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NEWBUILDINGS  
SPECIAL EQUIPMENT AND SYSTEMS – ADDITIONAL CLASS

# Loading Computer Systems (LCS) for Stability and Longitudinal Strength

JANUARY 2011

*This chapter has been amended since the main revision (January 2011), most recently in July 2011.  
See “Changes” on page 3.*

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## CHANGES

### General

As of October 2010 all DNV service documents are primarily published electronically.

In order to ensure a practical transition from the “print” scheme to the “electronic” scheme, all rule chapters having incorporated amendments and corrections more recent than the date of the latest printed issue, have been given the date January 2011.

An overview of DNV service documents, their update status and historical “amendments and corrections” may be found through [http://www.dnv.com/resources/rules\\_standards/](http://www.dnv.com/resources/rules_standards/).

### Amendments July 2011

- **General**

— The restricted use legal clause found in Pt.1 Ch.1 Sec.5 has been added also on the front page.

### Main changes

Since the previous edition (January 2005), this chapter has been amended, most recently in July 2008. All changes previously found in Pt.0 Ch.1 Sec.3 have been incorporated and a new date (January 2011) has been given as explained under “General”.

In addition, the layout has been changed to one column in order to improve electronic readability.

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## SECTION 1 GENERAL REQUIREMENTS

### A. Classification

#### A 100 Application

**101** A loading computer system is a computer based system for calculation and control of loading conditions for compliance with the applicable stability requirements and longitudinal and local strength requirements. The loading computer system consists of software (calculation program) and the computer (hardware) on which it runs.

**Guidance note:**

The DNV expression "loading computer system" covers the IACS expression "Loading instrument", and the IACS definition thereof: "A loading instrument is an instrument, which unless stated otherwise is digital, by means of which it can be easily and quickly ascertained that, at specified read-out points, the still water bending moments, shear forces, and the still water torsion moments and lateral loads, where applicable, in any load or ballast condition will not exceed the specified permissible values."

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**102** The requirements of this chapter apply to ships equipped with a loading computer system.

**103** Ships for which a loading computer system calculating hull strength is required, is defined in Pt.3 Ch.1 Sec.5, subsections A and F, and in Pt.3 Ch.2 Sec.4 E.

**104** The stability software, if installed onboard, shall cover all stability requirements applicable to the ship, except as given in 105.

**105** For installations onboard ships contracted prior to 2005-07-01 the following apply:

If the loading computer system does not check all the stability requirements as applicable for the ship and cargo type, the users are to be informed accordingly. The requirements not checked are to be displayed on the screen for the actual loading condition, and to be included when printouts are made.

(IACS UR L5)

#### A 200 General requirements

**201** The loading computer system is regarded as supplementary to the Loading Manual and the Stability Booklet and if relevant the Grain Loading Manual which are always to be provided on board.

**202** Approval and certification of the loading computer system shall be carried out for each specific ship for which the loading computer system is installed. The results of the calculations are only applicable to the ship for which the loading computer system has been approved and certified.

**203** The approval and certification process include the following procedures for each ship:

- a) Approval of software which results in approved Test Conditions.
- b) Approval of computer hardware, where necessary (see 206).
- c) Certification of the installed loading computer system which results in loading computer certificate.

**204** The approved test conditions shall be kept onboard together with the User's manual and the loading computer certificate.

**205** For ships with loading computer system approved for strength, all design conditions upon which the approval of hull scantlings is based, shall be within the system limits. For vessels with class notation **CONTAINER** or **Container Carrier** having large deck openings (see Pt.3 Ch.1 Sec.5 A200), the system is generally to include procedures for the control of the torsional response of the still water torsional moment distribution over the length.

**Guidance note:**

Guidance for calculation of still water torque at read out points:

- a) The ship structure may generally be assumed symmetric about the centre line.
- b) The possible angle of heel may be determined by summing the moments of cargo, ballast and fuel.
- c) The still water torque may be determined by summing the moments of cargo, ballast and fuel and uprighting moment by the angle of heel successively to each checkpoint. The effects of the angle of heel should be fully accounted for in the summation.

