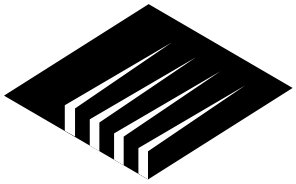
User's Manual

Autopower

FOR WINDOWS™

Release 3.0



a u t o s h i p
Systems Corporation

Suite 403
611 Alexander Street
Vancouver • B C
V6A 1E1 • Canada

Tel • (604) 254-4171
Fax • (604) 254-5171

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Getting Started

Introducing Autopower

Welcome to Auto*power*, an intuitive, yet sophisticated resistance and power prediction program that provides naval architects and designers with industry standard resistance and power prediction methods for displacement, planing, semi-displacement and catamaran vessels. The limits of each prediction method are clearly displayed, providing guidance on the selection of the most suitable methods. Up to five different hull alternatives can be considered simultaneously, facilitating comparative design studies and optimization. Parameters can be easily changed for quick recalculations.

Auto*power* has a fast link that enables input parameters to be imported from our Auto*ship* hull design / surface modeling program. High quality graphs and tables can be displayed on-screen or printed, either directly or via MS Word for customized reports.

Two Versions

Auto*power* comes in two versions: Demo version and Full version.

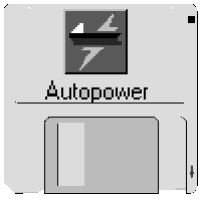
The Demo version is identical to the Full version except that the Demo version has a 30 day time limit. The Demo version may be upgraded to the Full version by sending in the Upgrade Order Form found at the front of this user's manual.

Package Contents

The contents of your Auto*power* package, which are the same for the Demo version and Full version, consist of:

- this user's manual

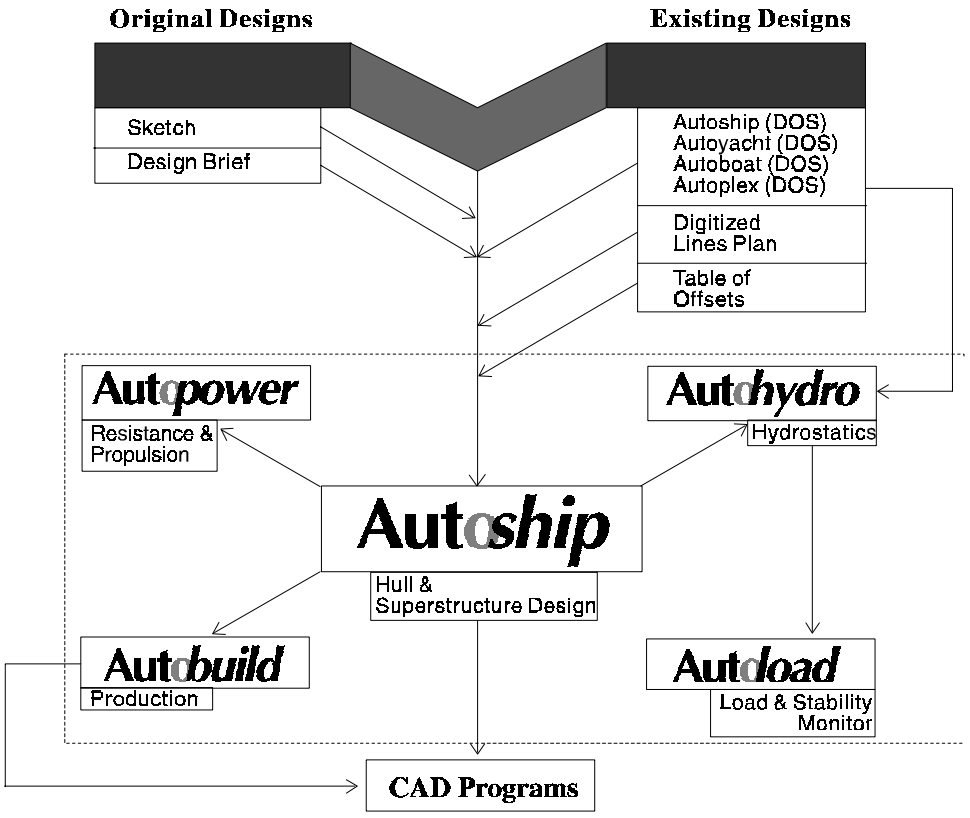
- a program disk



Contact Autoship Systems Corporation by phone, fax or mail if any items are missing from your package.

Autoship Program Suite

Auto*power* is part of our integrated suite of Windows programs.



Auto*ship*

Use Auto*ship* to model the hull and superstructure. If installed, you can access Auto*power* from Auto*ship* by selecting **Calcs-Auto*power***.

Auto*hydro*

Use Auto*hydro* to perform complete hydrostatic calculations and analyses.

Auto*build*

Use Auto*build* to design and model all internal structures.

Auto*load*

Once your vessel is built, use Auto*load* as an onboard load and stability monitor.

Contact us or any of our international dealers for more information on any of our programs.

About This Manual

We assume you are familiar with the Windows environment. If you have not worked with Windows before, please consult your Windows documentation. Here is what you will find in this user's manual:

Chapter 1
Getting Started introduces you to Auto*power* and helps you install it.

Chapter 2
About Autopower tells you how to run Auto*power* and familiarizes you with the display, keyboard and Auto*power's* main functions.

Chapter 3
Menu System provides information on each of Auto*power*'s menus.

Chapter 4
Hull Parameters describes how to enter hull parameters required to perform resistance calculations.

Chapter 5
Calculating Resistance describes how to calculate resistance.

Chapter 6
Propeller Design and Propulsion describes how to use Auto*power*'s propeller design options and to calculate propulsion.

Chapter 7
Algorithms describes Auto*power*'s resistance and propulsion methods.

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System Requirements

	Minimum	Recommended
CPU	386 DX 25 MHz with math co-processor	486 DX2 66 MHz or Pentium
Memory	8 Mb RAM	16 Mb RAM
Graphics Capability	640x480 resolution, 16-color VGA monitor with compatible video card	1024x768 resolution, 256-color VGA monitor with compatible video card
Free Hard Disk Space	5 Mb	
Operating System	Windows 3.1 or later version, or Windows NT	
Mouse	√	
Laser Printer	√	

Installing Autopower

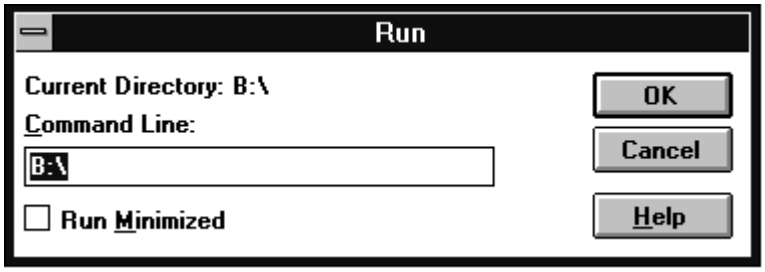
Before Installation

1. Check the Auto*power* program disk for the **readme.wri** and **history.wri** files and read them, if present, with Windows Write. **Readme.wri** contains the latest comments on the installation procedure and program use. **History.wri** contains a summary of the program revisions.
2. Disable floppy disk caching in Smartdrive before starting the installation. Otherwise, problems may arise with the Setup program due to disk buffering. To disable floppy disk caching, type the command **smartdrv a- b-** at the DOS prompt.
3. Ensure that you have enough hard disk space - approximately 5 Mb is required.
4. Ensure that your autoexec.bat file has the Windows directory in the path statement.
5. If you have MS Word, ensure that your autoexec.bat file has the MS Word directory in the path statement. This will enable you to transfer Auto*power* output to MS Word.

Installing Autopower

The installation procedure is the same for the Demo version and Full version.

1. Start Windows and open the File Manager.
2. Insert the Auto*power* program disk into your disk drive.
3. Enter **File-Run**. The Run dialog box appears. Enter **a:\setup.exe** or **b:\setup.exe**, depending on the disk drive you are using. Click **OK.** Disregard Run Minimized as this is a standard Windows option inappropriate for Auto*power*.

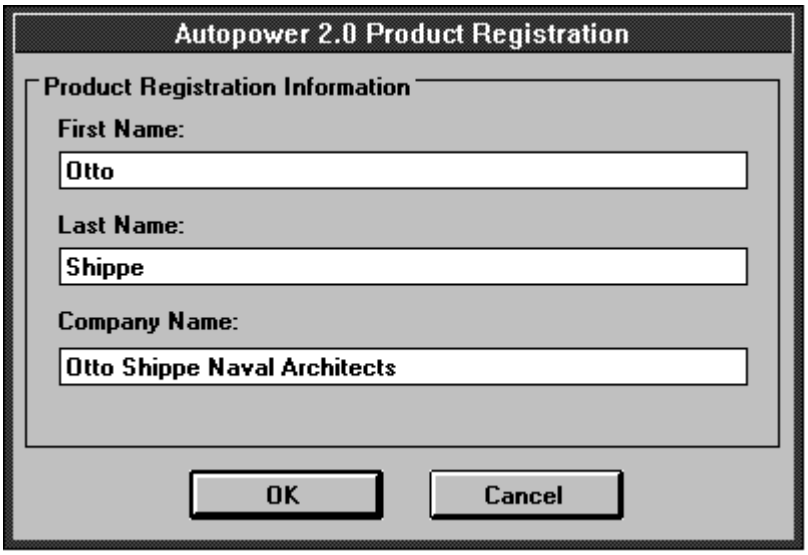


4. A Setup box appears while the setup files are being initialized.

5. Then the Autoship Directory Path dialog box appears.

6. Enter the drive and directory where you want to install Auto*power* and click **OK**. To use the default directory setting of C:\AUTOSHIP\APWR, click **OK** without entering anything in the input box.

7. The Product Registration dialog box appears.



8. Enter your first name, last name, and company name as you are prompted. Use the tab key after entering each line. Click **OK.**
9. The "Application Installation is Complete" message box appears. Click **OK**.

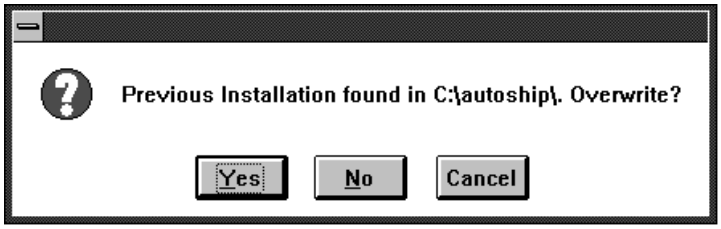
Note: The first time you run Auto*power*, the Font dialog box will appear so that you can set the font type and size to be used for printing reports. We recommend using a regular 10-point Arial font. These settings will remain until changed. To change these settings, select **File - Page Setup** and click on the **Fonts** button, which will open the Fonts dialog box.

Upgrading from Demo to Full Version

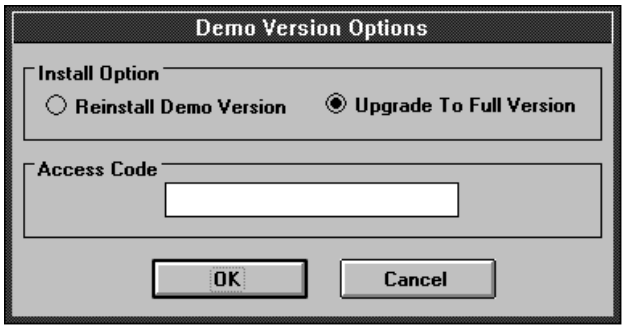
If you have a Demo version, each time you run Auto*power*, the startup screen will tell you how many days you have left in your 30 day demo period. At the end of the demo period, you will not be able to operate Auto*power*.

1. Complete the Upgrade Order Form found at the front of this user's manual and fax or mail it to us. Or, contact us by telephone and provide us with the full information on the Upgrade Order Form.

2. We will provide you with a 22 character Access Code which will remove the time limitation on your Demo version and make it a Full version.
3. Re-install Auto*power* following the steps under Installing Auto*power*. The “Previous Installation Found...Overwrite?” message box appears. Click **Yes**.



4. The "Please Wait" message box appears followed by the Demo Version Options dialog box. Select Upgrade to Full Version. Enter the Access Code. Click **OK**. If you enter more or less than the 22 character Access Code, you will be prompted to re-enter the string. If you enter 22 characters but not the correct Access Code, the setup program will terminate.



