



NCWG7-06.4

Depth Resolution on Charts



IHO

CURRENT IHO STANDARDS FOR DEPTH UNITS (1)

International
Hydrographic
Organization

S-4:

B-130 UNITS

The standard units for **depths** and **heights** must be metres (m) and decimetres (dm).

The standard units for **positional accuracy** must be metres (m).

The standard units for **distance** 'on the ground' must be nautical miles (M) and cables, or metres (m).

The standard units for **dimensions of charts** must be millimetres (mm).

The standard units for **time** must be hours (h), minutes (min or m) and seconds (sec or s), referred to Universal Time Co-ordinated (UTC).

The standard units for **speed** must be knots (kn).

The standard units for **geographical positions** should be degrees (°) minutes (') and decimals of a minute. Degrees (°), minutes (') and seconds (") may be used if appropriate.

The standard units for **bearings**, such as for a recommended track or magnetic variation, should be degrees (°) and decimals of a degree. Degrees (°) and minutes (') may be used if appropriate.

B-412 SOUNDINGS

Charted soundings must represent the depth measured from Chart Datum to the sea floor placed in such a way that the centre of gravity (geometric centre) of the set of numerals coincides with the position referred to.

Rounding of depths, including drying heights, must always be on the safe (shoaler) side (that is: soundings must be rounded down and drying heights rounded up, if necessary). The rounding should be:

For depths

- to the nearest decimetre between 0,1 and 21m:
0,001 to 0,099 rounds **down** to nearest decimetre for example: a recorded depth of 4,38m rounds down to 4,3m.
- to the nearest half metre from 21 to 31m:
0,001 to 0,499 rounds **down** to 0,0 for example: a recorded depth of 23,49 rounds down to 23m;
0,500 to 0,999 rounds **down** to 0,5 for example: a recorded depth of 23,51 rounds down to 23,5m.
- thereafter, to the nearest metre:
0,001 to 0,999 rounds **down** to 0,0 for example: a recorded depth of 31,85m rounds **down** to 31m.

For drying heights

- to the nearest decimetre:
0,001 to 0,099 rounds **up** to nearest decimetre for example: a recorded drying height of -2,32m rounds **up** to -2,4m

However, these soundings must be adjusted as a function of the degree of accuracy with which depths were actually measured, so that the precision with which soundings are recorded on charts can never be misleading as to the accuracy of such soundings.



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CURRENT IHO STANDARDS FOR DEPTH UNITS (2)

International Hydrographic Organization

S-57: (Appendix A, Chapter 2)

Attribute: Value of sounding

Acronym: VALSOU

Code: 179

Attribute type: F

Definition:

The value of the measurement of a sounding relative to the chart datum.

References:

INT 1: II 10, 11, 14, 15;

M-4: 410; 412 413.1;

Indication:

Unit: defined in the DUNI subfield of the DSPM record or in the DUNITs attribute of the M_UNIT meta object class, e.g. metre (m)
Resolution: 0.1 m or 0.1 fm or 0.1 ft

Format:

sxxxxx.xx
s: sign, negative values only.

Examples:

18.2 for a sounding of 18.2 metres.
-2.4 for a drying height of 2.4 metres.

S-57: (Appendix B.1, clause 4.4) (= S-4)

Depths are converted from decimal meters to integers by means of the A3-D (Sounding) Multiplication Factor \equiv [SOMF] subfield value in the AData Set Parameter \equiv [DSPM] field. The integer values are encoded in the A3-D (Sounding) Value \equiv [VE3D] subfield. Soundings are never encoded with a resolution greater than one decimeter, so the value of SOMF must be 10 encoded in binary form.

(= S-4)

(\neq S-4)





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CURRENT IHO STANDARDS FOR DEPTH UNITS (3)

International Hydrographic Organization

S-101: (\neq S-4)



10.1.2 Encoding of Depths

Depths are converted from decimal metres to integers by means of the [CMFZ] (see Annex B – clause B5.1.2). This Product Specification limits the resolution to two decimal places and therefore the [CMFZ] must be set to {100}.

