User Manual of SEAWAY

Release 4.19 (12-02-2001)

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Contents

1 Introduction

SEAWAY is a frequency-domain ship motions PC program, based on both the ordinary and the modified strip theory, to calculate the wave-induced loads and motions with six degrees of freedom of mono-hull ships and barges in seaway. When not accounting for interaction effects between the two individual hulls, also these calculations can be carried out for twin-hull ships, such as semi-submersibles or catamarans. The program is suitable for deep and shallow water. The underlying theory of the program has been given by [Journée, 2001b].
This new User Manual of program SEAWAY replaces the previous old manuals.
Program SEAWAY has been validated with results of other 2-D and 3-D computer programs and experimental data. Based on these validations and on experiences, obtained during an intensive use of SEAWAY for many years by the author, industrial users, institutes and students, it is expected that the program is free of significant errors.

SEAWAY requires two separate input data files:

- a hull form data file and
- a hydromechanical input data file.

The offsets of the cross-sections of the fully loaded ship have to be stored in a hull form data file, which can be obtained in different ways:

- The hull form data file can be made manually with any ASCII word processor, simply by following the descriptions given in this manual.
- Also, the hull form data file can be an output file of the PIAS program of SARC, an hydrostatic program which is frequently used in the Netherlands.
- For preliminary calculations, a set of hull form data files with 123 non-dimensional “parent hull forms” has been made available for the users. Selected hull forms from this set – with acceptable water plane area coefficients and block coefficients - can be scaled easily by the user to the principal dimensions of his actual ship.
- In a preliminary design stage of a ship, a pre-processing program SEAWAY-L can be used to create a Lewis hull form data file from the sectional breadths, draughts and areas only.

A control program, named SEAWAY-H, displays the body plan of the ship, as stored in the hull form data file, on the screen. Modifications can be carried out with this control program too.

A user's friendly input-editor, named SEAWAY-E, creates the hydromechanical input data file. Almost this editor takes the place of the User Manual.
At any actual loading of the ship - given in the hydromechanical input data file - new offsets will be calculated by the program and a linear transformation of the hull form can be carried out by an input of three independent scale factors.

Lewis or N-parameter close-fit conformal mapping methods and the potential theory of [Ursell, 1949] and [Tasai, 1959/1960/1961] in deep water can be used to calculate the two-dimensional hydrodynamic coefficients. Also the 2-D diffraction pulsating source theory of [Frank, 1967] can be used. Shallow water coefficients can be determined with the Lewis conformal mapping method and the shallow potential theory given by [Keil, 1974]. Special attention has been paid to submerged cross-sections and to surge coefficients.

Wave loads can be calculated by either the classic relative motion approach or by a simplified diffraction method. Always, the wave potentials are defined for the actual water depth.
The input data of the longitudinal mass distribution, required for calculating the vertical and horizontal shear forces and bending moments and the torsion moments, are independent of the hull form input. Jumps in these distributions are permitted.
Linear and non-linear (viscous) roll damping coefficients can be determined by the empirical method of [Miller, 1974] or by the semi-empirical method of [Ikeda et. al., 1978]. Damping coefficients, as derived from model tests, can be input too. If required, the program will carry out the linearisation.
Free surface anti-rolling tanks – based on theory or on experimental data - are included. External roll moments, to be defined by the user, can be input. Linear springs (mooring) can be used too.

At choice, the unidirectional wave spectra can be defined by the ideal Neumann spectra, modified Pierson-Moskowitz, ITTC, ISSC or Bretschneider spectra or JONSWAP spectra and by an input of (measured) wave spectra. Either the spectral centre period or the zero-crossing period can define these wave spectra. The printed output data of the statistics of the responses will follow this definition.

The major magnitudes of ships, barges, semi-submersibles or catamarans, which can be calculated by the program SEAWAY, are:

- Some geometrical data, such as areas and centroids of cross-sections and waterlines, volume of displacement, centre of buoyancy, metacenter heights, wetted surface of underwater hull, vertical shear forces and bending moments in still water, etc.
- Two-dimensional and three-dimensional frequency-dependent hydrodynamic coefficients calculated with either one of the conformal mapping methods or the pulsating source method.
- Natural heave, roll and pitch periods.
- Frequency characteristics of:
  - First order wave forces and moments.
  - Centre of gravity motions: surge, sway, heave, roll, pitch and yaw.
  - At specified points: absolute motions, velocities and accelerations in the three directions and vertical relative motions, including or excluding a dynamical swell-up.
  - Mean added resistance caused by waves and ship motions, calculated with both the radiated energy method and the integrated pressure method.
  - At specified cross-sections: vertical and lateral shear forces and bending moments and torsion moments.
- Energy spectra of unidirectional irregular waves defined by Neumann, Bretschneider, JONSWAP or measured wave spectra.
- With these wave spectra: energy distributions, significant amplitudes and average periods of all responses of which the frequency characteristics have been calculated.
- Probability as well as number per hour of exceeding threshold values by the relative motions, to be used for the calculation of shipping (green) water, propeller racing, etc.
- Probability and number per hour of slamming, according to a formulation by a vertical relative velocity and by a pressure criterion.

With print-options, a choice can be made for the desired output. A lot of attention has been paid to an well-ordered output of the calculated data. The ASCII output data are given in a

format that can be made suitable for other programs, spreadsheets and plot routines by a usual editor, easily.
Optionally, an ASCII data file, named SEAWAY.DAT, will be filled with data in a format defined by the user. The user has to inform the author about the required data in this file. Exclusive for each individual user, these formats can be fixed into program SEAWAY. Post-processing programs, spreadsheets or plot routines can read this personal SEAWAY.DAT file, directly. Standard, the SEAWAY.DAT file will be filled with LOTUS or QUATRO-PRO data.

The programs are written in FORTRAN/77, suitable for any MS-DOS Personal Computer. Easily, the main program SEAWAY can be made suitable for other computer systems, because all system-related parts have been assembled in one subroutine. The PC version of this program has been protected against an unauthorised use by a Sentinel-C software protection key.

A demo this SEAWAY program, which can be used freely for one particular ship only, can be downloaded from the Internet: http://dutw189.wbmt.tudelft.nl/~johan or a link to this homepage at http://www.shipmotions.nl.
Additional information on the SEAWAY-package and its theoretical background can be obtained from:

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+31 65 390 2290, GSM during vacation **(urgent cases only!)**

A full licence of the SEAWAY-package, including all future updates, costs about 5,000 US$. Universities and other non-profit educational organisations can obtain this SEAWAY-package and all future updates free of charge. In that case however, a restriction is that the program will be used for educational purposes only; any commercial use is prohibited.

The present licensees of the ship motions program SEAWAY are listed below.

- 000 S/Sd Author and Students of DUT, HTO and HNO
- 001 S IHC Gusto Engineering, Schiedam, The Netherlands
- 002 S Royal Dutch Navy, Ship Design Office, Den Haag, The Netherlands
- 003 S/Sd Royal Institute for the Dutch Navy, Den Helder, The Netherlands
- 004 S Allseas Engineering, Delft, The Netherlands
- 005 S Kupras Computer Systems, Zoetermeer, The Netherlands
- 006 S Hoger Technisch Onderwijs Rotterdam, Rotterdam, The Netherlands
- 007 S Technische Hogeschool Haarlem, Haarlem, The Netherlands
- 008 S/Sd Delft University of Technology, Dredging Lab., Delft, The Netherlands
- 009 S Wijsmuller Engineering, IJmuiden, The Netherlands
- 010 S Hollandse Signaalapparaten, Hengelo, The Netherlands

- 011 S/Sd Delft Shiphydromechanics Laboratory, Delft, The Netherlands
- 012 S Kahn Shipping, Rotterdam, The Netherlands
- 013 S University of Twente, Enschede, The Netherlands
- 014 S Norwegian Contractors, Stabekk, Norway
- 015 Sd Delft Hydraulics, Delft, The Netherlands
- 016 S Directorate General of Transport, Den Haag, The Netherlands
- 017 S Nevesbu, Den Haag, The Netherlands
- 018 S/Sd Delft University of Technology, Ship Design, Delft, The Netherlands
- 019 Sd TNO-CMC, Delft, The Netherlands
- 020 S Meteo Consult, Wageningen, The Netherlands
- 021 S Shipyard YVC, Capelle aan den IJssel, The Netherlands
- 022 S Directorate General of Transport, Den Haag, The Netherlands
- 023 S Bureau voor Scheepsbouw de Groot, Bloemendaal, The Netherlands
- 024 S Hoger Nautisch Onderwijs, Rotterdam, The Netherlands
- 025 S Damen Shipyards, Gorinchem, The Netherlands
- 026 Sd HAM, Capelle aan den IJssel, The Netherlands
- 027 Sd Boskalis-Westminster, Papendrecht, The Netherlands
- 028 Sd Ballast-Nedam, Zeist, The Netherlands
- 029 S/Sd SAM Consult, Delft, The Netherlands
- 030 S University of Ghent, Ghent, Belgium
- 031 S University of Izmir, Izmir, Turkey
- 032 S University of Trondheim, Trondheim, Norway
- 033 S Geomatic, Dordrecht, The Netherlands
- 034 S University of California, Berkeley, USA
- 035 S Vestfold College, Horten, Norway
- 036 S/Sd MTI Holland, Kinderdijk, The Netherlands
- 037 S Technical University of Berlin, Berlin, Germany
- 038 S Flanders Hydraulics, Antwerp, Belgium
- 039 S Bluewater Engineering, Hoofddorp, The Netherlands
- 040 S Pattimura University, Ambon, Indonesia
- 041 Sd JBR, Pijnacker, The Netherlands
- 042 S Shipyard de Hoop Lobith, Lobith, The Netherlands
- 043 S Bureau Veritas, Rotterdam, The Netherlands
- 044 S Marine Structure Consultants, Schiedam, The Netherlands
- 045 S Dockwise, Meer, Belgium
- 046 S Marine Treasure, Rotterdam, The Netherlands
- 047 S Boskalis, Papendrecht, The Netherlands
- 048 S Seaway Heavy Lifting, Zoetermeer, The Netherlands
- 049 S Alkyon, Marknesse, The Netherlands
- 050 S Oceanco Shipyards, Alblasserdam, The Netherlands
- 051 S Cochin University of Science and Technology, Cochin, India
- 052 S University of Belgrade, Belgrade, Yugoslavia
- 053 S University of Buenos Aires, Buenos Aires, Argentina
- 054 S Isfahan University of Technology, Isfahan, Iran
- 055 S Baar Maritime Cons. Int., Burgh-Haamstede, The Netherlands
- 056 S Sea of Solutions, Vlaardingen, The Netherlands
- 057 S University of Newcastle, United Kingdom

- 058 S University of Rijeka, Croatia.
- 059 S Polytechnics of Dubrovnik, Croatia.
- 060 S Yildiz Technical University, Istanbul, Turkey.

Legend: S = Licensee of the parent program SEAWAY.
Sd = Licensee of a derivative version of program SEAWAY, for instance a hydromechanic pre-processing program for time domain calculations.

Apart of these licensees, the SEAWAY programs are and have been used temporarily by and for a large number of other (mostly small) companies.

2 Installation and Use

To install the programs of the SEAWAY package in the computer system, it is advised to create a new directory - for instance C:\SEAWAY - for this.

Then, copy the SEAWAY.ZIP file to this new directory and open it there. This file contains:

- README.DOC, a Word'97 file with brief information about the SEAWAY package, installing it and its modifications with respect to earlier releases.
- MANUAL.DOC and APPENDIX OF MANUAL.DOC, this user manual.
- SEAWAY-L.EXE, the Lewis hull form creator.
- SEAWAY-H.EXE, the hull form controller.
- SEAWAY-E.EXE, the input editor of SEAWAY
- SEAWAY.EXE, the ship motions program SEAWAY
- LEWIS.INP, an input data file for SEAWAY-L.
- LEWIS.HUL, an output data file of SEAWAY-L, which is also a hull form input data file for SEAWAY.
- SHIP.HUL, a hull form input data file for SEAWAY.
- SHIP.INP, an input data file for SEAWAY.
- SHIP.OUT, an output data file of SEAWAY.
- SEAWAY.TDP, an unformatted file, which contains the potential coefficients being used or created during the execution of SEAWAY.
- SEAWAY.DAT, a personal ASCII-file with calculated data of SEAWAY - in an order defined by the user - suitable for post-processing, plot routines, etc.
- HULLFORMSERIES.ZIP, which contains a large number of hull form data files.

It is advised not to run any of these programs in the directory C:\SEAWAY itself. It is very convenient to run the SEAWAY programs in the working directory by using batch files, created with a normal editor, for instance:

SWL.BAT, with: **CALL C:\SEAWAY\SEAWAY-L**
SWH.BAT, with: **CALL C:\SEAWAY\SEAWAY-H**
SWE.BAT, with: **CALL C:\SEAWAY\SEAWAY-E**
SW.BAT, with: **CALL C:\SEAWAY\SEAWAY**

The main program SEAWAY is protected against an unauthorised use by a Sentinel-C security key. The program itself searches for the LPT-port, connected to this key. The Sentinel-C key is manufactured by Rainbow Technologies, 18011-A Mitchell South, Irvine, CA 92714 USA and distributed in the Netherlands by:
IntroCom, Welbergerweg 30, 7556 PE Hengelo, the Netherlands,
tel.: +31 74 243 0105, fax.: +31 74 242 9895, e-mail: Info@introcom.nl

The instructions below, for using the Sentinel-C key, are given by IntroCom:

- The products do not contain serviceable parts. Disassembling the key, expires the guarantee.
- Static electricity can damage electronic parts. Before touching Sentinel products, one has to discharge oneself by touching a metal desk or doorframe. When static discharge has been observed, an anti-static spray or carpets can remedy this.

- Be sure about the use of the parallel port of the computer. Take care that the proper side of the Sentinel-C key (labelled with: COMPUTER) will be connected in the right direction to the parallel port of the computer.
- Never connect the key to the serial port by turning it around. In that case it is highly probable that the Sentinel-C key will be damaged.
- The computer and the printer have to be properly connected to the electric power supply. An incorrect connection or a disconnection to the mass can cause potential differences between the connected apparatus, which can damage the computer hardware as well as the Sentinel product.
- When connecting the Sentinel-C key, the power supply of the computer and the printer must have been switched off.
- Avoid physical contact with the connector-pins of the Sentinel-C key.

The author does not accept any financial responsibility for damage of (and caused by) this Sentinel-C security key.

To run the MS-DOS Personal Computer versions of SEAWAY-L, SEAWAY-E and SEAWAY, the computer system must use a **`CONFIG.SYS`** file that contains the following statements:

- **`BUFFERS=nn`**
- **`FILES=nn`**
- **`DEVICE=C:\WINDOWS\COMMAND\ANSI.SYS`**

in which **nn is generally 40** or more and **`C:\WINDOWS\COMMAND`** is the name of the directory in which the **`ANSI.SYS`** file is placed.
This **`CONFIG.SYS`** file must be visible in the Explorer. If not so, set:

| *View* | *Folder Options* | Tab *View* | *Hidden Files* | ***Show all Files*** |.

Messages with **error 3012** are caused by too low a **nn**-value in the statement **Files=nn** in the **CONFIG.SYS** file.

Note for Windows2000 and WindowsNT:
The **ANSI.SYS** file in directory **C:\WINNT\SYSTEM32** has to be called in the **CONFIG.NT** file in this directory. Additionally, a new Sentinel System Driver 5.39 should be downloaded from: http://www.rainbow.com/tech/download.html. The huge downloaded file RainbowSSD539.exe (3.7 Mb) installs this driver easily. An LPT port must be available.

After these modifications: **Restart your computer !!!**

A typical error after calling SEAWAY is reflected on the screen by:

```
□[2J□[7m□[02;04H P R O G R A M   S E A W A Y □[0m
□[1m□[02;67HRelease 4.19□[0m□[03;67H(12-02-2001)
□[1m□[20;53HUse licensed only to:     □[0m□[21;53HDelft University of Techn.□[22
;53HShiphydromech. Laboratory □[23;53H
□[1m□[24;53H ©  Journée.         □[0m   011□[01;01H
□[04;04HDefault drive and directory will be used for data files. □[1m□[05;04HPre
ss ENTER to continue.□[0m
```

A missing **ANSI.SYS** statement in the **CONFIG.SYS** file causes this error.

After calling for SEAWAY, the display asks for three file names, to be entered by the keyboard:

- the name of the hull form data file; this file contains all information about the geometry of the underwater part of the hull of the fully laden ship

- the name of the input data file; this file contains information about the actual loading of the ship, the forward ship speeds, the wave or sea conditions and the user's requirements on the output data of the program
- the name of the output data file, the file to which the calculated data have to be written.

It is advised to use file names that contain the (abbreviated) name of the ship, for instance:

Hull form data file: SHIP.HUL
Input data file: SHIP.INP or SHIP.IN1, etc.
Output data file: SHIP.OUT or SHIP.UT1, etc.

in which SHIP is the name of the ship with a maximum of eight characters and HUL, INP, IN1, OUT and UT1 are the extension names of the data files with a maximum of three characters.
Note that any existing file in the same directory with the same output file name will be overwritten. The maximum number of characters in the ASCII output data file is 129.

A successful normal end of a program execution will be accompanied by the message: **END OF PROGRAM EXECUTION**, see Figure 1.

```
□□□□P R O G R A M   S E A W A Y                          Release 4.19
                                                          (12-02-2001)

   Date: 09-10-1999  Time: 23:17

   Hull form data file : SHIP.HUL

   Input data file     : SHIP.INP

   Output data file    : SHIP.OUT

 Execution terminated: END OF PROGRAM EXECUTION




                                              Use licensed only to:
                                              Delft University of Techn.
                                              Shiphydromech. Laboratory.

                                              © Journée            011
```

Figure 1 Screen Dump of Execution of Program SEAWAY

Also, it is possible to carry out up to 25 subsequent calculations automatically. After calling SEAWAY, the program searches on the default drive for a file named SEAWAY.FIL. If this file is not present, the file names have to be entered by the keyboard as described before. If the file SEAWAY.FIL is present, it should be formatted as given in the example below:

Line 00: 5
Line 01: SHIP.HUL SHIP.INP SHIP.OUT
Line 02: SHIP.HUL SHIP.IN1 SHIP.UT1

Line 03:	SHIP.HUL	SHIP.IN2	SHIP.UT2
Line 04:	SHIP.HUL	SHIP.IN3	SHIP.UT3
Line 05:	VESSEL.HUL	VESSEL.INP	VESSEL.OUT

Each line with three file names implies a calculation with SEAWAY. The three file names on each line have to be separated by one or more blanks. The maximum allowable number of characters on each line is 72. The maximum line number - or number of calculations - is 25.
After reading the file SEAWAY.FIL, this file will be rewritten by the program to the default drive with a number "0" on line 00. When calling this file afterwards by SEAWAY, this "0" will be read from the SEAWAY.FIL file and a keyboard input of the file names is requested again.
The disadvantage of this method is that any error in one of the files results in an "END OF PROGRAM EXECUTION", without carrying out the remaining calculations. However, this can be avoided by using a batch file with rename structures, using several renamed SEAWAY.FIL files for one calculation each.

When carrying out the first calculation for a ship, the potential coefficients and two check-sum values are automatically written to a "**T**wo-**D**imensional **P**roperties"-file, SEAWAY.TDP. At each following calculation, with for instance other print-options, ship speeds or wave directions, this file will be read and checked first. When the two check-sums are correct these two-dimensional properties will be used instead of repeating the calculations of the potential coefficients. This simple option saves the user a lot of computing time, especially when using the time consuming pulsating source method of Frank.

Optionally, an ASCII data file, SEAWAY.DAT, can be filled with calculated data in a format defined by the user. For this, the user has to inform the author about the desired sequence of output data inside the forward ship speed loop and the wave direction loop. Exclusive for each individual user, these output formats can be fixed into the program. These SEAWAY.DAT data can be read by spread sheets or plot routines, directly.

In a preliminary design stage, only sectional breadths, draughts and areas are known. Then the Lewis form creator, named SEAWAY-L, can be used to create a suitable hull form data file.

A hull form controller, named SEAWAY-H, has been made available to plot the body plan derived from these offsets on the screen. When using this controller, errors introduced in the offsets can be found easily.

An input editor, named SEAWAY-E, has been made available to create the input data file. Almost, this editor takes the place of this manual, as far as the input data file of the ship motions program is concerned.

3 Hull Form Data

The offsets of the cross-sections of the fully laden ship have to be stored in a hull form data file. A linear transformation of the hull form can be carried out easily, by an input of three scale factors. This means that the offsets can be measured with any scale or in arbitrary units. The actual dimensions (m) can be obtained with the three scale factors. This is convenient when this data file has to be created manually, by measuring from a body plan.
Also, this hull form data file can be a direct output of the PIAS program of SARC; see *http://www.sarc.nl* for more information.
In a preliminary design stage of a ship, information on the sectional breadth, draught and area is available only. If a detailed lines plan is not available, the Lewis form creator SEAWAY-L can be used to create a hull form, based on these parameters. A validation study showed that the offsets of the hull form, created by this program, could be used safely for getting an impression of the sea-keeping behaviour of a wide range of conventional hull forms. However, the use of Lewis hull forms holds that cross-sections with different shapes, but with a similar breadth, draught and area, will obtain similar offsets. Besides this, submerged and bulbous cross-sections will be created in a somewhat artificial manner. So these Lewis forms should not be used for detailed hull form parameter studies.
A hull form controller, named SEAWAY-H, displays the body plan of the ship, as stored in the hull form data file, on the screen for a visual control of the offsets. This controller can be used to judge the offsets, only. In the future the hull form controller will be extended with extra features, which makes it possible to correct mistakes in the offsets too. However, some features have been included already.
At any actual loading of the ship, new offsets of the underwater hull form will be calculated by the main program SEAWAY from these data by using the actual amidships draught and trim, as given in the input data file.

In this chapter detailed descriptions of the hull form data file of SEAWAY, the hull form controller SEAWAY-H and the Lewis form creator SEAWAY-L will be given, followed by some examples of the data files. Parameters in this chapter starting with *I, J, K, L, M* and *N* are integer data types. All other parameters are real data types, which can be given with an integer format too. A new line is required at some places in the input, which has been marked in the description.

3.1 Description of Hull Form Data File

```
* On first line of data set: RELINP
```

RELINP is the program release number, when creating the hull form data file.

```
* New line
* TEXT
```

TEXT is a text line, with a maximum of 80 characters, with general information about the ship, such as the name of the ship and its main dimensions, for instance:

```
Containership S175:   175.00 x 25.40 x 9.50 (11.00) meter.
```

The draught information here means that the hull form is given until a draught of 11.00 meter for a ship with a fully laden draught of 9.50 meter.

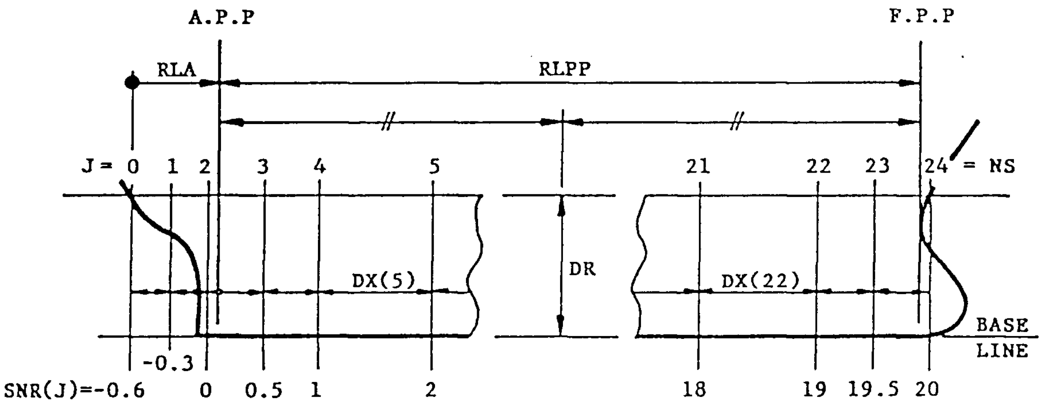

Figure 2 Definition of Longitudinal Values

```
* New line
* DR
* TR
* RLPP
* RLA
```

DR is the amidships draught of the measured underwater hull form, defined at half the length between the aft and forward perpendiculars, APP and FPP.

TR is the trim by stern, defined as the draught at APP minus draught at FPP
The amidships draught and trim are defined with respect to a reference line, for instance the ship's base or the keel line. This reference will be used in the input data file to define the actual draught and trim of the ship at which the calculations have to be carried out. Here after, this reference line is called base line. Generally, it is convenient to use a zero trim in the hull form data file.

RLPP is the length between the forward and aft perpendiculars, L_{pp}.

RLA is the distance of the aft perpendicular APP forward of the hindmost cross-section.

```
* NS
* For J = 1,...NS: - DX(J)
```

NS is the number of longitudinal cross-section intervals; 2 < NS < 50.
Because of using the general rule of Simpson for numerical integration, this number has to be even. In short waves, the interval lengths will not affect the numerical longitudinal integration of the wave loads. An advised value for a normal ship is 24 intervals: 20 equal intervals between the perpendiculars, 2 added cross-sections aft and 2 added cross-sections forward.

DX(J) is an element of the array with the longitudinal cross-section intervals.
The longitudinal intervals can be divided in NS/2 subsequent pairs of two cross-section intervals. With respect to the integration over the ship's length, note that within each pair of two intervals these two individual intervals may not differ more than 1:4 or 4:1. If they differ more, the program will switch locally from Simpson's general rule to the trapezoid rule, to avoid an inaccurate integration.
The constant amidships part can be given by two intervals.
An even index-number J (=0,…NS) is advised for any cross-section at a discontinuity in the longitudinal derivative of the load water line curve or the cross-sectional area curve.
Jumps in these curves, as for instance appear at the beginning and end of a column of a semi-submersible, are introduced by two zero-intervals, as presented in Figure 3. The cross-section at the boundary between these two intervals can be either the nearest left or the nearest right cross-section.

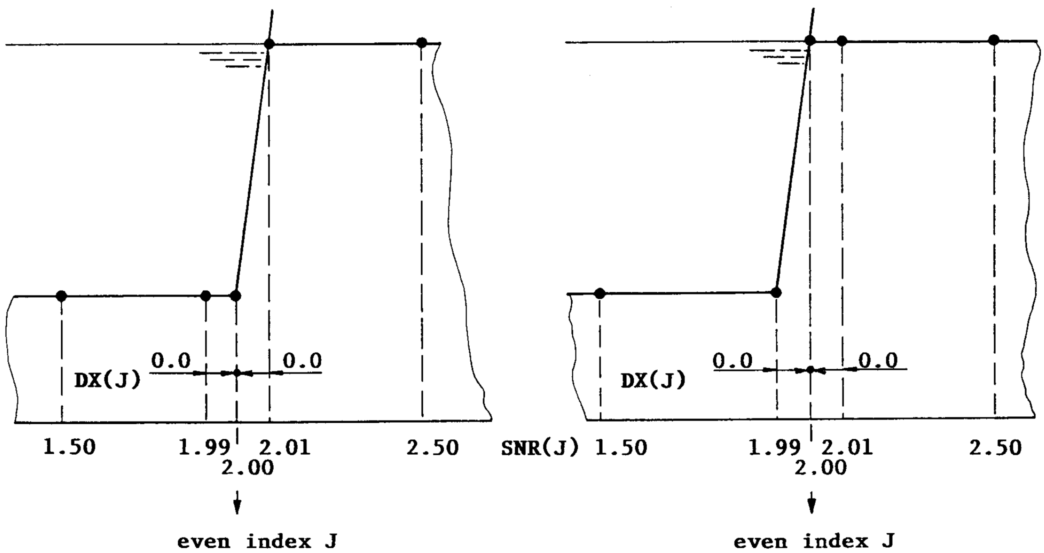

Figure 3 Cross-sections at a Longitudinal Jump

```
* KCON
```

KCON is the code for the input sequence of the offsets.
The contour of each cross-section J of the ship has to be given by a series of offsets, defined by [Y(J,I),Z(J,I)] or [Z(J,I),Y(J,I)] as given in Figure 4. The input-sequence of the co-ordinates of these offsets depends on the preference of the user, marked by:

- KCON = 1: input-sequence is [Y(J,I),Z(J,I)], a horizontal value followed by a vertical value as normally will be obtained with digitizers
- KCON = 2: input-sequence is [Z(J,I),Y(J,I)], a vertical value followed by a horizontal value, as naval architects are (or were) used to.

The contour of each cross-section has to be given by a series of offsets. For (local) twin-hull cross-sections, such as those of semi-submersibles or catamarans, these offsets represent the (local) mono-hull cross-section. This cross-section has to be symmetric with respect to its (local) centre line. Half the distance between the two (local) centre lines will be used to define the (local) mono-hull or twin-hull cross-section.

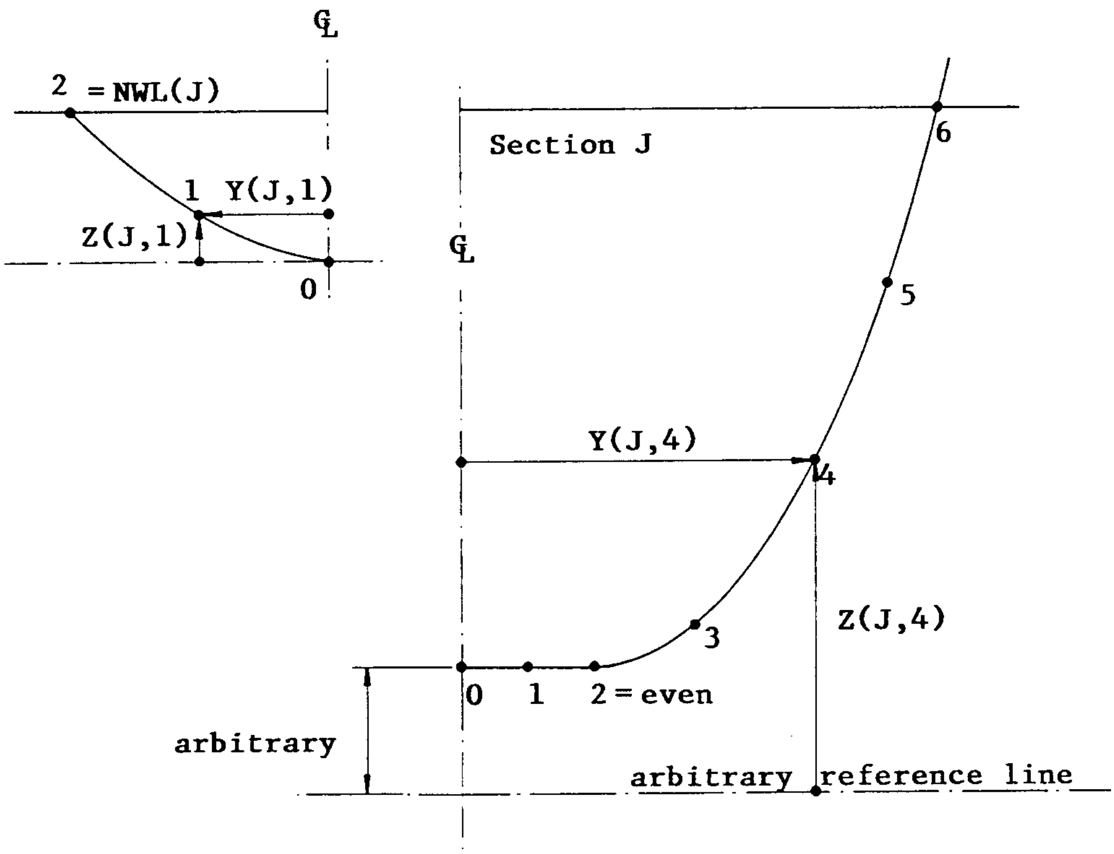

Figure 4 Offsets of Cross-Sections and Sequence of Input

```
 * For J = 0,...NS: - New line
                    - SNR(J)
                    - NWL(J)
                    - SDIST(J)
                    - New line
                    - For I = 0,...NWL(J):
                       - If KCON = 1: Y(J,I), Z(J,I)
                       - If KCON = 2: Z(J,I), Y(J,I)
```

SNR(J) is the station number.

This real value is printed in the output with two decimals. A negative station number for cross-sections behind A.P.P., often indicated in lines drawings or body plans by the characters A, B, etc., is permitted too.

NWL(J) is the number of offset intervals along the contour of the cross-section;
2 < NWL(J) < 22.
The value of this parameter may differ per cross-section. However, because of the use of Simpson's general rule, it has to be even. So the number of offsets to describe the cross-section is NWL(J)+1. Depending on the shape of the cross-section, at least 8 or 10 intervals are required mostly.

SDIST(J) is half the distance between the (local) centre lines, used for ships with (local) twin-hull cross-sections, for instance catamarans.
For a mono-hull cross-sections: SDIST(J) = 0.0.

Y(J,I) is the horizontal distance of the offset from the (mono-hull) centre plane.
Z(J,I) is the vertical distance, positive upwards, of the offset above a, for each cross-section arbitrarily, horizontal reference line, as shown in Figure 5.

The sequence of the input of the offsets is from keel upwards. The first "0" offset has to be the keel point and the last NWL(J) offset has to be an offset at the waterline, defined by the amidships draught DR and trim TR. For each cross-section the vertical position of the horizontal reference line is arbitrary. Before starting the geometrical calculations the program subtracts from all Z(J,I)-values the Z(J,0)-value. Then the first offset becomes (0,0) and all other offsets are related to this point. Since of all cross-sections the last NWL(J) offset is situated in the load waterline, this load water line will become the reference plane during the calculations.
An even index number is required for any offset at a discontinuity in the derivative of the cross-section contour, for instance at a knuckle. This holds also for the offset at the beginning or the end of a straight line or at the maximum breadth of a bulbous cross-section. Straight lines have to be defined by two intervals. Two subsequent zero interval-values are permitted, because numerical problems are avoided by the program itself by using a very small value. Figure 5 shows some examples.
Within the NWL(J)/2 pairs of two vertical intervals, these two individual intervals should not differ by more than 1:4 or 4:1. If they differ more the program replaces Simpson's general rule by the trapezoid rule locally, to avoid inaccurate calculations.

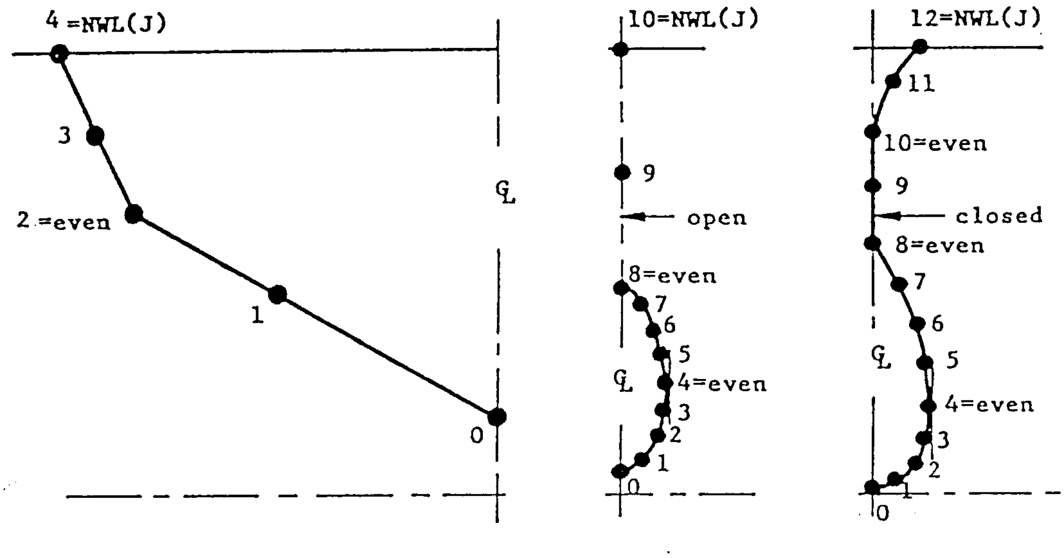

Figure 5   Requirements on Even Offset Numbers

To suppress so-called "irregular frequencies" in the calculation of the hydrodynamic potential coefficients by the pulsating source method of [Frank, 1967], the program itself closes not fully submerged cross-sections by adding one, two or three extra offsets at the load water line. Nevertheless, always check these sections for the occurrence of "irregular frequencies".
Tunnelled cross-sections are not permitted by the present Frank Close-Fit method. This problem is solved artificially in the program by "freezing" the water in the tunnelled part of any Frank section when calculating the potential coefficients.

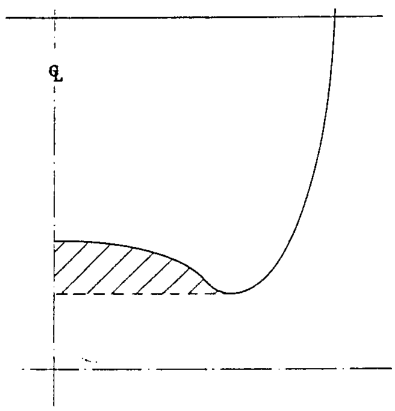

Figure 6   Tunnelled Cross-section

For KCON = 1 and KCON = 2, an input example of a cross-section J is given here:

```
For KCON = 1:                                  For KCON = 2:
   SNR(J)          =   ...                        SNR(J)          =   ...
   NWL(J)          =    10                        NWL(J)          =    10
   SDIST(J)        =  0.00                        SDIST(J)        =  0.00
   [Y(J,I), Z(J,I)] =  0.00  0.00                 [Z(J,I),Y(J,I)] =  0.00  0.00
                      0.67  0.00                                     0.00  0.67
                      1.33  0.00                                     0.00  1.33
                      2.79  0.50                                     0.50  2.79
                      3.40  1.00                                     1.00  3.40
                      4.10  2.00                                     2.00  4.10
                      4.70  3.00                                     3.00  4.70
                      5.45  5.00                                     5.00  5.45
                      6.10  7.00                                     7.00  6.10
                      6.81  9.00                                     9.00  6.81
                      7.71 11.00                                    11.00  7.71
```

In both cases the offsets are referenced to a horizontal line through the keel point of the cross-section.

Also, a cross-section can be a "zero-area" cross-section. Then the input data are as below:

```
   SNR(J)          =   ...
   NWL(J)          =     2
   SDIST(J)        =  0.00
   Z(J,I), Y(J,I)] =  0.00  0.00
                      0.00  0.00
                      0.00  0.00
```

So, do not use for a "zero-area" cross-section:

```
   SNR(J)          =   ...
   NWL(J)          =     2
   SDIST(J)        =  0.00
   Z(J,I), Y(J,I)] =  0.00  0.00
                      5.50  0.00
                     11.00  0.00
```

This cross-section represents a very thin plate.

```
 * New line
 * XS
 * YS
 * ZS
```

All data on the hull form in this file will be multiplied with scale factors:

XS = Linear scale factor in the longitudinal direction.

YS = Linear scale factor in the lateral direction.

ZS = Linear scale factor in the vertical direction.

When the actual hull form has been defined here, these three scale factors have to be set to 1.0. This option is convenient when calculating full-scale ship motions with a model-scale hull form data file. Also it can be used for preliminary calculations of a ship with the hull form data of another ship of the same type, of which the offsets are available.

A standard hull form of a barge with a length, breadth and draught of 1.00 meter and three scale factors can define any rectangular barge. Then 3 equal cross-sections at 2 mutual distances of 0.50 meter have to be defined with offsets at 4 intervals, as given below for KCON=2:

```
SNR(J)           =   ...
NWL(J)           =     4
SDIST(J)         =  0.00
Z(J,I), Y(J,I)] =  0.00  0.00
                    0.00  0.25
                    0.00  0.50
                    0.50  0.50
                    1.00  0.50
```

Then any rectangular barge with zero trim is simply defined by the scale factors:

XS = length of the barge.

YS = breadth of the barge.

ZS = draught of the barge.

```
* New line
* Write: *** End of File ***
* Save and Quit File
```

3.2 Examples of Hull Form Data Files

Three examples of hull form data files are given here.

3.2.1 Containership

An example is given here of the hull form data file of the S-175 containership design as used by the ITTC in 1978 for a comparative study.

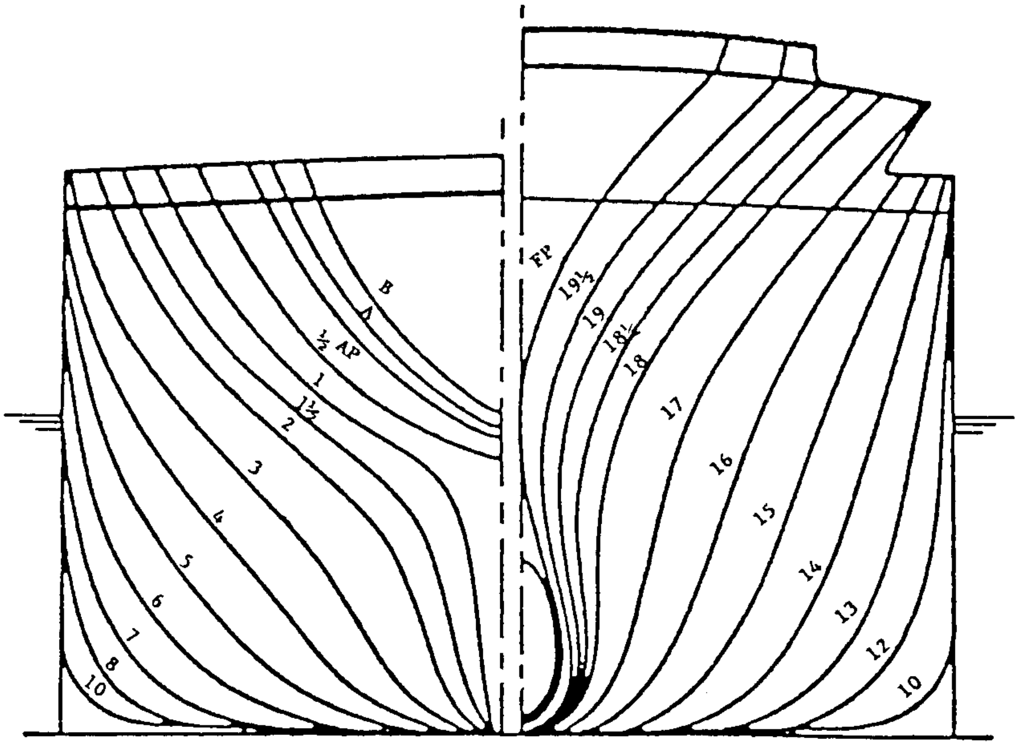

Figure 7 S-175 Container Ship Design

The hull form file of this containership reads as follows.

```
4.19
S-175 containership:   175.00 x 25.40 x 9.50 (11.00) meter.
  11.0000   0.0000 175.0000   3.2500
      24
   1.6250   1.6250   4.3750   4.3750   8.7500   8.7500   8.7500   8.7500
   8.7500   8.7500   8.7500   8.7500   8.7500   8.7500   8.7500   8.7500
   8.7500   8.7500   8.7500   8.7500   8.7500   8.7500   4.3750   4.3750
       2
   -0.38        2   0.0000
   9.5000   0.0000  10.2500   1.1200  11.0000   2.0400
   -0.19        4   0.0000
   9.0200   0.0000   9.2600   0.4300   9.5000   0.8500  10.2500   1.9700
  11.0000   2.8300
    0.00        6   0.0000
   8.7200   0.0000   8.8600   0.2600   9.0000   0.6500   9.2500   1.0800
   9.5000   1.5500  10.2500   2.5500  11.0000   3.3900
    0.50        6   0.0000
   8.2000   0.0000   8.5000   1.0500   9.0000   2.1900   9.2500   2.6300
   9.5000   3.0700  10.2500   4.1400  11.0000   4.9500
    1.00       12   0.0000
```

```
  0.0000   0.0000   0.5000   0.3200   1.0000   0.4100   2.0000   0.5500
  3.0000   0.6500   4.0000   0.7300   5.0000   0.8500   6.0000   1.0400
  7.0000   1.3100   8.0000   2.2000   9.0000   3.7400  10.0000   5.1800
 11.0000   6.2700
    2.00       14   0.0000
  0.0000   0.0000   0.0000   0.1500   0.0100   0.3000   0.5000   0.9700
  1.0000   1.3600   2.0000   1.8500   3.0000   2.1800   4.0000   2.5000
  5.0000   2.8800   6.0000   3.4500   7.0000   4.3000   8.0000   5.3800
  9.0000   6.4800  10.0000   7.5600  11.0000   8.5800
    3.00       14   0.0000
  0.0000   0.0000   0.0100   0.2700   0.0200   0.5300   0.5000   1.7700
  1.0000   2.4300   2.0000   3.2700   3.0000   3.8800   4.0000   4.4500
  5.0000   5.0800   6.0000   5.8600   7.0000   6.7900   8.0000   7.7500
  9.0000   8.6700  10.0000   9.5200  11.0000  10.2700
    4.00       14   0.0000
  0.0000   0.0000   0.0100   0.5100   0.0300   1.0300   0.5000   2.7900
  1.0000   3.7300   2.0000   4.9100   3.0000   5.8800   4.0000   6.5700
  5.0000   7.3700   6.0000   8.1700   7.0000   8.9000   8.0000   9.6700
  9.0000  10.3500  10.0000  10.9500  11.0000  11.4500
    5.00       14   0.0000
  0.0000   0.0000   0.0300   0.9600   0.0500   1.9100   0.5000   4.1900
  1.0000   5.3000   2.0000   6.7500   3.0000   7.7900   4.0000   8.6400
  5.0000   9.4000   6.0000  10.1400   7.0000  10.6200   8.0000  11.0900
  9.0000  11.5100  10.0000  11.8500  11.0000  12.1500
    6.00       14   0.0000
  0.0000   0.0000   0.0500   1.6700   0.0900   3.3300   0.5000   5.9300
  1.0000   7.1500   2.0000   8.6400   3.0000   9.6700   4.0000  10.2800
  5.0000  10.9600   6.0000  11.4200   7.0000  11.7500   8.0000  12.1300
  9.0000  12.2800  10.0000  12.4300  11.0000  12.5200
    7.00       14   0.0000
  0.0000   0.0000   0.0800   2.9100   0.1600   5.8300   0.5000   7.9900
  1.0000   9.0700   2.0000  10.1400   3.0000  11.1100   4.0000  11.6300
  5.0000  11.9800   6.0000  12.2400   7.0000  12.4000   8.0000  12.5200
  9.0000  12.6300  10.0000  12.6500  11.0000  12.6800
    8.00       14   0.0000
  0.0000   0.0000   0.1000   3.7500   0.2100   7.5000   0.5000   9.8100
  1.0000  10.6600   2.0000  11.6800   3.0000  12.0900   4.0000  12.3600
  5.0000  12.5100   6.0000  12.6000   7.0000  12.6600   8.0000  12.6900
  9.0000  12.7000  10.0000  12.7000  11.0000  12.7000
    9.00       14   0.0000
  0.0000   0.0000   0.1300   4.7200   0.2600   9.4300   0.5000  10.8600
  1.0000  11.6200   2.0000  12.2500   3.0000  12.6100   4.0000  12.6900
  5.0000  12.7000   6.0000  12.7000   7.0000  12.7000   8.0000  12.7000
  9.0000  12.7000  10.0000  12.7000  11.0000  12.7000
   10.00       14   0.0000
  0.0000   0.0000   0.1400   4.9500   0.2700   9.9100   0.5000  10.9600
  1.0000  11.7400   2.0000  12.4400   3.0000  12.6800   4.0000  12.7000
  5.0000  12.7000   6.0000  12.7000   7.0000  12.7000   8.0000  12.7000
  9.0000  12.7000  10.0000  12.7000  11.0000  12.7000
   11.00       14   0.0000
  0.0000   0.0000   0.1200   4.4800   0.2500   8.9500   0.5000  10.1000
  1.0000  11.0400   2.0000  11.8600   3.0000  12.2800   4.0000  12.5000
  5.0000  12.6000   6.0000  12.6300   7.0000  12.6500   8.0000  12.6600
  9.0000  12.6700  10.0000  12.6900  11.0000  12.7000
   12.00       14   0.0000
  0.0000   0.0000   0.1000   3.6600   0.2000   7.3200   0.5000   8.8000
  1.0000   9.6600   2.0000  10.6800   3.0000  11.3100   4.0000  11.7100
  5.0000  11.9800   6.0000  12.1400   7.0000  12.2600   8.0000  12.3500
  9.0000  12.4000  10.0000  12.4500  11.0000  12.4900
   13.00       14   0.0000
  0.0000   0.0000   0.0800   2.7900   0.1500   5.5800   0.5000   7.1000
  1.0000   8.0200   2.0000   9.1500   3.0000   9.8800   4.0000  10.2300
  5.0000  10.7300   6.0000  11.0100   7.0000  11.2400   8.0000  11.4400
  9.0000  11.6000  10.0000  11.7800  11.0000  11.9100
   14.00       14   0.0000
  0.0000   0.0000   0.0500   1.9700   0.1100   3.9400   0.5000   5.3200
  1.0000   6.3400   2.0000   7.4200   3.0000   8.1400   4.0000   8.6700
  5.0000   9.1000   6.0000   9.4600   7.0000   9.8000   8.0000  10.1000
```

```
   9.0000  10.3800  10.0000  10.6800  11.0000  10.9300
    15.00       14   0.0000
   0.0000   0.0000   0.0300   1.0200   0.0600   2.0300   0.5000   4.0000
   1.0000   4.7500   2.0000   5.7800   3.0000   6.3300   4.0000   6.8600
   5.0000   7.2800   6.0000   7.6600   7.0000   8.0400   8.0000   8.3800
   9.0000   8.7600  10.0000   9.1100  11.0000   9.5000
    16.00       14   0.0000
   0.0000   0.0000   0.0200   0.6700   0.0400   1.3300   0.5000   2.7900
   1.0000   3.4000   2.0000   4.1000   3.0000   4.7000   4.0000   5.1100
   5.0000   5.4500   6.0000   5.7900   7.0000   6.1000   8.0000   6.4500
   9.0000   6.8100  10.0000   7.2400  11.0000   7.7100
    17.00       14   0.0000
   0.0000   0.0000   0.0100   0.3000   0.0200   0.5900   0.5000   1.9200
   1.0000   2.4300   2.0000   3.0100   3.0000   3.3400   4.0000   3.5800
   5.0000   3.7800   6.0000   3.9900   7.0000   4.2100   8.0000   4.4800
   9.0000   4.8200  10.0000   5.2400  11.0000   5.7700
    18.00       14   0.0000
   0.0000   0.0000   0.0000   0.1300   0.0100   0.2500   0.5000   1.4200
   1.0000   1.8800   2.0000   2.2900   3.0000   2.3900   4.0000   2.4000
   5.0000   2.3900   6.0000   2.4200   7.0000   2.5200   8.0000   2.7000
   9.0000   2.8700  10.0000   3.2800  11.0000   3.8700
    19.00       14   0.0000
   0.0000   0.0000   0.0000   0.0800   0.0000   0.1500   0.5000   1.1300
   1.0000   1.4400   2.0000   1.7700   3.0000   1.7500   4.0000   1.6000
   5.0000   1.4500   6.0000   1.3200   7.0000   1.2700   8.0000   1.3000
   9.0000   1.4000  10.0000   1.7000  11.0000   2.0700
    19.50       14   0.0000
   0.0000   0.0000   0.2500   0.7000   0.5000   1.0000   0.7500   1.1600
   1.0000   1.3200   2.0000   1.5700   3.0000   1.5200   4.0000   1.3600
   5.0000   1.1600   6.0000   0.9500   7.0000   0.8000   8.0000   0.7000
   9.0000   0.8000  10.0000   0.9600  11.0000   1.2100
    20.00       14   0.0000
   0.1300   0.0000   0.2500   0.5400   0.5000   0.6600   0.7500   0.9100
   1.0000   1.0500   2.0000   1.3400   3.0000   1.3200   4.0000   1.1000
   5.0000   0.8200   6.0000   0.5600   7.0000   0.3500   8.0000   0.2000
   9.0000   0.1000  10.0000   0.1100  11.0000   0.2800
   1.0000   1.0000   1.0000
 *** End of file ***
```

3.2.2 Rectangular Barge

```
4.19
Rectangular Barge:   90.00 x 30.00 x 4.00 (4.00) meter.
   1.0000   0.0000   1.0000   0.0000
        2
   0.5000   0.5000
        2
   0.00          4   0.0000
   0.0000   0.0000   0.0000   0.2500   0.0000   0.5000   0.5000   0.5000
   1.000    0.5000
  10.00          4   0.0000
   0.0000   0.0000   0.0000   0.2500   0.0000   0.5000   0.5000   0.5000
   1.0000   0.5000
  20.00          4   0.0000
   0.0000   0.0000   0.0000   0.2500   0.0000   0.5000   0.5000   0.5000
   1.0000   0.5000
  90.0000  30.0000   4.0000
 *** End of file ***
```

3.2.3 Semi-submersible

Figure 8 shows a semi-submersible as used by [Pinkster, 1980] in his Doctor's Thesis.

