PROSEL
propulsion installation selection
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1 Introduction

PROSEL (propulsion installation selection) is a design system, that will help the ship designer to select the most optimal propulsion installation for a given set of design demands. The design of waste-heat, electric power, and auxiliary systems is also incorporated. For finding the optimum installation various evaluation procedures are offered. PROSEL is being developed to offer a general design procedure, applicable to the separate systems in the installation. The modules for designing the propulsion installation were recently completed. One of the auxiliary system PROSEL parts, the cooling system design, is being developed at the moment and will be completed at the beginning of 1991. A module for exploration of the waste heat steam generation was completed in 1990. This report will discuss the complete design sequence for a propulsion installation. Specific terms used in this paper are explained in paragraph 11.

2 General PROSEL description

Although this report discusses only the propulsion installation part of the PROSEL design system, in this chapter information will be given about the total system development. This information comprises background data, the premises and the general approach of the design problem.

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2.1 Background

The machinery installation of a modern ship comprises several systems, e.g. the propulsion plant, the electric power supply system, the heating system, the fuel oil, lubrication oil and cooling systems. The need for economy, both in building and operational costs, urges the naval architect to adopt an integrated design for the total installation, e.g. to use waste-heat recovery and power-take-offs from the main propulsion system for electricity generation. This integration consequently means, that an integrated design and evaluation tool is needed. Different solutions (twin or single engine, power take of generators or separate ones, etc.) can be defined and analyzed. The results for different layouts can be compared.
The choice of the machinery installation strongly influences the other system's design. Modern ships must be designed to perform well in different operational conditions. There can be different conditions on the hydrodynamic side, such as the weather state, towing load, operational speeds, and ship draft. On the other hand there can be different conditions concerning ship service requirements, e.g. the required electrical power, the heat demand, and mechanical power. One situation can be addressed as 'the' design condition. The performance of the ship in other conditions must also be analyzed. The interaction between the propulsion installation systems, considering design as well as off-design conditions, expresses the need for a complete CAD system offering an integrated design.
Design of PROSEL started in october 1988 at the Delft University of Technology in cooperation with Marin Wageningen. Also involved in the project is the dutch shipyard Yssel-Vliet-Combinatie B.V. The PROSEL project is sponsored by the dutch organization of maritime research (CMO). The program will be available as a part of the MARDES ship design system, as well as, as a stand alone program.

2.2 Premises

For the development of PROSEL the following premises were made:

* PROSEL must offer an integrated design environment for the propulsion system (engines, gearboxes, thrusters etc.), waste-heat-utilization system (steam, thermal oil), integrated electric power supply and auxiliary systems. When designing one of these systems the data description of other system's components should be directly available.
* The user will be completely free in choosing his own installation layout. This means that there are no limitations to an installation configuration, as far as the components allow.
* The program will be as hardware independent as possible. Initially PROSEL will be available on an AT type personal computer with DOS operating system and on work stations with UNIX operating system.
* The user of the program is assumed to be a member of the design department of a shipyard, a shipping company or a design agent. It is expected that he has a sound judgement in composing ship propulsion installations.

* The main objective of PROSEL is to enable a fast and efficient evaluation of a large number of alternative system designs, which may lead to a technically and economically most attractive result.

2.3 General description of the propulsion installation

A propulsion installation consists of components that are connected to each other. There are e.g. diesel engines, shafting systems, propellers, gearboxes, electric power generators etc. All these system parts can be represented by components. A connection between two components is called a link. A physical representation of a link is a flange, connecting e.g. a shaft with a gearbox, or a diesel engine to a coupling. Thus a propulsion installation can be represented by components and links. Some components have only 1 link, others can have more links. Via the links in a propulsion installation mechanical power is being transmitted with a certain rotational speed from one component to the other. 4 different types of components can be considered. These component types are:

Prime mover

A prime mover is a component that is defined to deliver power to the propulsion installation. It has 1 or 2 links, both having the same rotational speed. A prime mover only has an outgoing side, i.e. power leaves the prime mover. (At this moment, december 1990, diesel engines are implemented. Extensions will be made in the future to gasturbines, steamturbines, and possibly other kinds of prime movers).

Transmission

A transmission is a component with 2 sides. There are an ingoing and an outgoing side. Power is coming in via the links at the ingoing side, it is being transmitted internally from the link(s) at the ingoing side to the link(s) at the outgoing side and it is going out via the links at the outgoing side. Thus a transmission always has more than 1 link. (In december 1990 gearboxes, shafts, and flexible couplings are implemented. An electrical transmission must be added)

Thruster

A thruster is a component with only 1 link. It absorbs the power from the propulsion installation and it converts this mechanical power at a given rotational speed into a thrust at a certain ship speed. (Fixed pitch screw type propellers, controllable pitch screw type propellers and ducted propellers are incorporated. Modules for a waterjet type thruster must be added).

Power take off (pto)

Finally a power take off also has only 1 link, which is ingoing. It absorbs the mechanical power via it's link at a certain rotational speed. A pto can be a generator, pump or other mechanical power dump. It's behavior can follow a certain characteristic (e.g. constant power, power depending on rpm etc.), see paragraph 3.2.4

The mechanical power flow through an installation has a certain direction. In a propulsion installation the positive power flow

direction is defined to go from the components that deliver power (prime movers) via the components that transmit the power (transmissions), to the components that absorb the power (thrusters and pto's).
If a component has more than one link, then there will exist a relation between the power and/or rotational speed at the different links, e.g. the power between one end of a shaft is related to the power at the other end by means of the power efficiency, the rotational speed at both ends is the same. These relations between power and rotational speed at the different links of the same component are called transfer functions. The transfer functions are depending on the component type. (A description of these functions can be found in paragraph 4.2.2.)

2.4 The PROSEL design sequence

In order to achieve the most optimal installation the PROSEL design sequence is split up into 5 parts. This sequence can be applied to many problems:

1 specification of design demands
2 composition of installation alternatives
3 selection of interesting alternatives
4 detailed evaluation
5 final selection

These 5 parts can be run independently, of course only when the appropriate input is available, e.g. a detailed evaluation can only take place when an installation has been composed. All these design steps will be handled in the following chapters. The data flow during the design sequence is shown in figure 1.

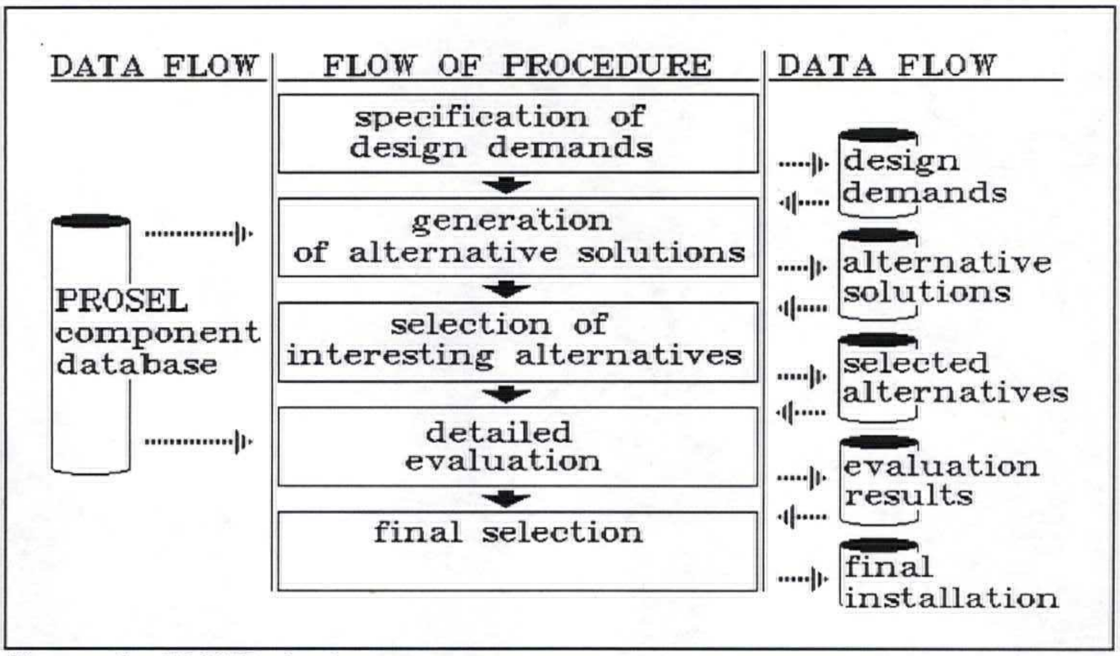

figure 1: PROSEL design sequence

3 Specification of Design Demands

The first step in designing an installation will be the specification of the user's design demands. These demands are the framework in which the installation design will take place. The user can build this framework according to his specific ideas. The design demands are split up into 4 parts:

* specification of the installation layout
* specification of the preferences concerning the components
* definition of the operational condition
* specification of ship data

The design demands that are given must be recorded into a data structure. This structure is given in appendix II. The data structure is a way of representing what the user wants.

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3.1 The Installation Layout

The layout of an installation is defined by means of it's components and the way they are connected to each other, i.e. the links between these components.

3.1.1 Component definition

For a propulsion system only 4 types of components are being considered, as already described in paragraph 2.3. All kinds of elements that can be present in a propulsion installation can be covered by one of these types. When specifying the components, they can be given a name by the user for convenience in recognizing them. Such a name however has no significance for the program algorithm. The order in which the components are defined is free. Up to 20 components can be defined. This is not an absolute limit, but it is related to the size of input screens and to computational time. It can easily be raised. An example of a component definition is given in example sheet 1.

Component definition

component number	*name*	*type*
1:	diesel_1	prime mover
2:	diesel_2	prime mover
3:	gearbox	transmission
4:	shaft	transmission
5:	propeller	thruster
6:	generator	pto

example sheet 1 : component definition

3.1.2 Link definition

The components must be linked together, completing the installation layout specification. At this moment, december 1990, this specification is done by typing the names of the linked components. This is meant to be replaced by a graphical way.

3.1.2.1 Link variables

The configurated links between components represent a power and rpm transfer between them. Physically the flanges of the components are meant. Power and rpm represent the operating condition of the propulsion arrangement. Besides this single power-rpm operating point also a power-rpm relation is transmitted specifying the link power value when another rpm value is chosen. This relation results from thruster design. It can be useful in e.g. prime mover selection when an mcr power that doesn't represent the lowest possible power flow through the installation, can result in a lower specific fuel oil consumption, thus giving a better total system design solution. This case will be discussed in a paragraph 4.3.3.5.

3.1.2.2 Link direction

Links between components are defined to have a direction. The direction concerns the power flow for design conditions. A link has a 'from' and a 'to' component. The 'from' component is always the component that is meant to deliver the power. The power receiving component is the 'to' component. Pto and thruster type components are always 'to' components, a prime mover is always a 'from' component. For a transmission the designer must specify which components are attached to the ingoing side (from which side power is coming in) and which are attached to the outgoing side (from which side the power is going out). In example sheet 2 for the given example's link definition the 'to' and 'from' components are indicated.

Link direction definition

component where power is coming from	*component where power is going to*
diesel_1	gearbox
diesel_1	generator
diesel_2	gearbox
gearbox	shaft
shaft	propeller

example sheet 2 : link definition including link direction

3.1.2.3 Link power percentage

When a component has more than one in- or outgoing link, e.g. a gearbox, then the link power percentage option can be used. This means the percentage of total in- or outgoing power of a component, that is flowing through this in- resp. outgoing link can be specified explicitly. It is also possible to specify the absolute link power value but when also a link power percentage has been given then a conflict situation can occur. When defining the links the designer will be warned for this. E.g. when 2 diesel engines are linked to the same gearbox then the user can define diesel engine 1 to deliver 40% of the total ingoing power into the gearbox, and diesel engine 2 will then deliver 60%. When the user defines diesel engine 1 to deliver 40% as well as 4000 Kw, then a conflict situation can occur. The total ingoing power into the gearbox can then be calculated to be 10000 Kw. This power value in most cases will not match the power that is required by e.g. the thruster. An example of these link percentages definition is given in example sheet 3.

Link power percentage definition

The total 'from' power is the sum of power that is being delivered by a 'from' component to all it's linked components. The part of this total power that is going through one specific link is indicated by a percentage.

'from' component	*'to' component*	*part of total 'from' power*	*part of total 'to' power*	*abs. rpm*	*abs. power*
diesel_1	gearbox	80%	50%	-	-
diesel_1	generator	20%	100%	-	-
diesel_2	gearbox	100%	50%	-	-
gearbox	shaft	100%	100%	-	-
shaft	propeller	100%	100%	-	-

example sheet 3 : link power and rpm definition

3.1.2.4 Link restrictions

There are some limitations on the linking of components, depending on their type. When the designer is defining the links between the components these limitations will be checked for immediately:

- Prime movers can be linked to transmissions, pto's and thrusters but not to other prime movers.
- Transmissions can be linked to prime movers, pto's, thrusters and other transmissions.
- Pto's can be linked to prime movers and transmissions, not to thrusters and other pto's.
- Thrusters can be linked to prime movers and transmissions but not to other thrusters.

3.2 Component Preferences

For every component the user can define his preferences. These preferences are additional demands besides the power and rpm requirements. For every component a form can be filled in for defining the user's wishes. This form is different for every component type. The preferences for the four types of components are handled subsequently in the paragraphs 3.2.1 to 3.2.4.

3.2.1 Prime mover preferences

For prime movers it is needed to specify the type (diesel, gasturbine...). When desirable the user can also prescribe the make (SWD, Sulzer...), the series, the number of cylinders, the operating principle (2 or 4 stroke), minimum and maximum allowed engine margin and preferred engine margin. When the minimum and maximum allowed engine margin are not given by the user then default values of 0.85 and 0.95 will be proposed. Also the fuel oil quality can be given by means of the lower calorific value. The preferences for a prime mover in the example installation are given in example sheet 4.

Prime mover preferences

component:		*diesel_1*	
type	:	MCR diesel engine	(MCR/LOF)
make	:	SWD	
series	:	-	
number of cylinders	:	-	
2 or 4 strokes	:	-	(2/4)
engine margin			
* preferred	:	0.85	(0-1)
* minimum acceptable	:	0.90	(0-1)
* maximum acceptable	:	0.95	(0-1)
lower calorific value fuel oil	:	-	

example sheet 4 : prime mover preferences

3.2.2 Transmission preferences

For the transmission it is needed to specify the type. This type can be a gearbox, an electrical transmission (not implemented yet), a shaft or a coupling. If the user want's to prescribe the make and the series he can do so. For completely describing a transmission it is necessary to specify the reduction ratios between the ingoing and outgoing link(s). This is done by means of normalized rpm values. These are defining in fact the rpm ratios between the different links. When the user wants to select his own transmission without PROSEL influence, these normalized rpm values have to be specified. Otherwise they will result from automatic PROSEL action. Shafts have two links with normalized rpm values, that are always equal, for couplings slip can be incorporated. If a shaft's normalized rpm values were not defined by the user, then the program will automatically take care of this. For both the shaft and the gearbox in the example installation the preferences are given in example sheet 5.

Transmission preferences

component:	*gearbox*		
type	:	GEARBOX	(GE/SH/CO/EL)
make	:	-	
series	:	-	
size	:	-	
accept custom made solution	:	YES	(Y/N)
normalized rpm values			
link to diesel_1	:	-	
link to diesel_2	:	-	
link to shaft	:	-	
component:	*shaft*		
type	:	SHAFT	(GE/SH/CO/EL)
make	:	-	
series	:	-	
accept custom made solution	:	YES	(Y/N)
normalized rpm values			
link to gearbox	:	100.00	
link to propeller	:	100.00	

example sheet 5 : transmission preferences

3.2.3 Thruster preferences

When the component is a thruster, it is necessary to indicate the thruster type. Further it is possible to specify the required thrust (if not specified it will be calculated from the ship's resistance curve and the design speed), the percentage of total thrust to be delivered by this thruster (default is an equal distribution among thrusters), the minimum and maximum allowed diameter, the minimum and maximum allowed rpm, the number of blades, the minimum and maximum allowed pitch/diameter ratio and the propeller clearance with the keel. Also the material (bronze or cunial) and the propeller position (central or side) can be specified. This material specification will be needed for calculating propeller weight and cost. If no material was chosen then bronze will be taken by default. If the material is bronze but during calculation it appeared to be cunial for strength reasons, this will be changed automatically. The example's thruster preferences are given in example sheet 6.

Thruster preferences

component:		*propeller*
type	:	Wageningen B-series
one of		
* absolute thrust	:	-
* thrust percentage	:	100%
minimum diameter	:	2.5 m
maximum diameters	:	5.0 m
minimum rpm	:	100
maximum rpm	:	200
minimum pitch/diameter ratio	:	0.6
maximum pitch/diameter ratio	:	1.4
number of blades	:	4
thruster-keel clearance	:	0.1 m
position	:	central
thruster material	:	bronze
sea margin on shaft power	:	1.0

example sheet 6 : thruster preferences

3.2.4 PTO preferences

For a pto no database choice will be made. Therefore the user himself must give the main characteristics. For a power take off several items can be given as preferences. The power and the rotational speed for a given operational condition can be explicitly defined by the user, but it is also possible that they will result from program execution. So these values can also be left blank as is done in the example (rpm will result from the prime mover database choice, the power will be calculated as a percentage of the total prime mover outgoing csr power, see link power percentage definition). Further preference items are the type (generator, pump or other) and the behavior as a function of the rotational speed (no relation, linear, cubic or third degree relation). For determining the engine room dimensions, the total installation weight and cost, the user must specify the mass, the cost and the dimensions of the pto. The preferences for the example's pto are given in example sheet 7. The specification of pto preferences is not yet made operational by MARIN in the user interface.

3.3 Ship data

For identification of the ship some data have to be given by the user. When working in a MARDES environment, PROSEL will be started for a certain ship name and version. Those values will be echoed, the user doesn't have to give additional identification. When working in a stand alone mode the ship name and version together with ship parameters and dimensions must be specified. Other input data are the length, breadth, depth and draft aft, some hull coefficients and the ship's resistance. Up to four different resistance curves can be

Power take off preferences

component:	*generator*
power	: -
rpm	: -
type	: GENERATOR
behavior	: LINEAR WITH RPM (P = C*Rpm)
rpm coefficient C	: 0.25
mass	: 3 ton
length	: 2.1
height	: 2.1
width	: 2.1
shaft above base	: 1.
cost estimate	: 40. x1000 Hfl

example sheet 7 : pto preferences

given, e.g. for different displacements. The ship's resistance can be entered as a function of the ship speed, represented by up to 30 points spread over the ship's speed range. Again for the example the data are presented, in example sheet 8.

Ship data definition

ship name	*: Atalante*
ship version	*: 1*
classification society	: Lloyd's Register
ice class factor	: 1
prismatic coeff. on LWL	: 0.8
midship coefficient	: 0.99
position center of buoyancy	: 50% of lpp
stern coefficient	: -
shaft aperture coefficient	: -
wetted surface area	: 0.6
maximum pitch/diameter ratio	: 1.4

4 resistance curves can be defined by entering up to 30 speed-resistance points (e.g. one curve for 4 different loading conditions). In a MARDES environment the curve can directly be read from the available ship data.

example sheet 8 : ship data definition

3.4 The operational condition

For completely defining the operational condition it will be required to specify the following data:

- the ship speed
- the sea margin
- the ship's resistance
- active components
- link power and rpm presettings

Components can be considered active or inactive. A component being inactive means that it is physically present in the installation configuration but it can be considered to be switched off. This option will be used when e.g. designing a father-son arrangement of the installation. An inactive component will not be selected during the execution of PROSEL for the specified design condition. If the user wants it to be selected then he has to define an operating condition for which this component is active. The sea margin can be applied to the resistance, or to the thruster shaft power. In the first case the resistance curve will be amplified with the defined sea margin, in the second case the user has to give a power amplification factor within the thruster preferences. Both options can also be used at the same time. The ship's resistance curve can be composed by adding the four resistance curves that were defined with the ship data specification. Each curve can be multiplied with a factor, representing the sea margin. Also the settings for link power and/or rpm values or percentages as already described in paragraph 3.1.2.3 must be given. An operational condition is given for the example installation in example sheet 9.

Operational condition

description:	*service condition*			
diesel_1	:	active		
diesel_2	:	active		
generator	:	active		
gearbox	:	active		
shaft	:	active		
propeller	:	active		
Ship draft	:	5 m		
Ship speed	:	14 knots		
Actual resistance	=	1.25	*	curve_1
		+ 0	*	curve_2
		+ 0	*	curve_3
		+ 0	*	curve_4

For link power and rpm specification see example sheet 3

example sheet 9 : operational condition definition

3.5 Design demand data representation

All design demands are stored in records. These records are stored in files, representing the installation data description. These files correspond to the paragraphs that were discussed in this chapter:

SHPDAT: the ship data
CMPNTS: component description
CMPLNK: link description

PMPREF: prime mover(s) preferences;
THRPRE: thruster(s) preferences;
TRPREF: transmission(s) preferences;
TRNMRR: reduction ratio(s) for transmission(s);

Also the next files are being generated for storing the results from database choices that will be made during the alternative composition part (paragraph 4):

PMCHDS: prime movers(s) database choice description;
TRANDS: transmission(s) database choice description;
THRPDS: thruster(s) database choice description;

An extensive description of these data files can be found in appendix II.

4 Composition of Installation Alternatives

After having specified the design demands, PROSEL will start composing the installation. One of the most important premises for PROSEL development is flexibility. The user must be free in choosing his own layout. In this field there must be no limitations. The program structure that is developed for propulsion installation generation must also be applicable to other system design, e.g. electric power supply system and auxiliary systems. In order to obtain this flexibility the strategy as described in the following paragraphs was chosen.

Contents

4.1 The algorithm structure

The structure of the chosen algorithm can be represented with figure 2.

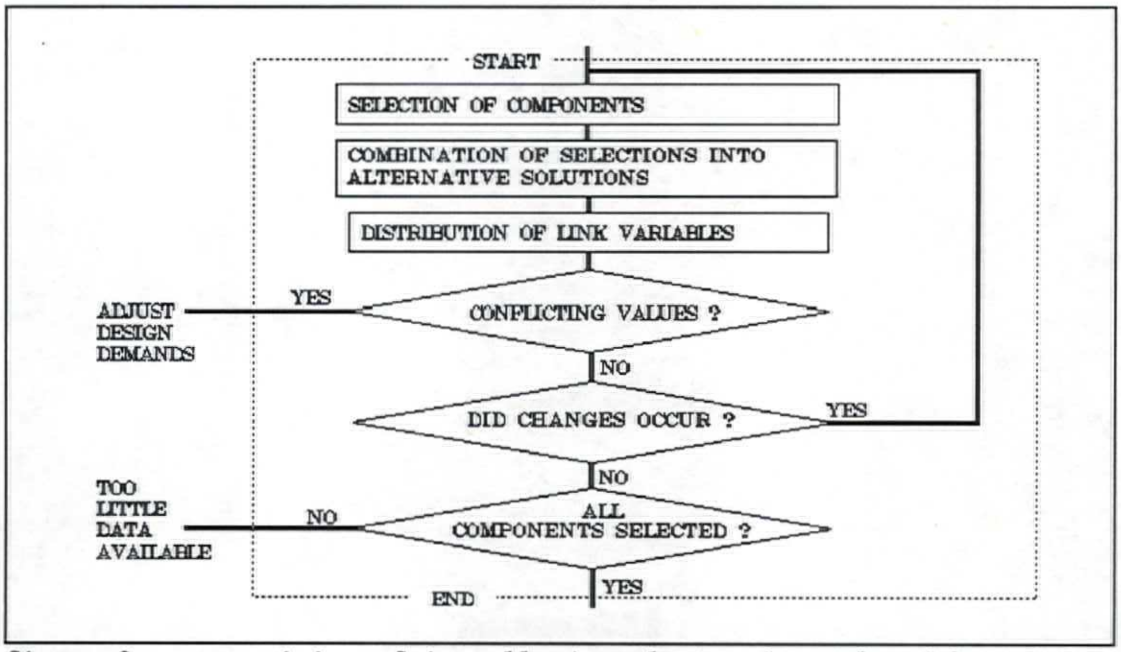

figure 2: composition of installation alternatives algorithm

During installation composition 3 basic processes are performed that make part of a loop:

- determination of link variable values and the distribution of these over the complete system (internal name: DISTRI)
- component selection from the PROSEL component database (internal name: SELECT)
- combining alternative components to installation alternatives (internal name: ADJUST)

The loop will be repeated until all alternatives are generated, or until a conflict situation occurs. The 3 processes are dealt with in detail in the paragraphs 4.2-4.4.
The sequence of the 3 processes as depicted in figure 2 was chosen to enable a faster completion of the program. In most cases the power and rpm values at the links between components are unknown at the start of the program. So executing DISTRI as a first step would be vain. The SELECT and ADJUST part must be executed in this sequence, since no adjustment can take place if no choices have been made.
The reason for the chosen algorithm structure can be found with the premises. The algorithm is straightforward. There is no limitation to the number of components and the way that components are linked together. The variables at the links are power and rpm for the propulsion installation, but the same algorithm can be used for handling e.g. pressures, mass flows and temperatures in a fuel oil system. The component types define the way in which the link

variables are distributed from one link to the other. Adding a new type of component will not inflect the main algorithm, it only involves the definition of a link variable distribution characteristic, and a selection procedure for this type of component.

4.2 Link variable value determination and distribution

The link variables are rpm and power. When the values of these variables are known at one specific link, it is possible to distribute them over the installation to the other links.
All components have an internal description, that can be seen as a transfer function. This function translates the power and rpm values from one of it's links to the other link(s); the transfer function for rpm values is the reduction ratio, the transfer function for power values can be a power distribution and/or an efficiency.
The transfer function is not always known directly from the start of the program. It can result from database choices, e.g. diesel engine and propeller choice determining the reduction ratio of a gearbox.
Link value deduction will be continued until no more changes occur.
If this is the case then the next main process (see figure 1, figure 2) in the PROSEL loop will be executed.

4.2.1 How to deduct the values at a component's link ?

The link variable values for all links of the component are read from the link record table. If other links were found besides the handled link, then a deduction for every other link will take place using the transfer function, depending on the type of the component. Since pto's and thrusters are defined to have only 1 link only for prime movers and transmissions a deduction can be executed.

4.2.2 Component transfer functions

For every component that is active in the specified design condition, the link rpm and power values will be determined. All components of the handled installation will be taken into consideration subsequently. This loop will be executed until no more new link variable assignments take place. This means that the link variable values are distributed over the installation as far as possible with the present installation description. When a component is handled, then for every link the variable values will be deducted from the values at the other links of the component by means of the component description. These deducted values and the values that are eventually present in the link record table already, are evaluated for inequality.

4.2.2.1 Prime mover transfer function

A prime mover has only outgoing links. So when an ingoing link was met then an error situation occurs and the program will be left. All the links of a prime mover have the same value for the rpm variable. So rpm deduction will take place by setting the deducted rpm value to the same value as the other link rpm value. For power value deduction the total outgoing power distribution among the links has to be known. This distribution can be known because the designer explicitly specified it per link in the link record table, or because the program has calculated the distribution in an earlier stage of execution. By means of these power percentages the link power value can be deducted from another link power value.

4.2.2.2 Transmission transfer function

For a transmission link the rpm value can be deducted from another link rpm value by means of the normalized link rpm value for each link. The ratio of both normalized rpm values gives the ratio of both actual link rpm values. The normalized link rpm values can be specified explicitly by the designer, or they can result from database selection.
When the link power value has to be deducted from other link power values then two different situations have to be considered. In the first situation both links have the same direction, i.e. both are in- or outgoing. In the second situation they have different directions, e.g. the power value of an ingoing link has to be deducted from the power value of an outgoing link.
When both links have the same direction then the power value will be deducted by means of the power percentages per link. The ratio of both percentages and the power value of the other link result in a deducted value for the handled link. The power percentage of an in- resp. outgoing link represents the part of the total in- resp. outgoing power for the transmission that is transmitted through this concerning link.
When the handled link and the other link have different directions then another procedure has to be followed. When the handled link is ingoing then the total outgoing power will be determined by adding the power values of all the outgoing links. The handled link power value can then be calculated by dividing the sum of the outgoing power by the transmission efficiency, and multiplying this sum of ingoing powers by the link power percentage. A similar procedure will be followed when the handled link is outgoing. In this case the sum of ingoing powers has to be multiplied by the transmission efficiency.

4.2.2.3 Thruster and PTO transfer function

No transfer function is needed (paragraph 4.2.1)

4.2.3 Evaluation of the found link values and conflicts

After the deduction procedures an evaluation of the found values for the handled link will take place. For this link a comparison is made between every value deducted from another link and it's own original value that is recorded in the link record table. If the link record table value is undefined and the deducted value is not undefined then the link record table value will be set to the deducted value. If the link record table value has already a value and the deducted value isn't undefined either then they have to be checked for inequality. If both values differ, an error situation occurs and the program will be left, with an appropriate message.

4.3 Component Selection

For every component that is not yet selected a selection procedure will be followed. The selection procedures are depending on the type of component. When selecting a component the link rpm and power values are read, together with the user's preferences for this component. If sufficient data are known then a database selection will take place. In not then this component's selection will be skipped and the next component in the installation will be handled. If all components were dealt with subsequently, and a change occurred, i.e. a component was selected in this sequence, then a new loop of component selections will be executed. Again all components will be handled. If no change occurred during a sequence then the program will jump to the next main PROSEL process (see figure 1, figure 2). This loop structure of the selection process was adapted because by means of a database choice for a component, an unknown link variable could become known, thus resulting in sufficient selection data for the linked component. An example of such a situation is a diesel engine selection with only a power demand. The diesel's rpm value is free. When a choice has been made from the database then the rpm value will be known. This rpm value in it's turn is required for the selection of the component that is linked to the diesel engine e.g. a flexible coupling.

4.3.1 Inactive components

The first check for component selection is to see whether it is active of inactive. When a component is not active then all it's links are set to inactive and it's selection will be stopped. This is done in order to make clear that when a component, that is linked to the current one, must be selected in it's turn, it must be known that it is linked to an inactive component.

4.3.2 Thruster Selection

When a thruster hasn't been designed yet then the 'first time' thruster selection procedure will be followed. An optimum thruster will be designed together with 5 additional thrusters.

It is also possible that a thruster has to be redesigned during PROSEL execution for reasons of an optimum prime mover-thruster adjustment. In this case the 5 additional thruster designs are used for interpolating a new thruster design.

4.3.2.1 First time thruster design

When a thruster is not selected yet, a new thruster will be designed. This new thruster design will result in an optimum thruster, together with 5 additional thrusters. The selection procedure is the same for the optimum thruster and the 5 additional thrusters, only the design demands are different.

4.3.2.1.1 The optimum thruster

For finding the optimum thruster the procedure as described in paragraph 4.3.2.1.3 will be used with a user specified rpm range as input. The optimum thruster is described, in the case of a Wageningen B-series propeller, with it's diameter, pitch/diameter ratio, number of blades, blade area ratio, open water efficiency, Kt- Kq- and J relations, shaft rpm and shaft power. A cavitation criterion is incorporated. The found thruster is the optimum one over the rpm range that was specified within the users preferences. The optimum thruster that was selected for the example installation is described in example sheet 10. (Due to diameter limitations the propeller efficiency in the example is very low). The shaft power to be delivered to the thruster can be determined in 2 ways:

* as a direct result from thruster design, in case the sea margin was added to the trial resistance before starting thruster selection (the ship owner's approach: propeller designed for service conditions)
* as the power resulting from thruster design, raised with the sea margin (the ship builder's approach: propeller designed for trial condition)

The user can make his own choice when specifying the design demands.

4.3.2.1.2 The 5 additional thrusters

Besides the optimum thruster that was found within the design demands, five other thruster descriptions are generated. The total rpm range that is specified by the designer to be available for thruster selection is covered by five equally spaced rpm values. For each of these rpm values an optimum thruster will be designed using the procedure in paragraph 4.3.2.1.3. The values for rpm and delivered power of the five thrusters represent a power-rpm link relation. Through these five power-rpm points a spline can generated that represents the range of optimum thruster designs for a range of rpm values. The reason for covering an rpm design range is as follows:

Optimum thruster description

component:		*propeller*	
type	:	Wageningen B-series	
diameter	:	5.00	m
pitch/diameter ratio	:	0.86	
number of blades	:	4	
blade area ratio	:	0.84	
absolute thrust	:	789.39	kN
percentage of total thrust	:	100%	
shaft rpm	:	137.5	1/min
shaft power	:	3802	kW
open water efficiency	:	0.47	
cavitation	:	no	

example sheet 10 : optimum thruster description

Imagine that there exists a fixed prescribed rpm ratio between thruster and prime mover, e.g. in a direct drive installation. After thruster design a choice is made for the prime mover from the database. The chosen engine has a specific rpm for it's design operating point. This prime mover rpm determines the thruster rpm. Because the chosen engine's rpm will seldom comply with the optimum thruster's rpm, a different thruster than the optimum one should be selected. This thruster can be interpolated from the five thruster descriptions, that represent the rpm range.
The thruster range has the shape of a power-rpm relation represented by five points (see figure 3).

This power-rpm relation will also be used for finding the optimum thruster-prime mover combination. Therefore the five power-rpm points will be distributed over the installation in the same way as described in paragraph 4.2.

4.3.2.1.3 Selection procedure

The thruster preferences are read and the thrust to be delivered is determined by means of the ship speed, resistance and thrust deduction. The thrusters are selected by using the systematic series diagrams that are being available in the form of polynomials. The rpm and diameter range, resulting from the user's preferences, are subdivided into a 5x5 dimensional matrix. This way 25 diameter-rpm combinations are evaluated. When one of these ranges is too small, e.g. when an optimum thruster for one specific rpm value must be found, a shortcut or will be invoked and the 5x5 matrix will be restricted to a 5x1 matrix. For each of the diameter-rpm combinations a blade area ratio is calculated by means of the Keller criterium. The required thrust determines the pitch/diameter ratio. For the resulting propeller an open water efficiency can be calculated. The best of the 25 (or 5) thrusters will be selected. After this a 'zoom-in' will take place. A new rpm and/or diameter range around the just

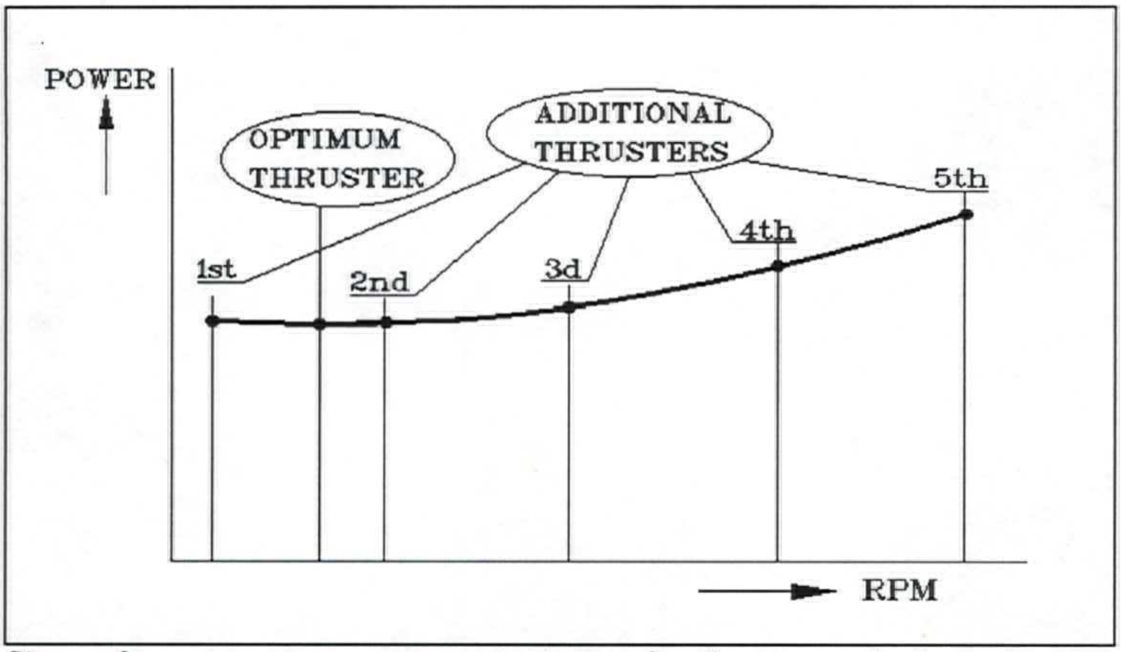

figure 3: power-rpm representation of thruster design (not a representation of example 1)

found thruster are being determined. The ranges are again divided into 5 values. When the differences between 2 successive rpm and diameter values become smaller then a given step size, then the required tolerance has been achieved and the optimum thruster has been found. The zooming-in will continue until this goal has been reached.

4.3.2.2 Thruster redesign

A redesigning of the thruster for a non optimum rpm will be done by using the 5 additional thruster designs (see paragraph 4.3.2.1.2). From these designs the values for diameter, pitch/diameter ratio, blade area ratio, open water efficiency, shaft rpm, shaft power and increase factors for shaft power and rpm due to cavitation are read into memory. For each of these descriptive variables a spline can be constructed as a function of thruster rpm. Selection can then take place by intersecting the splines at the appropriate rpm value, thus obtaining the descriptive values for the redesigned thruster.

4.3.3 Prime Mover Selection

Before a prime mover selection from the database can be executed the link power and rpm values must be read. These values are CSR values, so they have to be converted to MCR values. Depending on whether all power and/or rpm values are known/not known, three different selection procedures can be followed.

4.3.3.1 Reading the CSR link variable values

The prime mover delivers power to the propulsion arrangement. By definition all prime mover links have to have the same rpm value. For selection the total power value, built up from the separate link power values, has to be known. For every prime mover link the power, rpm and power-rpm relation values are considered.

4.3.3.2 Selection procedure determination

When a prime mover must be selected, it depends on the installation lay-out and the rpm and power values, that are available, which selection procedure out of 3 will be followed, or if no selection can take place yet. First it will be checked whether the power at all the prime mover's links is known. If not, then no selection can take place. The next component will be considered.
If the power to be delivered for the design operational condition is known, then it will be checked whether also the rpm is known. If not, then prime mover selection procedure 1 will be followed. This means selection with free prime mover speed. This is the case when a reduction gear is available between propeller and prime mover.
When the rpm is known and there exists a fixed reduction ratio between thruster and prime mover, selection procedure 2 will be executed. This involves an optimum thruster - prime mover adjustment.
If power and rpm at the prime mover links are known, there is a fixed reduction ratio and selection procedure 2 can not be followed, then selection procedure 3 will be adopted. This will be a very rare case, e.g. when 2 or more engines are connected via a fixed ratio gearing to the same thruster.

4.3.3.3 Conversion of CSR to MCR values

The resulting values for csr conditions will be converted to minimum, maximum and preferred mcr conditions. This conversion is done by means of the maximum, minimum and preferred engine margins respectively, that are read from the prime mover preferences. For the CSR-MCR conversion a third degree propeller curve (power-rpm) will be assumed. If no preferred engine margin was specified then the preferred engine margin will be interpolated linearly between maximum and minimum value. The result of the csr-mcr conversion is a so called 'prime mover selection area', PMSA. The appearance of the PMSA depends on the prime mover selection procedure that will be followed.
In case of selection procedure 1, only the CSR power value is known, the minimum required mcr power is obtained by dividing the link csr power by the maximum engine margin; the maximum mcr power is obtained similarly. In this way a prime mover selection area is created with the shape of a power band, see figure 4.
When there exists a fixed reduction ratio between prime mover and thruster, there will exist an rpm-power relation, resulting from additional thruster designs (see paragraph 4.3.2.1.2). Instead of a straight band in the selection procedure 1, a curved band will now be generated as the prime mover selection area. In figure 5 an example

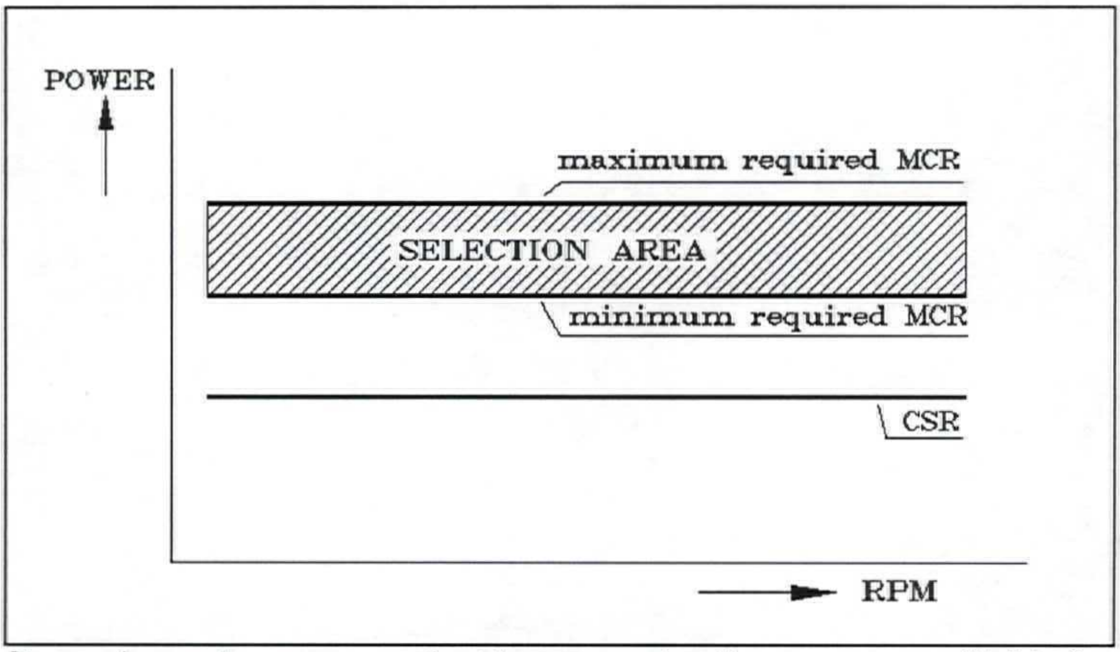

figure 4: prime mover selection area in the power-rpm field for selection procedure 1

is given of such a selection area.
The lower and upper limits of this band can be calculated by applying

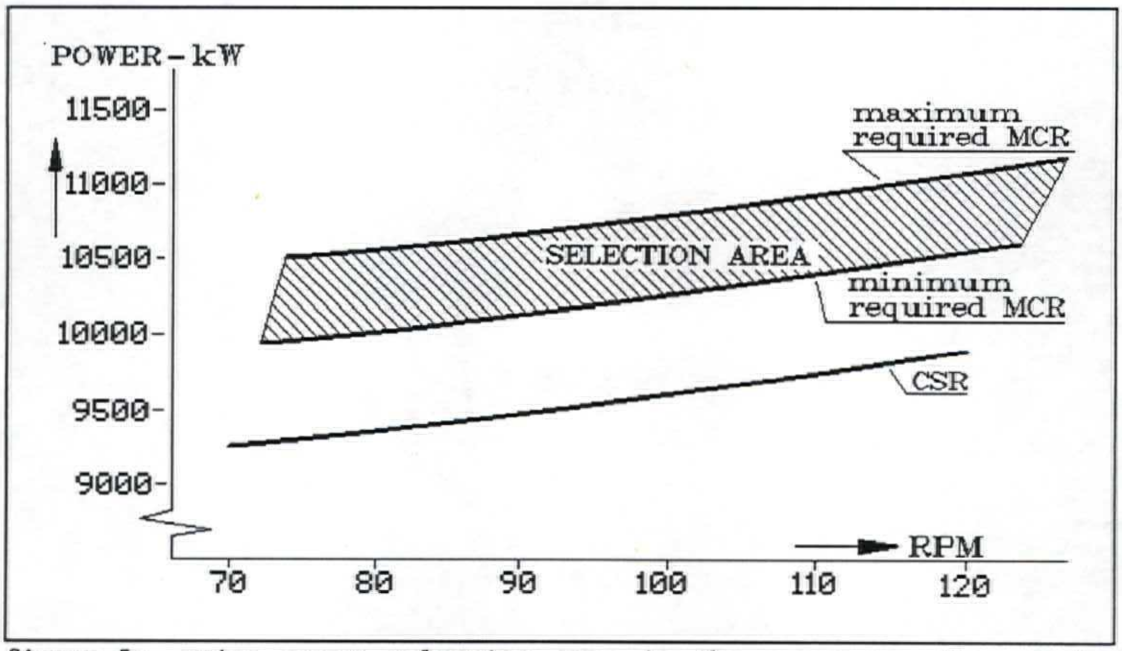

figure 5: prime mover selection area in the power-rpm diagram for selection procedure 2

the maximum and minimum engine margins to the power-rpm relation.

