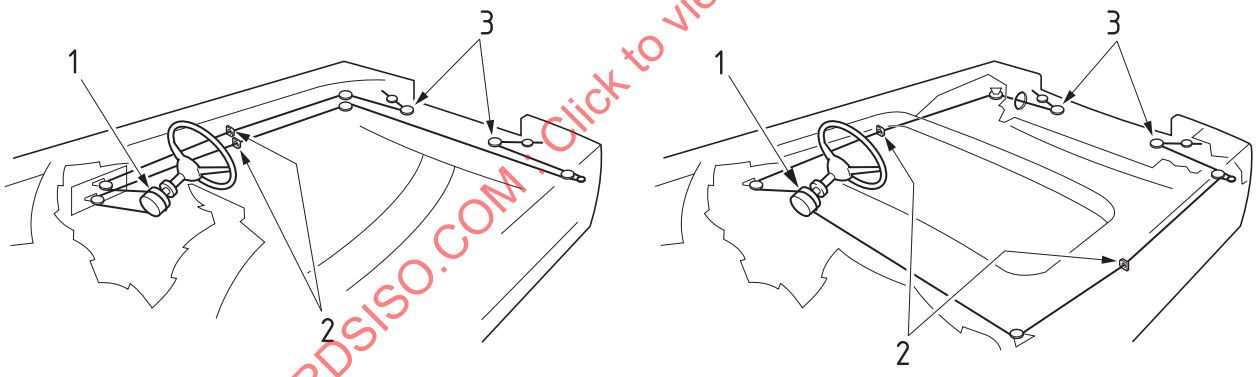
a) One stop — limited b) Two stop — limited

Figure 7 — Steering arm rotation stops

6.3 Steering systems of craft with outboard engine(s) shall meet the following additional requirements a) to g).

a) All pulleys, mountings and cable end straps shall be through bolted or may be solid-riveted with 5 mm or larger diameter fasteners.

b) The pulleys, fairleads and end fittings shall be mounted as indicated in Figure 8 and Figure 9.



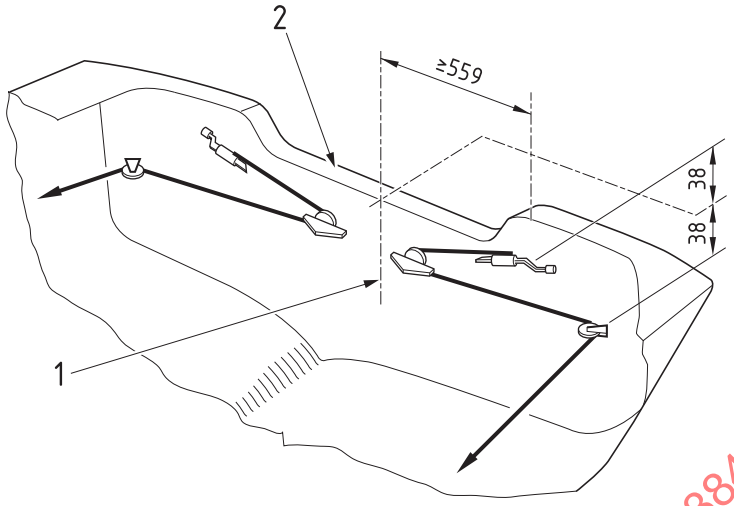
a) Single side b) Both sides

Key

1 steering cable drum
2 fairleads
3 engine attachments

Figure 8 — Cable over pulley steering arrangements for outboard engines

Dimensions in millimetres



Key

1 engine centerline

2 transom top

Figure 9 — Transom rigging for outboard engines

c) The craft structure shall be reinforced at the component mounting fasteners to withstand a minimum force of 3 340 N.

d) Rigging for craft using outboard engines shall provide a minimum of 760 mm of cable travel measured at the engine attachment point from hard over to hard over to move the engine through its steering range. The change of angle in cables at any fairlead shall not exceed 5°.

e) The pulleys and end fittings for the cable clamps shall be located on the transom face as far from the outboard engine as practicable. To prevent excessive tension in the cables as the outboard engine is pivoted or tilted, attachment straps shall be located with reference to the transom top as shown in Figure 9.

f) Spring(s) shall be provided in the outboard engine steering system because turning and tilting the engine causes a change in required cable length. Spring(s) shall be compressed to one-half their relaxed length after connection of the outboard engine steering system. Each spring shall have a minimum of 50 mm of travel and a minimum spring rate of 8,8 N/mm (50 lb/in) to prevent engine shimmy. Check spring compression after cycling steering system ten times full over to full over, since cable slackens after "bedding" down into helm drum grooves.