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**206** The approved software is either to be installed on a type approved hardware, or it shall be installed on two nominated computers. If two nominated computers are available, approval of the hardware may be waived, but both nominated computers are subject to certification. In addition, computers which shall be a part of a ship's network should be approved in accordance with other relevant requirements posed by the Society.

**207** On-line loading computers shall, if connected to the ship's network, comply with the requirements of Pt.4 Ch.9 Sec.4 for computer based systems.

**208** The loading computer system shall be capable of producing print-outs of the results in both numerical and graphical form. The numeric values for strength shall be in both absolute values and as the percentage of the allowable values. These print-outs shall include a description of the corresponding loading condition.

**209** All screen and hardcopy output data shall be presented in a clear and unambiguous manner with an identification of the calculation program and the version number. The date and time of the of a saved calculation shall be part of the screen display and hardcopy printout.

**210** If the software includes on-line interface, for instance remote tank sounding or draught reading, it is assumed that the remote system is maintained and calibrated as recommended by the manufacturers.

**211** Single point loading computer systems are not acceptable.

### **A 300 General software requirements**

**301** It is recommended that the design and production of the calculation program are in accordance with appropriate international quality standards, for example ISO 9000-3 or equivalent.

**302** The software shall present relevant parameters of each loading condition. The following shall be presented:

- 1) Deadweight definition
- 2) Light ship data
- 3) Displacement and centre of gravity
- 4) Draughts at the forward and aft perpendiculars and at midship
- 5) Draughts at the ship's draught marks forward, midship and aft
- 6) Where applicable, provision should be made available for the introduction of a longitudinal deflection
- 7) Trim
- 8) Metacentric height  $K_{Mt}$
- 9) Free surface moments from slack tanks, listed for each tank and in total for the vessel
- 10) Free surface correction on the initial metacentric height (GM)
- 11) Free surface correction on the righting lever (GZ)
- 12) Where applicable, effect of external heeling moments
- 13) Flooding angle
- 14) Stability limitations: Listing of all relevant stability criteria: description of the criteria, the limit values, the obtained values and the conclusions (criteria fulfilled or not fulfilled)
- 15) Strength limitations: Listing of obtained values compared with the limit values:
  - i) Shear forces and bending moments for sea going and harbour conditions
  - ii) Where applicable, shear force correction and corrected shear forces for sea-going and harbour conditions
  - iii) As applicable for bulk carriers, see Pt.5 Ch.2 Sec.5
    - 1) The mass of cargo and double bottom contents in way of each hold as a function of the draught at mid-hold position
    - 2) The mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds
    - 3) Above i) and ii) for the hold flooded conditions, seagoing only
    - 4) For bulk carriers which have been designed with two design bending moments, i.e. one reduced bending moment for alternate loading and one full moment for homogeneous loading, the software shall calculate maximum allowable and minimum required mass for each hold for intermediate still water bending moments.
  - iv) Where applicable, still water torsion moments.

The calculated forces and moments shall be displayed in both graphical and tabular format, including the percentage of permissible values. The screen and hardcopy output shall display the calculated forces or moments, and the corresponding permissible limit, at each specified read-out point. Alternative limits, e.g. vertical still water bending and torsion may be considered in accordance with the Society's Rules.

- 16) A clear warning shall be given if any of the strength-, stability- or general- loading limitations (see 304) are not complied with
- 17) Overall judgement whether all the strength-, stability- and general loading limitations are within the limiting values
- 18) The data shall be presented as screen and hard copy output to the user in a clear and unambiguous manner.

**303** If the software calculates damage stability, this shall be done either with control against approved limit curves (KG, GM) or with direct calculation and control against a predefined group of all the relevant damage cases. If the latter alternative is used, the following shall be fulfilled:

- 1) A list of the relevant damage cases shall be included
- 2) Any intended loading condition must be checked against these damage cases
- 3) The results of the calculation and control shall include the equilibrium position and the GZ curve after damage, as well as control against the criteria
- 4) The software shall give an overall judgement whether all damage cases comply with the applicable requirements, within an acceptable time.

Unprotected and weathertight openings shall be included and taken into account. Alternatively, zones or lines defining unprotected, weathertight and/or watertight area(s) can be accepted if it is ensured that the effect of all openings is covered.

