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Transport Canada Simplified Assessment of Intact Stability & Buoyancy of Small Non-Pleasure Vessels:

Assessment Guide

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Simplified Assessment of Intact Stability & Buoyancy of Small Non-Pleasure Vessels:

Assessment Guide (TP 14619E)

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Disclaimer
Transport Canada developed the Simplified Assessment of Intact Stability* & Buoyancy** of Small Non-Pleasure Vessels to assist in easily determining whether the intact stability of a vessel is adequate, however many factors affect stability. The vessel operator is responsible for monitoring the vessel and its surroundings at all times to identify and avoid or correct hazardous situations. Transport Canada expressly disclaims liability resulting from the use of this document.

* Intact stability – a vessel's capability to return to the upright condition after heeling due to waves stability when it is intact (undamaged).
** Buoyancy – ability to float

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Introduction

Stability is too important to leave to intuition

Stability is a fundamental aspect of a vessel's safety, but often it is not really understood. With terms like GZ, GM, righting lever and heeling moment, it's no wonder the science of stability seems complicated. In the end, it all comes down to whether your vessel will come back to the vertical position.

The *Canada Shipping Act (S 391)* requires the owner and the master to ensure that the vessel is seaworthy – including having adequate stability – both before setting out and for the duration of the voyage. While most operators have a feel for their vessel, this is generally based on operating in less than the most extreme conditions the vessel may encounter. How then can you show that the vessel has an adequate level of stability?

New vessels: In February 2005, Transport Canada established minimum stability criteria for **new** small commercial vessels – those built after March 31, 2005. New vessels must be assessed using the International Standards Organization standard ISO 12217-1 – *Small Craft Stability and Buoyancy Assessment and Categorization* or STAB 6 of the *Stability, Subdivision and Load Line Standards* (TP 7301) to determine the maximum wave height and wind speed the vessel can be expected to handle safely given its stability characteristics.

Existing vessels: For existing vessels – vessels built on or before March 31, 2005 - Transport Canada has taken steps to help owners and operators move beyond relying on "feel" in assessing their vessels' stability characteristics by identifying recognized stability standards that are appropriate for small non-pleasure vessels.

Ship Safety Bulletin 07/2006 sets out five standards that owners may choose from if they wish to assess their vessel. The *Transport Canada Simplified Assessment of Intact Stability & Buoyancy of Small Non-pleasure Vessels* is the easiest of the standards to use. With a few simple measurements, operators can assure themselves that their vessel is likely to stay right side up within defined operating conditions. It is important to remember though, that **compliance with any stability standard does not guarantee freedom from risk of capsizing or sinking**.

Intact Stability defined:

The vessel's stability in the intact (normal or undamaged) condition.

Stability – capability to return to the upright condition after heeling due to waves, wind, etc.

This guide explains how to carry out the *Transport Canada Simplified Assessment of Intact Stability & Buoyancy of Small Non-pleasure Vessels*. Read on to learn more.

Who can use this guide?

The simplified assessment described in this guide is **not** for all vessels. To be able to use it, a vessel:

MUST

- have been built before April 1, 2005; and
- be more than 6 metres in length overall.

MUST NOT

- be more than 15 tons gross tonnage, or if not measured for tonnage, not be more than 12 metres in length overall;
- carry more than 12 passengers and/or 1,000 kilograms of cargo;
- travel further than 25 nautical miles from shore;
- be inspected annually;
- make international voyages;
- operate in waves greater than 2 metres (6.5 feet) high if fully-decked or 1.2 metres (4 feet) high if open (fully-decked and open are defined on page 5);
- be a commercial fishing vessel; a sailing, inflatable or multi-hulled vessel; a vessel engaged in towing, dredging or lifting operations; or any other vessel of non-conventional design or usage.

If your vessel falls under the "must not", you can refer to other standards, as outlined in the table below.