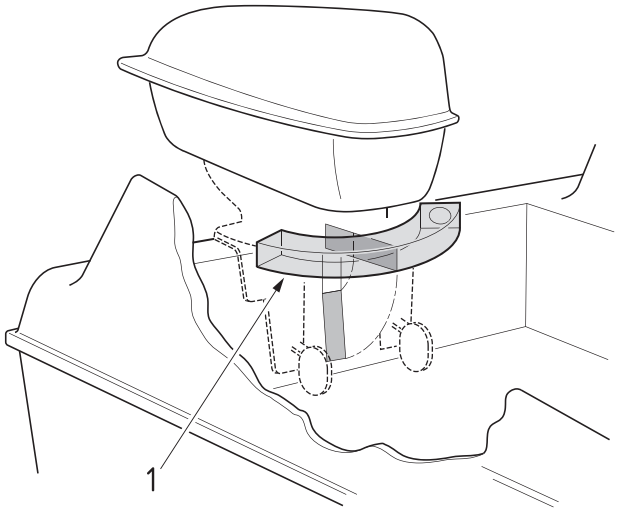
g) Steering cable clearance requirements are determined by use of a target. The target is the arc projected at the centreline of the outboard engine steering arm as the engine turns from side to side and tilts up and down. See Figure 10. To determine the size opening necessary in the side of the engine well or similar obstruction that the cables shall clear, perform the following:

   1) generate a line from the pulley or cable anchor point (point A), see Figure 12;

   2) project a line to the dimensions given in Figure 11;

   3) determine the opening size and location in the engine well for the cables as generated by the line out of point A, see Figure 12;

   4) determine the pulley or cable anchor point that passes around the target located at the centreline of the engine transom bracket: the opening size thus generated shall be kept clear for steering rigging.