EXAMPLE: A depth = 4.2 is converted in $Z = \text{depth} * \text{CMFZ} = 4.2 * 100 = 420$

S-101: (Annex A)

(\neq S-4)



27.183 value of sounding (VALSOU)

Value of sounding: IHO Definition: The value of the measurement of a sounding relative to the chart datum. (S-57 Edition 3.1, Appendix A – Chapter 2, Page 2.232, November 2000).

Attribute Type: Real

Unit: Defined as an attribute in the ENC dataset metadata: metre (m)

Resolution: 0.01m

Format: sxxxxx.xx
s: sign, negative values only

Examples: **18.20** for a sounding of 18.2 metres
-2.46 for a drying height of 2.46 metres

Remarks:

- A drying height is indicated by a negative value.

27.85 depth range minimum value (DRVAL1)

(= S-4)

Depth range minimum value: IHO Definition: Depth range is the depth from a specified sounding datum as a depth interval bounded by the minimum (shoalest) and maximum (deepest) depth values. (Defence Geospatial Information Working Group; Feature Data Dictionary Register, 2010).

depth range minimum value defines the minimum (shoalest) value of a depth range. (S-57 Edition 3.1, Appendix A – Chapter 2, Page 2.124, November 2000).

Attribute Type: Real

Unit: Defined in the AXUM subfield of the CSAX record: metre (m)

Resolution: 0.1m

Format: sxxxxx.x
s: sign, negative values only

Example: **50** for a minimum depth of 50 metres

Remarks:

- Where the area dries, the value is negative.



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ACCURACY OF DEPTHS ON CHARTS (ZOC)

International Hydrographic Organization

ZOC Table:

1	2	3		4	5
ZOC ¹	Position Accuracy ²	Depth Accuracy ³		Seafloor Coverage	Typical Survey Characteristics ⁵
A1	± 5 m + 5% depth	= 0.50 + 1% d		Full area search undertaken. Significant seafloor features detected ⁴ and depths measured.	Controlled, systematic survey ⁶ high position and depth accuracy achieved using DGPS or a minimum three high quality lines of position (LOP) and a multibeam, channel or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10	± 0.6		
		30	± 0.8		
		100	± 1.5		
		1000	± 10.5		
A2	± 20 m	= 1.00 + 2% d		Full area search undertaken. Significant seafloor features detected ⁴ and depths measured.	Controlled, systematic survey ⁶ achieving position and depth accuracy less than ZOC A1 and using a modern survey echosounder ⁷ and a sonar or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10	± 1.2		
		30	± 1.6		
		100	± 3.0		
		1000	± 21.0		
B	± 50 m	= 1.00 + 2% d		Full area search not achieved; uncharted features, hazardous to surface navigation are not expected but may exist.	Controlled, systematic survey achieving similar depth but lesser position accuracies than ZOCA2, using a modern survey echosounder ⁷ , but no sonar or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10	± 1.2		
		30	± 1.6		
		100	± 3.0		
		1000	± 21.0		
C	± 500 m	= 2.00 + 5% d		Full area search not achieved, depth anomalies may be expected.	Low accuracy survey or data collected on an opportunity basis such as soundings on passage.
		Depth (m)	Accuracy (m)		
		10	± 2.5		
		30	± 3.5		
		100	± 7.0		
		1000	± 52.0		
D	worse than ZOC C	Worse Than ZOC C		Full area search not achieved, large depth anomalies may be expected.	Poor quality data or data that cannot be quality assessed due to lack of information.
U	Unassessed - The quality of the bathymetric data has yet to be assessed				

1	2	3		4	5
ZOC ¹	Position Accuracy ²	Depth Accuracy ³		Seafloor Coverage	Typical Survey Characteristics ⁵
A1	± 5 m + 5% depth	= 0.50 + 1% d		Full area search undertaken. Significant seafloor features detected ⁴ and depths measured.	Controlled, systematic survey ⁶ high position and depth accuracy achieved using DGPS or a minimum three high quality lines of position (LOP) and a multibeam, channel or mechanical sweep system.
		Depth (m)	Accuracy (m)		
		10	± 0.6		
		30	± 0.8		
		100	± 1.5		
		1000	± 10.5		

S-4: (B-412)

However, these soundings must be adjusted as a function of the degree of accuracy with which depths were actually measured, so that the precision with which soundings are recorded on charts can never be misleading as to the accuracy of such soundings.