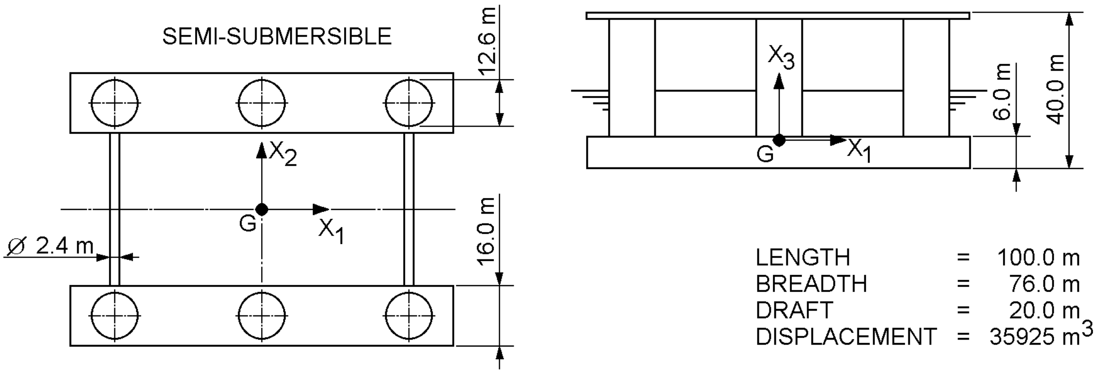

Figure 8 Semi-Submersible as used by J.A. Pinkster [1980]

The hull form file of this semi-submersible reads as follows.

```
4.19
Semi-Sub JAP:   100.00 x 16.00 x 20.00 (20.00) meter.
 20.0000   0.0000 100.0000   0.0000
      38
  3.1500   3.1500   0.0000   0.0000   1.5750   1.5750   3.1500   3.1500
  1.5750   1.5750   0.0000   0.0000  12.4000  12.4000   0.0000   0.0000
  1.5750   1.5750   3.1500   3.1500   1.5750   1.5750   0.0000   0.0000
 12.4000  12.4000   0.0000   0.0000   1.5750   1.5750   3.1500   3.1500
  1.5750   1.5750   0.0000   0.0000   3.1500   3.1500
       2
    0.00        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
 20.0000   0.0000
    0.50        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
 20.0000   0.0000
    0.99        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
 20.0000   0.0000
    1.00        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
 20.0000   0.0000
    1.01        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.7940   8.0000   1.0990  14.0000   1.0990
 20.0000   1.0990
    1.25        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   6.0830   8.0000   4.1670  14.0000   4.1670
 20.0000   4.1670
    1.50        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   6.7250   8.0000   5.4560  14.0000   5.4560
 20.0000   5.4560
    2.00        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   7.1500   8.0000   6.3000  14.0000   6.3000
 20.0000   6.3000
    2.50        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   6.7250   8.0000   5.4560  14.0000   5.4560
```

```
20.0000   5.4560
   2.75        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   6.0830   8.0000   4.1670  14.0000   4.1670
20.0000   4.1670
   2.99        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   4.7940   8.0000   1.0990  14.0000   1.0990
20.0000   1.0990
   3.00        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
20.0000   0.0000
   3.01        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
20.0000   0.0000
   3.50        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
20.0000   0.0000
   3.99        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
20.0000   0.0000
   4.00        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
20.0000   0.0000
   4.01        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   4.7940   8.0000   1.0990  14.0000   1.0990
20.0000   1.0990
   4.25        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   6.0830   8.0000   4.1670  14.0000   4.1670
20.0000   4.1670
   4.50        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   6.7250   8.0000   5.4560  14.0000   5.4560
20.0000   5.4560
   5.00        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   7.1500   8.0000   6.3000  14.0000   6.3000
20.0000   6.3000
   5.50        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   6.7250   8.0000   5.4560  14.0000   5.4560
20.0000   5.4560
   5.75        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   6.0830   8.0000   4.1670  14.0000   4.1670
20.0000   4.1670
   5.99        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   4.7940   8.0000   1.0990  14.0000   1.0990
20.0000   1.0990
   6.00        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
20.0000   0.0000
   6.01        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
20.0000   0.0000
   6.50        8  30.0000
 0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
 8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
```

```
 20.0000   0.0000
    6.99        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
 20.0000   0.0000
    7.00        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
 20.0000   0.0000
    7.01        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.7940   8.0000   1.0990  14.0000   1.0990
 20.0000   1.0990
    7.25        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   6.0830   8.0000   4.1670  14.0000   4.1670
 20.0000   4.1670
    7.50        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   6.7250   8.0000   5.4560  14.0000   5.4560
 20.0000   5.4560
    8.00        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   7.1500   8.0000   6.3000  14.0000   6.3000
 20.0000   6.3000
    8.50        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   6.7250   8.0000   5.4560  14.0000   5.4560
 20.0000   5.4560
    8.75        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   6.0830   8.0000   4.1670  14.0000   4.1670
 20.0000   4.1670
    8.99        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.7940   8.0000   1.0990  14.0000   1.0990
 20.0000   1.0990
    9.00        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
 20.0000   0.0000
    9.01        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
 20.0000   0.0000
    9.50        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
 20.0000   0.0000
   10.00        8  30.0000
  0.0000   0.0000   0.0000   4.0000   0.0000   8.0000   4.0000   8.0000
  8.0000   8.0000   8.0000   4.0000   8.0000   0.0000  14.0000   0.0000
 20.0000   0.0000
       1        1        1
*** End of file ***
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The jumps at the columns are located at cross-sections: 1.00, 2.00, 3.00, …… 9.00.

3.3 Hull Form Series

The table below shows the definitions of the various parameters used in this section:

L	Length between perpendiculars, L_{pp}
B	Maximum moulded breadth of the waterline
d	Fully laden draft at even keel
Ñ	Volume of displacement
C_b = **Ñ**/ (LBd)	Block coefficient
A_{wl}	Water plane area
$C_{wl} = A_{wl} / (L.B.d)$	Water plane area coefficient
$C_{vp} = C_b / C_{wl}$=**Ñ**/ $(A_{wl}.d)$	Vertical prismatic coefficient
L_{CoB} or L_{CoG}	Longitudinal position of the centre of buoyancy or the centre of gravity with respect to $L_{pp}/2$
D	Depth at even keel of the measured offsets, D ³ d

The next figure shows a hull form below the water line at depth *D,* which lies above the waterline which corresponds to the fully laden draught of the ship, *d*. Under this waterline at depth *D*, any amidships draught and trim can be chosen in SEAWAY for calculating the ship motions.

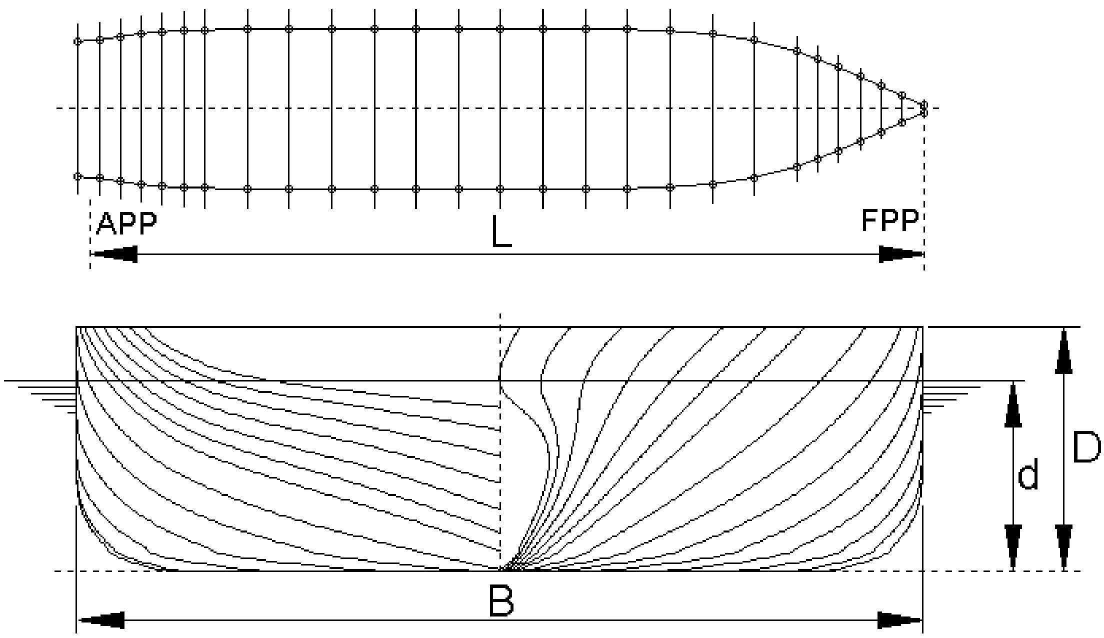

Figure 9 Hull Form Definitions

During the last decade, a large number of various hull forms of ships for SEAWAY have been collected; two Series are available now:

- Versluis-Series, a collection of [Versluis, 1995] with 63 hull forms.
  The design of a ship's hull form consumes a lot of time. However, in many cases it is possible an existing ship can be used by transforming its dimensions to those of the desired ship. A few decades ago, Versluis started with the generation of a collection of parent hull forms of various types of ships for this purpose.
- Journee-series, a collection of the author with 60 hull forms.

During one decade now, the ship motions computer program SEAWAY has been used frequently by the authors and by students and a very large number of hull form data files were the result.

A selection has been made from all of these data files. Only hull forms which were considered to belong to the public domain - as far as the author could determine this - are presented here.

Both hull form series have been described here and are gathered in the file HullFormSeries.ZIP.

These hull forms were made non-dimensional, in such a way that they have a length, a breadth and a draught of 1.00 meter. Then - to obtain its actual dimensions again - these normalised hull forms are resized by using the numerical values of L, B and d as scale factors at the end of the hull form data file.

Now, this hull form can be resized easily to the principal dimensions of any other ship by replacing the scale factors by the principal dimensions of the actual ship.

The most important hull form parameters of a ship with respect to its seakeeping behaviour are its length L, breadth B and draught d. The hydromechanical coefficients and wave loads are also influenced by the block coefficient C_b, the water plane coefficient C_{wl}, and the longitudinal position of the centre of buoyancy L_{CoB} or centre of gravity L_{CoG}.

Now, the procedure for using these hull form series is as follows.

Select a ship with a C_b and a C_{wl} close to their required values. If a ship of the same type has been selected too, only a small error in the value of L_{CoB} can be expected, generally. Then, a linear scaling of this hull form to the required dimensions of the ship results in a hull form, which - in general - can be used safely for preliminary ship motion calculations.

Two figures are presented here, to make (in a simple way) a quick selection of a ship with an acceptable C_b and C_{wl} value out of these 123 ships.

The numbers in the figures refer to the hull form file; for instance, number 56 of the Versluis-Series refers to the hull form data file VERSLUIS.056 and number 27 of the Journee-series refers to the hull form data file JOURNEE.027.

The main dimensions of the original ships are given here in two tables.

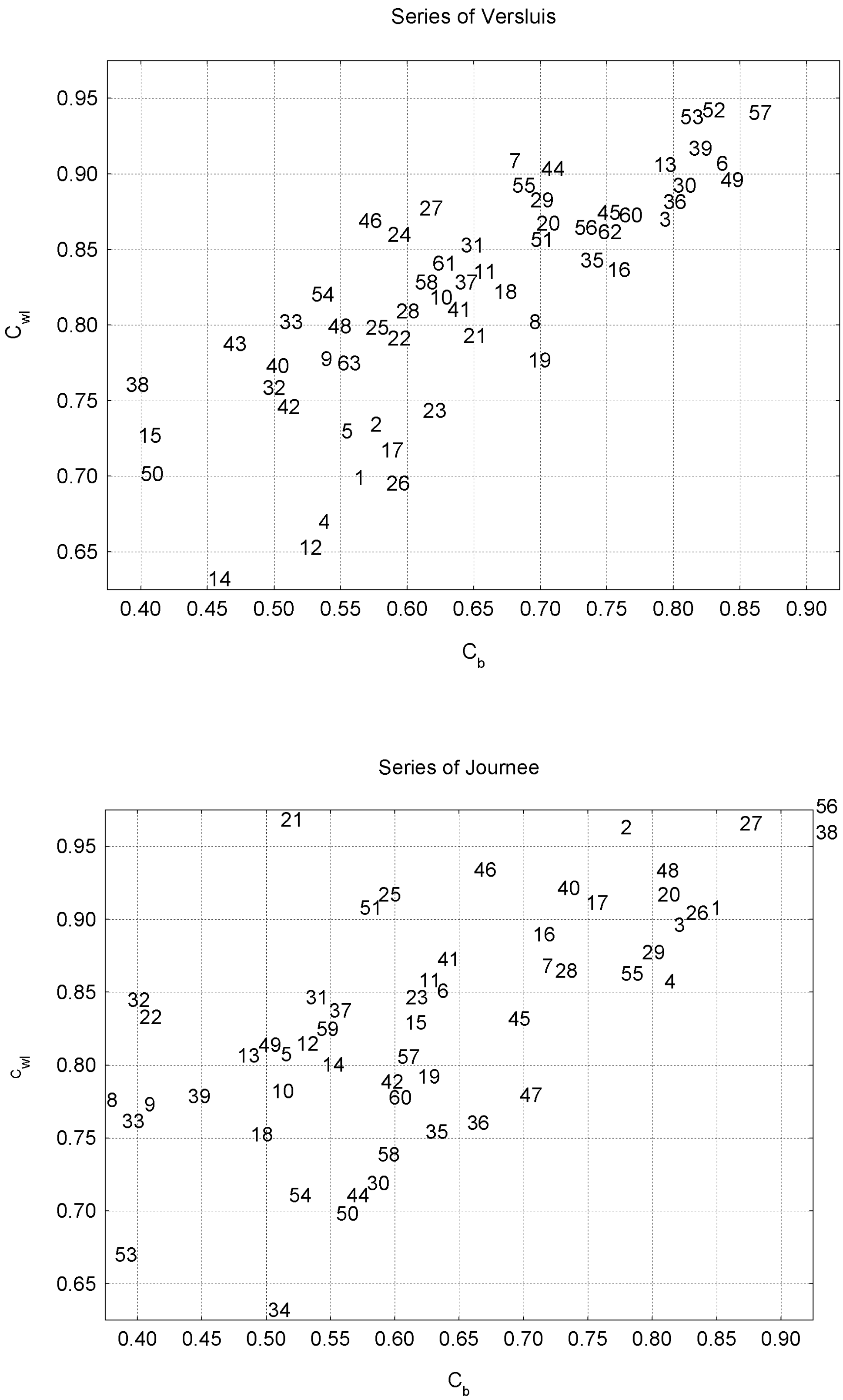

Figure 10 Hull Form Series of Versluis and Journée

File Name	Ship Type	L (m)	B (m)	d (m)	C_b (-)	C_{wl} (-)	C_{vp} (-)	L/B (-)	B/d (-)	L_{CoB} (%L)
VERSLUIS.001	Fast Freighter	152.50	22.80	9.14	0.564	0.699	0.807	6.68	2.50	-1.09
VERSLUIS.002	Container Ship	205.00	29.20	9.10	0.577	0.735	0.784	7.02	3.21	-1.51
VERSLUIS.003	Bulk Carrier	187.00	29.00	10.95	0.794	0.876	0.915	6.45	2.65	+1.80
VERSLUIS.004	Container Ship	250.00	32.00	9.00	0.538	0.670	0.803	7.81	3.52	-4.00
VERSLUIS.005	Container Ship	300.00	37.00	11.00	0.554	0.729	0.760	8.11	3.36	-3.10
VERSLUIS.006	Tanker	302.00	52.10	20.00	0.838	0.904	0.927	5.80	2.61	+2.90
VERSLUIS.007	Supply Vessel	54.63	12.88	4.75	0.682	0.908	0.751	4.24	2.71	-0.29
VERSLUIS.008	Coaster	72.00	13.00	4.24	0.696	0.801	0.869	5.54	3.07	+0.40
VERSLUIS.009	Stern Trawler	46.45	9.20	3.70	0.539	0.777	0.694	5.05	2.49	+0.01
VERSLUIS.010	Ro-Ro vessel	198.80	32.24	10.00	0.625	0.818	0.764	6.17	3.22	-1.31
VERSLUIS.011	Ferry	138.00	24.70	5.70	0.658	0.834	0.788	5.59	4.33	-2.49
VERSLUIS.012	Reefer Ship	133.00	19.60	6.18	0.527	0.652	0.808	6.79	3.17	-0.31
VERSLUIS.013	Inland Waterway Tanker	27.25	5.00	1.65	0.794	0.905	0.878	5.45	3.03	+1.08
VERSLUIS.014	Inland Waterway Ferry	61.40	15.75	3.80	0.459	0.620	0.740	3.90	4.15	0.00
VERSLUIS.015	Inland Waterway Ferry	50.00	12.29	3.25	0.405	0.726	0.557	4.07	3.78	+0.02
VERSLUIS.016	Multi-Purpose Ship	132.00	21.00	8.53	0.760	0.835	0.911	6.29	2.46	+1.19
VERSLUIS.017	Multi-Purpose Ship	155.40	23.30	9.20	0.588	0.716	0.821	6.67	2.53	-1.70
VERSLUIS.018	Multi-Purpose Ship	104.80	18.00	7.90	0.673	0.821	0.819	5.82	2.28	-0.70
VERSLUIS.019	Container Ship	106.00	20.28	4.25	0.699	0.777	0.900	5.23	4.72	+0.10
VERSLUIS.020	Barge Carrier	234.00	32.42	11.25	0.703	0.864	0.814	7.22	2.88	-1.51
VERSLUIS.021	Reefer Ship	73.38	11.80	4.80	0.654	0.792	0.826	6.64	2.46	-0.70
VERSLUIS.022	Stern Trawler	42.35	10.90	3.80	0.593	0.793	0.748	3.89	2.87	-1.36
VERSLUIS.023	Reefer Ship	88.00	16.00	4.19	0.621	0.742	0.837	5.50	3.82	-1.00
VERSLUIS.024	Tug Boat	33.00	9.45	3.20	0.594	0.860	0.691	3.49	2.95	+0.42
VERSLUIS.025	Stern Trawler	59.80	12.50	4.80	0.577	0.798	0.723	4.78	2.60	-0.91
VERSLUIS.026	Container Ship	178.00	25.85	9.00	0.592	0.695	0.851	6.89	2.87	-0.89
VERSLUIS.027	Supply Vessel	52.00	11.10	4.15	0.618	0.876	0.706	4.69	2.68	-1.12
VERSLUIS.028	Ro-Ro Vessel	183.20	32.24	10.00	0.599	0.809	0.740	5.68	3.22	-1.38
VERSLUIS.029	Heavy Lift Vessel	134.00	28.00	7.00	0.699	0.884	0.791	4.79	4.00	-2.41
VERSLUIS.030	Bulk Carrier	167.00	22.86	10.87	0.806	0.888	0.908	7.31	2.10	+1.81
VERSLUIS.031	Container Ship	247.00	32.26	12.00	0.648	0.852	0.761	7.66	2.69	-3.00
VERSLUIS.032	Ferry	84.50	18.70	4.80	0.500	0.758	0.660	6.55	2.79	+0.02
VERSLUIS.033	Tug Boat	17.00	4.99	1.40	0.511	0.801	0.639	3.41	3.56	-0.39
VERSLUIS.034	Sailboat	10.00	3.20	0.79	0.361	0.680	0.530	3.43	4.05	-2.24
VERSLUIS.035	Coaster	75.00	14.00	5.15	0.737	0.843	0.874	5.36	2.72	+1.51
VERSLUIS.036	Shallow Draft Tanker	211.00	39.00	12.50	0.799	0.882	0.905	5.41	3.12	+3.30
VERSLUIS.037	Ro-Ro Vessel	198.80	32.24	9.00	0.644	0.828	0.777	6.17	3.58	-1.20
VERSLUIS.038	Fast Displacement Vessel	25.40	4.04	1.40	0.397	0.760	0.523	6.29	2.89	-6.54
VERSLUIS.039	Inland Waterway Coaster	60.00	11.30	3.80	0.819	0.916	0.894	5.31	2.97	+1.10
VERSLUIS.040	Ice Breaker	72.00	16.39	6.50	0.503	0.771	0.652	4.39	2.52	-0.52
VERSLUIS.041	Ro-Ro Vessel	116.50	20.42	6.00	0.637	0.811	0.785	5.71	3.40	-1.89
VERSLUIS.042	Trawler	30.60	8.00	2.90	0.509	0.751	0.678	3.83	2.76	+3.31
VERSLUIS.043	Trawler	20.80	5.80	1.99	0.471	0.788	0.598	3.59	2.92	+2.69
VERSLUIS.044	Supply Vessel	50.00	12.13	4.50	0.709	0.902	0.786	4.12	2.70	-0.49
VERSLUIS.045	Coaster	60.00	10.70	4.12	0.752	0.873	0.862	5.61	2.60	+0.16
VERSLUIS.046	Tug Boat	25.00	8.59	3.00	0.572	0.868	0.660	2.91	2.86	+0.10
VERSLUIS.047	Motor Yacht	9.10	3.01	1.54	0.223	0.703	0.318	3.02	1.96	-2.32
VERSLUIS.048	Ferry	107.85	18.31	5.00	0.549	0.800	0.686	5.89	3.66	-2.59
VERSLUIS.049	Tanker	277.90	44.80	16.60	0.842	0.897	0.938	6.20	2.70	+2.28
VERSLUIS.050	Motor Yacht	14.56	5.03	1.31	0.408	0.701	0.582	2.90	3.84	-4.11
VERSLUIS.051	Container Ship	132.00	21.50	7.00	0.700	0.859	0.815	6.14	3.07	-0.86
VERSLUIS.052	Low Air Draft Coaster	76.95	12.21	5.00	0.830	0.941	0.883	6.30	2.44	-0.16
VERSLUIS.053	Low Air Draft Coaster	78.00	12.50	4.95	0.812	0.937	0.866	6.24	2.53	+0.91
VERSLUIS.054	Wooden Ship	17.80	4.52	1.25	0.536	0.820	0.654	3.94	3.62	-2.13
VERSLUIS.055	Seagoing Tug	58.50	14.18	5.80	0.687	0.892	0.771	4.12	2.45	-0.20
VERSLUIS.056	Bitumen Tanker	90.00	14.50	5.90	0.733	0.864	0.848	6.21	2.46	+0.67
VERSLUIS.057	Tanker	251.00	42.50	12.25	0.864	0.940	0.864	5.91	3.47	+2.59
VERSLUIS.058	Ro-Ro Vessel	150.00	29.00	6.50	0.616	0.828	0.744	5.17	4.46	-2.01
VERSLUIS.059	Yacht	19.18	4.24	1.00	0.298	0.660	0.452	4.52	4.24	-4.94
VERSLUIS.060	Container Feeder	85.00	13.75	4.20	0.767	0.872	0.879	6.18	3.27	-0.31
VERSLUIS.061	Ro-Ro Vessel	157.65	23.40	6.00	0.620	0.831	0.745	6.74	3.90	-2.75
VERSLUIS.062	Survey Vessel	46.00	10.00	3.00	0.751	0.866	0.890	5.34	2.99	+0.73
VERSLUIS.063	Hopper Dredger	104.60	19.60	6.55	0.555	0.774	0.717	4.60	3.33	-0.61

File Name	Ship Type	L (m)	B (m)	d (m)	C_b (-)	C_{wl} (-)	C_{vp} (-)	L/B (-)	B/d (-)	L_{CoB} (%L)
JOURNEE.001	Tanker	310.00	47.16	18.90	0.850	0.907	0.937	6.57	2.50	+2.82
JOURNEE.002	Trench Setter	94.00	19.60	4.54	0.780	0.962	0.810	4.80	4.32	-4.04
JOURNEE.003	Tanker	234.00	42.67	15.00	0.821	0.896	0.916	5.48	2.85	+2.64
JOURNEE.004	Bulk Carrier	172.00	23.10	7.86	0.814	0.857	0.950	7.45	2.94	+0.72
JOURNEE.005	Survey Vessel	60.00	11.50	3.65	0.511	0.809	0.632	5.22	3.15	-2.89
JOURNEE.006	Ro-Ro Vessel	128.00	23.00	6.10	0.634	0.852	0.744	5.57	3.77	-3.36
JOURNEE.007	Freighter	110.60	17.50	6.25	0.719	0.867	0.830	6.32	2.80	-0.27
JOURNEE.008	Pilot Vessel	21.00	4.33	1.06	0.378	0.775	0.488	4.85	4.08	-0.68
JOURNEE.009	Pilot Vessel	15.10	4.54	0.97	0.410	0.772	0.532	3.32	4.68	-11.0
JOURNEE.010	Oceanographic Vessel	84.50	14.40	5.00	0.512	0.781	0.655	5.87	2.88	-0.01
JOURNEE.011	Ro-Ro Vessel	118.50	21.00	6.00	0.626	0.850	0.736	5.64	3.50	-2.82
JOURNEE.012	Lemster Aak	8.58	3.26	0.64	0.532	0.814	0.654	2.63	5.09	+2.75
JOURNEE.013	Ferry	47.00	11.00	3.00	0.486	0.806	0.603	4.27	3.67	-1.35
JOURNEE.014	Trawler	36.00	8.51	3.49	0.551	0.800	0.688	4.23	2.44	-1.89
JOURNEE.015	Ferry	146.40	27.60	6.22	0.616	0.829	0.743	5.30	4.44	-2.03
JOURNEE.016	Ferry	169.20	24.92	6.08	0.716	0.889	0.806	6.79	4.10	-2.21
JOURNEE.017	Freighter	126.40	21.29	8.00	0.757	0.911	0.832	5.94	2.66	+0.72
JOURNEE.018	Trawler	30.53	8.00	2.92	0.496	0.752	0.659	3.82	2.74	+4.02
JOURNEE.019	Container Ship	202.00	32.24	9.95	0.626	0.792	0.791	6.27	3.24	-1.63
JOURNEE.020	Hopper Dredger	106.00	19.60	6.50	0.811	0.916	0.885	5.41	3.02	+0.36
JOURNEE.021	Tug Boat	39.00	12.87	4.38	0.520	0.981	0.530	3.03	2.94	+0.16
JOURNEE.022	Protection Vessel	24.85	5.82	1.62	0.410	0.833	0.492	4.27	3.59	-6.63
JOURNEE.023	Reefer Ship	114.00	20.00	7.00	0.620	0.849	0.731	5.70	2.86	-1.99
JOURNEE.024	Sailboat	41.95	11.22	5.00	0.218	0.699	0.311	3.74	2.24	-2.76
JOURNEE.025	Research Vessel	27.60	8.35	2.90	0.590	0.913	0.647	3.31	2.88	-2.47
JOURNEE.026	Tanker	285.00	49.00	20.46	0.835	0.903	0.924	5.82	2.40	+2.85
JOURNEE.027	Shallow Draft Vessel	173.00	36.00	10.00	0.877	0.965	0.909	4.81	3.60	-4.87
JOURNEE.028	Freighter	122.60	26.00	6.35	0.731	0.865	0.845	4.72	4.09	+0.77
JOURNEE.029	Product Tanker	185.00	32.00	11.50	0.800	0.876	0.914	5.78	2.78	+1.57
JOURNEE.030	Container Ship	193.10	30.80	9.00	0.585	0.718	0.815	6.27	3.42	-0.97
JOURNEE.031	Survey Vessel	25.70	7.41	2.54	0.538	0.846	0.637	3.47	2.92	+2.18
JOURNEE.032	Patrol Vessel	20.34	4.45	1.33	0.401	0.844	0.476	4.55	3.35	-5.60
JOURNEE.033	Catamaran Vessel	33.35	11.15	1.52	0.397	0.761	0.522	10.91	2.02	-9.19
JOURNEE.034	Reefer Ship	150.00	21.00	7.00	0.509	0.625	0.814	7.14	3.00	+0.39
JOURNEE.035	Drilling Vessel	137.06	27.00	7.22	0.632	0.753	0.839	5.08	3.74	-0.20
JOURNEE.036	Drilling Vessel	151.26	27.36	9.20	0.664	0.760	0.873	5.53	2.97	+0.92
JOURNEE.037	Trawler	36.30	8.35	2.73	0.556	0.833	0.668	4.35	3.06	-1.39
JOURNEE.038	Barge	234.20	43.20	14.99	0.935	0.961	0.973	5.42	2.88	-1.36
JOURNEE.039	High Speed Vessel	28.00	5.18	1.18	0.447	0.778	0.574	5.41	4.39	-6.45
JOURNEE.040	Diving Support Vessel	85.50	19.13	6.20	0.734	0.921	0.796	4.47	3.09	+0.06
JOURNEE.041	Container Ship	275.00	36.00	12.90	0.641	0.872	0.735	7.64	2.79	+0.12
JOURNEE.042	Container Ship	270.00	32.20	10.85	0.597	0.788	0.758	8.39	2.97	-3.73
JOURNEE.043	Heavy Lift Vessel	270.00	29.85	7.60	0.305	0.755	0.403	9.13	3.89	-6.81
JOURNEE.044	Container Ship	175.00	25.40	9.50	0.570	0.711	0.803	6.89	2.67	-1.46
JOURNEE.045	FPSO Vessel	200.31	38.00	8.00	0.696	0.832	0.836	5.27	4.75	-3.23
JOURNEE.046	Train Unit Loader	134.00	28.69	7.60	0.670	0.933	0.719	4.67	3.78	-4.87
JOURNEE.047	Tanker	207.42	42.00	8.87	0.705	0.779	0.906	4.94	4.74	+2.88
JOURNEE.048	Oil Pollution Fighter	51.00	9.14	3.25	0.811	0.932	0.870	5.58	2.81	-0.96
JOURNEE.049	Submarine Rescue Vessel	77.25	16.00	5.00	0.504	0.810	0.622	4.82	3.20	-3.71
JOURNEE.050	Fast Freighter	152.50	22.82	9.14	0.562	0.698	0.806	6.68	2.50	-1.05
JOURNEE.051	Research Vessel	27.60	8.35	2.90	0.585	0.912	0.642	3.31	2.88	-2.87
JOURNEE.052	Sailboat	10.00	3.19	0.79	0.362	0.682	0.531	3.14	4.03	-2.27
JOURNEE.053	Sailboat	10.00	2.24	0.91	0.391	0.670	0.584	4.46	2.47	-1.93
JOURNEE.054	Sailboat	10.00	3.65	0.35	0.525	0.711	0.738	2.74	10.45	-6.89
JOURNEE.055	Cutter Suction Dredger	90.26	19.00	4.60	0.784	0.862	0.909	4.75	4.13	+0.69
JOURNEE.056	Crane Vessel	198.33	80.00	14.00	0.962	0.983	0.979	3.73	5.71	-1.15
JOURNEE.057	Ro-Ro Vessel	157.65	23.40	5.80	0.610	0.804	0.759	6.74	4.04	-2.33
JOURNEE.058	Cruise Vessel	198.12	28.65	8.86	0.594	0.739	0.804	6.92	3.23	-1.93
JOURNEE.059	Sailboat	39.90	11.80	4.45	0.548	0.825	0.664	3.38	2.65	+3.56
JOURNEE.060	Container Ship	156.00	22.00	8.00	0.602	0.778	0.773	7.09	2.75	-1.79

An example of a result is given below.

```
JOURNEE.004: Bulk Carrier, 172.00 x 23.10 x 7.86 (13.00) meter.
1.654E+00 0.000E-01 1.000E+00 0.000E-01
24
2.500E-02 2.500E-02 2.500E-02 2.500E-02 5.000E-02 5.000E-02
5.000E-02 5.000E-02 5.000E-02 5.000E-02 5.000E-02 5.000E-02
5.000E-02 5.000E-02 5.000E-02 5.000E-02 5.000E-02 5.000E-02
5.000E-02 5.000E-02 2.500E-02 2.500E-02 2.500E-02 2.500E-02
1
0.00 6 0.000E-01
0.000E-01 0.000E-01 7.727E-02 6.997E-02 1.147E-01 1.336E-01
1.441E-01 1.972E-01 1.878E-01 3.244E-01 2.204E-01 4.517E-01
2.464E-01 5.789E-01
......... etcetera .........
......... etcetera .........
......... etcetera .........
20.00 14 0.000E-01
0.000E-01 0.000E-01 2.091E-02 3.181E-02 3.896E-02 9.542E-02
5.390E-02 1.590E-01 7.628E-02 2.863E-01 8.823E-02 4.135E-01
8.970E-02 5.407E-01 7.935E-02 6.679E-01 5.225E-02 7.952E-01
2.130E-02 9.224E-01 4.113E-03 1.050E+00 2.424E-03 1.177E+00
1.156E-02 1.304E+00 3.935E-02 1.431E+00 7.450E-02 1.559E+00
172.000 23.100 7.860
*** End of file***
```

This hull form can be resized easily to the principal dimensions of any other ship by replacing the scale factors - L=172.000 m, B=23.100 m and d=7.860 m - at the end of the data file, by the principal dimensions of the actual ship.

3.4 Lewis Hull Form Creator SEAWAY-L

The two-dimensional hydrodynamic coefficients can be calculated in SEAWAY via mapping of the cross-section to the unit circle by the "Lewis Conformal Mapping Method" or the "N-Parameter Close-Fit Conformal Mapping Method" or by a direct calculation of the pressures on the actual cross section with the pulsating source method of [Frank, 1967].
The advantage of conformal mapping is that the velocity potential of the fluid around an arbitrary shape of a cross-section in a complex plane can be derived from the more convenient circular cross-section in another complex plane. In this manner the hydrodynamic problems can be solved directly with the coefficients of the mapping function, which is much less computer time consuming than the pulsating source method of Frank.
The advantage of making use of the two-parameter Lewis conformal mapping method is that the frequency-depending potential coefficients will be determined as a function of the breadth, the draught and the area of the cross-section only.

In a preliminary design stage of a ship, information on the sectional breadth, draught and area is available only. A description is given here of a Lewis form creator, named SEAWAY-L, which creates a hull form data file with approximated offsets of the ship based on these three parameters. This option makes it possible to use the ship motions program SEAWAY in a preliminary design stage of a ship too.
The program SEAWAY-L requires an ASCII input data file, which contains simple information about the geometry of the underwater part of the ship. In case of twin-hull ships, the data of the single hull have to be given.
Parameters in this input description starting with *I, J, K, L, M* and *N* are integer data types. All other parameters are real data types, which can be given with an integer format too.

3.4.1 Description of Input Data for SEAWAY-L

```
 * On first line of data set: RELINP
```

RELINP is the program release number, when creating the hull form data file. Program releases created later, will be able to use this file too.

```
 * TEXT
 * New line
```

TEXT is a text line, with a maximum of 80 characters, with general information about the ship, such as the name of the ship and its principal dimensions, for instance:

```
Containership S-175:   175.00 x 25.40 x 9.50 (11.00) meter.
```

```
 * New line
 * IPRINT
 * KCON
```

IPRINT is the code for printing of input data:

IPRINT = 0: Suppress printing input data.
IPRINT = 1: Print input data, which have to be removed from the output data file, before using this file as an input data file for SEAWAY.

KCON is the code for the input sequence of the offsets.
The contour of each cross-section J of the ship has to be given by a series of offsets, defined by [Y(J,I),Z(J,I)] or [Z(J,I),Y(J,I)] as given . The input-sequence of the co-ordinates of these offsets depends on the preference of the user, marked by:

KCON = 1: input-sequence is [Y(J,I),Z(J,I)], so a horizontal value followed by a vertical value as normally will be obtained with digitizers.
KCON = 2: input-sequence is [Z(J,I),Y(J,I)], so a vertical value followed by a horizontal value, as naval architects are often used to.

```
 * New line
 * DR
 * TR
 * RLPP
 * RLA
```

DR is the amidships draught of the underwater hull form, defined at half the length between the forward and aft perpendiculars.

TR is the trim by stern, defined as the draught at A.P.P. minus draught at F.P.P.
The amidships draught and trim are defined with respect to a reference line, for instance the ship's base line or the keel line. This reference will be used in the input data file of the main program SEAWAY to define the actual draught and trim of the ship at which the calculations have to be carried out. Generally, it is convenient to use a zero trim in the hull form data file.

RLPP is the length between the forward and aft perpendiculars.

RLA is the distance of the aft perpendicular A.P.P. forward of the hindmost cross-section; see Figure 2.

```
 * NS
 * For J = 1,...NS: - DX(J)
```

NS is the number of longitudinal cross-section intervals, 2 < NS < 50.
Because of using the general rule of Simpson for numerical integration, this number has to be even. An advised value for a normal ship is 24 intervals: 20 equal intervals between the perpendiculars, 2 added cross-sections aft and 2 added cross-sections forward.

DX(J) is an element of the array with the longitudinal cross-section intervals. The longitudinal intervals can be divided in NS/2 subsequent pairs of two cross-section intervals. With respect to the integration over the ship's length, note that within each pair of two intervals these two individual intervals should not differ by more than 1:4 or 4:1. If they differ more, the program will switch locally from Simpson's general rule to the trapezoid rule, to avoid inaccurate integrations. An even index-number J is advised for any cross-section at a discontinuity in the longitudinal derivative of the load water line curve or the cross-sectional area curve. Jumps in these curves, as for instance appear at the beginning and end of a column of a semi-submersible, are introduced by two zero-intervals, as presented in Figure 3.

```
 * For J = 0,...NS: - New line
                    - SNR(J)
                    - YWL(J)
                    - D(J)
                    - AREA(J)
```

SNR(J) is the station number.
This (real) value is printed in the output with two decimals. A negative station number for cross-sections behind A.P.P., often indicated in lines drawings or body plans by the characters A, B, etc., is permitted too.

YWL(J) is the local half breadth at the load water line.

D(J) is the local draught.

AREA(J) is information on local cross-sectional area:

If AREA(J) > 0.0: +AREA(J) = sectional area.
If AREA(J) < 0.0: -AREA(J) = sectional area coefficient.

```
 * New line
 * Write: *** End of File ***
 * Save and Quit File
```

3.4.2 Examples of SEAWAY-L Data Files

An example of a SEAWAY-L input data file reads as follows:

```
4.19
Lewis hull form of S-175 Containership, created by SEAWAY-L.
0  2
9.500  0.000  175.000  3.250
24
1.625  1.625  4.375  4.375  8.750  8.750  8.750  8.750  8.750  8.750
8.750  8.750  8.750  8.750  8.750  8.750  8.750  8.750  8.750  8.750
8.750  8.750  4.375  4.375
-0.38   0.000  0.000    0.000
-0.19   0.850  0.480    0.411
 0.00   1.550  0.780    1.244
 0.50   3.070  1.300    4.642
 1.00   4.504  9.500   23.259
 2.00   7.028  9.500   61.448
 3.00   9.108  9.500   97.487
 4.00  10.663  9.500  132.855
 5.00  11.685  9.500  165.327
 6.00  12.362  9.500  192.594
 7.00  12.639  9.500  212.935
 8.00  12.700  9.500  226.775
 9.00  12.700  9.500  232.674
10.00  12.700  9.500  233.486
11.00  12.681  9.500  228.724
12.00  12.426  9.500  215.267
13.00  11.696  9.500  191.705
14.00  10.536  9.500  162.731
15.00   8.930  9.500  130.570
16.00   7.020  9.500   97.782
17.00   5.016  9.500   68.548
18.00   3.052  9.500   44.610
19.00   1.541  9.500   27.333
19.50   0.869  9.500   20.892
20.00   0.085  9.370   14.028
*** End of file ***
```

The output data file of program SEAWAY-L is a hull form data file for the main program SEAWAY:

```
4.19
Lewis hull form of S-175 Containership, created by SEAWAY-L.
   9.5000   0.0000 175.0000   3.2500
       24
   1.6250   1.6250   4.3750   4.3750   8.7500   8.7500   8.7500   8.7500
   8.7500   8.7500   8.7500   8.7500   8.7500   8.7500   8.7500   8.7500
   8.7500   8.7500   8.7500   8.7500   8.7500   8.7500   4.3750   4.3750
        2
    -0.38       16   0.0000
   0.0000   0.0000   0.0006   0.0006   0.0012   0.0012   0.0018   0.0018
   0.0024   0.0024   0.0030   0.0030   0.0036   0.0036   0.0042   0.0042
   0.0048   0.0048   0.0053   0.0053   0.0059   0.0059   0.0065   0.0065
   0.0071   0.0071   0.0077   0.0077   0.0083   0.0083   0.0089   0.0089
   0.0095   0.0095
    -0.19       16   0.0000
   0.0000   0.0000   0.0060   0.0460   0.0236   0.0937   0.0517   0.1445
   0.0886   0.1997   0.1320   0.2597   0.1796   0.3245   0.2286   0.3935
   0.2765   0.4651   0.3213   0.5374   0.3610   0.6081   0.3947   0.6743
   0.4219   0.7333   0.4429   0.7824   0.4585   0.8193   0.4703   0.8422
   0.4800   0.8500
     0.00       16   0.0000
   0.0000   0.0000   0.0098   0.0907   0.0385   0.1840   0.0844   0.2823
```

0.1447	0.3872	0.2157	0.4995	0.2933	0.6189	0.3732	0.7443
0.4514	0.8731	0.5242	1.0020	0.5889	1.1269	0.6435	1.2434
0.6875	1.3467	0.7212	1.4324	0.7462	1.4967	0.7648	1.5365
0.7800	1.5500						
0.50	16	0.0000					
0.0000	0.0000	0.0145	0.2171	0.0572	0.4370	0.1256	0.6618
0.2157	0.8930	0.3226	1.1308	0.4405	1.3742	0.5635	1.6205
0.6858	1.8657	0.8024	2.1047	0.9092	2.3312	1.0036	2.5384
1.0844	2.7196	1.1520	2.8682	1.2083	2.9788	1.2563	3.0470
1.3000	3.0700						
1.00	16	0.0000					
0.0000	0.0000	0.2299	0.0092	0.6490	0.0420	1.2644	0.1172
2.0327	0.2464	2.9072	0.4315	3.8388	0.6642	4.7760	0.9276
5.6654	1.2011	6.4550	1.4714	7.1051	1.7468	7.6111	2.0571
8.0124	2.4267	8.3655	2.8469	8.7128	3.2871	9.0802	3.7348
9.5000	4.5040						
2.00	16	0.0000					
0.0000	0.0000	0.1003	0.1350	0.3955	0.3003	0.8692	0.5233
1.4952	0.8257	2.2400	1.2209	3.0654	1.7129	3.9315	2.2955
4.7999	2.9522	5.6363	3.6576	6.4137	4.3792	7.1138	5.0799
7.7283	5.7210	8.2591	6.2653	8.7175	6.6800	9.1227	6.9396
9.5000	7.0280						
3.00	16	0.0000					
0.0000	0.0000	0.0904	0.4392	0.3569	0.9001	0.7858	1.4019
1.3553	1.9593	2.0374	2.5804	2.8001	3.2656	3.6099	4.0069
4.4344	4.7885	5.2444	5.5870	6.0166	6.3739	6.7348	7.1169
7.3906	7.7825	7.9843	8.3391	8.5235	8.7586	9.0224	9.0195
9.5000	9.1080						
4.00	16	0.0000					
0.0000	0.0000	0.0752	0.7460	0.2976	1.5019	0.6576	2.2762
1.1401	3.0740	1.7257	3.8967	2.3919	4.7405	3.1151	5.5964
3.8720	6.4504	4.6414	7.2839	5.4057	8.0751	6.1516	8.8000
6.8711	9.4344	7.5614	9.9554	8.2249	10.3431	8.8680	10.5822
9.5000	10.6630						
5.00	16	0.0000					
0.0000	0.0000	0.0559	1.0424	0.2221	2.0806	0.4946	3.1101
0.8666	4.1253	1.3296	5.1195	1.8732	6.0845	2.4863	7.0109
3.1574	7.8876	3.8753	8.7027	4.6294	9.4436	5.4105	10.0974
6.2109	10.6521	7.0242	11.0963	7.8457	11.4209	8.6718	11.6186
9.5000	11.6850						
6.00	16	0.0000					
0.0000	0.0000	0.0365	1.3056	0.1464	2.5932	0.3311	3.8456
0.5923	5.0467	0.9322	6.1821	1.3528	7.2395	1.8555	8.2091
2.4405	9.0833	3.1066	9.8569	3.8505	10.5269	4.6671	11.0919
5.5485	11.5519	6.4851	11.9077	7.4651	12.1606	8.4749	12.3117
9.5000	12.3620						
7.00	16	0.0000					
0.0000	0.0000	0.0170	1.5302	0.0705	3.0291	0.1670	4.4669
0.3170	5.8173	0.5335	7.0586	0.8306	8.1748	1.2225	9.1560
1.7212	9.9984	2.3353	10.7040	3.0691	11.2793	3.9211	11.7349
4.8840	12.0831	5.9443	12.3368	7.0833	12.5082	8.2774	12.6068
9.5000	12.6390						
8.00	16	0.0000					
0.0000	0.0000	-0.0001	1.7099	0.0037	3.3767	0.0228	4.9601
0.0750	6.4249	0.1829	7.7432	0.3716	8.8958	0.6660	9.8728
1.0887	10.6740	1.6572	11.3076	2.3820	11.7891	3.2653	12.1393
4.2997	12.3814	5.4688	12.5394	6.7476	12.6348	8.1038	12.6847
9.5000	12.7000						
9.00	16	0.0000					
0.0000	0.0000	-0.0085	1.7958	-0.0293	3.5428	-0.0486	5.1954
-0.0448	6.7141	0.0094	8.0678	0.1443	9.2358	0.3906	10.2085
0.7757	10.9870	1.3216	11.5831	2.0420	12.0164	2.9406	12.3128
4.0105	12.5012	5.2335	12.6108	6.5814	12.6679	8.0178	12.6931
9.5000	12.7000						
10.00	16	0.0000					
0.0000	0.0000	-0.0097	1.8080	-0.0340	3.5664	-0.0588	5.2288
-0.0618	6.7551	-0.0152	8.1139	0.1121	9.2841	0.3515	10.2561
0.7313	11.0315	1.2740	11.6221	1.9937	12.0486	2.8946	12.3374

3.9694	12.5182	5.2001	12.6210	6.5579	12.6725	8.0056	12.6943
9.5000	12.7000						
11.00	16	0.0000					
0.0000	0.0000	-0.0033	1.7406	-0.0088	3.4359	-0.0043	5.0437
0.0296	6.5272	0.1172	7.8572	0.2855	9.0140	0.5617	9.9879
0.9701	10.7792	1.5301	11.3973	2.2532	11.8594	3.1423	12.1882
4.1901	12.4093	5.3797	12.5483	6.6847	12.6287	8.0712	12.6689
9.5000	12.6810						
12.00	16	0.0000					
0.0000	0.0000	0.0095	1.5862	0.0409	3.1361	0.1032	4.6155
0.2099	5.9944	0.3783	7.2485	0.6274	8.3606	0.9762	9.3211
1.4412	10.1278	2.0351	10.7857	2.7650	11.3055	3.6308	11.7022
4.6253	11.9934	5.7338	12.1969	6.9347	12.3289	8.2006	12.4024
9.5000	12.4260						
13.00	16	0.0000					
0.0000	0.0000	0.0250	1.3575	0.1014	2.6898	0.2337	3.9732
0.4289	5.1861	0.6956	6.3107	1.0430	7.3331	1.4799	8.2441
2.0137	9.0391	2.6490	9.7176	3.3869	10.2829	4.2245	10.7411
5.1543	11.0999	6.1643	11.3677	7.2386	11.5524	8.3578	11.6605
9.5000	11.6960						
14.00	16	0.0000					
0.0000	0.0000	0.0389	1.1019	0.1559	2.1892	0.3516	3.2479
0.6267	4.2647	0.9821	5.2279	1.4182	6.1272	1.9347	6.9541
2.5306	7.7020	3.2031	8.3661	3.9484	8.9432	4.7605	9.4316
5.6318	9.8304	6.5529	10.1398	7.5129	10.3602	8.4997	10.4921
9.5000	10.5360						
15.00	16	0.0000					
0.0000	0.0000	0.0493	0.8396	0.1963	1.6731	0.4387	2.4945
0.7729	3.2972	1.1938	4.0747	1.6954	4.8200	2.2708	5.5257
2.9125	6.1844	3.6127	6.7886	4.3634	7.3306	5.1566	7.8035
5.9846	8.2005	6.8401	8.5158	7.7157	8.7447	8.6045	8.8835
9.5000	8.9300						
16.00	16	0.0000					
0.0000	0.0000	0.0557	0.5869	0.2214	1.1739	0.4931	1.7608
0.8642	2.3460	1.3260	2.9271	1.8685	3.4998	2.4806	4.0584
3.1510	4.5954	3.8683	5.1023	4.6224	5.5694	5.4038	5.9868
6.2049	6.3446	7.0193	6.6337	7.8422	6.8462	8.6700	6.9762
9.5000	7.0200						
17.00	16	0.0000					
0.0000	0.0000	0.0559	0.3881	0.2224	0.7784	0.4951	1.1725
0.8675	1.5711	1.3308	1.9735	1.8748	2.3771	2.4882	2.7778
3.1596	3.1697	3.8776	3.5456	4.6318	3.8969	5.4128	4.2147
6.2129	4.4899	7.0258	4.7140	7.8468	4.8798	8.6724	4.9816
9.5000	5.0160						
18.00	16	0.0000					
0.0000	0.0000	0.0475	0.2809	0.1896	0.5601	0.4242	0.8360
0.7486	1.1065	1.1586	1.3698	1.6493	1.6234	2.2149	1.8649
2.8490	2.0916	3.5445	2.3007	4.2943	2.4894	5.0907	2.6548
5.9259	2.7942	6.7923	2.9054	7.6819	2.9863	8.5871	3.0355
9.5000	3.0520						
19.00	16	0.0000					
0.0000	0.0000	0.0357	0.2530	0.1433	0.4977	0.3244	0.7265
0.5810	0.9328	0.9159	1.1115	1.3315	1.2595	1.8296	1.3758
2.4111	1.4610	3.0751	1.5180	3.8187	1.5508	4.6366	1.5649
5.5214	1.5658	6.4631	1.5593	7.4495	1.5506	8.4669	1.5436
9.5000	1.5410						
19.50	16	0.0000					
0.0000	0.0000	0.0250	0.2962	0.1014	0.5775	0.2338	0.8302
0.4290	1.0427	0.6957	1.2067	1.0431	1.3178	1.4801	1.3754
2.0139	1.3831	2.6491	1.3481	3.3871	1.2805	4.2246	1.1924
5.1544	1.0970	6.1644	1.0069	7.2387	0.9335	8.3578	0.8856
9.5000	0.8690						
20.00	16	0.0000					
0.0000	0.0000	0.0019	0.4474	0.0112	0.8654	0.0388	1.2270
0.1013	1.5099	0.2200	1.6984	0.4183	1.7845	0.7198	1.7685
1.1453	1.6592	1.7112	1.4728	2.4271	1.2315	3.2947	0.9614
4.3069	0.6905	5.4477	0.4461	6.6932	0.2522	8.0125	0.1278
9.3700	0.0850						

```
 1  1  1
 *** End of file ***
```

The results of this file are presented below.

The following figure shows the distribution of the breadth, draft and area of the cross sections over the ship length.

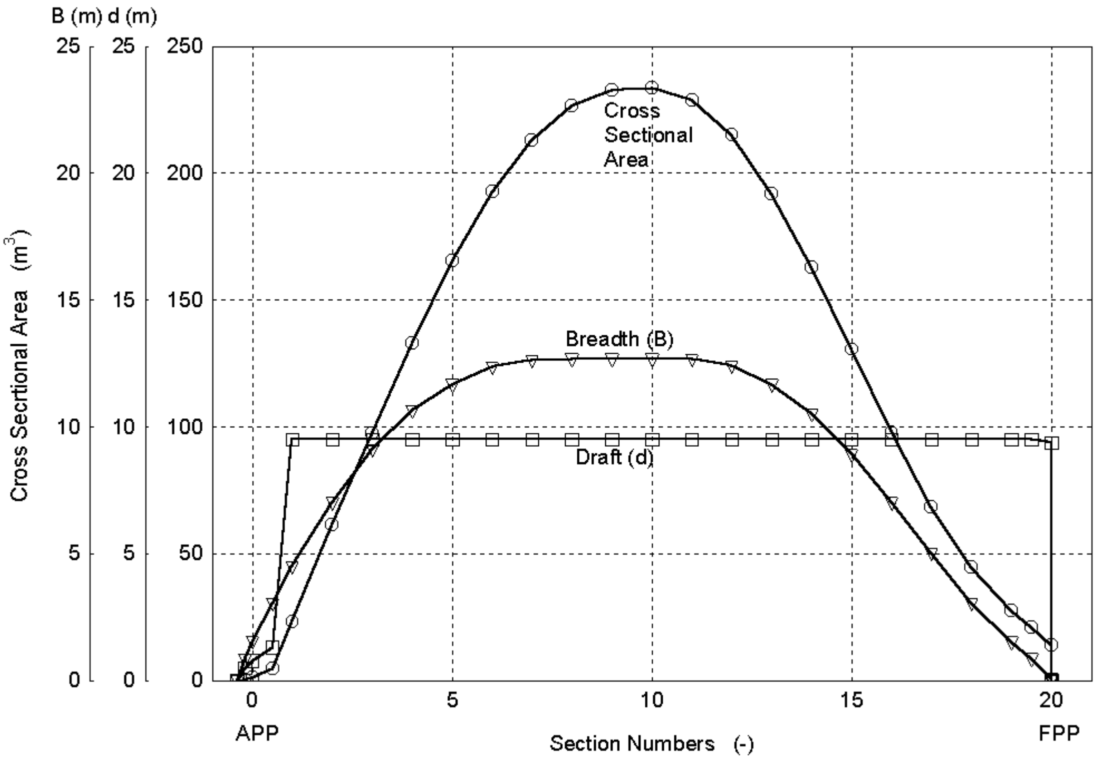

Figure 11 Required Sectional Information for Lewis Forms

The original and the Lewis hull forms are given below.

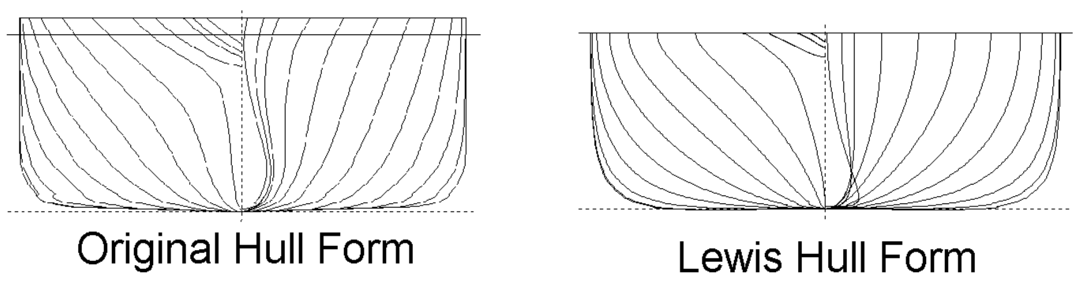

Figure 12 Creation of Lewis Hull Forms

3.5 Offsets Controller SEAWAY-H

The hull form data file contains all information about the geometry of the underwater hull form at a maximum load of the ship. This file can be made manually with a normal editor. Also use can be made of a digitizer. The hydrostatic PIAS program of SARC also delivers the hull form file. Especially when creating the hull form data file manually, errors in the offsets are possible. An effective visual control of the input data can be obtained by plotting these offsets on the display of the computer. This control can be carried with the hull form controller SEAWAY-H. This program uses the hull form data file as input and displays the cross-sectional shapes on the screen for a visual input control. In the future, correction features will be build into this program. However, some features have been built in already.

After starting program SEAWAY-H, the user has to select the "screen mode" of the computer with the vertical arrow keys. Then, it asks for the name of the hull form data file, to be entered by the keyboard. After pressing the <ENTER> key, the plot-procedure will start.
For the subsequent control steps of SEAWAY-H, the <ENTER> or the <ESC> key has to be used. During these control steps, the offsets are plotted on the display. The offsets with even indices are displayed with somewhat larger points. All offsets are multiplied already with the scale factors, given at the end of the hull form data file. The Y- en Z-values of the offsets are printed on the display too. However, all Z-values are printed and plotted with respect to the base line of the ship, defined by the draught and trim given in the hull form data file.

4 Input Data

This chapter describes the input data file as the input editor SEAWAY-E will create it and the main program SEAWAY will use it.

4.1 Description of Input Data File

```
* On first line of data set: RELINP
```

RELINP is the program release number when creating the input data file. Old input data files can be updated with the input editor SEAWAY-E.

```
* New line
* TEXT
```

TEXT is a text line with a maximum of 80 characters, with general information about the calculations being carried out. This text line will be printed at the head of each page of the output, together with the release number of the SEAWAY program, date and time of program execution and the page number of the output.