When as well the power values as the rpm values are prescribed, without the rpm-power relation being valid then the PMSA will have the appearance as given in figure 6.

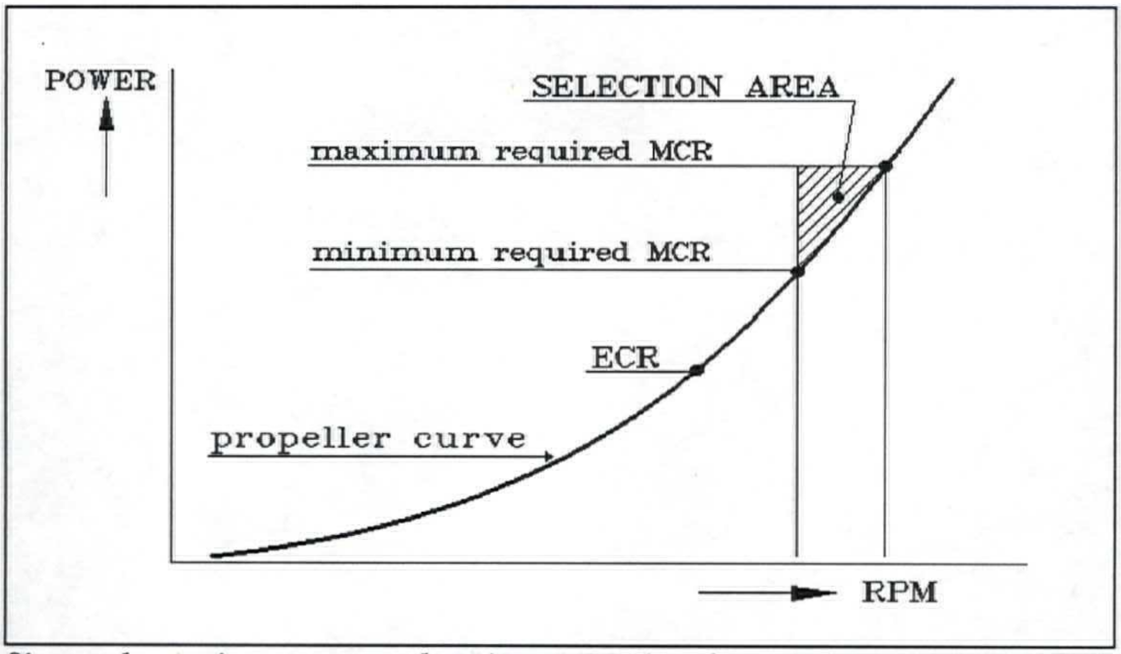

figure 6: prime mover selection area in the power-rpm diagram for selection procedure 3

4.3.3.4 Selection procedure 1: selection with only a power prescribed; prime mover speed is free

All database engines with an MCR point within the prime mover selection area, as described in figure 4, will be selected. When lay-out-field (LOF) engines are considered a complication is added to the selection. A LOF engine can be selected when an overlap exists between it's lay-out-field and the prime mover selection area. This is illustrated in figure 7.
A specific mcr point can then be chosen, according to different criteria, that have to be specified by the user, e.g. minimum fuel oil consumption or installation weight.
If a point in the overlap area meets the preferred engine margin, then this point is selected; otherwise the point with an engine margin, that is closest to the preferred margin is chosen. This selection procedure 1 will also be followed for the example installation's prime movers, because there doesn't exist a fixed reduction ratio between the thruster and the prime movers. (Even if the reduction ratios of the gearbox were prescribed by the user then also procedure 1 would be followed. There are two prime movers connected to the ingoing side of the gearbox, an optimization for one prime mover-thruster combination will result in most of the cases in a redesigned thruster (paragraph 4.3.2.2) that is not equal to the redesigned thruster resulting from the other prime-mover thruster

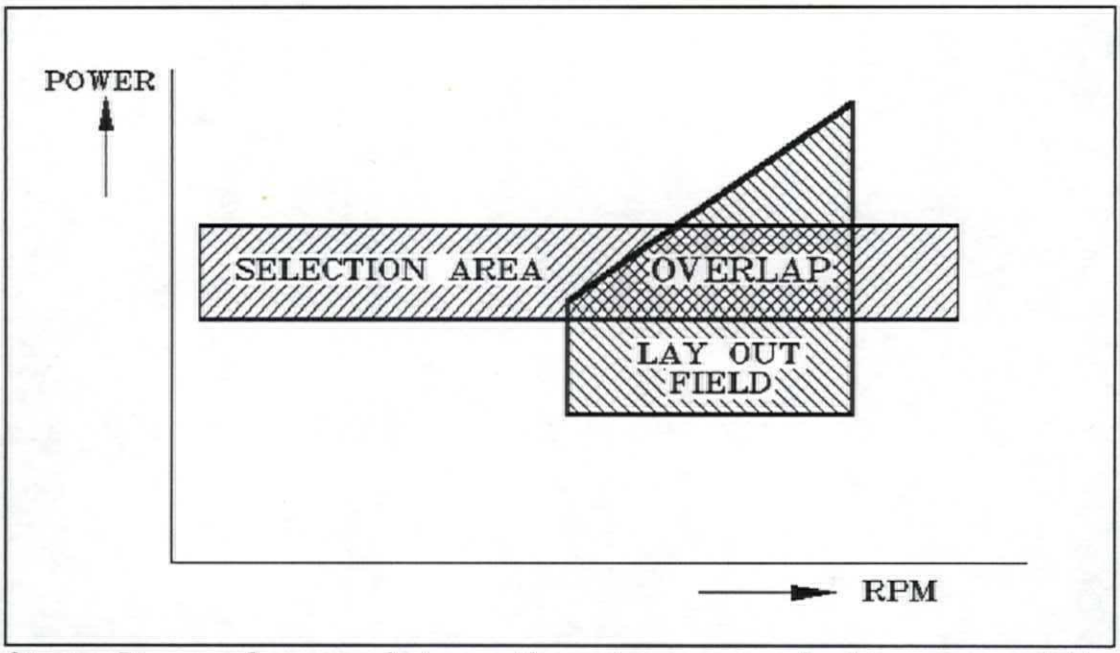

figure 7: overlap area between the prime mover selection area and the lay-out-field of a low speed diesel engine

combination. In both cases however we are dealing with the same thruster so optimization is omitted and procedure 1 will be followed) All suitable database engines will be added to a choice list. For one of the prime movers a choice is presented in example sheet 11.

Prime mover description

component:		*diesel_1*	
type	:	mcr diesel engine	
make	:	SWD	
series	:	TM410	
number of cylinders	:	9	
2 or 4 stroke	:	4	
mcr power	:	5580	kW
mcr rpm	:	600	1/min
csr power	:	5186	kW
csr rpm	:	586	1/min
engine margin	:	92.9	
csr fuel oil consumption	:	22.8	t/day

example sheet 11 : chosen prime mover description

4.3.3.5 Selection procedure 2: selection with a fixed reduction ratio between thruster and prime mover

Every database engine with an MCR point within, or an overlap area with the curved selection area (see figure 5), must be selected[1]. As in selection procedure 1 the mcr point will be chosen according to user's criterion (i.e. lowest fuel oil consumption or light weight). In the case of procedure 2 there exists a fixed reduction ratio between prime mover and thruster. This means that the power and rpm values, resulting from optimum thruster design, were distributed to the prime mover's link(s). The chosen MCR power and rpm values for a database prime mover will most likely differ from the values that were read from the prime mover's link(s), because the optimum prime mover-thruster combination was looked for. If this difference exists then additional actions are necessary. If the transmission(s) between the considered prime mover and the thruster(s) were selected already, then they have to be reset to unselected because they were dimensioned for the old power and rpm values. A re-selection has to take place for the power and rpm values resulting from this prime mover selection. The thruster (already designed) has to be redesigned for a different rpm value. The procedure for redesigning the thruster can be found in paragraph 4.3.2.2. An example of finding the optimum prime mover-thruster combination when a fixed reduction ratio exists, can be found in appendix VI.

4.3.3.6 Selection procedure 3: selection on the optimum propeller curve

The part of the propeller curve, where an engine's mcr point should be part of, is indicated in figure 6. When an engine's mcr point is lying within the rpm limits, but it's power is lying above the propeller curve, then it should also be selected. This is because it can be downrated to the power on the propeller curve. This selection procedure will seldom occur. When e.g. two prime movers are connected to the same thruster via a gearbox with prescribed reduction ratios, then both power and rpm, resulting from the optimum thruster design, are selection criteria for the prime movers. Selection procedure 2 will not be followed because two prime movers are involved.

4.3.4 Transmission Selection

For a transmission three kinds of subtypes exist at this stage of PROSEL design: gearbox, shaft and coupling. When the power and rpm at all links of an unselected transmission are known, then a selection from the database can be executed. If no choice can be made from the database then a custom made solution will be assumed.

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[1] When lay-out-field engines are concerned only engines with an overlap between the lay-out-field and the curve, resulting from applying the preferred engine margin to the csr power-rpm relation, are selected. In the future this must be extended to the selection of a point within the overlap area between lay-out-field and curved selection area.

4.3.4.1 Transmission types

The 3 transmission types that are available:

* *Gearboxes*:
  catalogue gearboxes have one or two ingoing links and only one outgoing link. In this number of links 'power-take-off's' are not included. When a gearbox doesn't meet the catalogue, type then it is assumed to be custom made.
* *Shafts*:
  shafts will be calculated according to the rules of a classification society (not implemented yet).
* *Couplings*:
  for couplings only elastic couplings are available.

For each transmission the type must be given when specifying the design demands.

4.3.4.2 Transmission efficiency

The power efficiency of a transmission must be entered by the user. Suggestions are made by the program for couplings, shafting systems and gearboxes. The user can accept the suggestion or enter his own value.

4.3.4.3 The custom made solution

If no catalogue entry could be selected from the transmission database, the user can decide whether he accepts a custom made solution. This means that the transmission acquires the 'selected' status, the reduction ratios resulting from link rpm values are filled into the reduction ratio table. The user must enter his own values for weight, cost and dimensions.

4.3.4.4 Selection procedure

The transmission selection procedure consists of a number of steps that will be described subsequently. The transmission configuration is checked, i.e. the number of in- and outgoing links are counted, the normalized reduction ratios and link power and rpm values are read, and the transmission type (paragraph 4.3.4.1) is checked. The transmission configuration will also be evaluated for transmission that were already selected. This is needed for an optimum prime mover-thruster adjustment and will be explained in paragraph 4.3.4.4.1. If not enough data are known yet then the selection will be stopped. The outcome of a successful selection can be a database choice or a custom made solution.

4.3.4.4.1 The transmission configuration

The first step in transmission selection is a configuration check. This is required for determining the validity of an optimum prime mover-thruster adjustment (prime mover selection procedure 2). The optimum adjustment remains necessary as long as no undefined reduction ratio was found in the installation (first reason, see next paragraph) and if no more then one prime mover is connected to a thruster (second reason). The configuration check is necessary for evaluating the second reason. This check consists of counting the number of ingoing and outgoing links, excluding links to PTO type components. If there are more than one in- or -outgoing links, and the transmission is of the gearbox type, then the power-rpm relation resulting from additional thruster design (paragraph 4.3.2.1.2) will be set to invalid, representing the fact that no optimum prime mover-thruster adjustment is necessary anymore.
Not only unselected transmissions will be submitted to a configuration check but also transmission that were already selected. This is done because user-predefined transmissions can have a selected status at the start of the program. If e.g. a gearbox, connecting two prime movers to the same thruster, was predefined by the user, then this gearbox, although it is already selected, must be submitted to a configuration check. In this case of two prime movers and one thruster no optimum adjustment has to be performed.
For an unselected transmission the transmission selection procedure will be continued, for an already selected one the procedure will be left at this stage. This is also the case if the transmission is unselected, a gearbox and there are more than 2 ingoing links or more than 1 outgoing link. If so then a custom made solution will be assumed and the selection procedure will be left.

4.3.4.4.2 Check the normalized reduction ratios

If the power-rpm relation is still valid (optimum prime mover-thruster adjustment is still necessary) then the reduction ratios are checked to be defined or undefined. When the reduction ratio appears to be undefined then the actions depend on the transmission type. For a shaft the reduction ratio will be set to 1. For a coupling the user will be asked to enter his own value (he can incorporate slip). For a gearbox this means that there is no fixed reduction ratio between linked thruster(s) and prime mover(s). The link power-rpm relation resulting from additional thruster design will be set to invalid for every link of the handled installation representing the fact that prime mover-thruster adjustment no longer has to take place (no prime mover selection procedure 2 has to be applied) and the optimum thruster will be chosen.

4.3.4.4.3 Reading link power and rpm values

When a database selection takes place then the link power and rpm values will be determined. These are CSR values and will be converted to MCR values. For all the transmission links the power and rpm

values have to be known. If there remains a value unknown then the procedure will be left. When there are more than one ingoing links (multiple input gearbox), then the power and rpm values for each of these links are evaluated to be equal. If an inequality exists between ingoing links then a custom made solution will be assumed (this is the procedure that is followed at this moment. It must be changed to a selection procedure based on the power and rpm values of the link having the greatest power value).
The CSR values at the ingoing links must be converted to the maximum MCR value that will occur. The power and rpm at 1 ingoing link are considered now. Among the selected prime movers the maximum engine margin is looked after. If this value exists then an MCR power and rpm value (assuming a third degree propeller curve) for the transmission is determined.

4.3.4.4.4 Gearbox selection

When a user has specified the transmission to be of gearbox type, when it is active and when all link rpm and power values are known then a database selection will take place. Only gearboxes that have a catalogue configuration (paragraph 4.3.4.4.1) can be chosen from the database. Dividing the MCR ingoing power value with the ingoing rpm value results in a performance value. This value must be adapted for the ice class that was defined with the transmission preferences. The performance value and reduction ration between ingoing and outgoing link(s), together with the user's preferences concerning make and series, are used for interpolation in the database selection diagrams (see appendix IV). Each diagram has a numerical representation, that is stored in a separate file. If a selection was successful then the gearbox make, series and number are added to the choice(s) for this transmission. An example of gearbox choice are given in example sheet 12.

Transmission description

component:	*gearbox*	
type	:	gearbox
make	:	RENK
series	:	NDS
size	:	33200
normalized rpm values		
link to diesel_1	:	100.00
link to diesel_2	:	97.95
link to shaft	:	23.48

example sheet 12 : gearbox choice description

4.3.4.4.5 Shaft selection

The selection of a shaft type transmission will be made according to the classification rules. At this moment the rules of Lloyd's register of Shipping are incorporated. A copy of these rules can be found in appendix V. The subroutine taking care of shaft selection exists, but it must be tested and built in.

4.3.4.4.6 Coupling selection

The coupling selection at this stage is limited to flexible couplings. Clutches are not yet incorporated. The selection procedure is rather straightforward. The csr power and rpm values are input. From these two data the torque can be calculated. The first coupling in a range with increasing permissible nominal torque that fulfills the torque demand, will be selected. A description of the couplings present in the database is given in appendix IV.

4.3.5 Power-take-off Selection

PTO's (power-take-offs) are not selected by PROSEL. They represent power extracted from the propulsion system. They can obtain however the 'selected' status as soon as both the link power and rpm values are known.

4.3.6 The Component Database

Components are selected from component databases. The component database consist of separate data files that can easily be edited with a text editor. A standard database package was not implemented for reasons of access speed. Direct file reading diminishes search times.
For prime movers the database consists of a large number of entries, comprising different types of diesel engines (appendix III).
For transmissions several catalogue gearboxes are present (appendix IV).
The thruster database involves a calculation module for Wageningen B-series propellers. Depending on the available data the propeller dimensions and characteristics will be calculated.

4.4 Combining Component Choices Into Installation Alternatives

For all components it will be checked whether they were just selected in the foregoing selection procedure. Alternative installations will be generated for all component choices. Depending on the component preferences and the required rpm and power values it is possible that for a certain propulsion lay-out a (large) number of different components are acceptable. For the example propulsion plant e.g. 4 different diesel engines were found to be acceptable and for the gearbox transmission there were 3 suitable options. This could lead then to 12 alternative system combinations, which all will be generated by PROSEL[2]. The procedure for a just selected component contains a number of steps:

The first step - reading the choice list for the component. If more than one choices were made, then the next step will be executed.

The second step - for every choice, an new installation description will be generated. An installation description is identified by it's installation number. The generation of a new description is done by copying the actual one and giving it a new installation number. The first choice for a component will be assigned to the actual installation, so in this case no new description will be generated.

The third step - this step is only applicable when the component is a prime mover. The csr power and rpm values belong to a specific choice made for a prime mover from the database. These values will be filled into the installation data description, the link records, after a new installation has been generated.

2 At this moment it is also possible to reduce the number of choices that were made for a certain component directly after the selection, so between selection and adjustment procedures. This is done to reduce the processing time for generation of alternative installations by omitting the non-interesting choices. A program interrupt will take place in this case. After reducing the choices, directly in the component's choice list(s), the program can be restarted.

5 Selection of interesting alternatives

With the 'composition of installation alternatives' program part all possible alternatives within the demands of the user were generated. These alternatives are gathered in the installations list. From these alternatives a selection can be made for further evaluation, the next PROSEL step. In order to make a sensible selection from the alternative installations in the installations list, a scoring and sorting option is offered. The user can choose this option, or he can directly make his selection by setting a selection flag for a selected installation. Not selected installation descriptions will be removed from the list.
For sorting a criterion is needed. This criterion is formed by a score that can be calculated for each installation. From the sorted list a selection can be made. It must be possible to sort and select from different alternative installations lists at the same time, i.e. lists belonging to different design demand packages.

Contents

5.1 Input

The input for this sorting and selection module consists of a list of installations, together with the main characteristics i.e. weight, first cost, total fuel oil consumption and maximum ship speed. Up to 5 different lists (e.g. five different design demand packages) can be handled and compared at the same time. This is preferable when the user e.g. wants to compare direct and indirect drive installation alternatives for the same ship. A list is identified by the ship name, ship version, design demand option and operational condition option as described in paragraph II, discussing the data identification.

5.2 Scoring and sorting

For sorting a criterion must exist. This criterion is calculated by a merit function. In this merit function the main installation characteristics are incorporated. The user can specify the importance of each characteristic by means of a weight factor. A score can be calculated for each installation, they can be sorted and from this sorted list the user can make his choice. The score for each installation alternative in the feasible installations list will be calculated with a merit function. The main characteristics of an installation are incorporated in this merit function. The user can specify the importance, or weight, of a specific characteristic by means of a weight factor.

5.2.1 The characteristics

The main characteristics of an installation are represented by the total weight, the total cost, the fuel oil consumption and the maximum ship speed. These characteristics were calculated during the 'building a propulsion arrangement' stage. Other characteristics can be added in the future, e.g. minimum installation length, present worth).

5.2.2 The weight factors

The importance of a characteristic in the total installation score can be specified by the user. For each characteristic there exists a weight factor, that has a value between 0.0 and 1.0. Each characteristic that must be involved in the score calculation must be given a weight factor value different from 0.0. If the characteristic has not been given a value for each installation in the list during 'building a propulsion arrangement', then the weight factor will be automatically set to 0.0. In this case the characteristic is of no importance.

5.2.3 The score

The score for each alternative installation is the result of the values of the installation characteristics together with the weight factors. The score will be calculated according to the following formula:

$$score = \sum_{i=1}^{nc} wf_i * \frac{cv_i}{cv_{i,min}}$$

nc	: number of installation characteristics
wf_i	: weight factor for characteristic 'i'
cv_i	: value for characteristic 'i'
$cv_{i,min}$	: minimum of all characteristic 'i' values

For all installation alternatives the characteristic values are scaled by dividing them by the minimum that occurs in the installation list for this characteristic. The scaled values are multiplied with the weight factors and the resulting products are added. The installation with the minimum score represents the best alternative according to the user defined criterion. In the case of maximum attainable ship speed the weight factor is set to negative because the maximum and not the minimum value is important.

5.3 Sorting procedure

The installations are sorted according to the value of the score that was calculated. A minimum score is aimed at so the installations are sorted in order of ascending scores. The resulting list will be saved together with the weight factor values. The list contains the installation number and the score.

5.4 Output

If there are more sorted lists available the user must be able to make a choice which of them he wants to see. After making this choice a sorted list of installation numbers with the corresponding scores will be sent to the screen. After examining this list the user can choose to see another list, or select an installation.

5.5 Selection of alternatives

The final goal of the PROSEL selection part is selecting interesting alternatives from all the possible ones that were generated earlier. The steps of calculating the score and sorting are help functions for making this selection. A selection can be made by indicating the name of the installation list and the number of the installation. All installations that were not selected will be removed from the list and the complete data description. The scoring and sorting mode is a help function so it must not necessarily be executed.

5.6 Data structures

As mentioned in the environment description use will be made of the installation descriptive file INSTLS (see paragraph II). Other input must be provided by hand. This input consists of menu choices and weight factors.
The first item that has to be given by the user is the name of the design demand package. The default one is the actual package that was recently processed by 'building a propulsion arrangement'.
After sorting the specified package the user will be asked if more packages must be handled. If so the name can be entered. During a selection session it is possible to sort 5 different packages (i.e. the outcome of 5 different 'building a propulsion arrangement' sessions). The 5 sorted lists are stored in memory until this selection session is left. The weight factors will be stored in memory. Thus a sorted list can be restored easily by performing a new sorting with the existing weight factors. If more than 5 packages are examined the user will be warned with the 6th package that the resulting sorted list of the first package will be overwritten.
The results from the sorting procedures can be recalled to the screen after leaving the sorting. After making a selection by entering the package name and installation number the sorting and selection module is left.

6 Detailed evaluation

The evaluation module contains the tools for studying in detail the characteristics and behavior in off-design situations of an installation. This report contains the detailed design for this module. The first part contains a description of the functions that the module must offer. The second part contains a discussion of the technical solution for these functional demands.

Contents

6.1 Description of functions

In this functional design of the installation evaluation module all the required functions are described in user terms. The program must be capable of performing the tasks that are stated in the following paragraphs. The operating situations that can be evaluated for off design conditions are the first part of the module. Subsequently economical calculations can be made and the option for positioning the installation into the engine room will be discussed, but not completely designed. The final part discusses the presentation of all the data from a generated installation that are of importance to the user. These data are generated for as well the design operating point as for a combination of different off-design operating situations.

6.1.1 Off design conditions

An important part to be evaluated is the behavior at other conditions than the design condition, the so called off-design conditions. Three kind of operating conditions can appear in PROSEL. First the behavior of an installation in a single off-design point, consisting of one specific operating situation, can be studied. Secondly the speed range from zero to maximum ship speed can be evaluated. Finally the installation can be submitted to a sequence of operating conditions in a time period, thus examining the trips that the ship will make.

6.1.1.1 Single off design point

All the following situations can be evaluated separately. Also a random combination of these options can be specified by the user. The behavior of the installation for this situation can be studied by means of the data presentations that will be described in paragraph 6.1.1.4.1.:

* Change of resistance curve
  (e.g. towing, hull fouling, change of displacement)
* Switch on/off components
  (e.g. propeller(s) trailing/stopped, prime mover(s) stopped)
* Set engine rpm or power
* Set power take off value
* Set ship speed
* Set pitch setting (c.p.p. propeller)

6.1.1.2 The speed range

Over the complete speed range of the ship, from zero (or minimum) speed to maximum speed, the installation characteristics can be determined. They will be stored in a matrix. The user will be able to explore the relations between each two of these characteristics as a function of the ship speed. The presentation of these relations will be discussed in paragraph 6.1.1.4.2.

6.1.1.3 The operational profile

The situations discussed in paragraph 6.1.1.1 offer the possibility to examine the installation behavior in a single off-design point. With PROSEL it is also possible the examine a sequence of operating conditions, thus incorporating the time factor into the evaluation. This can be done by the user by defining an operational profile. An operational profile consists of a definition of operating conditions, together with the time being spent in each of these conditions and the resistance curve that complies with the situation (e.g. full displacement, ballast). The time being spent can be given as an absolute or a relative value (percentage of total time period). Information can be made available to the user concerning bunker capacities versus operating range. Besides this information the single-operating-point data presentation as described in paragraph 6.1.1.4.1 will be given.

6.1.1.4 Evaluation results

In order to offer the user a base for making a good comparison between installation alternatives, or examining an installation's behavior, the presentation of evaluation results is split up into two parts. The first part contains the presentation of results representing the behavior of the installation in a specific operating condition. The second part deals with the representation of the behavior over a specified speed range of the ship.

6.1.1.4.1 Results for one operating condition

When an installation is defined, i.e. all the components that make part of the installation are selected, a large number of data is available. These data are of great importance to the user in order to give a good impression of the installation's characteristics. In the design stage the user can make a comparison between several solutions. He needs the data to make a sensible choice. There can be made a difference between data that are related to the installation layout and the chosen components only (e.g. first cost, weight), and the data also resulting from the operational condition. The first kind of data are constant once an installation has been completed, the other data are a function of the operational conditions. Therefore this presentation module can be used for representing the data from an installation in it's design operating point as well as for an installation in an off-design operating condition. These data are available for every generated installation.

6.1.1.4.1.1 Costs

The costs for an installation consist of two parts. First there are the costs for buying and installing the installation. The buying costs can be obtained from the manufacturers, the costs for installing are related to the component types and the layout.

These costs have to be paid once. A comparison can be made between alternatives when only these costs are concerned. Secondly there are the cost for operating the installation. They are relying on the operating condition.
At this stage of PROSEL design the maintenance costs will be omitted from this evaluation since they are relying strongly on the shipowner's ideas, so it is hard to quantify them. In the future they will certainly be added to the system.

* First cost (Not D.O.C.)
* Installation cost (Not D.O.C.)
* Fuel oil (D.O.C.)
* Lubricating oil (D.O.C.)

(D.O.C.) = depending on operational condition
(Not D.O.C.) = not depending on operational condition

6.1.1.4.1.2 Data of support systems

An overview of support system data, such as the flows, temperatures, etc, of all media through the installation components will be given. All these data are relying on the operating condition of the ship. Where applicable flows, temperatures and pressures will be given.

(all data are depending on the operational condition)

* Exhaust gas
* Fuel oil[3]
* Lubricating oil
* Combustion air
* Starting air
* Cooling media
* Radiated heat
* Heat data through heat exchangers

3 the fuel oil consumption will be based on a lower calorific value that can be specified by the user, or else on the manufacturer's default value.

6.1.1.4.1.3 Efficiencies

A presentation of the main installation efficiencies will be given. First there are the efficiencies of the prime movers. Secondly the mechanical efficiency is defined as the power value delivered to the thruster(s) divided by the total power value at the flywheel of the prime mover(s). The third main efficiency is the propulsion efficiency consisting of open water -, hull - and relative rotative efficiency for every thruster.

(all efficiencies are depending on the operational condition)

* Engine(s)
* Mechanical
* Open water * hull * relative rotative (= propulsive efficiency)

6.1.1.4.1.4 Conflict situation report

When an operating condition has been specified PROSEL will calculate the variable values that are presented in the one-operating-point data presentation. When a situation has been specified in which a component crosses the borders of it's operational capabilities, i.e. it's limits were reached, then this will be reported to the user, together with the reason for the failure. Therefore it is needed to define an internal representation of the operation capabilities of the prime mover types, the transmission types and the thruster types.

6.1.1.4.2 Results over a speed range

When the user decides to perform a more extensive evaluation of a specific installation more data can be made available. The behavior of the installation over the complete attainable ship speed range will be calculated. The data that were given in the one-operating-point-data-presentation will now be recorded as a function of the ship speed as well as the power and rpm values at all the installation's links.
It will be possible to present graphically any relation between two variables that make part of the recorded data over the ship speed range (e.g. fuel oil consumption versus ship speed, prime mover rpm versus exhaust gas temperature). The results will be plotted in a 2 dimensional graph. The results of 5 different installations can be presented at the same time so a comparison can be made between alternative installations over the ship speed range.

6.1.1.4.3 Results for operating profile

When an operating profile has been evaluated the user should want to know the data, described in paragraph 6.1.1.4.1, that rely on the operational condition. The data comprise fuel oil consumption and costs, lubricating oil consumption and costs and the required bunker capacity for the total duration of the period.

6.1.2 Economical calculations

The revenues of the ship are considered to be unknown at this stage of design. Therefore only the present worth of costs will be calculated.

6.1.3 Positioning into engine room

When components have been chosen from the database for a specific installation, then the dimensions of these components are available in the shape of box sizes (i.e. length, breadth and height). When putting together the installation it must be possible to deduct from these data the prescribed minimum length of the engine room. Therefore additional information must be available about how components contribute to the total installation length.
A further positioning in a 3-dimensional way into a model of the engine room, incorporating the ship hull shape, will be left out of the scope of PROSEL at this stage of design. The outcome of the positioning will be an overall minimum length, and a (minimum) breadth.

6.2 Technical solutions for functional demands

This chapter discusses the technical structure of the PROEVA module for evaluating an installation. The technical solutions for performing the tasks that are defined in the functional design are presented.
At this moment entering a new evaluation situation must be done by means of an editing directly in the data files. The reason is that the MARIN supplied PROINP user interface is not yet integrated with the other PROSEL parts. It can not read existing installation descriptive files and therefore e.g. a new operational condition for an existing installation for evaluation purposes can't be entered by means of PROINP.

6.2.1 Off design conditions

As described in the functional design a difference is made between a single operating point evaluation, and the evaluation of a sequence of combined operating situations, the operational profile. Of course the last option will make use of the technical solution that has been found for evaluating a single situation.

6.2.1.1 Initialization of the input data

Before an off-design evaluation can be performed, the data description resulting from the PROSEL composition part as described in chapter 4 has to be initialized. When reading the file data into the files, that are described in appendix II, the initialization actions that will be performed on the data will be handled subsequently:

SHPDAT:	ship dimensions, ship speed, resistance data, sea margin; file will be read unchanged
CMPNTS:	component identification, active flag; all components are set to be active
CMPLNK:	numbers of linked components, power and rpm values; all power and rpm values will be set to undefined
PMCHDS:	database choice for prime mover(s); file will be read unchanged
THRPDS:	database choice for thruster(s); file will be read unchanged
TRANDS:	database choice for transmission(s); file will be read unchanged
TRNMRR:	reduction ratio(s) for transmission(s); file will be read unchanged

6.2.1.2 Single operating point situation

For the single off-design situation the sequence of input, throughput and output will be handled subsequently.

6.2.1.2.1 Input specification

For specifying the operational condition to be evaluated the user can now specify his specific demands by changing the initialized data files. The actions that have to be performed on the input data in order to obtain the situations that were discussed in the functional design (paragraph 6.1.1.1) will be handled subsequently. Of course the user can specify any combination of input data. When conflicting information was given, the system will detect and report it to the user. This will be done the same way as with the alternative generation module. (for a description of the data files, indicated with their names in capitals, see paragraph II

* Change resistance curve:	enter desired resistance curve data in SHPDAT
* Switch on/off components:	set activity flags in CMPNTS to true/false[4]
* Set engine rpm or power:	set rpm and/or power values in CMPLNK
* Set power take off value:	set rpm and/or power values in CMPLNK
* Set ship speed:	set ship speed in SHPDAT
* Set pitch setting:	set P/D relation in THRPDS

[4] Inactive thruster: An inactive thruster can be specified to be trailing or stopped. This will be incorporated by two separate modules. For the stopped propeller a subroutine will be added. For the trailing propeller in a forward speed condition the B-series K_t-K_q-J diagrams will be taken. For the situations that propeller rotation direction and ship speed are conflicting the MARIN C_t diagrams will be used.

After having specified the operational condition the data describing this condition will be stored. The user will be asked to supply a name for identification purposes. For an installation a directory will be kept for the different operational condition specifications. The user defined name will be the identifier for the operational condition.

6.2.1.2.2 Throughput

This phase of the evaluation part will deal with the translation of input data to output data i.e. installation behavior. There will be made use of program parts from the alternative generator e.g. when transferring power and rpm values through components via links, use can be made of the link variable distribution module.
The most important part of the evaluation module consists of translating the power and rpm values into the data that describe the behavior of a component. The behavior of the components in it's turn will determine the behavior of the total installation.

6.2.1.2.2.1 Algorithm structure

The main goal of the evaluation is representing the installation behavior. Therefore the behavior of the components has to be described. Per component type this description will contain different descriptive parameters. A prime mover can be described by e.g. the fuel oil consumption, exhaust gas temperature and flow, the radiated heat etc., a thruster can operate whilst cavitating, for a shaft the torque can become too big, etc.
For each component type (prime mover, transmission, thruster and power take off) a routine has to be developed, that will translate the rpm and power value(s) at it's link(s) into values for the behavior descriptive variables.
A routine has also to be invoked to transfer the power and rpm values, resulting from a specific operating condition, over the installation. Use can be made of the link variable distribution module (see paragraph 4.2). Therefore this module doesn't have to be changed.
The data structure will be the same as for the alternative generator, so the same file reading and writing routines can be used.
The main algorithm structure can be represented by figure 8.

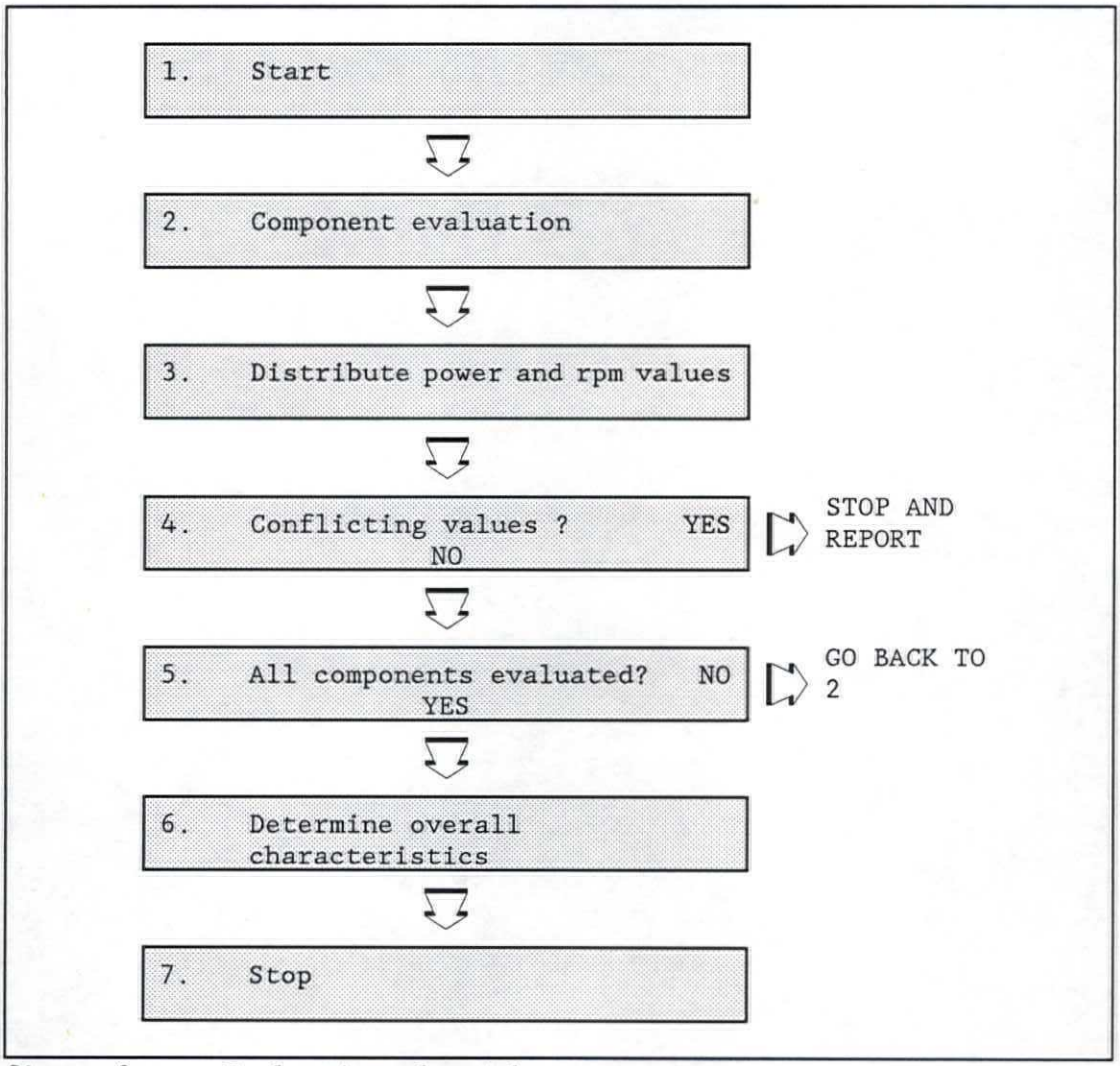

figure 8: Evaluation algorithm structure

If the link rpm and power values at a component's link(s) are known then, for prime mover, transmission and pto type components, a component evaluation takes place. Rpm and power are converted into component characteristics. For a thruster type component the evaluation procedure is a little bit different. In this case power and rpm values at the shaft side don't have to be known but can result from e.g. a prescribed thrust or speed. If, after this component evaluation, not all components appear to be handled yet, because not all power and/or rpm values at the links were known, then a power and rpm distribution will be executed. After this distribution an evaluation will take place for the components that were not evaluated yet. Now all components should be done and the loop can be left. The overall installation characteristics can be gathered from the separate component values e.g. total fuel oil consumption.

6.2.1.2.2.2 Prime mover evaluation

For prime movers the evaluation module will be restricted to diesel engines. The behavior of a diesel engine can only be described when it's characteristics are known as a function of power and rpm that are being delivered. Power and rpm are the input variables that both must be known for calculation of the diesel engine behavior. The parameters that are chosen to describe this behavior are (n.i.y. = not implemented yet):

Input:
- Power to be delivered (kW)
- Shaft rpm (1/min)
- Prime mover description
- Lower calorific value of fuel oil (default present)

Output:
- Fuel oil consumption
- Lubrication oil consumption
- Exhaust gas temperature (only some mcr engines)
- Exhaust gas flow (only some mcr engines)
- Cooling media temperatures (n.i.y.)
- Cooling media flows (n.i.y.)
- Combustion air temperatures (n.i.y.)
- Combustion air flows (n.i.y.)
- Radiated heat (n.i.y.)
- Heat data for heat exchangers (n.i.y.)
- Position in operating field

For representing the operating condition of the engine, percentage values of the mcr power and rpm values can be used. For giving more detailed information to the user
the position of the operating point in the operating field of the diesel engine will be given. By means of the position the operation mode for the prime mover can be characterized. This will be done with a text description now, a future expansion will be a graphical output of operating field and point.

6.2.1.2.2.3 Thruster evaluation

The thruster evaluation comprises two steps. The first step is a calculation of thruster performance over a speed range from zero to a specified ship speed value. An evaluation of propeller characteristics can be executed using the results of the performance calculation.

6.2.1.2.2.3.1 The performance module

The thruster performance module as supplied by MARIN will be used. With this module the thruster characteristics can be determined over a ship speed range. Input data are speed, a propeller description, a ship description and a description of the operational condition. The output will consist of performance parameters as a function of the speed, over the specified speed range. For fixed pitch screw type propellers the relations are unique. In case of a controllable pitch propeller the pitch value must be set by the user, because the characteristics can only be calculated for a given pitch setting. For determining the characteristics of controllable pitch type propellers an approximation will be made using the Wageningen B-series description.

Input for performance module:
* Maximum speed for performance calculation (m/s)
* Ship data:
    - Length on waterline (m)
    - Draught at forward PP (m)
    - Prismatic coefficient based on LWL
    - Moulded breadth (m)
    - Mean draught (m)
* Operational condition:
    - Draught at aft PP (m)
    - Operating speed (m/s)
* Propeller description:
    - Propeller diameter (m)
    - Clearance of propeller with keel plane (m)
    - Number of propeller blades
    - Relative rotative efficiency
    - Blade area ratio of propeller
    - Number of propellers
    - Pitch/diameter ratio

Output from performance module as a function of ship speed:
- revolution rate (1/min)
- effective power (kW)
- thrust (kN)
- open water efficiency
- relative rotative efficiency
- hull efficiency
- shaft power (kW)
- ship speed (m/s)

- power increase due to cavitation (if any)
- rpm increase due to cavitation (if any)

6.2.1.2.2.3.2 The evaluation module

Input for thruster evaluation must at least be one of the following items: thrust, speed, shaft rpm or shaft power. For each one of these values the corresponding values can be interpolated from the output relations that result from the thruster performance calculation. So when only one of the above values is given, the others can be deduced. When more input values were explicitly defined, conflicting values can occur, resulting in an error situation:
- If the rpm value was set, then the ship speed can be calculated. If this was also set then the 'calculated' and 'set' values will be compared. An inequality will result in a program stop with an error message.
- If the speed was set by the user then with this speed the propeller shaft power and the thrust can be determined.
- If the power was set by the user then 'set' and 'calculated' values will be compared. If a set value exceeds a calculated value, then the superfluous power amount will be output to the user. If the set value is smaller than the calculated value then an error situation occurs and the program will be stopped with an appropriate message.
- The same procedure as for the power will be followed when thrust has been explicitly defined. If the calculated thrust exceeds the specified thrust then the superfluous thrust value will be reported to the user, if not then an error occurs and the program will stop.

6.2.1.2.2.4 Transmission evaluation

For a transmission the total power that is going through from ingoing link(s) to outgoing link(s) will be compared to the torque for which the transmission was designed. This will be translated into an over/underload percentage. The same will be done for the rpm value(s). When and overload condition was met a warning will be presented to the user.

6.2.1.2.2.5 Power take off evaluation

At this stage of design no evaluation of a power take off is needed. The power going to the pto with the corresponding rpm value will be presented.