10.1.2 Encoding of Depths

Depths are converted from decimal metres to integers by means of the [CMFZ] (see Annex B – clause B5.1.2). This Product Specification limits the resolution to two decimal places and therefore the [CMFZ] must be set to {100}.

EXAMPLE: A depth = 4.2 is converted in Z = depth*CMFZ = 4.2*100 = 420



IHO

RECOMMENDATIONS (1)

International
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It is recommended that the NCWG discuss and reconfirm that the units of measure for all depths on charts must be metres and decimetres as currently quoted in S-4 – B-130 (taking into account paragraphs 4,6,7,8 of the Paper).

B-130 UNITS

The standard units for **depths** and **heights** must be metres (m) and decimetres (dm).



IHO

RECOMMENDATIONS (2)

International
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Organization

Pending this confirmation, it is recommended that the NCWG endorse the draft S-101PT8 Paper included at Annex A (taking into account paragraphs 6-9 of this Paper).

Paper for Consideration by S-101PT

Depth Resolution in S-101 ENCs

Submitted by:	IHO Secretariat (TSSO); Danish Geodata Agency.
Executive Summary:	This paper reports on the resolution for depths currently included in S-101 and resultant conflict with S-4 clauses B-130 and B-412; and proposes possible options for moving forward.
Related Documents:	S-4; S-101 Main document; S-101 Annex A.
Related Projects:	S-101 development.

Introduction / Background

1. For S-101 Edition 1.0.0 (December 2018) the coordinate multiplication factor for depths [CMFZ] has been set to 100, allowing soundings to be encoded to centimetre resolution. Additionally, the resolution for the S-101 simple attribute valueOfSounding has correspondingly been set to 0.01 metres.
2. IHO Publication S-4 – *Regulations of the IHO for International (INT) Charts and Chart Specifications of the IHO* provides the specifications for the structure and content of nautical charts, including both paper charts and ENCs. The specification included in S-4 for the resolution of depths on charts currently states that the standard units for depths and heights must be metres and decimetres (clause B-130).
3. The inclusion of centimetre resolution for encoded depths in S-101 ENCs introduces an inconsistency with the fundamental IHO specification for chart content (S-4). This paper is intended to facilitate the resolution of this inconsistency, taking into account additional factors that may influence any decision taken.



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RECOMMENDATIONS (3)

International
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It is recommended that the NCWG endorse the redline changes to S-4 as included in Annex B (taking into account paragraphs 8-11 of this Paper).

B-412 SOUNDINGS

Charted soundings must represent the depth measured from Chart Datum to the sea floor placed in such a way that the centre of gravity (geometric centre) of the set of numerals coincides with the position referred to.

The standard units of measure for the display of depths, including drying heights, on charts must be metres (m) and decimetres (dm) (see B-130).

Rounding of depths, including drying heights, must always be on the safe (shoaler) side (that is: soundings must be rounded down and drying heights rounded up, if necessary). The rounding should be:

For depths

- to the nearest decimetre between 0,001 and 21m:
0,001 to 0,099 rounds **down** to the nearest decimetre. For example: a recorded depth, **adjusted to Chart Datum**, of 4,38m rounds down to 4,3m.
- to the nearest half metre **between 21.001 and 31m***:
0,001 to 0,499 rounds **down** to 0,0. For example: a recorded depth, **adjusted to Chart Datum**, of 23,49m rounds down to 23m;
0,501 to 0,999 rounds **down** to 0,5. For example: a recorded depth, **adjusted to Chart Datum**, of 23,81m rounds down to 23,5m.
- ~~thereafter~~, to the nearest metre **from 31,001m**:
0,001m to 0,999 rounds **down** to ~~0,0~~ **the nearest metre**. For example: a recorded depth, **adjusted to Chart Datum**, of 31,85m rounds down to 31m.