```
* New line
* KPR(1)
* KPR(2)
* KPR(3)
* KPR(4)
* KPR(5)
```

KPR(1) is the code for printing the input data:

KPR(1) = 0: No reflection of input data.
KPR(1) = 1: Reflection of input data.

Generally, it is advised to use: KPR(1) = 1.

KPR(2) is the code for printing the geometrical and conformal mapping data:

KPR(2) = -1: Reflection of a hull form data file at a new draught, only.
KPR(2) = 0: No reflection of geometrical and mapping data.
KPR(2) = +1: Reflection of geometrical and mapping data.

To check of a newly made hull form data file or to print geometrical and mapping data, this option can be used. When carrying out a large number of ship motion calculations this parameter can be set to zero. In case of generating a hull form data file at a new draught, a few lines at the beginning of the file have to be removed with a normal text processor as for instance Wordpad.
Generally, it is advised to use: KPR(2) = +1.

KPR(3) is the code for printing output of hydromechanical coefficients:

KPR(3) = 0: No reflection of the coefficients.
KPR(3) = -1 or +1: Reflection of dimensional coefficients.

KPR(3) = -2 or +2: Reflection of coefficients, non-dimensionalised by the parameters: ***r***, ***Ñ***, *g* and *B/2*, see section 5.2.

KPR(3) = -3 or +3: Reflection of coefficients, non-dimensionalised by the parameters: ***r***, ***Ñ***, *g* and *Lpp*, see section 5.2.

KPR(3) = -4 or +4: Reflection of coefficients, non-dimensionalised by the parameters: ***r***, ***Ñ***, w_e, and *Lpp*, see section 5.2.

The sign of KPR(3) arranges in which term of the equations of motion the solid mass is included in the output:

KPR(3) < 0: Solid mass is included in the spring coefficient.

KPR(3) > 0: Solid mass is included in the mass coefficient.

Generally, it is advised to use: KPR(3) = 0.

KPR(4) is the code for printing output of the transfer functions:

KPR(4) = 0: No reflection of the transfer functions.

KPR(4) = -1 or +1: Reflection of dimensional transfer functions for a harmonic wave with an amplitude of 1.0 meter, see section 5.2.

KPR(4) = -2 or +2: Reflection of non-dimensional transfer functions, see section 5.2.

For KPR(4) > 0, possible negative added resistance values are set to zero.

Generally, it is advised to use: KPR(4) = +2.

KPR(5) is the code for printing output of spectral energy distributions:

KPR(5) = 0: No reflection of energy distributions.

KPR(5) = -1 or +1: Reflection of energy distributions of the basic motions (surge, sway, heave, roll, pitch and yaw) and the added resistance due to waves.

KPR(5) = -2 or +2: Reflection of energy distributions of the displacements of selected points and the vertical and horizontal shear forces and bending moments and the torsion moments.

KPR(5) = -3 or +3: Options -1 and -2 both or options +1 and +2 both.

The sign of KPR(5) arranges on which frequency the spectra are based:

KPR(5) < 0: Spectra based on the wave frequency.

KPR(5) > 0: Spectra based on the frequency of encounter.

This option can be used to check the frequency range in the spectral calculations, described further on. Also, it can be used in case of a comparative study of calculated and measured wave and response spectra. Mind you that a considerable amount of output can be the result.

Generally, it is advised to use: KPR(5) = 0.

```
* DRAUGHT
* TRIM
* DEPTH
* RHO
```

DRAUGHT is the actual amidships draught of the ship at which the calculations have to be carried out, defined with regard to the base line chosen in the hull form data file, at half the length between the perpendiculars APP and FPP.

TRIM is the actual trim by stern of the ship at which the calculations have to be carried out, defined with regard to the base line as the draught at APP minus the draught at FPP.

DEPTH is the water depth: DEPTH ≥ 1.05 * DRAUGHT.
The wave potentials are defined as a function of the water depth, *h*, but – also when not using the method of [Keil, 1974] - the hydrodynamic coefficients are determined for deep water only. However, in the ship motions frequency range, generally reliable computational results will be obtained for water depths with keel clearances down to about 50-100 percent of the amidships draught: DEPTH ≥ 1.5-2.0 * DRAUGHT. This minimum percentage depends on the breadth to draught ratio of the ship.

RHO is the density, *ñ*, of the surrounding water. This parameter arranges the force units N or kN in the output too, for instance:

Fresh water:	RHO = 1000 kg/m3,	so forces in N and moments in Nm.
	RHO = 1.000 ton/m3,	so forces in kN and moments in kNm.
Sea water:	RHO = 1025 kg/m3,	so forces in N and moments in Nm.
	RHO = 1.025 ton/m3,	so forces in kN and moments in kNm.

Generally, it is advised to use for seagoing vessels: RHO = 1.025, so forces in kN and moments in kNm.
The kinematic viscosity of the water, ν, used in viscous damping calculations, will be derived by the program itself from a fixed relation between ν and *ñ*, see Figure 13.

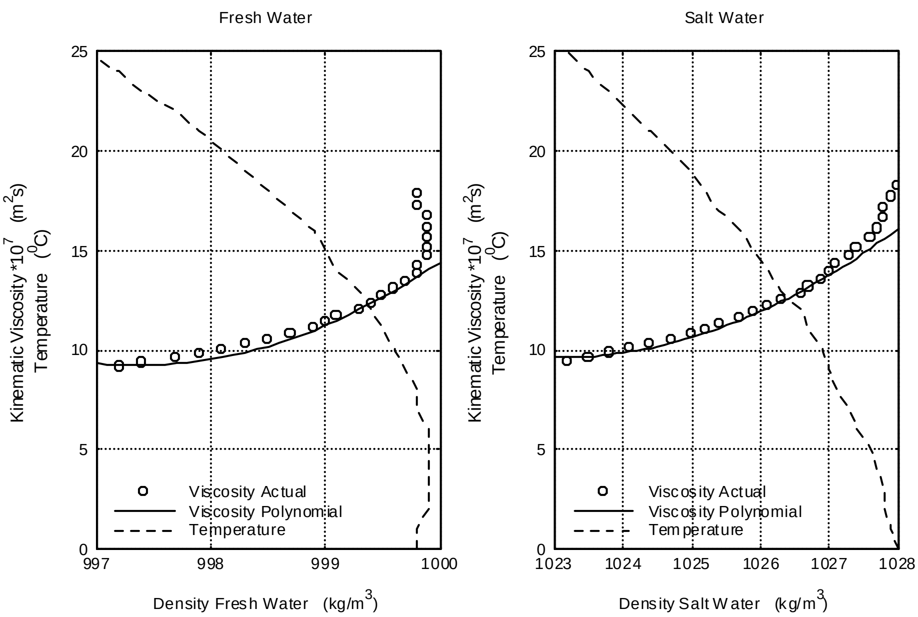

Figure 13 Relation Between Kinematic Viscosity, Density and Temperature

For instance, for a water temperature of 15 ^{0}C will be found:

Fresh water:	$\boldsymbol{r} = 999.0$ kg/m^3	from which follows: $\boldsymbol{n} = 1.123$ m^{2}s
Sea water:	$\boldsymbol{r} = 1025.9$ kg/m^3	from which follows: $\boldsymbol{n} = 1.178$ m^{2}s

```
 * MOT
```

MOT is the code for selecting the motions which the ship is permitted to carry out, i.e. the degrees of freedom.

This integer value consists of a number with a maximum of six-digit decimals, derived from the following codes:

|MOT| = 1.....: surge = *x*
|MOT| = .2....: sway = *y*
|MOT| = ..3...: heave = *z*
|MOT| = ...4..: roll = *f*
|MOT| = ...5.: pitch = *è*
|MOT| = ...6: yaw = *ø*

For normal strip theory calculations of free sailing ships in a seaway, generally one of the following three options has to be used:

|MOT| = 135
|MOT| = 246
|MOT| = 123456

Surge, heave and pitch motions are coupled. This applies also for sway, roll and yaw motions. No coupling is present between these two sets of motions of free-floating (not moored) vessels.
When analysing model experiments other options can be required, such as for instance:

|MOT| = 4: model free for roll motions only.
|MOT| = 35: model free for heave and pitch motions only.
|MOT| = 2345:model free for sway, heave, roll and pitch motions only.

If geometrical calculations have to be carried out only, the input is MOT = 0.
This option can be convenient for a quick check of the geometrical properties of a newly made hull form data file.

If MOT < 0, then its absolute value is taken to determine the degrees of freedom, so: MOT = |MOT|. However, then the accelerations in the horizontal plane are calculated in the earth-bound axes system instead of in the ship-bound axes system, so:

MOT > 0: Horizontal plane accelerations in ship-bound axes system.
MOT < 0: Horizontal plane accelerations in earth-bound axes system.

In the ship-bound axes system, the roll and pitch motions cause a contribution of the acceleration of gravity, *g*, in the “horizontal” plane accelerations.

Generally, it is advised to use: MOT = +123456.

* KTH

KTH is the code to define the version of the strip theory method:

KTH = +1: Ordinary strip theory method, with traditional wave loads.
KTH = +2: Modified strip theory method, with traditional wave loads.
KTH = -1: Ordinary strip theory method, with “diffraction” wave loads.
KTH = -2: Modified strip theory method, with “diffraction” wave loads.

These strip theory methods contain longitudinal integration of the derivatives of the coefficients from *0-å* until *L+å*, in literature called an "inclusion of end-terms". The meaning of this is fully explained in the theoretical manual, see [Journée, 2001b].
If KTH < 0, the wave loads are calculated by using a simple but very effective diffraction method as explained in the theoretical manual, see [Journée, 2001b].
For zero forward speed, the ordinary and the modified strip theory codes will provide similar results.

Based on a limited number of verifications, it is advised now to use KTH = -2 instead of using KTH = +1, as advised in earlier releases. But in case of very low frequencies, using KTH < 0 can result in too high motions; this aspect needs further research. So, always judge your computed frequency characteristics.
Exceptions on this general rule are the vertical motions of barge-shaped vessels. Then, it is advised to use KTH > 0.

*** MSER**

MSER is the number of terms in the potential series for the calculation of the hydrodynamic potential coefficients in the Ursell-Tasai method, after which the series expansion is truncated; $3 \leq \text{MSER} \leq 10$.
In most cases, 5-7 terms appears to be the minimum. Generally, it is advised to use the maximum value: MSER = 10.

*** KCOF**

KCOF is the code for defining the standard method in the program for the calculation of the two-dimensional potential coefficients of the cross-sections:

- KCOF = -1: The hydrodynamic potential coefficients will be set to zero.
- KCOF = 0: Ursell-Tasai's method with 2-parameter Lewis conformal mapping.
- KCOF = 2: Ursell-Tasai's method with 2-parameter Close-Fit conformal mapping.
- KCOF = 3: Ursell-Tasai's method with 3-parameter Close-Fit conformal mapping.
- KCOF = 4: Ursell-Tasai's method with 4-parameter Close-Fit conformal mapping.
- KCOF = 5: Ursell-Tasai's method with 5-parameter Close-Fit conformal mapping.
- KCOF = 6: Ursell-Tasai's method with 6-parameter Close-Fit conformal mapping.
- KCOF = 7: Ursell-Tasai's method with 7-parameter Close-Fit conformal mapping.
- KCOF = 8: Ursell-Tasai's method with 8-parameter Close-Fit conformal mapping.
- KCOF = 9: Ursell-Tasai's method with 9-parameter Close-Fit conformal mapping.
- KCOF = 10: Ursell-Tasai's method with 10-parameter Close-Fit conformal mapping.
- KCOF = 11: Frank's pulsating source method.
- KCOF = 12: Keil's shallow water method with 2-parameter Lewis conformal mapping.

The 2-parameter Lewis conformal mapping method, KCOF = 0 and KCOF = 12, determines the transformation parameters in such a manner that the breadth, b_s, draught, d_s, and area of the cross-section, A_s, are equivalent.
For cross-sections with very small or very large area coefficients, σ_s, this Lewis transformation delivers unacceptable results. Re-entrant forms or non-symmetric forms will appear. If so, the program will increase or decrease the area coefficient until a valid Lewis-form is obtained.

Figure 14 shows these typical areas in relation to the area coefficient σ_s and the aspect ratio H_0, where:

$$\sigma_s = \frac{A}{b_s \cdot d_s} \quad \text{and} \quad H_0 = \frac{b_s}{2 \cdot d_s}$$

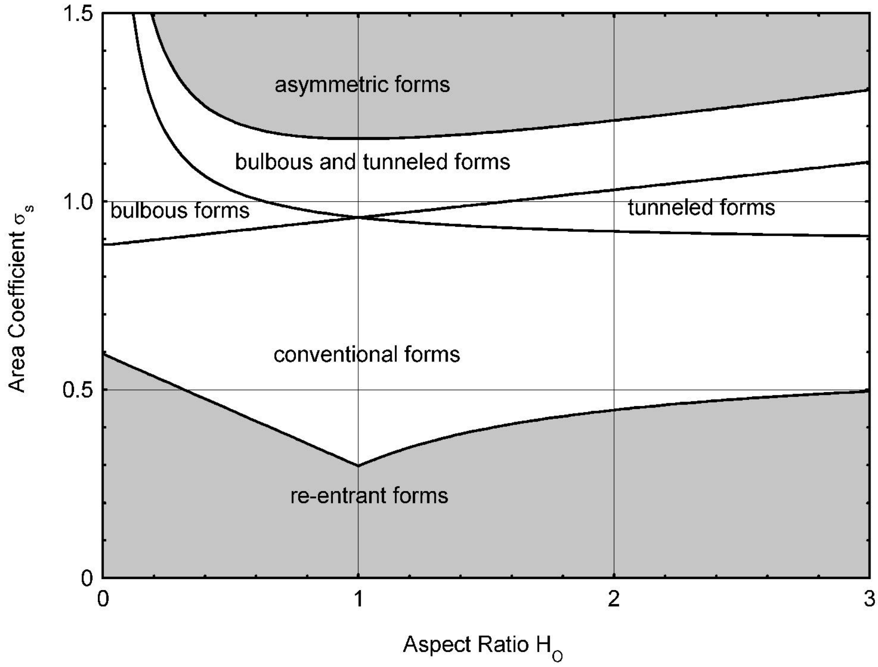

Figure 14 Ranges for Valid Lewis Forms

Close-Fit *N*-parameter conformal mapping, 2 ≤ KCOF ≤ 10, determines the *N* = KCOF parameters in such a manner that the sum of the squares of the deviations of the 32 points on the re-mapped cross-section from the actual cross-section is minimised.
Frank's pulsating source method, KCOF = 11, is very valuable for fully submerged cross-sections. However, the method requires a lot of computing time. In case of the use of this method for not fully submerged cross-sections, keep in mind that, in spite of an automatic close of the water line of these cross-sections by the program, the calculated potential coefficients should be checked with KPR(3) ≠ 0 for the presence of so-called "irregular frequencies", as discussed in the theoretical manual. So far, these irregular frequencies appear very seldom.
To obtain the most accurate calculation results, a standard use of Ursell-Tasai's 10-parameter Close-Fit conformal mapping, KCOF = 10, is advised, see [Journée, 2001b]. In case of submerged cross-sections and cross-sections with too low or too high area coefficients, Frank's pulsating source method has to be used for these cross-sections only, as described below.
For KCOF = 12, the potential coefficients will be calculated by Keil's method, using Lewis hull forms at a restricted water depth.
But, always **check yourself the RMS values of the deviations** between the offsets of the conformally mapped cross-sections and those of the actual cross-sections in the output.

*** NFR**

NFR is the number of "free-choice" cross-sections for the calculation of the two-dimensional potential coefficients, 0 ≤ NFR ≤ NS+1 where NS is given in the hull form data file.
The parameter KCOF defines the general method used by the program for the calculation of the 2-D potential coefficients by. However, NFR deviations at so-called "free-choice" cross-sections are allowed. Particularly, this can be of interest for submerged cross-sections at the bulbous bow, at the aft body and for semi-submersibles.

When this option is not used, the parameter has to be zero.

```
 * If NFR > 0:
    * New line
    * For I = 1,... NFR: - SNRFR(I)
                         - KNRFR(I)
```

SNRFR(I) is the station number of a "free-choice" cross-section, which has to correspond with one of the station numbers SNR(J) in the hull form data file.

KNRFR(I) is the deviating KCOF-code for cross-section SNRFR(I).

```
 * New line
 * NV
 * For K = 1,... NV: - VK(K)
```

NV is the number of forward ship speeds, $1 \leq NV \leq 5$.

VK(K) is the forward ship speed in knots.
If a negative ship speed is input, so VK(K) < 0, the program uses the absolute input value as the Froude number *Fn*. The forward ship speed in knots will be calculated from this Froude number by: VK(K) = *Fn .Ö{ g.*L_{pp}*}* / 0.5144.

```
 * NWD
 * For L = 1,... NWD: - WAVDIR(L)
```

NWD is the number of wave directions, $1 \leq NWD \leq 19$.

WAVDIR(L) is the wave direction *ì*, so the propagation of the waves, measured counter-clockwise relative to the ship's forward speed vector, in degrees; see Figure 15.
The wave directions are defined by any value between 0^0 and 360^0. Following waves is 0^0 or 360^0 and head waves is 180^0.
In following waves, "near zero frequency of encounter problems" can be solved by forcing the wave exciting forces and moments to go to zero artificially. In the program, this happens gradually in the frequency range: $0.75 \times ù^{*} < ù < 1.25 \times ù^{*}$ in which $ù^{*}$ is the wave frequency at $ù_e = 0$. However, this artificial approach can be avoided by subtracting 360^0 from the wave direction, so by giving a negative input value.

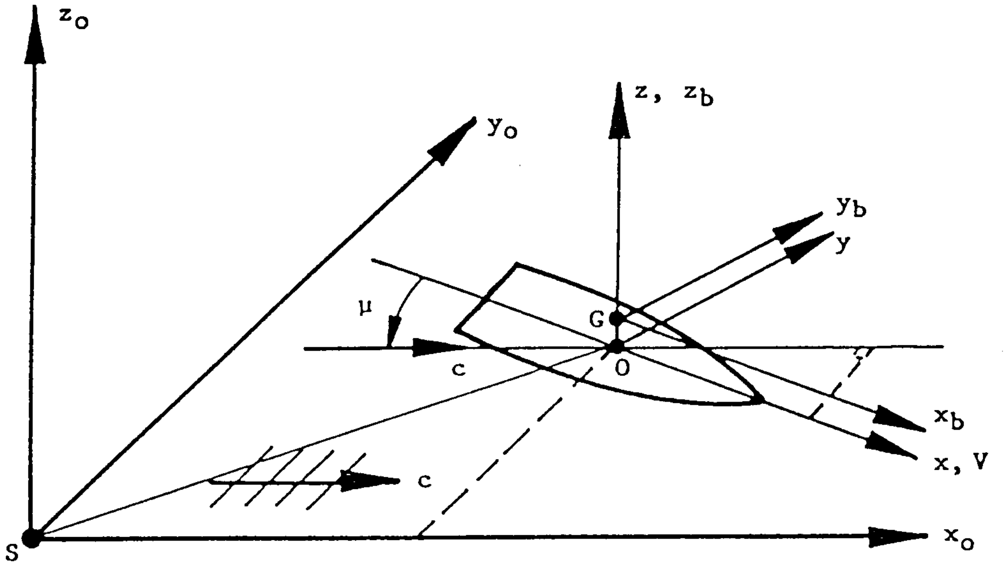

Figure 15 Co-ordinate System

* FREQMAX

FREQMAX is a parameter to obtain a series of circular frequencies of encounter, ω_e, at which the two-dimensional hydromechanical potential coefficients will be calculated.
The hydrodynamic coefficients have to be known at each frequency of encounter. This frequency depends on three variables: the circular wave frequency, ω, the forward ship speed, V, and the wave direction, μ, relative to the ship's speed vector:

$$\omega_e = \omega - k \cdot V \cos \mu \quad \text{with : } k = \frac{\omega^2}{g \cdot \tanh kh} \quad \left(\text{deep water : } k = \frac{\omega^2}{g} \right)$$

This can cause a large number of frequencies of encounter during the calculations. The calculation of the hydromechanical coefficients at all these frequencies of encounter consumes a lot of calculation time. In the computer code SEAWAY, these coefficients are calculated for a limited fixed number of frequencies of encounter. This series of circular frequencies are derived from an input value for the expected "maximum frequency of encounter": FREQMAX.
The program creates a series with 22 circular frequencies by multiplying FREQMAX with: 0.01, 0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1.00 and 1.25.
The hydrodynamic coefficients at the frequency of encounter, ω_e, in the calculations are found from the calculated coefficients at this frequency series by linear interpolation. For calculating the behaviour of a sailing ship in seaway, mostly a value for FREQMAX = 2.50 rad/sec is a suitable choice.
It is also possible to calculate a minimum and a maximum frequency of encounter by the program itself from the input values of the circular wave frequencies, the forward ship speeds and the wave directions relative to the ship's speed vector. This will be done by the program in case of an input value: FREQMAX = 0.00. Now the program creates a series of 22 frequencies by dividing the calculated circular frequency of encounter range into 21 parts.

```
 * KOMEG
 * OMMIN
 * OMMAX
 * OMINC
```

KOMEG is the code for determining the wave frequency range, defined by:

KOMEG = 1: Input of wave frequencies, *ù*.

KOMEG = 2: Input of wavelength to ship length ratios, *ë*/L_{pp}.

KOMEG = 3: Input of the square roots of the ship length to wavelength ratios, *Ö*{L_{pp}/*ë*}.

For KOMEG = 1, the range of circular wave frequencies ù, at which the transfer functions are calculated, is arranged by:

OMMIN = the minimum circular wave frequency, w_{min}.

OMMAX = the maximum circular wave frequency, w_{max}.

OMINC = the increment in circular wave frequencies, *Dw*.

It is obvious that OMMAX > OMMIN and for numerical reasons (deep water: $l = 2pg / w^2$), it is required that: OMMIN > 0.01 rad/sec.
The size of the frequency series becomes 0:NF and the number of increments NF should not exceed 50. For numerical reasons, the minimum value of NF is 1. So, the calculations are carried out at least for the two frequencies: OMMIN and OMMIN+OMINC.
For accurate ship motion calculations of normal full-scale merchant ships, suitable values are:

OMMIN = 0.20, so a maximum wavelength of about 1540 meters

OMMAX = 1.70, so a minimum wavelength of about 21 meters

OMINC = 0.033333, so NF = 45 frequency intervals.

It is advised not to use a frequency OMMIN smaller than 0.20 rad/s. The spectral density of wave components with a length of over 1.5 km is very small.

For KOMEG = 2 input of wavelength to ship length ratios *ë*/L_{pp} has to be used. The range of circular wave frequencies will be calculated from:

OMMIN = the minimum value of *ë*/L_{pp}.

OMMAX = the maximum value of *ë*/L_{pp}.

OMINC = the increment of the *ë*/L_{pp} values.

For KOMEG = 3 input of the square roots of the ship length to wavelength ratios *Ö*L_{pp}/*ë* has to be used. The range of circular wave frequencies will be calculated from:

OMMIN = the minimum value of *Ö*{L_{pp}/*ë*}.

OMMAX = the maximum value of *Ö*{L_{pp}/*ë*}.

OMINC = the increment of the *Ö*{L_{pp}/*ë*} values.

The options 2 and 3 are very convenient when plotting the calculated frequency characteristics at equidistant *ë*/L_{pp} or *Ö*{L_{pp}/*ë*} values. When calculating the relation between the wavelength and the wave frequency, for the restricted water depth effect has been accounted.

```
 * GKGM
```

GKGM is a parameter to obtain the vertical position of the ship's centre of gravity *G*, the origin of the ship's co-ordinate system in the equations of motion:

GKGM > 0.0: +GKGM = KG

This is the distance of the centre of gravity G above the base line. Then the transverse metacentric height GM will be calculated from KG and the ship's under water geometry.

GKGM < 0.0: -GKGM = GM

This is the transverse metacentric height. Then the vertical position of the centre of gravity KG will be calculated from GM and the ship's under water geometry.

This GM value may not include a free surface correction of the metacentric height. Dynamic behaviour of fluids in tanks has to be included in the radius of inertia for roll, in the natural roll period or in the external roll moments defined further on.

A zero value of GKGM is not permitted. Liquid cargo is considered to be “frozen” cargo, when determining the location of the ship’s centre of gravity, G.

```
* GYR(1)
* GYR(2)
* GYR(3)
```

GYR(1) is the radius of inertia for roll of the ship's solid mass k_{xx}.
Practical ranges for ships are:

$$k_{xx} \approx 0.30 \cdot B - 0.40 \cdot B$$

Another indication - obtained from an article of Bureau Veritas - for the radius of inertia for roll is:

$$k_{xx} = 0.289 \cdot B \cdot \left\{ 1.0 + \left(\frac{2 \cdot KG}{B} \right)^2 \right\}$$

Often, no reliable data on k_{xx} is available. When information about the natural roll period at zero forward speed is available, this period can be input too:

GYR(1) < 0.0: -GYR(1) = Natural roll period T_f in seconds and k_{xx} will be calculated from this T_f.

GYR(2) is the radius of inertia for pitch of the ship's solid mass k_{yy}.
Practical ranges for ships are:

$$k_{yy} \approx 0.22 \cdot L_{pp} - 0.27 \cdot L_{pp}$$

GYR(3) is the radius of inertia for yaw of the ship's solid mass k_{zz}.
Practical ranges for ships are:

$$k_{zz} \approx 0.23 \cdot L_{pp} - 0.28 \cdot L_{pp}$$

The radii of inertia of the ship’s solid mass have to be given in meters.

```
* NBTM
```

NBTM is the number of cross-sections for which the vertical and horizontal shear forces and bending moments and the torsion moments have to be calculated;
$0 \leq$ NBTM ≤ 5.
If NBTM = 0, then no further information about that subject has to be read.

```
•  If NBTM > 0:
    * New line
    * For I = 1,... NBTM: - XBTM(I)
                          - AXTM(I)
    * NSM
    * For J = 1,... NSM: - XSM(J}
                         - SM(J)
                         - SGK(J)
                         - SGYRX(J)
    * KTUNE(1)
    * KTUNE(2)
    * KTUNE(3)
```

XBTM(I) is the distance of load calculation cross-section number I from APP, positive forwards.

AXTM(I) is the vertical distance of the local torsion axis at cross-section number I from the base line, positive upwards.

NSM is the number of load input cross-sections; $2 \leq NSM \leq 44$.

XSM(J) is the distance of load input cross-section number J from APP, positive forwards.

SM(J) is the mass per unit length of cross-section number J, with mass units depending on the input value of RHO.

SGK(J) is the distance of the local centre of gravity of SM(J) above the base line.

SGYRX(J) is the local radius of inertia for roll of SM(J) around a horizontal line through the ship's centre of gravity.

KTUN(1) is the code for tuning of SM(J).

KTUN(2) is the code for tuning of SGK(J).

KTUN(3) is the code for tuning of SGYRX(J).

The data of the load input cross-sections J have to be imported from the hindmost point until the foremost point of the ship. The program connects all points [XSM(J),SM(J)], [XSM(J),SGK(J)] and [XSM(J),SGYRX(J)] with straight lines. Then, the program inserts intermediate points. The integration of acceleration forces and moments will be carried out with the general rule of Simpson. It is not required to have zero SM(J), SGK(J) and SGYRX(J) input values for the first and the last point. Jumps in the distributions can be introduced easily by using two subsequent equal XSM(J) input values, as has been shown in Figure 16.

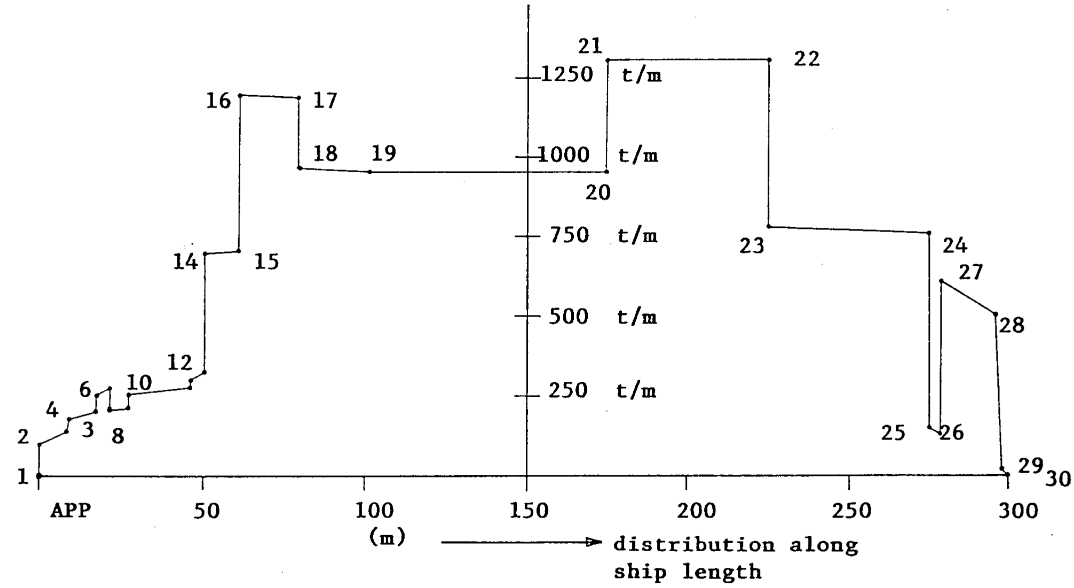

Figure 16 Example of Solid Mass Distributions

Automatically, the masses SM(J) are corrected first by the program for the mass of the ship's buoyancy and the longitudinal position of the centre of buoyancy.

The tuning code KTUN(1), for the longitudinal distribution of the mass per unit length SM(J), is defined by:

KTUN(1) = -1:	The input values of SM(J) can have any value, because they will be overwritten by the mass per unit length of the buoyancy (for author's test cases only).
KTUN(1) = 0:	No tuning; these SM(J) values are used during the calculations and new values for k_{yy} and k_{zz} will be derived from them.
KTUN(1) = +1:	Tune SM(J) with the input value of k_{yy}.
KTUN(1) = +2:	Tune SM(J) with the input value of k_{zz}.

The tuning code KTUN(2), for the longitudinal distribution of the vertical position of the cross-sectional centre of gravity SGK(J), is defined by:

KTUN(2) = -1:	The input values of SGK(J) can have any value, because they will be overwritten by KG, parallel to the waterline.
KTUN(2) = 0:	No tuning; these SGK(J) values are used during the calculations and a new value of KG will be derived from it.
KTUN(2) = +1:	Tune SGK(J) with KG.

The tuning code KTUN(3), for the longitudinal distribution of the cross-sectional radius of inertia for roll SGYRX(J), is defined by:

KTUN(3) = -1:	The input values of SGYRX(J) can have any value, because they will be overwritten by k_{xx}.
KTUN(3) = 0:	No tuning; these SGYRX(J) values are used during the calculations and a new value of k_{xx} will be derived from it.
KTUN(3) = +1:	Tune SGYRX(J) with the input value of k_{xx}.

In case of an input of the natural roll period instead of the mass radius of inertia for roll, so GYR(1) < 0.0, this tuning code has to be zero. This is caused by the structure of the program.

This disadvantage can be avoided by running the program first with an input of the natural roll period. Then the corresponding mass radius of inertia for roll becomes available and now this tuning code can be used in a new calculation.

```
 * New line
 * KRD
```

KRD is the code for determining the roll damping, -3 ≤ KRD ≤ +4.
The non-dimensional non-linear total roll-damping coefficient k, found from free rolling tests, as given in Figure 17-d, is expressed by:

$$k = k_1 + k_2 \cdot f_a \qquad \text{obtained for :} \quad w_e = w_0$$

in which f_a is the roll amplitude in radians, w_e is the frequency of oscillation (encounter frequency) and w_0 is the natural roll frequency in radians per second.
The coefficients k_1 and k_2 will provide an equivalent total coefficient $N_{44}(w_0, f_a)$. From this coefficient and the calculated potential damping coefficient $N_{44p}(w_0)$, an equivalent additional roll damping coefficient $N_{44a}(w_0, f_a)$ can be found:

$$N_{44a}(w_0, f_a) = N_{44}(w_0, f_a) - N_{44p}(w_0)$$

Another approach is to determine the equivalent additional roll-damping coefficient $N_{44a}(w_e, f_a)$ with the empirical method of [Miller, 1974] or [Ikeda et. al., 1978].

The manner, in which the program estimates the additional roll-damping coefficient $N_{44a}(w_e, f_a)$ will be ruled by the input parameter KRD:

KRD = 0; see Figure 17-a,b,c.
Only the potential roll damping, $N_{44p}(w_e, f_a)$, will be used in the calculations; the additional damping is supposed to be zero:

$$N_{44a}(w_e, f_a) = 0$$
$$N_{44}(w_e, f_a) = N_{44p}(w_e)$$

KRD = -1; see Figure 17-a.
The non-dimensional total roll damping coefficients k_1 and k_2 at forward ship speed V have been determined at the natural frequency w_0: $k = k_1 + k_2 \cdot f_a$ by model tests. This damping will be kept constant for all other oscillation frequencies. So, at each frequency of encounter, w_e, the total roll damping coefficient is defined by:

$$N_{44}(w_e, f_a) = \frac{2 rg\nabla \cdot GM}{w_0} \cdot (k_1 + k_2 \cdot f_a)$$

KRD = -2; see Figure 17-a.
The non-dimensional total roll damping coefficients k_1 and k_2 at forward ship speed V have been determined at the natural frequency w_0: $k = k_1 + k_2 \times f_a$ by model tests. At this natural frequency, the additional damping, $N_{44a}(w_0, f_a)$, will be determined and this will be kept constant for all other oscillation frequencies. So, at each frequency of encounter, w_e, the roll damping coefficients are defined by:

$$N_{44a}\left(w_0, f_a\right) = \frac{2\, rg\nabla \cdot GM}{w_0} \cdot \left(k_1 + k_2 \cdot f_a\right) - N_{44p}\left(w_0\right)$$

$$N_{44a}\left(w_e, f_a\right) = N_{44p}\left(w_e\right) + N_{44a}\left(w_0, f_a\right)$$

KRD = +1; see Figure 17-b.

The non-dimensional total roll damping coefficients k_1 and k_2 at forward ship speed V have been determined at the natural frequency w_0: $k = k_1 + k_2 \times f_a$ by model tests. The non-linear part of this damping, $k_2 \times f_a$, is assumed to be proportional to the frequency of oscillation. So, at each frequency of encounter, w_e, the total roll damping coefficient is defined by:

$$N_{44}\left(w_e, f_a\right) = \frac{2\, rg\nabla \cdot GM}{w_0} \cdot \left(k_1 + k_2 \cdot f_a \cdot \frac{w_e}{w_0}\right)$$

KRD = +2; see Figure 17-b.

The non-dimensional total roll damping coefficients k_1 and k_2 at forward ship speed V have been determined at the natural frequency w_0: $k = k_1 + k_2 \times f_a$ by model tests. The non-linear part of this damping, $k_2 \times f_a$, is assumed to be proportional to the frequency of oscillation. At the natural frequency, the additional damping coefficient, $N_{44a}(w_0, f_a)$, will be determined and the non-linear part will be added for the other frequencies of oscillation. So, at each frequency of encounter, w_e, the roll damping coefficients are defined by:

$$N_{44a}\left(w_e, f_a\right) = \frac{2\, rg\nabla \cdot GM}{w_0} \cdot \left(k_1 + k_2 \cdot f_a \cdot \frac{w_e}{w_0}\right) - N_{44p}\left(w_0\right)$$

$$N_{44}\left(w_e, f_a\right) = N_{44p}\left(w_e\right) + N_{44a}\left(w_e, f_a\right)$$

KRD = +3; see Figure 17-c.

The additional roll damping coefficient, $N_{44a}(w_e, f_a)_{Ikeda}$, is estimated by the empirical method of Ikeda and the potential damping, $N_{44p}(w_e)$, will be added:

$$N_{44}\left(w_e, f_a\right) = N_{44p}\left(w_e\right) + N_{44a}\left(w_e, f_a\right)_{Ikeda}$$

This method can not be used for unusual ship forms, for very full ship forms and for ships with a large breadth to draught ratio. Even a few cross-sections with a large breadth to draught ratio can result in an extremely large eddy-making component of the roll damping. So, always judge the components of this damping.

KRD = -3; see Figure 17-c.

The additional roll damping coefficient, $N_{44a}(w_0, f_a)_{Miller}$, is determined at the natural frequency by the empirical method of [Miller, 1974] and this non-potential part is kept constant in the whole frequency range:

$$\kappa_{Miller} = \kappa_1 + C_{Miller} \cdot \kappa_0 \cdot \sqrt{\phi_a}$$
$$\kappa_0 = 19.25 \cdot \frac{\left(l_{bk} \cdot h_{bk}^{\;3/2} + 0.0024 \cdot L_{pp} \cdot B \cdot \sqrt{r}\right) \cdot r^{5/2}}{\nabla \cdot B^2}$$
$$\kappa_1 = 0.00085 \cdot \frac{L_{pp}}{B} \cdot \sqrt{\frac{L_{pp}}{GM}} \cdot \left\{\left(\frac{Fn}{C_b}\right) + \left(\frac{Fn}{C_b}\right)^2 + 2 \cdot \left(\frac{Fn}{C_b}\right)^3\right\}$$

with:

ϕ_a = roll amplitude in radians.

$Fn = \frac{V}{\sqrt{g \cdot L_{pp}}}$

r = distance of O in water plane to bilge.

∇ = volume of displacement (= $L_{pp} \cdot B \cdot d \cdot C_b$)

C_{Miller} = extra additional coefficient.

Then:

$$N_{44a}(\omega_0, \phi_a) = \frac{2 \rho g \nabla \cdot GM}{\omega_0} \cdot \kappa_{Miller} - N_{44p}(\omega_0)$$
$$N_{44}(\omega_e, \phi_a) = N_{44p}(\omega_e) + N_{44a}(\omega_0, \phi_a)$$

In the original definition of [Miller, 1974] is:

$$C_{Miller} = 1.0$$

According to one experienced user of SEAWAY, Miller's method has to be used in SEAWAY for more or less slender conventional hull forms with:

$$C_{Miller} = 4.85 - 3.00 \cdot \sqrt{GM_{Full\ Scale}}$$

KRD = +4; see Figure 17-d.
Input of a discrete $\kappa(\phi_a)$ relation for each forward ship speed; see Figure 17-d.
A maximum number of NPTK = 6 points per input ship speed is permitted. A linear interpolation is used between these points and outside these points $\kappa(\phi_a)$ is taken as a constant value, so:

If:	$\phi_a < \phi_a(1)$	then:	$\kappa(\phi_a) = \kappa(1)$
If:	$\phi_a(1) < \phi_a < \phi_a(NPTK)$	then:	$\kappa(\phi_a)$ by linear interpolation
If:	$\phi_a > \phi_a(NPTK)$	then:	$\kappa(\phi_a) = \kappa(NPTK)$

Then, the total roll damping is determined by:

$$N_{44}(\omega_e, \phi_a) = \frac{2 \rho g \nabla \cdot GM}{\omega_0} \cdot \kappa(\phi_a)$$

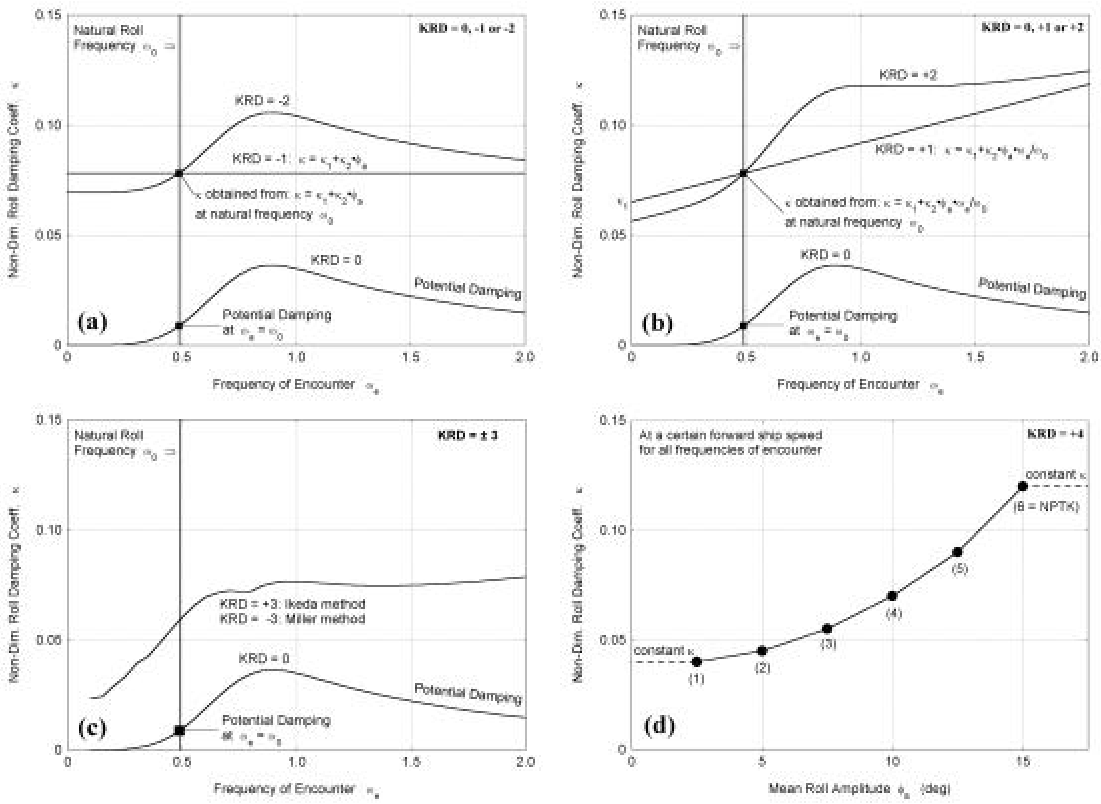

Figure 17 Roll Damping Coefficients

Ikeda's method (KRD = +3) and Miller's method (KRD = -3) are often valuable tools. But, always **judge the printed damping terms in the output data file!**
If these methods can not be used, the use of KRD = -2 is advised and very rough approximations of k_1 and k_2 for conventional ships with a very low potential k-value are:

- $k_1 = 0.010 - 0.030$: at zero forward ship speed, increasing with the breadth-draught ratio.
- $k_1 = 0.030 - 0.050$: at low forward ship speeds, increasing with the breadth-draught ratio and the forward ship speed.
- $k_1 = 0.050 - 0.100$: at higher forward ship speeds, increasing with the breadth-draught ratio and the forward ship speed.
- $k_2 = 0.000$

Two final remarks:

- Bilge keels will increase these approximations of k_1-values with about 0.010 - 0.030.
- The k_1-value should always be larger than the calculated potential k-value, which is printed in the output of the program. **Check this!**

```
* If |KRD| > 0:
   * New line
   * ROLAMP
   * WAVAMP
```

ROLAMP is the roll amplitude in degrees:

WAVAMP = 0.0: No iteration with WAVAMP will be used and the program takes ROLAMP as the roll amplitude with which the equivalent

	linear the additional roll damping coefficients will be determined.
WAVAMP > 0.0:	Iteration with WAVAMP will be used and ROLAMP will be used for the representation of the different parts of $\boldsymbol{k}$ in the output, only. This option can be used to simulate the results of a free rolling experiment with the Ikeda method.

WAVAMP is a mean wave amplitude in meters, used for linearisation.
In case of non-linear roll damping coefficients or anti-roll devices, WAVAMP will be used to determine the equivalent linear roll damping coefficients or anti-roll moments. An iterative method will be used to determine the frequency dependent roll amplitude at this wave amplitude.
In fact, this wave amplitude WAVAMP has to differ per sea-state, but this is not done here. An average sea state has to be chosen and the mean wave amplitude ($1.25 \cdot \sqrt{m_{0\zeta}}$), so about 1/3 of the significant wave height ($4 \cdot \sqrt{m_{0\zeta}}$), appeared to be a fairly good approximation of WAVAMP. When verifying calculated frequency characteristics with model test data, WAVAMP should be taken as the mean regular wave amplitude during the experiments in the natural frequency region.

```
* If |KRD| = 1 or |KRD| = 2:
   * For K = 1,...NV: - New line
                      - RDK1(K)
                      - RDK2(K)
```

RDK1(K) is the linear roll damping coefficient $\boldsymbol{k}_1$ at speed V(K).

RDK2(K) is the quadratic roll damping coefficient $\boldsymbol{k}_2$ at speed V(K).

```
* If |KRD| = +3:
   * New line
   * HBK
   * XBKA
   * XBKF
```

HBK is the height, h_{bk}, of the bilge keels.
In case of no bilge keels: HBK = 0.0, with arbitrary values for the aft and forward ends of the bilge keels.

XBKA is the distance from APP to the aft end of the bilge keels.

XBKF is the distance from APP to the forward end of the bilge keels.

It is obvious that: XBKF > XBKA; hence the bilge keel length l_{bk} = XBKF - XBKA.

```
* If KRD = -3:
   * CORMIL
```

CORMIL (C_{Miller}) is a multiplication factor for the forward speed effect in the damping, which is 1.00 when using the original Miller definition.

```
* If KRD = +4:
   * New line
   * NPTK
   * New line
   * For L = 1,... NPTK: - PHIAK(L)
                         - For K = 1,... NV: - RDKV(K,L)
```

NPTK is the number of points on each $k(f_a)$-curve; 1 ≤ NPTK ≤ 6.

PHIAK(L) is a mean roll angle f_a in degrees of the points on the k-curves.

RDKV(K,L) is the $k(f_a)$-value of point **L** on speed dependent k-curve **K**.

A linear interpolation is used between these $k(f_a)$ points and the damping coefficients will be kept constant outside the range of these points.

```
* New line
* KARD
```

KARD is the code for the presence of anti-roll devices:
KARD = 0: No anti-roll devices present.
KARD = 1: Anti-roll devices present.

```
* If KARD = 1:
   * New line
   * NARM
   * NART
```

|NARM| is the number of anti-roll moment curves; 0 ≤ |NARM| ≤ 3.
NARM < 0: Input of anti-roll moments independent of roll amplitude.
NARM = 0: No anti-roll moments used here.
NARM > 0: Input of anti-roll moments per degree roll amplitude.
If NARM = 0, then no further information about that input device has to be read.
Note that NARM < 0 can cause iteration problems.

|NART| is the number of anti-roll free-surface tanks, 0 ≤ |NART| ≤ 3.
NART < 0: Use of theory of Verhagen and Van Wijngaarden.
NART = 0: No anti-roll free-surface tanks used here.
NART > 0: Use of experimental data of Van den Bosch and Vugts.
If NART = 0, then no further information about that input device has to be read.

```
* If KARD = 1 and |NARM| > 0:
   * New line
   * For K = 1,... |NARM|: - ARIPHI(K)
                           - NARI(K)
                           - For L = 1,... NARI(K):
                              - ARIOME(K,L)
                              - ARIMOM(K,L)
                              - ARIEPS(K,L)
```

ARIPHI(K) is the roll angle amplitude in degrees of curve K.

NARI(K) is the number of anti-roll moments of curve K; 1 ≤ NARI(K) ≤ 21.

ARIOME(K,L) is the L^{th} circular frequency in rad/sec of curve K.

ARIMOM(K,L) is the L^{th} anti-roll moment amplitude information of curve K, with the dimensions depending on the input value of RHO and the sign of NARM.

ARIEPS(K,L) is the L^{th} phase lag in degrees between the anti-roll moment and the angular roll displacement of curve K.

Outside the roll amplitude range and frequency range, defined here, the anti-roll moment (if NARM >0: per degree roll amplitude) will be kept constant. Within this range, a linear interpolation between the input data will be used.
For instance, (static) free surface effects can be included here:

```
NARM = +1
ARIPHI(1)   =  5.0 (= arbitrary)
NARI(1)     =  2
ARIOME(1,1) =  0.0 (= arbitrary, but low)
ARIMOM(1,1) = +ρg∇·GG'·(π/180)
ARIEPS(1,1) =  0.0
ARIOME(1,2) = 10.0 (= arbitrary, but high)
ARIMOM(1,2) = +ρg∇·GG'·(π/180)
ARIEPS(1,2) =  0.0
```

in which the positive *GG'*–value is the reduction of the metacentric height caused by free surface effects and *G* is the ship's centre of gravity with a "frozen" liquid.

```
* If KARD = 1 and |NART| > 0:
   * New line
   * For L = 1,... |NART|: - ARTX(L)
                           - ARTZ(L)
                           - ARTL(L)
                           - ARTB(L)
                           - ARTH(L)
                           - RHOT(L)
```

ARTX(L) is the distance of the aft bulkhead of the tank forward of APP.

ARTZ(L) is the distance of the bottom of the tank above the base line.

ARTL(L) is the length of the tank, measured in the ship's longitudinal direction.

ARTB(L) is the full breadth of the tank, measured in the ship's transverse direction.

ARTH(L) is the height of the fluid in the tank.

RHOT(L) is the density of the fluid in the tank, with dimensions ruled by the input value of RHO.

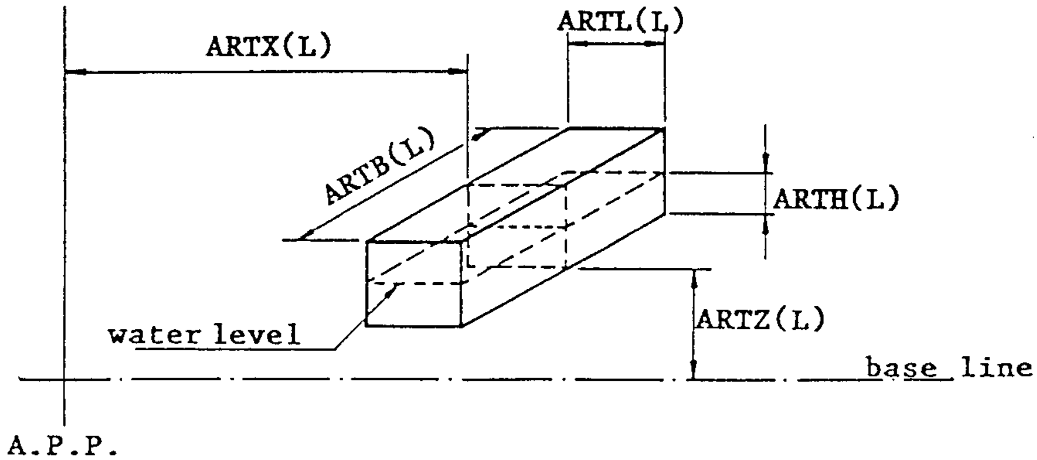

Figure 18 Definition of an Anti-Roll Free-Surface Tank

```
* New line
* NCAB
```

NCAB is the number of linear springs; 0 ≤ NCAB ≤ 8.
If NCAB = 0, then no further information about these springs has to be read.

```
* If NCAB > 0:
   * New line
   * For J = 1,... NCAB: - CABXYZ(J,1)
                         - CABXYZ(J,2)
                         - CABXYZ(J,3)
                         - CABCOF(J,1)
                         - CABCOF(J,2)
                         - CABCOF(J,3)
```

CABXYZ(J,1) is the distance of spring J, forward of APP.

CABXYZ(J,2) is the distance of spring J from centre plane, positive to port side.

CABXYZ(J,3) is the distance of spring J above the base line.

CABCOF(J,1) is the linear spring constant in the longitudinal direction.

CABCOF(J,2) is the linear spring constant in the lateral direction.

CABCOF(J,3) is the linear spring constant in the vertical direction.

```
* New line
* NPTS
```

|NPTS| is the number of arbitrarily selected points, at which the frequency characteristics and the statistics of the displacements, velocities and accelerations in the three directions and the vertical relative displacements have to be calculated;
-11 ≤ NPTS ≤ +11.

If NPTS < 0 then a dynamical swell-up, calculated from the radiated damping waves, will be included in the vertical relative motions. This option is still in a test phase.

```
* If |NPTS| > 0:
* New line
* For J = 1,... |NPTS|: - PTSXYZ(J,1)
                        - PTSXYZ(J,2)
                        - PTSXYZ(J,3)
```

PTSXYZ(J,1) is the distance of a selected point from APP, positive forwards.

PTSXYZ(J,2) is the distance of a selected point from the centre plane, positive to port side.

PTSXYZ(J,3) is the distance of a selected point from the base line, positive upwards.

Depending on the values of the parameters KPR(4) and KPR(5), the frequency characteristics and the energy distributions of the displacements in the three directions and the vertical relative displacements of these selected points will be printed too. The statistics will be printed always.

```
* New line
* NSEA
* If NSEA = 0: - New line
               - Write: *** End of File ***
               - Save and Quit File
```

NSEA is the number of sea states; 0 ≤ NSEA ≤ 12.
If NSEA = 0, then no further information has to be read.

```
* New line
* KSEA
```

KSEA is the code for the type of the irregular sea input, defined by:

KSEA = -1 or +1:	Analytical Neumann wave spectra.
KSEA = -2 or +2:	Analytical Bretschneider spectra (also called Modified Pierson-Moskowitz, I.S.S.C. or I.T.T.C. wave spectra).
KSEA = -3 or +3:	Analytical Mean JONSWAP wave spectra.
KSEA = -4 or +4:	Discretised measured wave spectra.

The sign of KSEA arranges the definition of the periods of the wave spectra:

If KSEA < 0: Wave spectra are based on the zero-upcrossing period T_2.

If KSEA > 0: Wave spectra are based on the centroid period T_1.

All wave and response statistics in the output will be expressed in the periods as defined above.

```
 * New line

 * If |KSEA| = 1:
    * For K = 1,... NSEA: - HW(K)
                          - TW(K)
 * If |KSEA| = 2:
    * For K = 1,... NSEA: - HW(K)
                          - TW(K)
 * If |KSEA| = 3:
    * For K = 1,... NSEA: - HW(K)
                          - TW(K)
                          - GAMMA(K)
 * If |KSEA| = 4:
    * For K = 1,... NSEA:
       - For L = 0,... NF: - SPS(K,L)
```

HW(K) is the significant wave height, $H_{1/3}$.

TW(K) is the average wave period, T_1 or T_2.

GAMMA(K) is the peakedness factor, usually equal to $\gamma = 3.3$.

The next table shows an indication of the average relations between wave spectra parameters for Bretschneider and JONSWAP wave spectra; see also [Journée, 2001b].

WIND DEFINITION		BRETSCHNEIDER (OPEN OCEAN AREAS)			JONSWAP (NORTH SEA AREAS)			
BF	V_w	$H_{1/3}$	T_1	T_2	$H_{1/3}$	T_1	T_2	γ
(-)	(kn)	(m)	(s)	(s)	(m)	(s)	(s)	(-)
1	2.0	1.10	5.80	5.35	0.50	3.50	3.25	3.3
2	5.0	1.20	5.90	5.45	0.65	3.80	3.55	3.3
3	8.5	1.40	6.00	5.55	0.80	4.20	3.90	3.3
4	13.5	1.70	6.10	5.60	1.10	4.60	4.30	3.3
5	19.0	2.15	6.50	6.00	1.65	5.10	4.75	3.3
6	24.5	2.90	7.20	6.65	2.50	5.70	5.30	3.3
7	30.5	3.75	7.80	7.20	3.60	6.70	6.25	3.3
8	37.0	4.90	8.40	7.75	4.85	7.90	7.35	3.3
9	44.0	6.10	9.00	8.30	6.10	8.80	8.20	3.3
10	51.5	7.45	9.60	8.88	7.45	9.50	8.85	3.3
11	59.5	8.70	10.10	9.30	8.70	10.00	9.30	3.3
12	>64.0	10.25	10.50	9.65	10.25	10.50	9.80	3.3

Table 1 Indication of Wave Spectra Parameters

The editor SEAWAY-E creates these data automatically when using NSEA = -1.

SPS(K,L) is the measured wave spectral value in m^2s. The spectral values have to be given at wave frequencies, following from the frequencies OMMIN, OMMAX and OMINC, as described before. The number of wave frequency increments is equal to NF, as defined earlier; $1 \leq NF \leq 50$.