6.2.1.2.2.6 Operating capabilities representation

For each of the PROSEL component types a representation must be defined of the operating capabilities. For prime mover, transmission

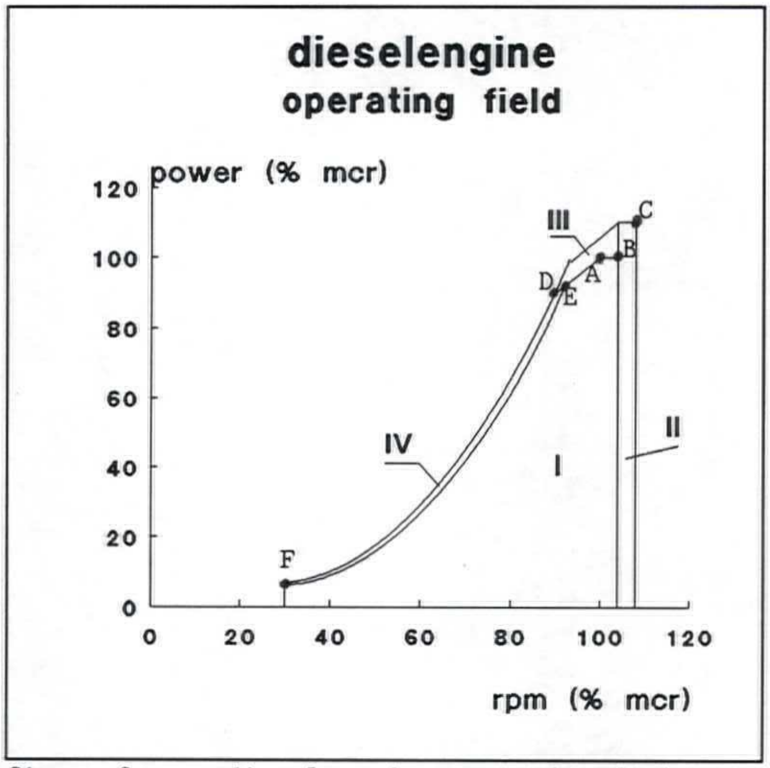

figure 9: diesel engine operating field

and thruster this will be done. For pto components no specification will be made. When prime movers are concerned only the diesel engine will be handled now. In the future other prime mover types will be given. The operating field of a diesel engine has an outline as shown in figure 9. The area can be represented by the points A-F and the curves between them. 4 areas are defined by these lines, each of them representing a load condition. The areas are marked I-IV. The area definition:

I	:	normal operating range
II	:	operating range with overspeed from only for sea trail
III	:	overload range, only for short periods
IV	:	operating range with time limit

The point definition is depending on the engine's manufacturer. The points A-E are represented in the database as a percentage of mcr power and rpm. For point F only the percentage of mcr rpm is given (minimum engine rpm). The line EA and the line through D are both lines of constant torque. The horizontal line through C is a line of constant power. The lines FE and FD are represented by the equation

$$Power = coeff \times Rpm^{exp}$$

The exponent value is given in the database. It's value is lying between 1 and 3, depending on the manufacturer. The coefficient will be calculated by the program. For the low power regions of the diagram it may be needed to define a more accurate description of the operating capabilities. Due to time limitations for this project this was not executed.

For transmission type components the operating capabilities can be represented by the maximum torque and rpm per link.
For thruster type components a maximum rpm value will be given. A cavitation calculation is directly incorporated in the thruster performance calculation as described in paragraph 6.2.1.2.2.3.1.

6.2.1.2.3 Output

The output from the single operating condition evaluation will be the results as described in the functional design. The resulting costs and efficiencies are discussed in the next paragraphs, a discussion of the other results will be omitted because they are rather straightforward.

6.2.1.2.3.1 Costs

When prime movers are concerned the costs depending on the operational condition are fuel oil and lubricating oil costs. These values can be calculated by determining the oil consumption multiplied with the oil price. The oil consumption modules are available from the alternative generation module. The user must specify the oil prices and lower calorific value[5]. If this last value was not given then a default manufacturer supplied value will be taken. Prime mover first costs can be read from the database (if supplied by the manufacturer).
Thruster first costs are calculated with a MARIN supplied subroutine as a function of material and weight. Prices per ton material must be given in the user's personal database.
The same will be the case for shaft first costs.
If no database gearbox was available then the user must enter his own values.

6.2.1.2.3.2 Data of support systems

The heat and flow data of support systems will be read from the prime mover database, and the actual values will be interpolated, depending on the operating load of the prime mover (% of mcr power and rpm).

6.2.1.2.3.3 Efficiencies

The prime mover efficiencies can be calculated by means of the relation:

---

5 The user can create his own personal database for prime movers, gearboxes, couplings, prices and fuel oil qualities (lower calorific values).

$$\eta_p = \frac{P_b}{H_o \cdot \phi_{mb}}$$

P_b = effective power (kW)
η_p = prime mover efficiency
H_o = lower calorific value (kJ/kg)
ϕ_{mb} = fuel oil consumption (kg/s)

This efficiency can be given for each prime mover in the installation. The mechanical efficiency is the product of the transmission efficiencies. The propulsive efficiency will be calculated for every thruster:

$$\eta_p = \eta_o \cdot \eta_h \cdot \eta_r$$

η_p = propulsive efficiency
η_o = open water efficiency
η_h = hull efficiency
η_r = relative rotative efficiency

$$\eta_h = \frac{1-t}{1-w}$$

t = thrust deduction
w = wake fraction

Wake fraction and thrust deduction factor are results from thruster design. The relative rotative efficiency is a result of user specification or else it is set to a default value of 1. The open water efficiency is a result from thruster performance calculations in the PERFRM module. Superfluous power or thrust values as described in paragraph 6.2.1.2.2.3.2. will also be given.

6.2.1.3 Speed range

The user will be offered the possibility to evaluate the installation's behavior over the entire speed range of the ship. All installation characteristics, as calculated for a single operating point condition, will be available as a function of the ship speed.

6.2.1.3.1 Input

After selection of this evaluation option by the user, the input files will be initialized (see paragraph 6.2.1.1). Now the user will be able, by means of the design demand specification module, to define the operating condition by setting the following options:

* Change resistance curve: enter desired resistance curve data in SHPDAT
* Switch on/off components: set activity flags in CMPNTS to true/false
* Set power take off value: set pto power for specific rpm and character of pto behavior[6]
* Set pitch setting: set P/D relation in THRPDS for each thruster
* Give bunker capacity or operational range

For this specified operational condition the speed range will be evaluated. This condition can be saved with a user defined identifier. Instead of explicitly defining an operating condition, also a description can be loaded from the operating condition directory, if not empty.

6.2.1.3.2 Throughput

The procedure that will be followed is different from the one that was followed for the single operating point situation. The speed is considered as being the input, the installation characteristics are output. The speed range will be divided into 10 discrete and equally spaced speed values. For each of these 10 values the installation characteristics will be calculated and recorded.
In order to obtain these values first a thruster performance calculation, as described in paragraph 6.2.1.2.2.3.1, that covers the complete ship speed range, will now be performed. For each one of the 10 discrete speed values the corresponding thruster shaft power and rpm values are determined. These values will be distributed over the installation. After distribution the power and rpm values at all the installation's links are known so for each component other than a thruster (already done during thruster performance calculation) an evaluation will be performed. These evaluations were described in paragraph 6.2.1.2.2.2 (prime mover) and 6.2.1.2.2.4 (transmission). All characteristics are stored as rows in a matrix. One of these rows is the ship speed. The rows of the matrix contain the following data values:

---

6 The pto behavior can be described by one of the following options:
- Constant : power does not vary with rpm
- Linear : power = constant * rpm
- Square : power = constant * rpm^2
- Third-grade : power = constant * rpm^3

- ship speed
- every link rpm
- every link power
- characteristics for each component
- characteristics for the installation

A row is being built up from a character field together with 10 fields containing the values of the variable that comply with the concerning 10 ship speed values.

Table 1: result storage matrix

owner identifier	variable identifier	value 1	.....	value 10
ship	speed	0	.....	v_{max}
diesel 1	fuel oil cons.	0	.....	43.3
diesel 1, gearbox 1	link rpm	0	.....	750
thruster 3	pitch	0	.....	1.2

The character field is built up from a row type specifier (speed, link rpm, link power, fuel oil consumption, exhaust gas temperature etc.) together with an identity for the link or a component to which the characteristic value belongs. The link identity can be defined by the two identities of the components that make part of the link, a component identity consists of a component name, given to it by the user in the PROSEL input phase.
This characteristics matrix will be used for output presentation. After ending the evaluation session the matrix will be stored on disk and it will be given an identity that is built up from the ship identity, the installation version, the installation number and an identifier for the operational condition description.

6.2.1.3.3 Output[7]

After completing the component evaluations the user can display in a two dimensional graph any two rows out of the characteristics matrix. To offer the user the possibility of comparing different installation alternatives for the same ship, the same characteristic can be displayed for up to 5 different installation alternatives at the same time. For each alternative a characteristics matrix must be available. An installation alternative can be specified by giving the installation version and number.

[7]: At this moment the graphical output is not available yet. This module will be added to PROSEL in the beginning of 1991.

A representation of the same characteristic for five different installations alternatives can be displayed at the same time using the same axes.
The drawing procedures comprise:

- the drawing of the axes
- automatic scaling of the axes
- writing of the corresponding labels
- writing a caption
- drawing a smooth line through the 10 specified matrix points, offering a different line type for each alternative installation
- drawing a legend for each line
- cleaning the screen

Other results that will become available are the operating range and the bunker capacity. One of these can be calculated as a function of ship speed when the other one was given. This relation can also be presented graphically.

Besides the graphical output the user can ask for a numerical representation of an item in a matrix row. Values can be interpolated e.g. if the user wishes to know the lubrication oil consumption of his main engine at a certain ship speed than he has to:
- identify the independent variable (ship speed)
- identify the dependent variable (lube oil consumption)
- give the independent variable value (speed value)

The program will look up the corresponding rows of the matrix, and interpolate the requested value. The results of these questions will be written to a report file. This value interpolation module is not available yet.

6.2.1.4 Operational profile

With the operational profile option a combination of operating conditions can be evaluated by the user. Thus the behavior of an installation in a period of time, representing e.g. a sailing route, can be studied.

6.2.1.4.1 Input

The input specification that will be needed for evaluating an operational profile comprises the following steps:

- number of operating conditions
- total time duration (optional)
- operating conditions specification

For each operating condition:

* Give time duration:	(percentage of total time or absolute value; percentage if absolute total time duration was given)
* Change resistance curve:	enter desired resistance curve data in SHPDAT
* Switch on/off components:	set activity flags in CMPNTS to true/false
* Set power take off value:	set rpm and/or power values in CMPLNK
* Set ship speed:	set ship speed in SHPDAT
* Set pitch setting:	set P/D relation in THRPDS for each thruster

The operating condition can be saved with a user defined name. Instead of explicitly defining an operating condition, also a description can be loaded from and existing operating condition, if not empty.

6.2.1.4.2 Throughput

The algorithm of the single operating condition evaluation will be executed several times, once for every different operational condition in the profile. Therefore the first thing that has to be determined is the number of different operational conditions. The specification of an operational condition has been defined in paragraph 6.2.1.4.1. All items will be checked.
The installation characteristics as described in the following output paragraph will be calculated in the same way as for the single operating condition. By multiplying these values by the time being spent in the condition, the output values can be deduced.

6.2.1.4.3 Output

The fuel oil and lubricating oil consumption (operating range evaluation as described in the functional design in paragraph 6.1.1.4.3) will be calculated for each different operating condition with the already available modules. The oil costs can be determined as described in the single operating point evaluation in paragraph 6.2.1.2.3. (not implemented yet) The total values over the operating range can then be found by multiplying the found values per operating condition with the time spent in the condition, and summing up these results. The required bunker capacity will be found by determining the total fuel oil consumption during the time period.

6.2.2 Economical calculations[8]

As an economical criterium the present worth will be calculated for the total costs of the installation. In the future a more extensive module could be added. Since this kind of calculations are rather widespread it must be possible to adopt an existing version, instead of making a new one.

6.2.3 Positioning into engine room

For determining the engine room length the user will be presented an installation overall length. Some additional information must be given to the program. The user has to indicate whether a component contributes to the overall length. The length values of these component as being read from the database will be added, thus making possible a comparison between alternatives.
In the same way the installation breadth can be determined. In this case the user has to supply some additional information about the lateral distances between components. These distances will be added to the sum of contributing components breadths resulting in an overall minimum breadth indication.
The length and breadth that were determined in this way should only be used as indication figures. This is an intermediate solution because an interactive graphical 3-dimensional positioning module will be added in the future. In the installation descriptive files it can be indicated by the user for each component whether it contributes to the overall length or breadth but the module using these data is not yet implemented.

[8]: this part is not yet available

7 Final selection

With the detailed evaluation the user is offered a set of tools to provide a good inside in an installation alternative's behavior and characteristics. By comparing the results of the different installations for the evaluations that were executed he must decide himself which installation he wants to adopt. This part of the design sequence is not a separate program part, but the result of the former steps.

8 Integrated System Design

In a propulsion installation many inter-relations exist between the mentioned systems. A few examples of the inter-relations are:
- the exhaust gases of a diesel engine can be used to generate steam, for a turbo generator, affecting the design of the power supply system
- the diesel engine scavenge air can be used to preheat the feedwater
- the diesel engine determines the lay-out and capacities of pumps, coolers and other equipment of the auxiliary systems

The connections between the different systems are represented by the components that are shared; e.g. the engine is a component in the heating system, as a heat source, and in the propulsion system as a source of mechanical energy. The amount of heat in the exhaust gases is an input value for the design of the heating system. Integration of the design of the separate systems will be achieved a.o. by giving access to other system's data descriptions. In this way the required system design input data can be collected from the same database. When certain data are not available the program will ask the user or will suggest default settings.

9 Future extensions

In this report the composition and evaluation of propulsion installations is discussed. In order to let PROSEL be an integrated design system, modules for designing the electrical, exhaust gas heat and auxiliary systems should be added.
For the propulsion installation design program as it exists at this moment the following points must be added:

prime movers

- The lay-out-field diesel engines are only partly represented in the database, because priority was given to mcr type engines. This means that this type of engine can be selected, but not all the engines characteristics can be determined. Exhaust gas flow and temperature are not calculated.
- The gasturbine type prime mover is not implemented at all.
- Prime mover selection procedure 2 is not using the minimum and maximum engine margins, only the preferred engine margin. An extension must be made to a similar procedure as used in selection procedure 1.
- Prime mover selection procedure 2, using the preferred engine margin, evaluates only the intersection points of the lay-out-field borders and the power-rpm selection curve. A routine must be developed for finding the optimum (fuel oil consumption / light weight) point along the total part of the curve lying within the lay-out-field.

thrusters

- The waterjet type thruster is not implemented.
- For the Wageningen Ka series the K_t-K_q-J polynomials must be inserted. An electrical transmission type must also be designed in order to make it possible to design e.g. a diesel-electric propulsion installation.
- distribution and calculation of thrust to be delivered to each thruster (incorporating resulting thrust) before thruster design
- What the thruster design module is concerned, not the maximum efficiency is gathered from the calculation algorithm. More data are generated than used. This problem will be solved by MARIN.
- The modules for evaluation of a stopped and a trailing propeller are available but they must be added.

transmissions

- The gearbox selection module doesn't remember yet the link power and rpm values resulting from a former composition step. This is important when e.g. designing a codog installation with gasturbines and diesel engines connected to the same gearbox. In this case the first step to do is designing the installation for gasturbine operation, with the diesel engines set inactive. The gearbox can not be selected because it has inactive links (to the diesels). The second step is redesigning the installation for diesel operation. Now the gasturbines are inactive. PROSEL should now not erase the link power and rpm values from the inactive gearbox links, but it should use them for selection. This is not yet implemented at this moment.

- The shaft selection module is already available (MARIN) but it must be tested and implemented

execution speed
- An aspect that must be paid attention to is the execution speed of the program. Data file access and reading, plus a non optimal use of the thruster design module, make the program more slow than needed. A solution for this problem, reading the installation descriptive files into memory, must be added.

user interface
- The user interface program PROINP must be extended to reading and writing the same packed storage files as the other PROSEL program parts. At this moment only a new set of files can be generated. These files are not packed into a storage file by PROINP. Also storage of the 4 resistance curves that can be defined with the ship data, must be integrated in the PROSEL data structure (At this moment they are stored in a temporary PROINP dump file).
- Graphical interface. For the input of the design demands another module must be added. At the moment all data are being entered numerically via the keyboard. This interface must be replaced with a graphical oriented user interface. The installation layout can be defined by placing icons into an installation field. Pop-up menus can be used for entering numerical information. A graphic interface is currently being developed for the cooling water system, and this will be adjusted for use with the propulsion installation.
- PTO preference specification must be implemented.

evaluation module
- A module for initialization of the installation descriptive files must be added.
- A graphical representation of the evaluation speed range result matrix must be made and implemented. This is also the case for a module interpolating these results.
- An economical evaluation, incorporating the calculation of the present worth, must be made and implemented.

cooling water system
- The cooling water system design module together with it's interface are planned to be ready in may 1991.

exhaust gas utilization module
- The exhaust gas utilization module was made by E.Rost of HTS Haarlem. It became available in 1990. The module has to be implemented in PROSEL.

10 Conclusion

With PROSEL it is possible now to generate a large number of alternative propulsion systems for a given set of requirements. The evaluation tools enable to select the most optimal plant, from a technical and economical viewpoint. The modules for waste-heat-utilization, electric power supply and auxiliary systems will enable in the future an integrated system design and a thorough evaluation of system alternatives.

11 Terminology

Continuous service rating :
the power-rpm point for which the engine is chosen to operate continuously during service condition

Engine margin :
the ratio between csr power and mcr power of a prime mover, specifying the design operation load

Father-son arrangement:
propulsion installation with two prime movers, that can often be found on e.g. trawlers; both engines operating for transfer speed to and from the harbor to the fishing grounds, one engine operating when trawling

Lay-out-field :
a field in the power-rpm diagram that represents the possible mcr point range. This field is found with low speed 2 stroke diesel engines.

LOF :
Lay-out-field

Maximum continuous rating :
the maximum power-rpm point in the rpm-power field for which a diesel engine is designed to operate continuously

Sea margin :
the ratio between power to be delivered in service condition and power to be delivered during trial condition
or:
the ratio between ship's resistance in service condition and that resistance in trial condition

REFERENCES

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[3] J. Klein Woud, Maritieme Werktuigkunde I (Delft, 1988)

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PROSEL
propulsion installation selection
ir C.C.P.J.M. Landa
dec 1990
Appendices
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APPENDIX I:	Subroutine structure
APPENDIX II:	Data file description
APPENDIX III:	Prime mover database
APPENDIX IV:	Transmission database
APPENDIX V:	Lloyd's rules for shaft dimensioning
APPENDIX VI:	Optimum prime mover-thruster adjustment with a fixed reduction ratio
APPENDIX VII:	Global design report (added separately, this is and unchanged edition since it's appearance at the start of the project; it is added to give some insight in the objectives at the start of the program development)
APPENDIX VIII:	User interface detailed design report (concept version, added separately)
APPENDIX IX:	Program listing (available at office prof. J. Klein Woud)

APPENDIX I: Subroutine structure

In this appendix the PROSEL subroutine structure is represented in the shape of a tree. PROSEL consists of 4 main program parts:
- PROINP: design demand specification
- PROBLD: composition of installation alternatives
- SELSOR: sorting and selecting interesting alternatives
- PROEVA: installation evaluation

Also 2 presentation parts, PRESENT and PRESSHT are available for presenting the resulting installation descriptions from PROBLD to the screen. These parts however are not interfaced yet to the PROBLD screen layout yet, and are rather separate programs. Therefore they are not further discussed.
PROINP is a MARIN manufactured program. No structural details are incorporated in this report. SELSOR has a very simple program structure. Therefore a description of this structure is omitted.
For both PROBLD and PROEVA the tree structure is given in this appendix. The names in the tree are the names of the subroutines. Reading from the left to the right, the right name is the subroutine being called by the left subroutine.
PROBLD, as can be seen in the scheme, has a structure, going 6 levels deep. The main PROBLD parts, DISTRI, SELECT and ADJUST (see chapter 4.1), can be found in the first level.
From the start of development it was chosen to make an extensive documentation in the listing of each subroutine's source code, describing all the features. Therefore the description of each subroutines task can be found in these listings, available at prof. J. Klein Woud's office.

PROSEL - composition of installation alternatives

```
PROBLD──┬─SCRINI
        ├─MAISCR──┬─PRILIN
        │         └─GETTIM
        ├─SCRENO────PRILIN
        ├─GETTIM
        ├─INITIA──┬─SCRENO────PRILIN
        │         ├─SELSHP
        │         ├─SELINS
        │         ├─SELCOM
        │         ├─SELLNK
        │         ├─SELTRA
        │         ├─SELTHC
        │         ├─SELTRR
        │         ├─SELPMC
        │         ├─SELPRO
        │         └─WRILRC
        ├─SELINS
        ├─SELECT──┬─SCRENO────PRILIN
        │         ├─SELCOM
        │         ├─PRMSEL──┬─SELLNK
        │         │         ├─WRILNK
        │         │         ├─SCRENO────PRILIN
        │         │         ├─CSRDED──┬─SELLNK
        │         │         │         └─SELCOM
        │         │         ├─SELPMP
        │         │         ├─PREPMP──┬─SELPMP
        │         │         │         ├─REFRSH────PRILIN
        │         │         │         ├─PRILIN
        │         │         │         └─CONTIN────PRILIN
        │         │         ├─PMFIT1──┬─SCRENO────PRILIN
        │         │         │         ├─SELMCR
        │         │         │         ├─SELPMG
        │         │         │         ├─PRMPRE──┬─SELPMP
        │         │         │         │         ├─REFRSH────PRILIN
        │         │         │         │         ├─PRILIN
        │         │         │         │         └─WRIPMP
        │         │         │         ├─FOCDET──┬─SELPMG
        │         │         │         │         ├─SELMCR
        │         │         │         │         ├─SELFC1
        │         │         │         │         ├─SELFP1
        │         │         │         │         ├─SELFC2
        │         │         │         │         └─SELFP2
        │         │         │         └─ADDPMC──┬─SELPMC
        │         │         │                   ├─EXHDET──┬─SELPMG
        │         │         │                   │         ├─SELMCR
        │         │         │                   │         └─SELEX2
        │         │         │                   ├─WRIPMC
        │         │         │                   ├─SELCOM
        │         │         │                   └─WRICOM
        │         │         ├─PMFIT2──┬─SCRENO────PRILIN
        │         │         │         ├─SPLINE
        │         │         │         ├─SELMCR
        │         │         │         ├─SELPMG
        │         │         │         ├─PRMPRE──┬─SELPMP
        │         │         │         │         ├─REFRSH────PRILIN
        │         │         │         │         ├─PRILIN
        │         │         │         │         └─WRIPMP
        │         │         │         ├─VOHINT
        │         │         │         ├─FOCDET──┬─SELPMG
        │         │         │         │         ├─SELMCR
        │         │         │         │         │
```

```
|    |    |    |    |--SELFC1
|    |    |    |    |--SELFP1
|    |    |    |    |--SELFC2
|    |    |    |    |--SELFP2
|    |    |    |--ADDPMC----SELPMC
|    |    |    |    |--EXHDET----SELPMG
|    |    |    |    |    |--SELMCR
|    |    |    |    |    `--SELEX2
|    |    |    |    |--WRIPMC
|    |    |    |    |--SELCOM
|    |    |    |    `--WRICOM
|    |    |    `--LINSPL----SPLIN1
|    |    |--PMFIT3----SCRENO----PRILIN
|    |    |    |--PRILIN
|    |    |    |--REFRSH----PRILIN
|    |    |    |--SELMCR
|    |    |    |--SELPMG
|    |    |    |--PRMPRE----SELPMP
|    |    |    |    |--REFRSH----PRILIN
|    |    |    |    |--PRILIN
|    |    |    |    `--WRIPMP
|    |    |    |--FOCDET----SELPMG
|    |    |    |    |--SELMCR
|    |    |    |    |--SELFC1
|    |    |    |    |--SELFP1
|    |    |    |    |--SELFC2
|    |    |    |    `--SELFP2
|    |    |    `--ADDPMC----SELPMC
|    |    |         |--EXHDET----SELPMG
|    |    |         |    |--SELMCR
|    |    |         |    `--SELEX2
|    |    |         |--WRIPMC
|    |    |         |--SELCOM
|    |    |         `--WRICOM
|    |    |--ADDPMC----PREDBN----PRILIN
|    |    |    |--SELPMC
|    |    |    |--EXHDET----SELPMG
|    |    |    |    |--SELMCR
|    |    |    |    `--SELEX2
|    |    |    |--WRIPMC
|    |    |    |--SELCOM
|    |    |    `--WRICOM
|    |    `--ERADBN----PRILIN
|    |--TRASEL----SCRENO----PRILIN
|    |    |--SELTRP
|    |    |--SELLNK
|    |    |--WRILNK
|    |    |--SELTRR
|    |    |--SELCOM
|    |    |--SELTRA
|    |    |--WRITRA
|    |    |--EFFDET----PRILIN
|    |    |    |--REFRSH----PRILIN
|    |    |    `--CONTIN----PRILIN
|    |    |--PRETRP----SELTRP
|    |    |    |--REFRSH----PRILIN
|    |    |    |--PRILIN
|    |    |    `--CONTIN----PRILIN
|    |    |--ADDTRM----SELTRA
|    |    |    |--WRITRA
```

```
│         │         │         ├─ADJRAS─────┬─SELLNK
│         │         │         │            ├─SELTRA
│         │         │         │            └─WRITRA
│         │         │         ├─SELCOM
│         │         │         └─WRICOM
│         │         ├─MAXMMA────┬─SELCOM
│         │         │           └─SELPMC
│         │         ├─ADJRAS────┬─SELLNK
│         │         │           ├─SELTRA
│         │         │           └─WRITRA
│         │         ├─TRSCR1────┬─REFRSH──────PRILIN
│         │         │           ├─PRILIN
│         │         │           └─YESNO───────PRILIN
│         │         └─WRICOM
│         ├─THRSEL──┬─SELTHC
│         │         ├─THRNEW────┬─SELLNK
│         │         │           ├─SELTHC
│         │         │           ├─SCRENO──────PRILIN
│         │         │           ├─SELPRO
│         │         │           ├─SPLINE──────SPLIN1
│         │         │           ├─VOHINT
│         │         │           ├─PSTHPS──────THDT
│         │         │           ├─PSWAPS──────WAK
│         │         │           ├─APWPPS──────INTPOL
│         │         │           └─WRITHC
│         │         ├─THRPFV────┬─SELTHC
│         │         │           ├─SELTHP
│         │         │           └─BSERI
│         │         ├─SELLNK
│         │         ├─WRILNK
│         │         ├─SCRENO──────PRILIN
│         │         ├─SELTHP
│         │         ├─SELCOM
│         │         ├─TRSCR1────┬─REFRSH──────PRILIN
│         │         │           ├─PRILIN
│         │         │           └─YESNO───────PRILIN
│         │         ├─PRETHP
│         │         ├─SELPRP────┬─GRDPRP────┬─PSTHPS──────THDT
│         │         │           │           ├─PSWAPS──────WAK
│         │         │           │           ├─KELBAR
│         │         │           │           ├─BSERI
│         │         │           │           └─INTPOL
│         │         │           └─WRERR─────┬─SCRENO──────PRILIN
│         │         │                       └─CONTIN──────PRILIN
│         │         ├─CONTIN──────PRILIN
│         │         ├─WRIPRO
│         │         ├─APWPPS──────INTPOL
│         │         ├─WRITHC
│         │         ├─SELPRO
│         │         ├─SELCOM
│         │         └─WRICOM
│         ├─PTOSEL──┬─SCRENO──────PRILIN
│         │         ├─SELCOM
│         │         └─WRICOM
│         └─SELSCR──┬─REFRSH──────PRILIN
│                   ├─SELCOM
│                   ├─PRILIN
│                   ├─YESNO───────PRILIN
│                   └─RESTRI────┬─REFRSH──────PRILIN
│                               ├─PRILIN
│                               │
```

```
                        └CONTIN──PRILIN
├ADJUST──┬SCRENO──PRILIN
         ├SELINS
         ├SELCOM
         ├WRICOM
         ├ADJPRM──┬SCRENO──PRILIN
         │        ├SELPMC
         │        ├NEWLNK──┬SELLNK
         │        │        ├WRILNK
         │        │        └RESTRA──┬SCRENO──PRILIN
         │        │                 ├SELCOM
         │        │                 ├WRICOM
         │        │                 ├ADJRRS──┬SELLNK
         │        │                 │        ├SELTRR
         │        │                 │        └WRITRR
         │        │                 ├SELTRA
         │        │                 └WRITRA
         │        ├ADDINS──┬SCRENO──PRILIN
         │        │        └WRIINS
         │        ├WRIPMC
         │        ├ADDCOM──┬SELCOM
         │        │        └WRICOM
         │        ├ADDLNK──┬SELLNK
         │        │        └WRILNK
         │        ├ADDTRA──┬SELTRA
         │        │        └WRITRA
         │        ├ADDTHR──┬SELTHC
         │        │        └WRITHC
         │        ├ADDTRR──┬SELTRR
         │        │        └WRITRR
         │        └ADDPRC──┬SELPMC
         │                 └WRIPMC
         ├ADJTRA──┬SELTRA
         │        ├SCRENO──PRILIN
         │        ├ADDINS──┬SCRENO──PRILIN
         │        │        └WRIINS
         │        ├WRITRA
         │        ├ADDCOM──┬SELCOM
         │        │        └WRICOM
         │        ├ADDLNK──┬SELLNK
         │        │        └WRILNK
         │        ├ADDTRA──┬SELTRA
         │        │        └WRITRA
         │        ├ADDTHR──┬SELTHC
         │        │        └WRITHC
         │        ├ADDTRR──┬SELTRR
         │        │        └WRITRR
         │        └ADDPRC──┬SELPMC
         │                 └WRIPMC
         ├ADJTHR──┬SELTHC
         │        ├SCRENO──PRILIN
         │        ├ADDINS──┬SCRENO──PRILIN
         │        │        └WRIINS
         │        ├WRITHC
         │        ├ADDCOM──┬SELCOM
         │        │        └WRICOM
         │        ├ADDLNK──┬SELLNK
         │        │        └WRILNK
         │        ├ADDPRC──┬SELPMC
         │        │        └WRIPMC
```

```
|                   |                     |
|                   |                     |-ADDTRA----+-SELTRA
|                   |                     |           |-WRITRA
|                   |                     |-ADDTHR----+-SELTHC
|                   |                     |           |-WRITHC
|                   |                     |-ADDTRR----+-SELTRR
|                   |                                 |-WRITRR
|                   |
|                   |-WRILAC
|-DISTRI-----------+-SCRENO---------PRILIN
|                  | SELCOM
|                  |-VARDET----+-SELLNK
|                              |-DEDVAR-----+-SELLNK
|                              |            |-PRMDED------SELLNK
|                              |            |-TRLDED----+-SELTRA
|                              |                        |-SELLNK
|                              |                        |-SELTRR
|                              |
|                              |-VAREVA
|                              |-WRILNK
|-CHECOM-----------SELCOM
|-INSDAT----------+-SCRENO---------PRILIN
|                 |-SELCOM
|                 |-SELPMC
|                 |-SELPMG
|                 |-SELTRA
|                 |-SELTHC
|                 |-THPERF-----+-SELTHC
|                              |-SELTHP
|                              |-SELPMC
|                              |-THRPFN-------BSERI
|
|-WRIINS
|-WRERR-----------+-SCRENO---------PRILIN
                  |-CONTIN---------PRILIN
```

PROSEL - evaluation of installation

```
PROEVA
├── SELSUP
├── SCRINI
├── MAISCR ── PRILIN
├── UPDSCR
│   ├── PRILIN
│   └── GETTIM
├── SCRENO ── PRILIN
├── EVACHO
│   ├── REFRSH ── PRILIN
│   └── PRILIN
└── EVALU1
    ├── SCRENO ── PRILIN
    ├── PROREA
    │   ├── SCRENO ── PRILIN
    │   ├── IDFILL
    │   │   ├── REFRSH ── PRILIN
    │   │   └── PRILIN
    │   ├── UPDSCR ── PRILIN
    │   ├── YESNO ── PRILIN
    │   ├── INITIA
    │   ├── SELINS
    │   └── WRERR
    │       ├── SCRENO ── PRILIN
    │       └── CONTIN ── PRILIN
    ├── WRERR
    │   ├── SCRENO ── PRILIN
    │   └── CONTIN ── PRILIN
    ├── DISTRI
    │   ├── SCRENO ── PRILIN
    │   ├── SELCOM
    │   └── VARDET
    │       ├── SELLNK
    │       ├── DEDVAR
    │       │   ├── SELLNK
    │       │   ├── PRMDED ── SELLNK
    │       │   └── TRLDED
    │       │       ├── SELTRA
    │       │       ├── SELLNK
    │       │       └── SELTRR
    │       ├── VAREVA
    │       └── WRILNK
    └── COMEVA
        ├── SCRENO ── PRILIN
        ├── SELCOM
        ├── PRMEVA
        │   ├── SELPMC
        │   ├── SELPMG
        │   ├── SELLNK
        │   ├── PRMPOS ── SELOFD
        │   ├── WRERR
        │   │   ├── SCRENO ── PRILIN
        │   │   └── CONTIN ── PRILIN
        │   ├── ADDARR
        │   │   ├── SELRAR
        │   │   └── WRIRAR
        │   ├── FOCDET
        │   │   ├── SELPMG
        │   │   ├── SELMCR
        │   │   ├── SELFC1
        │   │   ├── SELFP1
        │   │   ├── SELFC2
        │   │   └── SELFP2
        │   ├── LOCDET ── SELLOC
        │   ├── EXHDET
        │   │   ├── SELPMG
        │   │   ├── SELMCR
        │   │   └── SELEX2
        │   │   *COODET
        │   │   *AIRDET
        │   │   *HEADET
        │   │   *HEXDET
        │   ├── REFRSH ── PRILIN
        │   ├── PMEVSC ── PRILIN
        │   └── CONTIN ── PRILIN
        └── TRAEVA
            ├── SELLNK
            ├── SELCOM
            ├── SELTRR
            │
```

```
|        |        |        |-REFRSH-----PRILIN
|        |        |        |-TREVSC---+-PRILIN
|        |        |        |          L-CONTIN-----PRILIN
|        |        |        L-CONTIN-----PRILIN
|        |        |-THREVA-+-THRINI---+-SELTHC
|        |        |        |          |-SELTHP
|        |        |        |          |-NEWCUR
|        |        |        |          L-PSEPPS---+-BSERI
|        |        |        |                     L-CAVI
|        |        |        |-SELLNK
|        |        |        |-WRILNK
|        |        |        |-THEVSC---+-REFRSH-----PRILIN
|        |        |        |          L-PRILIN
|        |        |        L-CONTIN-----PRILIN
|        |        *PTOEVA
|        |-LNKMTX-+-SCRENO-----PRILIN
|        |        |-SELLNK
|        |        |-SELCOM
|        |        L-ADDARR---+-SELRAR
|        |                   L-WRIRAR
|        L-STORAR-+-SCRENO-----PRILIN
|                 L-WRERR----+-SCRENO-----PRILIN
|                            L-CONTIN-----PRILIN
|-EVALU2-+-SCRENO-----PRILIN
|        |-RESLNK-+-SELLNK
|        |        L-WRILNK
|        |-PROREA-+-SCRENO-----PRILIN
|        |        |-IDFILL---+-REFRSH-----PRILIN
|        |        |          L-PRILIN
|        |        |-UPDSCR-----PRILIN
|        |        |-YESNO------PRILIN
|        |        |-INITIA
|        |        |-SELINS
|        |        L-WRERR----+-SCRENO-----PRILIN
|        |                   L-CONTIN-----PRILIN
|        |-WRERR--+-SCRENO-----PRILIN
|        |        L-CONTIN-----PRILIN
|        |-SELCOM
|        |-THRINI
|        |-THRINI-+-SELTHC
|        |        |-SELTHP
|        |        |-NEWCUR
|        |        L-PSEPPS---+-BSERI
|        |                   L-CAVI
|        |-THRMTX-+-SCRENO-----PRILIN
|        |        L-WRIRAR
|        |-SELLNK
|        |-WRILNK
|        |-DISTRI-+-SCRENO-----PRILIN
|        |        |-SELCOM
|        |        L-VARDET---+-SELLNK
|        |                   |-DEDVAR---+-SELLNK
|        |                   |          |-PRMDED-----SELLNK
|        |                   |          L-TRLDED---+-SELTRA
|        |                   |                     |-SELLNK
|        |                   |                     L-SELTRR
|        |                   |-VAREVA
|        |                   L-WRILNK
|        |-LNKMTX-+-SCRENO-----PRILIN
|        |        |-SELLNK
|        |        |
```

```
|          |               |-SELCOM
|          |               |-ADDARR-----+-SELRAR
|          |               |            |-WRIRAR
|          |-COMEVA--------+-SCRENO-------PRILIN
|          |               |-SELCOM
|          |               |-PRMEVA-----+-SELPMC
|          |               |            |-SELPMG
|          |               |            |-SELLNK
|          |               |            |-PRMPOS-------SELOFD
|          |               |            |-WRERR------+-SCRENO-------PRILIN
|          |               |            |            |-CONTIN-------PRILIN
|          |               |            |-ADDARR-----+-SELRAR
|          |               |            |            |-WRIRAR
|          |               |            |-FOCDET-----+-SELPMG
|          |               |            |            |-SELMCR
|          |               |            |            |-SELFC1
|          |               |            |            |-SELFP1
|          |               |            |            |-SELFC2
|          |               |            |            |-SELFP2
|          |               |            |-LOCDET-------SELLOC
|          |               |            |-EXHDET-----+-SELPMG
|          |               |            |            |-SELMCR
|          |               |            |            |-SELEX2
|          |               |            *COODET
|          |               |            *AIRDET
|          |               |            *HEADET
|          |               |            *HEXDET
|          |               |            |-REFRSH-------PRILIN
|          |               |            |-PMEVSC-------PRILIN
|          |               |            |-CONTIN-------PRILIN
|          |               |-TRAEVA-----+-SELLNK
|          |               |            |-SELCOM
|          |               |            |-SELTRR
|          |               |            |-REFRSH-------PRILIN
|          |               |            |-TREVSC-----+-PRILIN
|          |               |            |            |-CONTIN-------PRILIN
|          |               |            |-CONTIN-------PRILIN
|          |               |-THREVA-----+-THRINI-----+-SELTHC
|          |               |            |            |-SELTHP
|          |               |            |            |-NEWCUR
|          |               |            |            |-PSEPPS-----+-BSERI
|          |               |            |                         |-CAVI
|          |               |            |-SELLNK
|          |               |            |-WRILNK
|          |               |            |-THEVSC-----+-REFRSH-------PRILIN
|          |               |            |            |-PRILIN
|          |               |            |-CONTIN-------PRILIN
|          |               *PTOEVA
|          |-STORAR--------+-SCRENO-------PRILIN
|                          |-WRERR------+-SCRENO-------PRILIN
|                                       |-CONTIN-------PRILIN
|-EVALU3-----+-SCRENO-------PRILIN
|            |-EV3INI------+-REFRSH-------PRILIN
|            |             |-PRILIN
|            |             |-IDFILL-----+-REFRSH-------PRILIN
|            |             |            |-PRILIN
|            |             |-UPDSCR-----+-PRILIN
|            |             |            |-GETTIM
|            |             |-READAR-------WRERR------+-SCRENO-------PRILIN
|            |             |                         |-CONTIN-------PRILIN
```

```
 |                    |                  └─WRERR──────┬─SCRENO──────PRILIN
 |                    |                               └─CONTIN──────PRILIN
 |                    ├─EVA3SC──────┬─REFRSH──────PRILIN
 |                    |             ├─PRILIN
 |                    |             ├─PROREA──────┬─SCRENO──────PRILIN
 |                    |             |             ├─IDFILL──────┬─REFRSH──────PRILIN
 |                    |             |             |             └─PRILIN
 |                    |             |             ├─UPDSCR──────PRILIN
 |                    |             |             ├─YESNO───────PRILIN
 |                    |             |             ├─INITIA
 |                    |             |             ├─SELINS
 |                    |             |             └─WRERR───────┬─SCRENO──────PRILIN
 |                    |             |                           └─CONTIN──────PRILIN
 |                    |             ├─WRERR───────┬─SCRENO──────PRILIN
 |                    |             |             └─CONTIN──────PRILIN
 |                    |             └─READAR──────WRERR───────┬─SCRENO──────PRILIN
 |                    |                                       └─CONTIN──────PRILIN
 |                    ├─SELRAR
 |                    ├─SELCOM
 |                    ├─SELPMC
 |                    ├─INTMTX──────┬─WRERR
 |                    |             └─INTPOL
 |                    └─STORAR──────┬─SCRENO──────PRILIN
 |                                  └─WRERR───────┬─SCRENO──────PRILIN
 |                                                └─CONTIN──────PRILIN
 ├─WRERR──────┬─SCRENO──────PRILIN
 |            └─CONTIN──────PRILIN
 └─WRISUP
```

APPENDIX II: Data file description

In this appendix the file handling and data structure are discussed. Three types of files are being considered:
- installation descriptive files (workfiles)
- storage files for workfiles
- storage files for evaluation results

When a PROSEL program part (design demand specification, composition, selecting and sorting, or evaluation) starts it will unpack the workfiles from a storage file. The identification of the storage file that has to be unpacked is discussed in paragraph II.1. After completion of the design demand specification and composition parts the installation descriptive files are packed again into the storage file. There is no need to do this after completing the other program parts. The results from the evaluation part are being stored in result storage files, having the same identification as the packed workfile storage files.

II.1 File packing/unpacking

The installation descriptive files as mentioned in paragraph II.2, will be packed and unpacked for storage reasons. The results from installation evaluation will also be stored into files. The names of data storage files and result files are related, so the corresponding values can always be found afterwards. In order to achieve this an identity must be given. This identity consists of the following entries:

- Ship name
- Ship version
- Design demand package version
- Operational condition version

The design demand package consists of the installation layout, together with the component preferences. As soon as something is changed by the user then the design demand package version number will be altered.
The same will be done when the operational condition is changed; the version number of the operational condition will be raised. This way a set of design demands with a certain operational condition remains unique and retraceable. The data storage can be done on the hard disk or on a floppy disk. For execution speed benefit the user can unpack the data files to e.g. a ram disk. The installation descriptive files are: INSTLS.DAT, SHPDAT.DAT, CMPNTS.DAT, CMPLNK.DAT, PMPREF.DAT, TRPREF.DAT, THRPRE.DAT, PTPREF.DAT, TRANDS.DAT, TRNMRR.DAT, PMCHDS.DAT, THRPDS.DAT, PROPDS.DAT, LASTRC.DAT.

The data file storage file will be given a name:NAME1122.F33

NAME	= first four characters of the ship name
11	= ship version
22	= design demand package version
33	= operational condition version

The evaluation results will be stored in files having three types of names, depending on one of three possible evaluations:
The one operating point evaluation results: NAME1122.P33
The speed range evaluation results: NAME1122.M33
The operating profile evaluation results: NAME1122.044

44 = operating profile version

All these result storage files are formatted so they can be read directly. The packing will take place direct after specifying the design demands. The files will be unpacked as soon as the 'composition of alternatives' module is started. When finished the files are packed again. Unpacking is also done before evaluation. In this way each program module can be seen separate from the other one. Storage of intermediate results takes place automatically between PROSEL design steps and a data redundancy is acquired. If some kind of technical trouble occurs then the situation at the start is still available in the packed storage file.