5. The "Installation is Complete" message box appears. Click **OK**.

Chapter 2
About Autopower

This chapter gives you an overview of Auto*power* and covers the following points:

- Entering and Exiting
- Mouse and Keyboard
- Main Screen
- Menu System
- Default Settings
- Resistance and Propulsion Methods

Entering and Exiting

Entering Double-click on the Auto*power* icon.

Alternatively, you can open the File Manager and select **c:\autoship\apwr\apwr.exe.**

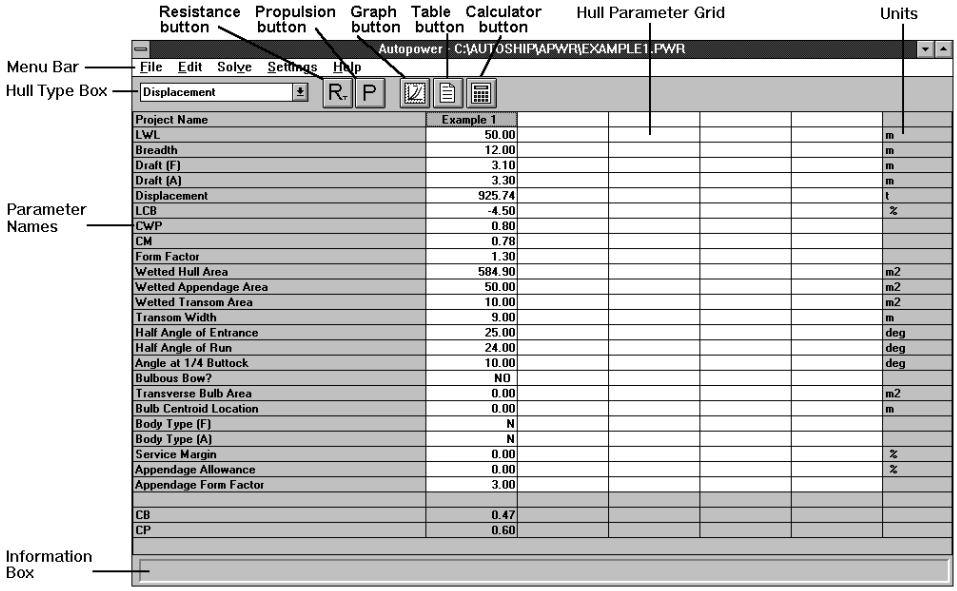
Exiting Select **File - Exit**.

Mouse and Keyboard

In Auto*power*, the mouse works the same way as it does in any Windows program. Use the left mouse button for all selecting. The right mouse button is not used.

Key	Use It To
Character Keys	Type in names and specify values.
Arrow keys	Move through grids.
Enter	Accept the entry you have just made.
F1 or Alt + H	Open Help menu.
F2	Edit active cell.
F5	Open Resistance dialog box.
F6	Open Propulsion dialog box.
F9	Run resistance calculations.
F12	Open Save-As dialog box.
Control + F12	Open "Save existing data?" dialog box. If you enter Yes, the Open File dialog box opens.
Shift + F12	Open Save dialog box. If file has not been named yet, the Save As dialog box opens.
Control + Shift + F12	Open Print dialog box. If a font has not been selected yet, the Font dialog box opens.
Alt + F	Open File menu.
Alt + E	Open Edit menu.
Alt + V	Open Solve menu.
Alt + S	Open Settings menu.

Main Screen


Resistance button
Propulsion button
Graph button
Table button
Calculator button
Hull Parameter Grid
Units
Menu Bar
Hull Type Box
Parameter Names
Information Box
Autopower - C:\AUTOSHIP\APWR\EXAMPLE1.PWR
File Edit Solve Settings Help
Displacement
R
P
Project Name | Example 1
LWL | 50.00 | m
Breadth | 12.00 | m
Draft (F) | 3.10 | m
Draft (A) | 3.30 | m
Displacement | 925.74 | t
LCB | -4.50 | %
CWP | 0.80
CM | 0.78
Form Factor | 1.30
Wetted Hull Area | 584.90 | m2
Wetted Appendage Area | 50.00 | m2
Wetted Transom Area | 10.00 | m2
Transom Width | 9.00 | m
Half Angle of Entrance | 25.00 | deg
Half Angle of Run | 24.00 | deg
Angle at 1/4 Buttock | 10.00 | deg
Bulbous Bow? | NO
Transverse Bulb Area | 0.00 | m2
Bulb Centroid Location | 0.00 | m
Body Type (F) | N
Body Type (A) | N
Service Margin | 0.00 | %
Appendage Allowance | 0.00 | %
Appendage Form Factor | 3.00
CB | 0.47
CP | 0.60

Menu System

File Edit Solve Settings Help

This table summarizes the menu system which is described in detail in ***Chapter 3, The Menu System***.

Menu	Contains
File Menu	Items for manipulating files.
Edit Menu	Items for copying, pasting and clearing the Hull Parameter Grids.
Solve Menu	Items for calculating resistance and propulsion and opening the Graph and Report windows.
Settings Menu	Items for specifying water density and units of measurement.
Help Menu	Items for accessing online help.

Default Settings

Auto*power*'s default settings are as follows:

- Displacement hull type
- Metric units
- Sea water density
- Printing is sent to the default system printer
- Pages are 8.5 x 11 inches with page margins 1 inch from all four sides

Resistance Methods

Auto*power* provides the following resistance methods which are described in detail in ***Chapter 5, Calculating Resistance*** and ***Chapter 7, Algorithms.***

Displacement

- Andersen/Guldhammer
- Fung
- Holtrop
- van Oortmerssen
- Digernes/Cheng
- Jin/Su/Tan
- Calisal
- FAO

Semi-Displacement

- Compton

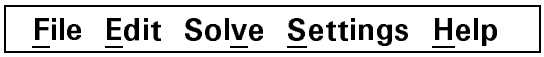
Planing

- Savitsky
- Radojcic

Catamaran

- Marintek Fastcat

Chapter 3
Menu System

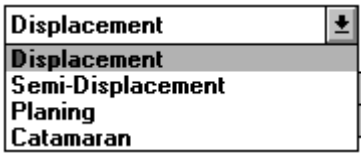


Auto*power*'s menu system consists of File, Edit, Solve, Settings, and Help menus.

Chapter 5
Calculating Resistance

To calculate resistance, take the following steps:

1. Select the hull type.

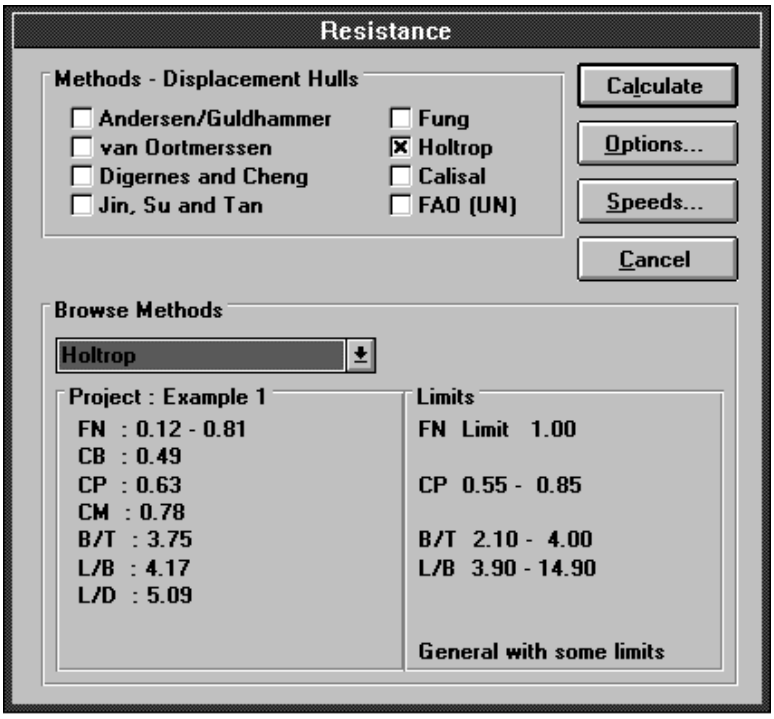


2. Enter the hull parameters into the Hull Parameter Grid or import the hull parameters from Auto*ship* (see ***Chapter 4, Hull Parameters***).

3. Click on the Resistance icon.

4. The Resistance dialog box opens. This dialog box contains the resistance method(s) appropriate to the hull type you have selected.

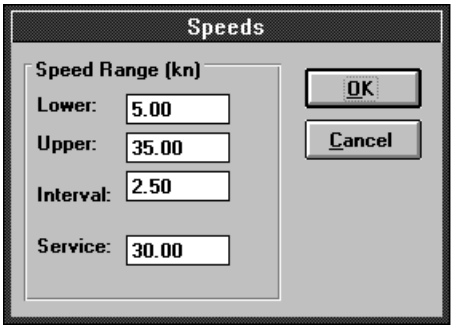
Resistance Dialog Box (Displacement)



5. Select the resistance method(s). You can use the Browse Methods box to compare the limits of the selected method(s) against the hull parameters of the active file.

6. Click on the Speeds button.

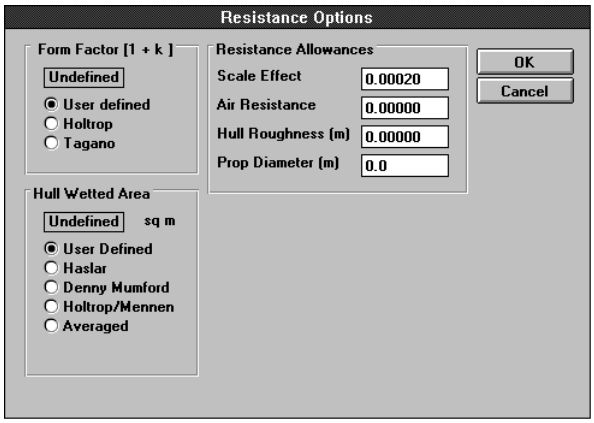
7. The Speeds dialog box opens. Enter the lower, upper, interval and service speeds. Click **OK**.



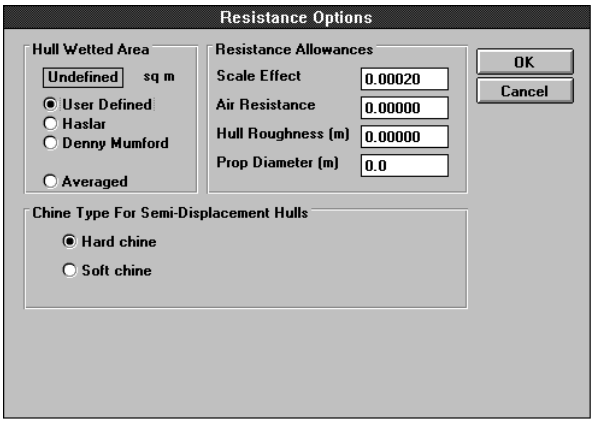
8. Click on the Options button.

9. The Resistance Options dialog box appears. There are four Options dialog boxes, depending on the hull type you have selected.

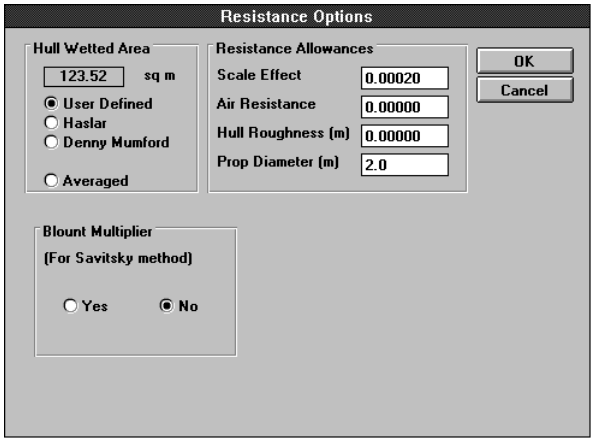
Resistance Options (Displacement)



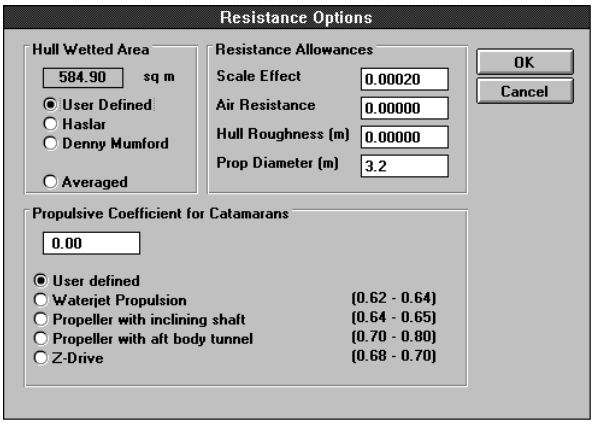
Resistance Options (Semi-Displacement)



Resistance Options (Planing)



Resistance Options (Catamaran)



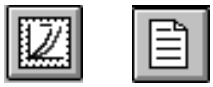
10. Enter the following resistance options and click **OK**.