Less than 6 metres	*Construction Standards for Small Vessels* (TP 1332) – Section 4
More than 15 gross tons, or 12 metres if not measured for tonnage, or carrying more than 12 passengers and/or 1,000 kg of cargo	*Stability, Subdivision and Load Line Standards* (TP 7301)- STAB 5 or STAB 6 Passenger Vessels only may use *Standards for the Construction and Inspection of Small Passenger Vessels* (TP 11717)
Going further than 25 nautical miles from shore or making international voyages	Select from one of several recognized stability standards (see Ship Safety Bulletin 07/2006)
Built on or after April 1, 2005	ISO 12217-1 – *Stability and buoyancy assessment and categorization* or *Stability, Subdivision and Load Line Standards* – (TP 7301) - STAB 6

If requirements for your vessel are not listed above, contact your local Transport Canada Centre or a marine consultant.

Scope of the Simplified Assessment

Transport Canada developed the *Simplified Assessment of Intact Stability & Buoyancy of Small Non-pleasure Vessels* from the International Organization for Standardization's (ISO) standard for stability and buoyancy for small craft.

The most important aspects of stability are taken into account – the resistance to swamping (watertight integrity; downflooding height) and the effect on the vessel of moving its load to one side (offset heel angle and residual downflooding height).

Because the *Simplified Assessment* does not include all the calculations of the ISO standard, the values for the criteria (e.g. maximum heel angle) are more conservative. In addition, where the ISO standard sets out four categories of environmental conditions (maximum wave height and wind speed) that a vessel can operate in, the *Simplified Assessment* is not for vessels that travel more than 25 nautical miles from shore and restricts fully decked vessels to operation in maximum wave heights of 2 metres. Open vessels are restricted to operating in waves of no more than 1.2 metres. The difference between fully-decked and open vessels is described later in this guide.

If these conditions are too restrictive for your operation, you should assess your vessel against a full stability standard.

In 2004, a workboat capsized. One person died.

The Transportation Safety Board found that a modification made to the vessel – the wheelhouse was raised 1.25 metres – was a contributing factor in the incident.

Stability can change:

If you modify your vessel, its stability can change. Carry out the stability assessment again after you have made any modifications.

Definitions

(L) Length - distance in metres from the tip of the bow to the furthest point aft on the stern, excluding removable parts that can be detached in a non-destructive manner and without affecting the structural integrity of the craft (e.g. spars, bowsprits, pulpits at either end of the craft, stemhead fittings, rudders, outdrives, outboard motors and their mounting brackets and plates, diving platforms, boarding platforms, rubbing strakes and fenders).

(B) Breadth – distance in metres between the outermost permanently fixed parts of the hull, including all structural or integral parts of the craft such as extensions of the hull, hull/deck joints and bulwarks. Breadth excludes removable parts that can be detached in a non-destructive manner and without affecting the integrity of the craft (e.g. rubbing strakes, fenders, guardrails and stanchions extending beyond the craft's side, and other similar equipment), but does not exclude detachable parts of the hull which act as hydrostatic or dynamic support when the craft is at rest or underway.

(F) Freeboard – distance in metres, measured amidships, between the waterline and:

a. the intersection between deck and hull; or
b. for rounded deck edges, the natural intersection, or,
c. where no deck is fitted or the hull extends above the deck (bulwark), the upper edge of the craft's hull.

What is the difference between a fully decked and an open vessel?

A vessel that can take on water and get rid of it quickly can operate in more unfavourable conditions than one that can't. The assessment criteria for fully decked vessels are considered valid for operation in waves up to 2 metres in height, whereas the criteria for open vessels are considered valid for waves up to 50 cm high. If your vessel meets the following criteria, it qualifies as a fully decked vessel.

Fully decked vessels have:

- a *watertight*[1] deck located at least the distance from Table 1[2] above the waterline when the vessel is fully loaded, and either:
- freeing ports[3] with total area not less than 4 per cent- of bulwark area; or
- *watertight*[1] cockpits/recesses with a combined volume not more than L*B*F/40 (length * breadth * freeboard/40)[4].

Note 1: A deck, cockpit or recess is watertight if you can spray it directly for three minutes with a hose that has a flow of at least 10 litres per minute and no more than 5 centilitres of water (less than a quarter cup) passes through.

Note 2: May be reduced to not less than 75 mm (3") above the waterline when the vessel is fully loaded when equipped with effective non-return devices. Consult your local Transport Canada Centre.

Note 3: At a minimum, two freeing ports (one port and one starboard) may be accepted each having a clear area of at least 225 cm^2 – the ports may be fitted in the transom on vessels where the shipping of water will not result in a trim by the head, preventing the deck from draining.