```
* New line
* KRIT
* If KRIT = 0:
   * New line
   * Write: *** End of File ***
   * Save and Quit File
```

KRIT is a parameter to include sea-keeping criteria:

KRIT = 0: No sea-keeping criteria; no further input is required.
KRIT = 1: Calculation of slamming phenomena.

```
* If KRIT = 1:
   * New line
   * SLAML
   * SLAMV
   * SLAMC
   * SLAMP
```

SLAML is the distance of the slam point from APP, positive forwards.

SLAMV is the critical vertical relative velocity in m/s.

SLAMC is the slamming pressure coefficient.

SLAMP is the critical slamming pressure in N/m^2 or kN/m^2.

Detailed information about these slamming phenomena is given in the theoretical manual, see [Journee, 2001b].

```
* New line
* Write: *** End of File ***
* Save and Quit File
```

4.2 Examples of Input Data Files

Two examples of the input data file are given at the following pages.

This example of an input data file, which includes mechanic load calculations, results almost into a maximum of output. It includes also all spectral data on the motions and the mechanic loads.

```
4.19
ITTC-ship S-175.   Test of program SEAWAY, release 4.19.
         +1          +1          +1          +1          +3
      9.500       0.000   10000.000  1.025E+00
     123456          -2          10         +10           4
       1.00         +11
      19.00         +11
      19.50         +11
      20.00         +11
          1
   +20.0000
          1
     +150.0
      2.500           1       0.200       1.500    0.033333
     +9.550      +7.620      42.000      42.000
          1
    131.250       9.550
         27
     -5.250  3.900E+01      12.400       0.400
     -3.250  4.300E+01      11.400       0.600
     -1.625  4.600E+01      11.400       0.800
      0.000  5.000E+01      10.300       1.200
      4.375  5.800E+01       8.300       2.300
      8.750  8.100E+01       7.200       3.400
     17.500  1.270E+02       5.500       5.400
     26.250  1.020E+02       6.200       6.900
     35.000  6.300E+01       7.300       8.100
     43.750  9.500E+01       7.000       8.900
     52.500  1.840E+02       9.300       9.300
     61.250  1.870E+02       9.800       9.600
     70.000  2.050E+02      10.300       9.700
     78.750  2.080E+02      10.300       9.700
     87.500  2.100E+02      10.300       9.700
     96.250  2.050E+02      10.300       9.600
    105.000  2.140E+02      10.300       9.400
    113.750  1.810E+02       9.800       8.900
    122.500  1.620E+02      10.400       8.000
    131.250  1.280E+02      10.500       7.000
    140.000  9.500E+01      10.100       6.300
    148.750  9.000E+01      10.000       5.500
    157.500  7.100E+01       9.400       4.800
    166.250  5.200E+01      11.000       4.200
    170.625  4.200E+01      11.400       3.000
    175.000  3.300E+01      12.500       2.300
    179.500  2.200E+01      12.500       0.400
         +1          +1          +1
          3
      5.000       1.250
      0.450      61.250     105.000
          0
          0
         +2
    148.750      12.000      24.000
    175.000       5.000      13.000
         12
         -2
```

```
       1.10       5.35
       1.20       5.45
       1.40       5.55
       1.70       5.60
       2.15       6.00
       2.90       6.65
       3.75       7.20
       4.90       7.75
       6.10       8.30
       7.45       8.85
       8.70       9.30
      10.25       9.65
          1
     157.50       3.85  2.000E+02  8.800E+01
*** End of file ***
```

Without internal load calculations this input file reads as follows:

```
4.19
ITTC-ship S-175.   Test of program SEAWAY, release 4.19.
         +1          +1          0         +1          0
      9.500      0.000  10000.000  1.025E+00
     123456          -2         10        +10          4
       1.00         +11
      19.00         +11
      19.50         +11
      20.00         +11
          1
   +20.0000
          1
     +150.0
      2.500           1      0.200      1.500   0.033333
     +9.550      +7.620     42.000     42.000
          0
          3
      5.000      1.250
      0.450     61.250    105.000
          0
          0
         +2
    148.750     12.000     24.000
    175.000      5.000     13.000
         12
         -2
       1.10       5.35
       1.20       5.45
       1.40       5.55
       1.70       5.60
       2.15       6.00
       2.90       6.65
       3.75       7.20
       4.90       7.75
       6.10       8.30
       7.45       8.85
       8.70       9.30
      10.25       9.65
          1
     157.50       3.85  2.000E+02  8.800E+01
*** End of file ***
```

4.3 Input Editor SEAWAY-E

SEAWAY-E is an input edit editor, which almost replaces the description of the input data in this manual.

5 Output Data of SEAWAY

This chapter describes the ASCII output data file.
Optionally, also an ASCII data file, named SEAWAY.DAT, can be filled by the author with output data in a format defined by the user. The user has to inform the author about the required data in this file. Exclusive for each individual user, these formats can be fixed into program SEAWAY. Other programs, spreadsheets or plot routines can read this personal SEAWAY.DAT file, directly. Standard, the SEAWAY.DAT file will be filled with LOTUS or QUATRO-PRO data.

5.1 Description of Output Data File

The computer code SEAWAY uses a right-handed co-ordinate system with the origin at the centre of gravity G of the ship and the vertical axis upwards, as has been shown in Figure 15.

The signs of the absolute displacements are defined by:

- longitudinal displacement (x): positive forward
- transverse displacement (y): positive to port side
- vertical displacement (z): positive upwards
- rotational displacement: positive right turning about its axis.

The vertical relative displacement is positive for a decreasing freeboard.
The signs of the wave forces and moments on the ship are comparable to those of the absolute displacements or rotations.
The shear forces and the bending and torsion moments are defined by the forces and moments acting on the front side of the hind part of the two ship parts, with signs comparable to those of the absolute displacements or rotations.
All phase lags are related to the absolute vertical elevation of the waves at the origin G of the co-ordinate system.

5.2 Non-Dimensionalising

The units are defined by:

- length: meter
- mass: kg or ton, defined by the input value of r
- force: N or kN, defined by the input value of r
- moment: Nm or kNm, defined by the input value of r
- time: seconds
- angle: degrees
- ship speed: knots
- probability: percent

A part of the output data can be presented in a non-dimensional format. For this, some symbols used in this section are defined here by:

z_a	wave elevation amplitude
l	wavelength
$k = 2p / ë$	wave number
$k^* = 2p / L$	length parameter
w	circular wave frequency
w_e	circular frequency of oscillation or encounter
w_0	undamped natural circular roll frequency
r	density of water
g	acceleration of gravity (= 9.806 m/s^2)
L	length between perpendiculars
B	breadth
Ñ	volume of displacement
A_m	amidships cross-sectional area
A_{wl}	water plane area
I_{wl}	moment of inertia of water plane around x-axis
GM	transverse metacentric height
k_{xx}	radius of inertia of the solid mass for roll
k_{yy}	radius of inertia of the solid mass for pitch
k_{zz}	radius of inertia of the solid mass for yaw

The (non-)dimensional frequencies of oscillation with the cross-sectional 2-D hydrodynamic potential coefficients in the output are obtained by dividing it through the values given below.
The sign of KPR(3) has no effect on the output data. In case of twin-hull cross-sections, the parameters and the coefficients above are those of the mono-hull cross-section, with the origin at the crossing of its centre plane and the water plane.

|KPR(3)| =	1	2	3	4
w_e' /…	1	Ö{g/(B/2)}	Ö{g/L}	Ö{g/L}
M_{11}' /…	1	rA_m	r (Ñ/L)	r (Ñ/L)
M_{22}' /…	1	rA_m	r (Ñ/L)	r (Ñ/L)
M_{42}' /…	1	rA_m (B/2)	r Ñ	r Ñ
M_{33}' /…	1	rA_m	r (Ñ/L)	r (Ñ/L)
M_{44}' /…	1	rA_m $(B/2)^2$	r ÑL	r ÑL
M_{24}' /…	1	rA_m (B/2)	r Ñ	r Ñ
N_{11}' / …	1	rA_m Ö{g/(B/2)}	r (Ñ/L) Ö{g/L)}	r (Ñ/L) w_e
N_{22}' /…	1	rA_m Ö{g/(B/2)}	r (Ñ/L) Ö{g/L)}	r (Ñ/L) w_e
N_{42}' /…	1	rA_m (B/2) Ö{g/(B/2)}	rÑÖ{g/L)}	r Ñw_e
N_{33}' /…	1	rA_m Ö{g/(B/2)}	r (Ñ/L) Ö{g/L)}	r (Ñ/L) w_e
N_{44}' /…	1	rA_m $(B/2)^2$ Ö{g/(B/2)}	r ÑL Ö{g/L)}	r ÑL w_e
N_{24}' /…	1	rA_m (B/2) Ö{g/(B/2)}	r ÑÖ{g/L)}	r Ñw_e

Table 2 Non-Dimensional 2-D Potential Coefficients

The (non-)dimensional frequencies of oscillation with the total (integrated) hydrodynamic potential coefficients in the output are obtained by dividing it through the values given below. The sign of KPR(3) has no effect on the output data. In case of twin-hull ships, the parameters and the coefficients above are those of the mono-hull ship, with the origin at the centre line of the water plane.

|KPR(3)| =	1	2	3	4
w_e /…	1	Ö{g/(B/2)}	Ö{g/L}	Ö{g/L}
M_{11} /…	1	rÑ	rÑ	rÑ
M_{22} /…	1	rÑ	rÑ	rÑ
M_{42} /…	1	rÑ(B/2)	rÑL	rÑL
M_{33} /…	1	rÑ	rÑ	rÑ
M_{44} /…	1	rÑ$(B/2)^2$	rÑL^2	rÑL^2
M_{24} /…	1	rÑ(B/2)	rÑL	rÑL
N_{11} /…	1	rÑÖ{g/(B/2)}	rÑÖ{g/L)}	rÑw_e
N_{22} /…	1	rÑÖ{g/(B/2)}	rÑÖ{g/L)}	rÑw_e
N_{42} /…	1	rÑ(B/2) Ö{g/(B/2)}	rÑL Ö{g/L)}	rÑLw_e
N_{33} /…	1	rÑÖ{g/(B/2)}	rÑÖ{g/L)}	rÑw_e
N_{44} /…	1	rÑ$(B/2)^2$ Ö{g/(B/2)}	rÑL^2 Ö{g/L)}	rÑ$L^2$$w_e$
N_{24} /…	1	rÑ(B/2) Ö{g/(B/2)}	rÑL Ö{g/L)}	rÑLw_e

Table 3 Non-Dimensional Total Potential Coefficients

The (non-)dimensional frequencies of oscillation and the coefficients of the surge, heave and pitch equations in the output are obtained by dividing it through the values given below.

|KPR(3)| =	**1**	**2**	**3**	**4**
w_e /...	1	Ö{g/(B/2)}	Ö{g/L}	Ö{g/L}
a_{11} /...	1	rÑ	rÑ	rÑ
b_{11} /...	1	rÑÖ{g/(B/2)}	rÑÖ{g/L}	rÑ w_e
c_{11} /...	1	rÑ{g/(B/2)}	rÑ(g/L)	rÑ w_e^2
a_{13} /...	1	rÑ	rÑ	rÑ
b_{13} /...	1	rÑÖ{g/(B/2)}	rÑÖ{g/L)}	rÑ w_e
c_{13} /...	1	rÑ{g/(B/2)}	rÑ(g/L)	rÑ w_e^2
a_{15} /...	1	rÑ(B/2)	rÑL	rÑL
b_{15} /...	1	rÑ(B/2) Ö{g/(B/2)}	rÑL Ö{g/L)}	rÑL w_e
c_{15} /...	1	rÑ(B/2) {g/(B/2)}	rÑL (g/L)	rÑL w_e^2
X_{w1} /...	1	rÑg k z_a	rÑg k z_a	rÑg (z_a/L)
a_{31} /...	1	rÑ	rÑ	rÑ
b_{31} /...	1	rÑÖ{g/(B/2)}	rÑÖ{g/L}	rÑ w_e
c_{31} /...	1	rÑ{g/(B/2)}	rÑ(g/L)	rÑ w_e^2
a_{33} /...	1	rÑ	rÑ	rÑ
b_{33} /...	1	rÑÖ{g/(B/2)}	rÑÖ{g/L}	rÑ w_e
c_{33} /...	1	rÑ{g/(B/2)}	rÑ(g/L)	rÑ w_e^2
a_{35} /...	1	rÑ(B/2)	rÑL	rÑL
b_{35} /...	1	rÑ(B/2) Ö{g/(B/2)}	rÑL Ö{g/L}	rÑL w_e
c_{35} /...	1	rÑ(B/2) {g/(B/2)}	rÑL (g/L)	rÑL w_e^2
X_{w3} /...	1	rÑ A_{wl} g z_a	rÑ A_{wl} g z_a	rÑ(g/L) z_a
a_{51} /...	1	rÑ(B/2)	rÑL	rÑL
b_{51} /...	1	rÑ(B/2) Ö{g/(B/2)}	rÑL Ö{g/L}	rÑL w_e
c_{51} /...	1	rÑ(B/2) {g/(B/2)}	rÑL (g/L)	rÑL w_e^2
a_{53} /...	1	rÑ(B/2)	rÑL	rÑL
b_{53} /...	1	rÑ(B/2) Ö{g/(B/2)}	rÑL Ö{g/L}	rÑL w_e
c_{53} /...	1	rÑ(B/2) {g/(B/2)}	rÑL (g/L)	rÑL w_e^2
a_{55} /...	1	rÑ$(B/2)^2$	rÑL^2	rÑL^2
b_{55} /...	1	rÑ$(B/2)^2$ Ö{g/(B/2)}	rÑL^2 Ö{g/L}	rÑL^2 w_e
c_{55} /...	1	rÑ$(B/2)^2$ {g/(B/2)}	rÑL^2 (g/L)	rÑL^2 w_e^2
X_{w5} /...	1	r I_{wl} g k z_a	r I_{wl} g k z_a	rÑg z_a

Table 4 Non-Dimensional Coefficients of Vertical Plane Motions

The (non-)dimensional frequencies of oscillation and the coefficients of the sway, roll and yaw equations in the output are obtained by dividing it through the values given below.

|KPR(3)| =	**1**	**2**	**3**	**4**
w_e /...	1	Ö{g/(B/2)}	Ö{g/L}	Ö{g/L}
a_{22} /...	1	**rÑ**	**rÑ**	**rÑ**
b_{22} /...	1	**rÑ**Ö{g/(B/2)}	**rÑ**Ö{g/L}	**rÑ** w_e
c_{22} /...	1	**rÑ**{g/(B/2)}	**rÑ**(g/L)	**rÑ** w_e^2
a_{24} /...	1	**rÑ**(B/2)	**rÑ**L	**rÑ**L
b_{24} /...	1	**rÑ**(B/2)Ö{g/(B/2)}	**rÑ**L Ö{g/L)}	**rÑ**L w_e
c_{24} /...	1	**rÑ**(B/2) {g/(B/2)}	**rÑ**L (g/L)	**rÑ**L w_e^2
a_{26} / ...	1	**rÑ**(B/2)	**rÑ**L	**rÑ**L
b_{26} /...	1	**rÑ**(B/2) Ö{g/(B/2)}	**rÑ**L Ö{g/L)}	**rÑ**L w_e
c_{26} /...	1	**rÑ**(B/2) {g/(B/2)}	**rÑ**L (g/L)	**rÑ**L w_e^2
X_{w2} /...	1	**rÑ**g k z_a	**rÑ**g k z_a	**rÑ**g (z_a/L)
a_{42} /...	1	**rÑ**(B/2)	**rÑ**L	**rÑ**L
b_{42} /...	1	**rÑ**(B/2) Ö{g/(B/2)}	**rÑ**L Ö{g/L}	**rÑ**L w_e
c_{42} /...	1	**rÑ**(B/2) {g/(B/2)}	**rÑ**L (g/L)	**rÑ**L w_e^2
a_{44} /...	1	**rÑ**$(B/2)^2$	**rÑ**L^2	**rÑ**L^2
b_{44} /...	1	**rÑ**$(B/2)^2$ Ö{g/(B/2)}	**rÑ**L^2 Ö{g/L}	**rÑ**L^2 w_e
c_{44} /...	1	**rÑ**$(B/2)^2$ {g/(B/2)}	**rÑ**L^2 (g/L)	**rÑ**L^2 w_e^2
a_{46} /...	1	**rÑ**$(B/2)^2$	**rÑ**L^2	**rÑ**L^2
b_{46} /...	1	**rÑ**$(B/2)^2$ Ö{g/(B/2)}	**rÑ**L^2 Ö{g/L}	**rÑ**L^2 w_e
c_{46} /...	1	**rÑ**$(B/2)^2$ {g/(B/2)}	**rÑ**L^2 (g/L)	**rÑ**L^2 w_e^2
X_{w4} /...	1	**rÑ**(B/2) g k z_a	**rÑ**L g k z_a	**rÑ**g z_a
a_{62} /...	1	**rÑ**(B/2)	**rÑ**L	**rÑ**L
b_{62} /...	1	**rÑ**(B/2) Ö{g/(B/2)}	**rÑ**L Ö{g/L}	**rÑ**L w_e
c_{62} /...	1	**rÑ**(B/2) {g/(B/2)}	**rÑ**L (g/L)	**rÑ**L w_e^2
a_{64} /...	1	**rÑ**$(B/2)^2$	**rÑ**L^2	**rÑ**L^2
b_{64} /...	1	**rÑ**$(B/2)^2$ Ö{g/(B/2)}	**rÑ**L^2 Ö{g/L}	**rÑ**L^2 w_e
c_{64} /...	1	**rÑ**$(B/2)^2$ {g/(B/2)}	**rÑ**L^2 (g/L)	**rÑ**L^2 w_e^2
a_{66} /...	1	**rÑ**$(B/2)^2$	**rÑ**L^2	**rÑ**L^2
b_{66} /...	1	**rÑ**$(B/2)^2$ Ö{g/(B/2)}	**rÑ**L^2 Ö{g/L}	**rÑ**L^2 w_e
c_{66} /...	1	**rÑ**$(B/2)^2$ {g/(B/2)}	**rÑ**L^2 (g/L)	**rÑ**L^2 w_e^2
X_{w6} /...	1	**r** I_{wl} g k z_a	**r** I_{wl} g k z_a	**rÑ**g z_a

Table 5 **Non-Dimensional Coefficients of Horizontal Plane Motions**

If KPR(3) > 0, the coefficients a_{11} to a_{66} include the solid mass or inertia terms. Then the coefficients c_{11} to c_{66} are pure spring coefficients.
If KPR(3) < 0, the coefficients c_{11} to c_{66} include the solid mass or inertia terms. Then the coefficients a_{11} to a_{66} are pure hydrodynamic mass or inertia coefficients.
The terms X_{w1} to X_{w6} are the wave loads.

The coefficients and the wave loads are related to the ship's centre of gravity. In case of twin-hull ships, the parameters, the coefficients and the wave loads above are those of the two hulls.

The dimensions of the motion amplitudes, the mean added resistance and the amplitudes of the shear forces and the bending and torsion moments are:

- translation: meter
- rotation: degree
- added resistance: N or kN, depending on ρ
- shear force: N or kN, depending on ρ
- bending moment: Nm or kNm, depending on ρ
- torsion moment: Nm or kNm, depending on ρ

The (non-)dimensional transfer functions in the output are obtained by dividing it through the values given below.

KPR(4) =	**-2**	**-1**	**+1**	**+2**
Surge /…	z_a	z_a	z_a	z_a
Sway /…	z_a	z_a	z_a	z_a
Heave /…	z_a	z_a	z_a	z_a
Roll /…	$k^* z_a \times 180/p$	z_a	z_a	$k z_a \times 180/p$
Pitch /…	$k^* z_a \times 180/p$	z_a	z_a	$k z_a \times 180/p$
Yaw /…	$k^* z_a \times 180/p$	z_a	z_a	$k z_a \times 180/p$
Added Resistance[1] /..	$rgz_a^2 B^2/L$	z_a	z_a	$rgz_a^2 B^2/L$
Relative Heave	z_a	z_a	z_a	z_a
Shear Force /…	$rgz_a LB$	z_a	z_a	$rgz_a LB$
Bending Moment /…	$rgz_a L^2B$	z_a	z_a	$rgz_a L^2B$
Torsion Moment /…	$rgz_a L^2B$	z_a	z_a	$rgz_a L^2B$

1) Note that for KPR(4) > 0, possible negative added resistance values are set to zero.

Table 6 Non-Dimensional Transfer Functions

All phase lags are related to the vertical elevation of the waves at the origin G of the co-ordinate system. The phase lags *å* are given in degrees, where $0^0 < å < 360^0$.
In case of twin-hull ships, the parameters and the coefficients above are those of the two hulls. So the breadth, *B*, is the full breadth.

The non-dimensional roll-damping coefficient $\hat{e}$ has been obtained from the dimensional roll damping coefficient b_{44} by:

$$\hat{e} = b_{44} / \{ 2\boldsymbol{r}g\tilde{\boldsymbol{N}}{}^{x}GM / \boldsymbol{w}_0 \} \qquad \text{with: } \boldsymbol{w}_0^2 = \{2\boldsymbol{r}g\tilde{\boldsymbol{N}}{}^{x}GM\} / (I_{xx}+a_{44})$$

in which the damping coefficient b_{44} includes the viscous damping. This ê-value is expressed as:

$$\boldsymbol{k} = \boldsymbol{k}_1 + \boldsymbol{k}_2{}^{x}\boldsymbol{f}_a \qquad \text{for: } \boldsymbol{w}_e = \boldsymbol{w}_0$$

with $\boldsymbol{f}_a$ in radians and $\grave{u}_0$ in radians per second.

5.3 *Example of an Output Data File*

This section shows parts of the output data of a calculation of loads and responses in a seaway, carried out for the S-175 Containership design.

Reflection of Input Data, KPR(1)=1

```
# # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #
# Program SEAWAY                               Journée #
#                                                      #
# STRIPTHEORY CALCULATIONS OF MOTIONS AND LOADS IN A SEAWAY #
#                                                      #
#                     Release 4.18                     #
#                     (09-10-1999)                     #
# # # # # # # # # # # # # # # # # # # # # # # # # # # # # # #

User: 011  / Delft University of Techn. / Shiphydromech. Laboratory.

INPUT DATA
~~~~~~~~~~

ITTC-ship S-175.   Test of program SEAWAY, release 4.18.

PRINT-CODE INPUT DATA ............. KPR(1) :      1
PRINT-CODE GEOMETRIC DATA ......... KPR(2) :      1
PRINT-CODE HYDRODYNAMIC COEFFICIENTS KPR(3) :      1
PRINT-CODE FREQUENCY CHARACTERISTICS KPR(4) :      1
PRINT-CODE SPECTRAL DATA .......... KPR(5) :      3

ACTUAL MIDSHIP DRAFT ............... DRAFT :  9.500 m
ACTUAL TRIM BY STERN ................ TRIM :  0.000 m

WATER DEPTH ........................ DEPTH :10000.0 m
DENSITY OF WATER ..................... RHO :  1.025 ton/m3

DEGREES OF FREEDOM CODE .............. MOT : 123456
VERSION-CODE OF STRIP THEORY METHOD ... KTH :     -2
NUMBER OF TERMS IN POTENTIAL SERIES .. MSER :     10
CODE OF USED 2-D APPROXIMATION ....... KCOF :     10
NUMBER OF "FREE-CHOICE" SECTIONS ...... NFR :      4
SECTION NUMBERS SNRFR(K)  /  CODES KNRFR(K) :   1.00  11
                                           19.00  11
                                           19.50  11
                                           20.00  11

NUMBER OF FORWARD SPEEDS .............. NV :      1
FORWARD SPEEDS (kn) ............... VK(NV) :  20.00

NUMBER OF WAVE DIRECTIONS ............ NWD :      1
WAVE DIRECTIONS (deg off stern) WAVDIR(NWD) :  150.0

MAX. FREQ. OF ENCOUNTER IN SERIES . FREQMAX :  2.500 rad/sec   (range =  0.000 -  3.125 rad/sec)
CODE FOR WAVE FREQUENCY INPUT ....... KOMEG :      1
MINIMUM CIRCULAR WAVE FREQUENCY ..... OMMIN :  0.200 rad/sec
MAXIMUM CIRCULAR WAVE FREQUENCY ..... OMMAX :  1.500 rad/sec
INCREMENT IN WAVE FREQUENCIES ....... OMINC :  0.033 rad/sec
```

The first three pages show the input data, in a sequence as it has been given in the input data file for this calculation. It is advised to print these data always; so it is advised to use KPR(1)=1.

Reflection of Input Data, KPR(1)=1 (Continued)


```
INPUT DATA (continued)
~~~~~~~~~~~~~~~~~~~~~~
BASE LINE TO CENTRE OF GRAVITY ... +GKGM=KG :  9.550 m

RADIUS OF INERTIA k-xx ............. GYR(1) :  7.620 m
RADIUS OF INERTIA k-yy ............. GYR(2) : 42.000 m
RADIUS OF INERTIA k-zz ............. GYR(3) : 42.000 m

NUMBER OF LOAD-CALCULATION SECTIONS .. NBTM :      1
LOCATIONS FORWARD A.P.P. AND ABOVE BASE (m) : 131.25   9.55

NUMBER OF LOAD-INFORMATION SECTIONS ... NSM :     27
```

X-APP (m)	SECTIONAL MASS (ton/m)	SECTIONAL KG (m)	SECTIONAL k-xx (m)
-5.250	3.900E+01	12.400	0.400
-3.250	4.300E+01	11.400	0.600
-1.625	4.600E+01	11.400	0.800
0.000	5.000E+01	10.300	1.200
4.375	5.800E+01	8.300	2.300
8.750	8.100E+01	7.200	3.400
17.500	1.270E+02	5.500	5.400
26.250	1.020E+02	6.200	6.900
35.000	6.300E+01	7.300	8.100
43.750	9.500E+01	7.000	8.900
52.500	1.840E+02	9.300	9.300
61.250	1.870E+02	9.800	9.600
70.000	2.050E+02	10.300	9.700
78.750	2.080E+02	10.300	9.700
87.500	2.100E+02	10.300	9.700
96.250	2.050E+02	10.300	9.600
105.000	2.140E+02	10.300	9.400
113.750	1.810E+02	9.800	8.900
122.500	1.620E+02	10.400	8.000
131.250	1.280E+02	10.500	7.000
140.000	9.500E+01	10.100	6.300
148.750	9.000E+01	10.000	5.500
157.500	7.100E+01	9.400	4.800
166.250	5.200E+01	11.000	4.200
170.625	4.200E+01	11.400	3.000
175.000	3.300E+01	12.500	2.300
179.500	2.200E+01	12.500	0.400

```
TUNE-CODE SECTIONAL MASSES ........ KTUN(1) :      1
TUNE-CODE SECTIONAL VERTICAL C.G. . KTUN(2) :      1
TUNE-CODE SECTIONAL k-xx .......... KTUN(3) :      1
```

Reflection of Input Data, KPR(1)=1 (Continued)

```
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INPUT DATA (continued)
~~~~~~~~~~~~~~~~~~~~~~

CODE OF ROLL DAMPING INPUT ............ KRD :      3
ROLL AMPLITUDE FOR PRINTING DAMPING  ROLAMP :  5.000 deg
WAVE AMPLITUDE FOR LINEARISATION ... WAVAMP :  1.250 m
HEIGHT OF BILGE KEEL .................. HBK :  0.450 m
DISTANCE OF A.P.P. TO AFT END B.K. ... XBKA :  61.25 m
DISTANCE OF A.P.P. TO FORWARD END B.K. XBKF : 105.00 m

CODE OF ANTI-ROLL DEVICES ............ KARD :      0

NUMBER OF LINEAR SPRINGS ............. NCAB :      0

NUMBER OF DISCRETE POINTS ............ NPTS :      2
COORDINATES OF POINTS (m) ..... PTSXYZ(.,.) : 148.75  12.00  24.00
                                             175.00   5.00  13.00

NUMBER OF SEA STATES ................. NSEA :     12
CODE OF IRREGULAR SEA DESCRIPTION .... KSEA :     -2
WAVE HEIGHTS (m) HW(K) / PERIODS (s) TW(K)  :   1.10   5.35
                                              1.20   5.45
                                              1.40   5.55
                                              1.70   5.60
                                              2.15   6.00
                                              2.90   6.65
                                              3.75   7.20
                                              4.90   7.75
                                              6.10   8.30
                                              7.45   8.85
                                              8.70   9.30
                                             10.25   9.65

INPUT-CODE OF CRITERA FOR SHIPMOTIONS  KRIT :      1
DISTANCE OF SLAMPOINT BEFORE A.P.P. . SLAML :    157.50 m
CRITICAL VERTICAL RELATIVE VELOCITY . SLAMV :      3.85 m/sec
SLAMMING PRESSURE COEFFICIENT ....... SLAMC : 2.000E+02
CRITICAL SLAMMING PRESSURE .......... SLAMP : 8.800E+01 kN/m2
```

Geometrical Hull Form Data and Stability Parameters, KPR(2)=1

```
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GEOMETRICAL HULLFORM DATA
~~~~~~~~~~~~~~~~~~~~~~~~~

ACTUAL MIDSHIP DRAFT (T) ................ :   9.500 m
ACTUAL TRIM BY STERN .................... :   0.000 m

LENGTH BETWEEN PERPENDICULARS (Lpp) ...... : 175.000 m
REAR SECTION TO A.P.P. .................. :   3.250 m

WATERLINE : LENGTH (Lwl) ................ : 178.250 m
            BEAM (B) .................... :  25.400 m
            AREA ........................ :    3159 m2
            AREA COEFFICIENT (Lpp) ....... :  0.7107
            AREA COEFFICIENT (Lwl) ....... :  0.6977
            CENTROID TO A.P.P. ........... :  80.471 m   ( -7.029 m or  -4.02 % Lpp/2)
            CENTROID TO REAR SECTION ..... :  83.721 m   ( -5.404 m or  -3.03 % Lwl/2)

DISPLACEMENT : VOLUME ................... :   24095 m3
               MASS ..................... :   24698 ton
               BLOCKCOEFFICIENT (Lpp) .... :  0.5706
               BLOCKCOEFFICIENT (Lwl) .... :  0.5602
               CENTROID TO A.P.P. ........ :  84.941 m   ( -2.559 m or  -1.46 % Lpp/2)
               CENTROID TO REAR SECTION .. :  88.191 m   ( -0.934 m or  -0.52 % Lwl/2)
               CENTROID TO WATERLINE ..... :   4.300 m
               CENTROID TO KEELLINE ...... :   5.200 m
               MIDSHIP SECTION COEFFICIENT :  0.9676
               LONG. PRISMATIC COEFFICIENT :  0.5897
               VERT. PRISMATIC COEFFICIENT :  0.8029
               RATIO Lpp/B ............... :   6.890
               RATIO Lwl/B ............... :   7.018
               RATIO B/T ................. :   2.674
               WETTED SURFACE HULL ....... :    5334 m2


STABILITY PARAMETERS
~~~~~~~~~~~~~~~~~~~~

KB ........... :   5.200 m
KG ........... :   9.550 m
OG ........... :   0.050 m
KM-TRANSVERSE . :  10.528 m
BM-TRANSVERSE . :   5.328 m
GM-TRANSVERSE . :   0.978 m
KM-LONGITUDINAL : 212.255 m
BM-LONGITUDINAL : 207.055 m
GM-LONGITUDINAL : 202.705 m
```

This page shows the output of some geometrical data of the underwater hull form, as obtained from the hull form data file and the amidships draft and trim defined in the input data file.

The waterline length, L_{wl}, is the sum of the intervals of the cross-sections, as defined in the hull form data file. In case of submerged cross-sections, this length is not the actual water plane length; in fact it is the ordinate length. The beam, B, is the maximum breadth of the waterline.

The longitudinal prismatic coefficient is the volume of displacement, Ñ, divided by the product of the length L_{pp} and the cross-sectional area at half the length between the perpendiculars L_{pp}. The vertical prismatic coefficient is the volume of displacement, Ñ, divided by the product of the amidships draft, DR, and the area of the water plane, A_{wl}.

Also, the transverse and longitudinal stability parameters are given. The vertical position of the centre of buoyancy, KB, is given with respect to the base line as defined in the hull form data file.

Load Distribution Data, KPR(2)=1 and NBTM>0

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ORIGINAL AND MODIFIED LOAD DISTRIBUTION DATA
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	...ORIGINAL DISTRIBUTION...			...MODIFIED DISTRIBUTION...		
X-APP	MASS	KG	k-xx	MASS	KG	k-xx
(m)	(ton/m)	(m)	(m)	(ton/m)	(m)	(m)
-5.250	3.900E+01	12.400	0.400	4.020E+01	12.428	0.366
-3.250	4.300E+01	11.400	0.600	4.440E+01	11.425	0.549
-1.625	4.600E+01	11.400	0.800	4.756E+01	11.425	0.731
0.000	5.000E+01	10.300	1.200	5.175E+01	10.323	1.097
4.375	5.800E+01	8.300	2.300	6.017E+01	8.318	2.103
8.750	8.100E+01	7.200	3.400	8.405E+01	7.216	3.109
17.500	1.270E+02	5.500	5.400	1.318E+02	5.512	4.937
17.844	1.260E+02	5.528	5.459	1.308E+02	5.540	4.991
26.250	1.020E+02	6.200	6.900	1.064E+02	6.214	6.309
35.000	6.300E+01	7.300	8.100	6.650E+01	7.316	7.406
40.937	8.471E+01	7.096	8.643	8.911E+01	7.112	7.902
43.750	9.500E+01	7.000	8.900	9.960E+01	7.016	8.137
52.500	1.840E+02	9.300	9.300	1.910E+02	9.321	8.503
61.250	1.870E+02	9.800	9.600	1.938E+02	9.822	8.777
64.031	1.927E+02	9.959	9.632	1.995E+02	9.981	8.806
70.000	2.050E+02	10.300	9.700	2.120E+02	10.323	8.869
78.750	2.080E+02	10.300	9.700	2.147E+02	10.323	8.869
87.125	2.099E+02	10.300	9.700	2.164E+02	10.323	8.869
87.500	2.100E+02	10.300	9.700	2.165E+02	10.323	8.869
96.250	2.050E+02	10.300	9.600	2.110E+02	10.323	8.777
105.000	2.140E+02	10.300	9.400	2.199E+02	10.323	8.595
110.219	1.943E+02	10.002	9.102	1.994E+02	10.024	8.322
113.750	1.810E+02	9.800	8.900	1.855E+02	9.822	8.137
122.500	1.620E+02	10.400	8.000	1.656E+02	10.423	7.314
131.250	1.280E+02	10.500	7.000	1.302E+02	10.523	6.400
133.312	1.202E+02	10.406	6.835	1.221E+02	10.429	6.249
140.000	9.500E+01	10.100	6.300	9.640E+01	10.122	5.760
148.750	9.000E+01	10.000	5.500	9.159E+01	10.022	5.029
156.406	7.337E+01	9.475	4.888	7.476E+01	9.496	4.469
157.500	7.100E+01	9.400	4.800	7.235E+01	9.421	4.389
166.250	5.200E+01	11.000	4.200	5.310E+01	11.024	3.840
170.625	4.200E+01	11.400	3.000	4.296E+01	11.425	2.743
175.000	3.300E+01	12.500	2.300	3.385E+01	12.528	2.103
179.500	2.200E+01	12.500	0.400	2.268E+01	12.528	0.366

MASS (ton)	: 23959	MASS (ton)	: 24698		
KG (m)	: 9.537	KG (m)	: 9.550		
APP-CoG (m)	: 85.250	APP-CoG (m)	: 84.941		
k-xx (m)	: 8.331	k-xx (m)	: 7.620	I-xx :	1.434E+06 ton.m2
k-yy (m)	: 42.015	k-yy (m)	: 42.000	I-yy :	4.357E+07 ton.m2
k-zz (m)	: 42.015	k-zz (m)	: 42.000	I-zz :	4.357E+07 ton.m2
				I-xz :	1.028E+06 ton.m2
				I-zx :	1.028E+06 ton.m2

VERTICAL STILL WATER LOADS
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X-APP	SHEAR FORCE	BENDING MOMENT
(m)	(kN)	(kNm)
131.250	-7.977E+03	2.569E+05

This page shows the original and the adapted load distribution data and the calculated vertical still water loads in a selected cross-section. The vertical distances are given with respect to the base line.

The data given for the original distribution are those obtained from the input data file. The sectional mass data are modified to satisfy the volume of displacement and the longitudinal position of the centre of buoyancy. Because KTUN(1), KTUN(2) and KTUN(3) are set to 1, also the sectional masses, the KG data and the k_{xx} data are modified to satisfy also the overall input values k_{yy}, KG and k_{xx} of the ship.

Lewis Conformal Mapping Coefficients, KPR(2)=1

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TWO-PARAMETER LEWIS CONFORMAL MAPPING COEFFICIENTS
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STATION NUMBER	X-APP	HALF CL-CL	HALF WIDTH	DRAFT	AREA	AREA COEFF	M(S)	A(-1)	A(1)	A(3)	RMS	HULLFORM REMARKS ON LEWIS CONF. MAPPING
(-)	(m)	(m)	(m)	(m)	(m2)	(-)	(m)	(-)	(-)	(-)	(m)	
-0.38	-3.250	0.000	0.001	0.001	0.0000	0.7500	0.0012	+1.0000	+0.0000	+0.0225	0.001	
-0.19	-1.625	0.000	0.850	0.480	0.4112	0.5039	0.5689	+1.0000	+0.3252	+0.1688	0.014	
0.00	0.000	0.000	1.550	0.780	1.2444	0.5146	1.0074	+1.0000	+0.3822	+0.1564	0.033	
0.50	4.375	0.000	3.070	1.300	4.6423	0.5816	1.9693	+1.0000	+0.4494	+0.1095	0.031	
1.00	8.750	0.000	4.504	9.500	23.2592	0.2718	5.8773	+1.0000	-0.4250	+0.1914	1.008 F	REENTRANT Cm:0.450
2.00	17.500	0.000	7.028	9.500	61.4475	0.4602	6.8374	+1.0000	-0.1808	+0.2086	0.438	
3.00	26.250	0.000	9.108	9.500	97.4868	0.5634	8.1359	+1.0000	-0.0241	+0.1435	0.374	
4.00	35.000	0.000	10.663	9.500	132.8554	0.6558	9.3111	+1.0000	+0.0624	+0.0827	0.336	
5.00	43.750	0.000	11.685	9.500	165.3268	0.7447	10.3274	+1.0000	+0.1058	+0.0257	0.264	
6.00	52.500	0.000	12.362	9.500	192.5941	0.8199	11.1729	+1.0000	+0.1281	-0.0216	0.214	
7.00	61.250	0.000	12.639	9.500	212.9348	0.8867	11.8200	+1.0000	+0.1328	-0.0635	0.129	
8.00	70.000	0.000	12.700	9.500	226.7749	0.9398	12.2977	+1.0000	+0.1301	-0.0974	0.074	TUNNELED
9.00	78.750	0.000	12.700	9.500	232.6740	0.9643	12.5190	+1.0000	+0.1278	-0.1133	0.154	TUNNELED
10.00	87.500	0.000	12.700	9.500	233.4861	0.9676	12.5504	+1.0000	+0.1275	-0.1156	0.179	TUNNELED
11.00	96.250	0.000	12.681	9.500	228.7239	0.9493	12.3720	+1.0000	+0.1286	-0.1036	0.093	TUNNELED
12.00	105.000	0.000	12.426	9.500	215.2668	0.9118	11.9114	+1.0000	+0.1228	-0.0796	0.106	
13.00	113.750	0.000	11.696	9.500	191.7049	0.8626	11.1416	+1.0000	+0.0986	-0.0488	0.245	
14.00	122.500	0.000	10.536	9.500	162.7306	0.8129	10.1961	+1.0000	+0.0508	-0.0175	0.322	
15.00	131.250	0.000	8.930	9.500	130.5698	0.7696	9.1230	+1.0000	-0.0312	+0.0101	0.372	
16.00	140.000	0.000	7.020	9.500	97.7820	0.7331	7.9995	+1.0000	-0.1550	+0.0326	0.358	
17.00	148.750	0.000	5.016	9.500	68.5479	0.7192	6.9913	+1.0000	-0.3207	+0.0382	0.363	
18.00	157.500	0.000	3.052	9.500	44.6091	0.7692	6.2288	+1.0000	-0.5176	+0.0076	0.326	
19.00	166.250	0.000	1.541	9.500	27.3320	0.9334	5.7829	+1.0000	-0.6881	-0.0454	0.222 F	BULBOUS
19.50	170.625	0.000	0.869	9.500	20.8925	1.2657	5.7282	+1.0000	-0.7534	-0.0949	0.131 F	BULBOUS
20.00	175.000	0.000	0.085	9.370	14.0285	8.8069	5.8443	+1.0000	-0.7936	-0.1903	0.291 F	BULBOUS

This page shows the output of the Lewis conformal mapping data.

The area-coefficients have been obtained with the local area, the local breadth on the waterline and the local draft. M(S) {= M_s} is the sectional scale factor of the Lewis coefficients A(1) {= a_1} and A(3) {= a_3}.

Half the contour of each actual cross-section has been divided in 32 intervals of equal length and RMS is the Root Mean Squares of the deviations of these 33 points from the Lewis form. Note that, instead of these points, the sectional breadth, draft and area have been used to obtain the Lewis coefficients. Note too that for station number 1.00 the area-coefficient for obtaining the Lewis coefficients has been increased by SEAWAY from 0.2718 to the minimum required value of 0.450; see Figure 14. Re-entrant and non-symmetric Lewis forms are prohibited.

These Lewis coefficients are used in the method of Ikeda, for obtaining the eddy making roll damping. If the conformal mapping coefficients are missing on the next page, these Lewis coefficients are also used to obtain the potential coefficients (as far as not marked with *F*, which indicates the use of Frank's method).
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Close-Fit Conformal Mapping Coefficients, KPR(2)=1 and KCOF=10

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N-PARAMETER CLOSE-FIT CONFORMAL MAPPING COEFFICIENTS
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STATION	M(S)	A(-1)	A(1)	A(3)	A(5)	A(7)	A(9)	A(11)	A(13)	A(15)	A(17)	A(19)	RMS	
(-)	(m)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(m)	
-0.38	+0.0035	+1.0000	-0.0105	-0.7445	+0.0105	+0.1061	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	0.000	
-0.19	+0.5654	+1.0000	+0.3376	+0.1449	-0.0118	+0.0163	-0.0039	+0.0060	-0.0007	+0.0041	+0.0060	+0.0048	0.003	
0.00	+1.0016	+1.0000	+0.3969	+0.1249	-0.0037	+0.0199	-0.0122	+0.0109	-0.0016	+0.0023	+0.0050	+0.0052	0.004	
0.50	+1.9646	+1.0000	+0.4543	+0.0961	+0.0057	+0.0129	-0.0013	+0.0028	-0.0024	+0.0004	-0.0058	+0.0000	0.007	
1.00	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	0.000	F
2.00	+7.0911	+1.0000	-0.1965	+0.2095	+0.0785	-0.0026	-0.0199	-0.0130	-0.0125	-0.0131	-0.0239	-0.0153	0.080	
3.00	+8.2593	+1.0000	-0.0526	+0.1432	+0.0528	+0.0034	-0.0023	+0.0002	-0.0026	-0.0048	-0.0190	-0.0155	0.125	
4.00	+9.3091	+1.0000	+0.0220	+0.0739	+0.0339	+0.0064	+0.0039	+0.0023	+0.0032	+0.0015	-0.0006	-0.0012	0.021	
5.00	+10.3133	+1.0000	+0.0763	+0.0203	+0.0208	+0.0010	+0.0043	+0.0021	+0.0038	+0.0023	+0.0008	+0.0014	0.014	
6.00	+11.1608	+1.0000	+0.1080	-0.0236	+0.0173	+0.0000	+0.0026	-0.0002	+0.0002	+0.0017	+0.0001	+0.0015	0.020	
7.00	+11.8137	+1.0000	+0.1235	-0.0642	+0.0105	-0.0039	-0.0015	+0.0041	+0.0001	-0.0003	+0.0002	+0.0013	0.013	
8.00	+12.3267	+1.0000	+0.1322	-0.1028	+0.0014	+0.0014	-0.0030	+0.0026	-0.0004	-0.0015	-0.0005	+0.0008	0.016	
9.00	+12.5803	+1.0000	+0.1376	-0.1225	-0.0068	+0.0033	-0.0042	+0.0007	+0.0021	+0.0004	-0.0015	+0.0004	0.012	
10.00	+12.6238	+1.0000	+0.1388	-0.1262	-0.0097	+0.0034	-0.0025	+0.0018	+0.0018	-0.0002	-0.0017	+0.0005	0.011	
11.00	+12.4062	+1.0000	+0.1340	-0.1098	-0.0024	+0.0017	-0.0038	+0.0012	+0.0007	-0.0002	-0.0003	+0.0011	0.010	
12.00	+11.9181	+1.0000	+0.1162	-0.0840	+0.0091	-0.0001	-0.0031	+0.0029	+0.0000	-0.0003	+0.0005	+0.0014	0.011	
13.00	+11.1486	+1.0000	+0.0766	-0.0576	+0.0189	+0.0014	+0.0013	+0.0023	-0.0016	+0.0015	+0.0034	+0.0030	0.022	
14.00	+10.2132	+1.0000	+0.0172	-0.0305	+0.0242	+0.0036	+0.0053	+0.0026	+0.0015	+0.0019	+0.0025	+0.0033	0.024	
15.00	+9.1768	+1.0000	-0.0738	-0.0093	+0.0311	+0.0061	+0.0073	+0.0021	+0.0031	+0.0027	+0.0013	+0.0026	0.019	
16.00	+8.0848	+1.0000	-0.2003	+0.0062	+0.0311	+0.0063	+0.0101	+0.0043	+0.0024	+0.0016	+0.0033	+0.0033	0.018	
17.00	+7.1201	+1.0000	-0.3621	-0.0044	+0.0296	+0.0134	+0.0100	+0.0047	+0.0041	+0.0025	+0.0035	+0.0031	0.020	
18.00	+6.3874	+1.0000	-0.5394	-0.0481	+0.0167	+0.0176	+0.0104	+0.0054	+0.0029	+0.0011	+0.0046	+0.0066	0.038	
19.00	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	0.000	F
19.50	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	0.000	F
20.00	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	+0.0000	0.000	F

This output data page shows the output of the close-fit conformal mapping data.
M(S) {= M_s} is the sectional scale factor of the conformal mapping coefficients A(1) {= a_1} until A(19) {= a_{19}}. Half the contour of each actual cross-section has been divided in 32 intervals of equal length and RMS is the Root Mean Squares of the deviations of these 33 points from the re-mapped hull form.
Always, **check these RMS-values**. If they are too large, the use of the Frank close-fit method is advised. The 4 marks F behind the RMS-column indicates that for these particular cross-sections the Frank close-fit method will be used, when obtaining the potential coefficients, because NFR = 4 is given in the input data file and the KCOF-values of these sections are 11.
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Example of 2-D Potential Mass, KPR(3)=1

ITTC-ship S-175. Test of program SEAWAY, release 4.18. SEAWAY-4.18 Date: 09-10-1999/23:17 Page: 10

2-D VALUES OF POTENTIAL M-22
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FREQUENCY: STATION	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875	1.000	1.125	1.250
-0.38	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
-0.19	2.605E-01	2.606E-01	2.612E-01	2.622E-01	2.636E-01	2.655E-01	2.680E-01	2.708E-01	2.741E-01	2.778E-01	2.816E-01
0.00	6.737E-01	6.743E-01	6.770E-01	6.817E-01	6.885E-01	6.976E-01	7.086E-01	7.211E-01	7.342E-01	7.466E-01	7.569E-01
0.50	2.036E+00	2.040E+00	2.057E+00	2.088E+00	2.133E+00	2.188E+00	2.247E+00	2.299E+00	2.331E+00	2.332E+00	2.293E+00
1.00	1.283E+02	1.292E+02	1.331E+02	1.400E+02	1.484E+02	1.528E+02	1.454E+02	1.260E+02	1.044E+02	8.768E+01	7.679E+01
2.00	1.311E+02	1.326E+02	1.378E+02	1.467E+02	1.556E+02	1.556E+02	1.395E+02	1.145E+02	9.226E+01	7.683E+01	6.712E+01
3.00	1.304E+02	1.328E+02	1.391E+02	1.494E+02	1.576E+02	1.524E+02	1.306E+02	1.044E+02	8.389E+01	7.040E+01	6.215E+01
4.00	1.355E+02	1.390E+02	1.470E+02	1.594E+02	1.673E+02	1.561E+02	1.275E+02	9.823E+01	7.722E+01	6.414E+01	5.646E+01
5.00	1.450E+02	1.499E+02	1.602E+02	1.760E+02	1.842E+02	1.658E+02	1.275E+02	9.226E+01	6.866E+01	5.464E+01	4.677E+01
6.00	1.578E+02	1.641E+02	1.771E+02	1.970E+02	2.054E+02	1.781E+02	1.283E+02	8.627E+01	5.981E+01	4.486E+01	3.696E+01
7.00	1.728E+02	1.803E+02	1.964E+02	2.210E+02	2.303E+02	1.921E+02	1.283E+02	7.849E+01	4.917E+01	3.371E+01	2.629E+01
8.00	1.891E+02	1.976E+02	2.169E+02	2.468E+02	2.570E+02	2.061E+02	1.267E+02	6.933E+01	3.804E+01	2.283E+01	1.644E+01
9.00	1.982E+02	2.072E+02	2.282E+02	2.612E+02	2.721E+02	2.131E+02	1.246E+02	6.353E+01	3.173E+01	1.707E+01	1.148E+01
10.00	1.998E+02	2.089E+02	2.302E+02	2.637E+02	2.747E+02	2.143E+02	1.241E+02	6.251E+01	3.067E+01	1.613E+01	1.068E+01
11.00	1.919E+02	2.006E+02	2.204E+02	2.514E+02	2.620E+02	2.085E+02	1.259E+02	6.711E+01	3.559E+01	2.056E+01	1.446E+01
12.00	1.809E+02	1.887E+02	2.060E+02	2.329E+02	2.433E+02	2.005E+02	1.296E+02	7.579E+01	4.520E+01	2.964E+01	2.256E+01
13.00	1.710E+02	1.774E+02	1.921E+02	2.151E+02	2.260E+02	1.940E+02	1.344E+02	8.549E+01	5.609E+01	4.031E+01	3.249E+01
14.00	1.620E+02	1.669E+02	1.792E+02	1.991E+02	2.111E+02	1.889E+02	1.384E+02	9.285E+01	6.400E+01	4.794E+01	3.959E+01
15.00	1.567E+02	1.603E+02	1.708E+02	1.885E+02	2.023E+02	1.886E+02	1.445E+02	9.955E+01	6.953E+01	5.251E+01	4.352E+01
16.00	1.526E+02	1.550E+02	1.641E+02	1.801E+02	1.958E+02	1.907E+02	1.526E+02	1.060E+02	7.288E+01	5.392E+01	4.400E+01
17.00	1.529E+02	1.544E+02	1.629E+02	1.783E+02	1.965E+02	1.993E+02	1.653E+02	1.128E+02	7.323E+01	5.109E+01	4.007E+01
18.00	1.578E+02	1.587E+02	1.673E+02	1.836E+02	2.058E+02	2.171E+02	1.836E+02	1.165E+02	6.551E+01	3.970E+01	2.856E+01
19.00	1.611E+02	1.616E+02	1.702E+02	1.869E+02	2.114E+02	2.298E+02	1.998E+02	1.203E+02	5.878E+01	3.033E+01	1.968E+01
19.50	1.605E+02	1.609E+02	1.695E+02	1.864E+02	2.122E+02	2.345E+02	2.065E+02	1.183E+02	5.041E+01	2.127E+01	1.163E+01
20.00	1.460E+02	1.464E+02	1.536E+02	1.675E+02	1.892E+02	2.111E+02	2.001E+02	1.300E+02	6.015E+01	2.536E+01	1.240E+01
SHIP:	2.723E+04	2.802E+04	3.010E+04	3.346E+04	3.555E+04	3.211E+04	2.391E+04	1.567E+04	1.021E+04	7.298E+03	5.902E+03