The packing procedure takes place by subsequently writing all records to the storage file. An end of file identifier consists of the considered data file name, being written to the storage file. When unpacking the storage file this data file name being read is indicating the end of the information for this file. The next data file can then be reconstructed.

II.2 Description of data file record variables

This paragraph contains the structure description of the installation descriptive files, the database files and internal usage files. For a description of the storage files, in which the installation descriptive files are stored, go to paragraph II.1.

Installation descriptive files

SHPDAT	-	ship data
INSTLS	-	list of installations
CMPNTS	-	component definition
CMPLNK	-	links between components
PMPREF	-	prime mover preferences
TRPREF	-	transmission preferences
THRPRE	-	thruster preferences
PTPREF	-	pto preferences
PMCHDS	-	prime mover choices
TRANDS	-	transmission choices
TRNMRR	-	transmission normalized reduction ratios
THRPDS	-	thruster (screw type) choices

Prime mover database

GNRLPM	-	general prime mover database
LOFFCP	-	'lay-out-field' diesel engine fuel oil consumption data for part load condition
LOFFOC	-	'lay-out-field' diesel engine fuel oil consumption data for mcr conditions
MCREXH	-	exhaust gas temperature and flow data for mcr type prime movers
MCRFCP	-	mcr diesel engine fuel oil consumption data for part load condition
MCRFOC	-	mcr diesel engine fuel oil consumption data for mcr load condition
MCRRNG	-	mcr condition power and rpm values for prime movers
OPEFLD	-	prime mover operating field representation
LUBOIL	-	prime mover lubricating oil and cylinder oil consumption data

Transmission database

RENK1.DAT	-	selection area of RENK HSU type gearbox
RENK2.DAT	-	selection area of RENK NDS1 type gearbox
RENK3.DAT	-	selection area of RENK HSC type gearbox
RENK4.DAT	-	selection area of RENK HSCZ type gearbox
RENK5.DAT	-	selection area of RENK NDS2 type gearbox
RENK6.DAT	-	selection area of RENK NDS3 type gearbox
RENK7.DAT	-	selection area of RENK NDS4 type gearbox
LOHM1.DAT	-	selection area of LOHMANN GC type gearbox

LOHM2.DAT - selection area of LOHMANN GVA type gearbox
COUPL.DAT - selection data for couplings

Internal usage

PROPDS - storage for additional thruster design
LASTRC - storage for last record number of each installation descriptive file

SHPDAT - ship data

Since the ship identity is incorporated in the packed storage file (see paragraph II.1) no key is needed. The data needed for dimensioning the ship's propulsion arrangement are specified in one record. As can be seen this file contains only 1 resistance curve specification. When specifying the design demands 4 curves could be given by the user. At this moment only the curve, resulting from combining the 4 different curves by multiplying and adding them, is stored in this file. The 4 original curves are stored in a separate, intermediate solution, dump file. This file is used by the MARIN developed design demand specification program, PROINP. This file can be compared to the packed storage file, but their structures are not compatible. Because no time was left for completely integrating the PROINP module with the other PROSEL parts the 4 original curves are not yet stored in this file. In the future this storage must be executed in this file.

SHPSPD	- DBLPREC	- ship speed (m/s)
SHPTAF	- DBLPREC	- draft aft (m)
SEAMRG	- DBLPREC	- sea margin
SEAICE	- DBLPREC	- ice class factor
SHPSPE	- DBLPREC	- resistance data array for speed (10 points) (m/s)
SHPRES	- DBLPREC	- resistance data array for resistance (10 points) (kN)
SHPCPW	- DBLPREC	- prismatic coefficient on the waterline
SHPCM	- DBLPREC	- midship coefficient
SHPCWP	- DBLPREC	-
SHPXAB	- DBLPREC	- position of center of buoyancy as a percentage of LPP
SHPCST	- DBLPREC	- stern coefficient
SHPCSC	- DBLPREC	- shaft aperture coefficient
SHPS	- DBLPREC	- wetted surface area
SHPLPP	- DBLPREC	- ship length between perpendiculars
SHPB	- DBLPREC	- ship breadth
SHPT	- DBLPREC	- ship draft

{resistance data are specified in a paired format; speed-resistance (point 1), speed-resistance (point 2), ...
speed-resistance (point 10)}

LENGTH: 350

FORMAT: 928
(T1,F7.2,T9,F6.3,T16,F6.3,T23,F5.2,T29,30F9.2)

COMMON BLOCK: SHPLST in file: SHPLST.CMN

READ SUBROUTINE: SELSHP in file: SELSHP.FOR
WRITE SUBROUTINE: WRISHP in file: WRISHP.FOR

INSTLS - list of installations

The first field is the key for the record. The second record gives the value of the completed flag. The value true means that all components of this installation have been selected.

INSNUM	- INTEGER	- installation number
CMPLTD	- LOGICAL	- installation completed flag
INSWGT	- DBLPREC	- installation total weight (tons)
INSCST	- DBLPREC	- installation total initial cost (1000 Hfl)
INSFOC	- DBLPREC	- total fuel consumption (tons/day)
INSVMA	- DBLPREC	- maximum attainable speed (m/s)

LENGTH: 80

FORMAT: 910
(T1,I5,T9,L1,T11,F10.3,T22,F10.3,T33,F10.3,T44,F10.3)

COMMON BLOCK: INSLST in file: INSLST.CMN

READ SUBROUTINE: SELINS in file: SELINS.FOR
WRITE SUBROUTINE: WRIINS in file: WRIINS.FOR

CMPNTS - component definition

The components off the installation are described by one record each. The key to the record is formed by the number of the installation and the number of the component. For the convenience of the user the component can be given a name. This name will only be used for output result labelling. As mentioned before 4 types of components are distinguished in the record 'type' field, i.e. prime mover, transmission, thruster and pto. Three more fields are specified for the component description records. The first two contain flags that are used by the composition algorithm, specifying whether the component has been selected from the database resp. whether the component has just been selected during a former algorithm loop. The CMPACT record field is used for specifying the component to be or not to be active. In the last two record fields the user himself must indicate whether the component contributes to the total installation length and breadth (this option however is not yet operational).

CMPINS	- INTEGER	- installation number
CMPNUM	- INTEGER	- component number
CMPNAM	- CHAR*15	- name
CMPTYP	- CHAR*15	- type
CMPSEL	- LOGICAL	- selected flag
CMPJSL	- LOGICAL	- just selected flag
CMPACT	- LOGICAL	- active flag
CMPCTL	- LOGICAL	- contributing to total length flag
CMPCTB	- LOGICAL	- contributing to total breadth flag

LENGTH: 80

FORMAT: 9I1
(T1,I5,T7,I5,T14,A15,T31,A15,T48,L5,T54,L5,T60,L5,T66,L5,T72,L5)

COMMON BLOCK: CMPLST in file: CMPLST.CMN

READ SUBROUTINE: SELCOM in file: SELCOM.FOR
WRITE SUBROUTINE: WRICOM in file: WRICOM.FOR

CMPLNK - links between components

The first three fields are forming the key for this record. The power and rpm values for the design operating condition at the location of this link are specified in the next two record fields. Further the value for the percentage of the total outgoing power of the 'from' component' that is being transferred through this link is given. The same is done for the percentage of the total 'to' ingoing power. During execution of the algorithm besides the actual link power and rpm value a power-rpm relation will be transferred through the links. This relation will be used for component selection to make an optimum component adjustment possible (see e.g. paragraph 5.2.1.1.1). Whether to choose from the relation or just take the separately specified values in the power and rpm fields, depends on the value of the power-rpm relation flag (true=yes, false=no). The relation itself is represented in the next 10 fields by a 5 point power-rpm array.

LNKINS	- INTEGER	- installation number
LNKCFR	- INTEGER	- number of 'from' component
LNKCTO	- INTEGER	- number of 'to' component
LNKPOW	- DBLPREC	- link power value (kW)
LNKRPM	- DBLPREC	- link rpm value (1/min)
LPRCFR	- DBLPREC	- percentage through link of total 'from' power
LPRCTO	- DBLPREC	- percentage through link of total 'to' power
LNKACT	- LOGICAL	- active flag (indicating an inactive component at this link)
LRELAT	- LOGICAL	- relation flag (power-rpm relation valid indicator)
LNKSPL	- DBLPREC	- power-rpm relation array resulting from additional thruster design (first 5 elements are power values, second 5 are corresponding rpm values)

LENGTH: 250

FORMAT: 912
(T1,I5,T7,I5,T13,I5,T19,F18.10,T38,F18.10,T57,F15.8,T73,
F15.8,T89,L5,T95,L5,T101,10F15.8)

COMMON BLOCK: LNKLST in file: LNKLST.CMN

READ SUBROUTINE: SELLNK in file: SELLNK.FOR
WRITE SUBROUTINE: WRILNK in file: WRILNK.FOR

PMPREF - prime mover preferences

The record key is formed by the first record field, the component number. The next fields are used for giving the preferred type (LOF = lay-out-field diesel engine, MCR = mcr diesel engine, GTU = gasturbine, STU = steamturbine or OTH = other), make, series etc. The last three fields are used to let the designer specify the load of the prime mover. He can give a minimum, maximum allowed and preferred engine margin.

PMPNUM	- INTEGER	- component number
PMTYPP	- CHAR*15	- prime mover type
PMMAKP	- CHAR*15	- prime mover make
PMSERP	- CHAR*15	- prime mover series
PMCILP	- CHAR*15	- prime mover number of cylinders
PMSTRP	- CHAR*15	- preferred operating principle (2/4 stroke)
EMGMIN	- DBLPREC	- minimum engine margin
EMGMAX	- DBLPREC	- maximum engine margin
EMGPRE	- DBLPREC	- preferred engine margin
PMPFQL	- DBLPREC	- preferred lower calorific value of fuel oil (kJ/kg)

LENGTH: 100

FORMAT: 921
(T1,I5,T7,A15,T23,A15,T39,A15,T55,I5,T61,I5,T67,F7.2,T75,F7.2,T83,F7.2,T91,F10.2)

COMMON BLOCK: PMPLST in file: PMPLST.CMN

READ SUBROUTINE: SELPMP in file: SELPMP.FOR
WRITE SUBROUTINE: WRIPMP in file: WRIPMP.FOR

TRPREF - transmission preferences

The key field for this record is the component number. The make and the series that are preferred can be specified in the next fields.

```
TRPCOM  - INTEGER    - component number
TRPTYP  - CHAR*15    - preferred type
TRPMAK  - CHAR*15    - preferred make
TRPSER  - CHAR*15    - preferred series
TRPSRN  - CHAR*15    - preferred series number
TRPRUB  - LOGICAL    - 'acceptance of rubber transmission' flag
```

LENGTH: 80

FORMAT: 934
(T1,I5,T7,A15,T23,A15,T39,A15,T55,A15,T71,L5)

```
COMMON BLOCK:          TRPLST  in file: TRPLST.CMN

READ  SUBROUTINE:      SELTRP  in file: SELTRP.FOR
WRITE SUBROUTINE:      WRILNK  in file: WRITRP.FOR
```

THRPRE - thruster preferences

The key for this record is the component number. The required thrust is now a direct input value for the designer but will be replaced by a thrust percentage per thruster. Together with the ship's resistance data the required thrust will be calculated. The minimum allowed propeller diameter is depending on the shaft diameter and the type of propeller (fixed pitch - controllable pitch).

THPCOM	- INTEGER	- component number
THPTHR	- DBLPREC	- required thrust (kN)
THPTPR	- DBLPREC	- percentage of total thrust
THPDMI	- DBLPREC	- minimum propeller diameter (m)
THPDMA	- DBLPREC	- maximum propeller diameter (m)
THPNLO	- DBLPREC	- lower propeller rpm boundary (1/min)
THPNHI	- DBLPREC	- higher propeller rpm boundary (1/min)
THPNBL	- INTEGER	- propeller number of blades
THPPMI	- DBLPREC	- minimum pitch/diameter ratio
THPPMA	- DBLPREC	- maximum pitch/diameter ratio
THPPCL	- DBLPREC	- propeller clearance (m)
THPPOS	- INTEGER	- propeller position (1=central, 2=side)
THPTYP	- INTEGER	- type of propeller (0=B-serie, 1-7=Ka-serie)
THPSMG	- DBLPREC	- sea margin on delivered power
THPMAT	- INTEGER	- material of propeller (0=bronze, 1=cunial)

LENGTH: 100

FORMAT: 923
(T1,I5,T7,F9.3,T17,F15.8,T33,F9.3,T43,F9.3,T53,F9.3,T64,
F9.3,T74,I2,T77,F9.3,T87,F9.3,T97,F9.3,T107,I2,T110,I2,
T113,F9.3,T123,I2)

COMMON BLOCK: THPLST in file: THPLST.CMN

READ SUBROUTINE: SELTHP in file: SELTHP.FOR
WRITE SUBROUTINE: WRITHP in file: WRITHP.FOR

PTPREF - pto preferences

PTPCOM	- INTEGER	- component number
PTPPOW	- DBLPREC	- power value (kW)
PTPRPM	- DBLPREC	- rpm value (1/min)
PTPTYP	- CHAR*1	- type (G=generator, F=fire-fighting pump, H=hydraulic pump, M=mechanical sink of other nature)
PTPCHR	- CHAR*1	- characteristic of behavior (C=power not varying with rpm, L=power varies linearly with rpm, Q=power varies quadratic with rpm, T=power varies with rpm in third degree)
PTPCNS	- DBLPREC	- constant for multiplying rpm in characteristic power-rpm relation (Power=Const.*rpm**exp.)
PTPMAS	- DBLPREC	- mass (kg)
PTPLON	- DBLPREC	- length (m)
PTPWID	- DBLPREC	- width (m)
PTPHGT	- DBLPREC	- height (m)
PTPHAB	- DBLPREC	- shaft height above pto base (m)
PTPCST	- DBLPREC	- cost (1000 hfl)

LENGHT: 95

FORMAT: 941
(T1,I5,T7,F9.3,T17,F9.3,T27,A1,T29,A1,T31,F5.2,T37,6F9.2)

COMMON BLOCK: THPLST in file: THPLST.CMN

READ SUBROUTINE: SELPTP in file: SELPTP.FOR
WRITE SUBROUTINE: WRIPTP in file: WRIPTP.FOR

PMCHDS - prime mover choices

The installation and component number are the key to the record. The prime mover database number refers to the choice that has been made from the database tables GNRLPM, MCRRNG and PMDAT1. The mcr power and rpm values are also given. For an 'ecr' or 'mcr' type engine this may not be necessary but for a lay-out-field engine it has to made clear what point in the lay-out-field has been selected for mcr conditions. The engine load for service conditions is specified in the engine margin field.

PMCINS	- INTEGER	- installation number
PMCCOM	- INTEGER	- component number
PMCDBN	- INTEGER	- prime mover database number
PMCPWR	- DBLPREC	- mcr (contract) power value (kW)
PMCRPM	- DBLPREC	- mcr (contract) rpm value (1/min)
PMCEMG	- DBLPREC	- engine margin value
PMCFOC	- DBLPREC	- fuel oil consumption (tons/day)
PMCEHF	- DBLPREC	- exhaust heat gas flow (kg/h)
PMCEHT	- DBLPREC	- exhaust heat gas temperature (C)
PMCFQL	- DBLPREC	- lower calorific value of fuel oil (kJ/kg)

LENGHT: 120

FORMAT: 913
(T1,I5,T7,I5,T13,I5,T19,F18.10,T38,F18.10,T57,F21.12,T79,4F10.2)

COMMON BLOCK: PMCLST in file: PMCLST.CMN

READ SUBROUTINE: SELPMC in file: SELPMC.FOR
WRITE SUBROUTINE: WRIPMC in file: WRIPMC.FOR

TRANDS - transmission choices

The installation number together with the component number are the key values for this record. When a choice has been made from the database for this transmission, then the database number is stored in the corresponding field. The numbers of ingoing and outgoing links are deducted from the link specifications. The efficiency must be given by the designer. Suggestions are being given by the program. The last record field states whether a 'rubber' transmission is acceptable for the designer. Rubber means that the transmission will not be selected from the database but it will be handled as if it were (e.g. the reduction ratio will be chosen freely, as a result of the rpm values of the linked components, the size results from the shaft spacing etc.). A rubber transmission is needed for installation dimensioning when no choice can be made from the database (e.g. only a tailor made solution is available for this component).
Fields are being reserved for gravity position and shaft design data. These fields are present, but the program parts using them are not yet operational.

TRAINS	- INTEGER	- installation number
TRACOM	- INTEGER	- component number
TRANAM	- CHAR*17	- transmission choice description
TRAINL	- INTEGER	- number of ingoing links
TRAOUT	- INTEGER	- number of outgoing links
TRAEFF	- DBLPREC	- efficiency
TRARUB	- LOGICAL	- rubber flag
TRATYP	- CHAR*15	- type
TRAMAK	- CHAR*15	- make
TRASER	- CHAR*15	- series
TRAWGT	- DBLPREC	- weight (tons)
TRAGRX	- DBLPREC	- x-position center of gravity (m)
TRAGRY	- DBLPREC	- y-position center of gravity (m)
TRAGRZ	- DBLPREC	- z-position center of gravity (m)
TRALEN	- DBLPREC	- overall length (m)
TRAWID	- DBLPREC	- overall width (m)
TRAHGT	- DBLPREC	- overall height (m)
TRADIA	- DBLPREC	- shaft diameter (m)
TRASTP	- INTEGER	- shaft type: 1=intermediate 2=tail
TRAYLD	- DBLPREC	- yield strength of shaft material (N/mm2)
TRADEK	- DBLPREC	- shaft design factor according to class
TRACST	- DBLPREC	- cost (1000 hfl)

LENGHT: 192

FORMAT: 914
(T1,I5,T7,I5,T13,A17,T31,I5,T37,I5,T43,D8.2,T52,L5,T58,
A15,T74,A15,T90,A15,T106,F10.3,T117,F10.3,T128,F10.3,
T139,F10.3,T150,F10.3,T161,F10.3,T172,F10.3,T183,F10.3)

COMMON BLOCK: TRALST in file: TRALST.CMN

READ SUBROUTINE: SELTRA in file: SELTRA.FOR
WRITE SUBROUTINE: WRITRA in file: WRITRA.FOR

TRNMRR - transmission normalized reduction ratios

The first two values are forming the record key. The other two records give the number of the component to which the transmission is linked and the normalized number of revolutions for this link.

TRRINS	- INTEGER	- installation number
TRRCOM	- INTEGER	- component number
TRRLCM	- INTEGER	- linked component number
TRRNNR	- DBLPREC	- normalized number of revolutions
TRRXRP	- DBLPREC	- design maximum rpm (1/min)
TRRXTQ	- DBLPREC	- design maximum torque (kNm)

LENGTH: 80

FORMAT: 916
(T1,I5,T7,I5,T13,I5,T19,F10.2,T30,F9.3,T41,F9.3)

COMMON BLOCK: TRRLST in file: TRRLST.CMN

READ SUBROUTINE: SELTRR in file: SELTRR.FOR
WRITE SUBROUTINE: WRITRR in file: WRITRR.FOR

THRPDS - thruster (screw type) choices

This record table is valid only for propeller type thrusters. For other types (e.g. waterjets) other descriptive record fields must be appended when these types are added to PROSEL.
The first two fields are the key for this record. When a thruster has been selected the properties of this thruster are stored in the record fields. Also power and rpm values for this thruster for the selected operational condition are stated. The number of blades was already specified with thruster preferences.

This thruster record is built up from the following fields:

THCINS	- INTEGER	- installation number
THCCOM	- INTEGER	- component number
THCRPM	- DBLPREC	- rpm value (1/min)
THCDIA	- DBLPREC	- diameter value (m)
THCPOD	- DBLPREC	- pitch/diameter value
THCAEO	- DBLPREC	- blade area ratio
THCETA	- DBLPREC	- open water efficiency value
THCPOW	- DBLPREC	- power value (kW)
THCTPR	- DBLPREC	- thruster thrust percentage
THCWAK	- DBLPREC	- wake fraction
THCTHD	- DBLPREC	- thrust deduction ratio
THCWGT	- DBLPREC	- weight value (tons)
THCCST	- DBLPREC	- cost value (1000 hfl)
THCINT	- LOGICAL	- interpolation flag

LENGTH: 160

FORMAT: 924
(T1,I5,T7,I5,T13,11F13.6,L2)

COMMON BLOCK: THCLST in file: THCLST.CMN

READ SUBROUTINE: SELTHC in file: SELTHC.FOR
WRITE SUBROUTINE: WRITHC in file: WRITHC.FOR

GNRLPM - general prime mover database

The key for the record is the prime mover database number. Further the general data for a prime mover are given. This record is valid for all types of prime movers despite the 'number of cylinders field'. For e.g. a gasturbine the number of cylinders will be undefined.

PRMNUM	- INTEGER	- prime mover database number
PRMTYP	- CHAR*15	- prime mover type
PRMMAK	- CHAR*15	- prime mover make
PRMSER	- CHAR*15	- prime mover series
PRMCIL	- INTEGER	- number of cylinders (for diesel engines)
PRMSTR	- INTEGER	- operating principle (2/4 stroke, for diesel engines)
PRMWGT	- DBLPREC	- total dry weight (tons)
PRMCST	- DBLPREC	- cost (1000 hfl)

FORMAT: 919
(T1,I5,T7,A15,T23,A15,T39,A15,T55,I5,T60,I2,T63,F8.2,T72,F8.2)

COMMON BLOCK: PMGLST in file: PMGLST.CMN

READ SUBROUTINE: SELPMG in file SELPMG.FOR
WRITE SUBROUTINE: WRIPMG in file WRIPMG.FOR

LOFFOC - 'lay-out-field' dieselengine fuel oil consumption data for mcr conditions

With the data in this file it can be calculated what the specific fuel oil consumption will be for a contract mcr point lying within the lay out field. The specific fuel oil consumption is given for the R1 lay out field point (the upper rightmost limit in the power-rpm diagram). For each g/kWh correction in relation the R1 sfoc a line is specified by it's left and right endpoints. These lines are illustrated on the next page for a Sulzer diesel engine. The endpoint power-rpm values are given as a percentage of R1 power and rpm, which are defined to be 100% in R1. By means of these lines the PROSEL program can interpolate the correction according to the position of the contract mcr point in the lay-out field.

FC1MAK	- CHAR*15	- prime mover make
FC1SER	- CHAR*15	- prime mover series
R1SFOC	- DBLPREC	- specific fuel oil consumption in lay-out-field point R1
NUMLIN	- INTEGER	- number of constant correction factor lines present in lay-out-field
POWER1	- DBLPREC	- left line endpoint power percentage
POWER2	- DBLPREC	- right line endpoint power percentage
RPM1	- DBLPREC	- left line endpoint rpm percentage
RPM2	- DBLPREC	- right line endpoint rpm percentage
LCVF	- DBLPREC	- lower calorific value of fuel for which oil consumption data are valid (kJ/kg)

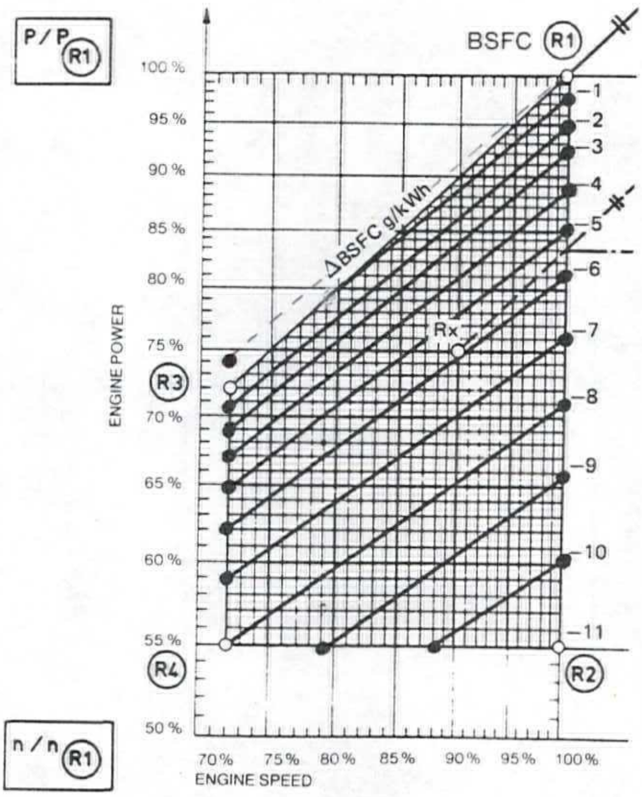
LENGTH: 266

FORMAT: 929
(T1,A15,T17,A15,T33,F5.1,T39,I2,T41,36F6.1,F10.2)

COMMON BLOCK: FC1LST in file: FC1LST.CMN

READ SUBROUTINE: SELFC1 in file: SELFC1.FOR
WRITE SUBROUTINE: WRIFC1 in file: WRIFC1.FOR

engine layout field and BSFC



LOFFCP - 'lay-out-field' dieselengine fuel oil consumption data for part load conditions

The correction on specific fuel oil consumption is depending on the percentage power load at which the engine is running in relation to contract mcr. In this file the relation for the correction of sfoc as a function of this load percentage is given. This correction is depending on the percentage of the mean effective pressure in relation to the mean effective pressure in the lay-out-field R1 point. The relations for 50% and 80% load are represented with three points. The specified points are illustrated in the figure on the next page, for a Sulzer dieselengine.

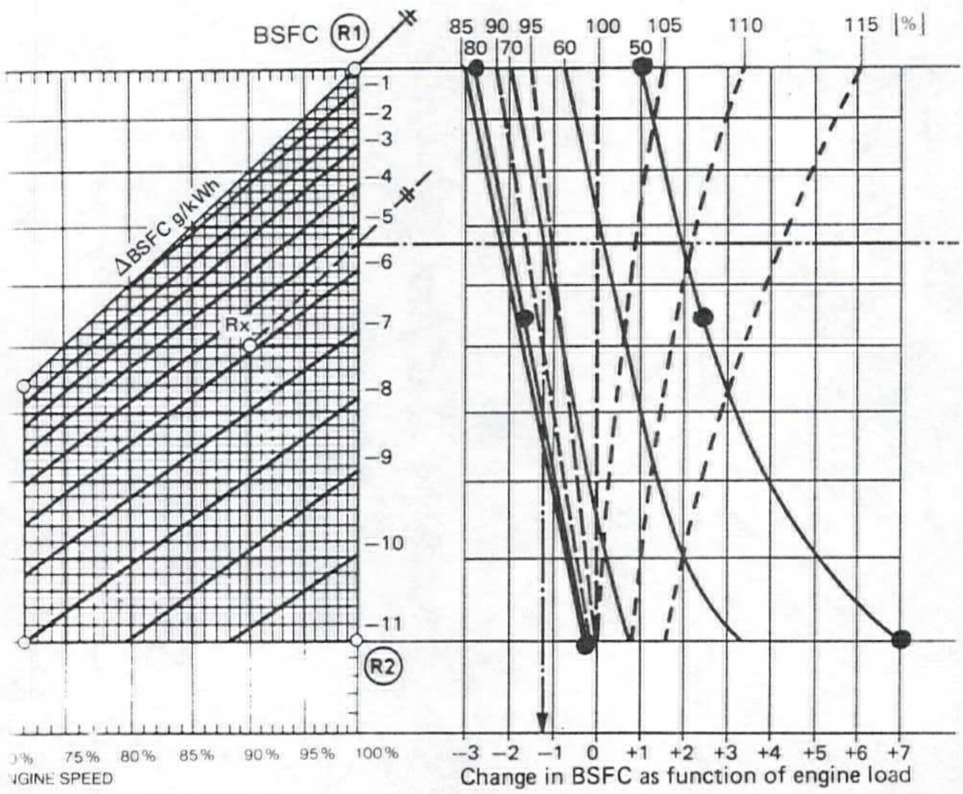
FP1MAK	- CHAR*15	- prime mover make
FP1SER	- CHAR*15	- prime mover series
COR50	- DBLPREC	- 3 points representing correction on the contract mcr sfoc as a function of the mean effective pressure percentage in relation to mep of R1, when the engine is running at a 50% load. The values read are the sfoc corrections, the corresponding mep percentages are depending on the lay-out-field specification.
COR80	- DBLPREC	- 3 points representing correction on the contract mcr sfoc when the engine is running at a 80% load

LENGTH: 68

FORMAT: 931
(T1,A15,T17,A15,T33,6F6.1)

COMMON BLOCK: FP1LST in file: FP1LST.CMN

READ SUBROUTINE: SELFP1 in file: SELFP1.FOR
WRITE SUBROUTINE: -


BSFC
R1
R2
Rx
ΔBSFC g/kWh
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
75%
80%
85%
90%
95%
100%
NGINE SPEED
85 90 95
80 70
60
100
105
50
110
115 |%|
-3 -2 -1 0 +1 +2 +3 +4 +5 +6 +7
Change in BSFC as function of engine load

MCRFOC - 'mcr' engine fuel oil consumption data for mcr conditions

For the mcr, ecr1 and ecr2 points (if present), the specific fuel oil consumption is given together with the lower calorific value for which these data are valid.

FC2MAK	- CHAR*15	- prime mover make
FC2SER	- CHAR*15	- prime mover series
ECRFOC	- DBLPREC	- 3 valued array for reading the specific fuel oil consumption values for each of possible three mcr/ecr points
LCVF	- DBLPREC	- lower calorific value of fuel for which oil consumption data are valid (kJ/kg)

LENGTH: 61

FORMAT: 930
(T1,A15,T17,A15,T34,3F6.1,F10.2)

COMMON BLOCK: FC2LST in file: FC2LST.CMN

READ SUBROUTINE: SELFC2 in file: SELFC2.FOR
WRITE SUBROUTINE: -

MCRFCP - 'mcr' prime mover fuel oil consumption data

The mcr engine values for specific fuel oil consumption can be given for 2 power load percentages in this file. The number of specified percentages is first read. For each of these percentages the percentage itself is given, plus the specific fuel oil consumption value for each of three possible mcr/ecr points. The percentages are given in relation to the contract mcr power value.

FP2MAK	- CHAR*15	- prime mover make
FP2SER	- CHAR*15	- prime mover series
NUMPRT	- INTEGER	- number of percentages
PERCT1	- DBLPREC	- value of first power load percentage
PERCT2	- DBLPREC	- value of second percentage
SFCPT1	- DBLPREC	- 3 valued array for specific fuel oil consumption value (for first load percentage) for mcr, ecr1 and ecr2 point
SFCPT2	- DBLPREC	- 3 valued array for specific fuel oil consumption value (for first load percentage) for mcr, ecr1 and ecr2 point

LENGTH: 82

FORMAT: 932
(T1,A15,T17,A15,T34,I1,8F6.1)

COMMON BLOCK: FP2LST in file: FP2LST.CMN

READ SUBROUTINE: SELFP2 in file: SELFP2.FOR
WRITE SUBROUTINE: -

MCREXH - 'mcr' prime mover exhaust gas data

For up to 4 power load percentages, the exhaust gas temperature and flow, corresponding to these power loads, can be given. Because these data are valid for mcr type diesel engines, the flow and temperature for a specific power load, have to be given for the mcr, ecr1 as well as for ecr2.

EX2MAK	- CHAR*15	- prime mover make
EX2SER	- CHAR*15	- prime mover series
EX2CIL	- CHAR*15	- prime mover number of cylinders
EX2PNT	- INTEGER	- number of power load percentage in relation to contract mcr power
EHPERC	- DBLPREC	- 4 point array for 4 possible load percentages
EHFLOW	- DBLPREC	- 4x3 point array, giving for each of the 4 possible percentages the exhaust gas flow (kg/h) for mcr, ecr1 and ecr2 layout
EHTEMP	- DBLPREC	- idem for temperature (C)

LENGTH: 224

FORMAT: 933
(T1,A15,T17,A15,T36,I2,T40,I1,T41,F7.1,F8.3,F5.0,F8.3,
F5.0,F8.3,F5.0,F7.1,F8.3,F5.0,F8.3,F5.0,F8.3,F5.0,F7.1,
F8.3,F5.0,F8.3,F5.0,F8.3,F5.0,F7.1,F8.3,F5.0,F8.3,F5.0,
F8.3,F5.0)

COMMON BLOCK: EX2LST in file: EX2LST.CMN

READ SUBROUTINE: SELEX2 in file: SELEX2.FOR
WRITE SUBROUTINE: -

MCRRNG - mcr condition power and rpm values for prime movers

The key field is the prime mover database number. The rest of the record fields specify the range of mcr points for which the prime mover is suitable. When a lay-out-field dieselengine is involved then the four power-points represent the four edges of the layout-field. When the record concerns an 'ecr' or 'mcr' dieselengine then each specified power-rpm point represents a possible mcr point.

PRMNUM	- INTEGER	- prime mover database number
MCRPOW	- DBLPREC	- 4 point array containing the power values (kW) for: lof engines: the edges of the lay-out-field R1-R4 mcr engines: the three power values for mcr, ecr1 and ecr 2 engine layout
MCRRPM	- DBLPREC	- idem for rpm values

LENGTH: 100

FORMAT: 920
(T1,I5,T7,F10.2,T18,F10.2,T29,F10.2,T40,F10.2,T51,F10.2,
T62,F10.2,T73,F10.2,T84,F10.2)

COMMON BLOCK: MCRLST in file: MCRLST.CMN

READ SUBROUTINE: SELMCR in file: SELMCR.FOR
WRITE SUBROUTINE: -

OPEFLD - prime mover operating field representation

The operating field of a diesel engine can be represented with the points A-F (see figure 9, paragraph 6.2.1.2.2.6 in the main report). For the points A-E the power percentages as well as the rpm percentages in relation to mcr (=100%) are given, for point F only the rpm percentage is given. For the lines from the origin through point D and E the exponent of rpm is given.

OFDMAK	- CHAR*15	- prime mover make
OFDTYP	- CHAR*15	- prime mover type
DIAPOW	- DBLPREC	- array containing the operating field power points
DIARPM	- DBLPREC	- array containing the operating field rpm points
EXPOD	- DBLPREC	- exponent of line equation OD

LENGTH: 150

FORMAT: 935
(T1,A15,T17,A15,T36,12F7.2)

COMMON BLOCK: OFDLST in file: OFDLST.CMN

READ SUBROUTINE: SELOFD in file: SELOFD.FOR
WRITE SUBROUTINE: -

```
LUBOIL   - prime mover lubricating oil and cylinder oil consumption
           data
```

The lubricating oil consumption can be given in 4 different ways, depending on the manufacturers specifications. Sometimes the cylinder oil consumption is stated separately, sometimes only a total lubricating oil consumption is given.

```
LOCTYP   - INTEGER     - Type of consumption data:
                         0 : kg   /cyl/day,     separate cyl. oil
                         1 :  g/kW/cyl/day, no separate cyl. oil
                         2 : kg   /cyl/day, no separate cyl. oil
                         3 :  g/kW    /day, no separate cyl. oil
LOCLOW   - DBLPREC     - Lower value lube oil consumption
LOCHIG   - DBLPREC     - Upper value lube oil consumption
LOCCIL   - DBLPREC     - Cylinder oil consumption (g/kWh)

LENGTH:  60

FORMAT:  936
(T1,A15,T17,A15,T32,I1,T33,3F9.2)

COMMON BLOCK:          LOCLST  in file: LOCLST.CMN

READ  SUBROUTINE:      SELLOC  in file: SELLOC.FOR
WRITE SUBROUTINE:      -
```

LASTRC - storage for last record number of each installation descriptive file

The file contains the numbers of the last records in each of the installation description tables. This is useful for adding new records and determining the number of components and links.

```
LRCINS  - INTEGER   - number of last record in INSTLS table
LRCCOM  - INTEGER   - number of last record in CMPNTS table
LRCLNK  - INTEGER   - number of last record in CMPLNK table
LRCTRA  - INTEGER   - number of last record in TRANDS table
LRCTHC  - INTEGER   - number of last record in THRPDS table
LRCTRR  - INTEGER   - number of last record in TRNMRR table
LRCPMC  - INTEGER   - number of last record in PMCHDS table
LRCPRO  - INTEGER   - number of last record in PROPDS table
```

LENGTH: 80

FORMAT: 925
(T1,I5,T7,I5,T13,I5,T19,I5,T25,I5,T31,I5,T37,I5,T43,I5)

COMMON BLOCK: LASTRC in file: LASTRC.CMN

READ SUBROUTINE: SELLRC in file: SELLRC.FOR
WRITE SUBROUTINE: WRILRC in file: WRILCR.FOR

PROPDS - storage for additional thruster design

This record has almost the same structure as the THRPDS table and contains the descriptive results of the 5 additionally designed thrusters. These record need no installation number because they are not bound to a specific installation alternative. They are used for prime mover selection and for interpolating a new thruster for a given rpm value if needed. Thrust percentage therefore isn't important either, and neither is the interpolation flag that is mentioned in the THRPDS table.

PROCOM	- INTEGER	- component number
PRORPM	- DBLPREC	- rpm (1/min)
PRODIA	- DBLPREC	- diameter (m)
PROPOD	- DBLPREC	- pitch/diameter
PROAEO	- DBLPREC	- blade area ratio
PROETA	- DBLPREC	- open water efficiency
PROPOW	- DBLPREC	- shaft power (kW)
PROWAK	- DBLPREC	- wake fraction
PROTHD	- DBLPREC	- thrust deduction ratio
PROWGT	- DBLPREC	- weight (ton)
PROCST	- DBLPREC	- cost (1000 Hfl)

LENGTH: 145

FORMAT: 926
(T1,I5,T13,10F13.6)

COMMON BLOCK: PROLST in file: PROLST.CMN

READ SUBROUTINE: SELPRO in file: SELPRO.FOR
WRITE SUBROUTINE: WRIPRO in file: WRIPRO.FOR

II.3 Record representation

For each data file a representation of the exact record structure is given on the following pages. The sequence of the fields in the records is given in the diagrams, each diagram representing 1 record. The data structure doesn't follow the rules for a relational database. The reason for this is the program execution speed. Several record fields are inserted for minimizing the data search time.

SHPDAT - ship data

SPEED
DRAFT
SEA MARGIN ON THRUST
ICE FACTOR
SPEED 1
RESISTANCE 1
....
....
SPEED 10
RESISTANCE 10
PRISMATIC COEFFICIENT ON WATERLINE
MIDSHIP COEFFICIENT
CWP
CENTER OF BUOYANCY POSITION
STERN COEFFICIENT
SHAFT APERTURE COEFFICIENT
LENGTH BETWEEN PERPENDICULARS
BREADTH
DRAFT

INSTLS - list of installations

INSTALLATION NUMBER
COMPLETED FLAG
TOTAL WEIGHT
TOTAL INITIAL COST
TOTAL FUEL OIL CONSUMPTION
MAXIMUM ATTAINABLE SPEED

CMPNTS - component definition

INSTALLATION NUMBER
COMPONENT NUMBER
NAME
TYPE
'SELECTED' FLAG
'JUST SELECTED' FLAG
'ACTIVE' FLAG
'CONTRIBUTING TO TOTAL LENGTH' FLAG
'CONTRIBUTING TO TOTAL BREADTH' FLAG

CMPLNK - links between components

INSTALLATION NUMBER
NUMBER OF 'FROM' COMPONENT
NUMBER OF 'TO' COMPONENT
LINK POWER VALUE
LINK RPM VALUE
PERCENTAGE THROUGH LINK OF TOTAL 'FROM' POWER
PERCENTAGE THROUGH LINK OF TOTAL 'TO' POWER
'ACTIVE' FLAG
'POWER-RPM RELATION VALID/INVALID' FLAG
POWER-RPM RELATION POWER VALUE 1
.....
POWER-RPM RELATION POWER VALUE 5
POWER-RPM RELATION RPM VALUE 1
.....
POWER RPM RELATION RPM VALUE 5

PMPREF - prime mover preferences

COMPONENT NUMBER
TYPE
MAKE
SERIES
NUMBER OF CYLINDERS
2 OR 4 STROKE
MINIMUM ACCEPTABLE ENGINE MARGIN
MAXIMUM ACCEPTABLE ENGINE MARGIN
PREFERRED ENGINE MARGIN
LOWER CALORIFIC VALUE OF FUEL OIL

TRPREF - transmission preferences

COMPONENT NUMBER
TYPE
MAKE
SERIES
SIZE
'CUSTOM MADE ACCEPTANCE' FLAG

THRPRE - thruster preferences

COMPONENT NUMBER
REQUIRED THRUST
PERCENTAGE OF SHIP'S TOTAL THRUST
MINIMUM PROPELLER DIAMETER
MAXIMUM PROPELLER DIAMETER
MINIMUM PROPELLER RPM
MAXIMUM PROPELLER RPM
NUMBER OF PROPELLER BLADES
MINIMUM PITCH/DIAMETER RATIO
MAXIMUM PITCH/DIAMETER RATIO
PROPELLER CLEARANCE WITH SHIP KEEL
PROPELLER POSITION (1=CENTRAL,2=SIDE)
PROPELLER TYPE (0=WAG.B,1-7=WAG.Ka)
SEA MARGIN OF SHAFT POWER
PROPELLER MATERIAL (0=BRONZE,1=CUNIAL)

PTPREF - pto preferences

COMPONENT NUMBER
POWER
RPM
TYPE
CHARACTERISTIC FOR BEHAVIOR
BEHAVIOR MULTIPLICATION FACTOR
MASS
LENGTH
WIDTH
HEIGHT
SHAFT HEIGHT ABOVE PTO BASE
COST

PMCHDS - prime mover choices

INSTALLATION NUMBER
COMPONENT NUMBER
DATABASE CHOICE NUMBER
CONTRACT MCR POWER
CONTRACT MCR RPM
ENGINE MARGIN
FUEL OIL CONSUMPTION
EXHAUST GAS FLOW
EXHAUST GAS TEMPERATURE
LOWER CALORIFIC VALUE OF FUEL

TRANDS - transmission choices

INSTALLATION NUMBER
COMPONENT NUMBER
DATABASE CHOICE DESCRIPTION
NUMBER OF INGOING LINKS
NUMBER OF OUTGOING LINKS
EFFICIENCY
'CUSTOM MADE' FLAG
TYPE
MAKE
SERIES
WEIGHT
CENTER OF GRAVITY: X-POSITION
CENTER OF GRAVITY: Y-POSITION
CENTER OF GRAVITY: Z-POSITION
LENGTH
WIDTH
HEIGHT
SHAFT DIAMETER
SHAFT TYPE
YIELD STRENGTH OF SHAFT MATERIAL
CLASSIFICATION DESIGN FACTOR
COST

TRNMRR - transmission normalized reduction ratios

INSTALLATION NUMBER
COMPONENT NUMBER OF TRANSMISSION
NUMBER OF LINKED COMPONENT
NORMALIZED NUMBER OF REVOLUTIONS
DESIGN MAXIMUM RPM
DESIGN MAXIMUM TORQUE

THRPDS - thruster (screw type) choices

INSTALLATION NUMBER
COMPONENT NUMBER
RPM VALUE
DIAMETER
PITCH/DIAMETER
BLADE AREA RATIO
OPEN WATER EFFICIENCY
POWER
THRUST PERCENTAGE
WEIGHT
COST
'NEW THRUSTER INTERPOLATION' FLAG

GNRLPM - general prime mover database

DATABASE NUMBER
TYPE
MAKE
SERIES
NUMBER OF CYLINDERS
2 OR 4 STROKE
DRY WEIGHT
COST

LOFFOC - 'lay-out-field' dieselengine fuel oil consumption data for mcr conditions

MAKE
SERIES
SFOC IN R1 POINT OF LAY OUT FIELD
NUMBER OF SFOC CORRECTION LINES IN LAY OUT FIELD
LEFT ENDPOINT POWER PERCENTAGE OF FIRST CORRECTION LINE
LEFT ENDPOINT RPM PERCENTAGE OF FIRST CORRECTION LINE
RIGHT LINE ENDPOINT POWER PERCENTAGE
RIGHT LINE ENDPOINT RPM PERCENTAGE
.....
.....
RIGHT LINE ENDPOINT RPM PERCENTAGE OF 10TH LINE
LOWEST CALORIFIC VALUE OF FUEL FOR OIL CONSUMPTION DATA

LOFFCP - 'lay-out-field' dieselengine fuel oil consumption data for part load condition

MAKE
SERIES
FIRST VALUE OF 50% LOAD SFOC CORRECTION LINE
SECOND VALUE OF 50% LOAD SFOC CORRECTION LINE
THIRD VALUE OF 50% LOAD SFOC CORRECTION LINE
FIRST VALUE OF 80% LOAD SFOC CORRECTION LINE
SECOND VALUE OF 80% LOAD SFOC CORRECTION LINE
THIRD VALUE OF 80% LOAD SFOC CORRECTION LINE

MCRFOC - mcr dieselengine fuel oil consumption data for mcr load condition

MAKE
SERIES
SFOC OF MCR POINT
SFOC OF ECR1 POINT
SFOC OF ECR2 POINT
LOWEST CALORIFIC VALUE OF FUEL FOR OIL CONSUMPTION DATA

MCRFCP - 'mcr' prime mover fuel oil consumption data

MAKE
SERIES
NUMBER OF LOAD PERCENTAGES (1 OR 2)
VALUE OF FIRST PERCENTAGE
SFOC FOR FIRST PERCENTAGE FOR MCR
SFOC FOR FIRST PERCENTAGE FOR ECR1
SFOC FOR FIRST PERCENTAGE FOR ECR2
VALUE OF SECOND PERCENTAGE
SFOC FOR SECOND PERCENTAGE FOR MCR
SFOC FOR SECOND PERCENTAGE FOR ECR1
SFOC FOR SECOND PERCENTAGE FOR ECR2

MCREXH - exhaust gas temperature and flow data for mcr type prime movers

MAKE
SERIES
NUMBER OF CYLINDERS
NUMBER OF AVAILABLE POWER LOAD PERCENTAGES
FIRST POWER LOAD PERCENTAGE
EXHAUST GAS FLOW FOR FIRST LOAD PERCENTAGE FOR MCR
EXHAUST GAS TEMPERATURE .... FOR MCR
EXHAUST GAS FLOW FOR FIRST LOAD PERCENTAGE FOR ECR1
EXHAUST GAS TEMPERATURE .... FOR ECR1
EXHAUST GAS FLOW FOR FIRST LOAD PERCENTAGE FOR ECR2
EXHAUST GAS TEMPERATURE .... FOR ECR2
SECOND POWER LOAD PERCENTAGE
.....
.....
FOURTH POWER LOAD PERCENTAGE
.....