Note 4: Freeboard (F) is used to determine whether a cockpit/recess can be ignored from the perspective of swamping by calculating its volume as a percentage of reserve buoyancy. If a vessel has a well deck with scuppers only, then F would be measured from the top of the gunwale. If, however, there are large freeing ports (minimum 4 per cent of bulwark area) or flush deck with rails only, F should be measured from the deck.

Table 1

Vessel Length	Distance deck above waterline when vessel fully loaded
6 metres	200 mm
9 metres	250 mm
12 metres	300 mm

For lengths between 6, 9 and 12 metres, calculate the appropriate distance.

An **open vessel** is any vessel that is not full decked.

Preparing for the assessment

A little preparation and some readily available equipment are all that's needed to carry out the assessment. Before you start, you will need:

- a measuring tape;
- weights representing the full complement of passengers and crew (75 kg per person) and, if applicable, cargo and diving equipment (36 kg per diver). Weights may consist of: water-filled drums; jerry cans; fish boxes; sandbags, etc. As a last resort, people may be used if lifejackets are worn and the testing is carried out with caution;
- a scale to measure the weights if their weight is not known and cannot be established by other means; and
- if you have not already determined whether the vessel qualifies as fully decked, a garden hose, with jet nozzle, capable of a continuous flow of a least 10 litres per minute (pressure = 200 kPa/30 psi).
- equipment for measuring the angle of heel: a pendulum (string and weight) and marker; or a clinometer - a simple instrument for measuring the angle from vertical.

On the day of the assessment, prepare the vessel as follows:

- moored in calm water, mooring lines slack;
- fully loaded at design trim;
- scuppers and downflooding openings that may be immersed during offset load test temporarily sealed as a precautionary measure to prevent water from entering the vessel during the test;
- tanks for carrying liquids filled to at least three-quarters full;
- the helmsperson at helming position; and
- weights distributed to represent the typical operational distribution of the complement, with the vertical centre of gravity (CG) for simulated passenger weights as close as practical to 75 cm above the deck.

  Note: For multi-deck vessels, place the weights so that they simulate the distribution of the complement among the decks with maximum capacity on upper decks.

Carrying out the assessment step by step

1. Determine the passing marks

Use the tables in the Appendixes to determine the minimum downflooding and residual downflooding heights and the maximum heel angle based on the overall length of your vessel. Write them down on the Record of Stability and Buoyancy Assessment in the following section.

As you carry out the assessment, you will be able to tell whether your vessel meets the criteria.

2. Measure the downflooding height

With the vessel upright and at the design trim in the fully loaded condition, measure the height in metres from the waterline and the downflooding opening (see below). This is known as the downflooding height. Record the outcome.

Determining the downflooding opening

The downflooding opening is the lowest point that could let a significant amount of water into the interior or bilge of a vessel. It can be an opening in the hull, or the deck for vessels being assessed as fully decked, such as a vent, non-watertight hatch, window or door. Openings that are equipped with non-opening appliances or watertight opening appliances that are clearly marked "Watertight Closure – Keep Shut While Underway" or that would not cause the vessel to sink if the affected compartments were flooded are not downflooding openings.

Engine space louvered vents (intakes) located just below the top of the gunwale on an open vessel may also be disregarded **provided a high water alarm and efficient bilge pumping system are fitted**.

Use the following as guidance to determine which openings are downflooding openings:

- cross sectional area in square mm bigger than 50 times the length in metres squared; or
- cross sectional area in square mm bigger than 660 times the fully loaded displacement in tonnes.

If displacement is available, use the smaller of the two values.

See Appendix 1 for examples of downflooding height measurement on vessels of varying configurations.

3. Measure the heel angle and downflooding height in the offset position

To measure the angle of heel, you can use a measuring tape, a pendulum, or a clinometer. If you have a clinometer, this is the easiest method and needs no further explanation. Start with the vessel in the upright position.

Measuring Tape method: Measure the distance from the centreline to the top of the gunwale, and from the top of the gunwale to the waterline. Record these in the record of assessment in the following section.