Option	Entry
Hull Wetted Area	This option is available for all vessel types. You must enter the hull wetted area either by entering a user-defined value into the Hull Parameters grid, or by selecting one of the following methods: • User Defined (this is the default) • Haslar • Denny Mumford • Holtrop/Mennen (displacement only) • Averaged
Form Factor (1 + k)	This option is available only for displacement vessels. You must enter the Form Factor in the Hull Parameters grid. Once entered, select among: • User Defined (this is the default) • Holtrop • Tagano

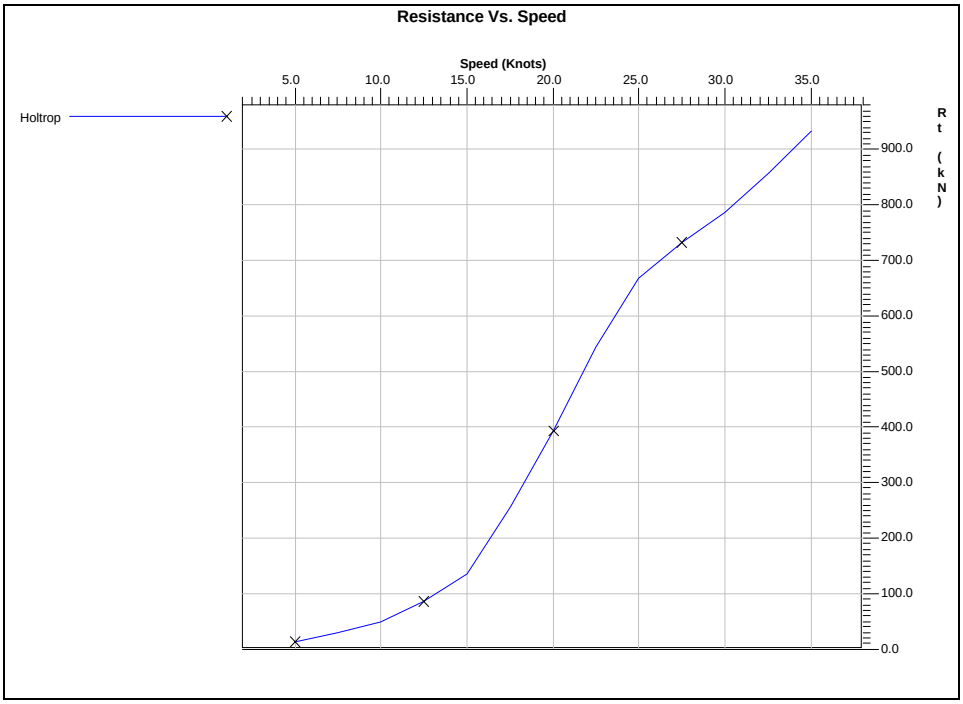
Option	Entry
Resistance Allowances	This option is available for all vessel types. Enter any of the following: • Scale Effect (% of total resistance) • Air Resistance (% of total resistance) • Hull Roughness (length unit) • Propeller Diameter (length unit) Autopower incorporates these allowances in calculating resistance.
Chine Type	This option is available only for semi-displacement vessels. Select either: • Hard Chine • Soft Chine
Blount Multiplier	This option is available only for planing vessels using Savitsky method. Select either: • Yes • No (this is the default)
Propulsive Coefficient	This option is available only for catamaran vessels. Select from among: • User defined • Waterjet Propulsion • Propeller with inclining shaft • Propeller with aft body tunnel • Z-Drive

11. Click on the Calculate button.

12. Click on the Graph or Table icon to view the output.



Sample Resistance Graph



Sample Resistance Table (partial)

Total Resistance, Rt (kN)

Speed (kt)	Fn	Holtrop
5.00	0.12	13.38
7.50	0.17	28.15
10.00	0.23	49.37
12.50	0.29	86.42
15.00	0.35	137.21
17.50	0.41	256.09
20.00	0.46	392.58
22.50	0.52	544.13
25.00	0.58	667.85
27.50	0.64	732.99
30.00	0.70	787.48
32.50	0.76	856.86
35.00	0.81	932.84

Effective Power, PE (kW)

Speed (kt)	Fn	Holtrop
5.00	0.12	34.41
7.50	0.17	108.61
10.00	0.23	253.99
12.50	0.29	555.72
15.00	0.35	1058.79
17.50	0.41	2305.52
20.00	0.46	4039.24
22.50	0.52	6298.34
25.00	0.58	8589.32
27.50	0.64	10369.80
30.00	0.70	12153.49
32.50	0.76	14326.27
35.00	0.81	16796.30

Notes on Calculating Resistance

1. Browse Methods
You can use the Browse Methods box to compare the limits of the selected method(s) against the hull parameters of the active file. When you select a method, its limitations, if provided by the originator of the method, are compared to those of the active file. The Browse Methods box uses the following abbreviations:

Parameter	Symbol
Froude number	Fn
Volume Froude number	Fv
Block coefficient	Cb
Prismatic coefficient	Cp
Midship section coefficient	Cm
Beam-draft ratio	BT
Length-beam ratio	LB
Length-displacement ratio	LD
Half entrance angle	IE
Trim angle	TR
Deadrise angle	DR
Shaft angle	EP
100 (LGC/Lp)	LC

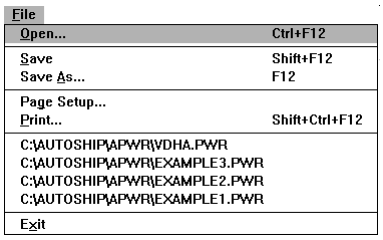
2. Printing Output
You have three options for printing your graphs and tables:

- Select **File - Print** from the File menu. The tables and graphs are printed on the default system printer.
- Click on the **MS Word** icon at the bottom of your report. This will transfer your report to your active MS Word document. This feature works with MS Word Versions 2 and 6. If you do not have an open document, your graphs and tables will be in Document 1. If MS Word is not open, Auto*power* will ask if you want Auto*power*

to open MS Word. If Auto*power* cannot locate MS Word, it will prompt you enter the proper path.

- Click on the **Copy** icon at the bottom of your report. This transfers your report to the Clipboard. Use the Paste function in your word processing or spreadsheet program to paste your report. To see a copy of your report in the Clipboard, click on the Clipboard Viewer icon in the Windows Program Manager screen (usually in the Main directory box).

File - Open



Use It To

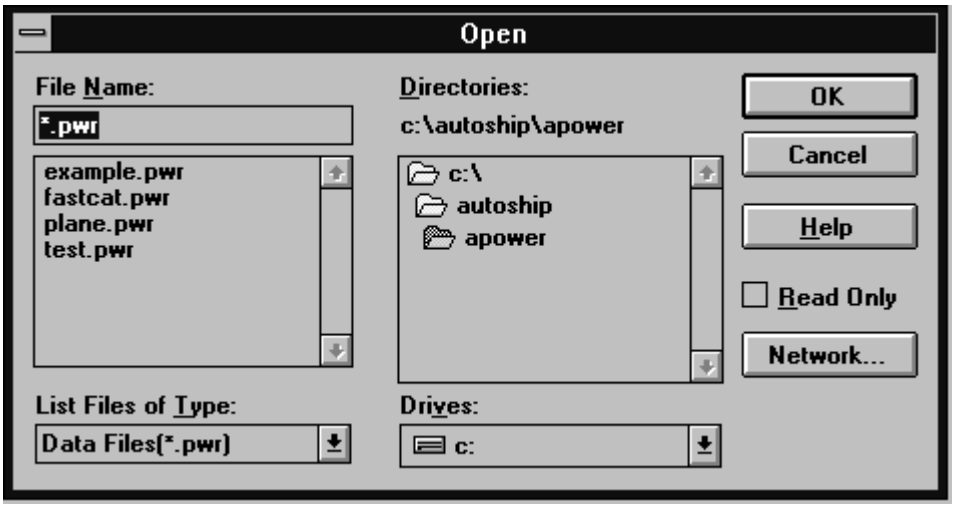
Load an Auto*power* file (denoted with .pwr extension) into the Hull Parameter Grid.

Quick Keys

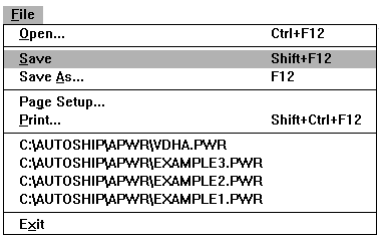
Control + F12 or Alt + FO

How It Works

Select **File-Open.** The Open dialog box appears. Select the desired file. Click **OK**.



File - Save



Use It To

Save all the changes you have made to the active file.

Quick Keys

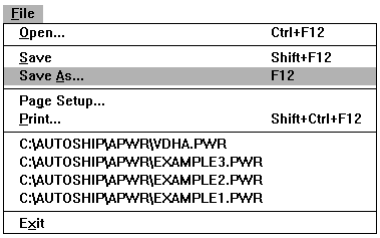
Shift + F12 or Alt + FS

How It Works

Select **File - Save** to save all the changes you have made to the active file. If the file has not been named yet, the Save As dialog box opens.

Note: Since Auto*power* saves only the active file, we recommend that you save your work before you switch vessel types (eg. from a displacement to planing vessel).

File - Save As



Use It To

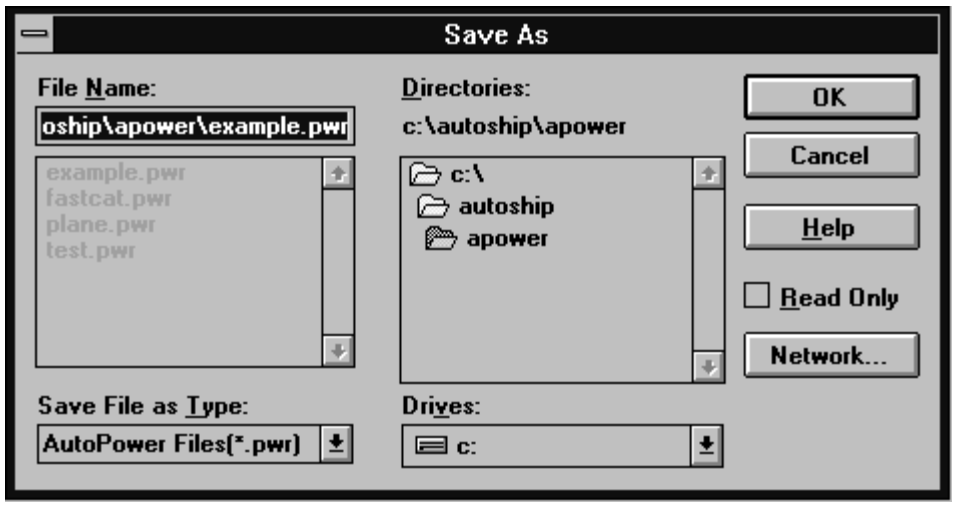
Save a copy of the active file with a new name.

Quick Keys

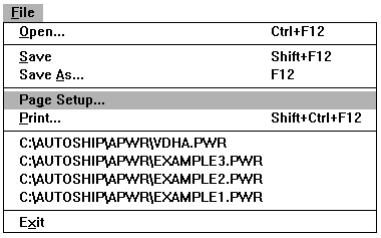
F12 or Alt + FA

How It Works

Select **File - Save As.** The Save As dialog box appears. Select the file name and directory. Click **OK**.