MCRRNG - mcr condition power and rpm values for prime movers

PRIME MOVER DATABASE NUMBER
FIRST POWER VALUE LOF ENGINE: R1 MCR ENGINE: MCR
FIRST RPM VALUE LOF ENGINE: R1 MCR ENGINE: MCR
SECOND POWER VALUE LOF ENGINE: R2 MCR ENGINE: ECR1
SECOND RPM VALUE LOF ENGINE: R2 MCR ENGINE: ECR1
THIRD POWER VALUE LOF ENGINE: R3 MCR ENGINE: ECR2
THIRD RPM VALUE LOF ENGINE: R3 MCR ENGINE: ECR2
FOURTH POWER VALUE LOF ENGINE: R4 MCR ENGINE: UNDEFINED
FOURTH RPM VALUE LOF ENGINE: R4 MCR ENGINE: UNDEFINED

OPEFLD - prime mover operating field representation

PRIME MOVER MAKE
PRIME MOVER TYPE
POWER PERCENTAGE OF POINT A
.....
POWER PERCENTAGE OF POINT E
RPM PERCENTAGE OF POINT A
.....
RPM PERCENTAGE OF POINT E
RPM PERCENTAGE OF POINT F
EXPONENT OF LINES FE AND FD

LUBOIL - prime mover lubricating oil and cylinder oil consumption data

PRIME MOVER MAKE
PRIME MOVER SERIES
CONSUMPTION DATA TYPE
MINIMUM LUBE OIL CONSUMPTION
MAXIMUM LUBE OIL CONSUMPTION
CYLINDER OIL CONSUMPTION

RENK1.DAT - gearbox selection area representation
RENK2.DAT
RENK3.DAT
RENK4.DAT
RENK5.DAT
RENK6.DAT
RENK7.DAT
LOHM1.DAT
LOHM2.DAT

first record:

NUMBER OF LINES IN SELECTION FIELD

further records:

FIRST LINE, PERFORMANCE VALUE OF FIRST REDUCTION RATIO
FIRST LINE, FIRST REDUCTION RATIO (= MINIMUM)
.....
FIRST LINE, PERFORMANCE VALUE OF 6TH REDUCTION RATIO
FIRST LINE, MAXIMUM REDUCTION RATIO
FIRST LINE, GEARBOX NAME,TYPE AND SIZE
SECOND LINE, PERFORMANCE VALUE OF FIRST REDUCTION RATIO
....
LAST LINE, GEARBOX NAME,TYPE AND SIZE

COUPL.DAT - selection data for couplings

TYPE
MAKE
SERIES
SIZE
NOMINAL TORQUE
MAXIMUM TORQUE
WEIGHT

PROPDS - storage for additional thruster design

COMPONENT NUMBER
RPM VALUE
DIAMETER
PITCH/DIAMETER
BLADE AREA RATIO
OPEN WATER EFFICIENCY
POWER
THRUST PERCENTAGE
WEIGHT
COST
'NEW THRUSTER INTERPOLATION' FLAG

LASTRC - storage for last record number of each installation descriptive file

LAST RECORD IN INSTLS
LAST RECORD CMPNTS
LAST RECORD CMPLNK
LAST RECORD TRANDS
LAST RECORD THRPDS
LAST RECORD TRNMRR
LAST RECORD PMCHDS
LAST RECORD PROPDS

APPENDIX III: Prime mover database

In this appendix the contents of the prime mover database files are printed. The database consists of 9 files, containing the database records. The structure of these records (the meaning of each number on the next pages) is described extensively in paragraph II. A future extension must be made to data describing the lay-out-field diesel engine exhaust gas data, cooling water data, compressed air data and data describing the dimensions of the engines.

PRIME MOVER DATABASE FILES

On the next pages the contents of the prime movers datafiles are given. The explanation for the contents is given in appendix IV. The value of 99999.00 or 99999 or * means that this resp. real, integer or character data is unknown.

GNRLPM table: general prime mover description

1	LOF	SULZER	RTA84M	4	2	630.00 99999.00
2	LOF	SULZER	RTA84M	5	2	760.00 99999.00
3	LOF	SULZER	RTA84M	6	2	890.00 99999.00
4	LOF	SULZER	RTA84M	7	2	1020.00 99999.00
5	LOF	SULZER	RTA84M	8	2	1190.00 99999.00
6	LOF	SULZER	RTA84M	9	2	1320.00 99999.00
7	LOF	SULZER	RTA84M	10	2	1440.00 99999.00
8	LOF	SULZER	RTA84M	12	2	1700.00 99999.00
9	LOF	SULZER	RTA84	4	2	590.00 99999.00
10	LOF	SULZER	RTA84	5	2	710.00 99999.00
11	LOF	SULZER	RTA84	6	2	830.00 99999.00
12	LOF	SULZER	RTA84	7	2	950.00 99999.00
13	LOF	SULZER	RTA84	8	2	1110.00 99999.00
14	LOF	SULZER	RTA84	9	2	1235.00 99999.00
15	LOF	SULZER	RTA84	10	2	1350.00 99999.00
16	LOF	SULZER	RTA84	12	2	1590.00 99999.00
17	LOF	SULZER	RTA76	4	2	450.00 99999.00
18	LOF	SULZER	RTA76	5	2	545.00 99999.00
19	LOF	SULZER	RTA76	6	2	640.00 99999.00
20	LOF	SULZER	RTA76	7	2	730.00 99999.00
21	LOF	SULZER	RTA76	8	2	825.00 99999.00
22	LOF	SULZER	RTA76	9	2	950.00 99999.00
23	LOF	SULZER	RTA76	10	2	1045.00 99999.00
24	LOF	SULZER	RTA76	12	2	1230.00 99999.00
25	LOF	SULZER	RTA72	4	2	99999.00 99999.00
26	LOF	SULZER	RTA72	5	2	99999.00 99999.00
27	LOF	SULZER	RTA72	6	2	99999.00 99999.00
28	LOF	SULZER	RTA72	7	2	99999.00 99999.00
29	LOF	SULZER	RTA72	8	2	99999.00 99999.00
30	LOF	SULZER	RTA68	4	2	335.00 99999.00
31	LOF	SULZER	RTA68	5	2	400.00 99999.00
32	LOF	SULZER	RTA68	6	2	470.00 99999.00
33	LOF	SULZER	RTA68	7	2	535.00 99999.00
34	LOF	SULZER	RTA68	8	2	605.00 99999.00
35	LOF	SULZER	RTA62	4	2	250.00 99999.00
36	LOF	SULZER	RTA62	5	2	295.00 99999.00
37	LOF	SULZER	RTA62	6	2	340.00 99999.00
38	LOF	SULZER	RTA62	7	2	385.00 99999.00
39	LOF	SULZER	RTA62	8	2	430.00 99999.00
40	LOF	SULZER	RTA58	4	2	220.00 99999.00
41	LOF	SULZER	RTA58	5	2	265.00 99999.00
42	LOF	SULZER	RTA58	6	2	305.00 99999.00
43	LOF	SULZER	RTA58	7	2	350.00 99999.00
44	LOF	SULZER	RTA58	8	2	395.00 99999.00
45	LOF	SULZER	RTA58	9	2	440.00 99999.00
46	LOF	SULZER	RTA52	4	2	155.00 99999.00
47	LOF	SULZER	RTA52	5	2	185.00 99999.00
48	LOF	SULZER	RTA52	6	2	210.00 99999.00
49	LOF	SULZER	RTA52	7	2	245.00 99999.00
50	LOF	SULZER	RTA52	8	2	270.00 99999.00
51	LOF	SULZER	RTA48	4	2	154.00 99999.00
52	LOF	SULZER	RTA48	5	2	180.00 99999.00
53	LOF	SULZER	RTA48	6	2	205.00 99999.00
54	LOF	SULZER	RTA48	7	2	240.00 99999.00
55	LOF	SULZER	RTA48	8	2	265.00 99999.00
56	LOF	SULZER	RTA48	9	2	290.00 99999.00
57	LOF	SULZER	RTA38	4	2	72.00 99999.00
58	LOF	SULZER	RTA38	5	2	83.00 99999.00

59	LOF	SULZER	RTA38	6	2	95.00	99999.00
60	LOF	SULZER	RTA38	7	2	110.00	99999.00
61	LOF	SULZER	RTA38	8	2	122.00	99999.00
62	LOF	SULZER	RTA38	9	2	134.00	99999.00
63	MCR	SULZER	AT25	5	4	99999.00	99999.00
64	MCR	SULZER	AT25	6	4	99999.00	99999.00
65	MCR	SULZER	AT25	6	4	99999.00	99999.00
66	MCR	SULZER	AT25	8	4	99999.00	99999.00
67	MCR	SULZER	AT25	8	4	99999.00	99999.00
68	MCR	SULZER	AT25	12	4	99999.00	99999.00
69	MCR	SULZER	AT25	12	4	99999.00	99999.00
70	MCR	SULZER	AT25	16	4	99999.00	99999.00
71	MCR	SULZER	AT25	16	4	99999.00	99999.00
72	MCR	SULZER	AT25	18	4	99999.00	99999.00
73	MCR	SULZER	AT25	18	4	99999.00	99999.00
74	MCR	SULZER	ZA40S	6	4	59.00	99999.00
75	MCR	SULZER	ZA40S	8	4	78.00	99999.00
76	MCR	SULZER	ZA40S	9	4	86.00	99999.00
77	MCR	SULZER	ZA40S	12	4	102.00	99999.00
78	MCR	SULZER	ZA40S	13	4	119.00	99999.00
79	MCR	SULZER	ZA40S	14	4	132.00	99999.00
80	MCR	SULZER	ZA40S	18	4	145.00	99999.00
81	LOF	MAN-B&W	K90MC	4	2	770.00	99999.00
82	LOF	MAN-B&W	K90MC	5	2	885.00	99999.00
83	LOF	MAN-B&W	K90MC	6	2	1015.00	99999.00
84	LOF	MAN-B&W	K90MC	7	2	1155.00	99999.00
85	LOF	MAN-B&W	K90MC	8	2	1295.00	99999.00
86	LOF	MAN-B&W	K90MC	9	2	1430.00	99999.00
87	LOF	MAN-B&W	K90MC	10	2	1535.00	99999.00
88	LOF	MAN-B&W	K90MC	11	2	1685.00	99999.00
89	LOF	MAN-B&W	K90MC	12	2	1820.00	99999.00
90	LOF	MAN-B&W	S70MC	4	2	435.00	99999.00
91	LOF	MAN-B&W	S70MC	5	2	495.00	99999.00
92	LOF	MAN-B&W	S70MC	6	2	570.00	99999.00
93	LOF	MAN-B&W	S70MC	7	2	650.00	99999.00
94	LOF	MAN-B&W	S70MC	8	2	725.00	99999.00
95	LOF	MAN-B&W	S50MC	4	2	180.00	99999.00
96	LOF	MAN-B&W	S50MC	5	2	205.00	99999.00
97	LOF	MAN-B&W	S50MC	6	2	235.00	99999.00
98	LOF	MAN-B&W	S50MC	7	2	270.00	99999.00
99	LOF	MAN-B&W	S50MC	8	2	300.00	99999.00
100	LOF	MAN-B&W	L42MC	4	2	100.00	99999.00
101	LOF	MAN-B&W	L42MC	5	2	115.00	99999.00
102	LOF	MAN-B&W	L42MC	6	2	130.00	99999.00
103	LOF	MAN-B&W	L42MC	7	2	150.00	99999.00
104	LOF	MAN-B&W	L42MC	8	2	170.00	99999.00
105	LOF	MAN-B&W	L35MC	4	2	51.00	99999.00
106	LOF	MAN-B&W	L35MC	5	2	58.00	99999.00
107	LOF	MAN-B&W	L35MC	6	2	66.00	99999.00
108	LOF	MAN-B&W	L35MC	7	2	76.00	99999.00
109	LOF	MAN-B&W	L35MC	8	2	84.00	99999.00
110	MCR	MAN-B&W	L32/36	6	4	27.00	99999.00
111	MCR	MAN-B&W	L32/36	8	4	37.00	99999.00
112	MCR	MAN-B&W	L32/36	9	4	42.00	99999.00
113	MCR	MAN-B&W	V32/36	12	4	44.00	99999.00
114	MCR	MAN-B&W	V32/36	14	4	50.00	99999.00
115	MCR	MAN-B&W	V32/36	16	4	58.00	99999.00
116	MCR	MAN-B&W	V32/36	18	4	65.00	99999.00
117	MCR	MAN-B&W	L20/27	5	4	5.30	99999.00
118	MCR	MAN-B&W	L20/27	6	4	6.10	99999.00

119	MCR	MAN-B&W	L20/27	7	4	6.70	99999.00
120	MCR	MAN-B&W	L20/27	8	4	7.40	99999.00
121	MCR	MAN-B&W	L20/27	9	4	8.10	99999.00
122	MCR	MAN-B&W	V20/27	12	4	10.90	99999.00
123	MCR	MAN-B&W	V20/27	14	4	12.30	99999.00
124	MCR	MAN-B&W	V20/27	16	4	13.50	99999.00
125	MCR	MAN-B&W	V20/27	18	4	15.20	99999.00
126	MCR	MAN-B&W	L25/30	6	4	12.00	99999.00
127	MCR	MAN-B&W	L25/30	8	4	15.50	99999.00
128	MCR	MAN-B&W	L25/30	9	4	17.00	99999.00
129	MCR	MAN-B&W	V25/30	12	4	21.00	99999.00
130	MCR	MAN-B&W	V25/30	16	4	27.50	99999.00
131	MCR	MAN-B&W	V25/30	18	4	30.00	99999.00
132	MCR	MAN-B&W	L52/55B	6	4	102.00	99999.00
133	MCR	MAN-B&W	L52/55B	7	4	116.00	99999.00
134	MCR	MAN-B&W	L52/55B	8	4	129.00	99999.00
135	MCR	MAN-B&W	L52/55B	9	4	142.00	99999.00
136	MCR	MAN-B&W	V52/55B	10	4	129.00	99999.00
137	MCR	MAN-B&W	V52/55B	12	4	150.00	99999.00
138	MCR	MAN-B&W	V52/55B	14	4	168.00	99999.00
139	MCR	MAN-B&W	V52/55B	16	4	189.00	99999.00
140	MCR	MAN-B&W	V52/55B	18	4	208.00	99999.00
141	MCR	MAN-B&W	L40/45	6	4	59.00	99999.00
142	MCR	MAN-B&W	L40/45	7	4	67.00	99999.00
143	MCR	MAN-B&W	L40/45	8	4	75.00	99999.00
144	MCR	MAN-B&W	L40/45	9	4	82.00	99999.00
145	MCR	MAN-B&W	V40/45	12	4	92.00	99999.00
146	MCR	MAN-B&W	V40/45	14	4	104.00	99999.00
147	MCR	MAN-B&W	V40/45	16	4	117.00	99999.00
148	MCR	MAN-B&W	V40/45	18	4	129.00	99999.00
149	MCR	MAN-B&W	L58/64	6	4	148.00	99999.00
150	MCR	MAN-B&W	L58/64	7	4	168.00	99999.00
151	MCR	MAN-B&W	L58/64	8	4	187.00	99999.00
152	MCR	MAN-B&W	L58/64	9	4	205.00	99999.00
153	MCR	SWD	TM410	6	4	61.00	99999.00
154	MCR	SWD	TM410	8	4	78.00	99999.00
155	MCR	SWD	TM410	9	4	88.00	99999.00
156	MCR	SWD	TM410	12	4	98.00	99999.00
157	MCR	SWD	TM410	16	4	130.00	99999.00
158	MCR	SWD	TM410	18	4	140.00	99999.00
159	MCR	SWD	DRo210K	6	4	7.60	99999.00
160	MCR	SWD	DRo210K	8	4	9.60	99999.00
161	MCR	SWD	DRo210	6	4	7.30	99999.00
162	MCR	SWD	DRo210	8	4	9.30	99999.00
163	MCR	SWD	DR210	6	4	7.10	99999.00
164	MCR	SWD	DR210	8	4	9.00	99999.00
165	MCR	SWD	SW280	6	4	16.00	99999.00
166	MCR	SWD	SW280	8	4	20.50	99999.00
167	MCR	SWD	SW280	9	4	22.90	99999.00
168	MCR	SWD	SW280	12	4	26.80	99999.00
169	MCR	SWD	SW280	16	4	36.60	99999.00
170	MCR	SWD	SW280	18	4	40.30	99999.00
171	MCR	SWD	F240	6	4	11.50	99999.00
172	MCR	SWD	F240	8	4	14.50	99999.00
173	MCR	SWD	F240	9	4	15.70	99999.00
174	MCR	SWD	TM620	6	4	175.00	99999.00
175	MCR	SWD	TM620	8	4	225.00	99999.00
176	MCR	SWD	TM620	9	4	260.00	99999.00
177	MCR	MAK	M332C	6	4	99999.00	99999.00
178	MCR	MAK	M332C	8	4	99999.00	99999.00

179 MCR	MAK	M453C	6	4	99999.00	99999.00
180 MCR	MAK	M453C	8	4	99999.00	99999.00
181 MCR	MAK	M453C	19	4	99999.00	99999.00
182 MCR	MAK	M453C	12	4	99999.00	99999.00
183 MCR	MAK	M453C	16	4	99999.00	99999.00
184 MCR	MAK	M552C	6	4	99999.00	99999.00
185 MCR	MAK	M552C	8	4	99999.00	99999.00
186 MCR	MAK	M601C	6	4	99999.00	99999.00
187 MCR	MAK	M601C	8	4	99999.00	99999.00
188 MCR	MAK	M601C	9	4	99999.00	99999.00
189 LOF	MAN-B&W	L70MC	4	2	435.00	99999.00
190 LOF	MAN-B&W	L70MC	5	2	495.00	99999.00
191 LOF	MAN-B&W	L70MC	6	2	570.00	99999.00
192 LOF	MAN-B&W	L70MC	7	2	650.00	99999.00
193 LOF	MAN-B&W	L70MC	8	2	725.00	99999.00

MCRRNG table: prime mover * lay-out-field power-rpm specification for lay-out-field type
* mcr, ecr1 and ecr2 specification for mcr type

1	13840.00	78.00	7600.00	78.00	9960.00	56.00	7600.00	56.00
2	17300.00	78.00	9500.00	78.00	12450.00	56.00	9500.00	56.00
3	20760.00	78.00	11400.00	78.00	14940.00	56.00	11400.00	56.00
4	24220.00	78.00	13300.00	78.00	17430.00	56.00	13300.00	56.00
5	27680.00	78.00	15200.00	78.00	19920.00	56.00	15200.00	56.00
6	31140.00	78.00	17100.00	78.00	22410.00	56.00	17100.00	56.00
7	34600.00	78.00	19000.00	78.00	24900.00	56.00	19000.00	56.00
8	41520.00	78.00	22800.00	78.00	29880.00	56.00	22800.00	56.00
9	13240.00	90.00	7280.00	90.00	9520.00	65.00	7280.00	65.00
10	16550.00	90.00	9100.00	90.00	11900.00	65.00	9100.00	65.00
11	19860.00	90.00	10920.00	90.00	14280.00	65.00	10920.00	65.00
12	23170.00	90.00	12740.00	90.00	16660.00	65.00	12740.00	65.00
13	26480.00	90.00	14560.00	90.00	19040.00	65.00	14560.00	65.00
14	29790.00	90.00	16380.00	90.00	21420.00	65.00	16360.00	65.00
15	33100.00	90.00	18200.00	90.00	23800.00	65.00	18200.00	65.00
16	39720.00	90.00	21840.00	90.00	28560.00	65.00	21840.00	65.00
17	10840.00	98.00	5960.00	98.00	7800.00	71.00	5960.00	71.00
18	13550.00	98.00	7450.00	98.00	9750.00	71.00	7450.00	71.00
19	16260.00	98.00	8940.00	98.00	11700.00	71.00	8940.00	71.00
20	18790.00	98.00	10430.00	98.00	13650.00	71.00	10430.00	71.00
21	21680.00	98.00	11920.00	98.00	15600.00	71.00	11920.00	71.00
22	24390.00	98.00	13410.00	98.00	17550.00	71.00	13410.00	71.00
23	27100.00	98.00	14900.00	98.00	19500.00	71.00	14900.00	71.00
24	32520.00	98.00	17880.00	98.00	23400.00	71.00	17880.00	71.00
25	10280.00	91.00	5640.00	91.00	7440.00	66.00	5640.00	66.00
26	12850.00	91.00	7050.00	91.00	9300.00	66.00	7050.00	66.00
27	15420.00	91.00	8460.00	91.00	11160.00	66.00	8460.00	66.00
28	17990.00	91.00	9870.00	91.00	13020.00	66.00	9870.00	66.00
29	20560.00	91.00	11280.00	91.00	14880.00	66.00	11280.00	66.00
30	8680.00	108.00	4760.00	108.00	6240.00	78.00	4760.00	78.00
31	10850.00	108.00	5950.00	108.00	7800.00	78.00	5950.00	78.00
32	13020.00	108.00	7140.00	108.00	9360.00	78.00	7140.00	78.00
33	15190.00	108.00	8330.00	108.00	10920.00	78.00	8330.00	78.00
34	17360.00	108.00	9520.00	108.00	12480.00	78.00	9520.00	78.00
35	7600.00	106.00	4200.00	106.00	5440.00	76.00	4200.00	76.00
36	9500.00	106.00	5250.00	106.00	6800.00	76.00	5250.00	76.00
37	11400.00	106.00	6300.00	106.00	8160.00	76.00	6300.00	76.00
38	13300.00	106.00	7350.00	106.00	9520.00	76.00	7350.00	76.00
39	15200.00	106.00	8400.00	106.00	10880.00	76.00	8400.00	76.00
40	6360.00	127.00	3480.00	127.00	4560.00	92.00	3480.00	92.00
41	7950.00	127.00	4350.00	127.00	5700.00	92.00	4350.00	92.00
42	9540.00	127.00	5220.00	127.00	6840.00	92.00	5220.00	92.00
43	11130.00	127.00	6090.00	127.00	7980.00	92.00	6090.00	92.00
44	12720.00	127.00	6960.00	127.00	9120.00	92.00	6960.00	92.00
45	14310.00	127.00	7830.00	127.00	10260.00	92.00	7830.00	92.00
46	5320.00	126.00	2960.00	126.00	3840.00	91.00	2960.00	91.00
47	6650.00	126.00	3700.00	126.00	4800.00	91.00	3700.00	91.00
48	7980.00	126.00	4440.00	126.00	5760.00	91.00	4440.00	91.00
49	9310.00	126.00	5180.00	126.00	6720.00	91.00	5180.00	91.00
50	10640.00	126.00	5920.00	126.00	7680.00	91.00	5920.00	91.00
51	4360.00	154.00	2400.00	154.00	3120.00	111.00	2400.00	111.00
52	5450.00	154.00	3000.00	154.00	3900.00	111.00	3000.00	111.00
53	6540.00	154.00	3600.00	154.00	4680.00	111.00	3600.00	111.00
54	7630.00	154.00	4200.00	154.00	5460.00	111.00	4200.00	111.00
55	8720.00	154.00	4800.00	154.00	6240.00	111.00	4800.00	111.00
56	9810.00	154.00	5400.00	154.00	7020.00	111.00	5400.00	111.00
57	2720.00	196.00	1480.00	196.00	1960.00	141.00	1480.00	141.00

58	3400.00	196.00	1850.00	196.00	2450.00	141.00	1850.00	141.00
59	4080.00	196.00	2220.00	196.00	2940.00	141.00	2220.00	141.00
60	4760.00	196.00	2590.00	196.00	3430.00	141.00	2590.00	141.00
61	5440.00	196.00	2960.00	196.00	3920.00	141.00	2960.00	141.00
62	6120.00	196.00	3330.00	196.00	4410.00	141.00	3330.00	141.00
63	800.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
64	1320.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
65	960.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
66	1760.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
67	1280.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
68	2640.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
69	1920.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
70	3520.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
71	2560.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
72	3960.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
73	2880.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
74	3960.00	510.00	3600.00	510.00	3300.00	510.00	99999.00	99999.00
75	5280.00	510.00	4800.00	510.00	4400.00	510.00	99999.00	99999.00
76	5940.00	510.00	5400.00	510.00	4950.00	510.00	99999.00	99999.00
77	7920.00	510.00	7200.00	510.00	6600.00	510.00	99999.00	99999.00
78	9240.00	510.00	8400.00	510.00	7700.00	510.00	99999.00	99999.00
79	10560.00	510.00	9600.00	510.00	8800.00	510.00	99999.00	99999.00
80	11880.00	510.00	10800.00	510.00	9900.00	510.00	99999.00	99999.00
81	15200.00	82.00	12160.00	82.00	12480.00	67.00	9960.00	67.00
82	19000.00	82.00	15200.00	82.00	15600.00	67.00	12450.00	67.00
83	22800.00	82.00	18240.00	82.00	18720.00	67.00	14940.00	67.00
84	26600.00	82.00	21280.00	82.00	21840.00	67.00	17430.00	67.00
85	30400.00	82.00	24320.00	82.00	24960.00	67.00	19920.00	67.00
86	34200.00	82.00	27360.00	82.00	28080.00	67.00	22410.00	67.00
87	38000.00	82.00	30400.00	82.00	31200.00	67.00	24900.00	67.00
88	41800.00	82.00	33440.00	82.00	34320.00	67.00	27390.00	67.00
89	45600.00	82.00	36480.00	82.00	37440.00	67.00	29880.00	67.00
90	10280.00	88.00	8200.00	88.00	8400.00	72.00	6720.00	72.00
91	12850.00	88.00	10250.00	88.00	10500.00	72.00	8400.00	72.00
92	15420.00	88.00	12300.00	88.00	12600.00	72.00	10080.00	72.00
93	17990.00	88.00	14350.00	88.00	14700.00	72.00	11760.00	72.00
94	20560.00	88.00	16400.00	88.00	16800.00	72.00	13440.00	72.00
95	5240.00	123.00	4200.00	123.00	4280.00	101.00	3440.00	101.00
96	6550.00	123.00	5250.00	123.00	5350.00	101.00	4300.00	101.00
97	7860.00	123.00	6300.00	123.00	6420.00	101.00	5160.00	101.00
98	9170.00	123.00	7350.00	123.00	7490.00	101.00	6020.00	101.00
99	10480.00	123.00	8400.00	123.00	8560.00	101.00	6880.00	101.00
100	3240.00	159.00	2600.00	159.00	2640.00	130.00	2120.00	130.00
101	4050.00	159.00	3250.00	159.00	3300.00	130.00	2650.00	130.00
102	4860.00	159.00	3900.00	159.00	3960.00	130.00	3180.00	130.00
103	5670.00	159.00	4550.00	159.00	4620.00	130.00	3710.00	130.00
104	6480.00	159.00	5200.00	159.00	5280.00	130.00	4240.00	130.00
105	2240.00	200.00	1800.00	200.00	1840.00	164.00	1480.00	164.00
106	2800.00	200.00	2250.00	200.00	2300.00	164.00	1850.00	164.00
107	3360.00	200.00	2700.00	200.00	2760.00	164.00	2220.00	164.00
108	3920.00	200.00	3150.00	200.00	3220.00	164.00	2590.00	164.00
109	4480.00	200.00	3600.00	200.00	3680.00	164.00	2960.00	164.00
110	2220.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
111	2960.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
112	3330.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
113	4440.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
114	5180.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
115	5920.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
116	6660.00	750.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
117	500.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00

118	600.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
119	700.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
120	800.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
121	900.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
122	1200.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
123	1400.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
124	1600.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
125	1800.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
126	1320.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
127	1760.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
128	1980.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
129	2640.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
130	3520.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
131	3960.00	1000.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
132	5910.00	500.00	5310.00	450.00	4650.00	450.00	99999.00	99999.00
133	6895.00	500.00	6195.00	450.00	5425.00	450.00	99999.00	99999.00
134	7880.00	500.00	7080.00	450.00	6200.00	450.00	99999.00	99999.00
135	8865.00	500.00	7965.00	450.00	6975.00	450.00	99999.00	99999.00
136	99999.00	99999.00	99999.00	99999.00	7750.00	450.00	99999.00	99999.00
137	99999.00	99999.00	99999.00	99999.00	9300.00	450.00	99999.00	99999.00
138	99999.00	99999.00	99999.00	99999.00	10850.00	450.00	99999.00	99999.00
139	99999.00	99999.00	99999.00	99999.00	12400.00	450.00	99999.00	99999.00
140	99999.00	99999.00	99999.00	99999.00	13950.00	450.00	99999.00	99999.00
141	3630.00	600.00	3300.00	600.00	99999.00	99999.00	99999.00	99999.00
142	4235.00	600.00	3850.00	600.00	99999.00	99999.00	99999.00	99999.00
143	4840.00	600.00	4400.00	600.00	99999.00	99999.00	99999.00	99999.00
144	5445.00	600.00	4950.00	600.00	99999.00	99999.00	99999.00	99999.00
145	7260.00	600.00	6600.00	600.00	99999.00	99999.00	99999.00	99999.00
146	8470.00	600.00	7700.00	600.00	99999.00	99999.00	99999.00	99999.00
147	9680.00	600.00	8800.00	600.00	99999.00	99999.00	99999.00	99999.00
148	10890.00	600.00	9900.00	600.00	99999.00	99999.00	99999.00	99999.00
149	7950.00	428.00	7290.00	428.00	6180.00	428.00	99999.00	99999.00
150	9275.00	428.00	8505.00	428.00	7210.00	428.00	99999.00	99999.00
151	10600.00	428.00	9720.00	428.00	8240.00	428.00	99999.00	99999.00
152	11925.00	428.00	10935.00	428.00	9270.00	428.00	99999.00	99999.00
153	3720.00	600.00	3150.00	600.00	99999.00	99999.00	99999.00	99999.00
154	4960.00	600.00	4200.00	600.00	99999.00	99999.00	99999.00	99999.00
155	5580.00	600.00	4750.00	600.00	99999.00	99999.00	99999.00	99999.00
156	7440.00	600.00	6300.00	600.00	99999.00	99999.00	99999.00	99999.00
157	9920.00	600.00	8400.00	600.00	99999.00	99999.00	99999.00	99999.00
158	11160.00	600.00	9500.00	600.00	99999.00	99999.00	99999.00	99999.00
159	510.00	900.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
160	680.00	900.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
161	420.00	900.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
162	560.00	900.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
163	282.00	900.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
164	376.00	900.00	99999.00	99999.00	99999.00	99999.00	99999.00	99999.00
165	1675.00	1000.00	1590.00	900.00	1450.00	750.00	99999.00	99999.00
166	2235.00	1000.00	2120.00	900.00	1935.00	750.00	99999.00	99999.00
167	2515.00	1000.00	2380.00	900.00	2170.00	750.00	99999.00	99999.00
168	3355.00	1000.00	3180.00	900.00	2900.00	750.00	99999.00	99999.00
169	4470.00	1000.00	4240.00	900.00	3870.00	750.00	99999.00	99999.00
170	5030.00	1000.00	4760.00	900.00	4340.00	750.00	99999.00	99999.00
171	1050.00	1000.00	995.00	900.00	850.00	750.00	99999.00	99999.00
172	1395.00	1000.00	1325.00	900.00	1135.00	750.00	99999.00	99999.00
173	1570.00	1000.00	1490.00	900.00	1280.00	750.00	99999.00	99999.00
174	8500.00	425.00	7200.00	400.00	99999.00	99999.00	99999.00	99999.00
175	11300.00	425.00	9600.00	400.00	99999.00	99999.00	99999.00	99999.00
176	12700.00	425.00	10800.00	400.00	99999.00	99999.00	99999.00	99999.00
177	1200.00	900.00	1000.00	750.00	99999.00	99999.00	99999.00	99999.00

178	1600.00	900.00	1300.00	750.00	99999.00	99999.00	99999.00	99999.00
179	2200.00	600.00	2000.00	600.00	1800.00	600.00	99999.00	99999.00
180	2940.00	600.00	2650.00	600.00	2400.00	600.00	99999.00	99999.00
181	3300.00	600.00	3000.00	600.00	2700.00	600.00	99999.00	99999.00
182	4400.00	600.00	4000.00	600.00	3600.00	600.00	99999.00	99999.00
183	5880.00	600.00	5300.00	600.00	4800.00	600.00	99999.00	99999.00
184	4050.00	500.00	3700.00	500.00	99999.00	99999.00	99999.00	99999.00
185	5400.00	500.00	4900.00	500.00	99999.00	99999.00	99999.00	99999.00
186	6600.00	425.00	6000.00	425.00	6000.00	400.00	99999.00	99999.00
187	8800.00	425.00	8000.00	425.00	8000.00	400.00	99999.00	99999.00
188	9900.00	425.00	9000.00	425.00	9000.00	400.00	99999.00	99999.00
189	9440.00	100.00	7560.00	100.00	7080.00	75.00	5680.00	75.00
190	11800.00	100.00	9450.00	100.00	8850.00	75.00	7100.00	75.00
191	14160.00	100.00	11340.00	100.00	10620.00	75.00	8520.00	75.00
192	16520.00	100.00	13230.00	100.00	12390.00	75.00	9940.00	75.00
193	18880.00	100.00	15120.00	100.00	14160.00	75.00	11360.00	75.00

LOFFOC table: prime mover lay out field type fuel oil consumption data

IMPORTANT! All figures were meant to be given in g/kWh. Since more manufacturer data were given in g/bhph, it was chosen to enter the specific oil consumption data in g/bhph, and convert the data internally in the program to g/kWh. No priority was given to conversion of the datafiles.

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SULZER        RTA84M         125.0  9  74.0  72.0 100.0 100.0  72.0  72.0  95.0 100.0  70.0  72.0  93.0 100.0  67.0
  72.0  88.0 100.0  64.0  72.0  83.0 100.0  60.5  72.0  77.0 100.0  55.0  72.0  70.0 100.0  50.0  73.0  62.0 100.0
  50.0  87.0  55.0 100.0  42700.00
SULZER        RTA84          126.0  7  74.0  72.0 100.0 100.0  72.0  72.0  95.0 100.0  70.0  72.0  90.0 100.0  68.0
  72.0  85.0 100.0  64.0  72.0  78.0 100.0  60.0  72.0  69.0 100.0  55.0  72.0  55.0 100.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
SULZER        RTA76          127.0  7  74.0  72.0 100.0 100.0  72.0  72.0  95.0 100.0  70.0  72.0  90.0 100.0  68.0
  72.0  85.0 100.0  64.0  72.0  78.0 100.0  60.0  72.0  69.0 100.0  55.0  72.0  55.0 100.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
SULZER        RTA72          126.0  9  74.0  72.0 100.0 100.0  72.0  72.0  95.0 100.0  70.0  72.0  93.0 100.0  67.0
  72.0  88.0 100.0  64.0  72.0  83.0 100.0  60.5  72.0  77.0 100.0  55.0  72.0  70.0 100.0  50.0  73.0  62.0 100.0
  50.0  87.0  55.0 100.0  42700.00
SULZER        RTA68          128.0  7  74.0  72.0 100.0 100.0  72.0  72.0  95.0 100.0  70.0  72.0  90.0 100.0  68.0
  72.0  85.0 100.0  64.0  72.0  78.0 100.0  60.0  72.0  69.0 100.0  55.0  72.0  55.0 100.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
SULZER        RTA62          127.0  9  74.0  72.0 100.0 100.0  72.0  72.0  95.0 100.0  70.0  72.0  93.0 100.0  67.0
  72.0  88.0 100.0  64.0  72.0  83.0 100.0  60.5  72.0  77.0 100.0  55.0  72.0  70.0 100.0  50.0  73.0  62.0 100.0
  50.0  87.0  55.0 100.0  42700.00
SULZER        RTA58          129.0  7  74.0  72.0 100.0 100.0  72.0  72.0  95.0 100.0  70.0  72.0  90.0 100.0  68.0
  72.0  85.0 100.0  64.0  72.0  78.0 100.0  60.0  72.0  69.0 100.0  55.0  72.0  55.0 100.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
SULZER        RTA52          128.0  9  74.0  72.0 100.0 100.0  72.0  72.0  95.0 100.0  70.0  72.0  93.0 100.0  67.0
  72.0  88.0 100.0  64.0  72.0  83.0 100.0  60.5  72.0  77.0 100.0  55.0  72.0  70.0 100.0  50.0  73.0  62.0 100.0
  50.0  87.0  55.0 100.0  42700.00
SULZER        RTA48          131.0  7  74.0  72.0 100.0 100.0  72.0  72.0  95.0 100.0  70.0  72.0  90.0 100.0  68.0
  72.0  85.0 100.0  64.0  72.0  78.0 100.0  60.0  72.0  69.0 100.0  55.0  72.0  55.0 100.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
SULZER        RTA38          133.0  7  74.0  72.0 100.0 100.0  72.0  72.0  95.0 100.0  70.0  72.0  90.0 100.0  68.0
  72.0  85.0 100.0  64.0  72.0  78.0 100.0  60.0  72.0  69.0 100.0  55.0  72.0  55.0 100.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
MAN-B&W       K90MC          126.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
MAN-B&W       K90-2MC        127.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
MAN-B&W       L90MC          126.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
MAN-B&W       K80MC          127.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
MAN-B&W       L80MC          127.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
MAN-B&W       S80MC          126.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
MAN-B&W       L70MC          127.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
MAN-B&W       S70MC          126.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0  42700.00
```