* Soundings sourced from high order surveys using modern survey techniques may be of a degree of accuracy such that the depths between 21.001 and 31m may be rounded down to the nearest decimetre as for depths up to 21m.

For depths stored in a source bathymetric database, the above rounding conventions equate to truncating the stored depth values to the required resolution. For ENC where depths may be stored in the dataset to the nearest centimetre, all numbers after the second decimal place of a metre should be truncated. For display of these depths in ECDIS, rounding to the nearest decimetre should be applied between 0.001 and 31m; and to the nearest metre from 31.001m, in accordance with the above rounding conventions.

For drying heights

- to the nearest decimetre:
0,001 to 0,099 rounds **up** to the nearest decimetre. For example: a recorded depth, **adjusted to Chart Datum**, of -2,32m rounds up to -2.4m.

For depths stored in a source bathymetric database, the above rounding conventions equate to truncating the stored depth values to the required resolution and adjusting the resolved value up by one where any removed integer is non-zero. For ENC where drying heights may be stored in the dataset to the nearest centimetre, the second decimal place of a metre should be rounded up if required (for example, -2.321m rounds up to -2.33m). For display of these drying heights in ECDIS, rounding up to the nearest decimetre should be applied in accordance with the above rounding convention.

However, these soundings must be adjusted as a function of the degree of accuracy with which depths were actually measured, so that the precision with which soundings are recorded on charts can never be misleading as to the accuracy of such soundings.



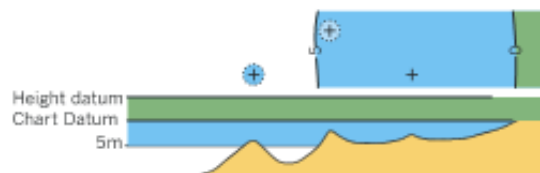
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RECOMMENDATIONS (3)

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B-421.4 Rocks which are always underwater must be shown as follows, according to their depth:

- a. Where the depth is unknown but the rock is considered to be dangerous to some surface vessels capable of navigating in the vicinity, by the symbol + with danger line and blue tint.



K13

- b. Where the depth is known, by either:
 - the symbol + with the depth, in metres and decimetres, alongside it in brackets, or
 - by a sounding with the abbreviation for a rocky seabed beneath it (see B-425).

35

R K15 Underwater rock of known depth, not dangerous to surface navigation.

Numerals for the depth must be shown, in metres and decimetres, in the normal style for soundings (see B-412). Blue tint should be added as appropriate to the depth.

If the rock is considered to be dangerous to some surface vessels capable of navigating in the vicinity, because the rock is significantly shallower than the general depth in the vicinity, the symbol + or the sounding should be enclosed in a danger line.



B-422 WRECKS, FOUL GROUND, OBSTRUCTIONS

- a. The **international abbreviation** ‘~~Wk~~’ must be used wherever the symbol for a charted feature does not identify it as a wreck.
- b. To give the mariner the maximum useful information, the least depth over a wreck (or, if unknown, an estimated safe clearance), **in metres and decimetres**, must be charted in preference to symbols K28 and K29. **Numerals for the depth must be shown in the normal style for soundings (see B-412)**. An exception is the remains of a wreck which are charted as foul ground (see B-422.9). For wrecks visible or partly visible at chart datum, the height or drying height should be shown in brackets, if known. **Drying heights must be shown above Chart Datum in the standard way (see B-413.1)**. The symbol K29 should be used for all wrecks in waters over 200 metres deep.
- c.