File - Page Setup



Use It To

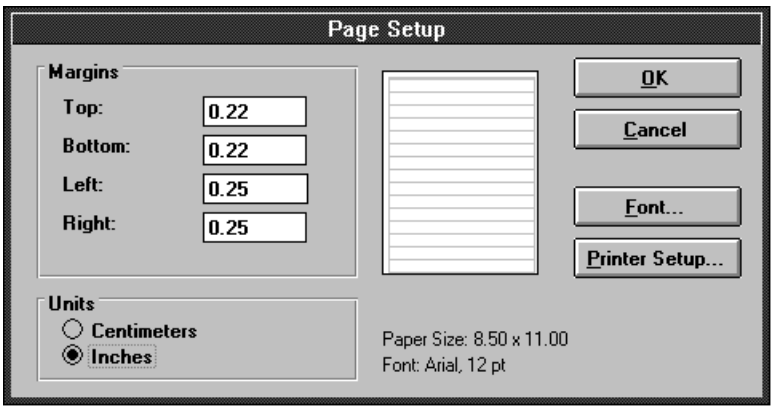
Set up page margins, size, font and printer.

Quick Key

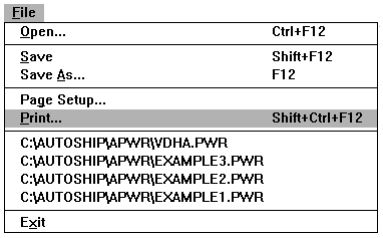
Alt + FG

How It Works

Select **Settings - Page Setup.** The Page Setup dialog box appears. Select the desired page size, font and printer. Click **OK**.



File - Print



Use It To

Print the current report(s).

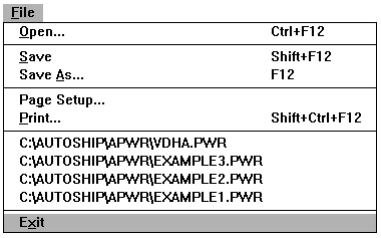
Quick Keys

Ctrl + Shift + F12 or Alt + FP

How It Works

Select **File - Print.** A message box appears showing the percentage of the report file transferred to the printer.

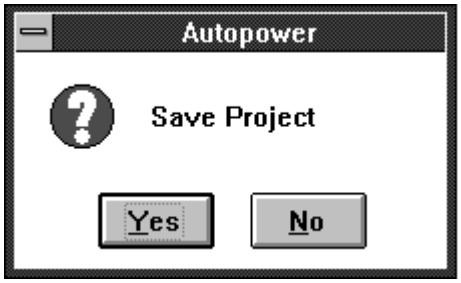
File - Exit



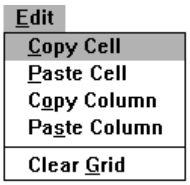
Use It To Exit Auto*power*.

Quick Key Alt + FX

How It Works Select **File - Exit**. If you have an open file, the Save Project message box appears. Click **Yes** or **No**, as appropriate.



Edit - Copy Cell
- Paste Cell

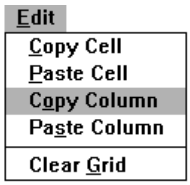


Use Them To Copy data from one cell to another.

Quick Keys Alt + EC and Alt + EP

How They Work Click on the cell you want to copy. Select **Edit - Copy Cell**. Then click on the cell you want to paste it to. Select **Edit - Paste Cell**. The data in the original cell is now copied to the new cell.

Edit - Copy Column
- Paste Column

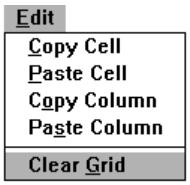


Use Them To Copy data from one column to another.

Quick Keys Alt + EO and Alt ES

How They Work Click on the column you want to copy. Select **Edit - Copy Column**. Then click on the column you want to paste it to. Select **Edit - Paste Column**. The data in the original column is now copied to the new column.

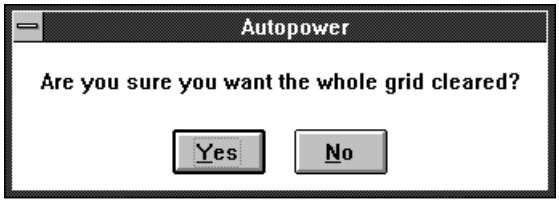
Edit - Clear Grid



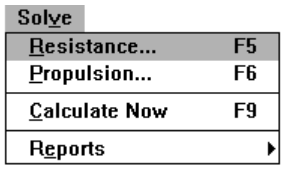
Use It To Clear the Hull Parameter Grid.

Quick Key Alt + EG

How It Works Select **Edit - Clear Grid**. A message box appears asking you to affirm that you want to clear the grid. Click **Yes** or **No**, as appropriate.



Solve - Resistance



Use It To

Open the Resistance dialog box. This is equivalent to clicking on the Resistance icon.

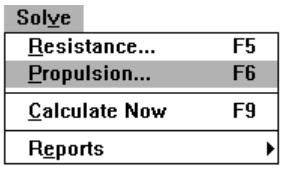
Quick Keys

Control + F5 or Alt + VR

How It Works

Select **Solve - Resistance**. The Resistance dialog box appears. Enter all required information. (See ***Chapter 5, Calculating Resistance.***)

Solve - Propulsion



Use It To

Open the Propulsion dialog box. This is equivalent to clicking on the Propulsion icon.

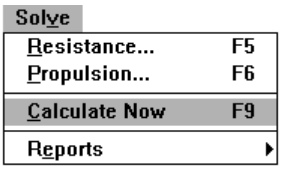
Quick Keys

Control + F6 or Alt + VP

How It Works

Select **Solve - Propulsion**. The Propulsion dialog box appears. Enter all required information. (See ***Chapter 6, Propeller Design and Propulsion***.)

Solve - Calculate Now



Use It To

Run resistance calculations using the active file.

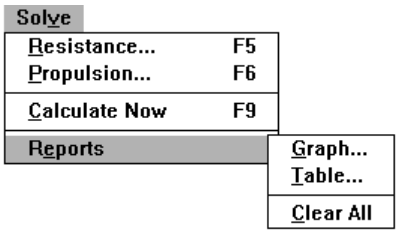
Quick Keys

Control + F9 or Alt + VC

How It Works

Select **Solve - Calculate Now**. Resistance calculations are run using the active file data. As soon as the calculations are complete, you can view the results by selecting Solve - Reports. (See ***Chapter 5, Calculating Resistance***.)

Solve - Reports



Use It To

Display and clear reports (graphs and, tables). Selecting Graph or Table from this menu is the equivalent of clicking on the Graph icon or Table icon.

Quick Key

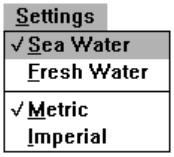
Alt + VE

How It Works

Select **Solve - Reports - Graph** or **Table.**. The Graph ot Table window appears. To print your reports, see the note on printing output at the end of ***Chapters 5*** or ***6.***

Select **Clear All** to clear your reports. Otherwise, successive graphs and tables will be added to all those generated since the last Clear All command.

Settings - Sea Water - Fresh Water



Use It To Toggle between Sea water and Fresh Water.

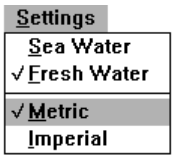
Quick Keys Alt + SS and Alt SF

How It Works Select **Settings - Sea Water** or **Fresh Water**. The default setting is Sea Water. The specific gravity of Sea water is 1.026. The specific gravity of Fresh water is 1.0.

Note: All Auto*power* calculations are based upon a water temperature of 15° C.

Settings - Metric

- Imperial



Use It To Toggle between metric or imperial units.

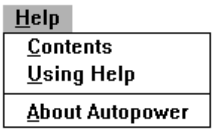
Quick Keys Alt + SM and Alt + SI

How It Works Select **Settings - Metric** or **Imperial**. The default setting is metric. The selected units appear at the right side of the Hull Parameters Grid.

Standard Units

Measurement	Metric Units	Imperial Units
Length	m	ft
Area	m^2	ft^2
Volume	m^3	ft^3
Displacement	tonnes	LT
Force	kN	lbs
Power	kW	hp
Density	t/m^3	lb/ft^3
Velocity	m/sec	ft/sec
Angles	degrees	degrees
Ship speed	knots	knots
Gravitational constant	9.81 m/sec^2	32.20 ft/sec^2

Help Menu

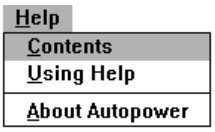


Quick Key

Alt + H

The Help menu contains information about Auto*power* and lets you access Auto*power*'s on-line help.

Help - Contents



Use It To

Display the on-line help table of contents.

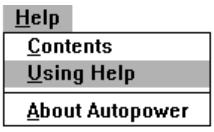
Quick Key

Alt + HC

How It Works

Select **Help - Contents.** The on-line help Table of Contents appears. Click on any topic you want to view. To return to Auto*power*, select **File - Exit** or close the Help window.

Help - Using Help

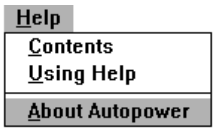


Use It To Learn how to use Windows help.

Quick Key Alt + HU

How It Works Select **Help - Using Help.** A help topic on Using Help appears. To return to Auto*power*, select **File - Exit**.

Help - About Autopower



Use It To Display the opening screen.

Quick Key Alt + HA

How It Works Select **Help - About Autopower**. The opening screen appears. This screen shows the release number, registered user and serial number. You will need this information to upgrade from a Demo to a Full version. Click anywhere on the screen to return to Auto*power*.

Chapter 4
Hull Parameters

Auto*power* has two Hull Parameter Grids for:

- displacement and catamaran hulls
- planing and semi-displacement hulls

The Hull Parameter Grid plays an important role in all Auto*power* work sessions. All hull parameters must be entered unless otherwise noted in the following tables. When you click on any hull parameter, a brief description of that parameter appears in an information box at the bottom of the Main Screen.

Parameters for Displacement & Catamaran Hulls

Parameter	Description	Range
Project Name	Project name.	
LWL	Length on waterline.	
Breadth	Breadth measured midship at design waterline.	
Draft (F)	Draft forward measured at the forward perpendicular.	
Draft (A)	Draft aft measured at the aft perpendicular.	
Displacement	Displacement weight.	
LCB	Longitudinal center of buoyancy measured as a percentage of LBP from midship. Positive = forward, negative = aft.	-50 - 50%
CWP	Waterplane area coefficient.	0 - 1
CM	Midship section coefficient.	0 - 1
Form Factor	Form factor [1 + k]. Default = 1. (Optional - this parameter can also be entered in Resistance Options.)	1 - 2
Wetted Hull Area	Wetted hull surface area, excluding appendages. (Optional - this parameter can also be estimated in Resistance Options.)	
Wetted Appendage Area	Total surface area of all wetted appendages. (Enter if there are wetted appendages.)	
Wetted Transom Area	Wetted transom surface area. (Enter if there is a wetted transom.)	
Transom Width	Transom width at waterline. (Required only for Fung method.)	
Half Angle of Entrance	Half angle of entrance in degrees. (Optional - will be estimated if not specified.)	0 - 60°

(continued...)

(...continued)

Parameters for Displacement & Catamaran Hulls

Parameter	Description	Range
Half Angle of Run	Half angle of run in degrees. (Required only for FAO method.)	0 - 60°
Angle at 1/4 Buttock	Angle at 1/4 buttock in degrees. (Required only for FAO method.)	0 - 60°
Bulbous Bow?	Bulbous bow? Yes / No Default is No.	
Transverse Bulb Area	Transverse sectional area of bulb at forward perpendicular. (Enter if there is a bulbous bow.)	
Bulb Centroid Location	Centroid location of bulb above keel. (Enter if there is a bulbous bow.)	
Body Type - (F)	Hull form type forward of midship. U-shaped, N (Normal), or V-shaped.	
Body Type - (A)	Hull form type aft of midship. U, N, or V.	
Service Margin	User-specified resistance margin. (Optional.)	0% - 50%
Appendage Margin	User-specified resistance margin for appendages. (Optional.)	0% - 30%
Appendage Form Factor	Effective form factor [1 + K2] for appendages. See note below. (Required only for Holtrop method.)	1 - 4
CB	Block coefficient. (Read only - calculated by Autopower.)	
CP	Longitudinal prismatic coefficient. (Read only - calculated by Autopower.)	