**Guidance note:**

Relevant damage cases are found in the ship's damage stability documentation.

To cover unsymmetrical tanks arrangements and/or loading the damage cases should be defined on both port and starboard side of the vessel.

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**304** The software shall include general loading limitations as applicable:

- 1) Maximum draught: not to exceed the loadline mark
- 2) Minimum draughts: due to strength considerations (slamming)
- 3) Minimum metacentric height (GM): to satisfy requirements for stability
- 4) Maximum metacentric height (GM): to limit sloshing in tanks
- 5) Maximum trim. The loading computer should be capable of accurate and reliable calculations for actual operating range of trim

**Guidance note:**

In cases where limit curves, hydrostatics and/or cross curves are given/approved for specific/limited trim a warning shall be given if the specific/limited trim is exceeded. If the software is based on interpolation for even keel data only, the limiting trim will be considered as maximum 1% of the ship's length.

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- 6) Lateral load limitation: due to strength considerations
- 7) Cargo tank filling height as a function of cargo density: due to strength and/or stability considerations
- 8) Limits to distributed loads on deck: to be limited by the strength for which the deck is approved.

**305** The software shall reject input errors by the user. For instance tank volume input shall not exceed maximum tank volume, or negative volume input shall not be accepted.

**306** The software and the stored characteristic data shall be protected against erroneous use. The software should be written to ensure that the user can not alter the following fixed data:

- 1) Light ship data: weight, centre of gravity and weight distribution:
- 2) Strength limitations
- 3) Stability criteria
- 4) Geometric hull form data
- 5) Hydrostatic data
- 6) Stability cross curves

- 7) Compartment definitions including frame spacing, and centres of volume, together with capacity tables (sounding/ullage tables), if appropriate
- 8) As applicable, flooding angle and/or unprotected and weathertight openings and/or zones or lines covering effect for all openings
- 9) Where applicable, group of damage cases
- 10) Where applicable, limit curves (KG, GM).

**307** If the software includes on-line interface, for instance remote tank sounding or draught reading, a warning shall be given in case of on-line interface failure. Further, it shall be possible to give the on-line input manually.

**308** The software shall be user-friendly, preferably with graphic presentation of loading conditions.

**309** Any changes made to the software, which may affect the longitudinal strength or stability aspects, shall be made by the manufacturer or his appointed representative. The Society shall be informed immediately of any changes. Failure to advise of any modifications to the software will invalidate the certificate issued. In such cases, the modified software shall be re-assessed in accordance with the approval and certification procedure.

**310** The loading computer system's software may be type approved. The validity and limitations of type approval shall be carefully noted. Type approval of loading computer software is described in Classification Note No. 21.1.

**Guidance note:**

Approval for each specific ship is required also for type approved software.

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**311** The software shall monitor operation and activate an alarm when the program is incorrectly or abnormally used.

**312** The software and any data stored in the system shall be protected from corruption by loss of power.

**A 400 General hardware requirements**

**401** In case two nominated computers are used, these are both to be equipped with separate screen and printing possibility.

## SECTION 2 APPROVAL

### A. Documentation to Submit for Approval

#### A 100 Documentation on hardware

**101** Requirements in Pt.4 Ch.9 shall be complied with.

**102** If the hardware shall be type approved, documentation for the computer shall be submitted for approval. For requirements to documentation types, see Pt.4 Ch.9.