B-422.8



Changing criteria for wrecks. B-422.1-6 provides guidance on charting new wrecks. However, historically the criteria used for differentiating between symbols K28 and K29 for wrecks were often based on a threshold value for the estimated depth over the wreck (for example: 20m; 28m). Criteria have varied between nations and over time (due to the increasing draught of large vessels). The term ‘non-dangerous wreck’ was formerly used for K29 symbols, even though they may be dangerous to some vessels capable of navigating in the vicinity. Unfortunately, the chart user is not necessarily aware of that fact or that, due to the changing criteria, the same symbol on a chart may have different meanings. Ideally, therefore, all charted K28 and K29 symbols should be re-assessed to conform to the guidance above.

B-422.9



A **Foul Area** is an area of numerous uncharted dangers to navigation. The area charted serves as a warning to the mariner that all dangers to navigation are not charted individually and that navigation through the area may be hazardous. The term ‘foul area’ should not be applied to a soft continuum with indefinite boundaries such as mud or sand; to areas congested with marine vegetation such as kelp or grass in water (unless attached to rocks or obstructions); or to materials not likely to cause damage to a vessel.

Foul Ground is an area over which it is safe to navigate but which should be avoided for anchoring, taking the ground or ground fishing (for example: remains of wreck; cleared platform).

It is important to distinguish between these two uses of the description ‘Foul’ on charts. Therefore, the word ‘Foul’ should be avoided on charts, because of the potential for confusion by the chart user. (Note: Historically, these two uses derive from differing nautical terminology, for example: Foul Area in US; Foul Ground in UK).



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RECOMMENDATIONS (3)

International Hydrographic Organization

B-444.8 Pipeline installations. Diffusers and cribs at the end of pipes, and templates, manifolds (see B-445.1) and other underwater installations associated with pipelines should be charted in the same way as other obstructions, either with the abbreviation '*obstn*' or an appropriate legend, eg. '*Diffuser*', '*Manifold*'. All specifications relating to obstructions apply; see B-411.6 and B-422.10.

B-445.1 Wells, Wellheads, Templates and Manifolds.

- a. **Abandoned wells.** In the course of developing an oil or gas field,
- b. **'Wellhead'** is a term used to describe a submarine structure projecting some distance above the sea floor

The symbol must be a danger circle with the legend '*Well*'. Where the depth of water over the top of the wellhead is known, it may be inserted within the danger circle (as for any other obstruction, see B-422.10).



f. **Templates and Manifolds.**

These installations must be charted, if required, as obstructions (see B-422.10) with the legends '*Template*', '*Manifold*', or equivalent, instead of '*Obstn*'.

B-422.9



A **Foul Area** is an area of numerous uncharted dangers to navigation. The area charted serves as a warning to the mariner that all dangers to navigation are not charted individually and that navigation through the area may be hazardous. The term 'foul area' should not be applied to a soft continuum with indefinite boundaries such as mud or sand; to areas congested with marine vegetation such as kelp or grass in water (unless attached to rocks or obstructions); or to materials not likely to cause damage to a vessel.

B-422.10



Submerged obstructions too small to be shown to scale must be charted similarly to wrecks (see B-422.3, 422.4, 422.7) but with the **international abbreviation** '*Obstn*' in place of '*Wk*'. Further information may be provided by replacement of the legend '*Obstn*' with appropriate legends to indicate the characteristics of the submerged obstruction, where known, for example: '*ODAS*'; '*Diffuser*'. Larger obstructions must be charted with a danger line and legend. Blue tint must be added over obstruction symbols in accordance with the charted depth, and in all cases where a depth numeral is not charted and the general depth of water is less than 100m.



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RECOMMENDATIONS (3)

B-422.9 A foul area is

The **foul ground** symbol should be used as a point symbol to indicate small areas of sea floor debris, for example: the distributed remains of a wreck; a dropped anchor; the site of cleared production platform (provided the platform has been removed to the sea floor):

K31/L22

Note: Platforms which have been cut-off **above** the sea floor must be charted as obstructions, see B-422.10.