Parameters for Planing & Semi-Displacement Hulls

Parameter	Description	Range
Project Name	Project name.	
LWL	Length on waterline.	
Breadth	Breadth measured midship at design waterline.	
Draft	Draft measured at loadline.	
Chine Beam	Maximum chine beam. (Enter if there is a chine.)	
Chine Length	Maximum chine length. (Enter if there is a chine.)	
CX	Maximum section coefficient. (Required only for Savitsky method.)	0 - 1
Displacement	Displacement weight.	
LCG	Longitudinal center of gravity measured from midship to the aft perpendicular.	
Half Angle of Entrance	Half angle of entrance in degrees. (Optional - will be estimated if not specified.)	0 - 60°
Deadrise Angle	Deadrise angle at mid-chine length. (Enter if there is a chine.)	
Wetted Hull Area	Wetted hull surface area.	
Wetted Transom Area	Wetted transom surface area.	
Strut Type	Propeller strut configuration. 0 for single, 1 for V.	0 or 1
Shaft Angle	Shaft inclination relative to buttock in degrees.	
Shaft Length	Length of wetted shaft or strut barrel. (Enter if there is a wetted shaft or a strut barrel.)	
Shaft Diameter	Diameter of wetted shaft or strut barrel. (Enter if there is a wetted shaft or a strut barrel.)	

(continued...)

(continued...)

Parameters for Planing & Semi-Displacement Hulls

Parameter	Description	Range
Projected Area of Skeg	Transverse projected area of skeg. (Enter if there is a skeg.)	
Number of Sea Inlets	Number of non-flush sea water inlets. (Enter if there are sea inlets.)	
Projected Area of Inlets	Frontal projected area of non-flush sea water inlets. Enter average of frontal areas if there is more than one inlet and of different sizes. (Enter if there are sea inlets.)	
Rudder Type	Type of rudder. See note below.	
Rudder Surface Area	Total rudder surface area.	
Flap Chord Length	Flap chord length. (Enter if there is a flap.)	
Flap Span to Beam Ratio	Flap span to beam ratio. (Enter if there is a flap.)	0 - 1
Flap Deflection Angle	Flap deflection angle in degrees. (Enter if there is a flap.)	0 - 15°
Service Margin	User-specified resistance margin. (Optional.)	0 - 50%
Appendage Margin	User-specified resistance margin for appendages. (Optional.)	0 - 30%

Hull Parameter Notes

1. Appendage Form Factor

Appendage Form Factor [1 + k_2] is used by the Holtrop method. This factor is derived using the wetted area of appendage components and ranges from 1 to 4. Default values for all allowances are zero. The following table shows the approximate [1 + k_2] values.

Rudder behind skeg	1.5 - 2.0
Rudder behind stern	1.3 - 1.5
Twin-screw balance rudders	2.8
Shaft brackets	3.0
Skeg	1.5 - 2.0
Strut bossings	3.0
Hull bossings	2.0
Shafts	2.0 - 4.0
Stabilizer fins	2.8
Dome	2.7
Bilge keels	1.4

Auto*power* accepts an equivalent [1 + k_2] factor for all appendages combined, calculated as follows:

$$(1 + k_2)eq = \Sigma (1 + k_2)_i \, S_{APPDi} \; / \; \Sigma \, S_{APPDi}$$

where S_{APPDi} is the surface area of the ith appendage in question.

2. Rudder Type
You can select one of four rudder types by entering 0, 1, 2, or 3 as shown in the table below. You must also enter a rudder surface area in the Hull Parameter grid. Otherwise, resistance due to rudders will be zero.

Rudder Section	Drag Coefficient	Thickness to Chord Ratio	Enter
NACA 0015	0.0013	0 - 15	0
Parabolic	0.0426	0 - 11	1
Flat Plate	0.0352	0 - 04	2
Wedge	0.0493	0 - 11	3

3. Auto*power* Files
Each file contains one hull type. This means that all of the projects within one file must be of the same hull type, although individual projects may be in either metric or imperial units.

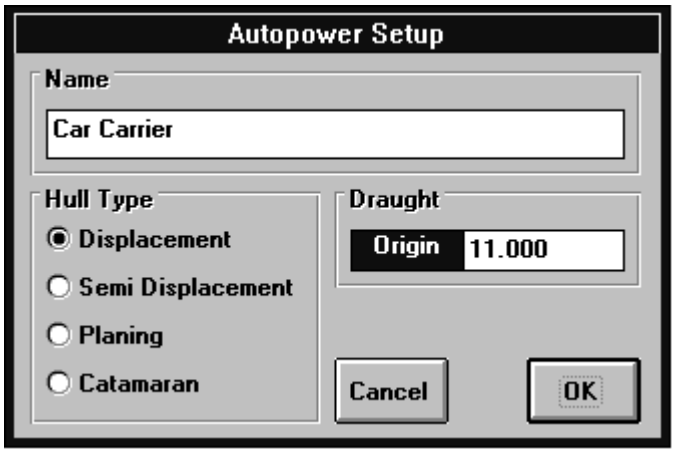
4. Saving Auto*power* Files
Auto*power* saves only the data in the currently displayed grid. For example, if you have been working on the displacement grid and then switch to the planing grid, the File - Save operation will result in a file containing data concerning the planing grid only (which may or may not contain any data). Each hull type grid should be saved to a different file.

5. Importing Hull Parameters from Autoship

You can import certain hull parameters from Auto*ship* to Auto*power*. You may be required to enter further hull parameters in Auto*power* before undertaking calculations.

1. In Auto*ship*, select **Calcs - Auto*power***. The Auto*power* Setup dialog box appears. Enter file name, hull type and draft value being used in Auto*ship*. Click **OK**.

   Note: The draft value you must use is the distance from V=0 to the waterline. For instance, if you define the waterline to be at V=0, then draft is zero.



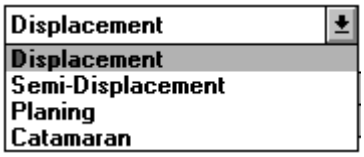
2. An Open File window then appears. Enter the file name. Click **OK**.

Note: Auto*ship* uses a demi-hull for catamarans. This should be taken into account in undertaking calculations.

Chapter 5
Calculating Resistance

To calculate resistance, take the following steps:

1. Select the hull type.

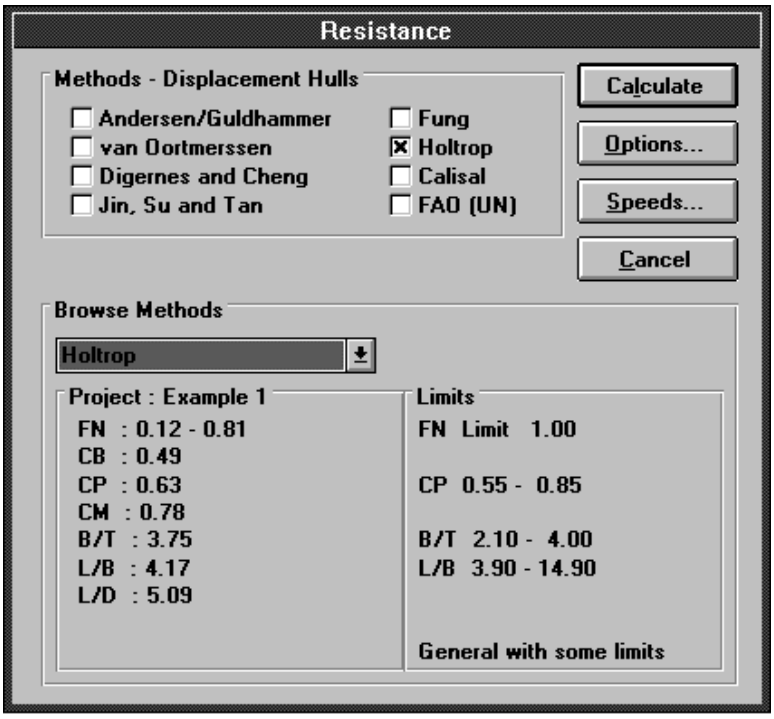


2. Enter the hull parameters into the Hull Parameter Grid or import the hull parameters from Auto*ship* (see ***Chapter 4, Hull Parameters***).

3. Click on the Resistance icon.

4. The Resistance dialog box opens. This dialog box contains the resistance method(s) appropriate to the hull type you have selected.

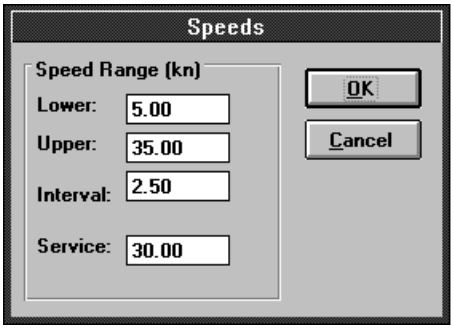
Resistance Dialog Box (Displacement)



5. Select the resistance method(s). You can use the Browse Methods box to compare the limits of the selected method(s) against the hull parameters of the active file.

6. Click on the Speeds button.

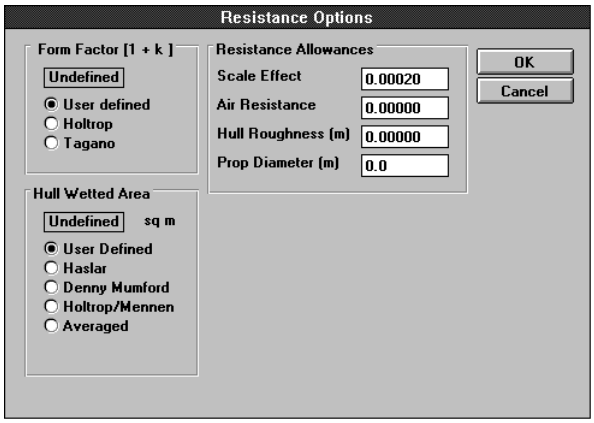
7. The Speeds dialog box opens. Enter the lower, upper, interval and service speeds. Click **OK**.



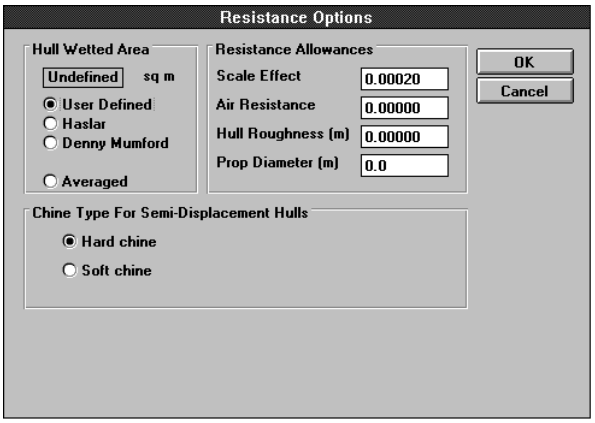
8. Click on the Options button.

9. The Resistance Options dialog box appears. There are four Options dialog boxes, depending on the hull type you have selected.

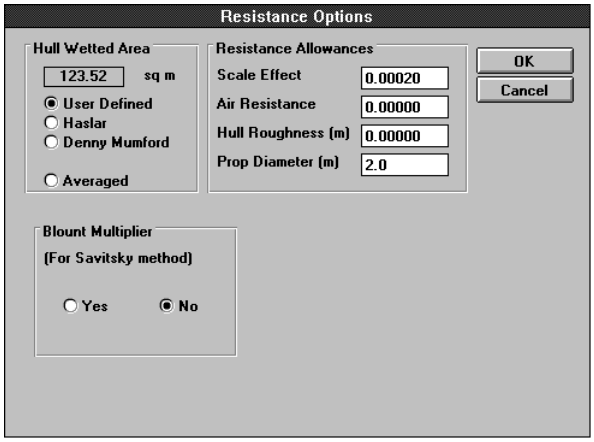
Resistance Options (Displacement)



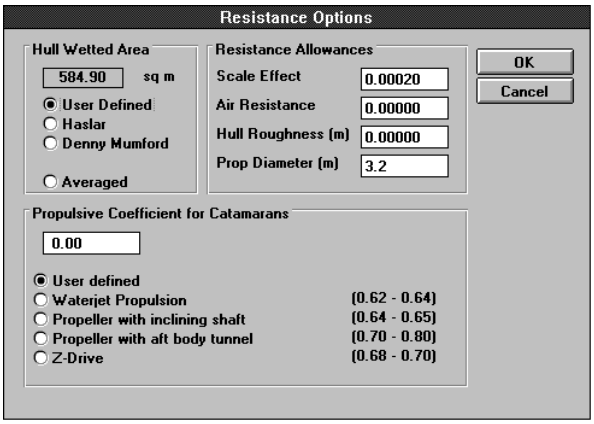
Resistance Options (Semi-Displacement)



Resistance Options (Planing)



Resistance Options (Catamaran)



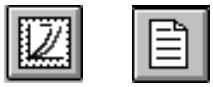
10. Enter the following resistance options and click **OK**.