**Guidance note:**

Stand-alone computer hardware

- a) The Society may issue a Certificate of Type Approval for the shipboard hardware, used by the program, when the hardware has been deemed to satisfy the recommendations specified in b). The Society may stipulate additional requirements.
- b) The manufacturer should submit details of the hardware to be installed onboard. The following information should be submitted for review and if found satisfactory, the manufacturer will be advised accordingly:
  - 1) The hardware specification
  - 2) Relevant design drawings with materials specified, catalogues, data sheets, calculations and functional descriptions
  - 3) Proposed test programme to demonstrate that the performance provisions of the specified standards may be fulfilled
  - 4) Certificates and reports for relevant tests previously obtained for the product.
- c) When considering the information described in b) the Society may recognise valid certificates or reports issued by another certification body or accredited laboratory.
- d) Performance and environmental testing should be carried out in the presence of a surveyor from the Society according to the type testing conditions for type approval detailed in IACS Unified Requirements (UR) E10 "Testing Procedure for Electrical, Control and Instrumentation Equipment, Computers and Peripherals covered by Classification". The following tests should be successfully completed:
  - 1) Visual inspection
  - 2) Performance test
  - 3) Electric power supply variations
  - 4) Dry heat
  - 5) Damp heat
  - 6) Vibration
  - 7) Inclination.
  - 8) Insulation resistance
  - 9) Cold temperatures
  - 10) Electromagnetic compatibility tests.
- e) The Society shall be advised of any alterations in the hardware specifications.

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#### A 200 Software documentation

**201** Approval of the software means that the Society approves the software for installation onboard a specific vessel. The approval is based on a review and acceptance of design, calculations method, verification of stored data and test conditions for the specific vessel. The approval is a confirmation that the software is able to give correct results provided that the user's input is correct.

**202** All program data shall be in accordance with the onboard strength and stability documentation.

**203** The units and reference system of the test conditions and the stored characteristic data shall be the same as used in the onboard strength and stability documentation.

**204** The documentation must be prepared in a language understood by the users. If this language is not English, a translation into English shall be included.

**205** All submitted documentation shall be identified with the following:

- 1) Name of vessel, name of yard and the yard building number of the ship for which the program applies
- 2) Program name, version number and version date
- 3) Program manufacturer name and address
- 4) List of content
- 5) For the test conditions, reference to where in the onboard loading and stability booklets the corresponding loading conditions are found.

**206** For each specific ship the following documentation shall be submitted:

- 1) Filled in approval request form, see 207.
- 2) User's manual, see 208.
- 3) Program description (not required for type approved software), see 209.
- 4) Preliminary test conditions, see 210.
- 5) Stored characteristic data, see 211.
- 6) Final test conditions, see 212.

**Guidance note:**

Preliminary test conditions are with the estimated light ship data implemented, while the final test conditions have final light ship data implemented.

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**207** The approval request form is as given in Classification Note No. 21.1:

- 1) For type approved software, use the form "Approval Request Form for Type Approved Loading Computer Software".
- 2) For not type approved software, use the form "Approval Request Form for Loading Computer Software".

**208** The user's manual shall be written in a concise and unambiguous manner. The use of illustrations and flow charts is recommended.

The user's manual shall contain:

- 1) A general description of the program denoting identification of the program and its version number stated
- 2) Where applicable, a copy of the type approval certificate
- 3) Hardware specification needed to run the loading program
- 4) Listing of error messages and warnings with instructions for actions to be taken by the user in each case
- 5) Name and drawing number of documentation used as reference for the calculation model: loading manual, trim and stability booklet, damage stability manual, line drawings internal arrangement, as applicable
- 6) Light ship weight and co-ordinates of its centre of gravity
- 7) A list of the approved permissible still water shear forces and still water bending moments in addition to the permissible cargo torque, as applicable for seagoing-, harbour- and flooded conditions
- 8) Where applicable, shear force correction factors
- 9) Where applicable, local permissible limits for single and two adjacent hold loading, i.e. maximum allowable and minimum required mass as, a function of the appropriate draught and the maximum weight for each hold
- 10) As applicable for bulk carriers, limits for permissible still water shear forces and still water bending moments in flooding
- 11) If appropriate, calculation method to derive the forward and after draughts at the actual position of the ships draught marks
- 12) Listing of stability criteria used
- 13) Listing of general loading limitations
- 14) Example of a calculation procedure supported by illustrations and sample computer output
- 15) Example of computer output of each screen display with explanatory text.

**209** The program description shall contain the following:

- 1) Description of functionality, calculation methods and principles, including flow chart(s)
- 2) Method of application of shear force correction factors.

Program description is not required for type approved software.