FREQUENCY: STATION	1.375	1.500	1.625	1.750	1.875	2.000	2.125	2.250	2.375	2.500	3.125
-0.38	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
-0.19	2.854E-01	2.890E-01	2.922E-01	2.946E-01	2.960E-01	2.963E-01	2.951E-01	2.925E-01	2.885E-01	2.832E-01	2.449E-01
0.00	7.636E-01	7.652E-01	7.607E-01	7.499E-01	7.331E-01	7.113E-01	6.860E-01	6.587E-01	6.307E-01	6.031E-01	4.911E-01
0.50	2.218E+00	2.114E+00	1.994E+00	1.869E+00	1.749E+00	1.638E+00	1.539E+00	1.453E+00	1.379E+00	1.316E+00	1.125E+00
1.00	7.022E+01	6.644E+01	6.440E+01	6.344E+01	6.315E+01	6.328E+01	6.365E+01	6.417E+01	6.477E+01	6.539E+01	6.832E+01
2.00	6.127E+01	5.788E+01	5.609E+01	5.536E+01	5.536E+01	5.589E+01	5.680E+01	5.798E+01	5.934E+01	6.078E+01	6.741E+01
3.00	5.730E+01	5.458E+01	5.321E+01	5.272E+01	5.279E+01	5.323E+01	5.392E+01	5.478E+01	5.574E+01	5.676E+01	6.185E+01
4.00	5.216E+01	4.994E+01	4.900E+01	4.885E+01	4.919E+01	4.982E+01	5.062E+01	5.149E+01	5.240E+01	5.330E+01	5.725E+01
5.00	4.264E+01	4.077E+01	4.028E+01	4.062E+01	4.145E+01	4.255E+01	4.378E+01	4.506E+01	4.633E+01	4.756E+01	5.267E+01
6.00	3.324E+01	3.199E+01	3.221E+01	3.330E+01	3.485E+01	3.663E+01	3.849E+01	4.033E+01	4.210E+01	4.376E+01	5.031E+01
7.00	2.346E+01	2.325E+01	2.451E+01	2.658E+01	2.901E+01	3.157E+01	3.410E+01	3.651E+01	3.876E+01	4.082E+01	4.854E+01
8.00	1.485E+01	1.588E+01	1.830E+01	2.139E+01	2.473E+01	2.805E+01	3.121E+01	3.415E+01	3.684E+01	3.925E+01	4.795E+01
9.00	1.069E+01	1.243E+01	1.546E+01	1.905E+01	2.280E+01	2.646E+01	2.990E+01	3.306E+01	3.592E+01	3.848E+01	4.756E+01
10.00	1.001E+01	1.185E+01	1.496E+01	1.862E+01	2.242E+01	2.613E+01	2.961E+01	3.281E+01	3.570E+01	3.829E+01	4.745E+01
11.00	1.316E+01	1.444E+01	1.708E+01	2.034E+01	2.380E+01	2.723E+01	3.048E+01	3.348E+01	3.621E+01	3.867E+01	4.746E+01
12.00	2.021E+01	2.050E+01	2.225E+01	2.474E+01	2.756E+01	3.044E+01	3.325E+01	3.589E+01	3.832E+01	4.055E+01	4.872E+01
13.00	2.921E+01	2.853E+01	2.934E+01	3.098E+01	3.303E+01	3.525E+01	3.748E+01	3.964E+01	4.168E+01	4.357E+01	5.081E+01
14.00	3.570E+01	3.438E+01	3.457E+01	3.561E+01	3.711E+01	3.884E+01	4.065E+01	4.244E+01	4.416E+01	4.578E+01	5.220E+01
15.00	3.917E+01	3.749E+01	3.737E+01	3.813E+01	3.939E+01	4.091E+01	4.253E+01	4.415E+01	4.573E+01	4.723E+01	5.328E+01
16.00	3.921E+01	3.733E+01	3.709E+01	3.779E+01	3.901E+01	4.049E+01	4.208E+01	4.369E+01	4.525E+01	4.673E+01	5.270E+01
17.00	3.510E+01	3.335E+01	3.337E+01	3.434E+01	3.582E+01	3.754E+01	3.934E+01	4.114E+01	4.286E+01	4.449E+01	5.092E+01
18.00	2.452E+01	2.388E+01	2.492E+01	2.679E+01	2.905E+01	3.143E+01	3.380E+01	3.607E+01	3.820E+01	4.017E+01	4.764E+01
19.00	1.678E+01	1.725E+01	1.922E+01	2.185E+01	2.472E+01	2.762E+01	3.040E+01	3.300E+01	3.539E+01	3.756E+01	4.548E+01
19.50	9.864E+00	1.128E+01	1.401E+01	1.726E+01	2.064E+01	2.395E+01	2.707E+01	2.994E+01	3.254E+01	3.488E+01	4.321E+01
20.00	8.921E+00	9.412E+00	1.163E+01	1.460E+01	1.783E+01	2.108E+01	2.419E+01	2.708E+01	2.971E+01	3.207E+01	4.041E+01
SHIP:	5.326E+03	5.198E+03	5.316E+03	5.569E+03	5.890E+03	6.239E+03	6.592E+03	6.935E+03	7.260E+03	7.563E+03	8.729E+03

This page shows an example for sway of 2-D and integrated potential mass coefficients, defined in a co-ordinate system with the origin O in the waterline. The frequency range follows from FREQMAX and the dimensions follow from KPR(3).
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Example of 2-D Potential Damping, KPR(3)=1

ITTC-ship S-175. Test of program SEAWAY, release 4.18. SEAWAY-4.18 Date: 09-10-1999/23:17 Page: 13

2-D VALUES OF POTENTIAL N-33
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FREQUENCY: STATION	0.000	0.125	0.250	0.375	0.500	0.625	0.750	0.875	1.000	1.125	1.250
-0.38	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
-0.19	0.000E-01	3.661E-01	7.134E-01	1.034E+00	1.324E+00	1.585E+00	1.816E+00	2.020E+00	2.198E+00	2.355E+00	2.490E+00
0.00	0.000E-01	1.208E+00	2.317E+00	3.296E+00	4.140E+00	4.857E+00	5.459E+00	5.962E+00	6.377E+00	6.717E+00	6.992E+00
0.50	0.000E-01	4.665E+00	8.707E+00	1.201E+01	1.462E+01	1.665E+01	1.820E+01	1.936E+01	2.020E+01	2.078E+01	2.115E+01
1.00	0.000E-01	8.222E+00	1.491E+01	2.001E+01	2.380E+01	2.660E+01	2.861E+01	3.000E+01	3.087E+01	3.133E+01	3.144E+01
2.00	0.000E-01	2.353E+01	4.126E+01	5.313E+01	6.031E+01	6.390E+01	6.477E+01	6.358E+01	6.082E+01	5.693E+01	5.222E+01
3.00	0.000E-01	3.895E+01	6.673E+01	8.402E+01	9.341E+01	9.705E+01	9.652E+01	9.304E+01	8.757E+01	8.090E+01	7.361E+01
4.00	0.000E-01	5.286E+01	8.899E+01	1.101E+02	1.202E+02	1.225E+02	1.193E+02	1.126E+02	1.038E+02	9.411E+01	8.438E+01
5.00	0.000E-01	6.295E+01	1.044E+02	1.269E+02	1.356E+02	1.346E+02	1.269E+02	1.151E+02	1.015E+02	8.757E+01	7.452E+01
6.00	0.000E-01	7.000E+01	1.147E+02	1.371E+02	1.434E+02	1.381E+02	1.254E+02	1.085E+02	9.035E+01	7.313E+01	5.802E+01
7.00	0.000E-01	7.283E+01	1.181E+02	1.389E+02	1.417E+02	1.319E+02	1.141E+02	9.275E+01	7.163E+01	5.312E+01	3.824E+01
8.00	0.000E-01	7.328E+01	1.177E+02	1.362E+02	1.353E+02	1.209E+02	9.878E+01	7.448E+01	5.236E+01	3.473E+01	2.200E+01
9.00	0.000E-01	7.315E+01	1.169E+02	1.338E+02	1.308E+02	1.139E+02	8.965E+01	6.426E+01	4.237E+01	2.599E+01	1.500E+01
10.00	0.000E-01	7.313E+01	1.167E+02	1.334E+02	1.299E+02	1.126E+02	8.802E+01	6.250E+01	4.072E+01	2.462E+01	1.398E+01
11.00	0.000E-01	7.303E+01	1.171E+02	1.350E+02	1.333E+02	1.181E+02	9.521E+01	7.052E+01	4.847E+01	3.129E+01	1.921E+01
12.00	0.000E-01	7.040E+01	1.139E+02	1.332E+02	1.346E+02	1.233E+02	1.044E+02	8.253E+01	6.160E+01	4.392E+01	3.029E+01
13.00	0.000E-01	6.282E+01	1.029E+02	1.225E+02	1.268E+02	1.202E+02	1.066E+02	8.953E+01	7.208E+01	5.624E+01	4.298E+01
14.00	0.000E-01	5.144E+01	8.557E+01	1.036E+02	1.095E+02	1.066E+02	9.786E+01	8.578E+01	7.260E+01	5.993E+01	4.870E+01
15.00	0.000E-01	3.738E+01	6.329E+01	7.799E+01	8.396E+01	8.346E+01	7.843E+01	7.065E+01	6.162E+01	5.253E+01	4.414E+01
16.00	0.000E-01	2.343E+01	4.047E+01	5.084E+01	5.571E+01	5.634E+01	5.388E+01	4.942E+01	4.391E+01	3.814E+01	3.263E+01
17.00	0.000E-01	1.214E+01	2.141E+01	2.737E+01	3.040E+01	3.104E+01	2.990E+01	2.756E+01	2.457E+01	2.140E+01	1.835E+01
18.00	0.000E-01	4.554E+00	8.157E+00	1.051E+01	1.165E+01	1.174E+01	1.106E+01	9.889E+00	8.501E+00	7.111E+00	5.858E+00
19.00	0.000E-01	1.229E+00	2.191E+00	2.762E+00	2.933E+00	2.771E+00	2.387E+00	1.905E+00	1.431E+00	1.030E+00	7.267E-01
19.50	0.000E-01	4.057E-01	7.000E-01	8.263E-01	7.859E-01	6.258E-01	4.160E-01	2.230E-01	8.778E-02	1.843E-02	6.139E-04
20.00	0.000E-01	5.726E-03	3.063E-03	2.473E-03	1.294E-02	8.289E-02	2.320E-01	4.576E-01	7.245E-01	9.794E-01	1.173E+00
SHIP:	0.000E-01	7.765E+03	1.277E+04	1.525E+04	1.583E+04	1.507E+04	1.347E+04	1.148E+04	9.490E+03	7.716E+03	6.248E+03

FREQUENCY: STATION	1.375	1.500	1.625	1.750	1.875	2.000	2.125	2.250	2.375	2.500	3.125
-0.38	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
-0.19	2.608E+00	2.709E+00	2.795E+00	2.868E+00	2.929E+00	2.979E+00	3.019E+00	3.050E+00	3.074E+00	3.090E+00	3.083E+00
0.00	7.210E+00	7.380E+00	7.507E+00	7.597E+00	7.654E+00	7.683E+00	7.686E+00	7.668E+00	7.630E+00	7.576E+00	7.130E+00
0.50	2.133E+01	2.136E+01	2.127E+01	2.107E+01	2.079E+01	2.044E+01	2.004E+01	1.959E+01	1.912E+01	1.862E+01	1.602E+01
1.00	3.126E+01	3.087E+01	3.032E+01	2.963E+01	2.886E+01	2.803E+01	2.717E+01	2.629E+01	2.541E+01	2.455E+01	2.056E+01
2.00	4.696E+01	4.135E+01	3.558E+01	2.981E+01	2.420E+01	1.893E+01	1.416E+01	1.004E+01	6.652E+00	4.050E+00	-2.625E-02
3.00	6.614E+01	5.876E+01	5.165E+01	4.491E+01	3.860E+01	3.276E+01	2.741E+01	2.258E+01	1.828E+01	1.451E+01	3.089E+00
4.00	7.514E+01	6.668E+01	5.909E+01	5.239E+01	4.651E+01	4.137E+01	3.689E+01	3.297E+01	2.954E+01	2.652E+01	1.596E+01
5.00	6.290E+01	5.289E+01	4.447E+01	3.747E+01	3.170E+01	2.694E+01	2.303E+01	1.979E+01	1.710E+01	1.486E+01	7.923E+00
6.00	4.544E+01	3.536E+01	2.745E+01	2.135E+01	1.666E+01	1.308E+01	1.034E+01	8.236E+00	6.610E+00	5.348E+00	2.077E+00
7.00	2.699E+01	1.883E+01	1.308E+01	9.100E+00	6.366E+00	4.495E+00	3.212E+00	2.328E+00	1.713E+00	1.281E+00	3.788E-01
8.00	1.345E+01	8.003E+00	4.671E+00	2.690E+00	1.536E+00	8.749E-01	4.992E-01	2.867E-01	1.667E-01	9.868E-02	1.190E-02
9.00	8.220E+00	4.303E+00	2.161E+00	1.042E+00	4.829E-01	2.148E-01	9.138E-02	3.707E-02	1.431E-02	5.316E-03	5.125E-04
10.00	7.513E+00	3.845E+00	1.880E+00	8.783E-01	3.917E-01	1.662E-01	6.668E-02	2.515E-02	8.798E-03	3.159E-03	1.604E-03
11.00	1.133E+01	6.484E+00	3.626E+00	1.996E+00	1.089E+00	5.937E-01	3.264E-01	1.828E-01	1.056E-01	6.378E-02	1.264E-02
12.00	2.042E+01	1.359E+01	8.997E+00	5.967E+00	3.986E+00	2.695E+00	1.852E+00	1.296E+00	9.267E-01	6.773E-01	1.947E-01
13.00	3.249E+01	2.448E+01	1.851E+01	1.410E+01	1.085E+01	8.465E+00	6.695E+00	5.371E+00	4.370E+00	3.604E+00	1.626E+00
14.00	3.927E+01	3.163E+01	2.556E+01	2.080E+01	1.708E+01	1.416E+01	1.185E+01	1.003E+01	8.561E+00	7.375E+00	3.887E+00
15.00	3.681E+01	3.065E+01	2.557E+01	2.145E+01	1.812E+01	1.542E+01	1.322E+01	1.143E+01	9.945E+00	8.713E+00	4.868E+00
16.00	2.770E+01	2.346E+01	1.991E+01	1.698E+01	1.457E+01	1.259E+01	1.097E+01	9.627E+00	8.506E+00	7.563E+00	4.520E+00
17.00	1.561E+01	1.327E+01	1.131E+01	9.700E+00	8.387E+00	7.315E+00	6.434E+00	5.705E+00	5.096E+00	4.579E+00	2.860E+00
18.00	4.804E+00	3.958E+00	3.299E+00	2.794E+00	2.408E+00	2.111E+00	1.879E+00	1.694E+00	1.542E+00	1.415E+00	9.628E-01
19.00	5.159E-01	3.791E-01	2.954E-01	2.478E-01	2.239E-01	2.154E-01	2.166E-01	2.237E-01	2.338E-01	2.446E-01	2.765E-01
19.50	6.586E-03	1.979E-02	2.771E-02	2.734E-02	2.081E-02	1.206E-02	4.589E-03	5.062E-04	4.354E-04	3.932E-03	4.027E-02
20.00	1.277E+00	1.286E+00	1.215E+00	1.089E+00	9.335E-01	7.715E-01	6.190E-01	4.855E-01	3.746E-01	2.861E-01	7.532E-02
SHIP:	5.080E+03	4.166E+03	3.450E+03	2.885E+03	2.432E+03	2.063E+03	1.761E+03	1.512E+03	1.306E+03	1.136E+03	6.489E+02

This page shows an example for heave of 2-D and integrated potential damping coefficients, defined in a co-ordinate system with the origin O in the waterline. The frequency range follows from FREQMAX and the dimensions follow from KPR(3).
~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Natural Frequencies and Roll Damping, KPR(4)=1

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ITTC-ship S-175.   Test of program SEAWAY, release 4.18.                 SEAWAY-4.18  Date: 09-10-1999/23:17   Page:  18

NATURAL FREQUENCIES AT ZERO FORWARD SPEED
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

          NATURAL   NATURAL
        FREQUENCY    PERIOD
          (rad/s)       (s)
SURGE:      0.000
SWAY:       0.000
HEAVE:      0.849      7.40
ROLL:       0.369     17.03
PITCH:      0.885      7.10
YAW:        0.000


ROLL MASS AND DAMPING DATA AT NATURAL FREQUENCY
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

FORWARD SHIP SPEED . (kn) :    20.00
MEAN ROLL AMPLITUDE (deg) :    5.000

NATURAL ROLL PERIOD . (s) :   17.033
NATURAL FREQUENCY (rad/s) :    0.369

MASS, k-phi-phi ..... (m) :    8.395
COMPONENTS k-phi-phi:
   SOLID MASS PART .. (m) :    7.620
   2-D POTENTIAL PART (m) :    3.524

DAMPING, kappa ...... (-) :   0.0690
COMPONENTS kappa:
   2-D POTENTIAL PART (-) :   0.0021
   SPEED EFFECT PART  (-) :   0.0118
   SKIN FRICTION PART (-) :   0.0006
   EDDY MAKING PART . (-) :   0.0001
   LIFT MOMENT PART . (-) :   0.0432
   BILGE KEEL PART .. (-) :   0.0111
```

This page shows the output of the natural frequencies of heave, roll and pitch motions and the components of the mass and damping coefficients for roll at the natural frequency according to the method of [Ikeda et. al. 1978], defined in a co-ordinate system with the origin at the centre of gravity *G*.

Example of Equation of Motion Coefficients, KPR(3)=1

ITTC-ship S-175. Test of program SEAWAY, release 4.18. SEAWAY-4.18 Date: 09-10-1999/23:17 Page: 22

MOTION COEFFICIENTS AND WAVE-LOADS FORWARD SPEED = 20.00 kn
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ WAVE DIRECTION = +150 deg off stern

ROLL EQUATION
~~~~~~~~~~~~~

SQRT SL/WL (-)	ENC FREQ (r/s)	COUPLING TO SWAY MASS (kN*s2/m)	COUPLING TO SWAY DAMPING (kN*s/m)	COUPLING TO SWAY RESTORING (kN/m)	ROLL MASS (kN*s2*m/m)	ROLL DAMPING (kN*s*m/m)	ROLL RESTORING (kN*m/m)	COUPLING TO YAW MASS (kN*s2*m/m)	COUPLING TO YAW DAMPING (kN*s*m/m)	COUPLING TO YAW RESTORING (kN*m/m)	WAVE-MOMENT AMPL (kN*m/m)	WAVE-MOMENT PHASE (deg)
0.337	0.236	1.457E+04	-6.406E+01	0.000E-01	1.731E+06	6.806E+04	2.369E+05	6.186E+05	-1.445E+05	0.000E-01	5.449E+02	226.9
0.393	0.283	1.481E+04	-1.595E+02	0.000E-01	1.734E+06	7.749E+04	2.369E+05	6.664E+05	-1.354E+05	0.000E-01	9.241E+02	207.1
0.449	0.331	1.516E+04	-2.895E+02	0.000E-01	1.738E+06	8.374E+04	2.369E+05	7.278E+05	-1.228E+05	0.000E-01	1.527E+03	199.6
0.506	0.382	1.563E+04	-4.198E+02	0.000E-01	1.742E+06	9.183E+04	2.369E+05	7.976E+05	-1.047E+05	0.000E-01	2.308E+03	194.1
0.562	0.434	1.694E+04	-5.219E+02	0.000E-01	1.746E+06	9.867E+04	2.369E+05	8.844E+05	-5.228E+04	0.000E-01	3.772E+03	183.4
0.618	0.489	1.829E+04	-6.279E+02	0.000E-01	1.750E+06	1.030E+05	2.369E+05	9.747E+05	2.137E+03	0.000E-01	5.391E+03	182.4
0.674	0.545	2.008E+04	2.159E+02	0.000E-01	1.751E+06	1.149E+05	2.369E+05	1.045E+06	1.358E+05	0.000E-01	7.554E+03	174.3
0.730	0.604	2.205E+04	1.333E+03	0.000E-01	1.751E+06	1.230E+05	2.369E+05	1.098E+06	2.940E+05	0.000E-01	9.847E+03	172.4
0.786	0.665	2.242E+04	3.725E+03	0.000E-01	1.745E+06	1.305E+05	2.369E+05	1.033E+06	5.291E+05	0.000E-01	1.182E+04	169.2
0.843	0.727	2.188E+04	6.876E+03	0.000E-01	1.734E+06	1.362E+05	2.369E+05	8.872E+05	8.114E+05	0.000E-01	1.339E+04	168.0
0.899	0.792	1.940E+04	9.625E+03	0.000E-01	1.718E+06	1.362E+05	2.369E+05	6.079E+05	1.047E+06	0.000E-01	1.401E+04	168.6
0.955	0.858	1.574E+04	1.218E+04	0.000E-01	1.699E+06	1.453E+05	2.369E+05	2.481E+05	1.259E+06	0.000E-01	1.397E+04	169.5
1.011	0.927	1.240E+04	1.301E+04	0.000E-01	1.684E+06	1.471E+05	2.369E+05	-6.884E+04	1.321E+06	0.000E-01	1.323E+04	172.9
1.067	0.998	9.095E+03	1.327E+04	0.000E-01	1.669E+06	1.464E+05	2.369E+05	-3.725E+05	1.334E+06	0.000E-01	1.205E+04	176.2
1.124	1.070	7.289E+03	1.242E+04	0.000E-01	1.662E+06	1.418E+05	2.369E+05	-5.380E+05	1.253E+06	0.000E-01	1.042E+04	182.7
1.180	1.145	5.758E+03	1.146E+04	0.000E-01	1.656E+06	1.368E+05	2.369E+05	-6.746E+05	1.164E+06	0.000E-01	8.417E+03	189.4
1.236	1.222	4.943E+03	1.034E+04	0.000E-01	1.653E+06	1.314E+05	2.369E+05	-7.458E+05	1.061E+06	0.000E-01	6.048E+03	198.9
1.292	1.301	4.453E+03	9.179E+03	0.000E-01	1.652E+06	1.262E+05	2.369E+05	-7.882E+05	9.597E+05	0.000E-01	3.447E+03	214.6
1.348	1.381	4.181E+03	7.990E+03	0.000E-01	1.651E+06	1.214E+05	2.369E+05	-8.118E+05	8.593E+05	0.000E-01	1.200E+03	275.5
1.404	1.464	4.169E+03	6.791E+03	0.000E-01	1.651E+06	1.181E+05	2.369E+05	-8.158E+05	7.714E+05	0.000E-01	2.850E+03	5.7
1.461	1.549	4.261E+03	5.666E+03	0.000E-01	1.652E+06	1.152E+05	2.369E+05	-8.117E+05	6.857E+05	0.000E-01	5.462E+03	25.9
1.517	1.636	4.439E+03	4.606E+03	0.000E-01	1.652E+06	1.124E+05	2.369E+05	-8.008E+05	6.028E+05	0.000E-01	7.737E+03	38.3
1.573	1.725	4.708E+03	3.633E+03	0.000E-01	1.653E+06	1.098E+05	2.369E+05	-7.845E+05	5.285E+05	0.000E-01	9.391E+03	48.5
1.629	1.816	5.017E+03	2.746E+03	0.000E-01	1.654E+06	1.073E+05	2.369E+05	-7.657E+05	4.604E+05	0.000E-01	1.017E+04	57.8
1.685	1.909	5.352E+03	1.934E+03	0.000E-01	1.656E+06	1.050E+05	2.369E+05	-7.453E+05	3.975E+05	0.000E-01	9.891E+03	66.1
1.741	2.003	5.705E+03	1.198E+03	0.000E-01	1.657E+06	1.029E+05	2.369E+05	-7.243E+05	3.408E+05	0.000E-01	8.495E+03	73.3
1.798	2.100	6.109E+03	3.928E+02	0.000E-01	1.657E+06	1.014E+05	2.369E+05	-7.075E+05	3.046E+05	0.000E-01	6.058E+03	79.4
1.854	2.199	6.359E+03	1.087E+02	0.000E-01	1.659E+06	1.001E+05	2.369E+05	-6.807E+05	2.460E+05	0.000E-01	3.327E+03	78.5
1.910	2.300	6.610E+03	-1.320E+02	0.000E-01	1.660E+06	9.909E+04	2.369E+05	-6.559E+05	1.948E+05	0.000E-01	9.670E+02	24.9
1.966	2.403	6.904E+03	-4.794E+02	0.000E-01	1.661E+06	9.855E+04	2.369E+05	-6.370E+05	1.601E+05	0.000E-01	2.290E+03	304.0
2.022	2.508	7.158E+03	-7.282E+02	0.000E-01	1.662E+06	9.826E+04	2.369E+05	-6.185E+05	1.291E+05	0.000E-01	3.568E+03	296.0
2.079	2.615	7.321E+03	-8.111E+02	0.000E-01	1.663E+06	9.854E+04	2.369E+05	-6.043E+05	1.098E+05	0.000E-01	3.669E+03	291.3
2.135	2.724	7.488E+03	-8.956E+02	0.000E-01	1.664E+06	9.882E+04	2.369E+05	-5.898E+05	9.019E+04	0.000E-01	2.736E+03	280.5
2.191	2.835	7.657E+03	-9.817E+02	0.000E-01	1.664E+06	9.910E+04	2.369E+05	-5.751E+05	7.017E+04	0.000E-01	1.624E+03	242.0
2.247	2.949	7.829E+03	-1.069E+03	0.000E-01	1.665E+06	9.939E+04	2.369E+05	-5.601E+05	4.979E+04	0.000E-01	2.000E+03	183.8
2.303	3.064	8.005E+03	-1.159E+03	0.000E-01	1.666E+06	9.969E+04	2.369E+05	-5.448E+05	2.904E+04	0.000E-01	2.796E+03	162.5
2.359	3.181	8.098E+03	-1.206E+03	0.000E-01	1.666E+06	1.005E+05	2.369E+05	-5.366E+05	1.799E+04	0.000E-01	2.783E+03	150.3
2.416	3.300	8.098E+03	-1.206E+03	0.000E-01	1.666E+06	1.019E+05	2.369E+05	-5.365E+05	1.799E+04	0.000E-01	1.863E+03	131.8
2.472	3.421	8.098E+03	-1.206E+03	0.000E-01	1.666E+06	1.033E+05	2.369E+05	-5.364E+05	1.799E+04	0.000E-01	1.013E+03	64.5
2.528	3.544	8.098E+03	-1.206E+03	0.000E-01	1.666E+06	1.047E+05	2.369E+05	-5.364E+05	1.799E+04	0.000E-01	1.905E+03	6.5

This page shows an example for roll of the coefficients and wave loads in the equations of motion. They are given as a function of SQRT SL/WL {= $\sqrt{L_{pp}/\lambda}$} and ENC FREQ {= ω_e}. They are defined in a right handed co-ordinate system with the origin in the centre of gravity G. The dimensions depend on KPR(3).

Frequency Characteristics of *CoG* Motions and Added Resistance, KPR(4)=1

ITTC-ship S-175. Test of program SEAWAY, release 4.18. SEAWAY-4.18 Date: 09-10-1999/23:17 Page: 25

FREQUENCY CHARACTERISTICS OF CoG MOTIONS FORWARD SPEED = 20.00 kn
~~~~~~ WAVE DIRECTION = +150 deg off stern

WAVE FREQ (r/s)	SQRT SL/WL (-)	ENC FREQ (r/s)	...SURGE... AMPL (m/m)	PHASE (deg)	...SWAY.... AMPL (m/m)	PHASE (deg)	...HEAVE... AMPL (m/m)	PHASE (deg)	...ROLL.... AMPL (deg/m)	PHASE (deg)	...PITCH... AMPL (deg/m)	PHASE (deg)	....YAW.... AMPL (deg/m)	PHASE (deg)	ADDED RESISTANCE GER/BEU (kN/m2)	BOESE (kN/m2)
0.200	0.337	0.236	0.685	90.9	0.746	270.0	1.039	356.7	0.398	246.3	0.194	296.7	0.117	358.6	7.12E-02	0.00E-01
0.233	0.393	0.283	0.667	89.0	0.823	269.9	1.031	356.1	0.820	231.7	0.277	286.9	0.167	355.2	1.01E-01	0.00E-01
0.267	0.449	0.331	0.620	87.5	0.773	270.3	1.022	355.5	2.093	206.9	0.378	279.7	0.217	356.0	1.55E-01	0.00E-01
0.300	0.506	0.382	0.566	86.5	0.713	269.9	1.013	355.1	3.897	116.8	0.498	273.5	0.244	350.0	3.61E-01	0.00E-01
0.333	0.562	0.434	0.527	85.5	0.718	269.0	0.995	354.9	2.107	67.0	0.627	268.1	0.295	352.6	9.25E-01	0.00E-01
0.367	0.618	0.489	0.473	85.4	0.645	268.7	0.982	355.0	1.530	54.5	0.774	262.6	0.333	355.4	2.44E+00	0.00E-01
0.400	0.674	0.545	0.427	85.1	0.603	267.9	0.971	355.5	1.311	44.3	0.932	257.0	0.389	355.5	6.58E+00	3.57E+00
0.433	0.730	0.604	0.376	85.3	0.533	266.9	0.976	356.1	1.222	40.8	1.103	250.7	0.424	357.4	1.66E+01	1.49E+01
0.467	0.786	0.665	0.327	85.5	0.456	265.6	1.011	356.4	1.143	37.0	1.286	243.2	0.450	358.9	3.94E+01	4.16E+01
0.500	0.843	0.727	0.279	85.7	0.373	263.6	1.102	354.2	1.086	35.5	1.470	233.7	0.459	1.1	8.79E+01	9.86E+01
0.533	0.899	0.792	0.232	85.9	0.289	261.2	1.257	344.7	0.995	34.3	1.638	221.3	0.449	3.2	1.82E+02	2.08E+02
0.567	0.955	0.858	0.187	86.2	0.209	258.0	1.332	321.9	0.900	33.9	1.746	203.9	0.426	4.9	3.08E+02	3.57E+02
0.600	1.011	0.927	0.145	85.9	0.137	253.9	1.005	287.3	0.774	33.8	1.606	179.2	0.386	6.4	3.27E+02	3.86E+02
0.633	1.067	0.998	0.105	85.5	0.076	247.3	0.450	259.9	0.648	33.5	1.130	155.7	0.339	7.5	2.05E+02	2.39E+02
0.667	1.124	1.070	0.068	85.0	0.029	228.2	0.109	264.0	0.504	34.8	0.667	140.6	0.277	8.8	1.14E+02	1.17E+02
0.700	1.180	1.145	0.037	85.7	0.017	128.1	0.086	4.4	0.367	36.6	0.349	132.8	0.212	10.5	6.86E+01	5.26E+01
0.733	1.236	1.222	0.012	89.3	0.035	95.7	0.139	15.7	0.234	41.3	0.145	132.5	0.145	13.6	4.78E+01	2.01E+01
0.767	1.292	1.301	0.006	251.9	0.045	89.3	0.151	15.9	0.118	52.5	0.031	175.9	0.083	20.1	3.86E+01	5.21E+00
0.800	1.348	1.381	0.017	257.5	0.046	87.3	0.146	14.9	0.039	106.4	0.065	266.3	0.032	43.0	3.48E+01	8.99E-02
0.833	1.404	1.464	0.021	256.0	0.039	87.4	0.129	14.3	0.071	190.0	0.100	273.2	0.023	139.2	3.27E+01	0.00E-01
0.867	1.461	1.549	0.020	251.7	0.029	88.4	0.111	14.0	0.115	208.0	0.111	274.2	0.044	169.6	3.02E+01	1.10E+00
0.900	1.517	1.636	0.015	243.7	0.017	89.9	0.093	13.9	0.138	218.0	0.105	274.2	0.054	178.4	2.68E+01	3.09E+00
0.933	1.573	1.725	0.010	227.5	0.006	91.0	0.078	13.8	0.141	226.6	0.089	274.2	0.051	183.8	2.27E+01	4.48E+00
0.967	1.629	1.816	0.006	193.1	0.003	279.4	0.068	13.3	0.129	235.2	0.068	275.3	0.039	188.2	1.83E+01	4.94E+00
1.000	1.685	1.909	0.005	142.7	0.008	279.7	0.063	11.7	0.105	244.1	0.047	278.8	0.022	192.3	1.44E+01	4.50E+00
1.033	1.741	2.003	0.006	110.0	0.009	281.9	0.063	8.9	0.076	253.3	0.031	287.5	0.006	197.1	1.11E+01	3.44E+00
1.067	1.798	2.100	0.005	84.6	0.008	283.4	0.066	5.9	0.045	263.4	0.023	302.1	0.007	19.2	8.34E+00	2.02E+00
1.100	1.854	2.199	0.004	46.5	0.005	282.1	0.073	2.8	0.020	271.5	0.025	311.5	0.014	23.3	5.85E+00	6.45E-01
1.133	1.910	2.300	0.003	8.2	0.001	253.1	0.082	0.2	0.001	136.7	0.036	311.6	0.015	26.7	3.07E+00	0.00E-01
1.167	1.966	2.403	0.003	338.1	0.002	137.3	0.095	354.6	0.014	108.0	0.035	312.9	0.010	29.2	0.00E-01	0.00E-01
1.200	2.022	2.508	0.004	302.9	0.003	129.2	0.111	350.8	0.019	111.9	0.036	300.1	0.004	28.1	0.00E-01	0.00E-01
1.233	2.079	2.615	0.003	274.2	0.003	127.0	0.100	349.6	0.018	113.3	0.038	281.9	0.002	236.1	0.00E-01	0.00E-01
1.267	2.135	2.724	0.003	240.9	0.002	123.6	0.089	349.0	0.011	108.3	0.040	266.2	0.005	225.2	0.00E-01	0.00E-01
1.300	2.191	2.835	0.002	195.8	0.001	93.5	0.078	349.5	0.005	68.6	0.041	251.8	0.006	225.3	0.00E-01	0.00E-01
1.333	2.247	2.949	0.002	152.8	0.001	330.1	0.069	351.9	0.007	357.5	0.040	236.4	0.004	225.1	0.00E-01	0.00E-01
1.367	2.303	3.064	0.002	121.1	0.002	321.2	0.064	357.7	0.010	342.3	0.041	210.5	0.001	215.1	6.69E-01	0.00E-01
1.400	2.359	3.181	0.002	87.8	0.001	315.8	0.073	0.9	0.009	335.2	0.022	273.5	0.002	66.3	0.00E-01	1.11E+00
1.433	2.416	3.300	0.001	43.3	0.001	300.8	0.051	0.7	0.006	323.5	0.015	276.1	0.003	58.5	0.00E-01	1.39E-01
1.467	2.472	3.421	0.001	349.2	0.000	189.6	0.033	0.5	0.002	252.8	0.009	282.9	0.003	55.5	0.00E-01	0.00E-01
1.500	2.528	3.544	0.001	312.1	0.001	157.8	0.019	0.2	0.005	184.8	0.005	295.2	0.002	46.4	0.00E-01	0.00E-01

This page shows the output of the frequency characteristics of the basic motions and the added resistance of the ship as a function of WAVE FREQ {= ω}, SQRT SL/WL {= $\sqrt{L_{pp}/\lambda}$} and ENC FREQ {= ω_e}.
AMPL is the response amplitude operator (RAO) or transfer function of the motions, with dimensions depending on KPR(4). PHASE is the phase lag of the motions in degrees, relative to the wave elevation in the centre of gravity *G*.
The ADDED RESISTANCE, marked by GER/BEU and BOESE, are obtained by the radiated energy method of [Gerritsma and Beukelman, 1972] and by the integrated pressure method of [Boese 1970], respectively. The dimensions depend on KPR(4).
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Frequency Characteristics of Internal Loads, KPR(4)=1 and NBTM>0

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ITTC-ship S-175.   Test of program SEAWAY, release 4.18.                 SEAWAY-4.18  Date: 09-10-1999/23:17   Page:  26

FREQUENCY CHARACTERISTICS OF INTERNAL LOADS    FORWARD SPEED = 20.00 kn
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~    WAVE DIRECTION =  +150 deg off stern
SECTION NR =      01
X-APP      = 131.250 m
Y-CL       =   0.000 m
Z-BL       =   9.550 m
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			INTERNAL FORCES						INTERNAL MOMENTS					
WAVE FREQ (r/s)	SQRT SL/WL (-)	ENC FREQ (r/s)	F-x AMPL (kN/m)	F-x PHASE (deg)	F-y AMPL (kN/m)	F-y PHASE (deg)	F-z AMPL (kN/m)	F-z PHASE (deg)	M-x AMPL (kNm/m)	M-x PHASE (deg)	M-y AMPL (kNm/m)	M-y PHASE (deg)	M-z AMPL (kNm/m)	M-z PHASE (deg)
0.200	0.337	0.236	3.918E+01	117.6	2.363E+01	41.4	1.262E+02	31.6	5.199E+02	209.0	3.296E+03	209.1	9.181E+02	69.8
0.233	0.393	0.283	5.290E+01	113.7	6.508E+01	36.2	1.166E+02	11.8	1.434E+03	200.5	3.193E+03	199.2	2.744E+03	62.8
0.267	0.449	0.331	5.808E+01	87.5	2.030E+02	14.6	1.038E+02	333.3	4.444E+03	188.7	2.758E+03	183.6	7.231E+03	40.7
0.300	0.506	0.382	7.706E+01	56.1	4.741E+02	290.3	1.537E+02	279.4	9.317E+03	110.6	2.131E+03	148.0	1.484E+04	310.1
0.333	0.562	0.434	1.106E+02	37.6	3.280E+02	248.2	2.968E+02	252.7	5.226E+03	73.3	2.796E+03	94.0	9.347E+03	255.9
0.367	0.618	0.489	1.819E+02	24.8	3.363E+02	246.4	5.263E+02	238.5	3.556E+03	71.0	5.004E+03	62.5	1.008E+04	242.4
0.400	0.674	0.545	2.688E+02	18.8	3.907E+02	243.0	8.287E+02	230.7	2.507E+03	74.1	8.087E+03	48.4	1.168E+04	225.4
0.433	0.730	0.604	3.838E+02	17.4	5.449E+02	247.0	1.218E+03	224.7	1.479E+03	86.2	1.155E+04	38.5	1.696E+04	225.7
0.467	0.786	0.665	5.152E+02	18.0	7.291E+02	247.9	1.694E+03	219.6	7.234E+02	147.3	1.480E+04	31.5	2.262E+04	222.1
0.500	0.843	0.727	6.552E+02	20.2	9.943E+02	249.4	2.257E+03	213.8	1.697E+03	214.8	1.699E+04	25.6	3.091E+04	223.9
0.533	0.899	0.792	7.964E+02	23.5	1.268E+03	250.3	2.850E+03	205.6	3.193E+03	227.9	1.673E+04	22.6	3.920E+04	226.3
0.567	0.955	0.858	9.236E+02	27.4	1.554E+03	250.2	3.219E+03	193.9	4.795E+03	233.5	1.372E+04	33.9	4.774E+04	228.1
0.600	1.011	0.927	1.029E+03	32.6	1.789E+03	251.0	2.936E+03	183.4	6.078E+03	237.5	1.743E+04	63.8	5.421E+04	231.4
0.633	1.067	0.998	1.109E+03	39.0	1.984E+03	251.2	2.376E+03	185.2	7.127E+03	240.2	2.493E+04	64.9	5.887E+04	233.7
0.667	1.124	1.070	1.154E+03	46.7	2.099E+03	253.7	2.086E+03	194.6	7.631E+03	245.2	2.710E+04	60.4	6.067E+04	239.3
0.700	1.180	1.145	1.163E+03	56.3	2.143E+03	256.6	1.892E+03	204.4	7.760E+03	250.8	2.474E+04	60.2	6.001E+04	245.1
0.733	1.236	1.222	1.136E+03	68.9	2.101E+03	261.3	1.653E+03	215.0	7.458E+03	259.0	1.947E+04	66.9	5.699E+04	253.6
0.767	1.292	1.301	1.092E+03	85.1	1.974E+03	267.5	1.349E+03	229.0	6.841E+03	269.5	1.269E+04	86.5	5.183E+04	264.2
0.800	1.348	1.381	1.066E+03	104.8	1.763E+03	275.8	1.068E+03	251.1	6.001E+03	282.8	8.853E+03	130.5	4.483E+04	277.7
0.833	1.404	1.464	1.081E+03	126.2	1.491E+03	287.2	9.607E+02	285.7	5.084E+03	299.8	1.284E+04	176.0	3.703E+04	295.9
0.867	1.461	1.549	1.140E+03	146.3	1.192E+03	303.5	1.169E+03	320.3	4.189E+03	320.9	2.059E+04	195.0	2.974E+04	321.0
0.900	1.517	1.636	1.206E+03	163.9	9.381E+02	327.8	1.588E+03	342.5	3.393E+03	347.3	2.820E+04	204.1	2.543E+04	354.7
0.933	1.573	1.725	1.238E+03	179.3	8.241E+02	0.2	2.022E+03	356.3	2.859E+03	19.7	3.367E+04	210.8	2.577E+04	30.9
0.967	1.629	1.816	1.201E+03	195.0	8.664E+02	30.9	2.376E+03	6.7	2.652E+03	55.5	3.618E+04	216.8	2.863E+04	60.8
1.000	1.685	1.909	1.103E+03	211.6	9.545E+02	53.2	2.602E+03	15.9	2.692E+03	89.5	3.543E+04	222.9	3.048E+04	84.6
1.033	1.741	2.003	9.747E+02	230.8	9.821E+02	69.0	2.685E+03	24.7	2.766E+03	119.3	3.135E+04	229.4	2.921E+04	106.1
1.067	1.798	2.100	8.784E+02	253.7	9.084E+02	81.5	2.607E+03	34.1	2.707E+03	146.1	2.397E+04	235.3	2.464E+04	129.1
1.100	1.854	2.199	8.794E+02	277.0	7.416E+02	93.5	2.432E+03	42.3	2.483E+03	173.5	1.408E+04	226.0	1.852E+04	159.2
1.133	1.910	2.300	8.729E+02	297.2	5.287E+02	108.1	2.217E+03	43.8	2.162E+03	202.6	2.010E+04	156.2	1.442E+04	202.4
1.167	1.966	2.403	8.474E+02	315.5	3.410E+02	132.4	2.185E+03	49.2	1.826E+03	234.9	2.640E+04	178.3	1.452E+04	247.0
1.200	2.022	2.508	7.993E+02	329.6	2.662E+02	171.0	2.037E+03	45.9	1.567E+03	269.8	3.365E+04	183.0	1.547E+04	278.8
1.233	2.079	2.615	6.994E+02	344.8	3.037E+02	199.8	1.680E+03	44.6	1.398E+03	305.1	3.839E+04	184.4	1.417E+04	302.7
1.267	2.135	2.724	5.951E+02	4.9	3.518E+02	210.2	1.499E+03	28.6	1.245E+03	340.0	4.826E+04	184.5	1.012E+04	328.9
1.300	2.191	2.835	5.489E+02	30.4	3.687E+02	212.7	1.775E+03	5.0	1.084E+03	14.5	6.053E+04	184.8	5.729E+03	15.9
1.333	2.247	2.949	5.786E+02	54.5	3.462E+02	214.5	2.581E+03	350.7	9.062E+02	48.6	7.377E+04	185.3	5.681E+03	87.2
1.367	2.303	3.064	6.280E+02	72.5	2.827E+02	222.3	4.045E+03	346.1	6.981E+02	82.3	9.272E+04	184.3	7.154E+03	124.6
1.400	2.359	3.181	6.377E+02	88.1	2.058E+02	247.2	3.572E+03	349.4	4.760E+02	120.8	7.262E+04	195.5	6.263E+03	149.6
1.433	2.416	3.300	5.910E+02	105.7	2.063E+02	293.8	3.317E+03	349.0	3.292E+02	177.7	5.638E+04	199.5	3.428E+03	190.8
1.467	2.472	3.421	5.277E+02	130.5	2.984E+02	324.5	2.839E+03	352.4	3.234E+02	239.8	3.884E+04	205.9	3.669E+03	286.3
1.500	2.528	3.544	5.132E+02	161.3	3.687E+02	339.7	2.173E+03	360.0	3.221E+02	287.3	2.211E+04	218.1	6.511E+03	323.9

This page shows the output of the frequency characteristics of the internal loads of the ship, in a cross-section defined in the input data file, as a function of WAVE FREQ {= *w*}, SQRT SL/WL {= $ÖL_{pp}/l$} and ENC FREQ {= w_e}.

AMPL is the response amplitude operator (*RAO*) or transfer function of the loads, with a dimension depending on KPR(4). PHASE is the phase lag of the loads in degrees, relative to the wave elevation in the centre of gravity *G*.

Frequency Characteristics of Local Motions, KPR(4)=1 and |NPTS|>0

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ITTC-ship S-175.   Test of program SEAWAY, release 4.18.                SEAWAY-4.18  Date: 09-10-1999/23:17   Page:  27

FREQUENCY CHARACTERISTICS OF MOTIONS POINTS       FORWARD SPEED = 20.00 kn
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~     WAVE DIRECTION =  +150 deg off stern
POINT NR =       01
X-APP    = 148.750 m
Y-CL     =  12.000 m
Z-BL     =  24.000 m
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			............ABSOLUTE MOTIONS					....	..REL MOT..	
WAVE	SQRT	ENC	.....X.....		.....Y.....		.....Z.....		.....Z.....	
FREQ	SL/WL	FREQ	AMPL	PHASE	AMPL	PHASE	AMPL	PHASE	AMPL	PHASE
(r/s)	(-)	(r/s)	(m/m)	(deg)	(m/m)	(deg)	(m/m)	(deg)	(m/m)	(deg)
0.200	0.337	0.236	0.642	91.2	0.679	284.6	0.908	3.6	0.160	62.7
0.233	0.393	0.283	0.603	90.3	0.744	294.7	0.837	6.2	0.222	54.0
0.267	0.449	0.331	0.528	90.2	0.903	322.4	0.573	13.9	0.435	29.1
0.300	0.506	0.382	0.449	91.1	1.785	293.4	1.341	63.1	0.813	291.1
0.333	0.562	0.434	0.376	93.9	1.253	274.8	1.562	40.6	0.593	235.2
0.367	0.618	0.489	0.289	101.4	0.997	277.6	1.639	38.9	0.639	219.3
0.400	0.674	0.545	0.225	115.8	0.884	281.3	1.795	38.9	0.813	210.0
0.433	0.730	0.604	0.190	142.3	0.784	285.5	2.017	38.7	1.085	204.6
0.467	0.786	0.665	0.218	169.8	0.680	290.3	2.293	36.3	1.465	198.7
0.500	0.843	0.727	0.296	184.4	0.576	295.4	2.619	30.8	1.980	191.3
0.533	0.899	0.792	0.391	186.8	0.470	301.8	2.927	19.7	2.614	180.0
0.567	0.955	0.858	0.479	179.9	0.377	309.7	2.984	1.4	3.164	163.0
0.600	1.011	0.927	0.496	163.4	0.298	319.7	2.395	338.0	3.086	142.8
0.633	1.067	0.998	0.386	146.5	0.236	331.9	1.476	323.1	2.407	132.0
0.667	1.124	1.070	0.246	137.6	0.187	345.4	0.831	321.3	1.819	134.0
0.700	1.180	1.145	0.137	137.3	0.148	0.4	0.473	330.5	1.468	144.1
0.733	1.236	1.222	0.063	149.8	0.114	17.1	0.283	350.1	1.276	158.1
0.767	1.292	1.301	0.029	203.6	0.087	37.5	0.204	16.7	1.185	173.7
0.800	1.348	1.381	0.039	255.5	0.068	62.7	0.185	39.3	1.156	189.5
0.833	1.404	1.464	0.049	270.0	0.059	90.0	0.175	53.4	1.150	204.7
0.867	1.461	1.549	0.049	275.8	0.056	112.9	0.159	61.0	1.146	219.5
0.900	1.517	1.636	0.041	278.9	0.052	128.9	0.135	64.0	1.133	234.4
0.933	1.573	1.725	0.029	281.1	0.043	139.1	0.107	63.1	1.106	250.0
0.967	1.629	1.816	0.018	283.1	0.030	143.7	0.081	57.4	1.070	266.7
1.000	1.685	1.909	0.008	286.1	0.015	136.6	0.063	45.4	1.031	284.7
1.033	1.741	2.003	0.002	311.8	0.007	77.7	0.055	30.1	0.995	304.2
1.067	1.798	2.100	0.002	358.9	0.012	30.4	0.055	20.9	0.968	324.9
1.100	1.854	2.199	0.005	320.7	0.017	23.6	0.058	20.1	0.951	346.4
1.133	1.910	2.300	0.010	308.0	0.016	22.5	0.063	28.5	0.941	8.5
1.167	1.966	2.403	0.011	309.4	0.010	20.9	0.070	18.6	0.932	32.7
1.200	2.022	2.508	0.013	296.8	0.004	5.3	0.090	13.2	0.934	58.1
1.233	2.079	2.615	0.013	281.1	0.003	247.1	0.092	16.8	0.959	82.6
1.267	2.135	2.724	0.012	264.4	0.007	229.4	0.095	18.6	0.993	107.2
1.300	2.191	2.835	0.010	245.3	0.008	226.1	0.097	18.2	1.034	131.5
1.333	2.247	2.949	0.010	224.4	0.006	222.6	0.098	15.9	1.073	155.3
1.367	2.303	3.064	0.010	198.4	0.003	206.7	0.107	10.9	1.105	178.9
1.400	2.359	3.181	0.004	273.7	0.002	103.1	0.077	18.8	1.077	203.7
1.433	2.416	3.300	0.004	284.8	0.003	71.3	0.053	17.8	1.045	229.7
1.467	2.472	3.421	0.003	292.9	0.004	62.4	0.032	17.2	1.016	257.5
1.500	2.528	3.544	0.002	296.0	0.002	50.0	0.016	17.4	1.000	286.7

This page shows the output of the frequency characteristics of the absolute displacements in the three directions and the vertical relative displacements, in a point defined in the input data file, as a function of WAVE FREQ {= ω}, SQRT SL/WL {= $\sqrt{L_{pp}/\lambda}$} and ENC FREQ {= ω_e}. AMPL is the response amplitude operator (*RAO*) or transfer function of the displacements, with dimensions depending on KPR(4). PHASE is the phase lag of the displacements in degrees, relative to the wave elevation in the centre of gravity *G*.

Statistics of *CoG* Motions and Added Resistance, NSEA>0

ITTC-ship S-175. Test of program SEAWAY, release 4.18. SEAWAY-4.18 Date: 09-10-1999/23:17 Page: 29

STATISTICS OF CoG MOTIONS
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FORWARD SPEED = 20.00 kn
WAVE DIRECTION = +150 deg off stern

SEA INPUT HEIGHT (m)	SEA INPUT PER (s)	SEA CALCULATED HEIGHT (m)	SEA CALCULATED PER (s)	SURGE AMPL (m)	SURGE PER (s)	SWAY AMPL (m)	SWAY PER (s)	HEAVE AMPL (m)	HEAVE PER (s)	ROLL AMPL (deg)	ROLL PER (s)	PITCH AMPL (deg)	PITCH PER (s)	YAW AMPL (deg)	YAW PER (s)	MEAN ADDED RESISTANCE GER/BEU (kN)	MEAN ADDED RESISTANCE BOESE (kN)
1.10	5.35	1.04	6.37	0.02	6.01	0.02	5.46	0.10	5.22	0.11	5.48	0.16	6.20	0.06	5.70	4.4	2.6
1.20	5.45	1.13	6.45	0.02	6.16	0.02	5.67	0.12	5.50	0.13	5.62	0.19	6.29	0.07	5.79	5.8	3.7
1.40	5.55	1.33	6.53	0.03	6.29	0.03	5.87	0.15	5.75	0.16	5.75	0.25	6.38	0.08	5.88	8.8	6.1
1.70	5.60	1.62	6.58	0.03	6.36	0.04	5.98	0.20	5.87	0.20	5.81	0.32	6.41	0.11	5.92	13.7	9.7
2.15	6.00	2.07	6.91	0.06	6.80	0.07	6.73	0.36	6.54	0.34	6.24	0.57	6.67	0.17	6.23	31.9	26.8
2.90	6.65	2.83	7.47	0.13	7.40	0.16	7.61	0.73	7.10	0.66	6.81	1.11	6.97	0.32	6.66	88.2	85.1
3.75	7.20	3.68	7.96	0.23	7.88	0.29	8.18	1.18	7.39	1.06	7.24	1.72	7.19	0.50	7.00	179.6	182.9
4.90	7.75	4.83	8.46	0.39	8.35	0.50	8.67	1.78	7.64	1.63	7.66	2.52	7.39	0.73	7.32	335.8	351.6
6.10	8.30	6.04	8.96	0.59	8.82	0.77	9.13	2.44	7.88	2.32	8.09	3.36	7.58	1.00	7.63	528.6	562.1
7.45	8.85	7.39	9.47	0.84	9.29	1.12	9.57	3.17	8.13	3.17	8.57	4.24	7.76	1.29	7.92	760.4	815.5
8.70	9.30	8.64	9.88	1.09	9.68	1.47	9.93	3.83	8.35	4.04	9.01	5.01	7.91	1.55	8.15	980.0	1054.9
10.25	9.65	10.19	10.21	1.38	9.98	1.88	10.21	4.61	8.53	5.10	9.41	5.90	8.01	1.85	8.32	1286.1	1386.5

SIGNIFICANT VALUES OF (ANGULAR) VELOCITIES

SEA INPUT HEIGHT (m)	SEA INPUT PER (s)	SEA CALCULATED HEIGHT (m)	SEA CALCULATED PER (s)	SURGE AMPL (m/s)	SURGE PER (s)	SWAY AMPL (m/s)	SWAY PER (s)	HEAVE AMPL (m/s)	HEAVE PER (s)	ROLL AMPL (d/s)	ROLL PER (s)	PITCH AMPL (d/s)	PITCH PER (s)	YAW AMPL (d/s)	YAW PER (s)
1.10	5.35	1.04	6.37	0.02	5.35	0.02	4.87	0.12	3.67	0.12	4.83	0.16	5.56	0.06	5.28
1.20	5.45	1.13	6.45	0.02	5.53	0.02	5.01	0.13	3.88	0.14	4.96	0.19	5.73	0.07	5.38
1.40	5.55	1.33	6.53	0.03	5.69	0.03	5.17	0.17	4.11	0.18	5.10	0.25	5.87	0.09	5.48
1.70	5.60	1.62	6.58	0.03	5.77	0.04	5.25	0.21	4.23	0.22	5.16	0.32	5.94	0.11	5.53
2.15	6.00	2.07	6.91	0.06	6.31	0.06	5.95	0.34	5.15	0.35	5.64	0.54	6.33	0.18	5.85
2.90	6.65	2.83	7.47	0.11	6.96	0.13	6.95	0.65	6.21	0.61	6.25	1.00	6.70	0.30	6.27
3.75	7.20	3.68	7.96	0.19	7.41	0.22	7.59	1.00	6.73	0.92	6.66	1.50	6.92	0.45	6.57
4.90	7.75	4.83	8.46	0.29	7.83	0.36	8.10	1.46	7.07	1.34	7.03	2.14	7.10	0.63	6.84
6.10	8.30	6.04	8.96	0.42	8.22	0.53	8.54	1.94	7.33	1.80	7.38	2.78	7.25	0.82	7.08
7.45	8.85	7.39	9.47	0.57	8.61	0.74	8.94	2.44	7.55	2.32	7.73	3.43	7.39	1.02	7.30
8.70	9.30	8.64	9.88	0.71	8.92	0.93	9.25	2.88	7.71	2.81	8.03	3.97	7.49	1.19	7.47
10.25	9.65	10.19	10.21	0.87	9.16	1.15	9.48	3.39	7.84	3.40	8.28	4.62	7.56	1.40	7.59

SIGNIFICANT VALUES OF (ANGULAR) ACCELERATIONS

SEA INPUT HEIGHT (m)	SEA INPUT PER (s)	SEA CALCULATED HEIGHT (m)	SEA CALCULATED PER (s)	SURGE AMPL (m/s2)	SURGE PER (s)	SWAY AMPL (m/s2)	SWAY PER (s)	HEAVE AMPL (m/s2)	HEAVE PER (s)	ROLL AMPL (d/s2)	ROLL PER (s)	PITCH AMPL (d/s2)	PITCH PER (s)	YAW AMPL (d/s2)	YAW PER (s)
1.10	5.35	1.04	6.37	0.02	4.42	0.03	4.37	0.20	2.71	0.16	4.15	0.18	4.23	0.07	4.68
1.20	5.45	1.13	6.45	0.02	4.59	0.03	4.46	0.22	2.77	0.18	4.26	0.21	4.45	0.08	4.80
1.40	5.55	1.33	6.53	0.03	4.76	0.04	4.55	0.25	2.85	0.22	4.36	0.27	4.66	0.10	4.90
1.70	5.60	1.62	6.58	0.04	4.84	0.04	4.61	0.31	2.89	0.27	4.42	0.33	4.76	0.13	4.95
2.15	6.00	2.07	6.91	0.06	5.46	0.07	5.09	0.42	3.32	0.39	4.83	0.53	5.43	0.19	5.31
2.90	6.65	2.83	7.47	0.10	6.25	0.12	5.99	0.66	4.18	0.61	5.44	0.93	6.10	0.30	5.76
3.75	7.20	3.68	7.96	0.16	6.75	0.18	6.68	0.94	4.85	0.87	5.85	1.36	6.43	0.43	6.05
4.90	7.75	4.83	8.46	0.23	7.17	0.28	7.25	1.30	5.38	1.19	6.20	1.89	6.65	0.58	6.29
6.10	8.30	6.04	8.96	0.32	7.53	0.39	7.71	1.66	5.79	1.53	6.51	2.41	6.82	0.73	6.49
7.45	8.85	7.39	9.47	0.41	7.85	0.52	8.11	2.03	6.10	1.89	6.78	2.92	6.94	0.88	6.66
8.70	9.30	8.64	9.88	0.50	8.10	0.63	8.40	2.34	6.31	2.20	7.00	3.33	7.03	1.00	6.79
10.25	9.65	10.19	10.21	0.60	8.29	0.76	8.60	2.71	6.45	2.58	7.16	3.84	7.09	1.16	6.88

This page shows the output of the significant amplitudes and average periods of the centre of gravity (*CoG*) motions and the mean added resistance of the ship as a function of the sea-state parameters HEIGHT {= $H_{1/3}$} and PER {= T_1 or T_2}, depending on the sign of KSEA. These sea-state parameters are printed as they were given in the input data file and as they were calculated from the wave spectra in the frequency range defined by OMMIN {= ω_{min}}, OMMAX {= ω_{max}} and OMINC {= $\Delta\omega$}. **Always, use the input sea-state as a reference**. AMPL is the significant amplitude $2\sqrt{m_0}$ of the motions in meters or degrees. PER is the average period of the motions in seconds. Depending on the sign of KSEA, this period is defined by T_1 or T_2. The MEAN ADDED RESISTANCE has dimensions depending on RHO {= ρ}.
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Example of Spectra of *CoG* Motions and Added Resist., KPR(5)=3 and NSEA>0

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ITTC-ship S-175.   Test of program SEAWAY, release 4.18.                    SEAWAY-4.18  Date: 09-10-1999/23:17   Page:  36

SPECTRA OF CoG MOTIONS                          FORWARD SPEED = 20.00 kn
~~~~~~~~~~~~~~~~~~~~~~~~                       WAVE DIRECTION =  +150 deg off stern
SPECTRUM NR =    07
WAVE HEIGHT =  3.75 m
WAVE PERIOD =  7.20 s
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ENC FREQ (r/s)	WAVE (m2s)	SURGE (m2s)	SWAY (m2s)	HEAVE (m2s)	ROLL (deg2s)	PITCH (deg2s)	YAW (deg2s)	ADDED RESISTANCE GER/BEU (kNs)	ADDED RESISTANCE BOESE (kNs)
0.236	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
0.283	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
0.331	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
0.382	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
0.434	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
0.489	0.002	0.000	0.001	0.002	0.005	0.001	0.000	0.01	0.00
0.545	0.026	0.005	0.010	0.025	0.045	0.023	0.004	0.17	0.09
0.604	0.124	0.017	0.035	0.118	0.185	0.151	0.022	2.06	1.85
0.665	0.319	0.034	0.066	0.326	0.417	0.527	0.065	12.56	13.28
0.727	0.562	0.044	0.078	0.682	0.663	1.214	0.119	49.42	55.43
0.792	0.775	0.042	0.065	1.224	0.768	2.079	0.156	141.13	161.25
0.858	0.910	0.032	0.040	1.613	0.737	2.775	0.165	280.60	324.95
0.927	0.959	0.020	0.018	0.968	0.574	2.472	0.143	313.62	369.99
0.998	0.939	0.010	0.005	0.190	0.395	1.199	0.108	192.93	224.34
1.070	0.876	0.004	0.001	0.010	0.222	0.389	0.067	99.45	102.44
1.145	0.789	0.001	0.000	0.006	0.106	0.096	0.036	54.09	41.46
1.222	0.694	0.000	0.001	0.013	0.038	0.015	0.015	33.15	13.96
1.301	0.601	0.000	0.001	0.014	0.008	0.001	0.004	23.23	3.13
1.381	0.516	0.000	0.001	0.011	0.001	0.002	0.001	17.94	0.05
1.464	0.439	0.000	0.001	0.007	0.002	0.004	0.000	14.35	0.00
1.549	0.373	0.000	0.000	0.005	0.005	0.005	0.001	11.27	0.41
1.636	0.316	0.000	0.000	0.003	0.006	0.003	0.001	8.48	0.97
1.725	0.268	0.000	0.000	0.002	0.005	0.002	0.001	6.07	1.20
1.816	0.227	0.000	0.000	0.001	0.004	0.001	0.000	4.16	1.12
1.909	0.192	0.000	0.000	0.001	0.002	0.000	0.000	2.77	0.87
2.003	0.163	0.000	0.000	0.001	0.001	0.000	0.000	1.81	0.56
2.100	0.139	0.000	0.000	0.001	0.000	0.000	0.000	1.16	0.28
2.199	0.119	0.000	0.000	0.001	0.000	0.000	0.000	0.70	0.08
2.300	0.102	0.000	0.000	0.001	0.000	0.000	0.000	0.31	0.00
2.403	0.088	0.000	0.000	0.001	0.000	0.000	0.000	0.00	0.00
2.508	0.075	0.000	0.000	0.001	0.000	0.000	0.000	0.00	0.00
2.615	0.065	0.000	0.000	0.001	0.000	0.000	0.000	0.00	0.00
2.724	0.056	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
2.835	0.049	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
2.949	0.043	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
3.064	0.037	0.000	0.000	0.000	0.000	0.000	0.000	0.02	0.00
3.181	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.04
3.300	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
3.421	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
3.544	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.00	0.00
A-1/3:	1.841	0.234	0.288	1.182	1.060	1.722	0.497		
T-01 :	8.274	7.988	8.301	7.488	7.371	7.254	7.112		
T-02 :	7.960	7.876	8.176	7.391	7.240	7.190	7.003		
MEAN :								179.60	182.86

This page shows the output of an example of the spectral distributions of the waves, the basic ship motions and the added resistance. Because KSEA is positive, these spectra are based here on the frequency of encounter ENC FREQ {= ω_e}. The dimensions of the spectral values of the motions are m^2s or deg^2s. Also the significant amplitudes $2\sqrt{m_0}$ and average wave periods, defined by T_1 and T_2, are given.
The dimensions of the spectra of the added resistance are Ns or kNs, depending on the input value of RHO {= ρ}. Also the mean added resistance is given.