Option	Entry
Hull Wetted Area	This option is available for all vessel types. You must enter the hull wetted area either by entering a user-defined value into the Hull Parameters grid, or by selecting one of the following methods: • User Defined (this is the default) • Haslar • Denny Mumford • Holtrop/Mennen (displacement only) • Averaged
Form Factor (1 + k)	This option is available only for displacement vessels. You must enter the Form Factor in the Hull Parameters grid. Once entered, select among: • User Defined (this is the default) • Holtrop • Tagano

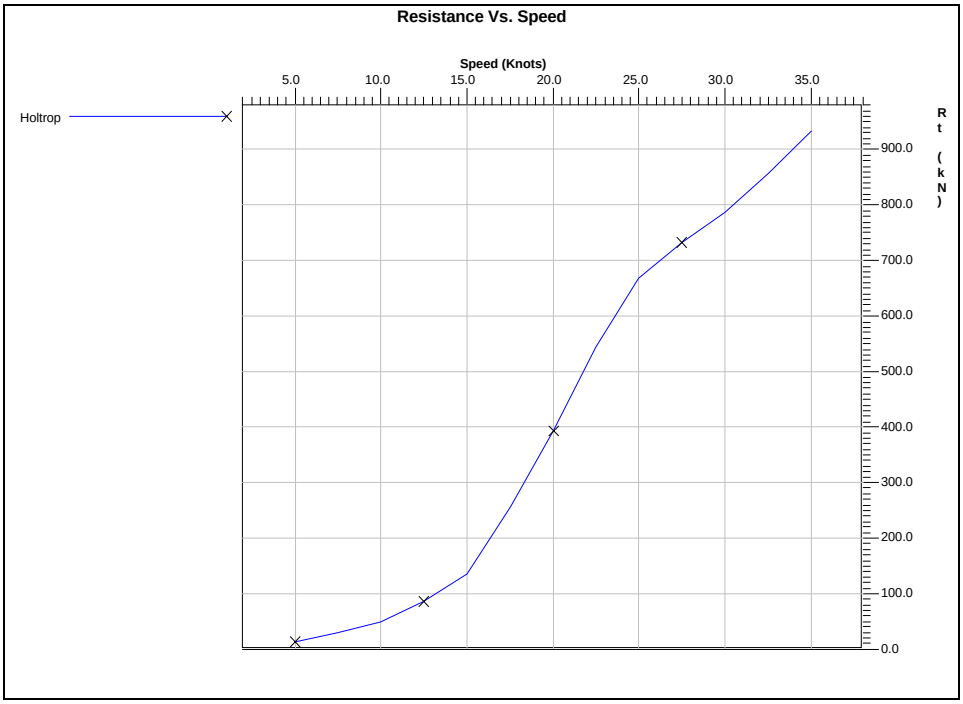
Option	Entry
Resistance Allowances	This option is available for all vessel types. Enter any of the following: • Scale Effect (% of total resistance) • Air Resistance (% of total resistance) • Hull Roughness (length unit) • Propeller Diameter (length unit) Autopower incorporates these allowances in calculating resistance.
Chine Type	This option is available only for semi-displacement vessels. Select either: • Hard Chine • Soft Chine
Blount Multiplier	This option is available only for planing vessels using Savitsky method. Select either: • Yes • No (this is the default)
Propulsive Coefficient	This option is available only for catamaran vessels. Select from among: • User defined • Waterjet Propulsion • Propeller with inclining shaft • Propeller with aft body tunnel • Z-Drive

11. Click on the Calculate button.

12. Click on the Graph or Table icon to view the output.



Sample Resistance Graph



Sample Resistance Table (partial)

Total Resistance, Rt (kN)

Speed (kt)	Fn	Holtrop
5.00	0.12	13.38
7.50	0.17	28.15
10.00	0.23	49.37
12.50	0.29	86.42
15.00	0.35	137.21
17.50	0.41	256.09
20.00	0.46	392.58
22.50	0.52	544.13
25.00	0.58	667.85
27.50	0.64	732.99
30.00	0.70	787.48
32.50	0.76	856.86
35.00	0.81	932.84

Effective Power, PE (kW)

Speed (kt)	Fn	Holtrop
5.00	0.12	34.41
7.50	0.17	108.61
10.00	0.23	253.99
12.50	0.29	555.72
15.00	0.35	1058.79
17.50	0.41	2305.52
20.00	0.46	4039.24
22.50	0.52	6298.34
25.00	0.58	8589.32
27.50	0.64	10369.80
30.00	0.70	12153.49
32.50	0.76	14326.27
35.00	0.81	16796.30

Notes on Calculating Resistance

1. Browse Methods
You can use the Browse Methods box to compare the limits of the selected method(s) against the hull parameters of the active file. When you select a method, its limitations, if provided by the originator of the method, are compared to those of the active file. The Browse Methods box uses the following abbreviations:

Parameter	Symbol
Froude number	Fn
Volume Froude number	Fv
Block coefficient	Cb
Prismatic coefficient	Cp
Midship section coefficient	Cm
Beam-draft ratio	BT
Length-beam ratio	LB
Length-displacement ratio	LD
Half entrance angle	IE
Trim angle	TR
Deadrise angle	DR
Shaft angle	EP
100 (LGC/Lp)	LC

2. Printing Output
You have three options for printing your graphs and tables:

- Select **File - Print** from the File menu. The tables and graphs are printed on the default system printer.
- Click on the **MS Word** icon at the bottom of your report. This will transfer your report to your active MS Word document. This feature works with MS Word Versions 2 and 6. If you do not have an open document, your graphs and tables will be in Document 1. If MS Word is not open, Auto*power* will ask if you want Auto*power*

to open MS Word. If Auto*power* cannot locate MS Word, it will prompt you enter the proper path.

- Click on the **Copy** icon at the bottom of your report. This transfers your report to the Clipboard. Use the Paste function in your word processing or spreadsheet program to paste your report. To see a copy of your report in the Clipboard, click on the Clipboard Viewer icon in the Windows Program Manager screen (usually in the Main directory box).

Chapter 6
Propeller Design and Propulsion

Before You Begin

Before calculating propulsion, you must have first calculated resistance (see ***Chapter 5, Calculating Resistance***). If you want to enter a known resistance value for a propulsion calculation, you can undertake a nominal resistance calculation and then edit the resistance value.

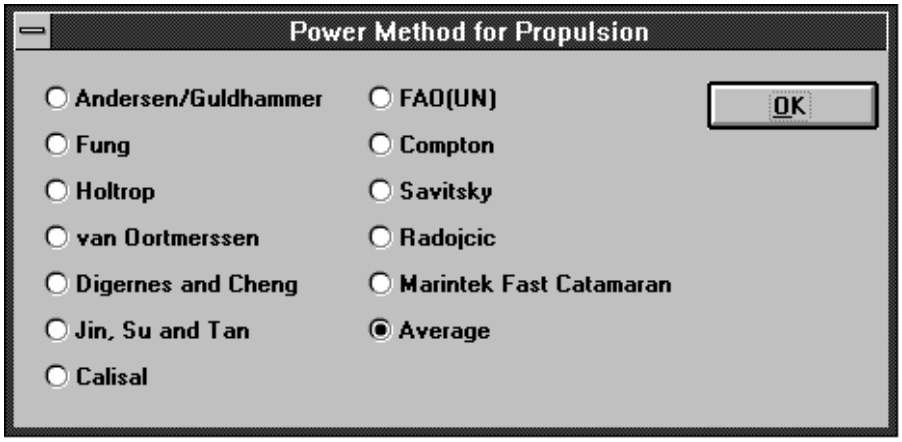
Important: Auto*power* does not support propulsion calculations for catamarans. Rather, effective power for the catamaran demi-hull is calculated as part the resistance calculation and is shown on the resulting resistance table. Double the effective power to account for both catamaran hulls.

To Calculate Propulsion

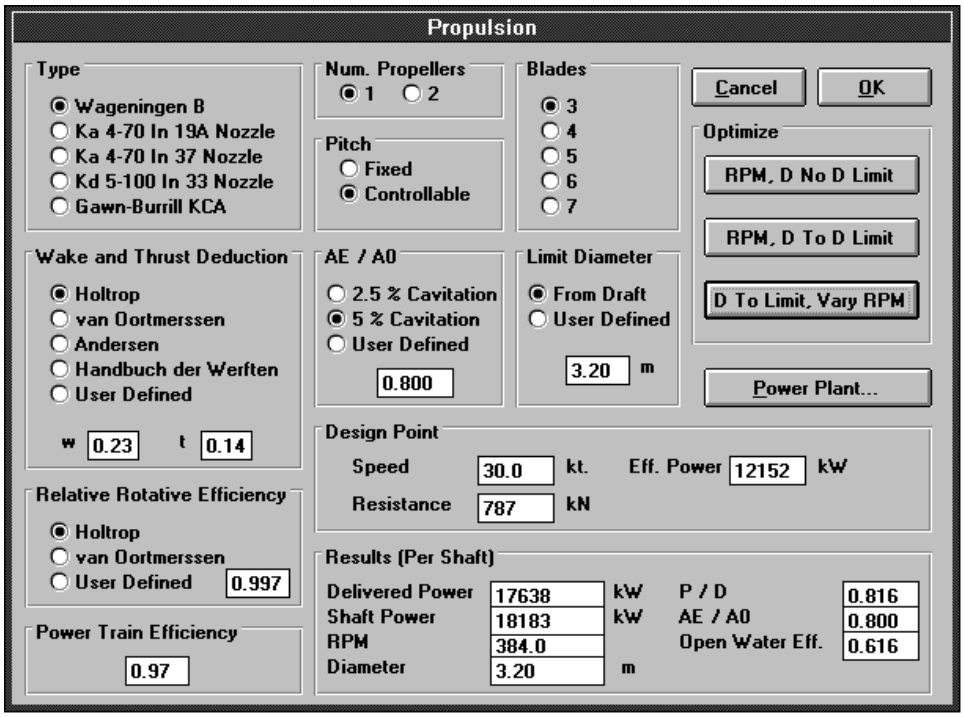
To calculate propulsion, you take the following steps:

1. After calculating resistance, click on the Propulsion icon.

2. If you have selected more than one method in your resistance calculation, the Power Method for Propulsion dialog box will appear. Select the desired propulsion method. The default is an average of the methods you selected for resistance. Click **OK**.



3. The Propulsion dialog box appears. This dialog box contains a number of options required to undertake propeller optimization and calculate propulsion.



4. The Design Point frame in the Propulsion dialog box displays speed, resistance and effective power values. These values are calculated from the resistance calculation results at the specified service speed. You may enter other speed and resistance values.

5. Enter the following options to undertake propeller optimization:

Option	Entry
Type	Select the propeller type: • Wageningen B • Ka 4-70 In 19A Nozzle • Ka 4-70 In 37 Nozzle • Kd 5-100 In 33 Nozzle • Gawn-Burrill KCA
Num. Propellers	Select the number of propellers: • 1 • 2
Blades	Select the number of propeller blades (Wageningen B only): • 3 • 4 • 5 • 6 • 7
Pitch	Select propeller pitch: • fixed • controllable
AE/AO	Select propeller expanded area ratio (Wageningen B and Gawn-Burrill KCA only): • 2.5% Cavitation • 5% Cavitation • User Defined (enter value)
Limit Diameter	Select propeller limit diameter: • From Draft • User Defined (enter value)

Option	Entry
Wake and Thrust Deduction	Select among wake and thrust deduction methods: • Holtrop • van Oortmerssen • Andersen • Handbuch der Werften • User Defined (enter values)
Relative Rotative Efficiency	Select among relative rotative efficiency methods: • Holtrop • van Oortmerssen • User Defined (enter value)
Power Train Efficiency	Enter value or accept default value.

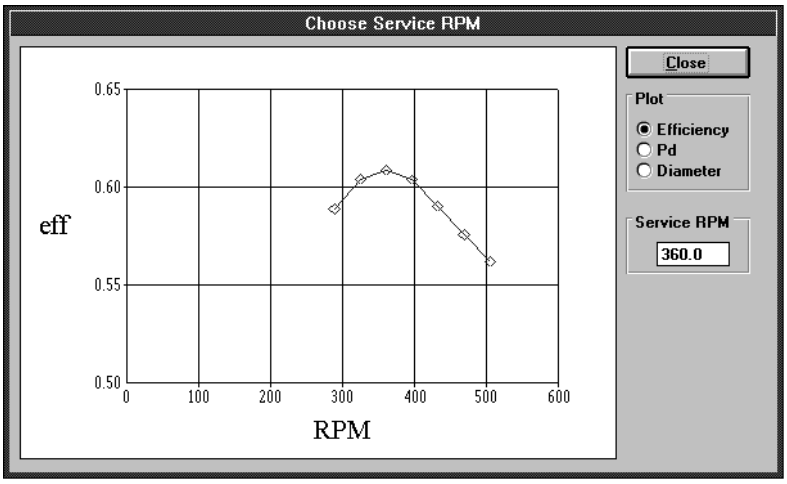
6. Once you have entered the above options, you can select from three propeller optimization methods:

   - **RPM, D No D Limit** - This optimizes RPM, propeller diameter and P/D ratio without any limitation on propeller diameter.