**210** The preliminary test conditions shall be as follows: Four standard representative test loading conditions chosen from the loading manual or stability booklet:

- 1) Light ship condition.
- 2) Ballast or partly loaded condition.
- 3) Fully loaded condition.
- 4) Extreme condition (anticipated worst condition for strength as found in the loading manual).
  - If the vessel is allowed to trade with some hold(s) empty on full draught, the test loading conditions 3 and 4 shall contain an alternate loading condition.
  - For bulk carriers as defined in Pt.5 Ch.2 Sec.5 the test loading conditions 3 and 4 shall contain one homogenous and one alternate loading condition, both with intact loading and corresponding hull girder loading in flooded condition.
  - When severe wind and rolling criteria are evaluated, the parameters and the calculations shall be shown in details for the most critical condition. The results shall be shown for all the conditions.
  - When damage stability is evaluated, the results of the evaluation shall be shown for all the relevant test conditions. Damage stability is either to be checked by using an approved limit curve (KG, GM) or by direct damage stability control against residual GZ curve. If the latter is included, detailed calculations shall be given for 3-4 damage cases for one of the test conditions. These damage cases shall demonstrate damage at mid- and in the fore- and aft- part of the ship, and they shall demonstrate damage of empty, partly filled and completely loaded compartments.

Within the range of these test conditions each compartment shall be loaded at least once. The conditions shall cover the range of draughts from the deepest envisaged loaded condition to the light ballast condition.

Where applicable:

- 5) For bulk carriers which have been designed with a reduced still water bending moment for some specified non-homogeneous conditions as reflected in **BC-A** and or **BC-B\*** notations. See also Pt.5 Ch.2 Sec.5 A100: Test condition demonstrating the program ability to calculate intermediate maximum allowable and minimum required masses in each hold for intermediate stillwater bending moments. See Pt.5 Ch.2 Sec.5. Note that this condition is normally not found in the loading manual.

Where applicable (chosen from loading manual / stability booklet / grain loading booklet):

- 6) Grain loading test condition including both completely filled and partly filled holds.
- 7) Grain loading test condition for untrimmed ends.
- 8) Container loading condition, timber loading condition, towing condition, crane lifting condition or others.
- 9) Allowable hold loading both for single and two adjacent holds.  
For not type approved software the warnings shall be demonstrated. The following test conditions shall be submitted:
- 10) Test condition where limit(s) for strength is (are) marginally exceeded.
- 11) Test condition where limit(s) for stability is (are) marginally exceeded.
- 12) Test condition where general loading limitation(s) is (are) marginally exceeded.

**211** Stored characteristic data (print out of data base):

- 1) Main dimensions and, if applicable, the ship's profile.
- 2) The position of the forward and aft perpendiculars.
- 3) The position of the forward and aft draught marks.
- 4) Ship's lightweight and lightweight distribution along the ship's length.
- 5) Lines plans and/or offset tables, or bonjean data at 21 stations in the length between perpendiculars.
- 6) Associated limits to still water shear force, bending moments and torque, as applicable for seagoing, harbour and flooded conditions.
- 7) Number, position and limits of read-out points. The shear force limits shall be specially considered for ships sides and longitudinal bulkheads (See Pt.3 Ch.1 Sec.5 D100). The loading computer shall take into account the local correction of the shear forces for conditions with greater pressure differences on the ship's bottom structure (see Pt.3 Ch.1 Sec.5 D200 to D500).
- 8) Where applicable, local permissible limits for single and two adjacent hold loading, i. e. maximum allowable and minimum required mass as a function of the appropriate draught and the maximum weight for each hold.
- 9) Hydrostatic data.
- 10) Cross curves of stability; (KN data)

- 11) Tank data; frame spacing, maximum volume, maximum VCG, TCG, LCG and maximum free surface moments (FSM).
- 12) List of unprotected openings / margin line / flooding angle.  
Where applicable (if installed in the program):
- 13) Tank data as function of sounding/filling; volume, VCG, TCG, LCG and FSM.
- 14) List of limit values (KG, GM).
- 15) List of weathertight openings /margin line.
- 16) Lists of grain data; tables of volumetric heeling moment for partly filled holds, tables pertaining to cargo holds filled with ends untrimmed, tables of maximum permissible grain heeling moment.
- 17) Group of damage cases.
- 18) Other data as; container data, timber loading data (cross curves), data for calculation of severe wind and rolling criteria
- 19) General loading limitations.