Statistics of Internal Loads, NBTM>0 and NSEA>0

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ITTC-ship S-175.   Test of program SEAWAY, release 4.18.                    SEAWAY-4.18  Date: 09-10-1999/23:17   Page:  42

STATISTICS OF INTERNAL LOADS                FORWARD SPEED = 20.00 kn
~~~~~~~~~~~~~~~~~~~~~~~~~~~~               WAVE DIRECTION =  +150 deg off stern

SECTION NR =      01
X-APP      = 131.250 m
Y-CL       =   0.000 m
Z-BL       =   9.550 m
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		............SIGNIFICANT VALUES OF............											
		......INTERNAL FORCES......						......INTERNAL MOMENTS......					
.....SEA....		......F-x......		......F-y......		......F-z......		......M-x......		......M-y......		......M-z......	
HEIGHT	PER	AMPL	PER	AMPL	PER	AMPL	PER	AMPL	PER	AMPL	PER	AMPL	PER
(m)	(s)	(kN)	(s)	(kN)	(s)	(kN)	(s)	(kNm)	(s)	(kNm)	(s)	(kNm)	(s)
1.10	5.35	5.307E+02	3.62	6.686E+02	4.42	1.078E+03	2.88	2.318E+03	4.49	1.690E+04	2.53	1.842E+04	4.38
1.20	5.45	5.846E+02	3.68	7.528E+02	4.48	1.176E+03	2.94	2.613E+03	4.55	1.818E+04	2.56	2.077E+04	4.46
1.40	5.55	6.880E+02	3.73	9.038E+02	4.55	1.374E+03	3.00	3.142E+03	4.61	2.092E+04	2.59	2.497E+04	4.53
1.70	5.60	8.388E+02	3.76	1.112E+03	4.58	1.670E+03	3.03	3.868E+03	4.64	2.523E+04	2.60	3.075E+04	4.57
2.15	6.00	1.085E+03	3.98	1.531E+03	4.81	2.153E+03	3.31	5.332E+03	4.86	3.030E+04	2.73	4.267E+04	4.82
2.90	6.65	1.477E+03	4.30	2.217E+03	5.11	3.055E+03	3.87	7.675E+03	5.12	3.781E+04	2.94	6.260E+04	5.16
3.75	7.20	1.881E+03	4.55	2.908E+03	5.31	4.098E+03	4.33	9.964E+03	5.28	4.597E+04	3.13	8.289E+04	5.39
4.90	7.75	2.383E+03	4.76	3.745E+03	5.48	5.450E+03	4.75	1.268E+04	5.41	5.660E+04	3.32	1.076E+05	5.58
6.10	8.30	2.841E+03	4.94	4.507E+03	5.63	6.768E+03	5.09	1.512E+04	5.52	6.642E+04	3.50	1.303E+05	5.74
7.45	8.85	3.294E+03	5.10	5.250E+03	5.75	8.103E+03	5.37	1.754E+04	5.64	7.642E+04	3.68	1.525E+05	5.87
8.70	9.30	3.669E+03	5.22	5.860E+03	5.84	9.216E+03	5.56	1.967E+04	5.76	8.491E+04	3.81	1.708E+05	5.96
10.25	9.65	4.157E+03	5.29	6.647E+03	5.90	1.058E+04	5.69	2.257E+04	5.89	9.618E+04	3.90	1.942E+05	6.03

This page shows the output of the significant amplitudes and average periods of the internal loads in a cross-section of the ship as a function of the sea-state parameters HEIGHT {= $H_{1/3}$ } and PER {= T_1 or T_2}, depending on the sign of KSEA.
AMPL is the significant amplitude $2Öm_0$ of the loads in Nm or kNm, depending on RHO {= r}. PER is the average period of the loads in seconds. Depending on the sign of KSEA, this period is defined by T_1 or T_2.

Example of Spectra of Internal Loads, KPR(5)=3, NBTM>0 and NSEA>0

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ITTC-ship S-175.   Test of program SEAWAY, release 4.18.                SEAWAY-4.18  Date: 09-10-1999/23:17   Page:  49

SPECTRA OF LOADS IN SECTION: 01              FORWARD SPEED = 20.00 kn
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~              WAVE DIRECTION =  +150 deg off stern
SPECTRUM NR =    07
WAVE HEIGHT =  3.75 m
WAVE PERIOD =  7.20 s
```

ENC FREQ (r/s)	WAVE (m2s)	F-x (kN)	F-y (kN)	F-z (kN)	M-x (kNm)	M-y (kNm)	M-z (kNm)
0.200	0.000	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
0.233	0.000	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01	0.000E-01
0.267	0.000	4.088E-10	4.217E-09	1.791E-13	2.476E+02	0.000E-01	1.631E-14
0.300	0.000	4.632E-04	1.531E-03	5.016E-08	8.679E+07	0.000E-01	3.129E-09
0.333	0.000	2.586E+00	1.876E+00	1.053E-05	1.244E+11	8.880E-01	4.597E-06
0.367	0.003	5.703E+02	1.172E+02	6.445E-06	9.181E+12	2.834E+01	6.782E-04
0.400	0.045	1.804E+04	1.398E+03	1.754E-06	1.240E+14	1.396E+02	0.000E-01
0.433	0.221	1.838E+05	6.252E+03	2.906E-05	6.103E+14	5.861E+03	0.000E-01
0.467	0.589	9.157E+05	1.538E+04	6.409E-07	1.620E+15	0.000E-01	0.000E-01
0.500	1.072	2.862E+06	2.568E+04	4.080E-07	0.000E-01	0.000E-01	0.000E-01
0.533	1.526	6.296E+06	3.277E+04	5.112E-08	0.000E-01	0.000E-01	0.000E-01
0.567	1.847	9.429E+06	3.421E+04	8.411E-09	2.441E+16	0.000E-01	0.000E-01
0.600	2.004	8.266E+06	3.226E+04	1.083E-09	1.742E+16	0.000E-01	1.886E-01
0.633	2.021	5.302E+06	3.222E+04	6.999E-10	1.027E+16	0.000E-01	2.896E-05
0.667	1.936	3.811E+06	3.316E+04	8.342E+10	3.576E+15	1.729E+00	2.331E-04
0.700	1.792	2.823E+06	3.294E+04	2.756E+10	2.663E+15	1.291E+00	8.458E-04
0.733	1.619	1.896E+06	3.208E+04	1.357E+10	2.481E+15	2.832E-01	2.088E-03
0.767	1.439	1.095E+06	3.154E+04	9.567E+09	2.352E+15	5.351E-03	4.104E-03
0.800	1.266	5.884E+05	3.252E+04	7.797E+09	2.166E+15	5.490E-01	6.943E-03
0.833	1.105	4.055E+05	3.586E+04	6.404E-02	0.000E-01	4.230E-01	1.057E-02
0.867	0.960	5.094E+05	3.826E+04	1.647E-01	0.000E-01	1.832E-02	1.490E-02
0.900	0.833	7.963E+05	3.706E+04	3.145E-01	0.000E-01	0.000E-01	0.000E-01
0.933	0.721	1.094E+06	3.397E+04	5.105E-01	1.983E+06	0.000E-01	0.000E-01
0.967	0.625	1.279E+06	1.028E+01	7.473E-01	1.786E+06	0.000E-01	1.062E-01
1.000	0.542	1.302E+06	4.851E+01	1.018E+00	1.064E+06	0.000E-01	4.295E-02
1.033	0.471	1.179E+06	1.001E+02	1.315E+00	6.140E+05	0.000E-01	8.787E-03
1.067	0.409	9.469E+05	1.618E+02	1.630E+00	2.416E+05	0.000E-01	1.880E-04
1.100	0.357	7.035E+05	2.126E+02	0.000E-01	5.857E+04	0.000E-01	4.663E-05
1.133	0.312	5.006E+05	1.952E+02	0.000E-01	5.131E+04	0.000E-01	3.516E-06
1.167	0.273	4.186E+05	2.122E+02	3.237E-08	4.407E+04	5.259E+00	1.132E-06
1.200	0.240	3.128E+05	1.586E+02	9.127E-01	0.000E-01	2.089E-02	3.497E-07
1.233	0.211	1.838E+05	1.297E+02	2.254E-01	0.000E-01	1.869E-03	0.000E-01
1.267	0.186	1.267E+05	4.608E+01	6.166E-05	6.487E+09	2.049E-06	0.000E-01
1.300	0.165	1.543E+05	1.212E+00	1.298E-06	1.351E+09	1.534E-03	0.000E-01
1.333	0.146	2.841E+05	5.245E+03	1.323E-09	1.351E+09	3.165E-03	2.196E-02
1.367	0.130	6.093E+05	4.461E+03	6.250E-12	4.711E+08	1.250E-02	5.186E-03
1.400	0.116	4.159E+05	3.981E+03	2.049E-13	4.049E+07	0.000E-01	2.829E-05
1.433	0.103	3.150E+05	3.487E+03	0.000E-01	7.305E+06	0.000E-01	4.453E-05
1.467	0.092	2.031E+05	3.128E+03	0.000E-01	4.930E+07	0.000E-01	1.617E-06
1.500	0.083	1.050E+05	2.880E+03	7.424E-13	7.221E+07	0.000E-01	9.917E-08
A-1/3:	1.841	1.881E+03	2.908E+03	4.098E+03	9.964E+03	4.597E+04	8.289E+04
T-01 :	1.841	4.790	5.461	4.847	5.405	3.438	5.552
T-02 :	1.841	4.546	5.315	4.333	5.282	3.132	5.392

This page shows the output of an example of the spectral distributions of the internal loads in a cross-section of the ship. Because KSEA is positive, these spectra are based here on the frequency of encounter ENC FREQ {= ω_e}. The dimensions of the spectral values of the loads are N, Nm, kN or kNm, depending on the kind of load and the input value of RHO {= ρ}.

Also the significant amplitudes and average wave periods, defined by T_1 or T_2 are given.

Statistics of Local Motions, |NPTS|>0 and NSEA>0

ITTC-ship S-175. Test of program SEAWAY, release 4.18. SEAWAY-4.18 Date: 09-10-1999/23:17 Page: 55

STATISTICS OF MOTIONS IN POINTS FORWARD SPEED = 20.00 kn
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ WAVE DIRECTION = +150 deg off stern

POINT NR = 01
X-APP = 148.750 m
Y-CL = 12.000 m
Z-BL = 24.000 m

.....SEA....		....SIGNIFICANT VALUES OF....																	
		..........DISPLACEMENTS..........						...........VELOCITIES............						..........ACCELERATIONS..........					
		....X....		....Y....		....Z....		....X....		....Y....		....Z....		....X....		....Y....		....Z....	
HEIGHT (m)	PER (s)	AMPL (m)	PER (s)	AMPL (m)	PER (s)	AMPL (m)	PER (s)	AMPL (m/s)	PER (s)	AMPL (m/s)	PER (s)	AMPL (m/s)	PER (s)	AMPL (m/s2)	PER (s)	AMPL (m/s2)	PER (s)	AMPL (m/s2)	PER (s)
1.10	5.35	0.05	6.03	0.04	5.49	0.23	6.13	0.06	5.52	0.05	4.97	0.24	5.08	0.09	4.97	0.06	4.22	0.30	3.40
1.20	5.45	0.06	6.11	0.05	5.61	0.29	6.27	0.07	5.65	0.06	5.09	0.29	5.32	0.10	5.16	0.07	4.32	0.34	3.60
1.40	5.55	0.08	6.19	0.07	5.74	0.38	6.39	0.08	5.77	0.07	5.21	0.37	5.54	0.13	5.33	0.08	4.43	0.42	3.81
1.70	5.60	0.10	6.23	0.08	5.80	0.48	6.44	0.11	5.82	0.09	5.26	0.47	5.64	0.16	5.40	0.10	4.49	0.52	3.91
2.15	6.00	0.18	6.45	0.14	6.29	0.88	6.77	0.17	6.14	0.14	5.72	0.81	6.23	0.27	5.89	0.15	4.97	0.82	4.72
2.90	6.65	0.32	6.71	0.29	7.03	1.76	7.12	0.30	6.46	0.26	6.41	1.55	6.77	0.47	6.34	0.25	5.79	1.44	5.70
3.75	7.20	0.48	6.88	0.50	7.61	2.80	7.36	0.44	6.63	0.41	6.95	2.39	7.04	0.68	6.58	0.39	6.44	2.14	6.21
4.90	7.75	0.68	7.02	0.81	8.16	4.18	7.57	0.61	6.77	0.63	7.44	3.47	7.24	0.94	6.75	0.58	7.03	3.01	6.55
6.10	8.30	0.88	7.17	1.22	8.69	5.65	7.77	0.77	6.88	0.88	7.91	4.56	7.42	1.20	6.87	0.81	7.57	3.86	6.78
7.45	8.85	1.09	7.34	1.75	9.22	7.22	7.97	0.93	6.99	1.19	8.36	5.69	7.57	1.44	6.98	1.10	8.09	4.72	6.96
8.70	9.30	1.27	7.51	2.29	9.66	8.61	8.13	1.06	7.08	1.49	8.72	6.65	7.69	1.65	7.05	1.37	8.52	5.43	7.08
10.25	9.65	1.50	7.67	2.93	10.0	10.2	8.26	1.23	7.15	1.84	9.00	7.77	7.77	1.89	7.10	1.70	8.86	6.28	7.16

.....SEA....		........VERTICAL RELATIVE MOTIONS........						...SLAMMING DEFINED BY...			
		..SIGNIFICANT VALUES OF...				.EXCEEDING.		....BOW EMERGENCE AND....			
		DISPLACEMENT		.VELOCITY.		....Z-BL...		.VELOCITY.		.PRESSURE.	
HEIGHT (m)	PER (s)	AMPL (m)	PER (s)	AMPL (m/s)	PER (s)	PROB (%)	NR/H (1/h)	PROB (%)	NR/H (1/h)	PROB (%)	NR/H (1/h)
1.10	5.35	0.64	3.65	0.62	3.16	0.0	0.0	0.0	0.0	0.0	0.0
1.20	5.45	0.72	3.77	0.69	3.25	0.0	0.0	0.0	0.0	0.0	0.0
1.40	5.55	0.86	3.90	0.82	3.35	0.0	0.0	0.0	0.0	0.0	0.0
1.70	5.60	1.07	3.96	1.01	3.40	0.0	0.0	0.0	0.0	0.0	0.0
2.15	6.00	1.54	4.49	1.38	3.84	0.0	0.0	0.0	0.0	0.0	0.0
2.90	6.65	2.46	5.23	2.10	4.55	0.0	0.0	0.0	0.0	0.0	0.0
3.75	7.20	3.49	5.70	2.89	5.04	0.0	0.0	0.0	0.0	0.0	0.0
4.90	7.75	4.78	6.05	3.88	5.42	0.0	0.0	0.0	0.1	0.0	0.1
6.10	8.30	6.03	6.31	4.83	5.71	0.0	0.0	0.3	1.8	0.4	1.9
7.45	8.85	7.29	6.51	5.78	5.93	0.0	0.2	1.8	10.0	2.3	10.3
8.70	9.30	8.34	6.65	6.55	6.08	0.2	1.3	4.4	24.3	5.4	24.1
10.25	9.65	9.60	6.74	7.51	6.17	1.0	5.6	9.4	50.6	10.9	48.3

This page shows the output of the significant amplitudes and average periods of the motions in a selected point on the ship as a function of the sea-state parameters HEIGHT {= $H_{1/3}$} and PER {= T_1 or T_2}, depending on the sign of KSEA.
AMPL is the significant amplitude $2\sqrt{m_0}$ of the motions in meters. PER is the average period of the motions in seconds. Depending on the sign of KSEA, this period is defined by T_1 or T_2.
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Example of Spectra of Local Motions, KPR(5)=3, |NPTS|>0 and NSEA>0

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SPECTRA OF MOTIONS IN POINTS FORWARD SPEED = 20.00 kn
~~~~~~~~~~~~~~~~~~~~~~~~~~~~ WAVE DIRECTION = +150 deg off stern
SPECTRUM NR = 07
WAVE HEIGHT = 3.75 m
WAVE PERIOD = 7.20 s

ENC		.... POINT 01				.... POINT 02			
FREQ	WAVE	...X...	...Y...	...Z...	..Z-r..	...X...	...Y...	...Z...	..Z-r..
(r/s)	(m2s)	(m2s)	(m2s)	(m2s)	(m2s)	(m2s)	(m2s)	(m2s)	(m2s)
0.236	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.283	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.331	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.382	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.434	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.489	0.002	0.000	0.002	0.006	0.001	0.000	0.002	0.006	0.001
0.545	0.026	0.001	0.021	0.085	0.017	0.004	0.020	0.104	0.035
0.604	0.124	0.004	0.076	0.504	0.146	0.012	0.088	0.662	0.332
0.665	0.319	0.015	0.147	1.677	0.685	0.022	0.204	2.311	1.623
0.727	0.562	0.049	0.186	3.855	2.202	0.027	0.309	5.461	5.109
0.792	0.775	0.118	0.171	6.640	5.293	0.028	0.351	9.580	11.463
0.858	0.910	0.209	0.130	8.099	9.105	0.031	0.334	12.044	17.743
0.927	0.959	0.236	0.085	5.500	9.131	0.033	0.274	8.826	15.596
0.998	0.939	0.140	0.052	2.047	5.442	0.022	0.205	3.590	7.621
1.070	0.876	0.053	0.031	0.605	2.897	0.009	0.131	1.100	3.018
1.145	0.789	0.015	0.017	0.176	1.700	0.003	0.074	0.297	1.352
1.222	0.694	0.003	0.009	0.056	1.129	0.000	0.034	0.073	0.858
1.301	0.601	0.000	0.005	0.025	0.844	0.000	0.013	0.026	0.727
1.381	0.516	0.001	0.002	0.018	0.690	0.000	0.004	0.022	0.648
1.464	0.439	0.001	0.002	0.013	0.581	0.000	0.002	0.021	0.536
1.549	0.373	0.001	0.001	0.009	0.490	0.000	0.002	0.017	0.404
1.636	0.316	0.001	0.001	0.006	0.406	0.000	0.002	0.012	0.289
1.725	0.268	0.000	0.000	0.003	0.327	0.000	0.001	0.007	0.214
1.816	0.227	0.000	0.000	0.001	0.260	0.000	0.001	0.003	0.176
1.909	0.192	0.000	0.000	0.001	0.204	0.000	0.000	0.002	0.162
2.003	0.163	0.000	0.000	0.000	0.162	0.000	0.000	0.001	0.154
2.100	0.139	0.000	0.000	0.000	0.131	0.000	0.000	0.000	0.144
2.199	0.119	0.000	0.000	0.000	0.108	0.000	0.000	0.000	0.130
2.300	0.102	0.000	0.000	0.000	0.090	0.000	0.000	0.000	0.114
2.403	0.088	0.000	0.000	0.000	0.076	0.000	0.000	0.000	0.098
2.508	0.075	0.000	0.000	0.001	0.066	0.000	0.000	0.001	0.080
2.615	0.065	0.000	0.000	0.001	0.060	0.000	0.000	0.001	0.062
2.724	0.056	0.000	0.000	0.001	0.056	0.000	0.000	0.001	0.048
2.835	0.049	0.000	0.000	0.000	0.052	0.000	0.000	0.001	0.039
2.949	0.043	0.000	0.000	0.000	0.049	0.000	0.000	0.001	0.036
3.064	0.037	0.000	0.000	0.000	0.045	0.000	0.000	0.001	0.038
3.181	0.033	0.000	0.000	0.000	0.038	0.000	0.000	0.000	0.035
3.300	0.029	0.000	0.000	0.000	0.031	0.000	0.000	0.000	0.032
3.421	0.025	0.000	0.000	0.000	0.026	0.000	0.000	0.000	0.027
3.544	0.022	0.000	0.000	0.000	0.022	0.000	0.000	0.000	0.023
A-1/3:	1.841	0.483	0.497	2.805	3.487	0.227	0.743	3.447	4.382
T-01 :	8.274	6.933	7.763	7.423	6.047	7.462	7.262	7.364	6.548
T-02 :	7.960	6.876	7.609	7.355	5.699	7.342	7.130	7.298	6.244

This page shows the output of an example of the spectral distributions of the motions in a selected point on the ship. Because KSEA is positive, these spectra are based here on the frequency of encounter ENC FREQ {= ω_e}. Also the significant amplitudes and average wave periods, defined by T_1 or T_2 are given.
~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Additional Statistics of Slamming, NSEA>0 and KRIT=1

```
ITTC-ship S-175.   Test of program SEAWAY, release 4.18.                SEAWAY-4.18  Date: 09-10-1999/23:17   Page:  69