Pendulum method: Create a pendulum on the centreline by setting up a string with a weight at the end. Make it as long as possible and mark the resting position of the weight on the deck. Measure the length of the pendulum and record it in the record of assessment. Suspending the pendulum weight in a liquid such as oil will dampen excessive movement and make measurement easier and more exact.

Taking care to ensure that the vessel's stability remains within acceptable limits, shift weights to one side of the vessel simulating realistic passenger and crew shift to the side and re-measure the distance from top of the gunwale to water (measuring tape method), the distance the pendulum moved (pendulum method) or angle of heel (clinometer method). Re-measure the downflooding height. Record the results, calculate the angle of heel and record it as well.

Shift the weights to the other side of vessel and repeat the measurements.

Note: The weights are to be placed so that they represent the most extreme situation that may occur. If all passengers are likely to rush to one side of the vessel if a whale is sighted, for example, move only the weights representing passengers but leave the cargo weights in place, assuming the cargo will be secured and will not shift as the passengers change position.

If your vessel does not pass

If the vessel doesn't meet the pass criteria, you can remove weights totalling 75 kg at a time until the vessel meets the criteria. You will then know how many people the vessel can carry and still meet the *Simplified Assessment* criteria.

Other options are also available. Assessment against a full stability standard – ISO, US or UK – is recommended. Because the assessment is more extensive, the full standards have less stringent criteria than the *Simplified Assessment* and should result in less restrictive operating constraints for your vessel.

For more information on the options available, check the Small Vessels webpage on the Transport Canada Marine Safety website at www.tc.gc.ca/smallvessels.

Capsizing and swamping are the most likely of all marine incidents to result in fatality.

- Transportation Safety Board

Record of Stability Assessment

Vessel Particulars

Vessel Name	**Official Number**	
Date	**Location**	
L - Length Overall ……..metres	**Weight Required for Assessment**	
B – Breadth…… metres	**Max crew**	____ x 75 kg = kg
F – distance from waterline at mid-length to top of gunwale (open vessel) or deck (fully decked vessel) ……. metres	**Max passengers**	____ x 75 kg = kg
Lowest Downflooding Opening (describe)	**Divers equipment**	____ x 36 kg = kg
	Maximum cargo	kg
	Total weight	kg

Assessment Details: Vessel Assessed as: Fully Decked/ Open *(select one)*

Note: Assessments are considered valid only when operating in **waves not exceeding** 2 metres if fully decked, 1.2 metres if open.

		As Measured (metres)	**Evaluation Criteria (from Appendix 2)**	
Downflooding Height		_____	More than _____ metres	
Residual Downflooding Height		_____	More than _____ metres	
Offset Heel Angle			Measurements converted to degrees[1]	
Measuring tape method:	**Pendulum method:**			
Centreline to gunwale:	Pendulum length :	_____		
Gunwale to waterline (vertical)		_____	Port ____°	Less than _____ °
Gunwale to waterline (offset to port)	Plumb bob travel (offset to port)	_____		
Gunwale to waterline (offset to stbd)	Plumb bob travel (offset to stbd)	_____	Stbd ____°	

[1]See next section "Converting to degrees"

Assessment carried out by:_____ Signature: _____

Multi-deck vessels: Vertical distribution of equivalent passengers:
Main Deck ____ Upper Deck ____ Flybridge ____

Converting to degrees

If you use the measuring tape or pendulum method to determine the offset heel angle, you will need to convert the measurements taken to angle in degrees. This is done with some simple arithmetic and comparing the result to the values on the table below.

Measuring tape method:

- Subtract the distance from the gunwale to the waterline (offset) from the distance gunwale to the waterline (vertical).
- Divide the result by the distance from centreline to gunwale.
- Compare the result to the values for *tan (Angle)* in the table below to find the approximate angle of heel.

Pendulum method:

- Divide the distance travelled by the plumb bob by the length of the pendulum.
- Compare the result to the values for *tan (Angle)* in the table below to find the approximate angle of heel.