The depth over the area, if known and required, may be shown **in metres and decimetres**, adjacent to the symbol, for example:

(22)

Numerals for the depth must be shown in the normal style for soundings (see B-412).

Larger areas of foul ground should

B-422.9



A **Foul Area** is an area of numerous uncharted dangers to navigation. The area charted serves as a warning to the mariner that all dangers to navigation are not charted individually and that navigation through the area may be hazardous. The term 'foul area' should not be applied to a soft continuum with indefinite boundaries such as mud or sand; to areas congested with marine vegetation such as kelp or grass in water (unless attached to rocks or obstructions); or to materials not likely to cause damage to a vessel.

B-422.10



Submerged obstructions too small to be shown to scale must be charted similarly to wrecks (see B-422.3, 422.4, 422.7) but with the **international abbreviation** 'Obstn' in place of 'Wk'. Further information may be provided by replacement of the legend 'Obstn' with appropriate legends to indicate the characteristics of the submerged obstruction, where known, for example: 'ODAS'; 'Diffuser'. Larger obstructions must be charted with a danger line and legend. Blue tint must be added over obstruction symbols in accordance with the charted depth, and in all cases where a depth numeral is not charted and the general depth of water is less than 100m.



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RECOMMENDATIONS (3)


B-445.10 Underwater turbines, for generating electricity from tidal currents, must be represented:



Where the depth of water over the turbine is known, it may be inserted within the danger circle. The rules for blue tint, swept and safe clearance depths must be applied as for wrecks and other obstructions (see B-411.6, B-415, B-422.3-5 and B-422.10), for example:




B-422.3

A wreck which has been wire swept, or has had its least depth determined by a diver, must be shown by sounding numerals showing the depth to which it has been swept, surrounded by a danger line, with the abbreviation 'Wk'; the swept depths symbol  K2 must be inserted under the danger line, for example:





B-422.4

A wreck over which the least depth that is known has been found by sounding only, must be shown as in B-422.3 but without the swept  symbol, for example:



B-422.5

A wreck with estimated safe clearance. For a wreck (in water less than 200m deep) over which the least depth is unknown, a safe clearance depth must be estimated if possible.

To avoid the ambiguity in interpreting the symbols  and , the 'safe clearance bar' must be used for a wreck which is considered to have a safe clearance to the depth shown, for example:



B-422.10

Submerged obstructions too small to be shown to scale must be charted similarly to wrecks (see B-422.3, 422.4, 422.7) but with the **international abbreviation** 'Obstn' in place of 'Wk'. Further information may be provided by replacement of the legend 'Obstn' with appropriate legends to indicate the characteristics of the submerged obstruction, where known, for example: 'ODAS'; 'Diffuser'. Larger obstructions must be charted with a danger line and legend. Blue tint must be added over obstruction symbols in accordance with the charted depth, and in all cases where a depth numeral is not charted and the general depth of water is less than 100m.

B-422.9



A **Foul Area** is an area of numerous uncharted dangers to navigation. The area charted serves as a warning to the mariner that all dangers to navigation are not charted individually and that navigation through the area may be hazardous. The term 'foul area' should not be applied to a soft continuum with indefinite boundaries such as mud or sand; to areas congested with marine vegetation such as kelp or grass in water (unless attached to rocks or obstructions); or to materials not likely to cause damage to a vessel.



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ACTIONS REQUESTED OF NCWG

- 1) **Confirm** that the current specification mandating that the units of measure for depths on charts must be metres and decimetres as included at S-4 – B-130.
- 2) **Endorse** the draft Paper for submission to the S-101 Project Team included at Annex A.
- 3) **Discuss** and **Approve** the redline amendments to the impacted S-4 clauses relating to the rounding and depiction of depths on charts as included at Annex B.
- 4) **Initiate** any further action as appropriate.



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THANK YOU

NCWG7 Remote Meeting 24-25 November 2021