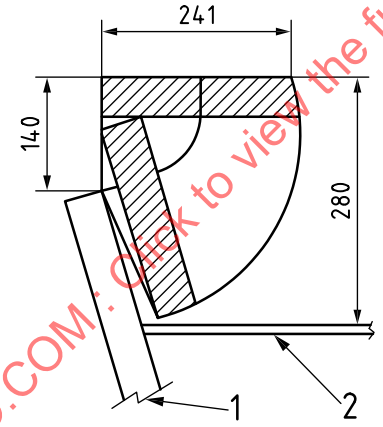


Key

1 steering cable target

Figure 10 — Steering cable target for outboard engines

Dimensions in millimetres



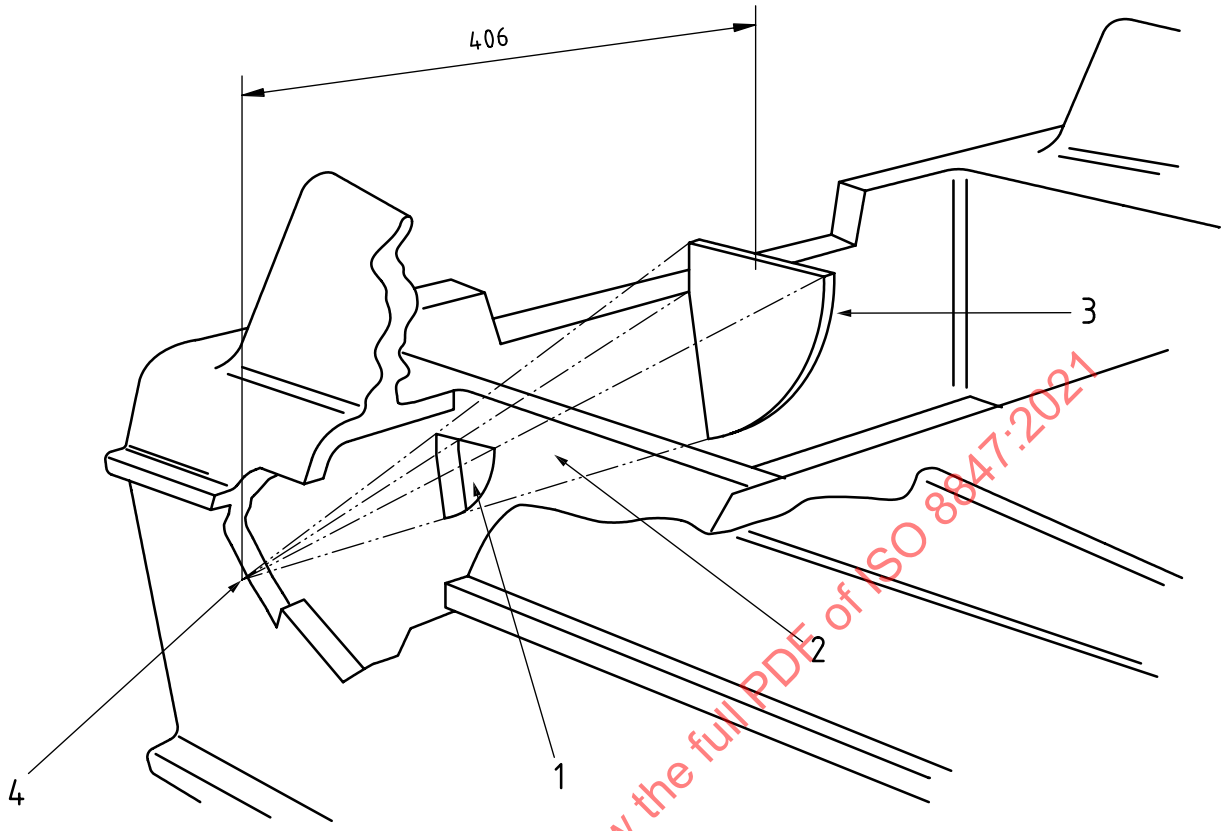
Key

1 transom

2 bottom of engine well

Figure 11 — Target dimensions

Dimensions in millimetres



Key

1 size of opening
2 side of engine well
3 target
4 point A

Figure 12 — Steering cable target used to size engine well opening for cables

7 Testing requirements

7.1 Component tests — The following tests establish minimum design criteria for the components of cable over pulley steering systems of a sailing boat with or without a propulsion engine(s) and small craft with outboard engine(s).

7.1.1 For steering systems on a sailing boat with or without a propulsion engine(s), all components shall be of sufficient strength to transmit either the tangential force of 450 N at D_s on the steering wheel or at the maximum torque necessary to steer the rudder without loss of steering function.

7.1.2 For steering systems of craft with outboard engine(s), the following component tests in a) to c) shall be met.

a) All components shall be capable of withstanding 100 000 cycles of operation through 200 mm of cable travel in each direction under a cable load of 110 N without loss of function that would cause loss of minimum retained system performance. One cycle is defined from starting at hard over to opposite hard over and back to the original starting position. Components shall be installed as intended to be used and shall not be lubricated or adjusted during the test.

b) Covered steering cables used in outboard engine cable over pulley steering systems shall meet the following requirements at a temperature between 21 °C and 27 °C, see Figure 13:

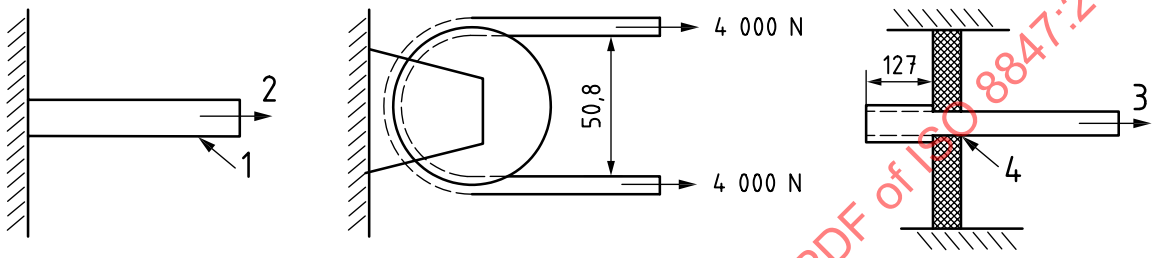
1) the breaking strength shall not be less than 4 000 N. See Figure 13 a);

2) as installed, the cable covering shall not crack or otherwise expose the cable core under a cable load of 4 000 N for 1 min. See Figure 13 b);

3) the cable covering shall not strip from the core of a 130 mm sample under a static load of 450 N for 15 min. See Figure 13 c).

c) Outboard engine pulley assemblies shall be capable of sustaining a 3 340 N pulley pin load without permanent deformation.