ADDITIONAL STATISTICS OF SLAMMING                FORWARD SPEED = 20.00 kn
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~               WAVE DIRECTION =  +150 deg off stern
X-APP = 157.500 m
```

.....SEA....		........VERTICAL RELATIVE MOTIONS........ ..SIGNIFICANT VALUES OF...				....BOW....		...SLAMMING DEFINED BY... ....BOW EMERGENCE AND....			
		DISPLACEMENT		.VELOCITY.		.EMERGENCE.		.VELOCITY.		.PRESSURE.	
HEIGHT (m)	PER (s)	AMPL (m)	PER (s)	AMPL (m/s)	PER (s)	PROB (%)	NR/H (1/h)	PROB (%)	NR/H (1/h)	PROB (%)	NR/H (1/h)
1.10	5.35	0.65	3.71	0.63	3.25	0.0	0.0	0.0	0.0	0.0	0.0
1.20	5.45	0.73	3.84	0.70	3.35	0.0	0.0	0.0	0.0	0.0	0.0
1.40	5.55	0.89	3.99	0.84	3.46	0.0	0.0	0.0	0.0	0.0	0.0
1.70	5.60	1.10	4.06	1.03	3.52	0.0	0.0	0.0	0.0	0.0	0.0
2.15	6.00	1.61	4.63	1.43	4.01	0.0	0.0	0.0	0.0	0.0	0.0
2.90	6.65	2.65	5.42	2.23	4.76	0.0	0.0	0.0	0.0	0.0	0.0
3.75	7.20	3.81	5.90	3.11	5.26	0.0	0.0	0.0	0.0	0.0	0.0
4.90	7.75	5.26	6.23	4.20	5.63	0.1	0.8	0.1	0.3	0.1	0.6
6.10	8.30	6.67	6.48	5.25	5.91	1.7	9.6	0.8	4.7	1.6	7.3
7.45	8.85	8.08	6.66	6.28	6.11	6.3	33.9	3.8	20.4	6.0	26.8
8.70	9.30	9.23	6.78	7.12	6.24	12.0	63.9	8.0	42.6	11.6	51.5
10.25	9.65	10.63	6.86	8.15	6.33	20.3	106.3	14.8	77.7	19.7	86.8

This page shows the output of the significant amplitudes and average periods of the vertical relative displacements and velocities of a keel-point at the centre line of the ship as a function of the sea-state parameters HEIGHT {= $H_{1/3}$} and PER {= T_1 or T_2}, depending on the sign of KSEA.

The dynamic swell-up of the waves, obtained from the radiated waves, is included in the relative motions.

AMPL the significant amplitude of the relative displacements and velocities in m and m/s, respectively. PER is the average period of the motions in seconds. Depending on the sign of KSEA, this period is defined by T_1 or T_2.

Also the probability PROB on bow emergence and the number per hour NR/H that this happens are given.

The slamming phenomena are defined by a relative VELOCITY criterion, as defined by [Ochi, 1964], and a PRESSURE criterion, as defined by [Conolly, 1974], with threshold values as given in the input data file. The algorithms of these calculations are given in the theoretical manual, see [Journée, 2001b].

5.4 Restrictions of Linear Strip Theory

The ship is considered to be a rigid body floating in an ideal fluid: homogeneous, incompressible, free of surface tension, irrotational and without viscosity. It is assumed that the problem of the motions of this floating body in waves is linear or can be linearized. As a result of this, only the external loads on the underwater part of the ship are considered and the effect of the above water part is fully neglected.
The incorporation of seakeeping theories in ship design has been discussed clearly by [Faltinsen and Svensen, 1990]. They concluded that - nevertheless some limitations - strip theories are the most successful and practical tools for the calculation of the wave induced motions of the ship, at least in an early design stage of a ship.

With respect to the limitations of the linear strip theory, some remarks have been given:

- The strip theory solves the three-dimensional problem of the hydromechanical and exciting wave forces and moments on the ship by integrating the two-dimensional potential solutions over the ship's length. Interactions between the cross sections are ignored for the zero-speed case. So each cross section of the ship is considered to be part of an infinitely long cylinder.
- The strip theory is a slender body theory, so one should expect less accurate predictions for ships with low length to breadth ratios. However, experiments showed that the strip theory appears to be remarkably effective for predicting the motions of ships with length to breadth ratios down to about 3.0, or even sometimes lower.
- The strip theory is based on the potential flow theory. This holds that viscous effects are neglected, which can deliver serious problems when predicting roll motions at resonance frequencies. In practice, for viscous roll damping effects can be accounted fairly by empirical formulas.
- Because of the way that the forced motion problems are solved generally in the strip theory, substantial disagreements can be found between the calculated results and the experimental data of the wave loads at low frequencies of encounter in following waves. In practice, these "near zero frequency of encounter problems" can be solved here by forcing the wave loads to go to zero artificially.
- For high-speed vessels and for large ship motions, as appear in extreme sea states, the strip theory can deliver less accurate results. Then, the so-called "end-terms" can be important too.
- The strip theory accounts for the interaction with the forward speed in a very simple way. The effect of the steady wave system around the ship is neglected and the free surface conditions are simplified, so that the unsteady waves generated by the ship are propagating in directions perpendicular to the centre plane of the ship. In reality the wave systems around the ship are far more complex. For high-speed vessels, unsteady divergent wave systems become important. This effect is neglected in the strip theory.
- The strip theory is based on linearity. This means that the ship motions are supposed to be small, relative to the cross sectional dimensions of the ship. Only hydrodynamic effects of the hull below the still water level are accounted for. So when parts of the ship go out of or into the water or when green water is shipped, inaccuracies can be expected. Also, the strip theory does not distinguish between alternative above water hull forms.
- In general, the overall wave loads and resulting ship motions will be calculated fairly well by the linear strip theory, but this is not always the case for the local loads. The next

figure shows a comparison between computed linear and non-linear amidships bending moments in a frigate.

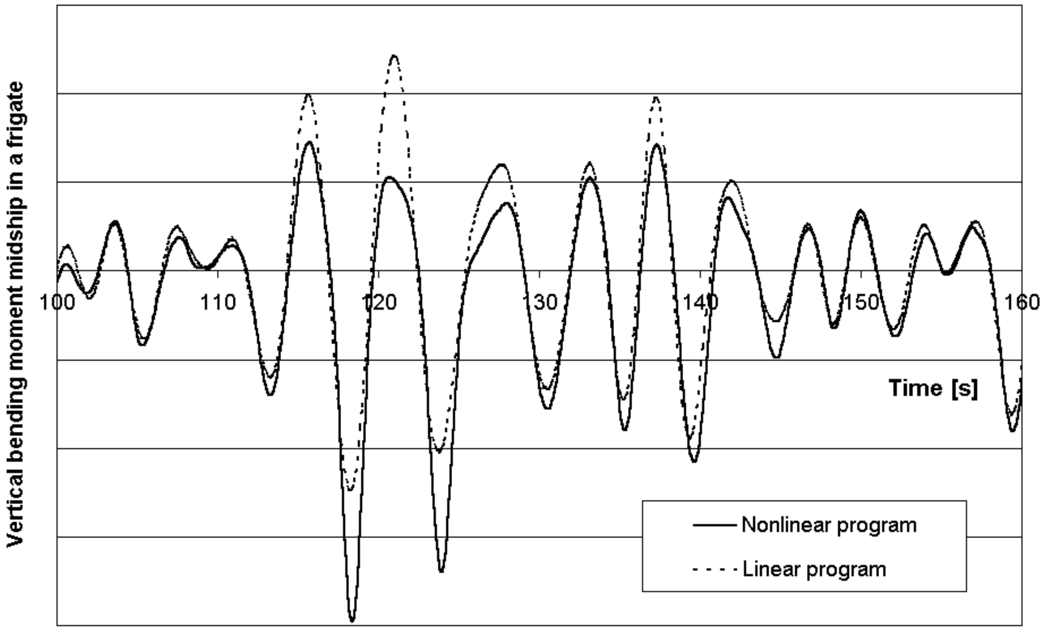

Figure 19 Linear and Non-Linear Bending Moments

- Because of the added resistance of a ship due to the waves is proportional to the relative motions squared, its inaccuracy will be gained strongly by inaccuracies in the predicted motions.

Nevertheless these limitations, seakeeping prediction methods based upon the linear strip theory provide a sufficiently good basis for optimization studies at an early design stage of the ship. At a more detailed design stage, it can be considered to carry out additional model experiments to investigate for instance added resistance, bending moments or extreme event phenomena, such as shipping green water and slamming.

6 Error Return Messages

The hull form controller SEAWAY-H is written in Quick Basic and consequently Quick Basic error numbers on the screen will reflect the errors. In case of an error, check the hull form data file.

All possible errors of the other (Fortran/77) programs SEAWAY-L, SEAWAY-E and SEAWAY are described in this chapter.

A successful normal end of a program execution will be accompanied by the message:

- **`END OF PROGRAM EXECUTION`**

Special error return messages are build into the program, to protect the program execution against exceeding the limits of the input data file. Also, messages are given on the screen in case of FORTRAN/77 runtime read errors of the input data file. These messages will be showed further on.

Numbered or not numbered runtime error messages from the compiler can appear. Runtime error numbers are written as 4-digit decimal integers. They are split into groups according to the type of the runtime routine that detects the error:

- **`1000 to 1999: Intrinsic Function.`**
- **`2000 to 2499: I/O other than Format Control.`**
- **`2500 to 2999: Format Control I/O.`**
- **`3000 to 3999: Operating System Interface.`**
- **`4000 to 4999: Miscellaneous.`**
- **`5000 to 5999: Debug I/O.`**
- **`Not numbered: DOS System Return Codes for Runtime.`**

An example of one of these error types is for instance error number 3033 (a write error on a formatted sequential record). Generally, this error means that no sufficient disk space for writing the output is available.
Detailed explanations of all these errors are given in FORTRAN reference manuals like:

- Reference of IBM Personal Computer Professional FORTRAN, by Ryan-McFarland Corporation, First Edition, November 1984.
- RM Fortran Version 2.4 (DOS), by Ryan-McFarland Corporation.

However, these error messages from the RMF-compiler should be avoided by messages given further on, build into the program. If these runtime errors appear, make a copy of the input data file and inform the author.

6.1 Error Return Messages of SEAWAY-L

FORTRAN/77 runtime errors when opening the two data files are reflected by:

- **`Input error: False keyboard input.`**
- **`Input error: Similar file names.`**
- **`Open error: Input data file.`**
- **`Open error: Output data file.`**

Generally, the user causes these errors. Check the status of the files, to be opened.

The following error return messages are build into the program, to protect the program execution against an overstep of the limits of the input data file:

- **`Input error: IPRINT out of range.`**
- **`Input error: KCON out of range.`**
- **`Input error: NS out of range.`**
- **`Input error: NS = odd number.`**

The names of the data types are explained before. The user should fulfil the requirements for the limits, given in the description of the input data file. If not done so, these error messages will appear.
However, also these error messages can be a consequence ignoring the input instruction "new line" before a data type.

The following messages are reflected in case that FORTRAN/77 runtime read errors appear in the input data file:

- **`Read error: Input exhausted in input data file.`**
- **`Read error: RELINP.`**
- **`Read error: TEXT.`**
- **`Read error: IPRINT,KCON,DR,TR,RLPP,RLA,NS,(DX(J),J=1,NS),`**
`SNR(J),YWL(J),D(J),AREA(J).`

The names of the data types are explained before. These errors can appear in case of an input of a real value for an integer data type or when the array declaration conflicts with the number of input array elements.

6.2 Error Return Messages of Editor SEAWAY-E

FORTRAN/77 runtime errors when opening the data files are given by:

- **Input error: Similar file names.**
- **Input error: False keyboard input.**
- **Open error: Hull form data file.**
- **Open error: Input data file.**

Generally, the user causes the open errors. Check the status of the files, to be opened.

Error return messages are build into the input editor, to protect the program execution against exceeding the limits of the input data in the hull form and input data file. Also, messages are given in case that FORTRAN/77 runtime read errors appear in these data files.

Input error return messages and runtime read error messages, with respect to the **hull form data file**, are given by:

- **Input error: NS out of range.**
- **Input error: NS = odd number.**
- **Input error: KCON out of range.**
- **Input error: NWL(J) out of range.**
- **Input error: NWL(J) is odd number.**
- **Input error: Y(J,I) less than zero.**
- **Read error: Input exhausted in hull form data file.**
- **Read error: TEXTH80 in UNIT=7.**
- **Read error: DR,TR,RLPP,RLA,NS,(DX(J),J=1,NS),KCON.**
- **Read error: SNR(J),NWL(J),SDIST(J).**
- **Read error: SNR(J),NWL(J).**
- **Read error: (Y(J,I),Z(J,I),I=0,NWL(J)).**
- **Read error: (Z(J,I),Y(J,I),I=0,NWL(J)).**
- **Read error: XS,YS,ZS.**

Input error return messages and runtime read error messages, with respect to the **input data file**, are given by:

- **Input error: KPR(1) out of range.**
- **Input error: KPR(2) out of range.**
- **Input error: KPR(3) out of range.**
- **Input error: KPR(4) out of range.**
- **Input error: KPR(5) out of range.**
- **Input error: DEPTH less than 1.05*DRAFT.**
- **Input error: KTH out of range.**
- **Input error: MSER out of range.**
- **Input error: KCOF out of range.**
- **Input error: NFR out of range.**
- **Input error: SNRFR(I) does not exist.**
- **Input error: KNRFR(I) out of range.**
- **Input error: NV out of range.**
- **Input error: NWD out of range.**
- **Input error: FREQMAX less than zero.**
- **Input error: KOMEG out of range.**
- **Input error: OMMIN less than <0.010.**
- **Input error: OMMAX less than OMMIN.**
- **Input error: OMINC equal to zero.**

- Input error: GKGM equal to zero.
- Input error: NBTM out of range.
- Input error: NSM out of range.
- Input error: KTUN(1) out of range.
- Input error: KTUN(2) out of range.
- Input error: KTUN(3) out of range.
- Input error: ABS(KTUNE(3)) > 0 and GYR(1) < 0.0.
- Input error: KRD out of range.
- Input error: WAVAMP less than zero.
- Input error: ROLAMP less than zero.
- Input error: XBKF less than XBKA.
- Input error: KARD out of range.
- Input error: NARI(1) out of range.
- Input error: NARM out of range.
- Input Error: NARI out of range.
- Input error: NART out of range.
- Input error: NCAB out of range.
- Input error: NPTS out of range.
- Input error: NSEA out of range.
- Input error: NF exceeds limit.
- Input error: KSEA out of range.
- Input error: HW(K) less than zero.
- Input error: TW(K) less than zero.
- Input error: GAMMA(K) less than zero.
- Input error: SPS(K,L) less than zero.
- Input error: KRIT out of range.
- Input error: MOT out of range.
- Read error: Input exhausted in input data file.
- Read error: RELINP.
- Read error: TEXT80 in UNIT=5.
- Read error: (KPR(I),I=1,5),DRAFT,TRIM,DIST,DEPTH,RHO,MOT,KTH
  MSER,NCOF,NFR.
- Read error: (SNRFR(I),KNRFR(I),I=1,NFR)
- Read error: NV,(VK(K),K=1,NV),NWD,(WAVDIR(L),L=1,NWD),FREQMAX
  KOMEG,OMMIN,OMMAX,OMINC,WAVAMP,GKGM,(GYR(I),I=1,3),
  NBTM.
- Read error: (XBTM(I),AXTM(I),I=1,NBTM),NSM,(XSM(J),SM(J),SGK(J),
  SGYRX(J),J=0,NSM-1),(KTUN(I),I=1,3).
- Read error: KRD.
- Read error: ROLAMP.
- Read error: ROLAMP,WAVAMP.
- Read error: (RDK1(K),RDK2(K),K=1,NV)
- Read error: HBK,XBKA,XBKF,CORMIL.
- Read error: HBK,XBKA,XBKF.
- Read error: NPTK.
- Read Error: PHIAK(I),(RDKV(J,I),J=1,NV).
- Read error: KARD.
- Read error: NARI(1),NART.
- Read error: NARM,NART.
- Read error: (ARIOME(1,K),ARIMOM(1,K),ARIEPS(1,K),K=0,NARI(1)-1).
- Read error: (ARIPHI(I),NARI(I),(ARIOME(I,K),ARIMOM(I,K),
  ARIEPS(I,K),K=0,NARI(I)-1)).
- Read error: ARTX(L),ARTZ(L),ARTL(L),ARTB(L),ARTH(L),RHOT(L).
- Read error: NCAB.

- `Read error: (CABXYZ(J,I),I=1,3),(CABCOF(J,I),I=1,3).`
- `Read error: NPTS.`
- `Read error: (PTS(J,1),PTS(J,2),PTS(J,3),J=1,ABS(NPTS)).`
- `Read error: NSEA.`
- `Read error: KSEA.`
- `Read error: (HW(K),TW(K),K=1,NSEA).`
- `Read error: (HW(K),TW(K),GAMMA(K),K=1,NSEA).`
- `Read error: (SPS(K,L),L=0,NF).`
- `Read error: KRIT.`
- `Read error: SLAML,SLAMV,SLAMC,SLAMP.`

In principle, input data files created earlier by SEAWAY-E will not have these errors but the user, using a normal editor, can create these errors.
The names of the data types are explained in this User Manual. These errors can appear in case of an input of a real value for an integer data type or when the array declaration conflicts with the number of input array elements. Also, these error messages can be a consequence of ignoring the input instruction "new line" before a data type.

6.3 Error Return Messages of Main Program SEAWAY

FORTRAN/77 runtime errors when opening the data files are given by:

- **`Input error: Number of files in SEAWAY.FIL too large.`**
- **`Input error: File name in SEAWAY.FIL too large.`**
- **`Input error: Similar file names.`**
- **`Input error: False keyboard input.`**
- **`Read error: Number of files in SEAWAY.FIL.`**
- **`Read error: File names in SEAWAY.FIL.`**
- **`Open error: Hull form data file.`**
- **`Open error: Input data file.`**
- **`Open error: Optional data file.`**

Generally, the user causes the open errors. Check the SEAWAY.FIL file or the status of the files, to be opened.

The program SEAWAY is protected against a not authorised use by a SENTINEL-C software security system. Security control statements, build into the program, can result in control errors, reflected by one of the following messages:

- **`Control error: LPT-port for Sentinel-key not found.`**
- **`Control error: Check of Sentinel-key fails.`**

If these errors appear, adequate assignments for the user will be displayed on the screen, such as:

- **`Stop because of:`**
  `- No Sentinel-key or an improper Sentinel-key in LPT port.`
  `Use a proper Sentinel-key!`
  `- A proper Sentinel-key connected with a not-powered printer.`
  `Set power-switch of printer to ON or disconnect printer!`
  `- Temporary internal error in Sentinel-key.`
  `Try again!`

If the release number of the input data file is not suitable for to the present program release number, the program SEAWAY stops with the message:

- **`Convert input file with SEAWAY-E to release 4.19 !!!`**

Doing this, the editor SEAWAY-E will read the old input data file and it will be updated automatically. Saving this file results in a new (updated) input data file for SEAWAY.

The input error return messages and the runtime read error messages, with respect to the hull form data file and to the input data file, are similar to those of the input editor SEAWAY-E, as given in the previous section.
Additional error messages could be:

- **`Error: Calculated GM-value less than zero.`**
  This error is caused by the input value of *GK*, which is too low.
- **`Error: Unable to determine natural frequency.`**
  Unrealistic external roll moments or linear spring stiffness coefficients causes this error.
- **`Error: Unable to determine roll amplitude by iteration.`**
  Security-stop in a computation-loop for the linearisation of the non-linear roll damping. This error occurs very seldom. It can appear when using KTH < 0 for ships with a very low natural frequency for roll; $T_{\hat{o}}$ is something like about 30 seconds or more. In that case the problem can be solved by using KTH > 0. This error can also be caused by the input of (unrealistic) external moments or anti-roll devices. Send your hull form file and input data file to the author.

The subroutines SOLVE and SOLVEN in the program SEAWAY solve one or more sets of *NxN* linear equations. These subroutines are used when calculating the two-dimensional potential hydrodynamic coefficients with the Ursell-Lewis-Tasai methods or the Frank Close-Fit method and when solving the set of maximum 12 coupled equations of the in and out of phase motions. In case of a singularity, the program returns with one of the following messages:

- **`Error in subroutine SOLVEN in TASAI.`**
- **`Error in subroutine SOLVE in FRANK.`**
- **`Error in subroutine SOLVE in CHARMOT.`**

These singularity error messages have not been arisen so far, but if one of these serious error messages appear, mail the error message together with the hull form and input data files to the author (e-mail: J.M.J.Journee@wbmt.tudelft.nl).

7 Operability-Limiting Criteria

For the theory behind the motion phenomena, which are related to operability-limiting criteria for ships, reference is given here to [Journee, 2001b], the *Theoretical Manual of SEAWAY.*
Often, operability-limiting criteria are expressed as *RMS* (Root Mean Square) values, which are commonly used in offshore practice. It may be stipulated here that the *RMS*-value of a signal *s(t)* is equal to the variance $\mathbf{s}_s$ of this signal or equal to half the significant amplitude $s_{a1/3}$, thus:

$$RMS_s = \mathbf{s}_s = \sqrt{m_{0s}} = \frac{1}{2} s_{a1/3}$$

If the short-term probability P_s of exceeding a threshold value a by a motion s is known:

$$P\{s_a > a\} = P_s = \exp\left\{\frac{-a^2}{2m_{0s}}\right\}$$

this threshold value (for instance a required minimum freeboard) can simply be found from the output of SEAWAY by:

$$a = \sqrt{-2m_{os} \cdot \ln\{P_s\}} = s_{a1/3} \cdot \sqrt{\frac{-\ln\{P_s\}}{2}}$$

7.1 Definitions

Firstly, some phenomena related to operability-limiting criteria have to be defined. For the definitions and an inclusion or exclusion of a static and/or a dynamic swell-up of the water surface reference is given to the Theoretical Manual.

7.1.1 Shipping Water

Shipping water is defined as exceeding the local effective freeboard, f_e, by the vertical relative motion amplitude, s_a. Using the Rayleigh probability density distribution, the short term probability, P, on shipping water in a given storm condition is given by:

$$P\{\text{shipping water}\} = P\{s_a > f_e\} = \exp\left(\frac{-f_e^2}{2m_{0s}}\right)$$

where m_{0s} is the area of the relative motion spectrum, S_s.

7.1.2 Propeller Racing

Propeller racing can occur when the propeller comes partially out of the water. This is largely prevented nowadays by rpm-governors on the engine. However, large thrust and torque fluctuations occur in waves, even at a constant number of revolutions per minute. This is reason why propeller racing is sometimes defined as an emergence of the propeller, which causes a decrease of torque in excess of 25 %.
However, often a more simple definition is used, which defines propeller racing as an emergence of the propeller by more than one third of the propeller diameter, thus the short term probability, P, on shipping water in a given storm condition is given by:

$$P\{\text{propeller racing}\} = P\{s_a > z_{axis} - D/6\} = \exp\left(\frac{-(z_{axis} - D/6)^2}{2m_{0s}}\right)$$

where z_{axis} is the (positive) distance of the propeller axis below the still water level and D is the diameter of the propeller.

7.1.3 Bow Slamming

Bow slamming is a two-node vibration of the ship caused by suddenly pushing the ship by the waves. This occurs when the bow of the ship comes completely out of the water and then "crashes down" with an impact against the next wave. Slamming influences the local pressures on the hull plating and a local damage can be the result. The impulse nature of the impact also causes internal vibrations which can contribute to structural fatigue in the ship. Slamming does not necessarily influence the overall vertical displacements of the ship significantly.

Slamming forces can be very large, but they act on the ship during a very short time. A complete prediction of slamming phenomena is a very complex task, which is beyond the scope of any existing theory. Slamming impact pressures are affected by the local hull section shape, the relative velocity between ship and wave at impact, the relative angle between the keel and the water surface, the local flexibility of the ship's bottom plating and the overall flexibility of the ship's structure.

[Ochi, 1964] has translated the slamming phenomena into requirements for the vertical relative motions of the ship. He defined bow slamming by an emergence of the bow of the ship at $0.90L_{pp}$ and, at the instant of impact, exceeding a certain critical vertical relative velocity, between the wave surface and the bow of the ship.

The spectral moments of the vertical relative displacements and velocities are defined by m_{0s} and $m_{0\dot{s}}$. Emergence of the bow of the ship happens when the vertical relative displacement amplitude, s_a, at $0.90L_{pp}$ is larger than the ship's draft, d, at this location. The second requirement states that the vertical relative velocity exceeds a certain threshold value. Based on model experiments and full-scale experiments with frigates, Ochi used 12 feet per second as a threshold value for a ship with a length of 520 feet. Froude-scaling of this threshold value results in $\dot{s}_{cr} = 0.093\sqrt{gL_{pp}}$, with g in m/s^2 and L_{pp} in m.

Both occurrences - emergence of the bow and exceeding the threshold velocity $\dot{s}_{cr}$ - are statistically independent. In case of slamming both occurrences have to appear at the same time. Thus, the short term probability, P, on a slam in a given storm condition is the product of the two independent probabilities and using the Rayleigh distribution for each of these results in:

$$P\{slamming\} = P\{s_a > d \text{ and/or } \dot{s}_a > \dot{s}_{cr}\} = \exp\left(\frac{-d^2}{2m_{0s}} + \frac{-\dot{s}_{cr}^2}{2m_{0\dot{s}}} \right)$$

7.1.4 Voluntary Speed Reduction

When a ship enters a severe storm the ship's captain can decide to reduce power (and as a consequence the ship’s speed) or even change course in order to reduce motions. When exceeding certain limits, shipping green water, propeller racing, slamming and heavy accelerations forward can damage the ship or the cargo and are therefore often a reason for voluntary speed reduction and/or even change of heading.

7.2 Criteria on Ship Motions

Criteria for acceptable levels of ship motions in a seaway have been discussed in the Nordic Cooperative Project: "Seakeeping Performance of Ships", see reference [NORDFORSK, 1987]. Considerations have been given there to hull safety, operation of equipment, cargo safety, personnel safety and efficiency.

General operability-limiting criteria for ships are given in the table below.

General Operability-Limiting Criteria for Ships [NORDFORSK, 1987]			
Phenomena	Merchant Ships	Naval Vessels	Fast Small Craft
RMS of vertical accelerations at F.P.P.	0.275 *g* (L_{pp} < 100 m) 0.050 *g* (L_{pp} > 330 m)	0.275 *g*	0.650 g