   - **RPM, D To D Limit** - This optimizes RPM, propeller diameter and P/D ratio subject to the maximum specified propeller diameter. Use this method if you can accept an optimum RPM calculated by the program.

   - **D To Limit, Vary RPM** - This optimizes propeller diameter and P/D ratio for several discrete values of RPM, subject to the maximum specified propeller diameter. When the calculations are completed, the Choose Service RPM box appears with three graphs showing (1) open water efficiency, (2) delivered power and (3) propeller diameter, all over a range of RPM values. Use this method if your choice of service RPM is limited (i.e. by available

gearbox models), then choose the service RPM closest to the optimum.



Click **Close** to return to the Propulsion box.

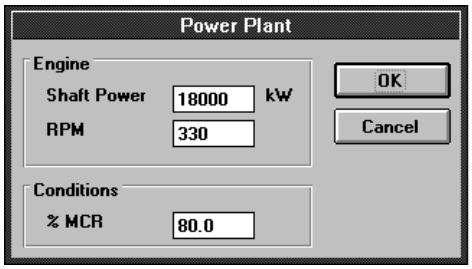
7. The following per propeller optimization results are displayed in the Results (Per Shaft) frame in the Propulsion box:

   - Delivered Power
   - Shaft Power
   - RPM
   - Diameter
   - P/D (pitch/diameter ratio)
   - AE/AO (expanded area ratio)
   - Open Water Efficiency

8. Click on the Power Plant button. The Power Plant box appears displaying the following values:

    - Shaft Power (power required for the service speed.)
    - RPM
    - % MCR (% maximum power)

    You can edit these values to represent an available power plant and gear box before making your propulsion calculation.



9. Click **OK** in the Power Plant box. The Graph display window appears with three graphs showing (1) resistance versus speed, (2) effective power versus speed and (3) thrust and resistance versus speed. Click **OK** to close the Graph display window.

10. Click **OK** to close the Propulsion box. To see the results of your calculation, click on the Graph or Table icon.

Notes On Propeller Design and Propulsion

1. Propeller Type

Auto*power* allows you to choose from among several propeller series currently in use. For further information on the propeller types used in Auto*power*, we refer you to the following:

- Wageningen B-Series propellers are described briefly in ***Chapter 7, Algorithms*** and in detail in *The Wageningen Propeller Series*, Kuiper, G., MARIN Publication 92-001, 1992 and in *Principles of Naval Architecture Vol. II, Resistance, Propulsion and Vibration*, Editor Lewis E.V., Published by SNAME, 1988 (pp. 186-204).

- Ducted Ka propellers with accelerating nozzles and the Kd decelerating nozzle are described in *Principles of Naval Architecture Vol. II, Resistance, Propulsion and Vibration*, Editor Lewis E.V., Published by SNAME, 1988 (pp. 213-225).

- Gawn-Burrill KCA propeller series is described briefly in ***Chapter 7, Algorithms.***

2. AE/AO (propeller expanded area ratio)

For ducted propellers, only the Ka 4-70 (4 blades and .7 area ratio) is provided. For the Wageningen B and Gawn-Burrill KCA propeller series, you may choose to have Auto*power* calculate the minimum AE/AO allowed to limit cavitation, or enter a value of your choice.

3. P/D (pitch / diameter ratio)
Auto*power* optimizes P/D in all calculations subject to the following limits:

Propeller Series	Minimum P/D	Maximum Fixed P/D	Maximum Controllable P/D
Wageningen B	0.5	1.4	1.25
Ka Nozzle	0.6	1.8	1.25
Kd Nozzle	1.0	1.8	1.25
Gawn-Burrill KCA	0.8	1.8	1.40

4. Wake and Thrust Deduction
You may enter your estimate of wake factor and thrust deduction factor by selecting the User Defined method. Otherwise, they are calculated by the selected algorithm.

5. RPM, D, No D Limit
This propeller method enables you to calculate the "ideal" propeller for the design point speed and thrust (resistance). The resulting propeller is unrestricted in diameter, is subject to P/D ratio limits and is designed to achieve maximum theoretical open water efficiency.

This method may not represent a practical propeller design (i.e. the diameter is often too large). However, it is intended to give the designer a theoretical yardstick against which developed data can be measured. This method enables you to compare calculated optimum efficiency against the efficiency of the propeller optimized to the actual diameter limit.

When the efficiency of the diameter-limited propeller is significantly lower than that of the "ideal" propeller, the designer can consider design changes to the hull such as increasing draft. In some instances where calculated diameter is less than the limit, (e.g. slow, low-power vessels) this method offers an instant optimum propeller.

6. D To Limit, Vary RPM

This method generates displays of optimal efficiency, delivered power and propeller diameter as functions of RPM. This allows you to choose an operating RPM (by typing it into the entry box) and to see the resulting efficiency of that choice.

7. Printing Output

You have three options for printing your reports:

- Select **File - Print** from the File menu. Your reports are printed on the default system printer.

- Click on the **MS Word** icon at the bottom of your report. This will transfer your report to your active MS Word document. This feature works with MS Word Versions 2 and 6. If you do not have an open document, your graphs and tables will be in Document 1. If MS Word is not open, Auto*power* will ask if you want Auto*power* to open MS Word. If Auto*power* cannot locate MS Word, it will prompt you enter the proper path.

- Click on the **Copy** icon at the bottom of your report. This transfers your report to the Clipboard. Use the Paste function in your word processing or spreadsheet program to paste your report. To see a copy of your report in the Clipboard, click on the Clipboard Viewer icon in the Windows Program Manager screen (usually in the Main directory box).

Chapter 7
Algorithms

Technical Information on Autopower's Algorithms

This chapter contains:

- Tables comparing the applicable limits as given by the originator of each method.
- Brief descriptions for each method, including background information and form of regression equations.
- Brief descriptions of the propeller series used in Auto*power*.

Parameter Symbols

The following symbols are used throughout this chapter:

Parameter	Symbol
Froude number	Fn
Block coefficient	Cb
Prismatic coefficient	Cp
Midship section coefficient	Cm
Beam-Draft ratio	BT
Length-Beam ratio	LB
Length-Displ ratio	LD
Half entrance angle	IE
Volume Froude number	Fv
Trim angle	TR
Deadrise angle	DR
Shaft angle	EP
Length-Beam ratio	LB
100 (LCG/LBP)	LC
100 (LCG / Lp)	-

Applicable Limits - Displacement

Parameter	Method			
	Anderson Min/Max	**Fung** Min/Max	**Holtrop** Min/Max	**Oortmers** Min/Max
Fn	- /0.33	0.18/0.51	- / 1.00	- / 0.50
Cb	0.55/0.85	- / -	- / -	- / -
Cp	- / -	0.52/0.70	0.55/0.85	0.52/0.70
Cm	- / -	0.62/0.90	- / -	0.73/0.98
BT	- / -	2.20/5.20	2.10 / 4.0	1.90/3.40
LB	5.00/8.00	- / -	3.90/14.9	3.40/6.20
LD	4.00/6.00	5.75/11.3	- / -	- / -
IE	- / -	4.00/16.0	- / -	10.0/38.0

Parameter	Method			
	Digernes Min/Max	**Jin/Su/Tan** Min/Max	**Calisal** Min/Max	**FAO** Min/Max
Fn	- / 0.50	0.40 / 1.00	- / 0.43	- / 0.36
Cb	- / -	- / -	0.53 / 0.62	- / -
Cp	- / -	0.57 / 0.76	- / -	0.55 / 0.70
Cm	- / -	- / -	- / -	0.53 / 0.93
BT	- / -	- / -	2.00 / 3.00	2.00 / 4.50
LB	- / -	- / -	2.60 / 4.00	3.10 / 5.60
LD	- / -	4.50 / 8.70	3.00 / 4.50	- / -
IE	- / -	7.60 / 26.6	- / -	15.0 / 37.0

Applicable Limits - Semi-Displacement

Parameter	Method
	Compton Min/Max
Fn	0.10 / 0.60
Fv	0.30 / 1.50
TR	- / -
DR	- / -
EP	- / -
LB	4.00 / 5.20
100 (LCG/LBP)	37.0 / 48.0

Applicable Limits - Planing

Parameter	Method	
	Savitsky Min/Max	**Radojcic** Min/Max
Fn	- / -	- / -
Fv	>1.00	1.00 / 3.50
TR	3.00 / 7.00	0.00 / 10.00
DR	10.0 / 30.00	13.00/ 37.40
EP	- / -	7.00 /15.00
LB	3.00 / 5.00	2.36 / 6.72
100 (LCG / Lp)	- / -	30.00/ 44.80

Applicable Limits - Catamaran

Parameter	Method
	Fastcat Min/Max
Fn	0.80 / 1.60
Cb	- / -
Cp	- / -
Cm	- / -
BT	- / -
LB	- / -
LD	5.75 / 7.50
IE	- / -

Andersen and Guldhammer

Limits of Application

Parameter	Minimum	Maximum
Fn	-	0.33
Cb	0.55	0.85
Cp	-	-
Cm	-	-
BT	-	-
LB	5.00	8.00
LD	4.00	6.00
IE	-	-

Comments

Used for slower displacement hulls.

Background

- Based on The Technical University of Denmark preliminary design procedure.
- No form factor is used in the formulation.
- Contains guidelines for propeller diameter reduction when behind the hull as functions of the expanded area ratio. This is implemented in Auto*power*'s third (D To Limit, Vary RPM) propeller optimization option.

Form of Equation

$$C_T = C_R + C_F + C_A + \Delta C$$

where
C_T : residuary resistance coefficient
C_R : residuary resistance coefficient
C_F : frictional resistance coefficient
C_A : incremental resistance coefficient
ΔC : air and steering resistance coefficient

Selected Reference

- *A Computer-Oriented Power Prediction Procedure*, Andersen P. and Guldhammer H.E., Proceedings CADMO 86, 1986.

Fung

Limits of Application

Parameter	Minimum	Maximum
Fn	0.18	0.51
Cb	-	-
Cp	0.52	0.70
Cm	0.62	0.90
BT	2.20	5.20
LB	-	-
LD	5.75	11.26
IE	4.00	16.00

Comments

Used for transom stern hulls.

Background

- Claimed to cover a broad range of hull forms and Froude numbers.
- Data used in the regression analysis include 426 transom stern ships.
- The difference in resistance characteristics between transom and cruiser stern ships is highlighted in the paper.

Form of Equation

$$C_R = CR1 + CR2 + CR3 + \ldots + CR10$$

where

C_R is the residuary resistance coefficient and

$CR_1 \ldots CR_{10}$ are tabulated for different hull parameters over a range of Froude numbers corresponding to 0.18 to 0.51.

Selected Reference

- *Resistance and Powering Prediction for Transom Stern Hull Forms During Early Stage Ship Design,* Fung S.C., SNAME Transactions, Vol. 99, 1991.

Holtrop

Limits of Application

Parameter	Minimum	Maximum
Fn	-	1.00
Cb	-	-
Cp	0.55	0.85
Cm	-	-
BT	2.10	4.00
LB	3.90	14.90
LD	-	-
IE	-	-

Comments

Used for any monohull displacement vessels. Although the maximum Fn allowed by the algorithm is 1.00, it is not recommended that Froude numbers greater than .4 be used.

Background

- Based on regression analysis of full-scale and model test data on 334 models at NSMB.
- The 1984 publication also used published Series 64 results.