Dimensions in millimetres



a) Breaking test b) Covering test c) Stripping test

Key

1 cable
2 breaking load
3 stripping load
4 hole

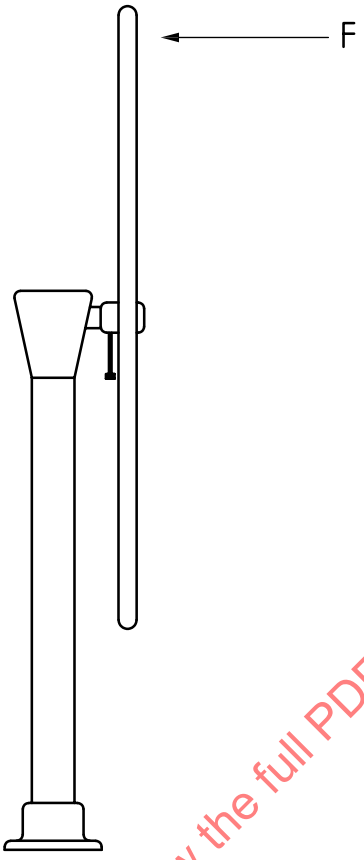
Figure 13 — Cable tests for outboard engine cable over pulley systems

7.2 As installed tests — The following tests are intended to establish the acceptability of the strength of steering systems as installed in a craft to the mechanical interface with 1) the outboard engine or 2) the rudder steering arm.

7.2.1 For a sailing boat with or without a propulsion engine(s), the steering system as installed shall withstand, without loss of steering, the following tests in a) and b).

a) Axial load test — A 670 N push-pull force shall be applied at any single location, in a direction parallel to the axis of the steering shaft, for 10 cycles at a duration of 5 s per loading, distributed over not more than 100 mm of the steering wheel rim or at D_s on the handgrip of an external spoke steering wheel. See Figure 14.

NOTE For this paragraph, a cycle is defined as a load application in one direction for 5 s followed immediately by a load reversal in the opposite direction for 5 s followed by an unload. Thus, a cycle is slightly over 10 s in duration.



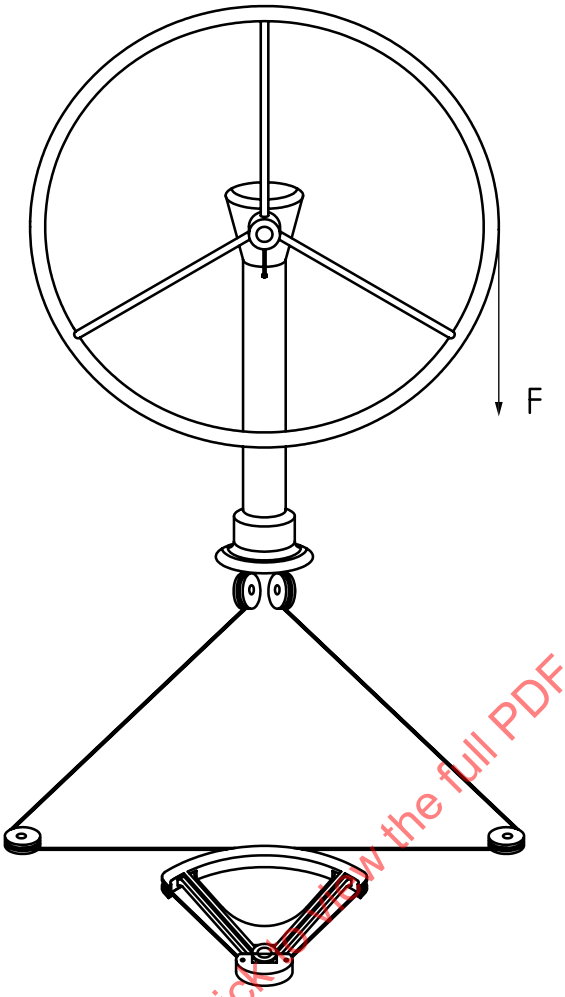
Key

F load

Figure 14 — Application of axial load

b) Tangential load test — With the rudder shaft interface point locked to prevent movement and not against a stop, a 450 N load in each direction shall be applied at any point on the steering wheel rim or at D_s of any handgrip of an external spoke steering wheel, tangentially in the plane of the steering wheel rim, for 10 cycles at a duration of 5 s per loading, without separation of the wheel. See Figure 15.