```
MAN-B&W        L60MC         128.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0 42700.00
MAN-B&W        S60MC         127.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0 42700.00
MAN-B&W        L50MC         129.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0 42700.00
MAN-B&W        S50MC         128.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0 42700.00
MAN-B&W        L42MC         130.0  6  75.0  75.0 100.0 100.0  72.0  75.0  96.0 100.0  69.0  75.0  92.0 100.0  66.0
  75.0  88.0 100.0  63.0  75.0  84.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0 42700.00
MAN-B&W        L35MC         132.0  5  82.0  82.0 100.0 100.0  78.0  82.0  94.0 100.0  74.0  82.0  89.0 100.0  70.0
  82.0  85.0 100.0  66.0  82.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0 42700.00
MAN-B&W        S26MC         130.0  5  75.0  75.0 100.0 100.0  71.0  75.0  94.0 100.0  67.0  75.0  89.0 100.0  63.0
  75.0  85.0 100.0  60.0  75.0  80.0 100.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0
   0.0   0.0   0.0   0.0 42700.00
```

LOFFCP table: prime mover lay out field type fuel oil consumption data at part load conditions

IMPORTANT! All figures were meant to be given in g/kWh. Since more manufacturer data were given in g/bhph, it was chosen to enter the specific oil consumption data in g/bhph, and convert the data internally in the program to g/kWh. No priority was given to conversion of the datafiles.

SULZER	RTA84M	5.0	1.7	0.6	-0.6	-1.2	-2.0
SULZER	RTA84	5.1	1.8	0.8	-0.3	-1.2	-2.0
SULZER	RTA76	5.1	1.8	0.8	-0.3	-1.2	-2.0
SULZER	RTA72	5.0	1.7	0.6	-0.6	-1.2	-2.0
SULZER	RTA68	5.1	1.8	0.8	-0.3	-1.2	-2.0
SULZER	RTA62	5.0	1.7	0.6	-0.6	-1.2	-2.0
SULZER	RTA58	5.1	1.8	0.8	-0.3	-1.2	-2.0
SULZER	RTA52	5.0	1.7	0.6	-0.6	-1.2	-2.0
SULZER	RTA48	5.1	1.8	0.8	-0.3	-1.2	-2.0
SULZER	RTA38	5.1	1.8	0.8	-0.3	-1.2	-2.0
MAN-B&W	K90MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	K90-2MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	L90MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	K80MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	L80MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	S80MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	L70MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	S70MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	L60MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	S60MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	L50MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	S50MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	L42MC	1.0	0.5	0.0	-2.0	-2.0	-2.0
MAN-B&W	L35MC	3.0	2.5	2.0	-1.0	-1.0	-1.0
MAN-B&W	S26MC	1.0	1.0	1.0	-1.0	-1.0	-1.0

MCRFOC table: prime mover MCR type fuel oil consumption data

IMPORTANT! All figures were meant to be given in g/kWh. Since more manufacturer data were given in g/bhph, it was chosen to enter the specific oil consumption data in g/bhph, and convert the data internally in the program to g/kWh. No priority was given to conversion of the datafiles.

SULZER	AT25	156.0	0.0	0.0	42700.00
SULZER	ZA40S	136.0	133.0	131.0	42700.00
MAN-B&W	L32/36	155.0	0.0	0.0	42700.00
MAN-B&W	V32/36	154.0	0.0	0.0	42700.00
MAN-B&W	L20/27	147.0	0.0	0.0	42700.00
MAN-B&W	V20/27	146.5	0.0	0.0	42700.00
MAN-B&W	L25/30	147.0	0.0	0.0	42700.00
MAN-B&W	V25/30	146.0	0.0	0.0	42700.00
MAN-B&W	L52/55B	131.5	130.0	128.0	42700.00
MAN-B&W	V52/55B	131.5	130.0	128.0	42700.00
MAN-B&W	L40/45	139.5	136.0	0.0	42700.00
MAN-B&W	V40/45	137.5	134.0	0.0	42700.00
MAN-B&W	L58/64	128.0	126.0	124.0	42700.00
SWD	TM410	135.0	131.0	0.0	42700.00
SWD	DRo210K	163.0	0.0	0.0	42700.00
SWD	DRo210	171.0	0.0	0.0	42700.00
SWD	DR210	180.0	0.0	0.0	42700.00
SWD	SW280	144.8	142.6	139.7	42700.00
SWD	F240	142.0	140.5	138.5	42700.00
SWD	TM620	129.0	126.0	0.0	42700.00
MAK	M332C	140.0	135.0	0.0	42700.00
MAK	M453C	134.0	131.0	129.0	42700.00
MAK	M552C	132.0	130.0	0.0	42700.00
MAK	M601C	130.0	129.0	129.0	42700.00

MCRFCP table: prime mover MCR type fuel oil consumption data
at part load conditions

IMPORTANT! All figures were meant to be given in g/kWh. Since more manufacturer data were given in g/bhph, it was chosen to enter the specific oil consumption data in g/bhph, and convert the data internally in the program to g/kWh. No priority was given to conversion of the datafiles.

SULZER	AT25	1	73.0	151.0	0.0	0.0	0.0	0.0	0.0	0.0
SULZER	ZA40S	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAN-B&W	L32/36	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAN-B&W	V32/36	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAN-B&W	L20/27	1	85.0	147.0	0.0	0.0	0.0	0.0	0.0	0.0
MAN-B&W	V20/27	1	85.0	146.5	0.0	0.0	0.0	0.0	0.0	0.0
MAN-B&W	L25/30	1	85.0	146.0	0.0	0.0	0.0	0.0	0.0	0.0
MAN-B&W	V25/30	1	85.0	145.0	0.0	0.0	0.0	0.0	0.0	0.0
MAN-B&W	L52/55B	1	85.0	129.5	128.5	127.0	0.0	0.0	0.0	0.0
MAN-B&W	V52/55B	1	85.0	129.5	128.5	127.0	0.0	0.0	0.0	0.0
MAN-B&W	L40/45	1	85.0	137.5	133.0	0.0	0.0	0.0	0.0	0.0
MAN-B&W	V40/45	1	85.0	135.5	131.0	0.0	0.0	0.0	0.0	0.0
MAN-B&W	L58/64	1	85.0	125.0	125.0	123.0	0.0	0.0	0.0	0.0
SWD	TM410	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SWD	DRo210K	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SWD	DRo210	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SWD	DR210	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SWD	SW280	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SWD	F240	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SWD	TM620	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MAK	M332C	2	85.0	138.3	135.7	0.0	50.0	145.6	142.0	0.0
MAK	M453C	2	85.0	133.1	130.2	128.7	50.0	138.3	136.8	138.3
MAK	M552C	2	85.0	130.9	129.4	0.0	50.0	138.3	138.3	0.0
MAK	M601C	2	85.0	130.6	129.0	129.0	50.0	139.7	138.3	138.3

MCREXH table: prime mover MCR type exhaust gas temperatures and flows at contract mcr
at part load conditions

SULZER	AT25	5	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	AT25	6	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	AT25	6	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	AT25	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	AT25	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	AT25	12	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	AT25	12	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	AT25	16	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	AT25	16	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	AT25	18	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	AT25	18	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	ZA40S	6	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	ZA40S	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	ZA40S	9	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	ZA40S	12	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	ZA40S	13	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	ZA40S	14	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SULZER	ZA40S	18	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	L32/36	6	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	L32/36	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	L32/36	9	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	V32/36	12	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	V32/36	14	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	V32/36	16	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	V32/36	18	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	L20/27	5	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	L20/27	6	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	L20/27	7	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	L20/27	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L20/27 9 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V20/27 12 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V20/27 14 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V20/27 16 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V20/27 18 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L25/30 6 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L25/30 8 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L25/30 9 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V25/30 12 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V25/30 16 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V25/30 18 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L52/55B 6 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L52/55B 7 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L52/55B 8 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L52/55B 9 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V52/55B 10 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V52/55B 12 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V52/55B 14 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V52/55B 16 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V52/55B 18 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L40/45 6 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L40/45 7 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L40/45 8 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L40/45 9 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V40/45 12 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V40/45 14 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V40/45 16 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W V40/45 18 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L58/64 6 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

MAN-B&W L58/64 7 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0

0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	L58/64	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAN-B&W	L58/64	9	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	TM410	6	4	100.0	27.200	330	0.000	0	0.000	0	85.0	24.208	330	0.000	0
0.000	0	75.0	20.944	340	0.000	0	0.000	0	50.0	15.504	340	0.000	0	0.000	0
SWD	TM410	8	4	100.0	34.500	330	0.000	0	0.000	0	85.0	30.705	330	0.000	0
0.000	0	75.0	26.565	340	0.000	0	0.000	0	50.0	19.665	340	0.000	0	0.000	0
SWD	TM410	9	4	100.0	40.900	330	0.000	0	0.000	0	85.0	36.401	330	0.000	0
0.000	0	75.0	31.493	340	0.000	0	0.000	0	50.0	23.313	340	0.000	0	0.000	0
SWD	TM410	12	4	100.0	54.500	330	0.000	0	0.000	0	85.0	48.505	330	0.000	0
0.000	0	75.0	41.965	340	0.000	0	0.000	0	50.0	31.065	340	0.000	0	0.000	0
SWD	TM410	16	4	100.0	72.500	330	0.000	0	0.000	0	85.0	64.525	330	0.000	0
0.000	0	75.0	55.825	340	0.000	0	0.000	0	50.0	41.325	340	0.000	0	0.000	0
SWD	TM410	18	4	100.0	81.700	330	0.000	0	0.000	0	85.0	72.713	330	0.000	0
0.000	0	75.0	62.909	340	0.000	0	0.000	0	50.0	46.569	340	0.000	0	0.000	0
SWD	DRo210K	6	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	DRo210K	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	DRo210	6	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	DRo210	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	DR210	6	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	DR210	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	SW280	6	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	SW280	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	SW280	9	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	SW280	12	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	SW280	16	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	SW280	18	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	F240	6	1	100.0	8.395	317	7.725	307	6.450	290	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	F240	8	1	100.0	11.210	317	10.305	307	8.610	290	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	F240	9	1	100.0	12.620	317	11.600	307	9.690	290	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	TM620	6	1	100.0	58.700	350	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	TM620	8	1	100.0	78.300	350	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
SWD	TM620	9	1	100.0	88.100	350	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAK	M332C	6	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAK	M332C	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAK	M453C	6	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0
0.000	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0	0.000	0
MAK	M453C	8	0	0.0	0.000	0	0.000	0	0.000	0	0.0	0.000	0	0.000	0

0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0
MAK M453C 19 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0
0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0
MAK M453C 12 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0
0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0
MAK M453C 16 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0
0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0
MAK M552C 6 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0
0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0
MAK M552C 8 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0
0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0
MAK M601C 6 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0
0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0
MAK M601C 8 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0
0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0
MAK M601C 9 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0
0.000 0 0.0 0.000 0 0.000 0 0.000 0 0.0 0.000 0 0.000 0 0.000 0

LUBOIL table: prime mover lubricating and cilinder oil consumption data

SULZER	RTA84M	0	99999.00	99999.00	0.80
SULZER	RTA84	0	99999.00	99999.00	0.80
SULZER	RTA76	0	99999.00	99999.00	0.80
SULZER	RTA72	0	99999.00	99999.00	0.80
SULZER	RTA68	0	99999.00	99999.00	0.80
SULZER	RTA62	0	99999.00	99999.00	0.80
SULZER	RTA58	0	99999.00	99999.00	0.80
SULZER	RTA52	0	99999.00	99999.00	0.80
SULZER	RTA48	0	99999.00	99999.00	0.80
SULZER	RTA38	0	99999.00	99999.00	0.80
MAN-B&W	K90MC	0	10.00	13.00	0.80
MAN-B&W	K90-2MC	0	10.00	13.00	0.80
MAN-B&W	L90MC	0	10.00	13.00	0.80
MAN-B&W	K80MC	0	8.00	10.00	0.80
MAN-B&W	L80MC	0	8.00	10.00	0.80
MAN-B&W	S80MC	0	9.00	11.00	0.80
MAN-B&W	L70MC	0	6.00	8.00	0.80
MAN-B&W	S70MC	0	7.00	9.00	0.80
MAN-B&W	L60MC	0	5.00	6.00	0.80
MAN-B&W	S60MC	0	5.00	7.00	0.80
MAN-B&W	L50MC	0	3.00	4.00	0.80
MAN-B&W	S50MC	0	4.00	5.00	0.80
MAN-B&W	L42MC	0	2.00	3.00	0.80
MAN-B&W	L35MC	0	2.00	3.00	0.80
MAN-B&W	S26MC	0	1.00	2.00	0.80
SULZER	AT25	0	99999.00	99999.00	99999.00
SULZER	ZA40S	0	99999.00	99999.00	99999.00
MAN-B&W	L32/36	0	99999.00	99999.00	99999.00
MAN-B&W	V32/36	0	99999.00	99999.00	99999.00
MAN-B&W	L20/27	0	99999.00	99999.00	99999.00
MAN-B&W	V20/27	0	99999.00	99999.00	99999.00
MAN-B&W	L25/30	0	99999.00	99999.00	99999.00
MAN-B&W	V25/30	0	99999.00	99999.00	99999.00
MAN-B&W	L52/55B	0	99999.00	99999.00	99999.00
MAN-B&W	V52/55B	0	99999.00	99999.00	99999.00
MAN-B&W	L40/45	0	99999.00	99999.00	99999.00
MAN-B&W	V40/45	0	99999.00	99999.00	99999.00
MAN-B&W	L58/64	0	99999.00	99999.00	99999.00
SWD	TM410	2	16.20	20.25	99999.00
SWD	DRo210K	1	3.90	4.41	99999.00
SWD	DRo210	1	3.90	4.41	99999.00
SWD	DR210	1	3.90	4.41	99999.00
SWD	SW280	1	3.90	4.41	99999.00
SWD	F240	1	3.90	4.41	99999.00
SWD	TM620	2	39.60	49.50	99999.00
MAK	M332C	3	24.00	24.00	99999.00
MAK	M453C	3	24.00	24.00	99999.00
MAK	M552C	3	24.00	24.00	99999.00
MAK	M601C	3	24.00	24.00	99999.00

OPEFLD table: prime mover operating field specification

SULZER	MCR	100.00	100.00	110.00	90.00	95.00	100.00	104.00	108.00	90.00	95.00	30.00	2.50
SULZER	LOF	100.00	100.00	110.00	90.00	95.00	100.00	104.00	108.00	90.00	95.00	30.00	2.50
MAN-B&W	MCR	100.00	100.00	110.00	90.00	95.00	100.00	104.00	108.00	90.00	95.00	30.00	2.50
MAN-B&W	LOF	100.00	103.30	110.00	91.00	97.00	100.00	103.30	106.00	91.00	97.00	30.00	2.50
SWD	MCR	100.00	100.00	110.00	90.00	95.00	100.00	104.00	108.00	90.00	95.00	30.00	2.50
MAK	MCR	100.00	100.00	110.00	90.00	95.00	100.00	104.00	108.00	90.00	95.00	30.00	2.50

APPENDIX IV: Transmission database

In this appendix the contents of the transmission database files are printed. The database consists of 10 files, containing the database records. The structure of these records (the meaning of each number on the next pages) is described extensively in paragraph II.

RENK1 table: the representation of the RENK HSU type gearbox selection area

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0.500	1.4	0.400	2.0	0.250	3.0	0.170	4.0	0.130	5.0	0.100	6.4	6.4	TOO BIG
0.965	1.4	0.680	2.0	0.460	3.0	0.295	4.0	0.215	5.0	0.140	6.4	6.4	RENK HSU280
1.350	1.4	0.990	2.0	0.610	3.0	0.420	4.0	0.310	5.0	0.210	6.4	6.4	RENK HSU315
1.900	1.4	1.400	2.0	0.880	3.0	0.600	4.0	0.440	5.0	0.290	6.4	6.4	RENK HSU355
2.700	1.4	1.970	2.0	1.230	3.0	0.850	4.0	0.625	5.0	0.420	6.4	6.4	RENK HSU400
3.800	1.4	2.800	2.0	1.800	3.0	1.220	4.0	0.890	5.0	0.600	6.4	6.4	RENK HSU450
5.300	1.4	3.850	2.0	2.400	3.0	1.670	4.0	1.200	5.0	0.800	6.4	6.4	RENK HSU500
7.360	1.4	5.500	2.0	3.400	3.0	2.300	4.0	1.700	5.0	1.130	6.4	6.4	RENK HSU560
10.400	1.4	7.700	2.0	4.850	3.0	3.650	4.0	2.400	5.0	1.600	6.4	6.4	RENK HSU630
15.000	1.4	11.000	2.0	7.000	3.0	4.800	4.0	3.500	5.0	2.350	6.4	6.4	RENK HSU710
22.000	1.4	16.000	2.0	10.000	3.0	6.850	4.0	5.000	5.0	3.350	6.4	6.4	RENK HSU800
31.000	1.4	26.000	2.0	14.000	3.0	9.750	4.0	7.100	5.0	4.750	6.4	6.4	RENK HSU900
41.500	1.4	31.000	2.0	19.500	3.0	13.400	4.0	9.900	5.0	5.650	6.4	6.4	RENK HSU1000
68.500	1.4	43.500	2.0	27.500	3.0	18.800	4.0	13.800	5.0	9.250	6.4	6.4	RENK HSU1120

RENK2 table: the representation of the RENK NDS1 type gearbox selection area

10

0.900	1.4	0.650	2.0	0.400	3.0	0.280	4.0	0.210	5.0	0.200	5.2	5.2	TOO BIG
1.385	1.4	1.150	2.0	0.650	3.0	0.430	4.0	0.325	5.0	0.300	5.2	5.2	RENK NDS11250
1.950	1.4	1.415	2.0	0.920	3.0	0.625	4.0	0.440	5.0	0.425	5.2	5.2	RENK NDS11400
2.950	1.4	2.150	2.0	1.350	3.0	0.925	4.0	0.675	5.0	0.630	5.2	5.2	RENK NDS11600
4.150	1.4	3.000	2.0	1.930	3.0	1.300	4.0	0.950	5.0	0.890	5.2	5.2	RENK NDS11800
5.650	1.4	4.200	2.0	2.650	3.0	1.800	4.0	1.300	5.0	1.230	5.2	5.2	RENK NDS12000
8.000	1.4	5.900	2.0	3.800	3.0	2.550	4.0	1.830	5.0	1.730	5.2	5.2	RENK NDS12250
11.000	1.4	8.000	2.0	5.200	3.0	3.500	4.0	2.490	5.0	2.370	5.2	5.2	RENK NDS12500
15.500	1.4	11.300	2.0	7.300	3.0	4.950	4.0	3.600	5.0	3.350	5.2	5.2	RENK NDS12800
23.000	1.4	16.850	2.0	11.750	3.0	7.300	4.0	5.250	5.0	5.000	5.2	5.2	RENK NDS13200

RENK3 table: the representation of the RENK HSC type gearbox selection area

11

0.600	1.4	0.450	2.0	0.300	3.0	0.180	4.0	0.150	5.0	0.120	6.4	6.4	TOO BIG
0.975	1.4	0.675	2.0	0.445	3.0	0.330	4.0	0.270	5.0	0.220	6.4	6.4	RENK HSC280
1.420	1.4	0.975	2.0	0.635	3.0	0.475	4.0	0.380	5.0	0.310	6.4	6.4	RENK HSC315
2.000	1.4	1.400	2.0	0.900	3.0	0.685	4.0	0.550	5.0	0.440	6.4	6.4	RENK HSC355
2.800	1.4	1.970	2.0	1.250	3.0	0.960	4.0	0.775	5.0	0.625	6.4	6.4	RENK HSC400
4.000	1.4	2.800	2.0	1.800	3.0	1.375	4.0	1.100	5.0	0.885	6.4	6.4	RENK HSC450
5.550	1.4	3.850	2.0	2.500	3.0	1.895	4.0	1.520	5.0	1.200	6.4	6.4	RENK HSC500
7.700	1.4	5.400	2.0	3.500	3.0	2.650	4.0	2.150	5.0	1.700	6.4	6.4	RENK HSC560
11.200	1.4	7.700	2.0	5.000	3.0	3.750	4.0	3.000	5.0	2.400	6.4	6.4	RENK HSC630
16.000	1.4	11.000	2.0	7.250	3.0	5.500	4.0	4.350	5.0	3.550	6.4	6.4	RENK HSC710
25.000	1.4	17.700	2.0	10.200	3.0	7.750	4.0	6.300	5.0	5.100	6.4	6.4	RENK HSC800

RENK4 table: the representation of the RENK HSCZ type gearbox selection area

6

15.000	1.9	14.000	2.0	8.500	3.0	7.500	4.0	5.500	5.0	5.500	5.1	5.1	TOO BIG
23.300	1.9	22.200	2.0	14.400	3.0	11.850	4.0	8.800	5.0	8.600	5.1	5.1	RENK HSCZ710
33.200	1.9	31.500	2.0	20.650	3.0	15.550	4.0	12.350	5.0	12.150	5.1	5.1	RENK HSCZ800
47.800	1.9	45.000	2.0	30.600	3.0	23.300	4.0	17.850	5.0	17.500	5.1	5.1	RENK HSCZ900
65.000	1.9	61.500	2.0	40.400	3.0	30.700	4.0	24.600	5.0	24.000	5.1	5.1	RENK HSCZ1000
92.000	1.9	87.500	2.0	56.500	3.0	42.900	4.0	34.500	5.0	33.800	5.1	5.1	RENK HSCZ1120

RENK5 table: the representation of the RENK NDS2 type gearbox selection area

10

1.125	1.4	0.812	2.0	0.500	3.0	0.350	4.0	0.262	5.0	0.250	5.2	5.2	TOO BIG
1.731	1.4	1.437	2.0	0.812	3.0	0.537	4.0	0.406	5.0	0.375	5.2	5.2	RENK NDS21250
2.437	1.4	1.769	2.0	1.150	3.0	0.781	4.0	0.550	5.0	0.531	5.2	5.2	RENK NDS21400
3.687	1.4	2.687	2.0	1.687	3.0	1.156	4.0	0.844	5.0	0.787	5.2	5.2	RENK NDS21600
5.187	1.4	3.750	2.0	2.412	3.0	1.625	4.0	1.187	5.0	1.112	5.2	5.2	RENK NDS21800
7.062	1.4	5.250	2.0	3.312	3.0	2.250	4.0	1.625	5.0	1.537	5.2	5.2	RENK NDS22000
10.000	1.4	7.375	2.0	4.750	3.0	3.187	4.0	2.287	5.0	2.162	5.2	5.2	RENK NDS22250
13.750	1.4	10.000	2.0	6.500	3.0	4.375	4.0	3.112	5.0	2.962	5.2	5.2	RENK NDS22500
19.375	1.4	14.125	2.0	9.125	3.0	6.187	4.0	4.500	5.0	4.187	5.2	5.2	RENK NDS22800
28.750	1.4	21.062	2.0	14.687	3.0	9.125	4.0	6.562	5.0	6.250	5.2	5.2	RENK NDS23200

RENK6 table: the representation of the RENK NDS3 type gearbox selection area

10

1.431	1.4	1.034	2.0	0.636	3.0	0.445	4.0	0.334	5.0	0.318	5.2	5.2	TOO BIG
2.203	1.4	1.829	2.0	1.034	3.0	0.684	4.0	0.517	5.0	0.477	5.2	5.2	RENK NDS31250
3.102	1.4	2.251	2.0	1.464	3.0	0.994	4.0	0.700	5.0	0.676	5.2	5.2	RENK NDS31400
4.693	1.4	3.420	2.0	2.148	3.0	1.472	4.0	1.074	5.0	1.002	5.2	5.2	RENK NDS31600
6.602	1.4	4.773	2.0	3.070	3.0	2.068	4.0	1.511	5.0	1.416	5.2	5.2	RENK NDS31800
8.989	1.4	6.682	2.0	4.216	3.0	2.864	4.0	2.068	5.0	1.957	5.2	5.2	RENK NDS32000
12.727	1.4	9.386	2.0	6.045	3.0	4.057	4.0	2.911	5.0	2.752	5.2	5.2	RENK NDS32250
17.500	1.4	12.727	2.0	8.273	3.0	5.568	4.0	3.961	5.0	3.770	5.2	5.2	RENK NDS32500
24.659	1.4	17.977	2.0	11.614	3.0	7.875	4.0	5.727	5.0	5.330	5.2	5.2	RENK NDS32800
36.591	1.4	26.807	2.0	18.693	3.0	11.6134.0		8.352	5.0	7.955	5.2	5.2	RENK NDS33200

RENK7 table: the representation of the RENK NDS4 type gearbox selection area

10

1.800	1.4	1.300	2.0	0.800	3.0	0.560	4.0	0.420	5.0	0.400	5.2	5.2	TOO BIG
2.770	1.4	2.300	2.0	1.300	3.0	0.860	4.0	0.650	5.0	0.600	5.2	5.2	RENK NDS41250
3.900	1.4	2.830	2.0	1.840	3.0	1.250	4.0	0.880	5.0	0.850	5.2	5.2	RENK NDS41400
5.900	1.4	4.300	2.0	2.700	3.0	1.850	4.0	1.350	5.0	1.260	5.2	5.2	RENK NDS41600
8.300	1.4	6.000	2.0	3.860	3.0	2.600	4.0	1.900	5.0	1.780	5.2	5.2	RENK NDS41800
11.300	1.4	8.400	2.0	5.300	3.0	3.600	4.0	2.600	5.0	2.460	5.2	5.2	RENK NDS42000
16.000	1.4	11.800	2.0	7.600	3.0	5.100	4.0	3.680	5.0	3.460	5.2	5.2	RENK NDS42250
22.000	1.4	16.000	2.0	10.400	3.0	7.000	4.0	4.980	5.0	4.740	5.2	5.2	RENK NDS42500
31.000	1.4	22.600	2.0	14.600	3.0	9.900	4.0	7.200	5.0	6.700	5.2	5.2	RENK NDS42800
46.000	1.4	33.700	2.0	23.500	3.0	14.600	4.0	10.500	5.0	10.000	5.2	5.2	RENK NDS43200

LOHM1 table: the representation of the LOHMANN GC type gearbox selection area

13

2.675 2.0	2.675 2.0	1.620 3.0	1.000 4.0	9.999 9.999	8.999 8.999 4.0	LOHMANN GC450
3.330 2.0	3.330 2.0	2.200 3.0	1.450 4.0	0.430 4.050	8.999 8.999 4.050	LOHMANN GC500
4.740 2.0	4.740 2.0	3.120 3.0	2.150 3.95	9.999 9.999	8.999 8.999 3.95	LOHMANN GC560
6.300 2.0	6.300 2.0	4.250 3.0	2.900 4.0	2.450 4.45	8.999 8.999 4.45	LOHMANN GC600
7.150 2.0	7.150 2.0	4.770 3.0	3.200 4.0	2.650 4.5	8.999 8.999 4.5	LOHMANN GC630
8.200 2.0	8.200 2.0	5.450 3.0	3.680 4.0	2.900 4.6	8.999 8.999 4.6	LOHMANN GC665
10.7002.0	10.7002.0	6.800 3.0	4.400 4.0	3.730 4.4	8.999 8.999 4.4	LOHMANN GC710
12.3002.0	12.3002.0	8.200 3.0	5.530 4.0	4.650 4.43	8.999 8.999 4.43	LOHMANN GC750
14.7002.0	14.7002.0	9.450 3.0	6.200 4.0	5.100 4.45	8.999 8.999 4.45	LOHMANN GC800
17.5002.0	17.5002.0	11.5003.0	7.750 4.0	6.400 4.65	8.999 8.999 4.65	LOHMANN GC850
21.5002.0	21.5002.0	14.0003.0	9.300 4.0	7.900 4.38	8.999 8.999 4.38	LOHMANN GC900
25.8002.0	25.8002.0	16.3003.0	10.7004.0	8.850 4.43	8.999 8.999 4.43	LOHAMNN GC950
30.7002.0	30.7002.0	20.3003.0	13.6004.0	11.3004.5	8.999 8.999 4.5	LOHMANN GC1000

LOHM2 table: the representation of the LOHMANN GVA type gearbox selection area

16

9.999	2.0	3.750	2.0	2.650	3.0	1.870	4.0	1.450	5.0	1.175	6.0	6.0	UP
9.999	2.0	4.200	2.0	2.880	3.0	2.130	4.0	1.650	5.0	1.350	6.0	6.0	LOHMANN GVA1000B
9.999	2.0	5.250	2.0	3.500	3.0	2.560	4.0	1.960	5.0	1.580	6.0	6.0	UP
9.999	2.0	5.850	2.0	4.000	3.0	2.940	4.0	2.250	5.0	1.850	6.0	6.0	LOHMANN GVA1120B
9.999	2.0	6.850	2.0	4.650	3.0	3.350	4.0	2.600	5.0	2.580	6.0	6.0	UP
9.999	2.0	7.800	2.0	5.300	3.0	3.900	4.0	3.100	5.0	2.470	6.0	6.0	LOHMANN GVA1250B
9.999	2.0	10.250	2.0	6.900	3.0	5.100	4.0	3.850	5.0	3.200	6.0	6.0	UP
9.999	2.0	11.350	2.0	7.750	3.0	5.700	4.0	4.500	5.0	3.650	6.0	6.0	LOHMANN GVA1400B
9.999	2.0	12.400	2.0	8.400	3.0	6.150	4.0	4.700	5.0	3.800	6.0	6.0	UP
9.999	2.0	13.700	2.0	9.400	3.0	6.850	4.0	5.350	5.0	4.350	6.0	6.0	LOHMANN GVA1500B
9.999	2.0	17.500	2.0	11.800	3.0	8.500	4.0	6.550	5.0	5.300	6.0	6.0	UP
9.999	2.0	19.700	2.0	13.500	3.0	9.850	4.0	7.650	5.0	6.250	6.0	6.0	LOHMANN GVA1700B
9.999	2.0	24.300	2.0	16.400	3.0	12.000	4.0	9.300	5.0	7.600	6.0	6.0	UP
9.999	2.0	27.000	2.0	18.350	3.0	13.600	4.0	10.500	5.0	8.500	6.0	6.0	LOHMANN GVA1875B
9.999	2.0	32.000	2.0	21.200	3.0	15.600	4.0	12.000	5.0	9.750	6.0	6.0	UP
9.999	2.0	35.000	2.0	23.800	3.0	17.700	4.0	13.750	5.0	11.100	6.0	6.0	LOHMANN GVA2050B

COUPL.DAT : database file for flexible couplings

FLEX VULKAN	EZR	0412	0.40	1.20	3.3
FLEX VULKAN	EZR	0422	0.50	1.50	3.3
FLEX VULKAN	EZR	0512	0.63	1.90	4.6
FLEX VULKAN	EZR	0522	0.75	2.30	4.6
FLEX VULKAN	EZR	0612	1.00	3.00	7.6
FLEX VULKAN	EZR	0622	1.25	3.75	7.6
FLEX VULKAN	EZR	0712	1.60	4.80	12.8
FLEX VULKAN	EZR	0722	2.00	6.00	12.8
FLEX VULKAN	EZR	0732	2.50	7.50	12.8
FLEX VULKAN	EZR	0812	3.15	9.45	26.4
FLEX VULKAN	EZR	0822	4.00	12.00	26.4
FLEX VULKAN	EZR	1012	5.00	15.00	40.1
FLEX VULKAN	EZR	1022	6.30	18.90	40.1
FLEX VULKAN	EZR	1202	8.00	24.00	62.9
FLEX VULKAN	EZR	1222	10.00	30.00	62.9
FLEX VULKAN	EZR	1232	12.50	37.50	62.9
FLEX VULKAN	EZR	1411	16.00	48.00	107.1
FLEX VULKAN	EZR	1412	16.00	48.00	103.0
FLEX VULKAN	EZR	1421	20.00	60.00	107.1
FLEX VULKAN	EZR	1422	20.00	60.00	103.0
FLEX VULKAN	EZR	1711	25.00	75.00	174.1
FLEX VULKAN	EZR	1712	25.00	75.00	168.0
FLEX VULKAN	EZR	1721	31.50	94.50	74.1
FLEX VULKAN	EZR	1722	31.50	94.50	168.0
FLEX VULKAN	EZR	2011	40.00	120.00	273.7
FLEX VULKAN	EZR	2012	40.00	120.00	262.0
FLEX VULKAN	EZR	2021	50.00	150.00	273.7
FLEX VULKAN	EZR	2022	50.00	150.00	262.0
FLEX VULKAN	EZR	2031	63.00	189.00	273.7
FLEX VULKAN	EZR	2032	63.00	189.00	262.0
FLEX VULKAN	EZR	2411	80.00	240.00	464.1
FLEX VULKAN	EZR	2412	80.00	240.00	444.0
FLEX VULKAN	EZR	2421	100.00	300.00	464.1
FLEX VULKAN	EZR	2422	100.00	300.00	444.0
FLEX VULKAN	EZR	2812	125.00	375.00	742.0
FLEX VULKAN	EZR	2822	160.00	480.00	742.0
FLEX VULKAN	EZR	3012	200.00	600.00	882.0
FLEX VULKAN	EZR	3022	250.00	750.00	882.0
FLEX VULKAN	EZR	3512	315.00	945.00	2360.0
FLEX VULKAN	EZR	3522	350.00	1050.00	99999.0
FLEX VULKAN	EZR	3812	400.00	1200.00	99999.0
FLEX VULKAN	EZR	3822	500.00	1500.00	99999.0
FLEX VULKAN	EZR	4012 V	570.00	1710.00	99999.0
FLEX VULKAN	EZR	4022 V	630.00	1890.00	99999.0
FLEX VULKAN	EZR	4212 V	720.00	2160.00	99999.0
FLEX VULKAN	EZR	4222 V	900.00	2700.00	99999.0
FLEX VULKAN	EZR	4622 T	1300.00	3900.00	99999.0

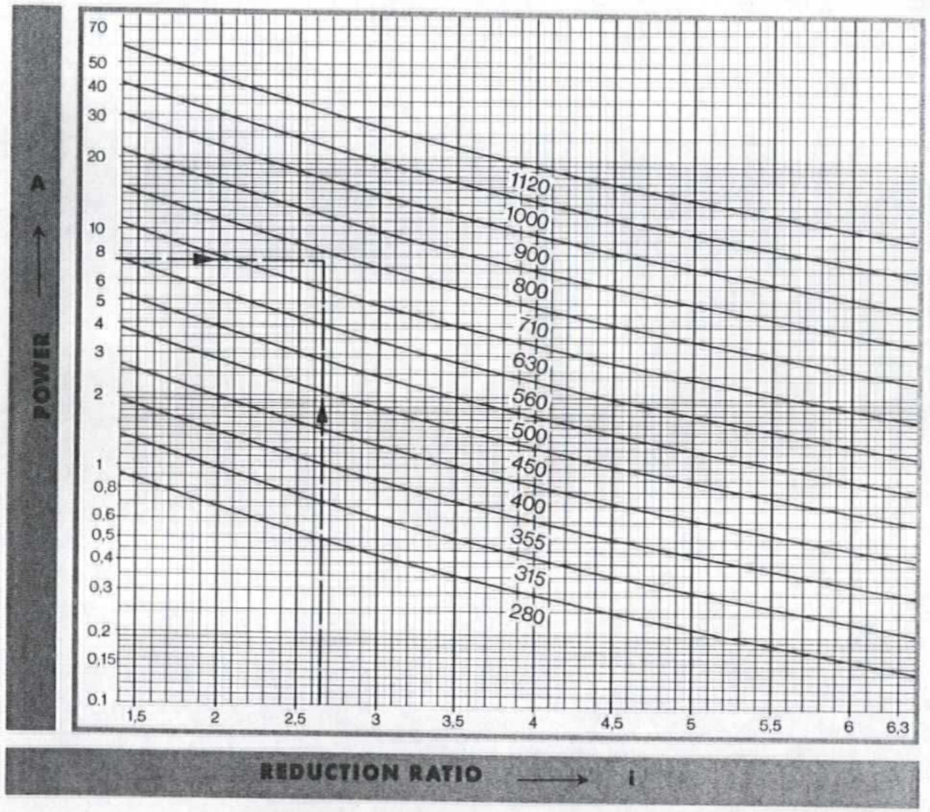
SINGLE MARINE BOXES HSU

SUPERIMPOSED SHAFTS

SELECTION GRAPH

Factors for Ice classes

German Lloyd	Lloyd's Register	Bureau Veritas	Norske Veritas	American Bureau of Shipping	Registro Italiano Navale
E f = 1,0	1* f = 1,5	I s f = 1,5	Ice breaker	A f = 1,25	RG 1 f = 1,5
E 1 f = 1,0	1 f = 1,25	I f = 1,25	bow propeller f = 2,0	B f = 1,15	RG 2 f = 1,25
E 2 f = 1,15	2 f = 1,15	II f = 1,15	Ice breaker with f = 1,5	C f = 1,0	RG 3 f = 1,15
E 3 f = 1,25	3 f = 1,0	III f = 1,0	I s - A f = 1,25		
E 4 f = 1,5			I s - B f = 1,15		
			I s - C f = 1,0		



Example of selection

$A = \frac{N}{n_i} \cdot f$

Acceptance by German Lloyd
Ice class E 2 f = 1,15
Engine power N = 3200 HP
Engine speed n_i = 500 rpm
Reduction ratio i = 2,65

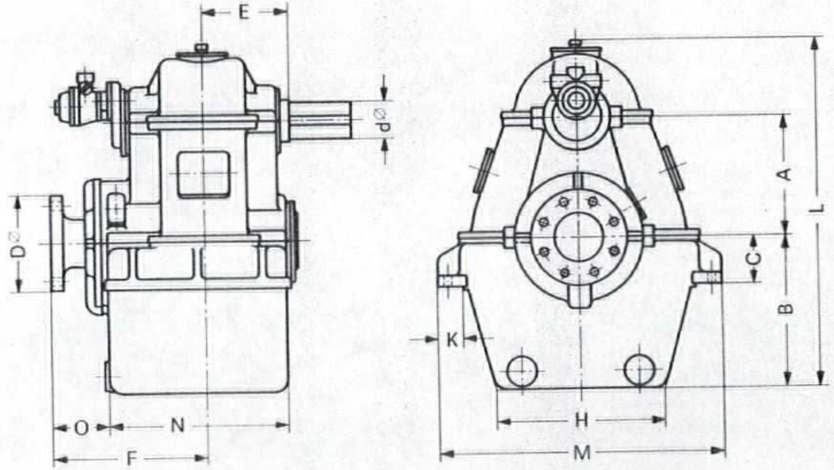
$A = \frac{N}{n_i} \cdot f = \frac{3200}{500} \cdot 1{,}15 = 7{,}36$

Gear box size: HSU – 710

SINGLE MARINE GEAR HSU

SUPERIMPOSED SHAFTS

DIMENSION TABLE



The dimensions are not strictly binding.

Series HSU Size	GEAR BOX DIMENSIONS A	B	C	D	E	F	H	K	L	M	N	O	max. d	Weight approx. kg
280	280	360	110	220	220	380	460	70	840	760	440	145	85	710
315	315	400	125	250	245	440	520	70	930	830	510	165	95	940
355	355	450	140	280	270	480	580	75	1 050	930	560	180	105	1 300
400	400	500	160	320	295	520	650	80	1 170	1 030	620	190	120	1 650
450	450	560	180	360	325	590	720	90	1 300	1 140	690	220	135	2 200
500	500	630	200	400	360	640	800	100	1 450	1 260	760	235	155	2 900
560	560	710	225	450	395	720	880	110	1 620	1 400	840	270	175	3 850
630	630	800	250	500	440	780	1 000	120	1 820	1 570	920	290	195	5 100
710	710	900	280	560	560	960	1 110	130	2 040	1 740	1 180	330	220	7 600