Form of Equation

$$R_T = R_F (1 + k) + R_W + R_{APP} + R_A$$

where
R_W : wave resistance
R_{APP} : appendage resistance (including bulb and transom)
R_A : correlation allowance

Selected References

- *A Statistical Power Prediction Method*, Int. Shipbuilding Progress, Holtrop J. and Mennen G.G.J., Vol 25, 1978.
- *An Approximate Power Prediction Method*, Holtrop J. and Mennen G.G.J., Int. Shipbuilding Progress, Vol 29, 1982.
- *A Statistical Re-analysis of Resistance and Propulsion Data*, Holtrop J., Int. Shipbuilding Progress, Vol 31, 1984.

van Oortmerssen

Limits of Application

Parameter	Minimum	Maximum
Fn	-	0.50
Cb	-	-
Cp	0.52	0.70
Cm	0.73	0.98
BT	1.90	3.40
LB	3.40	6.20
LD	-	-
IE	-	-

Comments

Used for small vessels.

Background

- The formulae were obtained using small vessel data (trawlers and tugs) from NSMB.
- Equations were also given for the wake factor, thrust deduction factor and the relative rotative efficiency.
- Frictional resistance was found using the ITTC 1957 line.

Form of Equation

$$R_R / \Delta = C_1X_1 + C_2X_2 + C_3X_3 + C_4X_4$$

where
C_1 ... C_4 are tabulated coefficients
X_1 .. X_4 are parameters which are f(Cp , Fn)

Selected Reference

- *A Power Prediction Method and its Application to Small Ships*, Int. Shipbuilding Progress, Vol 18, No.207, 1971.

Digernes and Cheng

Limits of Application

Parameter	Minimum	Maximum
Fn	-	0.50
Cb	-	-
Cp	-	-
Cm	-	-
BT	-	-
LB	-	-
LD	-	-
IE	-	-

Comments

Regression analysis was based on a limited number of fishing vessels.

Background

- Based on regression analysis of 34 Norwegian and 20 Danish ships.
- This simple method was compared to several other methods and found to give good results for fishing vessels.

Form of Equation

$$R_t = a\,(LB)^b(BT)^c\,V^{\partial}\exp(\beta Fn)$$

where
a , b, c, ∂, β are constants
V : displacement

Selected Reference

- *Utproving av utvalgte formler for beregning av motstand i stille vann*, Kjetil Liene, The Norwegian Institute of Fishery Technology Research Report (FTFI).

Jin, Su and Tan

Limits of Application

Parameter	Minimum	Maximum
Fn	0.40	1.00
Cb	-	-
Cp	0.57	0.76
Cm	-	-
BT	-	-
LB	-	-
LD	4.50	8.70
IE	7.60	26.60

Comments

Used for small, round bilge vessels.

Background

- This method is for fast round bilge displacement crafts such as motor boats and workboats.
- The paper indicated that resistance is affected by the displacement volume to length ratio, the prismatic coefficient, the transom area to maximum sectional area ratio, the longitudinal center of buoyancy, the half entrance angle and the Froude number.

Form of Equation

$$C_R = B_0X_0 + B_1X_1 + ... + B_{53}X_{53}$$

where
B_0 ... B_{53} are tabulated coefficients
X_0 ... X_{53} are parameters which are functions of geometry and Fn.

Selected Reference

- *A Parametric Study on High-Speed Round Bilge Displacement Hulls,* Jin P., Su B. and Tan Z., High-Speed Surface Craft, 1980.

Calisal

Limits of Application

Parameter	Minimum	Maximum
Fn	-	0.42
Cb	0.53	0.62
Cp	-	-
Cm	-	-
BT	2.00	3.00
LB	2.60	4.00
LD	3.00	4.50
IE	-	-

Comments

Regression analysis for the University of British Columbia model series which are based on a typical purse seiner.

Background

- Formulae are derived in forms similar to those of Oortmerssen.
- Not accurate for Froude number > 0.42.

Form of Equation

$$R_R / \Delta = C_1X_1 + C_2X_2 + C_3X_3 + C_4X_4$$

where
C_1 ... C_4 are tabulated coefficients
X_1 .. X_4 are parameters which are f(Cp , Fn)

Selected Reference

- *A Resistance Study on a Systematic Series of Law L/B Vessels*, Calisal S.M. and McGreer D., Marine Technology, Vol. 30 No. 4, 1993.

FAO

Limits of Application

Parameter	Minimum	Maximum
Fn	-	0.36
Cb	-	-
Cp	0.55	0.70
Cm	0.53	0.93
BT	2.00	4.50
LB	3.10	5.60
LD	-	-
IE	15.00	37.00

Comments

Used for small fishing vessels.

Background

- Based on Japanese, European and other sources of data, the regression formula was obtained using 570 model test results.

Form of Equation

$$CR = CR16 - A (SL/\Delta) \{ [\log (B\ V/(L)^{.5}]^{-2} - [\log (C\ V(L)^{.5}]^{-2} \}$$

where
A, B, C are constants
CR16 is the residuary resistance coefficient for a standard 16 ft model

Selected Reference

- *Computer-Aided Studies of Fishing Boat Hull Resistance*, Hayes J.G. and Engvall L.O., Food and Agriculture Organization of the United Nations, FAO Fisheries Technical Paper No. 87 1969.

Marintek Fastcat

Limits of Application

Parameter	Minimum	Maximum
Fn	0.80	1.60
Cb	-	-
Cp	-	-
Cm	-	-
BT	-	-
LB	-	-
LD	5.75	7.50
IE	-	-

Comments

Used for fast catamarans.

Background

- Based on Marintek (Norway) tests on high speed slender catamarans.
- Model to full scale correlation for high speed catamarans has been developed based on extensive full scale experiments.
- Propulsion efficiencies are given as options in the program.
- The frictional coefficient is found using the ITTC 1957 line.

Form of Equation

$$R_T = A (C_F + C_R + \Delta C_F) V^2 S + R_{AA}$$

where
A : constant
ΔC_F : roughness allowance (0.0005 corresponds to hull roughness of approximately 150 μm)
R_{AA} : air resistance allowance
S : total wetted hull surface area
V : velocity

Selected Reference

- *Design Tool for High Speed Slender Catamarans*, Werenskold, Published letter from Marintek, Ocean Laboratories in Trondheim, Norway.

Compton

Limits of Application

Parameter	Minimum	Maximum
Fn	0.10	0.60
Fv	0.30	1.50
TR	-	-
DR	-	-
EP	-	-
LB	4.00	5.20
100 (LCG/LBP)	37.00	48.00

Comments

US Naval Academy YP Series.

Background

- Based on experimental investigations of a systematic series of small semi-displacement models.
- Both soft and hard chine crafts are accommodated.

Form of Equation

$$C_R * 10^3 = A + B (LB) + C (\Delta) + D (100 [LCG/LBP])$$

where

A, B, C, D : tabulated coefficients

Δ : displacement based on LBP

Selected Reference

- *Resistance of a Systematic Series of Semi-Planing Transom-Stern Hulls*, Compton R.H., Marine Technology, Vol 23 No. 4, 1986.

Savitsky

Limits of Application

Parameter	Minimum	Maximum
Fn	0.60	1.79
Fv	>1.00	-
TR	3.00	7.00
DR	10.00	30.00
EP	-	-
LB	3.00	5.00
100 (LCG/Lp)	-	-

Comments

Constant deadrise.

Background

- Resistance and trim are calculated in the preplaning (where $1.00 < Fv < 2.00$) and planing ($Fv \geq 2.00$) regimes for prismatic planing hulls.
- The user can also use the Blount multiplier, a correction ratio to compensate for hump-speed resistance under-prediction using the pure Savitsky method.
- Wave added resistance is not considered in this program.

Form of Equation

Preplaning Regime : $R_T/\Delta = A_1F_1 + ... A_{27}F_{27}$

where
A_1 ... A_{27} : tabulated coefficients
F_1 ... F_{27} : f(entrance angle, max chine beam, ∇)

Planing Regime : $R_T = \Delta \tan(TR) + F(\text{hull parameters,TR,Speed})$

Selected References

- *Hydrodynamic Design of Planing Hulls*, Savitsky D., Marine Technology, Vol. 1 No. 1, 1964.
- *Small-craft Power Prediction*, Blount D.L. and Fox D.L., Marine Technology, Vol. 13 No. 1, 1976.
- *Procedures for Hydrodynamic Evaluation of Planing Hulls in Smooth and Rough Water*, Savitsky D. and Brown W., Marine Technology, Vol. 13 No. 4, 1976.

Radojcic

Limits of Application

Parameter	Minimum	Maximum
Fn	-	-
Fv	1.00	3.50
TR	0.00	10.00
DR	13.00	37.40
EP	7.00	15.00
LB	2.36	6.72
100 (LCG/Lp)	30.00	44.80

Comments

Used for hard-chined planing hulls.

Background

- Based on Series 65-B, TMB-62 and DL-62-A hulls.
- Transom flap effects are based on Savitsky and Brown (see Savitsky algorithm).

Form of Equation

$$R/\Delta = A_0X_0 + ... A_{26}X_{26}$$
$$TR = B_0X_0 + ... B_{26}X_{26}$$

where
A_0 ... A_{26} : tabulated coefficients
B_0 ... B_{26} : tabulated coefficients
X_0 ... X_{26} : f(hull parameters)

Selected Reference

- *An Engineering Approach to Predicting the Hydrodynamic Performance of Planing Craft Using Computer Techniques,* Radojcic D., Trans RINA, 1991.

B-Series Propellers (MARIN)

The B-series of propellers are among the most popular to date. Thrust and torque coefficients are represented by polynomials (see reference) in terms of the following propeller parameters: advance ratio J, pitch ratio P/D, expanded area ratio A_E/A_0 and number of blades Z.

$$K_T = f (J , P/D , A_E/A_0 , Z)$$
$$K_Q = f (J , P/D , A_E/A_0 , Z)$$

The following parameter ranges are applicable:

- P/D : 0.50 - 1.40
- A_E/A_0 : 0.30 - 1.05
- Z : 3 - 7

A Reynolds number correction is required for $Rn > 2 \times 10^6$.

The propeller open water efficiency is given by:

$$\eta_0 = J/2\pi \, K_T / K_Q$$

Except where the user chooses a value, the optimization algorithm sets the expanded area ratio to the smallest value consistent with the chosen back cavitation limit. An initial estimate is obtained from Keller's formula and this is refined in each solution iteration by applying Burrill's formula. The number of blades is normally dictated by vibration considerations. Propeller diameter is limited by considerations of hull clearance and adequate immersion in the ballast condition. Propeller RPM should be chosen with regard to engine and transmission gear limitations. Depending on the optimization mode chosen, a range of pitch ratios and RPMs/propeller diameters are used to determine the optimum open water efficiency.

Selected Reference

- *Principles of Naval Architecture Vol II, Resistance, Propulsion and Vibration*, Editor Lewis E.V., Published by SNAME, 1988.

Gawn-Burrill KCA Series

Thrust and torque coefficients are represented by polynomials (see reference below) in terms of the following propeller parameters: advance ratio J, pitch ratio P/D, expanded area ratio A_D/A_0. The polynomials are given for 3-bladed propellers only.

$$K_T = f (J , P/D , A_D/A_0)$$
$$K_Q = f (J , P/D , A_D/A_0)$$

The following parameter ranges are applicable:

- P/D : 0.80 - 1.80
- A_D/A_0 : 0.50 - 1.10
- Z : 3
- J : ≥ 0.3

The minimum back cavitation design criterion results in the required developed area ratio to be:

$$A_D/A_0 = A\ K_T\ f (w , \sigma_0 , J , P/D)$$

where A : constant depending on the degree of allowed back cavitation.
w : wake factor
σ_0 : cavitation number based on advance velocity

Propeller diameter is limited by considerations of hull clearance. Propeller RPM should be chosen with regard to engine and transmission gear limitations. Depending on the optimization mode chosen, a range of pitch ratios and RPMs/propeller diameters are used to determine the optimum open water efficiency.

Selected Reference

- *An Engineering Approach to Predicting the Hydrodynamic Performance of Planing Craft Using Computer Techniques*, Radojcic D., Trans RINA, 1991.

Ducted Propellers (MARIN)

Auto*power* provides a choice of three ducted propeller series:

- Ka 4-70 (4-blade propeller, $A_E/A_0 = 0.70$) in 19A nozzle
- Ka 4-70 (4-blade propeller, $A_E/A_0 = 0.70$) in 37 nozzle
- Kd 5-100 (5-blade propeller, $A_E/A_0 = 1.00$) in 33 nozzle.

The properties of these combinations are discussed in Lewis (see reference below). The formulae for total thrust coefficient and torque coefficient are polynomials in P/D and J.

Selected Reference

- *Principles of Naval Architecture Vol II, Resistance, Propulsion and Vibration*, Editor Lewis E.V., Published by SNAME, 1988.

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