**Guidance note:**

<b>Table A1 Data for strength limitations to be provided to/or accepted by the Society</b>	
<i>Calculation</i>	<i>Data to be provided to/or accepted by the Society</i>
Still Water Shear Force (SWSF)	<ol style="list-style-type: none"> <li>a) The read-out points (frame locations) for the SWSF calculations. These points are normally selected at the position of the transverse bulkhead or other obvious boundaries. Additional read-out points may be specified between the bulkheads of long holds or tanks or between container stacks.</li> <li>b) Shear force correction factors and method of application.</li> <li>c) The permissible seagoing and harbour SWSF limits at the read-out points specified in a). Where appropriate, additional sets of permissible SWSF values may be specified.</li> </ol>
Still Water Bending Moment (SWBM)	<ol style="list-style-type: none"> <li>a) The read-out points (frame locations) for the SWBM calculations. These points are normally selected at the position of the transverse bulkhead, mid-hold or other obvious boundaries.</li> <li>b) The permissible seagoing and harbour SWBM limits at the read-out points specified in a). Where appropriate, additional sets of permissible SWBM values may be specified.</li> </ol>
Still Water Torsion Moment (SWTM), where applicable	<ol style="list-style-type: none"> <li>a) The read-out points (frame locations) for the SWTM calculations.</li> <li>b) The permissible limits at the read-out points specified in a).</li> </ol>

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**212** Final test conditions shall contain the test conditions as listed in 208. The test conditions shall have the final light ship data implemented and they shall be taken from the approved onboard loading and stability information.

**A 300 Acceptable tolerances, stability software**

**301** Depending on the type and scope of programs, the acceptable tolerances shall be determined differently, according to 302 or 303.

Deviation from these tolerances shall not be accepted unless the Society considers that there is a satisfactory explanation for the difference and that there will be no adverse effect on the safety of the ship.

**Guidance note:**

Examples of pre-programmed input data include the following:

*Hydrostatic data:* Displacement, LCB, LCF, VCB, KMt and MCT versus draught.

*Stability data:* KN or MS values at appropriate heel/ trim angles versus displacement, stability limits.

*Compartment data:* Volume, LCG, VCG, TCG and FSM/Grain heeling moments versus level of the compartment's contents.

Examples of output data include the following:

*Hydrostatic data:* Displacement, LCB, LCF, VCB, KMt and MCT versus draught as well as actual draughts, trim.

*Stability data:* FSC (free surface correction), GZ-values, KG, GM, KG/GM limits, allowable grain heeling moments, derived stability criteria, e.g. areas under the GZ curve, weather criteria.

*Compartment data:* Calculated volume, LCG, VCG, TCG and FSM/ Grain heeling moments versus level of the compartment's contents.

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**302** Programs which use only pre-programmed data from the approved stability information as the basis for stability calculations, shall have zero tolerances for the printouts of input data.

Output data tolerances shall be close to zero, however, small differences associated with calculation rounding or abridged input data are acceptable. Additionally differences associated with the use of hydrostatic and stability data for trims that differ from those in the approved stability information, may be accepted subject to closer review.

**303** Programs which use hull form models as their basis for stability calculations, shall have tolerances for the printouts of basic calculated data established against either data from the approved stability information or data obtained using the approval authority's model. Acceptable tolerances shall be in accordance with Table A2.

<b>Table A2 Acceptable tolerances</b>	
<i>Hull form dependent parameters</i>	
Displacement	2%
Longitudinal centre of buoyancy	1%/50 cm max
Vertical centre of buoyancy	1%/5 cm max
Transverse centre of buoyancy	0.5% of B/5 cm max
Longitudinal centre of flotation	1%/50 cm max
Moment to change trim 1 cm	2%
Transverse metacentric height	1%/5 cm max
Longitudinal metacentric height	1%/50 cm max
<i>Compartment dependent parameters</i>	
Volume or deadweight	2%
Longitudinal centre of gravity	1%/50 cm max
Vertical centre of gravity	1%/5 cm max
Transverse centre of gravity	0.5% of B/5 cm max
Free surface moment	2%
Shifting moment	5%
Level of contents	2%
<i>Trim and stability parameters</i>	
Draughts (forward/aft/mean)	1%/ 5 cm max
GMt	1%/5 cm max
GZ-values	5%/5 cm max
Free Surface correction	2%
Downflooding angle	2 degrees
Equilibrium angle	1 degree
Distance to unprotected opening or margin line from WL, if applicable	5%/5 cm
Areas under righting arm curve	5% or 0.0012 mrad
<i>Strength parameters</i>	
Still Water Shear Force	±5%
Still Water Bending Moment	±5%
Still Water Torsion Moment	±5%