800	800	1 000	315	630	630	1 080	1 220	140	2 280	1 920	1 320	370	245	10 450
900	900	1 120	355	710	690	1 210	1 400	150	2 550	2 160	1 480	400	275	14 500
1 000	1 000	1 250	400	800	770	1 330	1 530	170	2 830	2 380	1 650	450	310	19 750
1 120	1 120	1 400	450	900	850	1 550	1 700	200	3 170	2 700	1 880	530	350	29 500

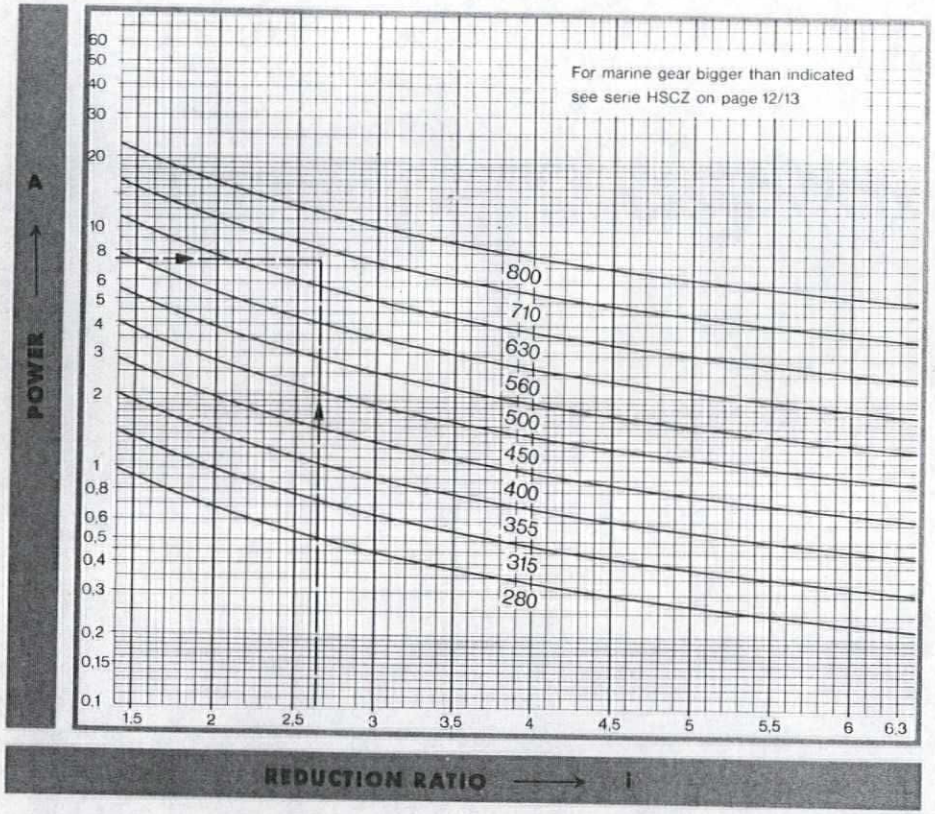
SINGLE MARINE GEAR BOX HSC

CO-AXIAL SHAFTS

SELECTION GRAPH

Factors for ice classes

German Lloyd	Lloyd's Register	Bureau Veritas	Norske Veritas	American Bureau of Shipping	Registro Italiano Navale
E f = 1,0	1* f = 1,5	Is f = 1,5	Ice breaker	A f = 1,25	RG 1 f = 1,5
E 1 f = 1,0	1 f = 1,25	I f = 1,25	bow propeller f = 2,0	B f = 1,15	RG 2 f = 1,25
E 2 f = 1,15	2 f = 1,15	II f = 1,15	Ice breaker with f = 1,5	C f = 1,0	RG 3 f = 1,15
E 3 f = 1,25	3 f = 1,0	III f = 1,0	Is - A f = 1,25		
E 4 f = 1,5			Is - B f = 1,15		
			Is - C f = 1,0		



Example of selection

$A = \frac{N}{n_1} \cdot f$

Acceptance by German Lloyd
Ice class E 2 f = 1,15
Engine power N = 3200 HP
Engine speed n_1 = 500 rpm
Reduction ratio i = 2.65

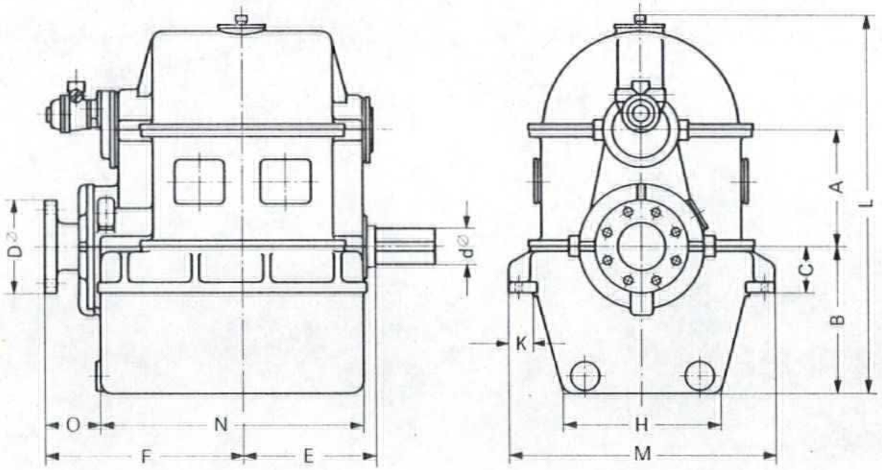
$A = \frac{N}{n_1} \cdot f = \frac{3200}{500} \cdot 1,15 = 7,36$

Gear box size: HSC – 710

SINGLE MARINE GEAR BOX HSC

CO-AXIAL SHAFTS

DIMENSION TABLE



Dimensions are not strictly binding.

Series HSC Size	A	B	C	D	E	F	H	K	L	M	N	O	max. d	Weight approx. kg
280	280	360	110	220	355	515	390	70	930	700	690	145	85	1 050
315	315	400	125	250	395	595	450	70	1 030	780	790	165	95	1 350
355	355	450	140	280	435	645	500	75	1 165	870	860	180	105	1 850
400	400	500	160	320	485	710	570	80	1 300	950	965	190	120	2 500
450	450	560	180	360	535	800	620	90	1 450	1 060	1 075	220	135	3 300
500	500	630	200	400	595	875	690	100	1 615	1 160	1 190	235	155	4 300
560	560	710	225	450	660	985	780	110	1 805	1 280	1 330	270	175	5 750
630	630	800	250	500	730	1 075	870	120	2 025	1 450	1 470	290	195	7 950
710	710	900	280	560	820	1 220	990	130	2 280	1 600	1 660	320	220	11 000
800	800	1 000	315	630	910	1 350	1 100	140	2 540	1 770	1 840	360	245	15 300

All dimensions in millimetres.

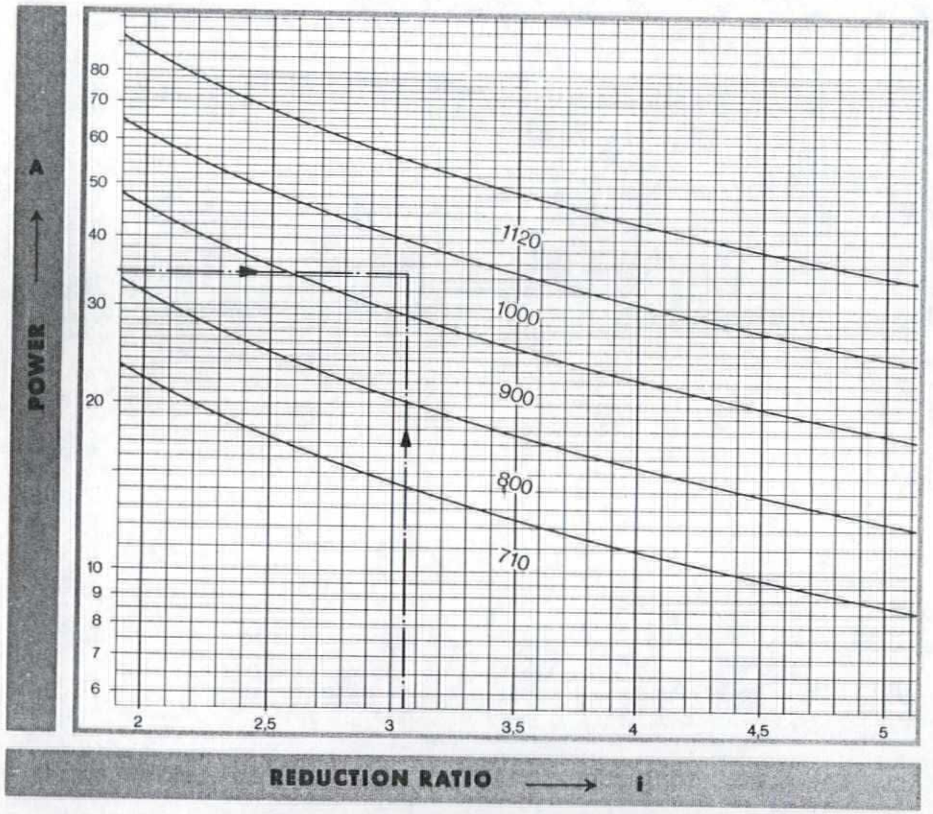
SINGLE MARINE GEAR BOX HSCZ

IN TWO WAY DESIGN, CO-AXIAL SHAFTS

SELECTION GRAPH

Factors for ice classes

German Lloyd	Lloyd's Register	Bureau Veritas	Norske Veritas	American Bureau of Shipping	Registro Italiano Navale
E f = 1,0	1* f = 1,5	Is f = 1,5	Ice breaker	A f = 1,25	RG 1 f = 1,5
E 1 f = 1,0	1 f = 1,25	I f = 1,25	bow propeller f = 2,0	B f = 1,15	RG 2 f = 1,25
E 2 f = 1,15	2 f = 1,15	II f = 1,15	Ice breaker with f = 1,5	C f = 1,0	RG 3 f = 1,15
E 3 f = 1,25	3 f = 1,0	III f = 1,0	Is - A f = 1,25		
E 4 f = 1,5			Is - B f = 1,15		
			Is - C f = 1,0		



Example of selection

$A = \frac{N}{n_1} \cdot f$

Acceptance by German Lloyd
Ice class E 2 f = 1,15
Engine power N = 15 000 HP
Engine speed n_1 = 500 rpm
Reduction ratio i = 3,05

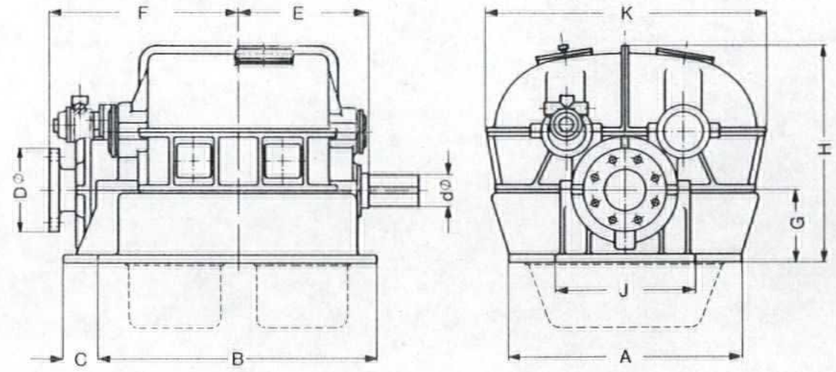
$A = \frac{N}{n_1} \cdot f = \frac{15\,000}{500} \cdot 1{,}15 = 34{,}5$

Gear box size: HSCZ – 1 000

SINGLE MARINE GEAR BOX HSCZ

IN TWO WAY DESIGN, CO-AXIAL SHAFTS

DIMENSION TABLE



Housing for oil sump can be supplied as well in welded construction as in cast iron.

Dimensions are not strictly binding.

Series HSCZ	GEAR BOX DIMENSIONS											Weight approx.
Size	A	B	C	D	E	F	G	H	J	K	max. d	kg
710	2 000	2 410	300	710	1 040	1 690	630	1 930	1 200	2 400	275	20 000
800	2 200	2 660	340	800	1 170	1 870	710	2 170	1 350	2 700	310	27 500
900	2 400	3 010	390	900	1 340	2 120	800	2 430	1 500	3 000	350	37 500
1 000	2 640	3 310	440	1 000	1 490	2 340	900	2 730	1 700	3 400	390	51 000
1 120	2 900	3 660	500	1 120	1 660	2 590	1 000	3 050	1 900	3 750	440	70 000

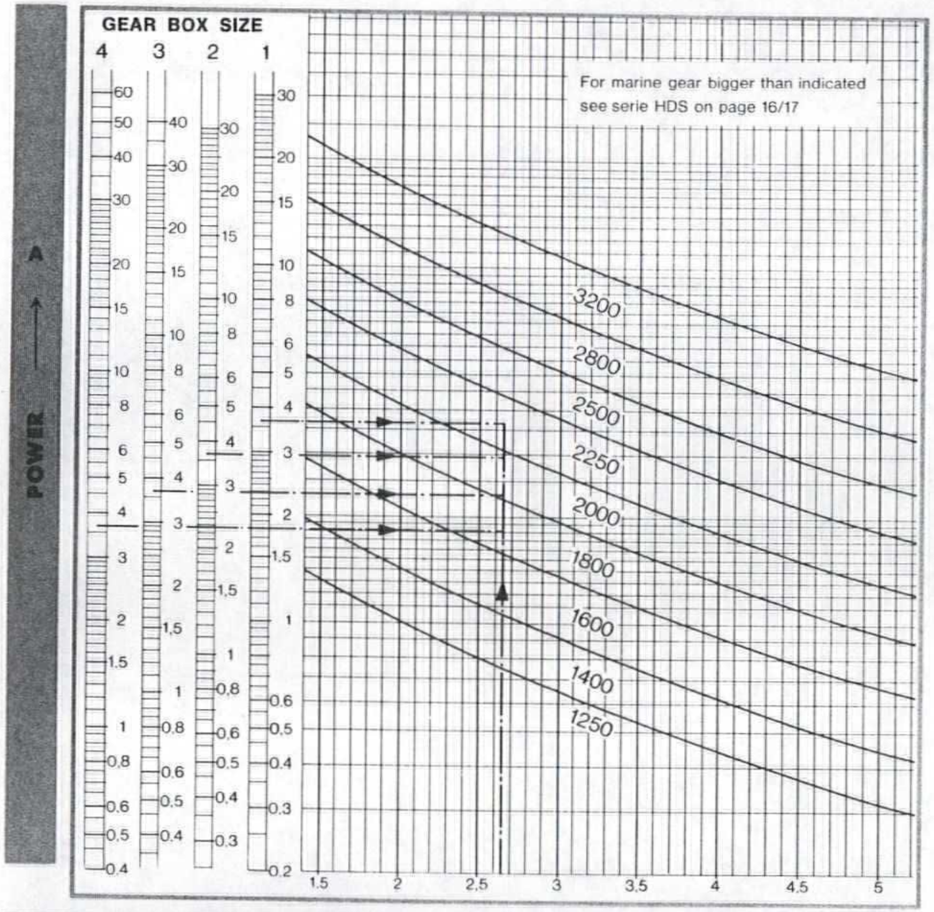
All dimensions in millimetres.

DOUBLE MARINE GEAR BOX NDS

AXIAL DISTANCE 1250 TO 3200

SELECTION GRAPH

Factors for ice classes, see page 12 or 16



REDUCTION RATIO ⟶ i

Designation for a double marine gear box in Series NDS with an engine distance of 2000 mm, size 4 = NDS 2004

Example of selection

$A = \frac{N}{n_1} \cdot f$

Acceptance by German Lloyd
Ice class E 2 f = 1,15
Engine power N = 2 x 1600 HP
Engine speed n_1 = 500 rpm
Reduction ratio i = 2,65

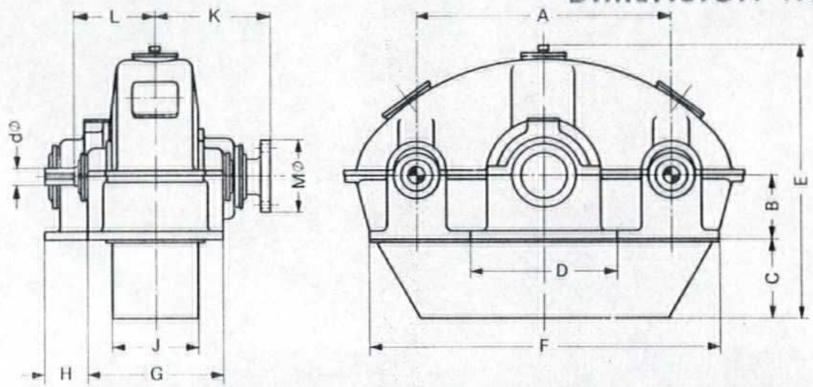
$A = \frac{N}{n_1} \cdot = f \frac{1600}{500} \cdot 1,15 = 3,68$

Gear box size: NDS – 1804
or: NDS – 2002
or: NDS – 2003
or: NDS – 2251

DOUBLE MARINE GEAR BOX NDS

AXIAL DISTANCE 1250 TO 3200

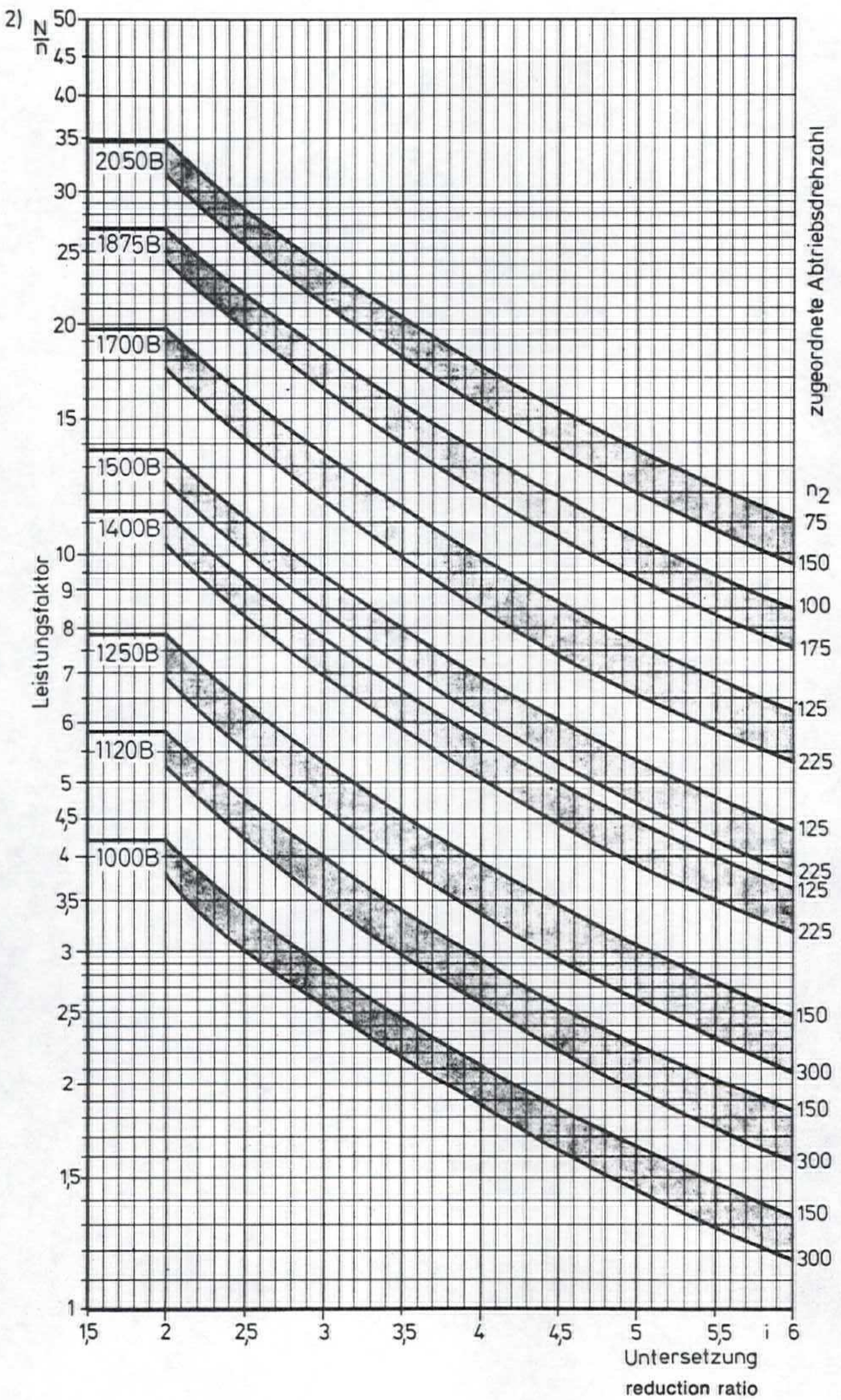
DIMENSION TABLE



Dimensions shown are maximum values, but may be reduced depending on the reduction ratio.

Series NDS Size	GEAR BOX DIMENSIONS A	B	C	D	E	F	G	H	J	K	L	M	max. d	Weight approx. kg
1 251	1 250	340	410	–	1 400	1 750	520	–	320	390	340	360	120	2 235
1 252	1 250	340	410	–	1 400	1 750	520	–	320	390	340	360	120	2 590
1 253	1 250	400	390	815	1 400	1 750	610	275	410	465	400	450	135	2 920
1 254	1 250	400	330	815	1 400	1 750	610	275	410	465	400	450	135	3 630
1 401	1 400	370	480	–	1 550	1 950	560	–	350	465	350	400	120	2 970
1 402	1 400	370	480	–	1 550	1 950	560	–	350	465	350	400	120	3 245
1 403	1 400	430	450	880	1 550	1 950	650	370	440	485	430	500	155	4 070
1 404	1 400	430	450	880	1 550	1 950	650	370	440	485	430	500	155	4 730
1 601	1 600	400	550	835	1 750	2 200	600	270	375	440	400	450	155	4 180
1 602	1 600	400	550	835	1 750	2 200	600	270	375	440	400	450	155	4 730
1 603	1 600	470	520	930	1 750	2 200	730	370	510	600	470	560	175	5 390
1 604	1 600	470	520	930	1 750	2 200	730	370	510	600	470	560	175	6 380
1 801	1 800	430	620	900	1 950	2 500	660	365	425	555	420	500	155	5 500
1 802	1 800	430	620	900	1 950	2 500	660	365	425	555	420	500	155	6 050
1 803	1 800	500	580	970	1 950	2 500	780	465	545	715	520	630	195	7 150
1 804	1 800	500	580	970	1 950	2 500	780	465	545	715	520	630	195	8 140
2 001	2 000	470	630	950	2 100	2 750	700	465	455	570	450	560	175	7 150
2 002	2 000	470	630	950	2 100	2 750	700	465	455	570	450	560	175	7 920
2 003	2 000	550	580	1 060	2 100	2 750	880	495	635	770	560	710	220	9 240
2 004	2 000	550	580	1 060	2 100	2 750	880	495	635	770	560	710	220	10 670
2 251	2 250	520	750	1 050	2 350	3 150	780	480	510	700	490	630	195	9 240
2 252	2 250	520	750	1 050	2 350	3 150	780	480	510	700	490	630	195	10 670
2 253	2 250	600	680	1 200	2 350	3 150	990	570	720	905	630	800	245	12 980
2 254	2 250	600	680	1 200	2 350	3 150	990	570	720	905	630	800	245	14 410
2 501	2 500	570	850	1 150	2 600	3 500	850	545	560	785	540	710	220	12 100
2 502	2 500	570	850	1 150	2 600	3 500	850	545	560	785	540	710	220	13 640
2 503	2 500	650	800	1 330	2 600	3 500	1 070	650	780	1 025	670	900	260	16 390
2 504	2 500	650	800	1 330	2 600	3 500	1 070	650	780	1 025	670	900	260	19 030
2 801	2 800	620	900	1 310	2 900	4 600	1 270	440	950	865	580	800	245	17 930
2 802	2 800	620	900	1 310	2 900	4 600	1 270	440	950	865	580	800	245	20 570
2 803	2 800	710	820	1 530	2 900	4 600	1 550	550	1 230	1 105	730	1 000	295	24 420
2 804	2 800	710	820	1 530	2 900	4 600	1 550	550	1 230	1 105	730	1 000	295	28 160
3 201	3 200	680	1 050	1 470	3 250	5 200	1 400	505	1 080	980	660	900	295	23 980
3 202	3 200	680	1 050	1 470	3 250	5 200	1 400	505	1 080	980	660	900	295	27 830
3 203	3 200	770	960	1 680	3 250	5 200	1 660	655	1 340	1 245	800	1 120	330	32 780
3 204	3 200	770	960	1 680	3 250	5 200	1 660	655	1 340	1 245	800	1 120	330	36 520

All dimensions in millimetres.



Anmerkungen:

1) Die Leistungsangaben der Diagramme beziehen sich jeweils auf einen Motor.

2) N = Höchst- bzw. Nennleistung eines Motors in PS
n = Motordrehzahl in U/min

Wird auf Grund des erforderlichen Achsabstandes eine Getriebegröße nicht voll ausgelastet, so bitten wir, die Größenbestimmung durch uns vornehmen zu lassen.

Remarks:

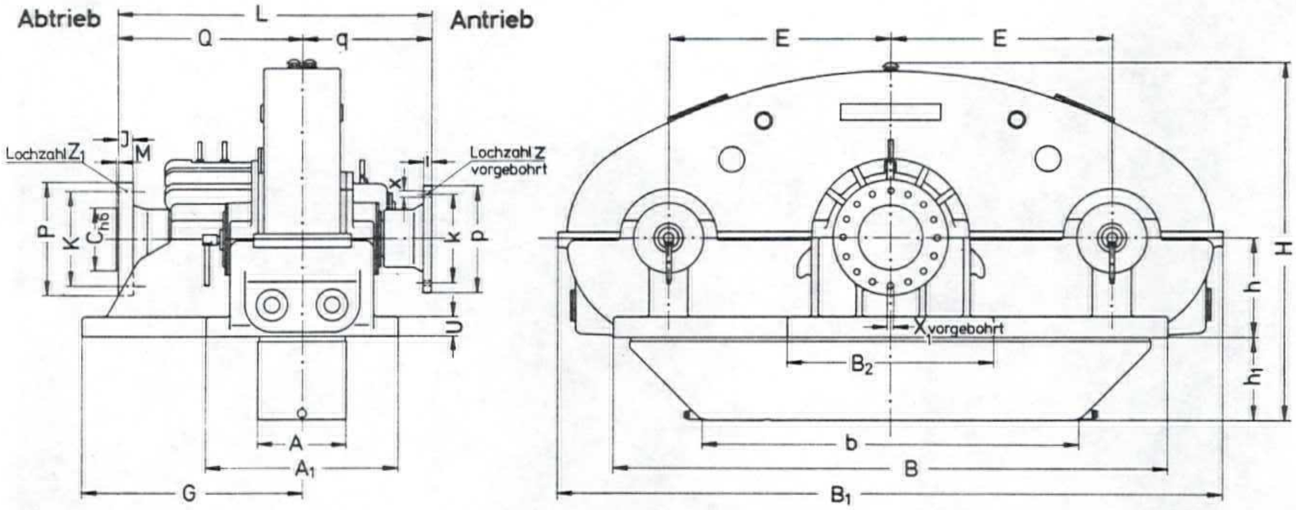
1) The rating values in the diagrams relate to only one engine

2) N = MCR of one engine in PS (DIN)
n = input speed in rpm

If a gear size is not fully employed to capacity due to the required center distance it is recommended to leave the selection to L & S.

Leistungsfactor – rating factor

zugeordnete Abtriebsdrehzahl – adjoined output speed



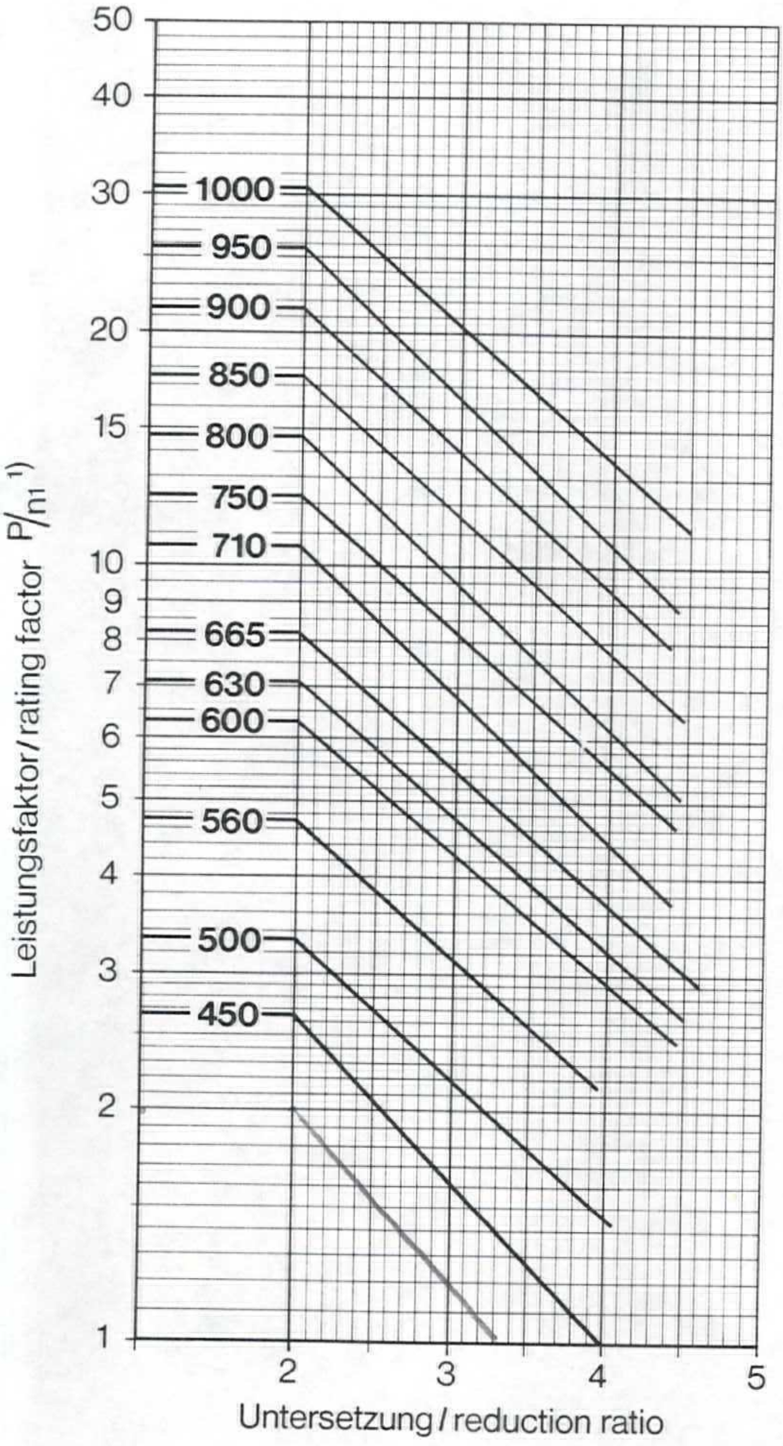
Abtrieb = output Antrieb = input Lochzahl = number of holes vorgebohrt = pilot bored

Getriebe-Größe / gear size	Antrieb ¹) / input ¹)								Abtrieb / output					Abmessungen / dimensions						Gehäuse / casing								Gewicht / weight
	p	k	i	x	z	P	K	C	M	J	Q	X_1	Z_1	A	A_1	B	B_1	B_2	b	E	G	H ²)	h	h_1 ²)	L	q	U	
					Lochzahl / number of holes								Lochzahl / number of holes	mm														kg
GVA 1000 B	480	440	36	18	16	520	440	300	10	70	910	34	16	496	900	2500	3100	1060	1470	1000	990	1900	475	485	1515	605	50	7100
GVA 1000 C	530	490	38	18	16	570	490	300	10	80	950	34	16	556	950	2500	3100	1100	1470	1000	1060	1900	500	460	1585	635	50	7950
GVA 1120 B	530	490	38	18	16	570	490	320	10	80	980	34	16	476	860	2800	3440	1130	1660	1120	1080	2100	500	560	1560	580	55	8900
GVA 1120 C	580	530	42	22	16	620	530	320	10	85	1060	39	16	586	980	2800	3440	1210	1660	1120	1150	2100	530	530	1760	700	55	9900
GVA 1250 B	580	530	42	22	16	620	530	350	10	85	1070	39	16	556	960	3140	3800	1220	1870	1250	1180	2350	560	600	1750	680	60	11400
GVA 1250 C	680	620	50	28	16	660	570	350	10	90	1100	39	16	616	1020	3140	3800	1220	1870	1250	1210	2350	600	560	1830	730	60	12800
GVA 1400 B	680	620	50	28	16	660	570	400	10	90	1115	39	16	586	1140	3440	4200	1260	2070	1400	1280	2560	630	650	1875	760	65	15250
GVA 1400 C	750	680	55	28	16	720	620	400	10	105	1200	44	16	636	1200	3440	4200	1340	2070	1400	1350	2560	670	610	2015	815	65	17950
GVA 1500 B	750	680	55	28	16	720	620	430	10	105	1180	44	16	596	1180	3660	4450	1380	2200	1500	1300	2750	670	690	2005	825	70	18500
GVA 1500 C	840	760	60	28	16	800	690	430	10	110	1270	49	16	676	1300	3660	4450	1500	2200	1500	1400	2750	710	650	2155	885	70	21600
GVA 1700 B	840	760	60	28	16	800	690	450	10	110	1300	49	16	636	1320	4180	5000	1580	2450	1700	1420	3050	710	820	2155	855	75	25000
GVA 1700 C	900	820	65	34	16	850	730	450	10	120	1355	53	16	716	1420	4180	5000	1580	2450	1700	1530	3050	750	780	2280	925	75	29100
GVA 1875 B	900	820	65	34	16	850	730	500	10	120	1370	53	16	656	1400	4600	5450	1580	2650	1875	1550	3350	750	920	2385	1015	80	30650
GVA 1875 C	1000	920	70	34	24	900	780	500	10	130	1470	53	18	696	1480	4600	5450	1690	2650	1875	1700	3350	800	870	2560	1090	80	35700
GVA 2050 B	1000	920	70	34	24	900	780	550	10	145	1560	53	18	676	1520	5000	6100	1750	3000	2050	1750	3650	850	980	2680	1120	85	41100
GVA 2050 C	1060	980	75	34	24	1000	860	550	10	160	1700	62	18	796	1620	5000	6100	1900	3000	2050	1900	3650	900	930	2900	1200	85	47500

¹) Veränderliche Maße, entsprechend der erforderlichen PNEUMAFLEX-Kupplungsgröße.
²) Die Maße H und h_1 gelten für eine Untersetzung von 4 : 1, bei kleineren und größeren Untersetzungen ändern sich die Maße entsprechend.

¹) variable measures, corresponding to the necessary size of PNEUMAFLEX clutch.
²) the measures H and h_1 are valid for a reduction ratio i = 4. For smaller or bigger ratios the measures alter correspondingly.

Auswahldiagramm / *selection diagram*[1])



Anmerkungen

Den Auslegungskurven zugrunde gelegte Drehzahlen:

Getriebegröße	Antriebs *) drehzahl max. 1/min	Abtriebs-drehzahl min. 1/min
450 bis 560	1000	110
600 bis 750	800	110
800 bis 1000	650	110

*) Bei höheren Drehzahlen erbitten wir Rückfrage.

1) Bei Abnahme durch ABS oder BV erbitten wir Rückfrage.
P = Nennleistung in kW (1 kW = 1,36 PS)
n1 = Antriebsdrehzahl in 1/min

Den Auslegungskurven liegen nachstehende Bedingungen zugrunde:
- die Reihenmotoren müssen mindestens 6 Zylinder und die V-Motoren mindestens 8 Zylinder haben
- zwischen Motor und Getriebe ist eine hochelastische Kupplung vorzusehen.

Bei anderen Bedingungen bitten wir um Rückfrage.

Remarks

The selection curves are based on following speeds:

Gear box size	*Input *) speed max. 1/min*	*Output speed min. 1/min*
450 to 560	*1000*	*110*
600 to 750	*800*	*110*
800 to 1000	*650*	*110*

**) If higher speeds are required please request.*

1) Survey ABS or BV classification on request.
P = MCR-kW (metric) acc. DIN (1 kW = 1,36 HP)
n1 = input speed in 1/min

The selection curves are based on following conditions:
- *in-line engines with more than 5 cylinders and vee-engines with more than 6 cylinders*
- *engine and gearbox to be connected by a highly elastic coupling or clutch.*

In case of different conditions please contact us.

Technische Angaben Hochelastische VULKAN-EZR Kupplungen

Technical Data Highly flexible VULKAN-EZR Couplings

Hinweise zu den Listen der Technischen Daten

1. Bei der Auswahl der Kupplungen sind die Dauerleistungen der Motoren zugrundezulegen. Überleistungen, Höchst- und Kurzhöchstleistungen nach DIN 6271 brauchen nicht berücksichtigt zu werden.

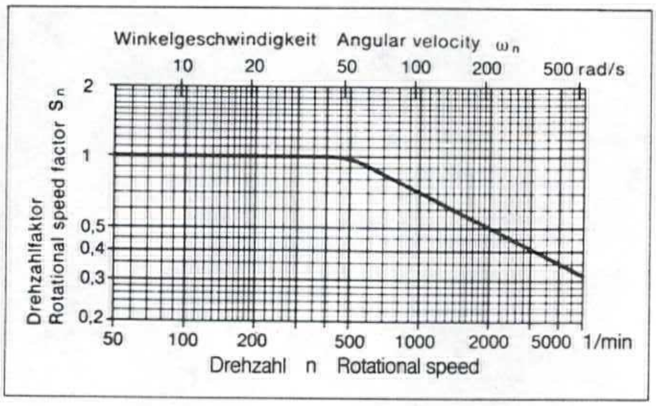
Reference for the Lists of Technical Data

1. When selecting the couplings the permanent outputs of the engines are to be taken as a basis. Overloads, peak and short peak outputs acc. to DIN 6271 need not to be taken into consideration.

$$T_N = 9{,}555 \cdot \frac{P_N\,[\mathrm{kW}]}{n_N\,[1/\mathrm{min}]}\,[\mathrm{kNm}] \qquad T_N = 716{,}2 \cdot \frac{P_N\,[\mathrm{PS}]}{n_N\,[1/\mathrm{min}]}\,[\mathrm{kpm}] \qquad T_N \leqq T_{KN}$$

2. Bezugsgröße; die zulässige Größe ΔK_r ergibt sich nach untenstehender Beziehung unter Berücksichtigung der Faktoren S_n und S_ϑ
3. Falls größere Adapterflansche verwendet werden, muß die zulässige Umfangsgeschwindigkeit überprüft werden.
4. Die Ausrichttoleranz beim Einbau ist kleiner als der zulässige Kupplungsversatz, empfohlene Ausrichttoleranzen siehe Seite 47.
6. Die statischen Drehwinkel sind ermittelt aus den Mittelpunktskurven der Hysteresisschleife mit einer Amplitude von $\pm$ 1,5 T_{KN}
7. Werte sind statisch ohne Drehmomentbelastung der Kupplung ermittelt.

2. Reference value; the permissible value ΔK_r (see below) on consideration of the factors S_n and S_ϑ.
3. When using larger adapter flanges you have to check the permissible circumferential speed.
4. The alignment tolerance for the installation is smaller than the permissible coupling displacement, recommended alignment tolerances see dimensions page 47.
6. The static torsional angles are based on the average value obtained from the hysteresis curves with an amplitude of $\pm$ 1,5 T_{KN}
7. Values are measured statically without torque load on the coupling.



zulässiger radialer Wellenversatz

$$\Delta K_r = \Delta K_r^{!} \cdot S_n \cdot S_\vartheta$$

$\vartheta \leqq 333$ K (60° C) : $S_\vartheta = 1$
$\vartheta > 333$ K (60° C) : $S_\vartheta = 0{,}6$

permissible radial shaft displacement

$n \leqq 500$ U/min : $S_n = 1$ $\qquad$ $n > 500$ U/min : $S_n = \sqrt{\dfrac{500}{n}}$

Liste

Größ
Size

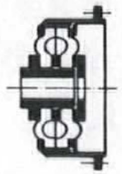
EZF

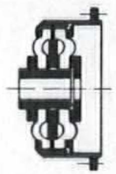
041
042
051
052
061
062
071
072
073
081
082
101
102
121
122
123
141
141
142
142
171
171
172
172
201
201
202
202
203
203
241
241

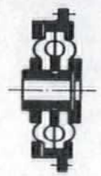
Liste der Technischen Daten — List of Technical Data

Größe Size EZR	Baugruppe Dimension Group	Zulässige Drehmomentgrößen / Permissible Torque Values: Nenndrehmoment / Nominal Torque T_{KN} [1]		Max. Drehm. / Max. Torque $T_{K max}$	Federsteife / Stiffness [7]: axial c_a [7]	radial c_r [7]	Statischer Drehwinkel / Static Torsional Angle φT_{KN} [6]	Zul. Drehz. / Permissible Rotational Speed, Material GGG $n_{K max}$ [3]	Zul. Kupplungsversatz / Permissible coupling Displacement [4]: axial ΔK_a	radial ΔK_r [2]	max. radial $\Delta K_{r max}$ [4]
		kNm	kpm	kNm	kN/mm	kN/mm	°	1/min	mm	mm	mm
0412	0402	0,40	41	1,20	0,25	0,30	11,0	5870	3,5	1,0	2,0
0422	0402	0,50	51	1,50	0,25	0,30	12,5	5870	3,5	1,0	2,0
0512	0502	0,63	64	1,90	0,45	0,50	12,0	5100	4,0	1,2	2,5
0522	0502	0,75	76	2,30	0,45	0,50	13,5	5100	4,0	1,2	2,5
0612	0602	1,00	102	3,00	0,50	0,60	13,0	4480	4,5	1,4	3,0
0622	0602	1,25	127	3,75	0,50	0,60	14,5	4480	4,5	1,4	3,0
0712	0702	1,60	163	4,80	0,65	0,95	13,5	3890	5,0	1,6	3,5
0722	0702	2,00	204	6,00	0,65	0,95	15,5	3890	5,0	1,6	3,5
0732	0702	2,50	255	7,50	0,65	0,95	17,5	3890	5,0	1,6	3,5
0812	0802	3,15	321	9,45	0,85	0,90	17,0	3330	6,0	1,9	4,0
0822	0802	4,00	408	12,00	0,85	0,90	17,0	3330	6,0	1,9	4,0
1012	1002	5,00	510	15,00	1,10	1,30	14,0	2880	7,0	2,2	4,5
1022	1002	6,30	642	18,90	1,30	1,40	15,5	2880	7,0	2,2	4,5
1212	1202	8,00	815	24,00	1,40	1,60	15,5	2550	7,5	2,5	5,0
1222	1202	10,00	1019	30,00	1,40	1,60	16,0	2550	7,5	2,5	5,0
1232	1202	12,50	1274	37,50	1,40	1,60	18,0	2550	7,5	2,5	5,0
1411	1401	16,00	1631	48,00	1,80	3,60	13,5	1840	9,0	3,5	7,0
1412	1402	16,00	1631	48,00	2,10	2,40	17,0	2150	8,0	2,9	6,0
1421	1401	20,00	2039	60,00	2,00	4,00	15,0	1840	9,0	3,5	7,0
1422	1402	20,00	2039	60,00	2,10	2,40	17,5	2150	8,0	2,9	6,0
1711	1701	25,00	2548	75,00	3,30	4,90	15,0	1540	10,0	4,0	8,0
1712	1702	25,00	2548	75,00	1,90	2,00	18,0	1840	9,0	3,5	7,0
1721	1701	31,50	3221	94,50	3,90	5,90	16,5	1540	10,0	4,0	8,0
1722	1702	31,50	3221	94,50	2,30	2,70	17,0	1840	9,0	3,5	7,0
2011	2001	40,00	4077	120,00	2,40	3,20	14,5	1340	11,0	4,5	9,0
2012	2002	40,00	4077	120,00	2,90	3,75	15,0	1540	10,0	4,0	8,0
2021	2001	50,00	5097	150,00	3,00	4,00	14,5	1340	11,0	4,5	9,0
2022	2002	50,00	5097	150,00	3,25	3,85	15,0	1540	10,0	4,0	8,0
2031	2001	63,00	6422	189,00	3,00	4,00	19,5	1340	11,0	4,5	9,0
2032	2002	63,00	6422	189,00	3,25	3,85	16,5	1540	10,0	4,0	8,0
2411	2401	80,00	8155	240,00	3,40	5,10	16,0	1170	12,0	5,0	10,0
2412	2402	80,00	8155	240,00	3,90	4,10	19,0	1340	11,0	4,5	9,0

Größe Size EZR	Baugruppe Dimension Group	Zulässige Drehmomentgrößen / Permissible Torque Values: Nenndrehmoment / Nominal Torque T_{KN} [1]		Max. Drehm. / Max. Torque $T_{K max}$	Federsteife / Stiffness [7]: axial c_a [7]	radial c_r [7]	Statischer Drehwinkel / Static Torsional Angle φT_{KN} [6]	Zul. Drehz. / Permissible Rotational Speed, Material GGG $n_{K max}$ [3]	Zul. Kupplungsversatz / Permissible coupling Displacement [4]: axial ΔK_a	radial ΔK_r [2]	max. radial $\Delta K_{r max}$ [4]
		kNm	kpm	kNm	kN/mm	kN/mm	°	1/min	mm	mm	mm
2421	2401	100,00	10194	300,00	4,50	6,40	17,0	1170	12,0	5,0	10,0
2422	2402	100,00	10194	300,00	3,90	4,00	19,5	1340	11,0	4,5	9,0
2812	2802	125,00	12742	375,00	6,00	6,00	14,5	1170	12,0	5,0	10,0
2822	2802	160,00	16310	480,00	6,00	6,00	15,5	1170	12,0	5,0	10,0
3012	3002	200,00	20387	600,00	9,00	10,00	14,5	1080	13,0	5,5	11,0
3022	3002	250,00	25484	750,00	9,00	10,00	16,5	1080	13,0	5,5	11,0
3512	3502	315,00	32110	945,00	8,00	8,50	15,0	930	14,0	5,5	11,0
3522	3502	350,00	35678	1050,00	9,90	10,60	15,5	930	14,0	5,5	11,0
3812	3802	400,00	40775	1200,00	7,50	7,80	13,5	830	14,0	6,0	12,0
3822	3802	500,00	50968	1500,00	9,00	9,50	13,5	830	14,0	6,0	12,0
4012 V		570,00	58104	1710,00	16,00	17,00	14,5	930	14,0	5,5	11,0
4022 V		630,00	64220	1890,00	19,80	21,20	15,0	930	14,0	5,5	11,0
4212 V		720,00	73395	2160,00	15,00	15,60	12,5	830	14,0	6,0	12,0
4222 V		900,00	91743	2700,00	18,00	19,00	13,0	830	14,0	6,0	12,0
4622 T		1300,00	132518	3900,00	27,00	28,50	12,5	830	14,0	6,0	12,5







Baugruppe / Dimension Group	Baureihe 1000 Series Gewicht/Weight I	A	G	J I	A	Baureihe 1001 Series Gewicht/Weight I	A	G	J I	A	Baureihe 1010 Series Gewicht/Weight I	A	G	J I	A
	kg	kg	kg	kgm²	kgm²	kg	kg	kg	kgm²	kgm²	kg	kg	kg	kgm²	kgm²
0402	3,3	5,2	8,5	0,005	0,049	3,6	5,5	9,1	0,006	0,052	3,3	3,4	6,7	0,005	0,030
0502	4,6	7,9	12,5	0,010	0,099	5,1	8,4	13,5	0,011	0,102	4,6	5,5	10,1	0,010	0,065
0602	7,6	10,5	18,1	0,018	0,172	8,6	11,2	19,8	0,022	0,180	7,6	8,1	15,7	0,018	0,124
0702	12,8	17,9	30,7	0,041	0,387	14,1	19,3	33,4	0,048	0,408	12,8	14,6	27,4	0,041	0,295
0802	26,4	25,0	51,4	0,133	0,700	28,5	27,1	55,6	0,152	0,820	26,4	19,3	45,7	0,133	0,550
1002	40,1	39,8	79,9	0,266	1,656	43,0	43,7	86,7	0,299	1,772	40,1	32,3	72,4	0,266	1,259
1202	62,9	57,4	120,3	0,589	3,217	68,8	58,4	127,2	0,686	3,244	62,9	41,5	104,4	0,589	2,212
1401	107,1	157,5	264,7	1,440	16,280	108,0	164,4	272,4	1,470	16,610	–	–	–	–	–
1402	103,0	94,2	197,2	1,314	7,038	105,0	95,7	200,7	1,349	7,101	103,0	66,4	169,4	1,314	4,671
1701	174,1	237,1	411,2	3,390	34,350	175,5	247,8	423,3	3,450	35,070	–	–	–	–	–
1702	168,0	150,0	318,0	3,081	15,740	170,0	153,0	323,0	3,163	15,900	–	–	–	–	–
2001	273,7	369,0	642,7	8,400	72,210	276,0	388,0	664,0	8,560	73,910	–	–	–	–	–
2002	262,0	241,0	503,0	6,518	35,090	265,0	247,0	512,0	6,704	35,500	–	–	–	–	–
2401	464,1	696,6	1160,7	17,640	171,900	467,0	722,0	1189,0	17,920	175,120	–	–	–	–	–
2402	444,0	369,0	813,0	15,780	72,410	448,0	378,0	826,0	16,120	73,370	–	–	–	–	–
2802	742,0	695,0	1437,0	37,050	175,800	750,0	700,0	1450,0	37,760	173,600	–	–	–	–	–
3002	882,0	938,0	1820,0	51,050	279,900	896,0	967,0	1863,0	52,680	285,400	–	–	–	–	–

Alle Gewichte und Massenträgheitsmomente beziehen sich auf vorgebohrte Naben.

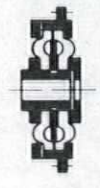
Fehlende Daten auf Anfrage.

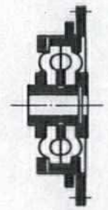
Teile: I = Innen, A = Außen, G = Gesamt

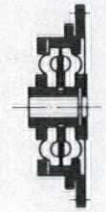
All weights and mass moments of inertia refer to pilot-bored hubs.

Data not printed on request.

Parts: I = Inner, A = Outer, G = Total







Baugruppe / Dimension Group	Baureihe 1011 Series Gewicht/Weight I	A	G	J I	A	Baureihe 1020 Series Gewicht/Weight I	A	G	J I	A	Baureihe 1021 Series Gewicht/Weight I	A	G	J I	A
	kg	kg	kg	kgm²	kgm²	kg	kg	kg	kgm²	kgm²	kg	kg	kg	kgm²	kgm²
0402	3,6	3,7	7,3	0,006	0,032	3,3	6,6	9,9	0,005	0,074	3,6	6,9	10,5	0,006	0,076
0502	5,1	6,0	11,1	0,011	0,069	4,6	10,5	15,1	0,010	0,158	5,1	11,1	16,2	0,011	0,163
0602	8,6	8,8	17,4	0,022	0,132	7,6	13,0	20,6	0,018	0,241	8,6	13,7	22,3	0,022	0,249
0702	14,1	16,0	30,1	0,048	0,316	12,8	25,2	38,0	0,041	0,708	14,1	26,6	40,7	0,048	0,729
0802	28,5	21,3	49,8	0,152	0,596	26,4	34,9	61,3	0,133	1,266	28,5	36,9	65,4	0,152	1,312
1002	43,0	35,8	78,8	0,299	1,366	40,1	52,0	92,1	0,266	2,441	43,0	55,5	98,5	0,299	2,548
1202	68,8	46,1	114,9	0,686	2,403	62,9	75,3	138,2	0,589	4,956	68,8	79,9	148,7	0,686	5,147
1401	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1402	105,0	74,0	179,0	1,349	5,080	103,0	117,0	220,0	1,314	9,757	105,0	124,0	229,0	1,349	10,170

Alle Gewichte und Massenträgheitsmomente beziehen sich auf vorgebohrte Naben.

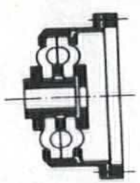
Fehlende Daten auf Anfrage.

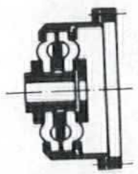
Teile: I = Innen, A = Außen, G = Gesamt

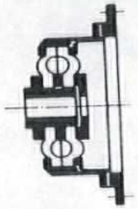
All weights and mass moments of inertia refer to pilot-bored hubs.

Data not printed on request.

Parts: I = Inner, A = Outer, G = Total







Baugruppe / Dimension Group	Baureihe 1100 Series Gewicht Weight I kg	A kg	G kg	J I kgm²	J A kgm²	Baureihe 1101 Series Gewicht Weight I kg	A kg	G kg	J I kgm²	J A kgm²	Baureihe 1110 Series Gewicht Weight I kg	A kg	G kg	J I kgm²	J A kgm²
0402	3,3	7,3	10,6	0,005	0,078	3,6	7,7	11,3	0,006	0,081	3,3	9,5	12,8	0,005	0,123
0502	4,6	9,8	14,4	0,010	0,150	5,1	10,4	15,5	0,011	0,153	4,6	12,3	16,9	0,010	0,215
0602	7,6	15,4	23,0	0,018	0,282	8,6	16,1	24,7	0,022	0,290	7,6	24,1	31,7	0,018	0,639
0702	12,8	21,9	34,7	0,041	0,509	14,1	23,3	37,4	0,048	0,529	12,8	31,8	44,6	0,041	1,020
0802	26,4	30,3	56,7	0,133	0,997	28,5	32,4	60,9	0,152	1,043	26,4	42,8	69,2	0,133	1,819
1002	40,1	48,5	88,6	0,266	2,146	43,0	52,1	95,1	0,299	2,252	40,1	68,0	108,1	0,266	3,893
1202	62,9	69,8	132,7	0,589	4,142	68,8	73,0	141,8	0,686	4,288	62,9	93,3	156,2	0,589	6,754
1401	107,1	212,2	319,3	1,440	24,370	108,0	219,1	327,1	1,470	24,730	–	–	–	–	–
1402	103,0	114,0	217,0	1,314	9,009	105,0	115,0	220,0	1,349	9,030	–	–	–	–	–
1701	174,1	328,3	502,4	3,390	53,250	175,5	338,8	514,3	3,450	53,970	–	–	–	–	–
1702	168,0	205,0	373,0	3,081	23,840	170,0	208,0	378,0	3,163	23,980	–	–	–	–	–
2001	273,7	529,2	802,9	8,400	116,750	276,0	548,2	824,2	8,560	118,450	–	–	–	–	–
2002	262,0	332,0	594,0	6,518	53,950	265,0	338,0	603,0	6,704	54,370	–	–	–	–	–
2401	464,0	962,0	1426,0	17,640	267,250	467,0	988,0	1455,0	17,920	270,480	–	–	–	–	–
2402	444,0	529,0	973,0	15,780	117,000	448,0	538,0	986,0	16,120	118,000	–	–	–	–	–
2802	742,0	961,0	1703,0	37,050	268,300	750,0	966,0	1716,0	37,760	269,000	–	–	–	–	–
3002	882,0	1321,0	2203,0	51,050	446,400	896,0	1350,0	2246,0	52,680	452,000	–	–	–	–	–

Alle Gewichte und Massenträgheitsmomente beziehen sich auf vorgebohrte Naben.

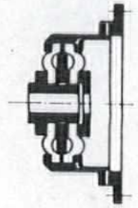
Fehlende Daten auf Anfrage.

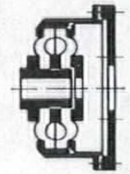
Teile: I = Innen, A = Außen, G = Gesamt

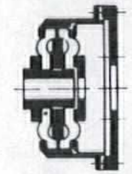
All weights and mass moments of inertia refer to pilot-bored hubs.

Data not printed on request.

Parts: I = Inner, A = Outer, G = Total







Baugruppe / Dimension Group	Baureihe 1111 Series Gewicht Weight I kg	A kg	G kg	J I kgm²	J A kgm²	Baureihe 1200 Series Gewicht Weight I kg	A kg	G kg	J I kgm²	J A kgm²	Baureihe 1201 Series Gewicht Weight I kg	A kg	G kg	J I kgm²	J A kgm²
0402	3,6	9,7	13,3	0,006	0,122	3,3	9,8	13,1	0,005	0,097	3,6	10,1	13,7	0,006	0,100
0502	5,1	12,7	17,8	0,011	0,213	4,6	13,4	18,0	0,010	0,186	5,1	13,9	19,0	0,011	0,189
0602	8,6	24,8	33,4	0,022	0,647	7,6	21,6	29,2	0,018	0,367	8,6	22,3	30,9	0,022	0,375
0702	14,1	33,2	47,3	0,048	1,040	12,8	32,3	45,1	0,041	0,691	14,1	33,7	47,8	0,048	0,711
0802	28,5	44,9	73,4	0,152	1,865	26,4	45,0	71,4	0,133	1,392	28,5	47,1	75,6	0,152	1,438
1002	43,0	71,6	114,6	0,299	4,000	40,1	72,6	112,7	0,266	3,001	43,0	76,2	119,2	0,299	3,107
1202	68,8	96,5	165,3	0,686	6,900	62,9	110,0	172,9	0,589	6,085	68,8	114,0	182,8	0,686	6,232
1401	–	–	–	–	–	107,1	271,1	378,2	1,440	27,850	108,0	278,0	386,0	1,470	28,180
1402	–	–	–	–	–	103,0	172,0	276,0	1,314	12,910	105,0	174,0	279,0	1,349	12,980
1701	–	–	–	–	–	174,1	416,7	590,8	3,390	60,490	175,5	427,5	602,9	3,450	61,210
1702	–	–	–	–	–	168,0	264,0	432,0	3,081	27,590	170,0	267,0	437,0	3,163	27,730
2001	–	–	–	–	–	273,7	659,0	932,7	8,400	131,810	276,0	678,0	954,0	8,560	133,510
2002	–	–	–	–	–	262,0	421,0	683,0	6,518	62,060	265,0	427,0	692,0	6,704	62,480
2401	–	–	–	–	–	464,0	1173,0	1637,0	17,640	299,600	467,0	1199,0	1666,0	17,920	302,820
2402	–	–	–	–	–	444,0	704,0	1148,0	15,780	140,200	448,0	713,0	1161,0	16,120	141,100
2802	–	–	–	–	–	742,0	1185,0	1927,0	37,050	307,300	750,0	1190,0	1940,0	37,760	308,000
3002	–	–	–	–	–	882,0	1598,0	2480,0	51,050	495,600	896,0	1627,0	2523,0	52,680	501,200

Alle Gewichte und Masseträgheitsmomente beziehen sich auf vorgebohrte Naben.

Fehlende Daten auf Anfrage.

Teile: I = Innen, A = Außen, G = Gesamt

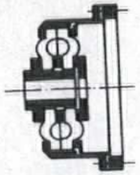
All weights and mass moments of inertia refer to pilot-bored hubs.

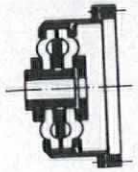
Data not printed on request.

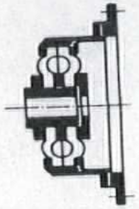
Parts: I = Inner, A = Outer, G = Total

Gewichte und Massenträgheitsmomente

Weights and mass moments of inertia







Baugruppe / Dimension / Group	Baureihe 1100 Series Gewicht/Weight I kg	A kg	G kg	J I kgm²	J A kgm²	Baureihe 1101 Series Gewicht/Weight I kg	A kg	G kg	J I kgm²	J A kgm²	Baureihe 1110 Series Gewicht/Weight I kg	A kg	G kg	J I kgm²	J A kgm²
0402	3,3	7,3	10,6	0,005	0,078	3,6	7,7	11,3	0,006	0,081	3,3	9,5	12,8	0,005	0,123
0502	4,6	9,8	14,4	0,010	0,150	5,1	10,4	15,5	0,011	0,153	4,6	12,3	16,9	0,010	0,215
0602	7,6	15,4	23,0	0,018	0,282	8,6	16,1	24,7	0,022	0,290	7,6	24,1	31,7	0,018	0,639
0702	12,8	21,9	34,7	0,041	0,509	14,1	23,3	37,4	0,048	0,529	12,8	31,8	44,6	0,041	1,020
0802	26,4	30,3	56,7	0,133	0,997	28,5	32,4	60,9	0,152	1,043	26,4	42,8	69,2	0,133	1,819
1002	40,1	48,5	88,6	0,266	2,146	43,0	52,1	95,1	0,299	2,252	40,1	68,0	108,1	0,266	3,893
1202	62,9	69,8	132,7	0,589	4,142	68,8	73,0	141,8	0,686	4,288	62,9	93,3	156,2	0,589	6,754
1401	107,1	212,2	319,3	1,440	24,370	108,0	219,1	327,1	1,470	24,730	–	–	–	–	–
1402	103,0	114,0	217,0	1,314	9,009	105,0	115,0	220,0	1,349	9,030	–	–	–	–	–
1701	174,1	328,3	502,4	3,390	53,250	175,5	338,8	514,3	3,450	53,970	–	–	–	–	–
1702	168,0	205,0	373,0	3,081	23,840	170,0	208,0	378,0	3,163	23,980	–	–	–	–	–
2001	273,7	529,2	802,9	8,400	116,750	276,0	548,2	824,2	8,560	118,450	–	–	–	–	–
2002	262,0	332,0	594,0	6,518	53,950	265,0	338,0	603,0	6,704	54,370	–	–	–	–	–
2401	464,0	962,0	1426,0	17,640	267,250	467,0	988,0	1455,0	17,920	270,480	–	–	–	–	–
2402	444,0	529,0	973,0	15,780	117,000	448,0	538,0	986,0	16,120	118,000	–	–	–	–	–
2802	742,0	961,0	1703,0	37,050	268,300	750,0	966,0	1716,0	37,760	269,000	–	–	–	–	–
3002	882,0	1321,0	2203,0	51,050	446,400	896,0	1350,0	2246,0	52,680	452,000	–	–	–	–	–

Alle Gewichte und Massenträgheitsmomente beziehen sich auf vorgebohrte Naben.

Fehlende Daten auf Anfrage.