NOTE for this paragraph, a cycle is defined as a load application in one direction for 5 s followed immediately by a load reversal in the opposite direction for 5 s followed by an unload. Thus, a cycle is slightly over 10 s in duration.



Key

F load

Figure 15 — Application of tangential load

7.2.2 For craft with outboard engine(s), the steering system as installed shall meet the following requirements of a) to c).

a) Outboard engine cable over pulley systems shall withstand a static cable tension load of 1 668 N minimum applied in both directions at the outboard engine interface The steering wheel shall be locked during this test so that it cannot turn.

b) Outboard engine cable over pulley steering systems shall withstand a single tangential load in either direction of 267 N, and the system shall maintain minimum retained system performance. This load shall be applied, as appropriate, at any point on the steering wheel rim or at D_s of any handgrip of an external spoke steering wheel.

NOTE See Annex B for recommended test procedures to demonstrate compliance with this requirement on outboard engine applications.

c) A separate single axial load of 670 N push-pull force in a direction parallel to the axis of the steering shaft shall be distributed over not more than 100 mm of the rim, spoke or handgrip at any location maintaining minimum retained system performance. See Figure 14.

8 Owner's manual

The following information shall be included in the craft owner's manual:

— routine maintenance procedures;

— largest diameter D_s and deepest dish steering wheel that can be used with the steering mechanism;

— specific precautions critical for correct operation, if relevant.

NOTE 1 Requirements for an owner's manual are provided in ISO 10240.

NOTE 2 Installation manual information can be included in the owner's manual.

9 Instruction manual

An instruction manual shall be provided with the steering system. It shall include at least the following information:

— reference of the model type and identification of basic components;

— general description of operation and reference to specification of rating;

— maximum corresponding rudder torque;

— installation instructions;

— recommended installation test procedures;

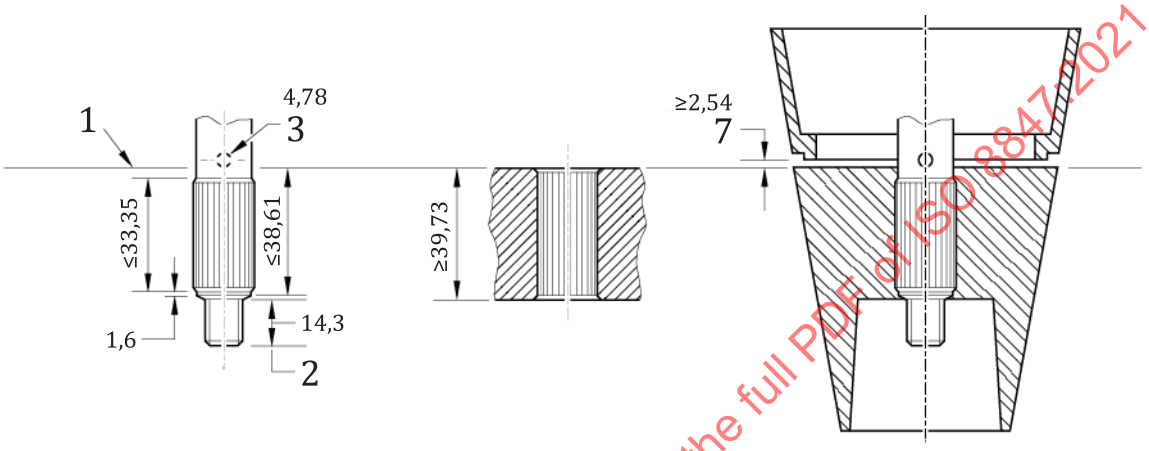
— general description of installations of rudder stops in accordance with 6.2 a);

— largest diameter D_s and deepest dish wheel that can be used with the helm.

Annex A
(informative)

Steering wheel and helm shaft fit

Dimensions in millimetres



Spline data – Shaft		Spline data – Hub	
Module	1.14	Module	1.14
# of teeth	19	# of teeth	19
Pressure angle	45°	Pressure angle	45°
Outside diameter	17,78 - 17,45	Outside diameter	17,86 - 17,81
Minor diameter	15,77 - 15,66	Minor diameter	16,15 - 16,00
Pitch diameter	16,64	Pitch diameter	16,64
Tooth thickness @ P.D	1,47 - 1,44	Tooth thickness @ P.D.	1,47 - 1,44
Base circle diameter	11,77	Base circle diameter	11,77

a) Spine shaft and steering wheel hub