**Guidance note:**

*General:*

Deviation (%) = {(base value-applicant's value)/base value} \* 100

Where the "base value" may be from the approved stability information or the Society's computer model.

*Strength parameters:*

Approval of the software is mainly based on comparing the input and the results of the software calculations with the approved onboard strength and stability documentation. The computational accuracy of the program should be within the acceptable tolerance band of the results at each read-out point obtained by the Society, specified in Table A2, using an independent program or the approved loading manual with identical input.

The table is taken from IACS Recommendation No.48. The DNV interpretation is that the results of the Loading Instrument must not deviate from the approved results of the loading manual/stability booklet by more than ±5%, where the deviation is generally related to the permissible value of the individual readout point. An example follows:

Permissible	128 000
Loading Instrument	70 000
Manual	77 000

Deviation =  $77000/128000 - 70000/128000 = 0.05469$ ; i.e. 5.5%.

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#### **A 400 Note for ships in operation, documentation for software approval**

**401** Normally ships in operation already have approved light ship data, hence for these vessels the documentation to submit is as listed in 206, except for item 4 "Preliminary test conditions".

**Guidance note:**

Before preparation of the software for ships in operation, the manufacturer should approach the Society with request for still water bending moment and shear force limits, and as applicable, shear force correction factors and/or flooding limits. The limits for both seagoing and harbour conditions should always be included in the loading computer system.

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## **SECTION 3 CERTIFICATION**

### **A. Certification**

#### **A 100 Principles for certification**

**101** Certification is carried out to ensure that the loading computer system works properly onboard and to ensure that the correct approved version of the software has been installed.

#### **A 200 Procedure for certification**

**201** The approved test conditions shall be tested on the loading computer system in presence of a surveyor from the Society, before the loading computer certificate is issued.

**202** During the test, the loading conditions calculated on the installed loading computer system shall be verified to be identical to the approved test conditions. If numerical output from the loading computer system is at significant variance with the approved test conditions, a certificate can not be issued.

**203** During the tests, at least one of the test conditions shall be built up from scratch, to ensure that the loading methods function properly.

**204** As an alternative to 203 can the following procedure be followed:

- retrieve the test load case and start a calculation run; compare stability results with those in the documentation
- change several items of deadweight (tank weights and the cargo weight) sufficiently to change the draught or displacement by at least 10%. The results shall be reviewed to ensure that they differ in a logical way from those of the approved test condition
- revise the above modified load condition to restore the initial test condition and compare the results. The relevant input and output data of the approved test condition shall be replicated.

**205** During the test relevant warnings should be checked, which should include max draught, strength limits and stability limits.

**206** Where the hardware is not type approved, the test shall be carried out on both the first and the second nominated computers prior to issuing of the loading computer certificate.

**207** After completion of satisfactory tests, the loading computer certificate shall be issued.

**208** The loading computer certificate and the approved test conditions shall be kept onboard together with the user's manual.

**209** The certification shall be carried out onboard.

**210** If the final loading manual or the final stability booklet has not been approved before delivery, testing onboard may take place after these documents have been approved.

## SECTION 4 ADDITIONAL CLASS NOTATION **LCS-DC**

### A. Application

#### A 100 Application

**101** This class notation applies to integrated systems developed to assist the master as a decision aid when the ship has been subjected to damage and consequent flooding.

**102** Ships having installed a system approved, certified and surveyed in accordance with this section may be given the class notation **LCS-DC**. The letters are denoting Loading Computer System – Damage Control.