RMS of vertical accelerations at bridge	0.150 *g*	0.200 *g*	0.275 g
RMS of lateral accelerations at bridge	0.120 *g*	0.100 *g*	0.100 *g*
RMS of roll motions	6.0 deg	4.0 deg	4.0 deg
Probability on slamming	0.03 (L_{pp} < 100 m) 0.01 (L_{pp} > 300 m)	0.03	0.03
Probability on deck wetness	0.05	0.05	0.05

Table 7 General Operability Limiting Criteria for Ships

For intermediate lengths in the criteria for the *RMS* of the vertical accelerations forward and for the criteria for the probability on slamming, a linear interpolation can be used.
The limiting criteria for fast small craft are only indicative of trends. A fast craft is defined as a vessel under about 35 meters in length with a speed in excess of 30 knots. A reason why the vertical acceleration level for fast small craft is set higher than for merchant ships and naval vessels is that personnel can tolerate higher vertical acceleration when the frequency of oscillation is high.

Operability-limiting criteria for accelerations and roll motions for various types of work and for passenger comfort are given in the following table.

Operability-Limiting Criteria for Accelerations and Roll Motions for Various Type of Work and for Passenger Comfort [NORDFORSK, 1987]			
Phenomena	*RMS* of Vertical Accelerations	*RMS* of Lateral Accelerations	*RMS* of Roll Motions
Light manual work	0.20 *g*	0.10 *g*	6.0 deg
Heavy manual work	0.15 *g*	0.07 *g*	4.0 deg
Intellectual work	0.10 *g*	0.05 *g*	3.0 deg
Transit passengers	0.05 *g*	0.04 *g*	2.5 deg
Cruise liner	0.02 *g*	0.03 *g*	2.0 deg

Table 8 Operability Limiting Criteria for Type of Work and Roll

Criteria on Voluntary Speed Reduction

Criteria for reducing speed or changing course can be found in various publications. They are commonly expressed as probability limits, P, for the accelerations forward and probability limits for the occurrence of shipping water at the bow or for bow slamming. In some cases, probability limits for propeller racing are included too.

The combined criteria of [Ochi and Motter, 1974], which distinguish between two typical loading conditions of the ship, are given here:

- **Fully laden condition:**

$$P\left\{s_a > f_B \text{ and/or } \ddot{z}_{a1/3} > 0.40g\right\} < 0.07$$

  This probability can be rewritten as:

$$P\left\{s_a > f_B \text{ and/or } \ddot{z}_a > 0.46g\right\} < 0.07$$

  or:

$$P\left\{s_a > f_B\right\} + P\left\{\ddot{z}_a > 0.46g\right\} - P\left\{s_a > f_B\right\} \cdot P\left\{\ddot{z}_a > 0.46g\right\} < 0.07$$

- **Light laden condition:**

$$P\left\{\text{slamming and/or } \ddot{z}_{a1/3} > 0.40g\right\} < 0.03$$

  This probability can be rewritten as:

$$P\left\{\text{slamming and/or } \ddot{z}_a > 0.53g\right\} < 0.03$$

  or:

$$P\left\{\text{slamming}\right\} + P\left\{\ddot{z}_a > 0.53g\right\} - P\left\{\text{slamming}\right\} \cdot P\left\{\ddot{z}_a > 0.53g\right\} < 0.03$$

Bow deck wetness $s_a > f_B$, the amplitude $\ddot{z}_a$ of the vertical accelerations of the bow and the significant amplitude $\ddot{z}_{a1/3}$ of the vertical accelerations of the bow have to be determined at the forward perpendicular F.P.P. Slamming has to be determined at $0.90L_{pp}$.

In principle, these two criteria of Ochi and Motter are rather moderate. Speed limiting criteria should also depend on the type of the ship and on its cargo, but the author has found in the past generally fair realistic voluntary speed reduction data with these criteria.

8 List of Modifications

4.00 (21-03-1992)

- First edition of the new release series of SEAWAY-L, SEAWAY-H, SEAWAY-E and SEAWAY.

4.01 (21-04-1992)

- An update of SEAWAY-E. Some small errors have been removed.
- Modifications in some output sequences of SEAWAY.

(12-06-1992)

- Standard writing of LOTUS-output to SEAWAY.DAT. Optional writing of calculated data in a format, specified by the users.
- Inclusion of an equivalent linear GM value.
- Adjustment of the spring term for pitch (equivalent to roll).

(20-06-1992)

- Second degree interpolation in body plan plot of SEAWAY-H.
- Small modifications in the IKEDA routine.

4.04 (19-09-1992)

- Internal modifications in SEAWAY with respect to an implementation of SEAWAY routines in SEAWAY-D, a pre-processing program for time domain calculations.
- The original optional print of the offsets, KPR(1), has been removed. Because of SEAWAY-H has been made available, this option is not required anymore. The new KPR(1) arranges an optional print of input data. In case of old input data files, KPR(1)=+1 will be used.
- An inclusion of local half distances of centerlines in the hull form data file. The program SEAWAY and the editor SEAWAY-E will transform old hull form data files into new ones with distances equal to zero automatically. The new release number will be added too.
- Adjustment of SEAWAY-H for plotting twin-hull cross sections. Old hull form data files will be observed as single hull ships.
- So far, the distances in the hull form data file are not active in the program SEAWAY yet. There, twin hulls are defined by DIST in the input data file.
- Mind you, for twin-hull ships the shear forces and the bending and torsion moments have not been checked yet.
- A modification of the "near zero frequency of encounter" problem in following waves. The diffraction part of the wave loads will be forced to go to zero only.
- A modified creation of not-valid Lewis forms in SEAWAY-L.
- Modified security-control checks in the DEMO-programs.

4.05 (24-10-1992)

- SDIST(J) has been made active.
- Maximum value of NPTS changed from 10 into ABS(NPTS)<=5.
- An inclusion of the calculation of the dynamical swell-up, determined from the radiated waves, in the vertical relative motions. This will be done in case of NPTS<0.

4.06 (07-11-1992)
- KPR(2)=-1: Output of hull form-data in SHIP.HUL format.
- DELFRAC.DAT can be included in HULLGEOM.FOR.
- Upper boundaries of arrays in parameter specification statement.
- Linear and quadratic interpolation in hull form plot of SEAWAY-H.
- A start of a modification of SEAWAY-H into a hull form-editor.

4.07 (14-11-1992)
- Modifications in the integration routines for wave loads, added resistance and structural loads in high frequency waves. Any barge can be defined by three cross sections now.

4.08 (21-11-1992)
- Inclusion of an optional output for the DELFRAC program.

4.09 (05-12-1992)
- Modification of the wave loads for roll.

4.10 (02-01-1993
- Complete new organisation of the program.

4.11 (22-05-1993)
- Improved calculation of surge coefficients.
- KTH=-2 and KTH=-1 have been removed.
- No adjustment of wave loads for KTH=1 in following waves.
- Modifications in editor SEAWAY-E.
- Maximum values: NWD = 19 and NCAB = 8

4.12 (31-07-1993)
- To increase the available memory, an overlay-structure has been included.
- Modification of the wave loads for roll (return to the definitions in release 4.08 and earlier releases).
- An inclusion of the shallow water effect on the hydrodynamic potential coefficients, based on theory published by Keil, in program SEAWAY.
- Modified security-control checks in the programs.
- Remove of a small error in Raw, present since release 4.07.
- Maximum value of ABS(NPTS) changed from 5 into 10 and adjustment of SEAWAY-E for this.

4.13 (07-10-1995)
- Adjustment of JONSWAP definition, to obtain correct period.
- Original definition of wave loads for heave, with a protection for a zero-breadth on the waterline.
- Inclusion of external springs into subroutine CHARMOM, to obtain shear forces and bending and torsion moments.

4.14 (01-11-1996)
- Remove of an error in bending moments of a trimmed ship.
- New definition of sway and roll wave loads.

- Original definition of heave wave loads.
- Addition of velocities and accelerations of and around *CoG*.
- Inclusion of internal *Fx*, change of sign of *Mz* and new output of internal loads.
- Some numerical adjustments in subroutine KEIL for potential calculations at shallow water (no effect for user)

4.15 (15-03-1997)
- Some numerical adjustments subroutine KEIL for potential calculations at shallow water.
- Adjust of wave loads of a bulbous cross section.

4.16 (01-08-1998)
- From here: **All old input data files have to be updated by editor SEAWAY-E**
- NPTS increased from 10 to 11.
- Remove of the dummy value DIST.
- Addition of cubic roll damping coefficient RDK3(K).
- Modified addition of external anti-roll moments.

4.16 (05-12-1998)
- Modification of strip theory definitions:
- KTH<0: similar to release 4.13:
- Equivalent GM value, taking Scribanti effects into account.
- Adaptation for bulbous bows.
- Original wave loads for sway, roll and yaw.
- KTH>0: similar to releases 4.14 – 4.16.

4.17 (26-05-1999)
- Remove of Scribanti effects in GM.
- Output of natural frequencies for heave and pitch too and natural frequencies of all motions in case of linear springs.
- Possibility to obtain horizontal accelerations in the earth-bound axes system, defined by MOT<0.

4.18 (09-10-1999)
- Adding diffraction wave loads, defined by KTH<0.
- Adding a new definition of the viscous roll damping (KRD).
- Adding an input curve of k.
- Adding the Miller method.
- Adding new input modes of external roll moments.

4.19 (12-02-2001)
- Remove of an error when calculating the natural roll period of roll for twin hull ships.
- New interpolation routine for roll linearisation.
- Adding anti-roll-tank moments according to the theory of Verhagen and Van Wijngaarden.
- Remove of a print error in case of internal load spectra.
- Modification of heave wave loads in deep and shallow water for KTH>0.

4.20 (??-??-????)

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9 Closure Remarks

The Fortran/77 source code of the program SEAWAY counts about 13,000 lines. The memory size of the executable file is about 630 kB. Because of using an overlay structure during the compilation of the program, only 440 kB will be used during the execution. This means that the program can be used within the MS-DOS environment, without using extended or expanded memory. However, the program runs under Windows'95 and Windows'98 too.

Computer program SEAWAY has been validated extensively in the past with results of other 2-D or 3-D computer programs and model experiments on a large number of various ship types. The results of a recently carried out extensive validation study, which is still in progress, have been published by [Journée, 2001a].

Based on validation studies and on user's experiences, obtained during an extensive use of the program for many years by the author, students, institutes and industrial users, it is expected that the program is free of significant errors. But, in case of problems or doubts about the reliability of the calculated data, please feel free to contact the author.
Criticisms, remarks or proposals for additions to this program are very welcome: J.M.J.Journee@wbmt.tudelft.nl.

Some extensions and modifications of the computer code SEAWAY are still in mind for the future:

- Except for Lewis hull forms, the hydrodynamic coefficients are calculated for an infinite water depth. An extension will be made to calculate all hydrodynamic coefficients for arbitrary water depths, as has been done here already for Lewis hull forms (Keil's method) and for the wave potential.
- Extra attention will be paid to viscous effects on all motions by appendages and various anti-rolling devices.
- The second order wave drift forces will be included.
- Until now, only uni-directional irregular waves can be used. This will be extended with directional-spread energy of the irregular waves.
- Finally, extra attention will be paid to an inclusion of several sea-keeping criteria.

But, a time schedule can not be given.

The author has tried to create a personal computer program, based on scientific developments as published in the open literature, while fulfilling user's requirements. It is believed that the result is a user's friendly and fairly reliable tool for ship designers and operators.
But - when using this computer program - please keep in mind:

> **"Ship motion calculations can be carried easily by almost any Naval Architect, but a professional judgement of the results remains required"**.

This is reason why the author does not accept any responsibility for the consequences of using the computational results.

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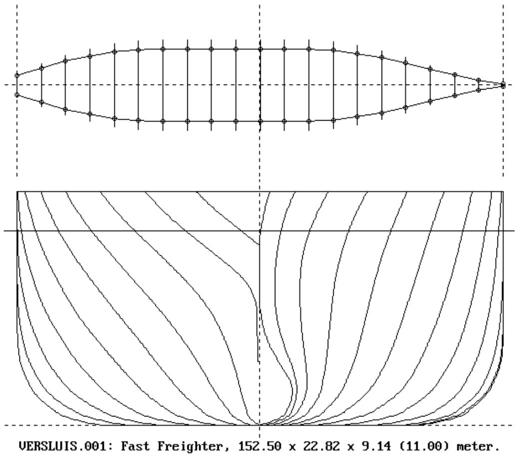
11 Appendix: Body Plans of Hull Forms Series



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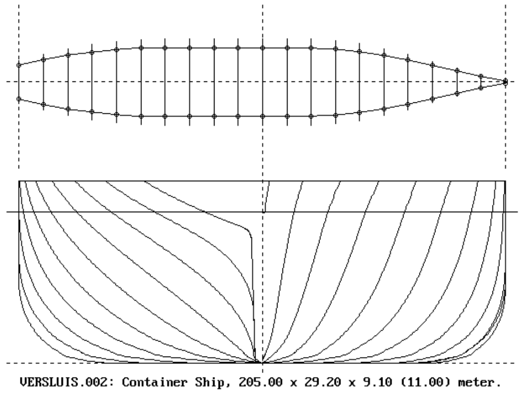

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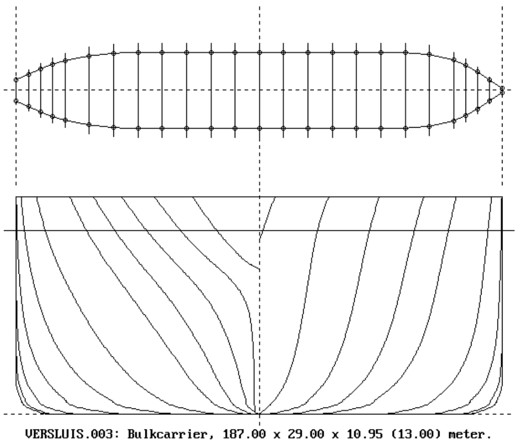

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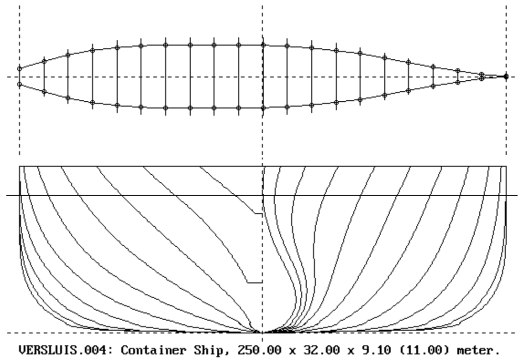

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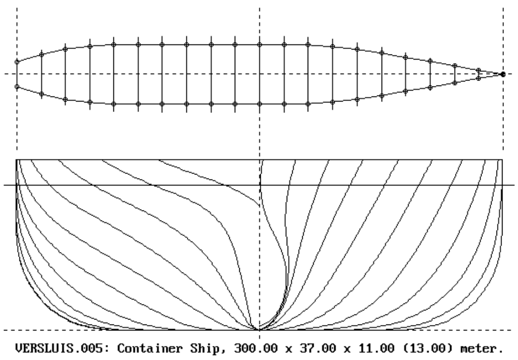

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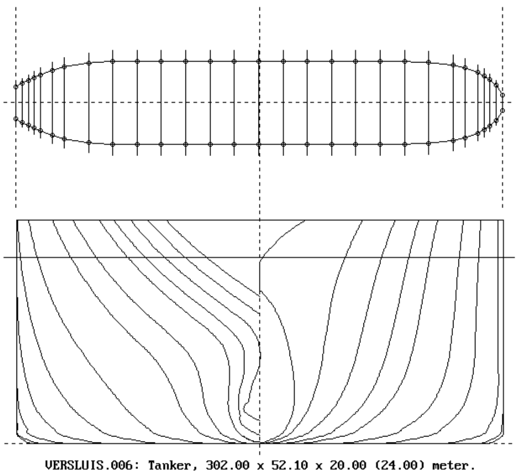

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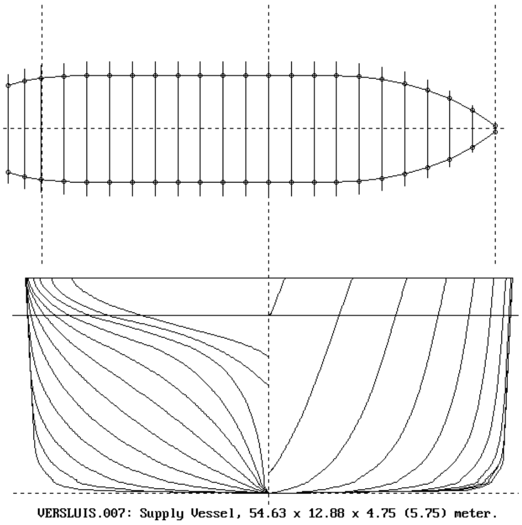

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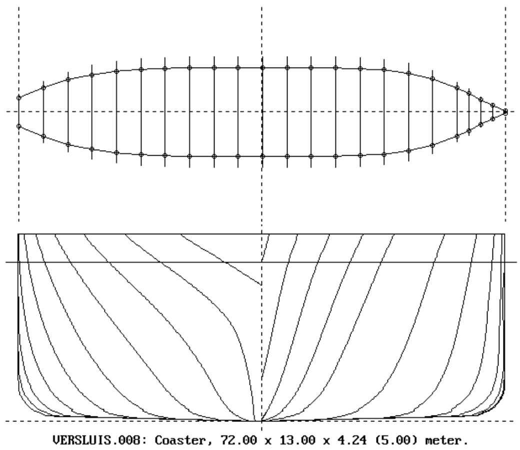

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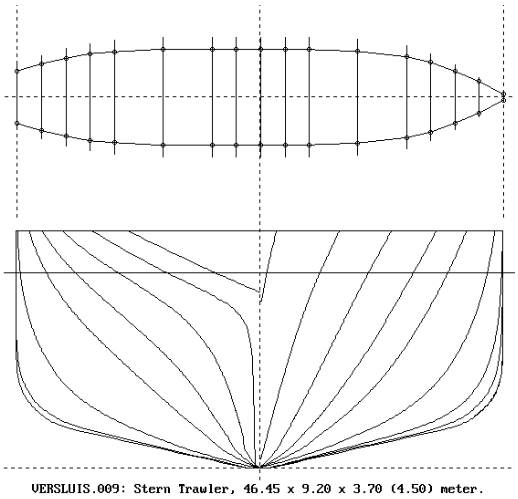

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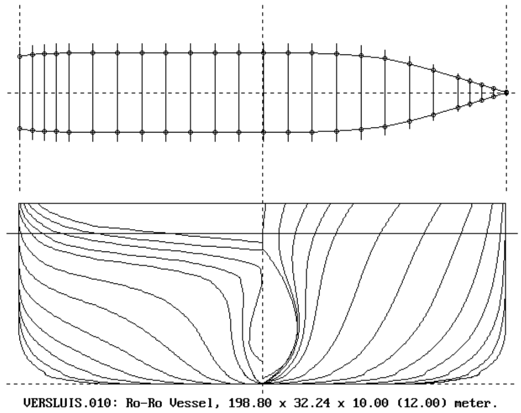

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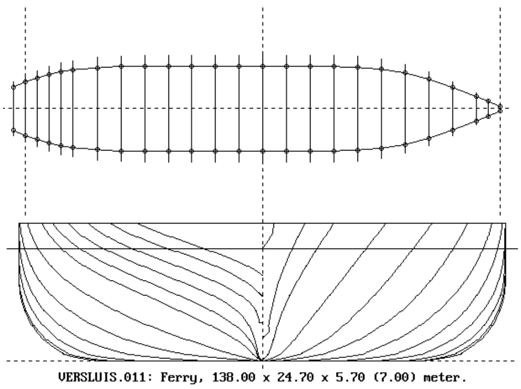

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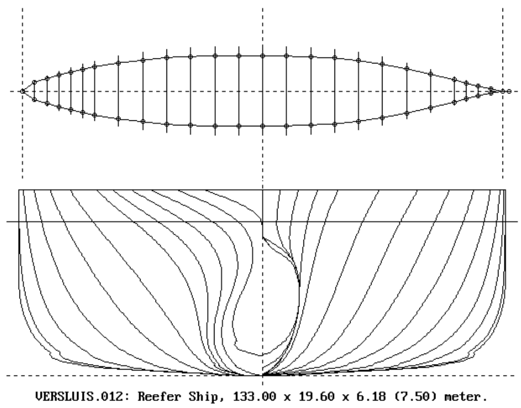

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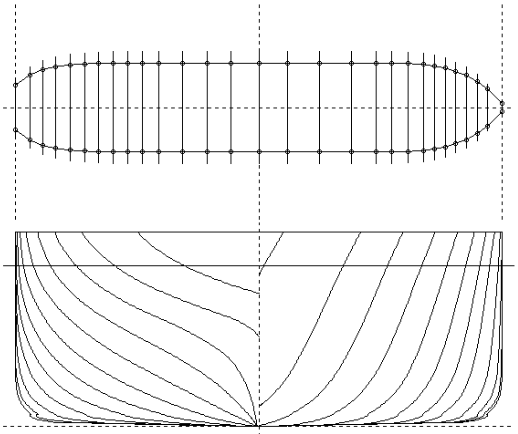
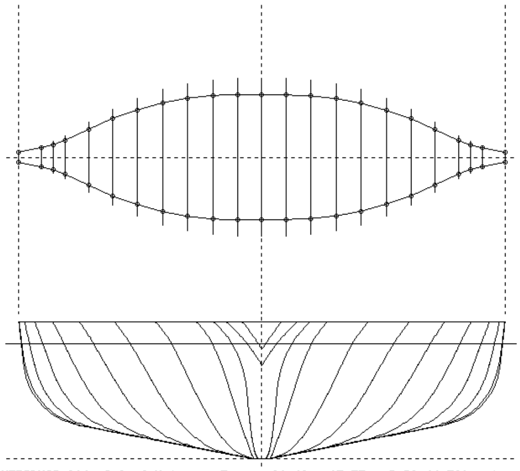


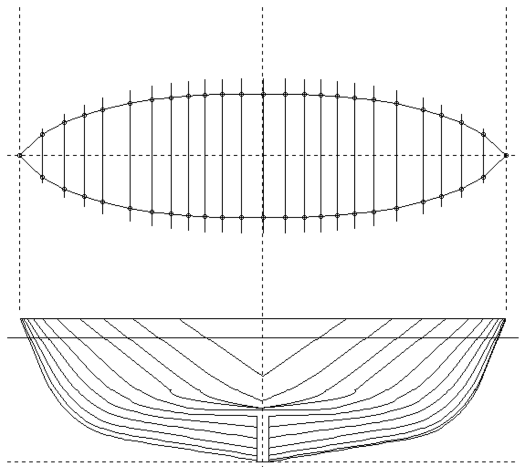
VERSLUIS.013: Inland Waterway Tanker, 27.25 x 5.00 x 1.65 (2.00) m.

Hull Form VERSLUIS.013



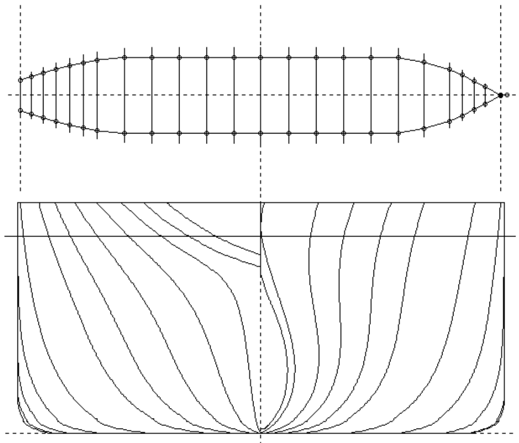
VERSLUIS.014: Inland Waterway Ferry, 61.40 x 15.75 x 3.80 (4.50) meter.

Hull Form VERSLUIS.014



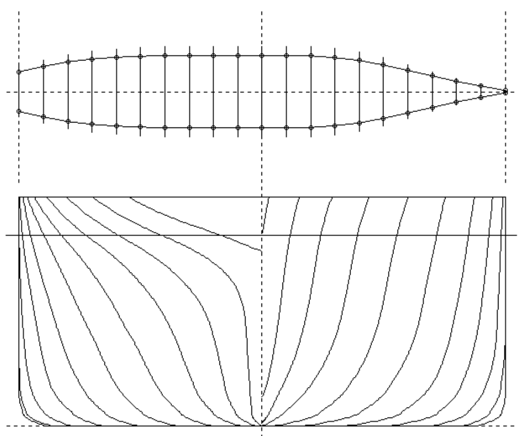
VERSLUIS.015: Inland Waterway Ferry, 50.00 x 12.29 x 3.25 (3.75) meter.

Hull Form VERSLUIS.015



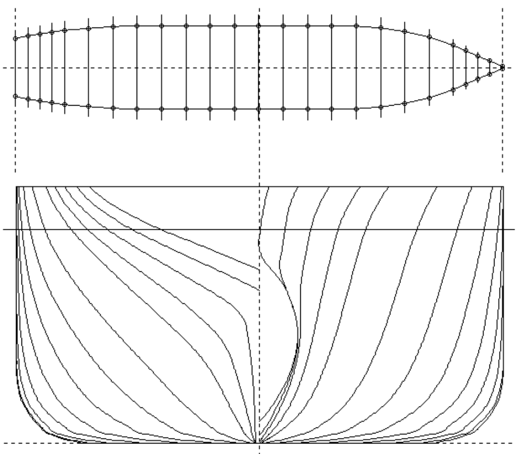
VERSLUIS.016: Multi-Purpose Ship, 132.00 x 21.00 x 8.53 (10.00) meter.

Hull Form VERSLUIS.016



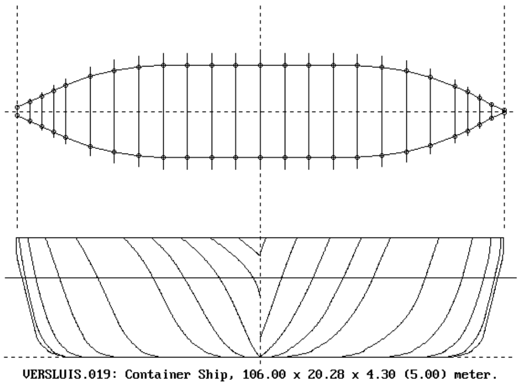
VERSLUIS.017: Multi-Purpose Ship, 155.40 x 23.30 x 9.20 (11.00) meter.

Hull Form VERSLUIS.017



VERSLUIS.018: Multi-Purpose Ship, 104.80 x 18.00 x 7.90 (9.50) meter.

Hull Form VERSLUIS.018



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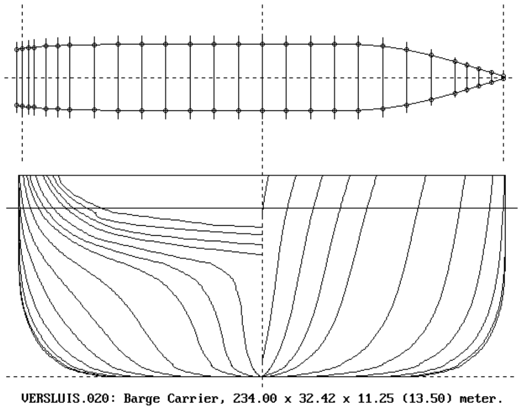

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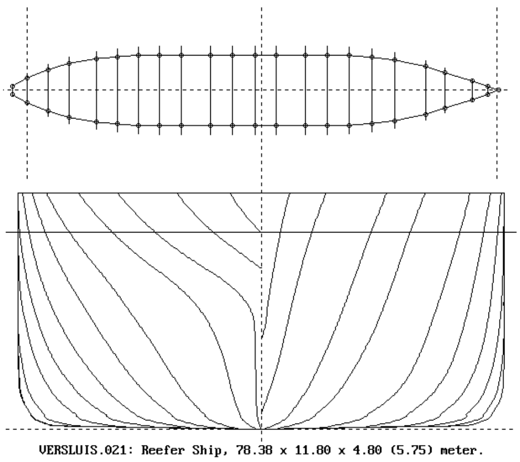

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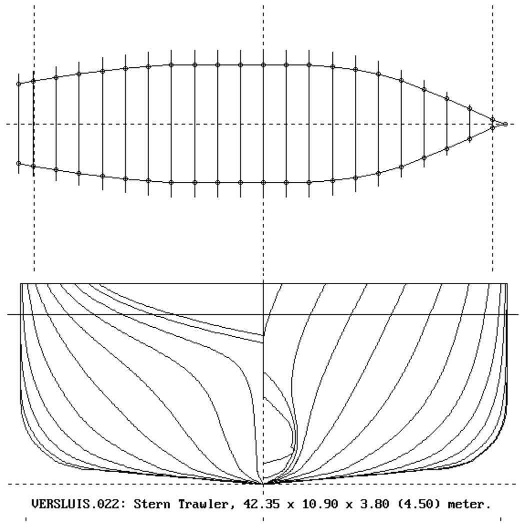

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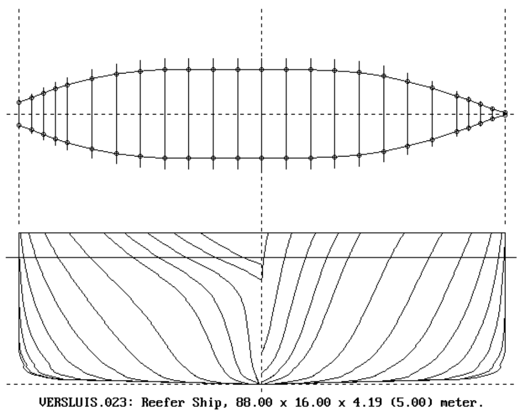

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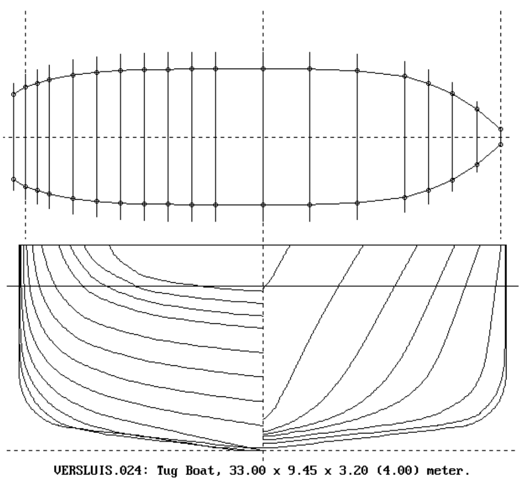

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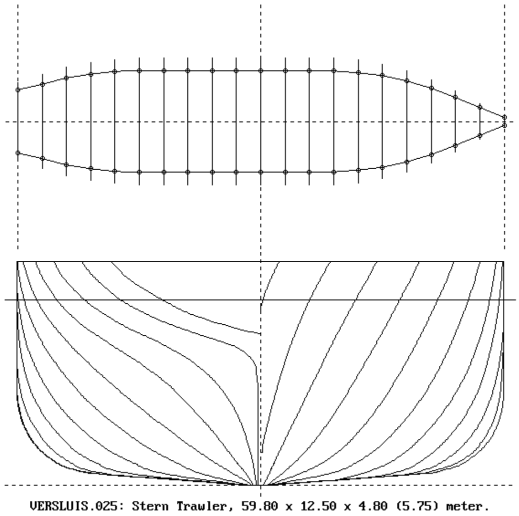

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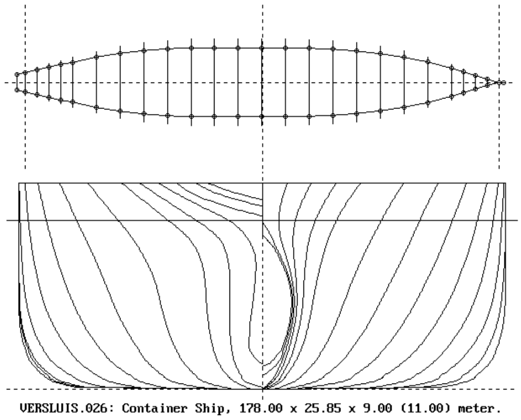

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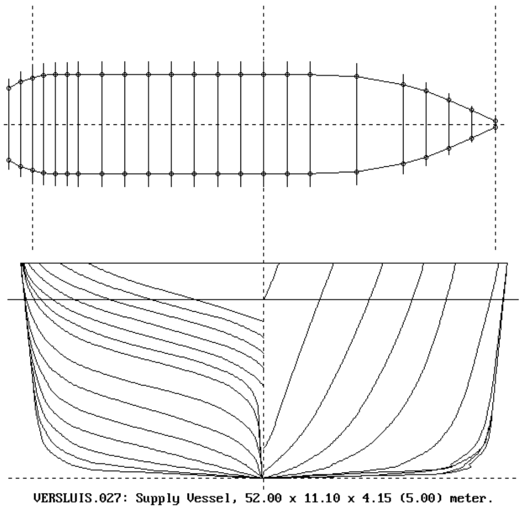

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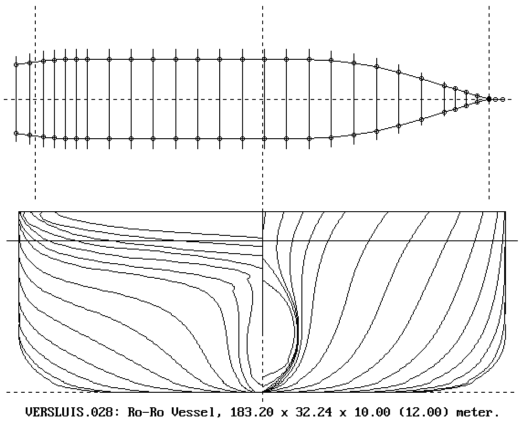

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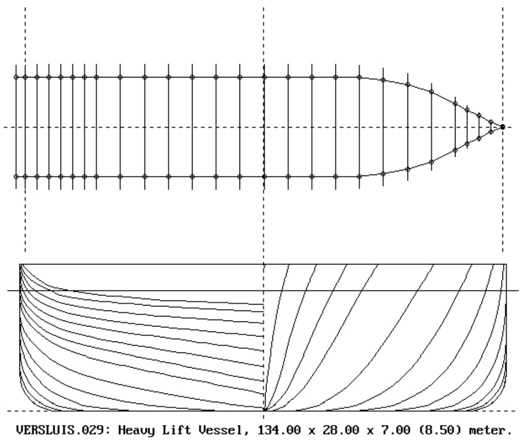

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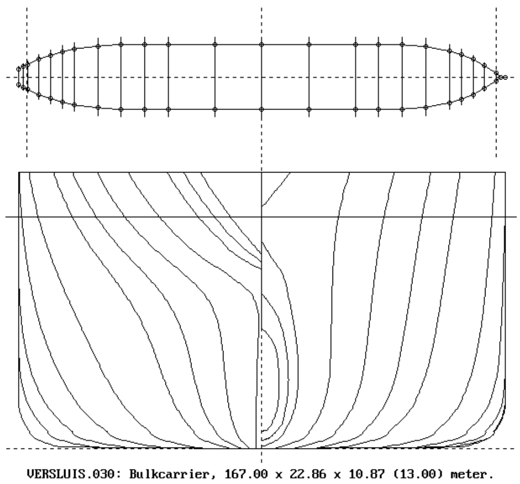

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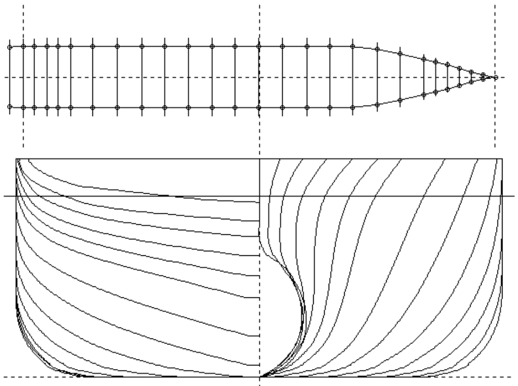
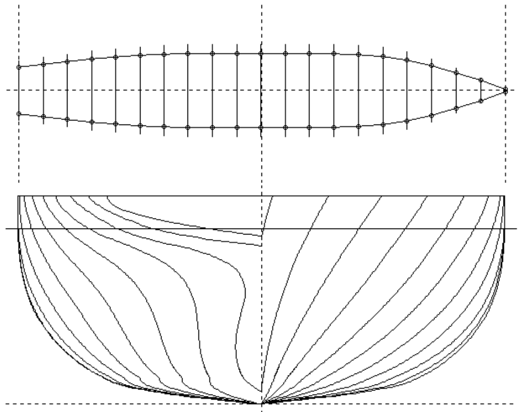


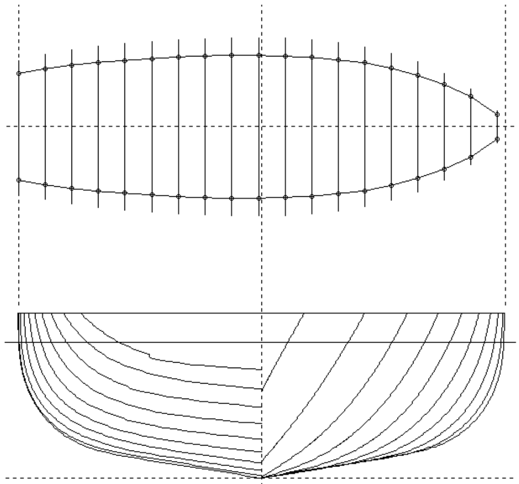
VERSLUIS.031: Container Ship, 247.00 x 32.26 x 12.00 (14.50) meter.

Hull Form VERSLUIS.031



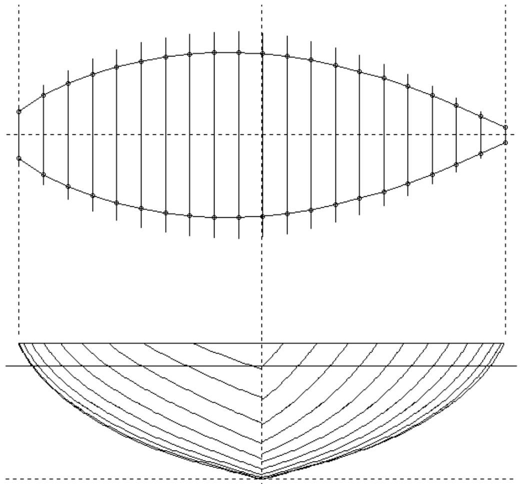
VERSLUIS.032: Ferry, 122.50 x 18.70 x 6.70 (8.00) meter.

Hull Form VERSLUIS.032



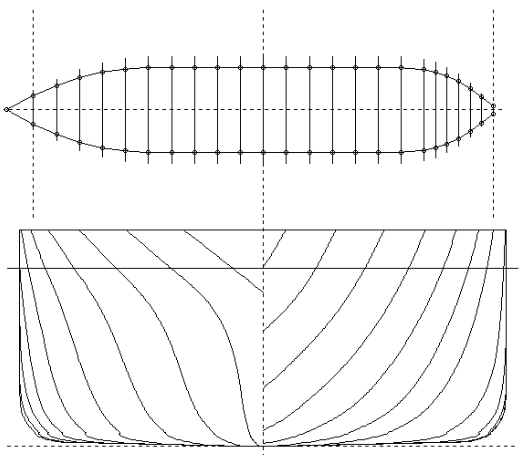
VERSLUIS.033: Tug Boat, 17.00 x 4.99 x 1.40 (1.70) meter.

Hull Form VERSLUIS.033



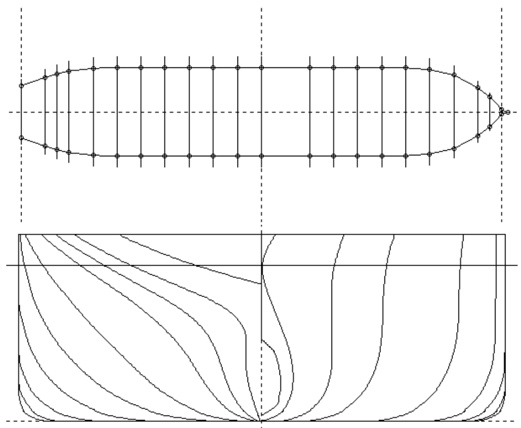
VERSLUIS.034: Sail Yacht, 10.00 x 3.20 x 0.79 (0.95) meter.

Hull Form VERSLUIS.034



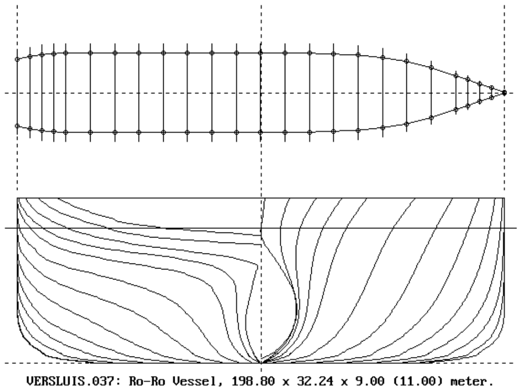
VERSLUIS.035: Coaster, 75.00 x 14.00 x 5.15 (6.25) meter.

Hull Form VERSLUIS.035



VERSLUIS.036: Shallow Draft Tanker, 211.00 x 39.00 x 12.50 (15.00) m.

Hull Form VERSLUIS.036



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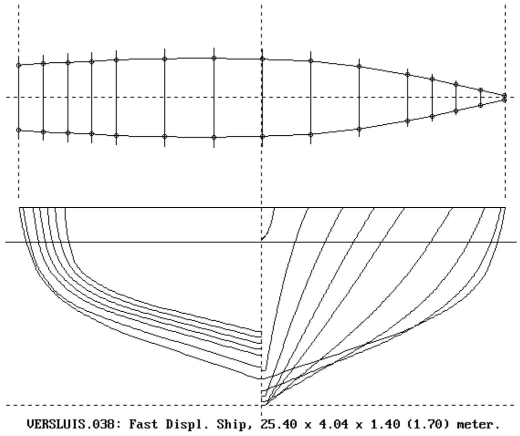

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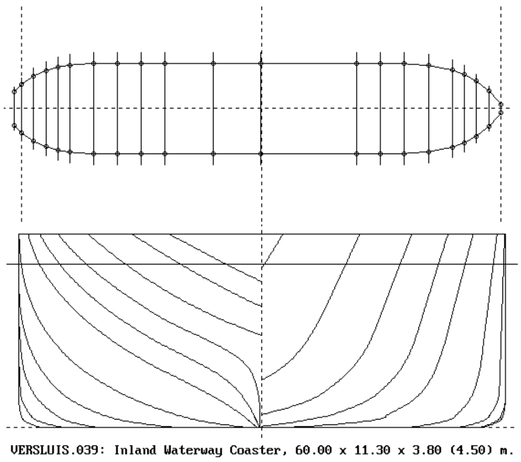

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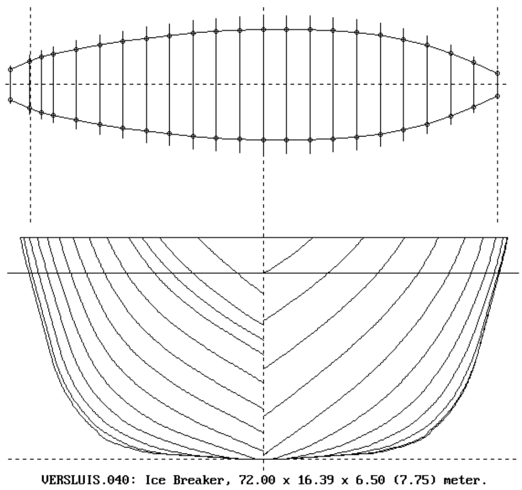

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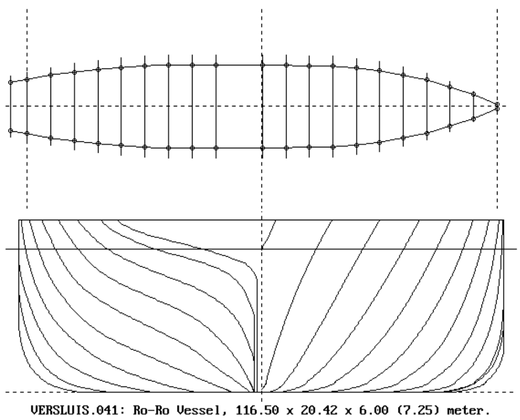

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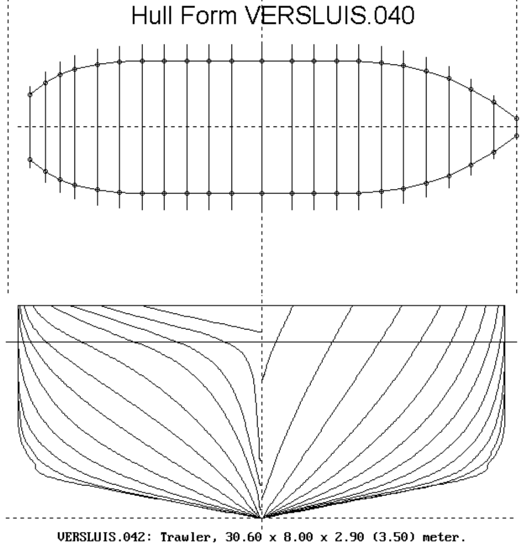

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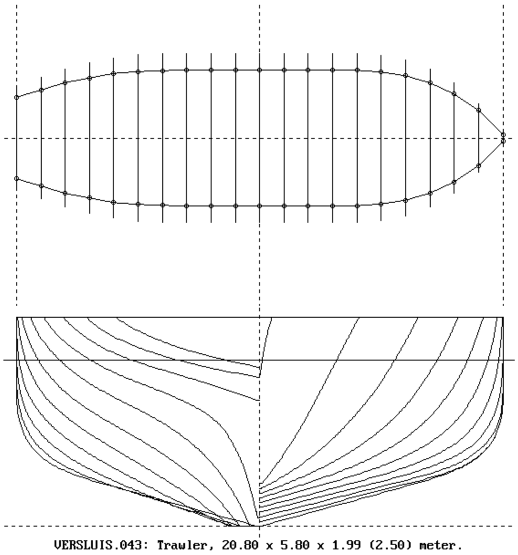

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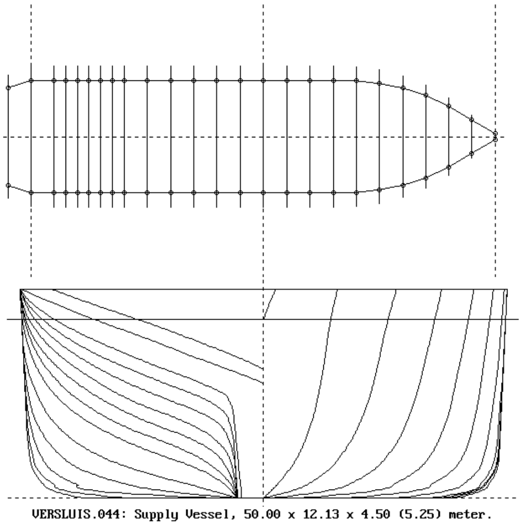

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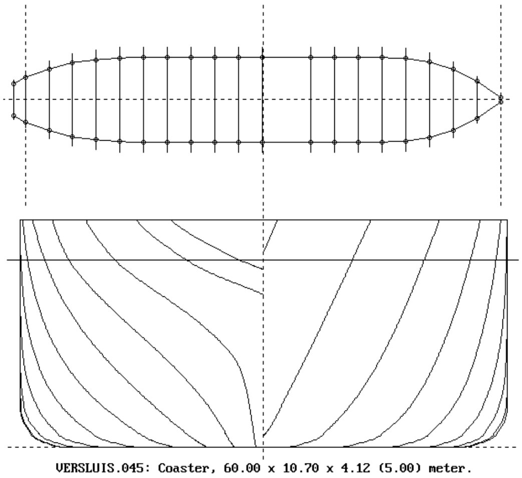

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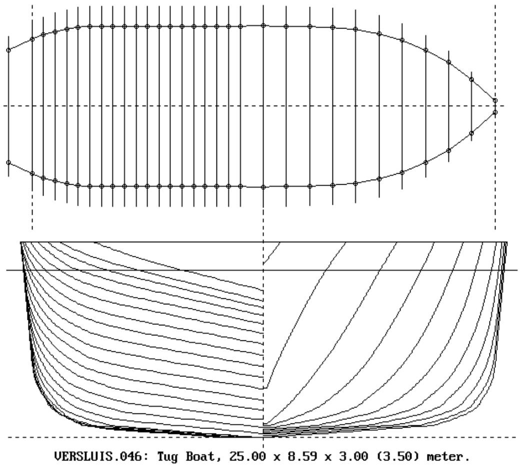

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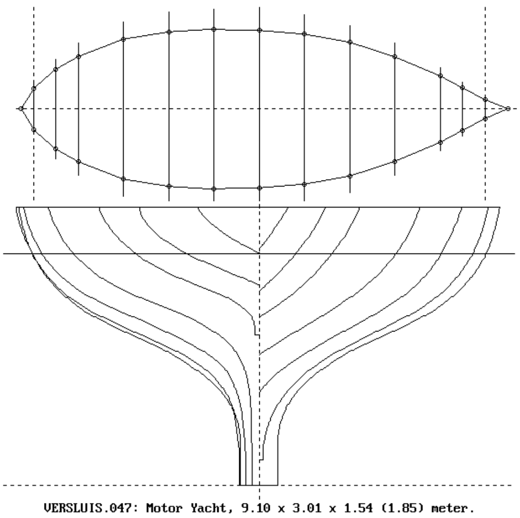

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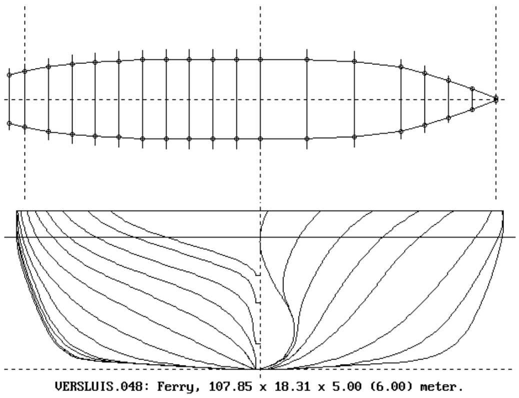

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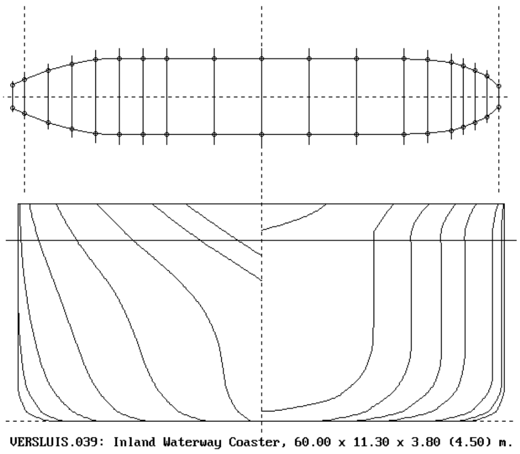

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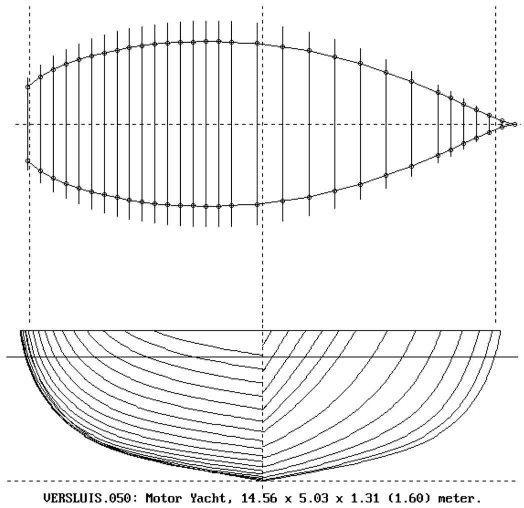

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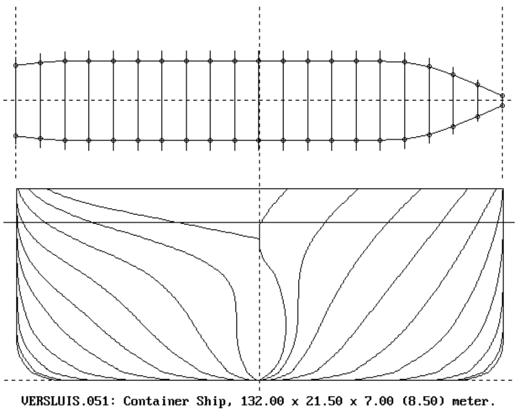

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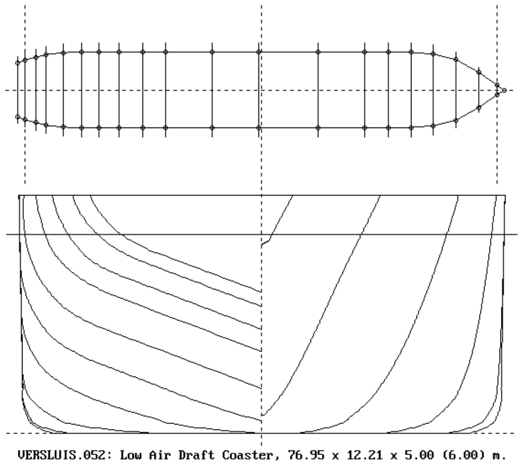

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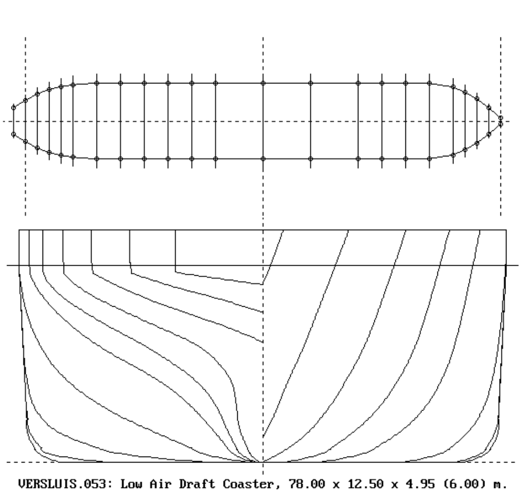

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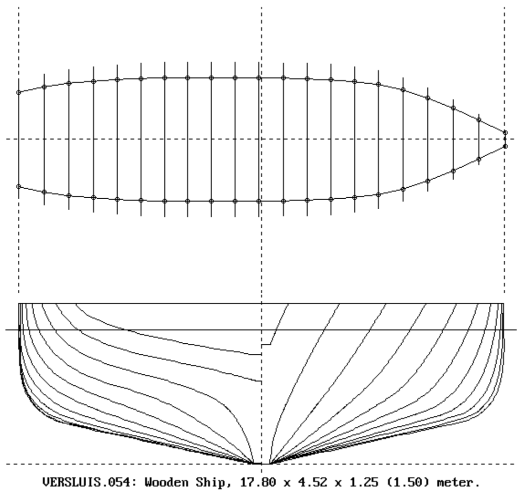

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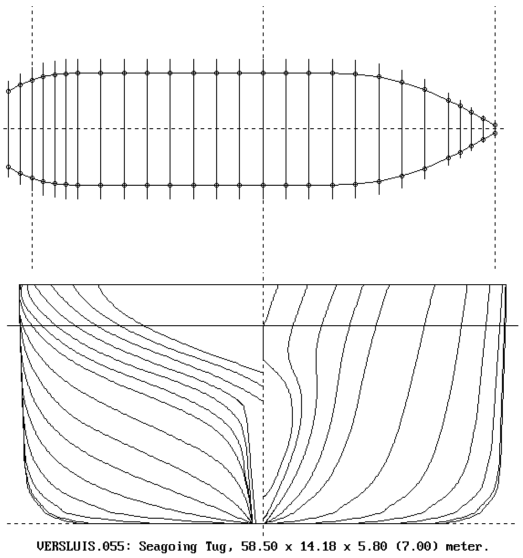

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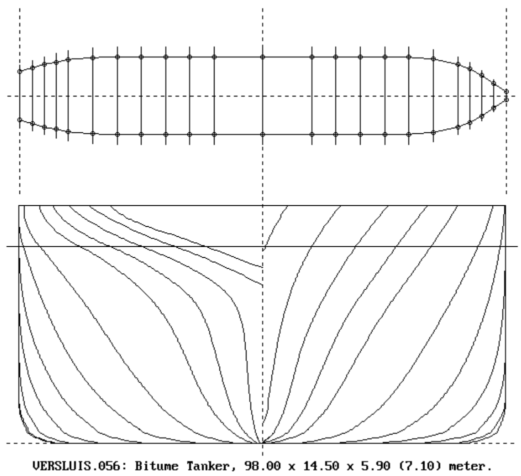

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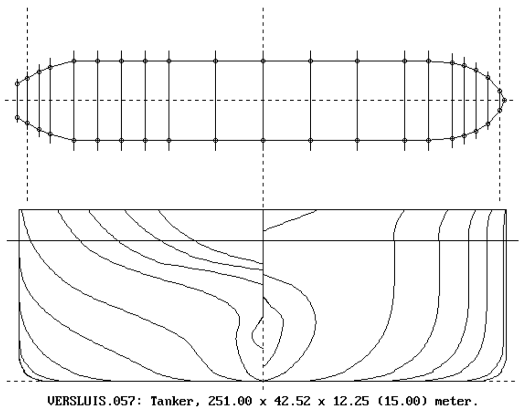

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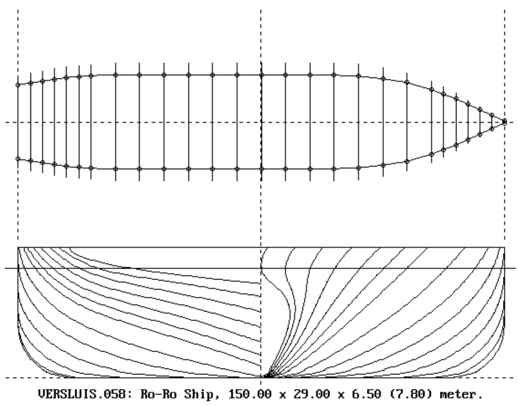

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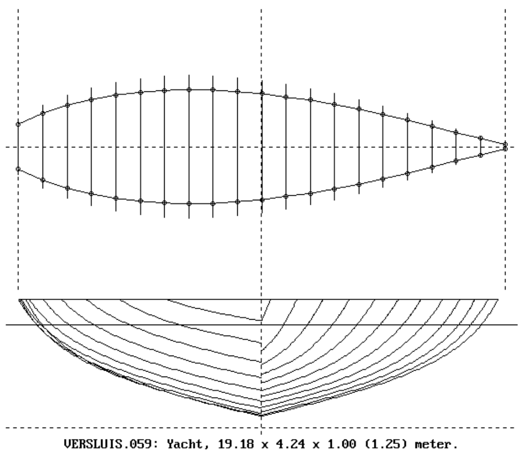

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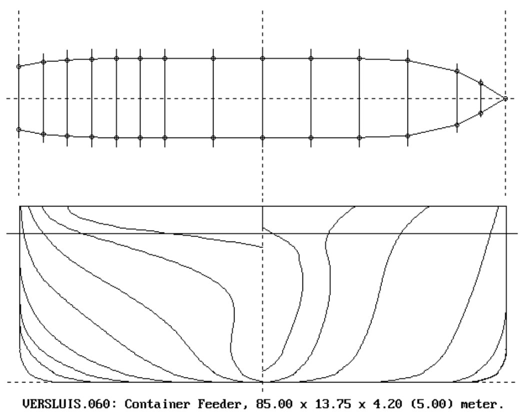

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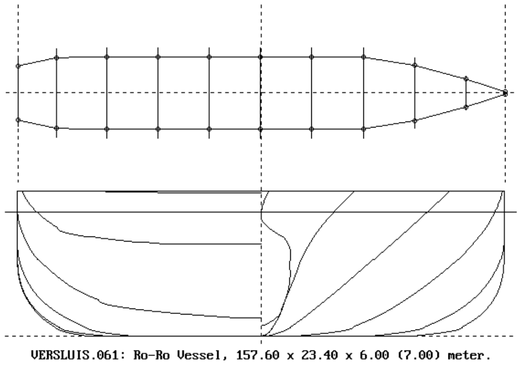

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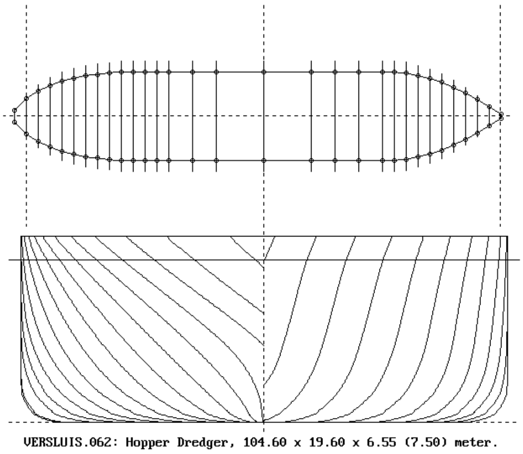

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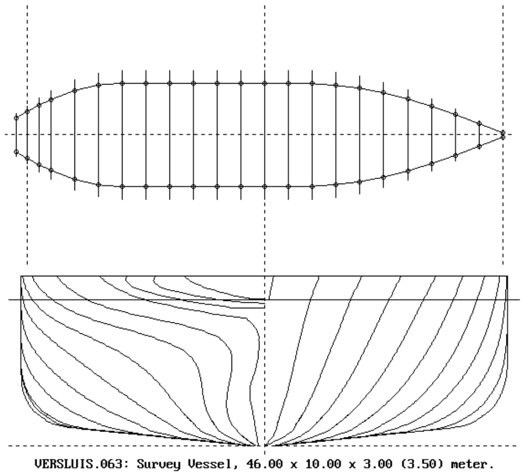

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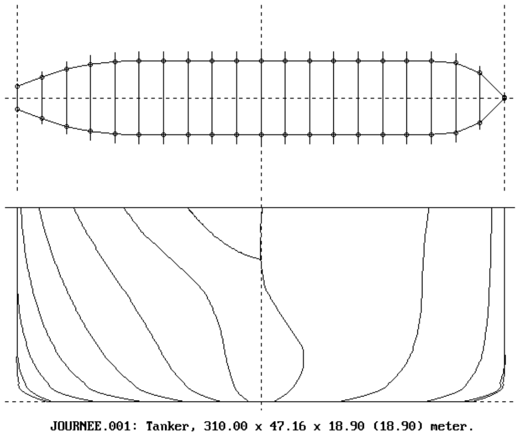
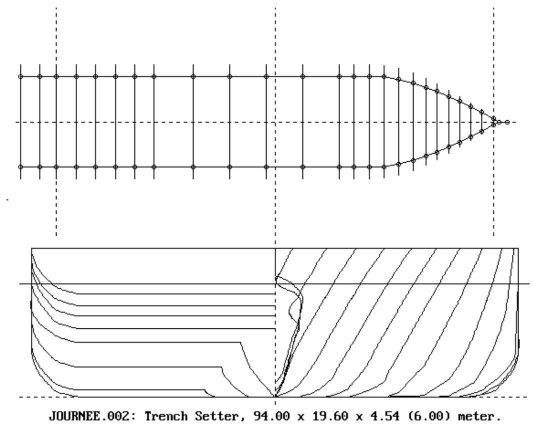


Hull Form JOURNEE.001



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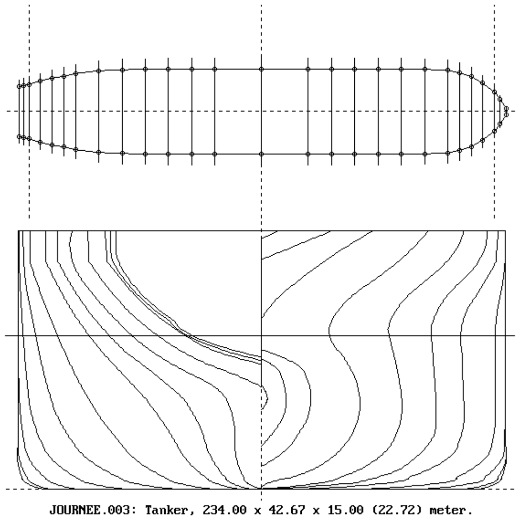

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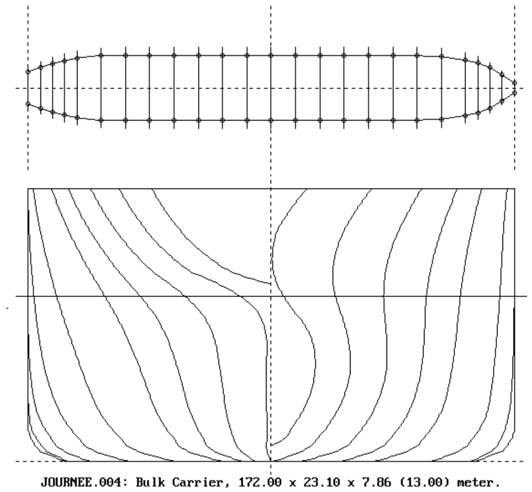

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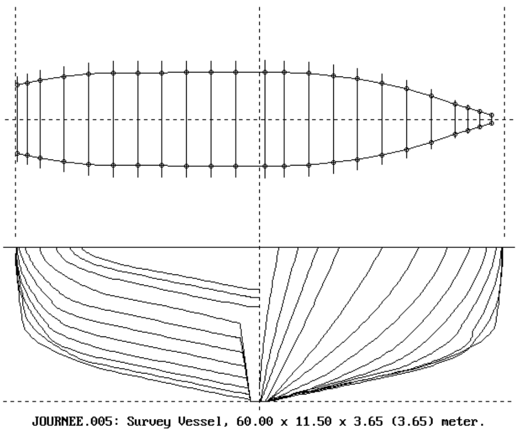

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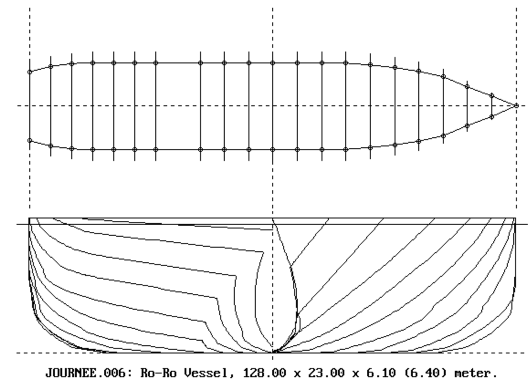

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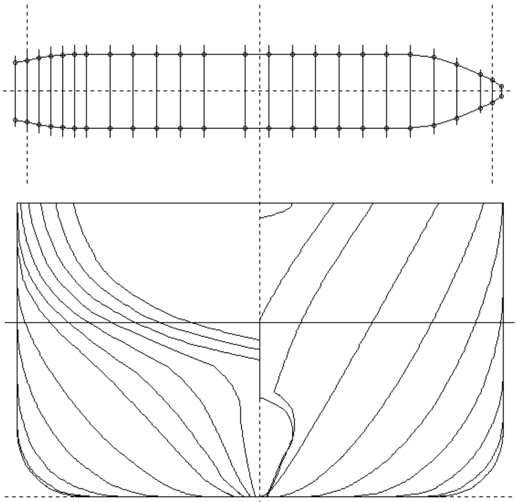
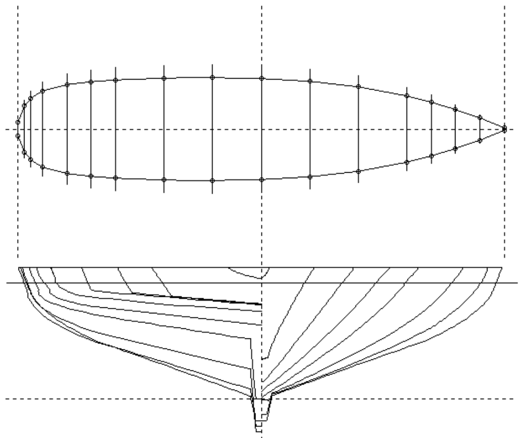


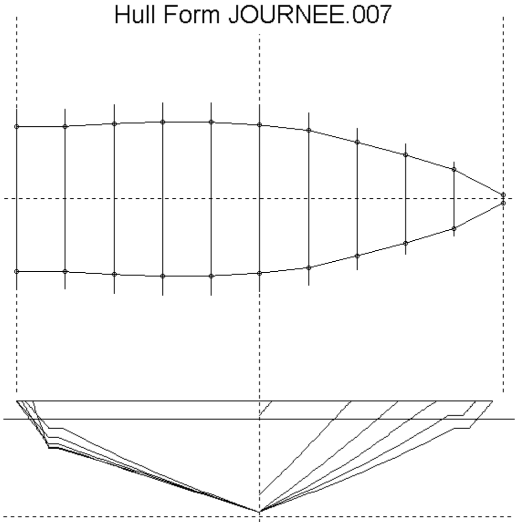
JOURNEE.007: Freighter, 110.60 x 17.50 x 6.25 (10.58) meter.

Hull Form JOURNEE.007



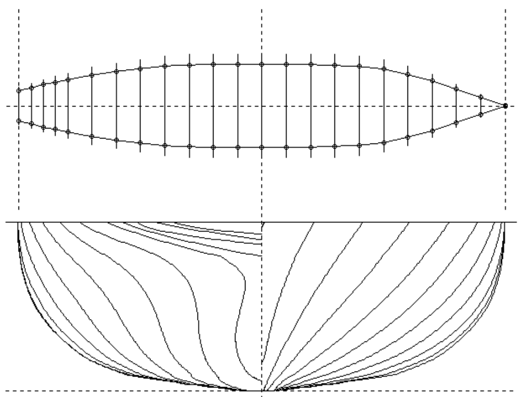
JOURNEE.008: Pilot Vessel, 21.00 x 4.40 x 1.06 (1.20) meter.

Hull Form JOURNEE.008



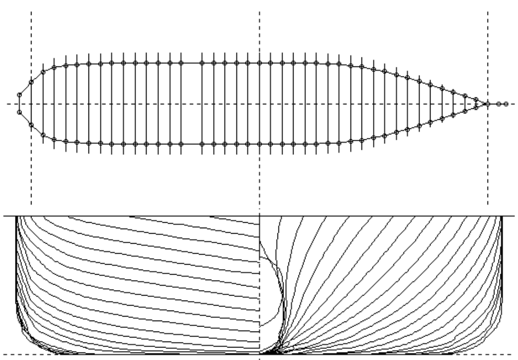
JOURNEE.009: Pilot Vessel, 15.10 x 4.81 x 0.97 (1.15) meter.

Hull Form JOURNEE.009



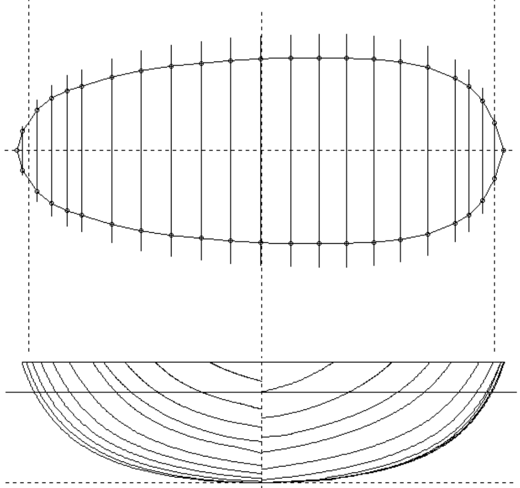
JOURNEE.010: Oceanographic Vessel, 84.50 x 14.40 x 5.00 (5.00) meter.

Hull Form JOURNEE.010



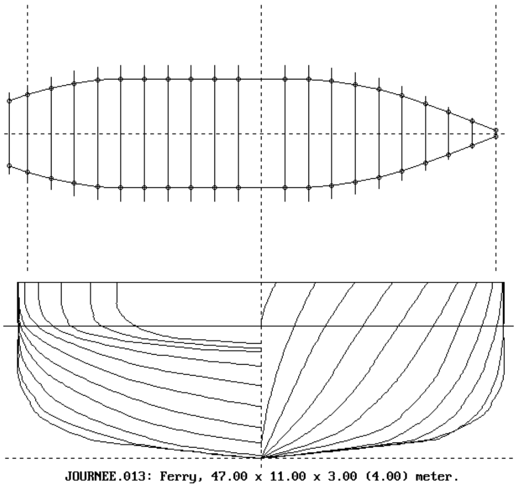
JOURNEE.011: Ro-Ro Vessel, 118.50 x 21.00 x 6.00 (6.00) meter.

Hull Form JOURNEE.011

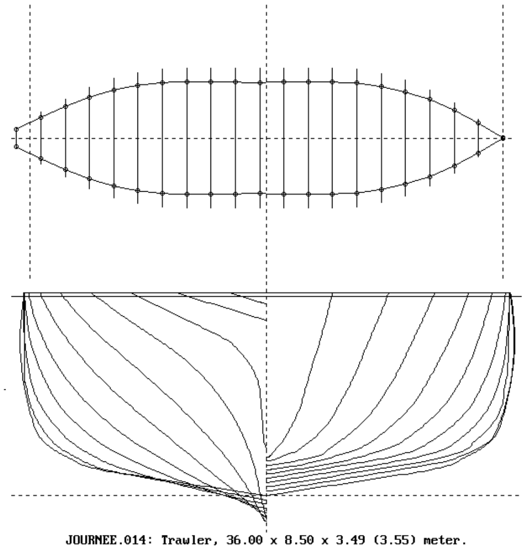


JOURNEE.012: Lemmster Aak, 8.58 x 3.58 x 0.64 (0.85) meter.

Hull Form JOURNEE.012



Hull Form JOURNEE.013



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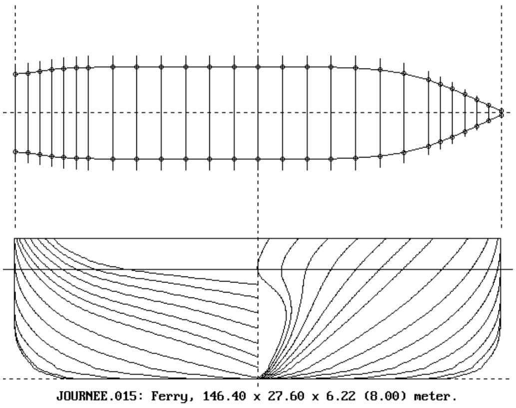

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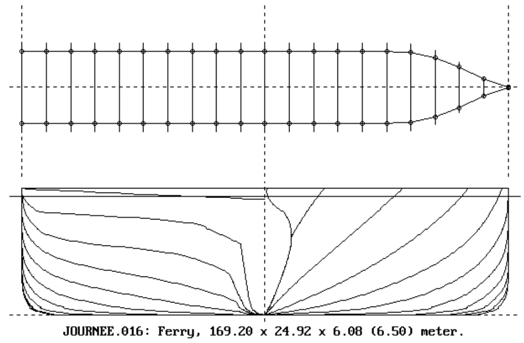

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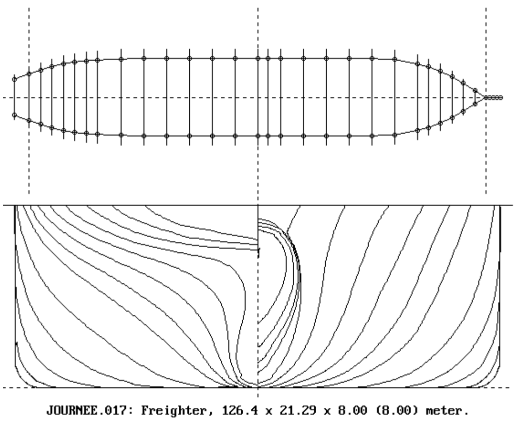

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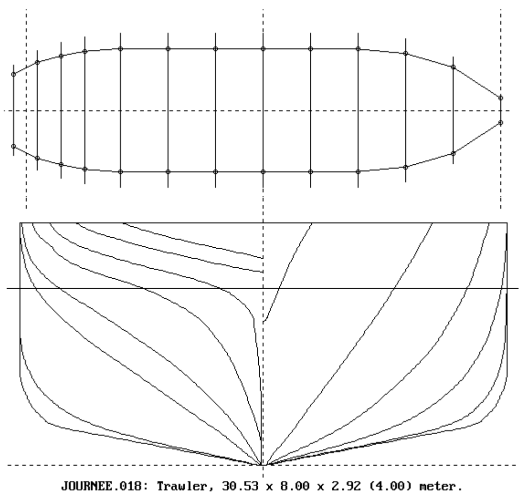

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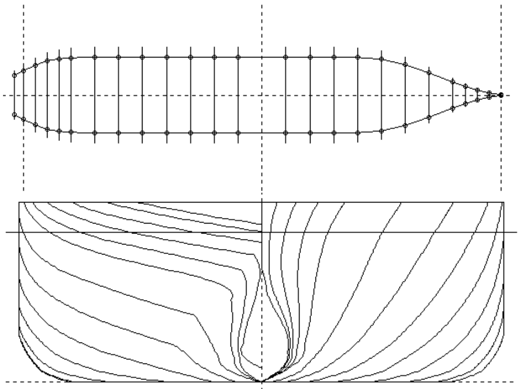
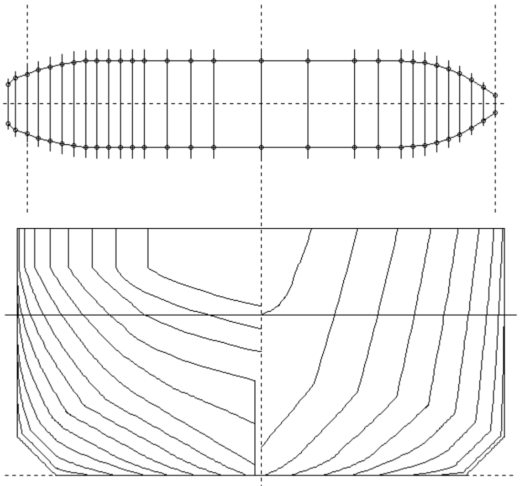


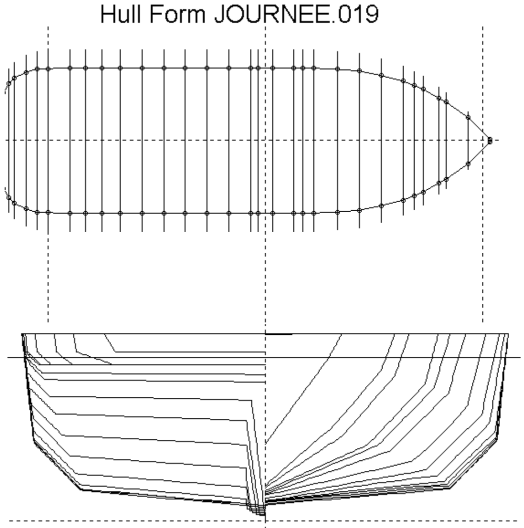
JOURNEE.019: Container Ship, 202.00 x 32.24 x 9.95 (12.00) meter.

Hull Form JOURNEE.019



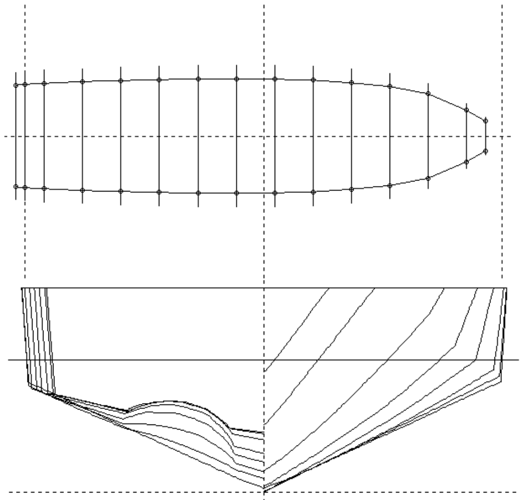
JOURNEE.020: Hopper Dredger, 106.00 x 19.60 x 6.50 (10.00) meter.

Hull Form JOURNEE.020



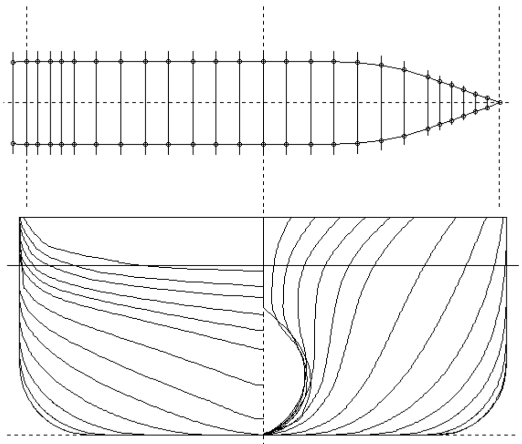
JOURNEE.021: Tug Boat, 39.00 x 13.00 x 4.38/0.50 (5.00) meter.

Hull Form JOURNEE.021



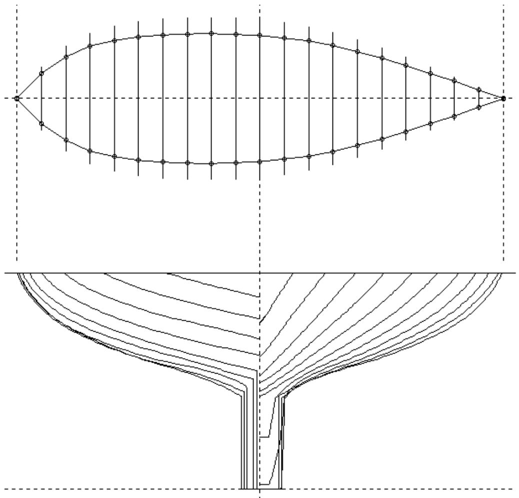
JOURNEE.022: Protection Vessel, 24.85 x 4.85 x 1.62 (2.50) meter.

Hull Form JOURNEE.022



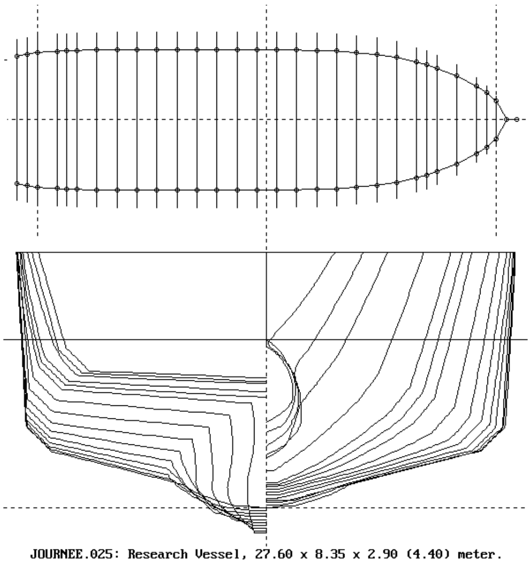
JOURNEE.023: Reefer Ship, 114.00 x 20.00 x 7.00 (9.00) meter.

Hull Form JOURNEE.023



JOURNEE.024: Sail Yacht, 41.95 x 11.22 x 5.00 (5.00) meter.

Hull Form JOURNEE.024



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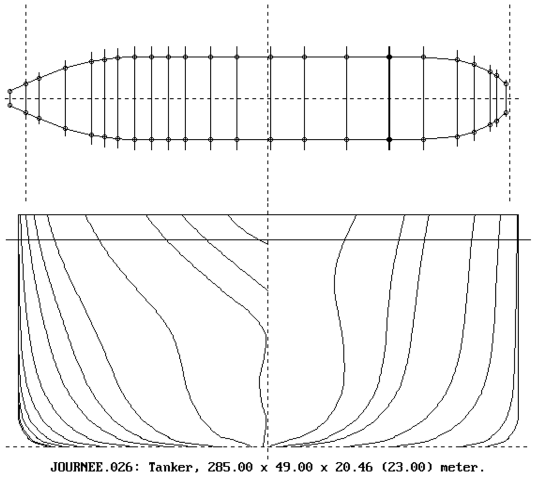

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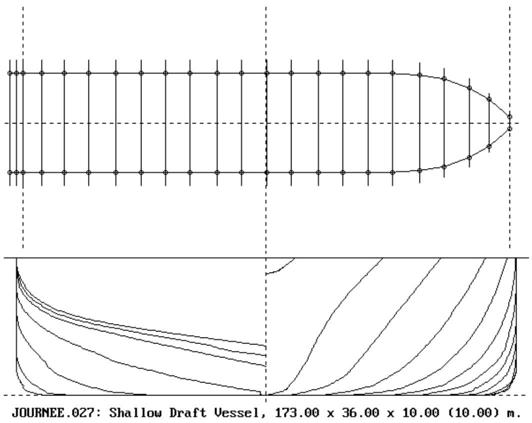

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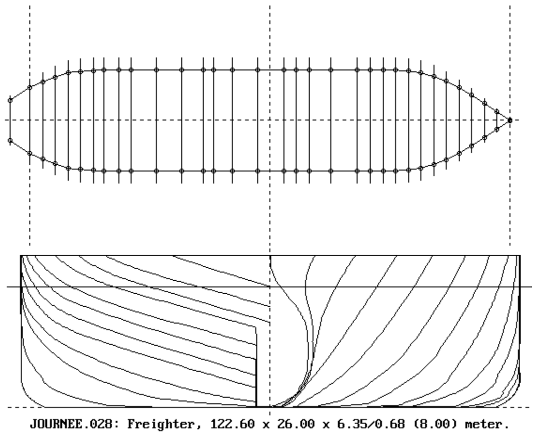

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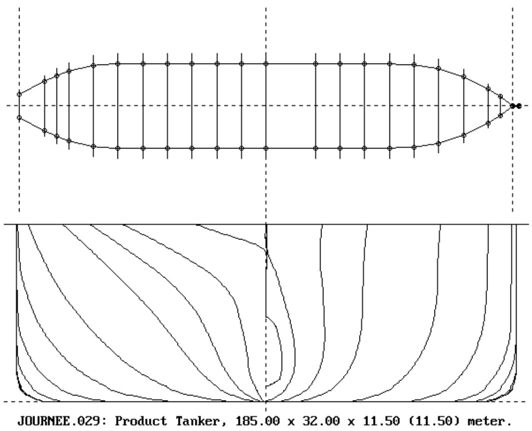

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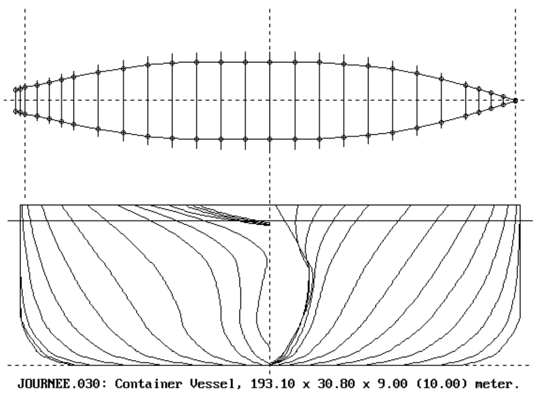

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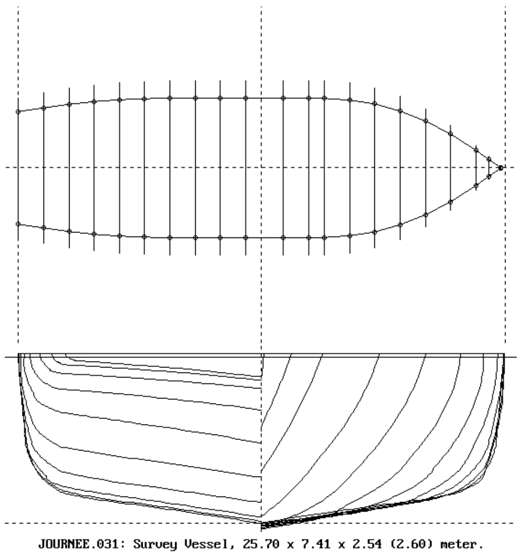

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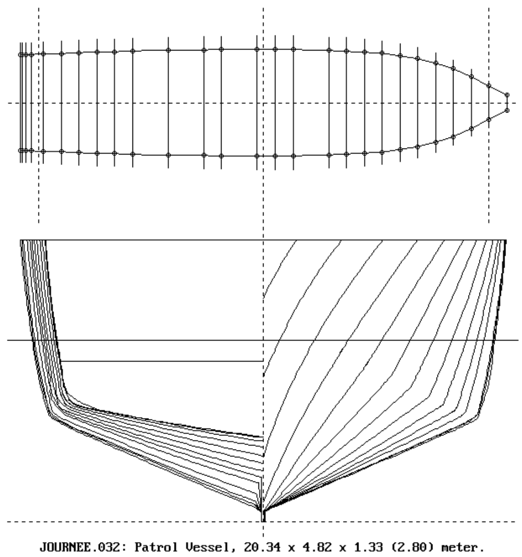

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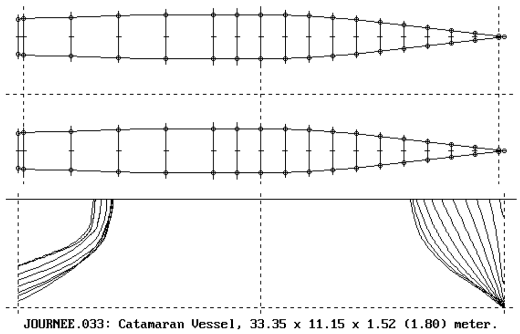

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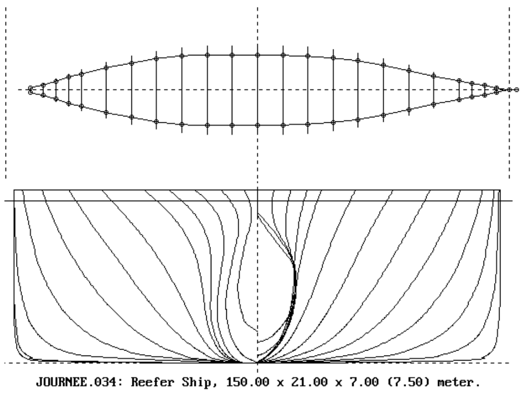

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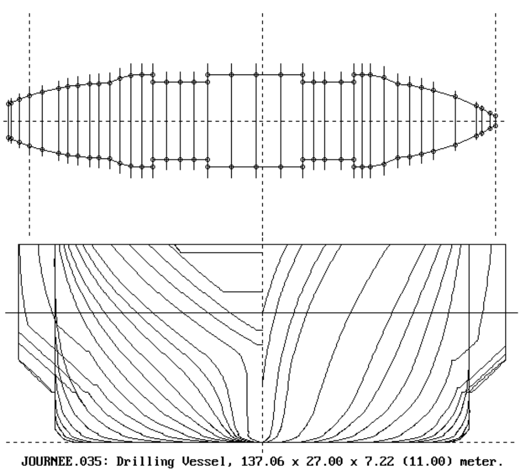

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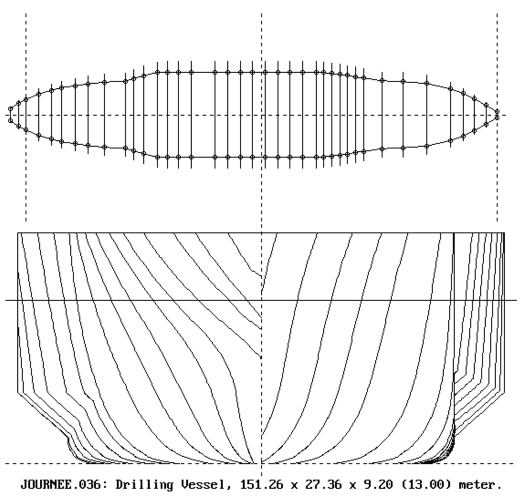

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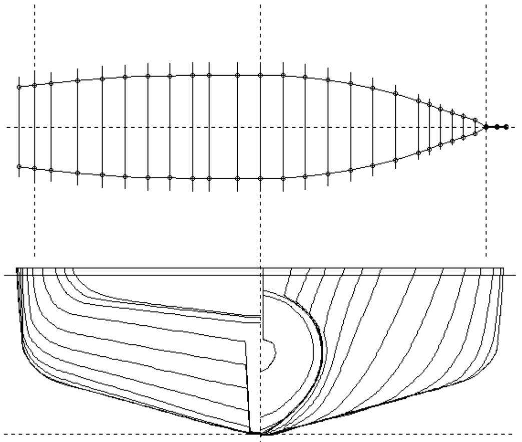
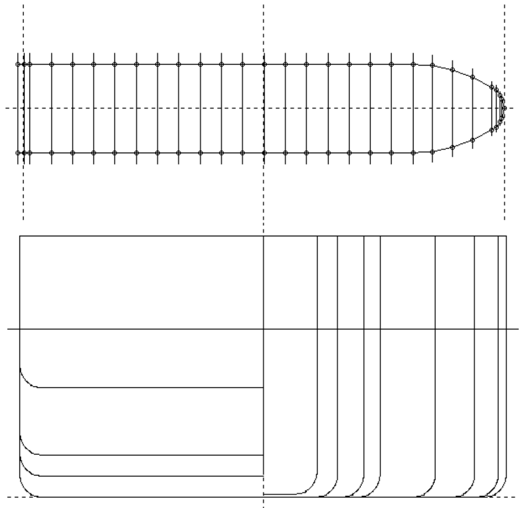


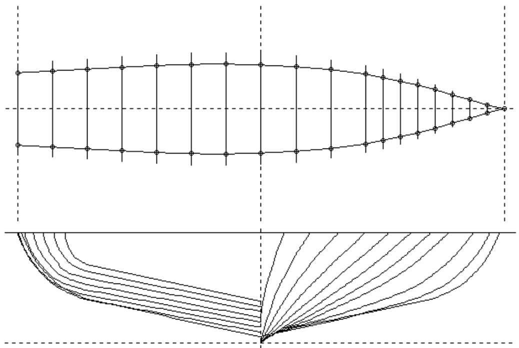
JOURNEE.037: Trawler, 36.30 x 8.36 x 2.73 (2.85) meter.

Hull Form JOURNEE.037



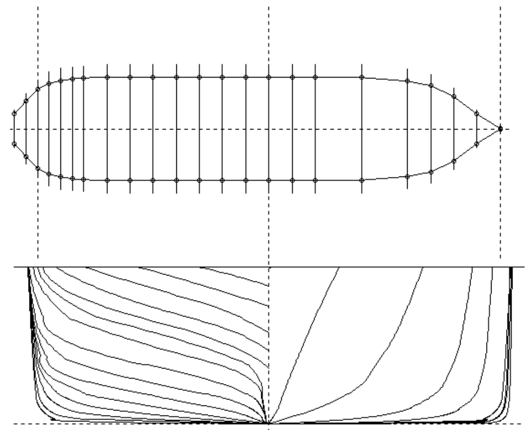
JOURNEE.038: Barge, 234.20 x 43.20 x 14.99 (23.20) meter.

Hull Form JOURNEE.038



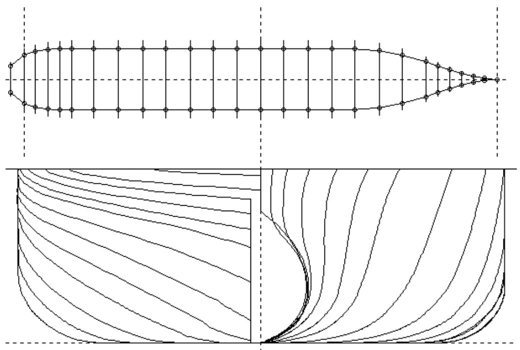
JOURNEE.039: High Speed Vessel, 28.00 x 4.88 x 1.18 (1.18) meter.

Hull Form JOURNEE.039



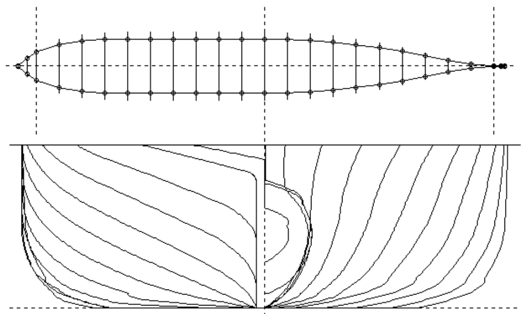
JOURNEE.040: Diving Support Vessel, 85.50 x 18.97 x 6.20 (6.20) meter.

Hull Form JOURNEE.040



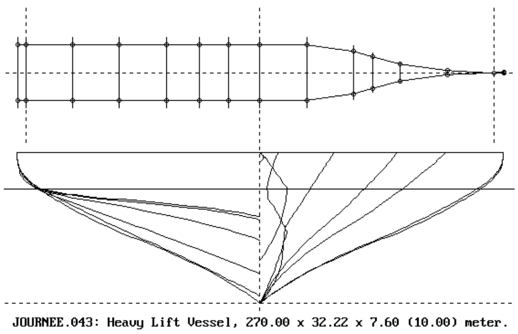
JOURNEE.041: Container Ship, 275.00 x 36.00 x 12.90 (12.90) meter.

Hull Form JOURNEE.041

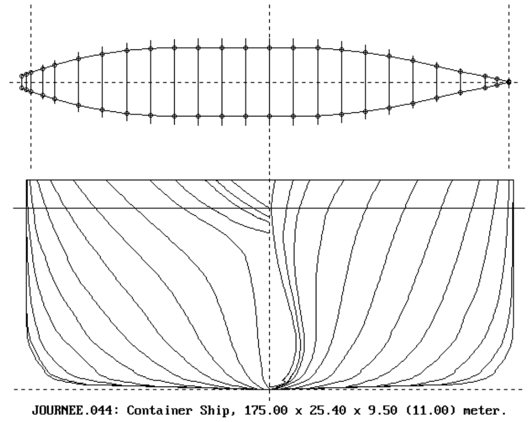


JOURNEE.042: Container Vessel, 270.00 x 32.20 x 10.85 (10.85) meter.

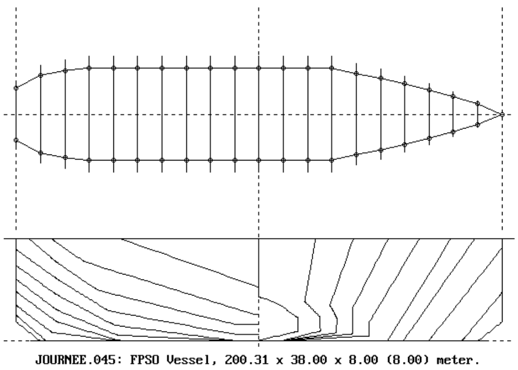
Hull Form JOURNEE.042



Hull Form JOURNEE.043



Hull Form JOURNEE.044



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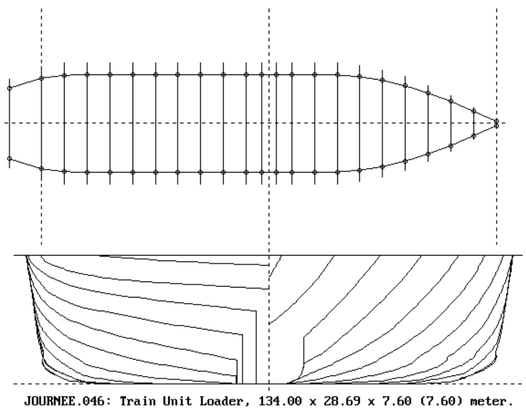

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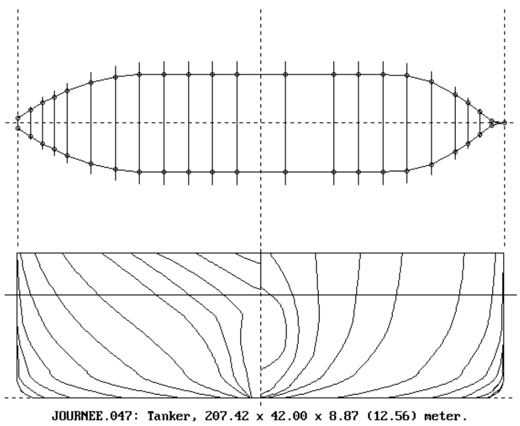

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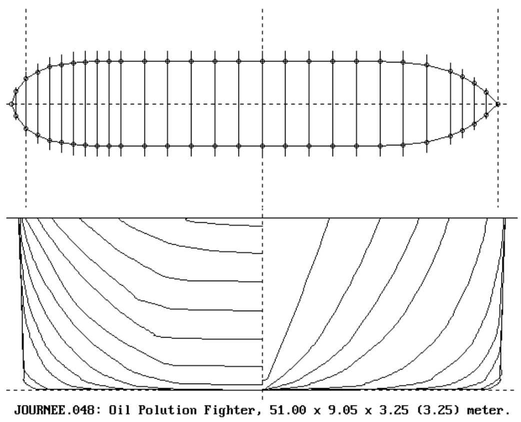

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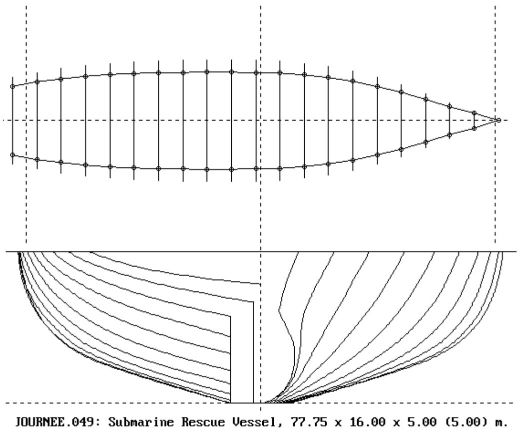

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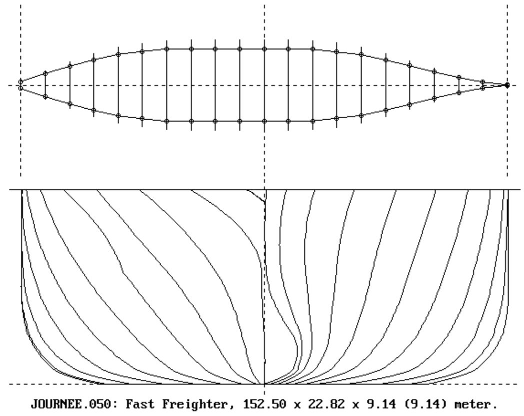

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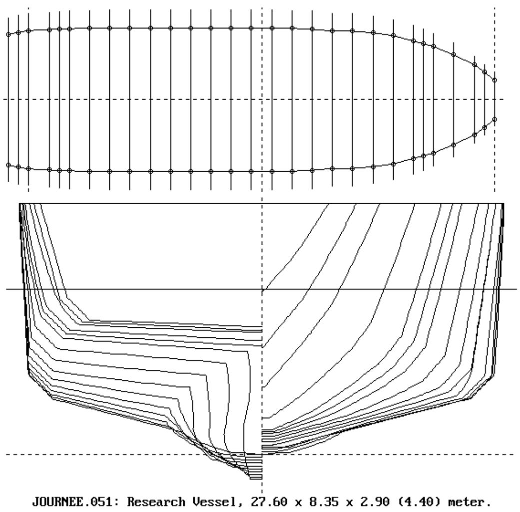

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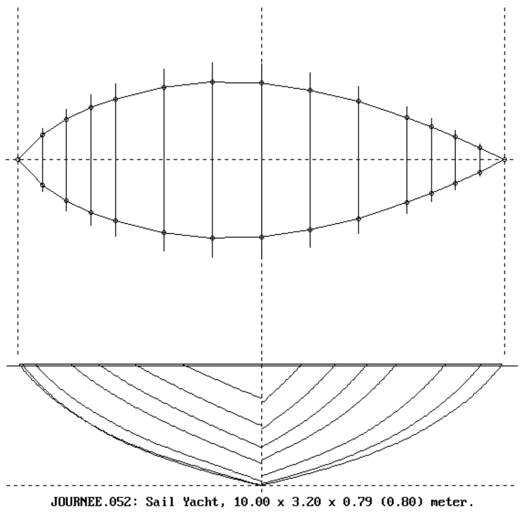

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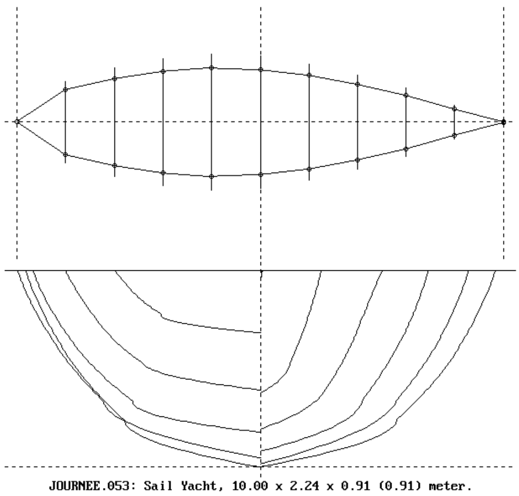

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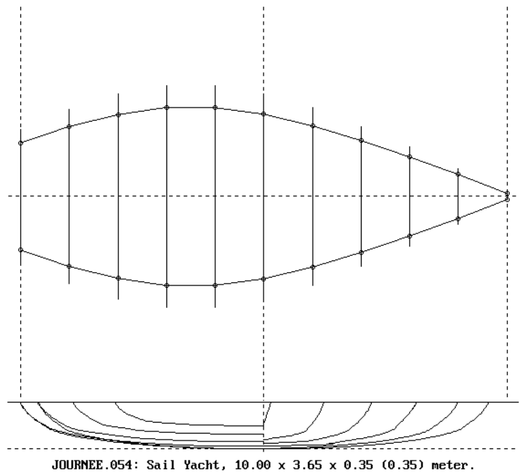

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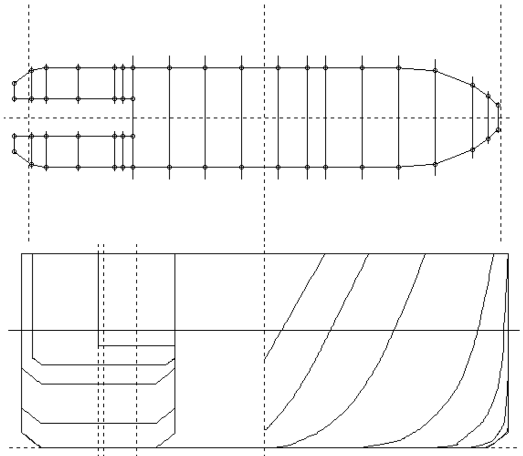
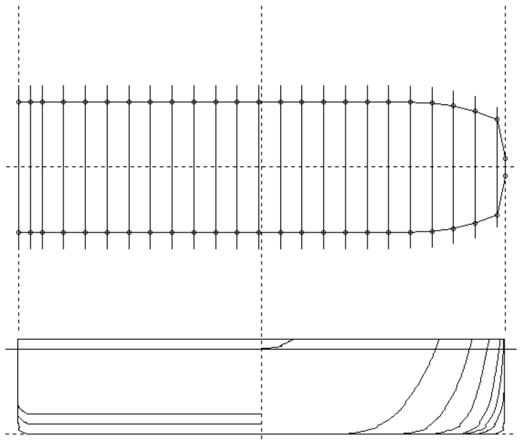


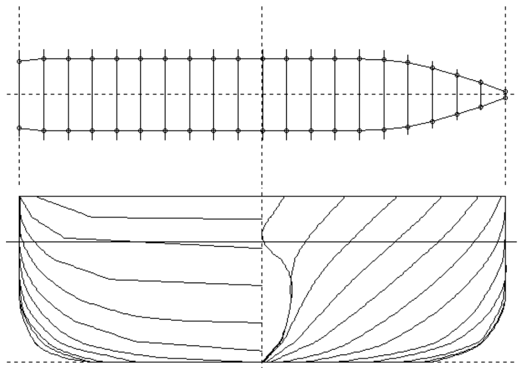
JOURNEE.055: Cutter Suction Dredger, 90.26 x 19.00 x 4.60 (7.60) meter.

Hull Form JOURNEE.055



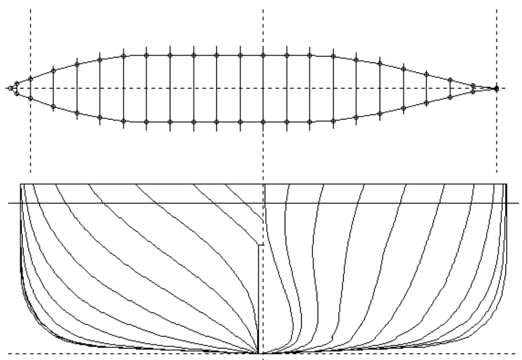
JOURNEE.056: Crane Vessel, 298.33 x 80.00 x 14.00 (15.69) meter.

Hull Form JOURNEE.056



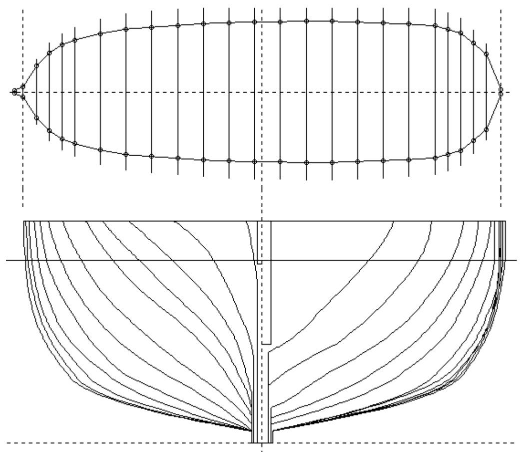
JOURNEE.057: Ro-Ro Vessel, 157.65 x 23.40 x 5.80 (8.00) meter.

Hull Form JOURNEE.057



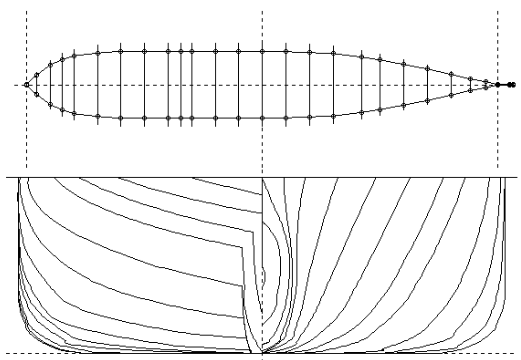
JOURNEE.058: Cruise Vessel, 198.12 x 28.65 x 8.86 (10.00) meter.

Hull Form JOURNEE.058



JOURNEE.059: Sail Yacht, 39.90 x 11.80 x 4.45 (5.40) meter.

Hull Form JOURNEE.059



JOURNEE.060: Container Ship, 156.00 x 22.00 x 8.00 (8.00) meter.

Hull Form JOURNEE.060