Example:
Measuring tape method:

Gunwale to waterline (offset) 1.2 metres
Gunwale to waterline (vertical) 1.5 metres

1.5 – 1.2 = 0.3

Centreline to gunwale 2.5 metres

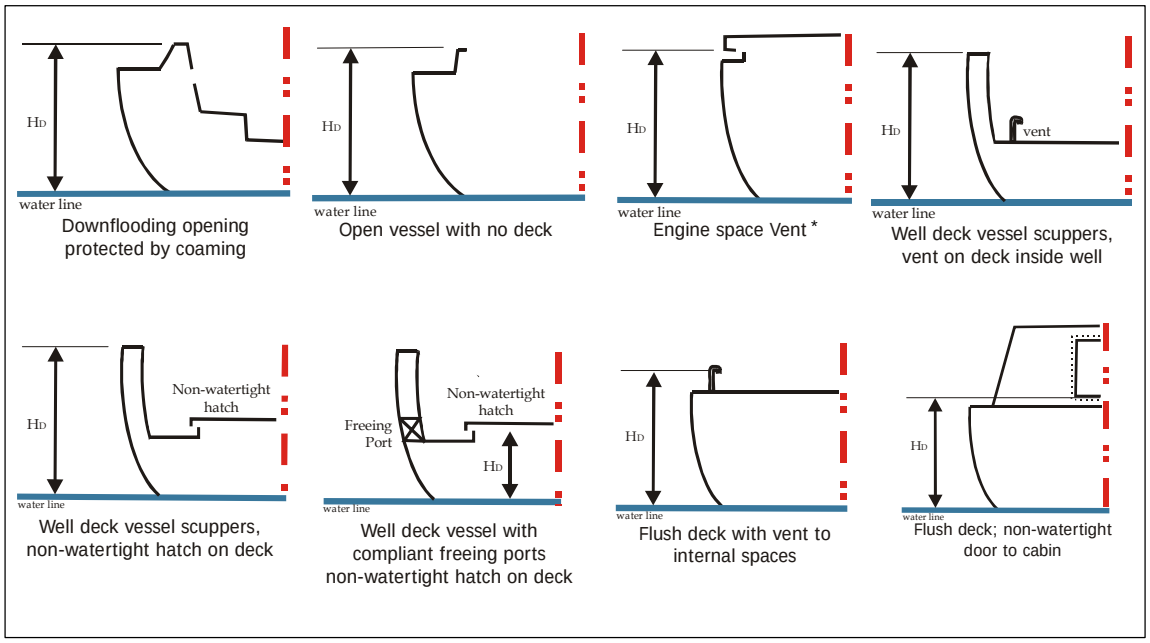
0.3 / 2.5 = .120

The value of tan (Angle) closest to .120 is .123, so the approximate angle of heel is 7°.

tan (Angle)	*Angle*	tan (Angle)	*Angle*	tan (Angle)	*Angle*
0.000	0°	0.176	10°	0.364	20°
0.017	1°	0.194	11°	0.384	21°
0.035	2°	0.213	12°	0.404	22°
0.052	3°	0.231	13°	0.424	23°
0.070	4°	0.249	14°	0.445	24°
0.087	5°	0.268	15°	0.466	25°
0.105	6°	0.287	16°	0.488	26°
0.123	7°	0.306	17°	0.510	27°
0.141	8°	0.325	18°	0.532	28°
0.158	9°	0.344	19°	0.554	29°

Appendix 1 - Downflooding height measurement examples

Downflooding Height (upright)
H_D



* If the engine space of an open boat is provided with a high water alarm and fitted with an efficient bilge pumping system, louvered engine space vents are not considered downflooding openings.

Appendix 2 - Evaluation criteria

Minimum downflooding height (m) in upright condition

Fully decked vessel		L/17
Open vessel	6m – 7.5m	L/10
	7.5m – 12m	0.75m

L – Length, as defined on page 4, in metres.

Examples: *7 metre fully decked vessel* *41 cm (7 m/17 = 0.41 m)*
7 metre open vessel *70 cm (7 m/10 = 0.70 m)*

Maximum allowed offset load heel angle

Vessel length (m)	6	7	8	9	10	11	12
Maximum offset heel angle (°)	15.2	13.8	12.5	11.0	10.0	9.1	8.3

Minimum residual downflooding height

Vessel length (m)	6	7	8	9	10	11	12
Minimum residual downflooding height (m)	0.27	0.29	0.31	0.33	0.35	0.36	0.38

Note: Calculate values for intermediate lengths and for lengths over 12 m (not more than 15 tons gross tonnage)