#### A 200 System description

**201** A loading computer system designed for this purpose is assumed to consist of the following main parts:

- level sensors in all spaces which enables sounding of flooded compartments
- draught readings sensors to read draughts of the ship fore, midship (port and starboard ) and aft
- a loading computer system able to calculate the stability based on the input provided by the sensors.

### B. General Requirements

#### B 100 Documentation

**101** The documentation listed in Sec.2 should be submitted as far as applicable.

**102** The following documentation shall be submitted for approval in addition:

- details of the compartment sensors, including type, make and the proposed location in each compartment
- details of the draught reading sensors, including type, make and proposed location
- at least 5 test damage cases calculated onboard together with evidence of verification from an independent software source. The test damage cases should include damages in the forward, aft and midship part of the vessel.
- an installation and in-service test programme for all sensors.

**103** The following documentation shall be submitted for information:

- wiring and cabling indicated on a general arrangement plan
- details of all relevant hardware included in the system
- details of the loading computer software including algorithms for handling of input data, calculation routines etc.

#### B 200 System requirements

**201** The software and hardware shall in general comply with and be documented in accordance with Sec.1.

**202** The software shall be able to operate in two modes, a surveillance mode which reflects the actual situation of the ship and a simulation mode where the operator can simulate corrective actions. The two modes shall be clearly marked on the computer screen so that there is no doubt about in which mode the computer is operated.

**203** In both modes it must be clearly indicated whether the stability margins are adequate for both the actual condition and the simulated condition. The following could be regarded as guidance for a simple judgement of the conditions:

- conditions where all the relevant criteria are met, it may be assumed that the ship remains afloat in a safe condition unless the weather conditions are extreme and increasing flooding is observed
- conditions where one or more of the relevant stability criteria are not met and the situation and correctness of the further actions may be critical. Important parameters are excessive angle of heel, height and range of the GZ-curve compared with the external overturning forces: wind, passenger crowding on one side and lifeboat launching. The relevant parameters should be included and the relevant warnings be given if the stability margins becomes critical.

#### Guidance note:

For passenger vessels the relevant criteria according to SOLAS Ch. 8 are generally considered to indicate the safe condition:

- static angle of heel less than 7 or 12 degrees

- range of positive stability at least 15 or 10\* degrees
- area under gz-curve exceeding 0.015 mrad or increased when \* applies
- height of gz-curve 0.04 m in excess of heeling lever arm from passenger crowding, wind force or launching of life boats on one side.
- distance to unprotected openings.

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**204** The software should enable continuously monitoring of the flooding situation and record or plot those compartments where a change in content is registered after the flooding.

**205** The software shall give a clear warning in case there is a discrepancy between calculated draughts and the remote draught readings.

**206** It should be possible to give manually input for compartment fillings in those cases where it becomes evident that a failure has occurred influencing the accuracy of one or more sensors.

**207** It should be possible to manually enter an estimated value for permeability for any compartment assumed to be reflecting the actual situation in lieu of those set forth by the rules.

**208** Those compartments which permeability has been altered should be clearly indicated on the computer screen.

### **B 300 Location of sensors in internal compartments and spaces**

**301** The intended location of all sensors shall be indicated on a general arrangement plan or a tank plan. The effects of heel and trim have to be considered when the location of the sensors are decided. It might be required to install two or more sensors within a compartment. All compartments that may be subject to flooding shall have sensors.

**302** The sensor wiring or cabling should as far as practicable possible be carried through transverse watertight bulkheads as close to the centreline as possible.

## **C. Testing**

### **C 100 Installation testing**

**101** When the installation has been completed in accordance with the approved documentation and the testing of the remote sounding equipment has been successfully completed the approved test cases shall be simulated onboard. The test cases should as far as possible be applied for the actual condition with the online readings applied as far as applicable. The sounding values for flooded compartments shall be given as manually input.

### **C 200 Testing during operation**

**201** The level sensors installed in dry compartments or tanks that are seldom in use should be subject to frequent testing. A suitable arrangement for testing of each such sensor shall be worked out together with a scheme for the periodical testing. Evidence that such tests has been carried out shall be provided at annual surveys in order to maintain the class notation.