Teile: I = Innen, A = Außen, G = Gesamt

All weights and mass moments of inertia refer to pilot-bored hubs.

Data not printed on request.

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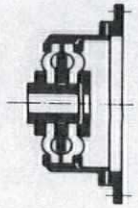

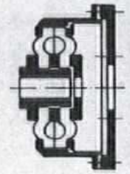

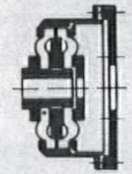

Baugruppe / Dimension / Group	Baureihe 1111 Series Gewicht/Weight I kg	A kg	G kg	J I kgm²	J A kgm²	Baureihe 1200 Series Gewicht/Weight I kg	A kg	G kg	J I kgm²	J A kgm²	Baureihe 1201 Series Gewicht/Weight I kg	A kg	G kg	J I kgm²	J A kgm²
0402	3,6	9,7	13,3	0,006	0,122	3,3	9,8	13,1	0,005	0,097	3,6	10,1	13,7	0,006	0,100
0502	5,1	12,7	17,8	0,011	0,213	4,6	13,4	18,0	0,010	0,186	5,1	13,9	19,0	0,011	0,189
0602	8,6	24,8	33,4	0,022	0,647	7,6	21,6	29,2	0,018	0,367	8,6	22,3	30,9	0,022	0,375
0702	14,1	33,2	47,3	0,048	1,040	12,8	32,3	45,1	0,041	0,691	14,1	33,7	47,8	0,048	0,711
0802	28,5	44,9	73,4	0,152	1,865	26,4	45,0	71,4	0,133	1,392	28,5	47,1	75,6	0,152	1,438
1002	43,0	71,6	114,6	0,299	4,000	40,1	72,6	112,7	0,266	3,001	43,0	76,2	119,2	0,299	3,107
1202	68,8	96,5	165,3	0,686	6,900	62,9	110,0	172,9	0,589	6,085	68,8	114,0	182,8	0,686	6,232
1401	–	–	–	–	–	107,1	271,1	378,2	1,440	27,850	108,0	278,0	386,0	1,470	28,180
1402	–	–	–	–	–	103,0	172,0	276,0	1,314	12,910	105,0	174,0	279,0	1,349	12,980
1701	–	–	–	–	–	174,1	416,7	590,8	3,390	60,490	175,5	427,5	602,9	3,450	61,210
1702	–	–	–	–	–	168,0	264,0	432,0	3,081	27,590	170,0	267,0	437,0	3,163	27,730
2001	–	–	–	–	–	273,7	659,0	932,7	8,400	131,810	276,0	678,0	954,0	8,560	133,510
2002	–	–	–	–	–	262,0	421,0	683,0	6,518	62,060	265,0	427,0	692,0	6,704	62,480
2401	–	–	–	–	–	464,0	1173,0	1637,0	17,640	299,600	467,0	1199,0	1666,0	17,920	302,820
2402	–	–	–	–	–	444,0	704,0	1148,0	15,780	140,200	448,0	713,0	1161,0	16,120	141,100
2802	–	–	–	–	–	742,0	1185,0	1927,0	37,050	307,300	750,0	1190,0	1940,0	37,760	308,000
3002	–	–	–	–	–	882,0	1598,0	2480,0	51,050	495,600	896,0	1627,0	2523,0	52,680	501,200

Alle Gewichte und Masseträgheitsmomente beziehen sich auf vorgebohrte Naben.

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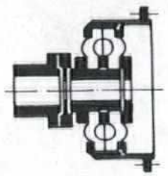

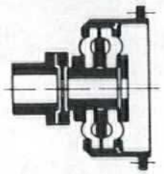

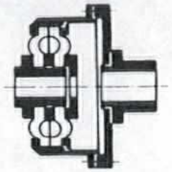

Baugruppe / Dimension Group	Baureihe 1300 Series					Baureihe 1301 Series					Baureihe 1400 Series				
	Gewicht Weight			J		Gewicht Weight			J		Gewicht Weight			J	
	I	A	G	I	A	I	A	G	I	A	I	A	G	I	A
	kg	kg	kg	kgm²	kgm²	kg	kg	kg	kgm²	kgm²	kg	kg	kg	kgm²	kgm²
0402	6,4	5,2	11,6	0,011	0,049	6,7	5,5	12,2	0,012	0,052	3,3	12,4	15,7	0,005	0,100
0502	10,0	7,9	17,9	0,023	0,099	10,5	8,4	18,9	0,025	0,102	4,6	17,7	22,3	0,010	0,194
0602	16,3	10,5	26,8	0,045	0,172	17,1	11,2	28,3	0,048	0,180	7,6	28,5	36,1	0,018	0,382
0702	31,8	17,9	49,7	0,138	0,387	33,1	19,3	52,4	0,145	0,408	12,8	47,4	60,2	0,041	0,748
0802	53,6	25,0	78,6	0,322	0,700	55,8	27,1	82,9	0,341	0,820	26,4	68,9	95,3	0,133	1,513
1002	82,2	39,8	122,0	0,661	1,656	85,1	43,7	128,8	0,694	1,772	40,1	109,0	149,1	0,266	3,250
1202	123,0	57,4	180,4	1,289	3,217	129,0	58,4	187,4	1,387	3,244	62,9	166,0	228,9	0,589	6,562
1401	214,5	157,5	372,0	3,170	16,280	215,4	164,4	379,8	3,200	16,610	107,1	361,6	468,7	1,440	28,970
1402	210,0	94,2	304,2	3,039	7,038	211,0	95,7	306,7	3,053	7,101	103,0	262,0	365,0	1,314	14,030
1701	337,8	237,1	574,9	7,070	34,350	339,2	247,8	587,0	7,140	35,070	174,1	558,5	732,6	3,390	62,910
1702	329,0	150,0	482,0	6,764	15,740	331,0	153,0	482,0	6,766	15,900	168,0	406,0	574,0	3,081	30,010
2001	549,9	369,0	918,9	18,320	72,210	552,3	388,0	940,3	18,480	73,910	273,6	917,4	1191,0	8,400	138,750
2002	495,0	241,0	736,0	15,020	35,090	506,0	247,0	753,0	15,820	35,500	262,0	672,0	934,0	6,518	68,580
2401	929,0	696,6	1625,6	40,720	171,900	932,0	722,0	1654,0	41,000	175,120	464,0	1604,8	2068,8	17,640	315,630
2402	833,0	369,0	1202,0	35,110	72,410	846,0	378,0	1224,0	36,180	73,370	444,0	1127,0	1571,0	15,780	155,500
2802	1194,0	695,0	1889,0	71,890	175,800	1216,0	700,0	1916,0	74,240	173,600	742,0	1723,0	2465,0	37,050	335,000
3002	1850,0	938,0	2788,0	133,000	279,900	1887,0	967,0	2854,0	137,800	285,400	882,0	2548,0	3430,0	51,050	556,200
3502	2360,0	1047,0	3407,0	203,000	369,300	2394,0	1075,0	3469,0	208,200	375,000	–	–	–	–	–
3802	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Alle Gewichte und Massenträgheitsmomente beziehen sich auf vorgebohrte Naben.

Fehlende Daten auf Anfrage.

Teile: I = Innen, A = Außen, G = Gesamt

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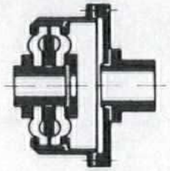
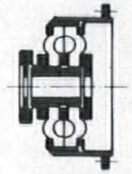
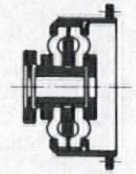






Baugruppe / Dimension Group	Baureihe 1401 Series					Baureihe 1500 Series					Baureihe 1501 Series				
	Gewicht Weight			J		Gewicht Weight			J		Gewicht Weight			J	
	I	A	G	I	A	I	A	G	I	A	I	A	G	I	A
	kg	kg	kg	kgm²	kgm²	kg	kg	kg	kgm²	kgm²	kg	kg	kg	kgm²	kgm²
0402	3,6	12,8	16,4	0,006	0,103	3,8	5,2	9,0	0,007	0,049	4,1	5,5	9,6	0,008	0,052
0502	5,1	18,2	23,3	0,011	0,196	5,6	7,9	13,5	0,015	0,099	6,2	8,4	14,6	0,017	0,102
0602	8,6	29,2	37,8	0,022	0,391	9,4	10,5	19,9	0,030	0,172	10,1	11,2	21,3	0,033	0,180
0702	14,1	48,8	62,9	0,048	0,769	16,7	17,9	34,6	0,081	0,387	18,0	19,3	37,3	0,088	0,408
0802	28,5	70,9	99,4	0,152	1,559	29,7	25,0	54,7	0,201	0,700	31,9	27,1	59,0	0,220	0,820
1002	43,0	113,0	156,0	0,299	3,356	45,8	39,8	85,6	0,412	1,656	48,7	43,7	92,4	0,445	1,772
1202	68,8	169,0	237,8	0,686	6,709	67,8	57,4	125,2	0,812	3,217	73,8	58,4	132,2	0,909	3,244
1401	108,0	368,4	476,4	1,470	29,300	124,0	157,5	281,5	2,040	16,280	125,0	164,4	289,4	2,080	16,610
1402	105,0	264,0	369,0	1,349	14,100	120,0	94,2	214,2	1,917	7,038	122,0	95,7	217,7	1,952	7,101
1701	175,5	569,2	744,7	3,450	63,630	196,0	237,1	433,1	4,650	34,350	197,4	247,8	445,2	4,720	35,070
1702	170,0	409,0	579,0	3,163	30,150	190,0	150,0	340,0	4,342	15,740	192,0	153,0	345,0	4,424	15,900
2001	276,0	936,4	1212,4	8,560	140,450	291,5	369,0	660,5	11,380	72,210	293,8	388,0	681,8	11,540	73,910
2002	265,0	685,0	950,0	6,704	69,410	244,0	241,0	485,0	8,502	35,090	248,0	247,0	495,0	8,688	35,500
2401	467,0	1631,0	2098,0	17,920	318,850	497,1	696,6	1193,7	24,690	171,900	500,0	722,0	1222,0	24,970	175,120
2402	448,0	1144,0	1592,0	16,120	157,100	410,0	369,0	779,0	19,800	72,410	414,0	378,0	792,0	20,130	73,370
2802	750,0	1742,0	2492,0	37,760	337,400	656,0	695,0	1351,0	44,170	175,800	664,0	700,0	1364,0	44,870	173,600
3002	896,0	2599,0	3495,0	52,680	565,000	900,0	938,0	1838,0	72,340	279,900	915,0	967,0	1882,0	73,970	285,400
3502	–	–	–	–	–	1149,0	1047,0	2196,0	111,800	369,300	1183,0	1074,0	2257,0	117,100	375,000
3802	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Alle Gewichte und Massenträgheitsmomente beziehen sich auf vorgebohrte Naben.

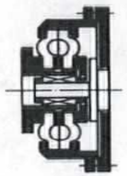
Fehlende Daten auf Anfrage.

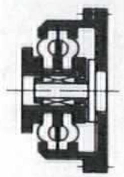
Teile: I = Innen, A = Außen, G = Gesamt

All weights and mass moments of inertia refer to pilot-bored hubs.

Data not printed on request.

Parts: I = Inner, A = Outer, G = Total





Baugruppe / Dimension Group	Baureihe 1510 Series Gewicht Weight I kg	A kg	G kg	J I kgm²	J A kgm²	Baureihe 1511 Series Gewicht Weight I kg	A kg	G kg	J I kgm²	J A kgm²
0402	–	–	–	–	–	–	–	–	–	–
0502	–	–	–	–	–	–	–	–	–	–
0602	–	–	–	–	–	–	–	–	–	–
0702	–	–	–	–	–	–	–	–	–	–
0802	–	–	–	–	–	–	–	–	–	–
1002	–	–	–	–	–	–	–	–	–	–
1202	–	–	–	–	–	–	–	–	–	–
1401	–	–	–	–	–	–	–	–	–	–
1402	111,0	192,0	303,0	1,940	12,280	112,0	199,0	311,0	1,960	12,690
1701	–	–	–	–	–	–	–	–	–	–
1702	191,0	289,0	480,0	4,600	25,780	194,0	304,0	498,0	4,730	26,860
2001	–	–	–	–	–	–	–	–	–	–
2002	304,0	473,0	777,0	10,410	57,270	308,0	495,0	803,0	10,600	59,530
2401	–	–	–	–	–	–	–	–	–	–
2402	499,0	777,0	1276,0	25,170	121,700	509,0	808,0	1317,0	25,860	126,700
2802	766,0	1259,0	2025,0	52,200	255,600	773,0	1304,0	2077,0	52,700	264,800
3002	973,0	1675,0	2648,0	79,600	408,200	978,0	1749,0	2727,0	81,500	424,500

Fehlende Daten auf Anfrage.
Teile: I = Innen, A = Außen, G = Gesamt

Data not printed on request.
Parts: I = Inner, A = Outer, G = Total

Baureihen-Übersicht

Im Laufe der Zeit haben sich ganz bestimmte Anbauformen für die **VULKAN-EZR** Kupplungen herausgestellt. Diese Anbauformen wurden von uns typisiert und mit Baureihen-Nummern versehen.

Auf den folgenden Seiten finden Sie die charakteristischen Angaben für jede einzelne Baureihe.

Die Aufteilung in der Baureihenbeschreibung ist so gewählt, daß die vorhandenen Wellenanschlüsse berücksichtigt sind, z. B. Welle-Welle oder Welle-Flanschwelle usw.

Bei größeren zu verbindenden Maschinen sollte zwingend darauf geachtet werden, daß eine Baureihe gewählt wird, die den Ausbau der elastischen **EZR** Elemente gestattet, ohne daß die zu verbindenden Maschinen versetzt werden müssen.

Die Werkstoffwahl ist abhängig von Umfangsgeschwindigkeiten und den Vorschriften der Klassifikationsgesellschaften.

Die Metallteile sind aus vergütetem Stahl, Flanschmantel und Tellerflansch aus hochwertigem Sphäroguß.

Beim Einbau ist darauf zu achten, daß die axialen Montage-Kontrollmaße eingehalten werden, um die benachbarten Lager frei von Axialkräften zu halten. Auch der radiale Wellenversatz ist zu kontrollieren.

Survey of Series

In the course of time certain definite forms of connecting "Series" for **VULKAN-EZR** couplings have evolved. We have standardised these connecting arrangements according to series numbers.

The characteristics of each individual series is given on the following pages.

The series is selected by taking into account required forms of connections, e. g. shaft-shaft, or shaft-flange etc.

With large machines to be connected special attention must be given to selecting a series which allows the removal of the **EZR** elements without moving the adjacent connected machinery.

The selection of the coupling materials is dependent on the peripheral speeds and also on the requirements of the Classification Societies.

The metal parts are made from annealed steel, flanged casing and adapter flange are made from high quality spheroidal graphite cast iron.

During the installation care must be taken that the axial alignment-control dimensions are adhered to, so that the adjacent bearings are free from axial forces. The radial shaft displacement must also be checked.

APPENDIX V: Lloyd's rules for shaft dimensioning

Chapter 6

Main Propulsion Shafting

CONTENTS

Scope

The requirements of this Chapter relate, in particular, to formulae for determining the diameters of shafting for main propulsion installations, but requirements for couplings, coupling bolts, keys, keyways, sternbushes and other associated components are also included. The diameters may require to be modified as a result of alignment considerations and vibration characteristics (*see* Chapter 8), or the inclusion of stress raisers, other than those contained in this Chapter.

SECTION 1

Plans and particulars

1.1 Shafting plans

1.1.1 The following plans, together with the necessary particulars of the machinery, including the maximum power and revolutions per minute, are to be submitted for consideration before the work is commenced:

Final gear shaft.
Thrust shaft.
Intermediate shafting.
Tube shaft, where applicable.
Screwshaft.
Screwshaft oil gland.
Sternbush.

1.1.2 The specified minimum tensile strength of each shaft is to be stated.

1.1.3 In addition, a shafting arrangement plan indicating the relative position of the main engines, flywheel, flexible coupling, gearing, thrust block, line shafting and bearings, sterntube, 'A' bracket and propeller, as applicable, is to be submitted for information.

SECTION 2

Materials

2.1 Materials for shafts

2.1.1 The specified minimum tensile strength of forgings for shafts is to be selected within the following general limits:

(a) Carbon and carbon-manganese steel— 400 to 600 N/mm^2 (41 to 61 kgf/mm^2).

(b) Alloy steel—not exceeding 800 N/mm^2 (82 kgf/mm^2).

2.1.2 Where it is proposed to use alloy steel, details of the chemical composition, heat treatment and mechanical properties are to be submitted for approval.

2.2 Ultrasonic tests

2.2.1 Ultrasonic tests are required on shaft forgings where the diameter is 250 mm or greater.

SECTION 3

Design

3.1 Intermediate shafts

3.1.1 The diameter, *d*, of the intermediate shaft is to be not less than determined by the following formula:

$$d = Fk\sqrt[3]{\frac{P}{R}\left(\frac{560}{\sigma_u + 160}\right)}\ \text{mm}$$

$$\left(d = Fk\sqrt[3]{\frac{H}{R}\left(\frac{57}{\sigma_u + 16}\right)}\ \text{mm}\right)$$

where F = 95(86) for turbine installations, electric propulsion installations and oil engine installations with slip type couplings,

= 100 (90,5) for other oil engine installations,

k = 1,0 for shafts with integral coupling flanges complying with 3.7 or shrink fit couplings,

= 1,10 for shafts with keyways, where the fillet radii in the transverse section of the bottom of the keyway are to be not less than 0,0125d,

= 1,10 for shafts with transverse or radial holes where the diameter of the hole is not greater than 0,3d,

= 1,20 for shafts with longitudinal slots having a length of not more than 1,4d and a width of not more than 0,2d where d is determined with k = 1,0,

P (H) and R are defined in Ch 1,3.3,

σ_u = specified minimum tensile strength of the shaft material, in N/mm^2 (kgf/mm^2).

After a length of 0,2d from the end of a keyway, transverse hole or radial hole and 0,3d from the end of a longitudinal slot, the diameter of the shaft may be gradually reduced to that determined with k = 1,0.

3.1.2 For shafts with design features other than stated in 3.1.1, the value of k will be specially considered.

3.1.3 The Rule diameter of the intermediate shaft for oil engines, turbines and electric propelling motors may be reduced by 3,5 per cent for ships classed exclusively for smooth water service, and by 1,75 per cent for ships classed exclusively for service on the Great Lakes.

3.2 Gear quill shafts

3.2.1 The diameter of the quill shaft is to be not less than given by the following formula:

$$\text{Diameter of quill shaft} = 101\sqrt[3]{\frac{P400}{R\sigma_u}} \text{ mm}$$

$$\left(91\sqrt[3]{\frac{H41}{R\sigma_u}} \text{ mm}\right)$$

Where P (H) and R are as defined in Ch 1,3.3.

σ_u = specified minimum tensile strength of the material, in N/mm² (kgf/mm²) but is not to exceed 1100 N/mm² (112 kgf/mm²).

3.3 Final gear wheel shafts

3.3.1 Where there is only one pinion geared into the final wheel, or where there are two pinions which are set to subtend an angle at the centre of the shaft of less than 120 degrees, the diameter of the shaft at the final wheel and the adjacent journals is to be not less than 1,15 times that required for the intermediate shaft.

3.3.2 Where there are two pinions geared into the final wheel opposite, or nearly opposite, to each other, the diameter of the shaft at the final wheel and the adjacent journals is to be not less than 1,1 times that required for the intermediate shaft.

3.3.3 In both 3.3.1 and 3.3.2, abaft the journals, the shaft may be gradually tapered down to the diameter required for an intermediate shaft determined according to 3.1, where σ_u is to be taken as the specified minimum tensile strength of the final wheel shaft material, in N/mm² (kgf/mm²).

3.4 Thrust shafts

3.4.1 The diameter at the collars of the thrust shaft transmitting torque or in way of the axial bearing where a roller bearing is used as a thrust bearing is to be not less than that required for the intermediate shaft in accordance with 3.1 with a k value of 1,10. Outside a length equal to the thrust shaft diameter from the collars, the diameter may be tapered down to that required for the intermediate shaft with a k value of 1,0. For the purpose of the foregoing calculations, σ_u is to be taken as the minimum tensile strength of the thrust shaft material, in N/mm² (kgf/mm²).

3.5 Screwshafts and tube shafts

3.5.1 The diameter, d_p, of the screwshaft immediately forward of the forward face of the propeller boss or, if applicable, the forward face of the screwshaft flange, is to be not less than determined by the following formula:

$$d_p = 100k\sqrt[3]{\frac{P}{R}\left(\frac{560}{\sigma_u + 160}\right)} \text{ mm}$$

$$\left(d_p = 90{,}5k\sqrt[3]{\frac{H}{R}\left(\frac{57}{\sigma_u + 16}\right)} \text{ mm}\right)$$

where k = 1,22 for a shaft carrying a keyless propeller, or where the propeller is attached to an integral flange, and where the shaft is fitted with a continuous liner or is oil lubricated and provided with an approved type of oil sealing gland,

= 1,26 for a shaft carrying a keyed propeller and where the shaft is fitted with a continuous liner or is oil lubricated and provided with an approved type of oil sealing gland,

P(H) and R are defined in Ch 1,3.3,

σ_u = specified minimum tensile strength of the shaft material, in N/mm² (kgf/mm²) but is not to be taken as greater than 600 N/mm² (61 kgf/mm²).

3.5.2 The diameter, d_p, of the screwshaft determined in accordance with the formula in 3.5.1 is to extend over a length not less than that to the forward edge of the bearing immediately forward of the propeller or $2{,}5d_p$ whichever is the greater.

3.5.3 The diameter of the portion of the screwshaft and tube shaft forward of the length required by 3.5.2 to the forward end of the stern tube seal is to be determined in accordance with the formula in 3.5.1 with a k value of 1,15. The change of diameter from that determined with k = 1,22 or 1,26 to that determined with k = 1,15 should be gradual.

3.5.4 Screwshafts which run in sterntubes and tube shafts may have the diameter forward of the forward stern tube seal gradually reduced to the diameter of the intermediate shaft. Abrupt changes in shaft section at the screwshaft/tube shaft to intermediate shaft couplings are to be avoided.

3.5.5 Unprotected screwshafts and tube shafts of corrosion resistant material will be specially considered.

3.5.6 For shafts of non-corrosion resistant materials which are exposed to sea water, the diameter of the shaft is to be determined in accordance with the formula in 3.5.1 with a k value of 1,26 and σ_u taken as 400 N/mm² (41 kgf/mm²).

3.6 Hollow shafts

3.6.1 Where the thrust, intermediate and tube shafts and screwshafts have central holes, the outside diameters of the shafts are to be not less than given by the following formula:

$$d_o = d\sqrt[3]{\frac{1}{\left[1-\left(\frac{d_i}{d_o}\right)^4\right]}}$$

where d_o = outside diameter, in mm,

d = Rule size diameter of solid shaft, in mm,

d_i = diameter of central hole, in mm.

However, where the diameter of the central hole does not exceed 0,4 times the outside diameter, no increase over Rule size need be provided.

3.7 Couplings

3.7.1 The minimum thicknesses of the coupling flanges are to be equal to the diameters of the coupling bolts at the face of the couplings as required by 3.8, and for this purpose the minimum tensile strength of the bolts is to be taken as equivalent to that of the shafts. However, for intermediate and thrust shafts, the thickness of the coupling flange is in no case to be less than 0,20 of the diameter of the intermediate shaft as required by 3.1. Similarly, the thickness of the inboard screwshaft coupling flange is to be not less than 0,20 of the diameter of the screwshaft as required by 3.5.1.

3.7.2 The fillet radius at the base of the coupling flange is to be not less than 0,08 of the diameter of the shaft at the coupling, but in the case of crankshafts, the fillet radius at the centre coupling flanges may be 0,05 of the diameter of the shaft at the coupling. The fillets are to have a smooth finish and are not to be recessed in way of nut and bolt heads.

3.7.3 Where the propeller is attached by means of a flange, the thickness of the flange is to be not less than 0,25 of the actual diameter of the adjacent part of the screwshaft. The fillet radius at the base of the coupling flange is to be not less than 0,125 of the diameter of the shaft at the coupling.

3.7.4 All couplings which are attached to shafts are to be of approved dimensions.

3.7.5 Where couplings are separate from the shafts, provision is to be made to resist the astern pull.

3.7.6 Where a coupling is shrunk on to the parallel portion of a shaft or is mounted on a slight taper, e.g. by means of the oil pressure injection method, full particulars of the coupling including the interference fit are to be submitted for special consideration.

3.8 Coupling bolts

3.8.1 The diameter of the bolts at the joining faces of the couplings is to be not less than given by the following formula:

$$\text{Diameter of coupling bolts} = 3{,}65\, B\sqrt{\frac{10^6}{nr\sigma_u}\,\frac{P}{R}}\ \text{mm}$$

$$\left(B\sqrt{\frac{10^6}{nr\sigma_u}\,\frac{H}{R}}\ \text{mm}\right)$$

where $B = 4{,}0$ for crankshaft and thrust shaft/crankshaft couplings,
$= 3{,}0$ for other shaft couplings,
n = number of bolts in the coupling,
r = radius of pitch circle of bolts, in mm,
σ_u = specified minimum tensile strength of bolts, in N/mm^2 (kgf/mm^2),
$P(H)$ and R are as defined in Ch 1,3.3.

3.8.2 At the joining faces of couplings, other than within the crankshaft and at the thrust shaft/crankshaft coupling, the Rule diameter of the coupling bolts may be reduced by 5,2 per cent for ships classed exclusively for smooth water service, and 2,6 per cent for ships classed exclusively for service on the Great Lakes.

3.9 Bronze or gunmetal liners on shafts

3.9.1 The thickness, t, of liners fitted on screwshafts or on tube shafts, in way of the bushes, is to be not less, when new, than given by the following formula:

$$t = \frac{D + 230}{32}\ \text{mm}$$

where t = thickness of the liner, in mm,
D = diameter of the screwshaft or tube shaft under the liner, in mm.

3.9.2 The thickness of a continuous liner between the bushes is to be not less than $0{,}75t$.

3.9.3 Continuous liners should preferably be cast in one piece.

3.9.4 Where liners consist of two or more lengths, these are to be butt welded together. In general, the lead content of the gunmetal of each length forming a butt welded liner is not to exceed 0,5 per cent. The composition of the electrodes or filler rods is to be substantially lead-free.

3.9.5 The circumferential butt welds are to be of multi-run, full penetration type. Provision is to be made for contraction of the weld by arranging for a suitable length of the liner containing the weld, if possible about three times the shaft diameter, to be free of the shaft. To prevent damage to the surface of the shaft during welding, a strip of heat resisting material covered by a copper strip should be inserted between the shaft and the liner in way of the joint. Other methods for welding this joint may be accepted if approved. The welding is to be carried out by an approved method and to the Surveyor's satisfaction.

3.9.6 Each continuous liner or length of liner is to be tested by hydraulic pressure to 2,0 bar (2,0 kgf/cm^2) after rough machining.

3.9.7 Liners are to be carefully shrunk on, or forced on, to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

3.9.8 Effective means are to be provided for preventing water from reaching the shaft at the part between the after end of the liner and the propeller boss.

3.10 Keys and keyways

3.10.1 Round ended or sled-runner ended keys are to be used, and the keyways in the propeller boss and cone of the screwshaft are to be provided with a smooth fillet at the bottom of the keyways. The radius of the fillet is to be at least 0,0125 of the diameter of the screwshaft at the top of the cone. The sharp edges at the top of the keyways are to be removed.

3.10.2 Two screwed pins are to be provided for securing the key in the keyway, and the forward pin is to be placed at least one-third of the length of the key from the end. The depth of the tapped holes for the screwed pins is not to exceed the pin diameter, and the edges of the holes are to be slightly bevelled.

3.10.3 The distance between the top of the cone and the forward end of the keyway is to be not less than 0,2 of the diameter of the screwshaft at the top of the cone.

3.10.4 The effective sectional area of the key in shear, is to be not less than $\dfrac{d^3}{2{,}6d_1}$ mm^2

where d = diameter, in mm, required for the intermediate shaft determined in accordance with 3.1, based on material having a specified minimum tensile strength of 400 N/mm^2 (41 kgf/mm^2) and $k = 1$,
d_1 = diameter of shaft at mid-length of the key, in mm.

3.11 Propellers

3.11.1 For keyed and keyless propellers, *see* Chapter 7.

3.12 Sternbushes

3.12.1 The length of the bearing in the sternbush next to and supporting the propeller is to be as follows:

(a) For water lubricated bearings which are lined with lignum vitae, rubber composition or staves of approved plastics material, the length is to be not less than 4 times the diameter required for the screwshaft under the liner.

(b) For water lubricated bearings lined with two or more circumferentially spaced sectors of an approved plastics material, in which it can be shown that the sectors operate on hydrodynamic principles, the length of the bearing is to be such that the nominal bearing pressure will not exceed 5,5 bar (5,6 kgf/cm^2). The length of the bearing is to be not less than twice its diameter.

(c) For bearings which are white-metal lined, oil lubricated and provided with an approved type of oil sealing gland, the length of the bearing is to be approximately twice the diameter required for the screwshaft and is to be such that the nominal bearing pressure will not exceed 8,0 bar (8,1 kgf/cm^2). The length of the bearing is to be not less than 1,5 times its diameter.

(d) For bearings of cast iron and bronze which are oil lubricated and fitted with an approved oil sealing gland, the length of the bearing is, in general, to be not less than 4 times the diameter required for the screwshaft.

(e) For bearings which are grease lubricated, the length of the bearing is to be not less than 4 times the diameter required for the screwshaft.

3.12.2 Forced water lubrication is to be provided for all bearings lined with rubber or plastics and for those bearings lined with lignum vitae where the shaft diameter is 380 mm or over. The supply of water may come from a circulating pump or other pressure source. Flow indicators are to be provided for the water service to plastics and rubber bearings. The water grooves in the bearings are to be of ample section and of a shape which will be little affected by weardown, particularly for bearings of the plastics type.

3.12.3 The shut-off valve or cock controlling the supply of water is to be fitted direct to the after peak bulkhead, or to the sterntube where the water supply enters the sterntube forward of the bulkhead.

3.12.4 Oil sealing glands fitted in ships classed for unrestricted service must be capable of accommodating the effects of differential expansion between hull and line of shafting in sea temperatures ranging from arctic to tropical. This requirement applies particularly to those glands which span the gap and maintain oiltightness between the sterntube and the propeller boss.

3.12.5 Where a tank supplying lubricating oil to the sternbush is fitted, it is to be located above the load waterline and is to be provided with a low level alarm device in the engine room.

3.12.6 Where sternbush bearings are oil lubricated, provision is to be made for cooling the oil by maintaining water in the after peak tank above the level of the sterntube or by other approved means. Means for ascertaining the temperature of the oil in the sterntube are also to be provided.

3.12.7 Where there is compliance with the terms of 3.12.1 (c) and (d) to the Surveyor's satisfaction, a screwshaft will be assigned the notation 'OG' in the *Supplement to the Register Book* for periodical survey purposes (*see* Pt 1, Ch 3).

3.12.8 Screwshafts which are grease lubricated are not eligible for the 'OG' notation.

3.13 Vibration and alignment

3.13.1 For the requirements for torsional, axial and lateral vibration, and for alignment of the shafting, *see* Chapter 8.

APPENDIX VI: Optimum prime mover-thruster adjustment with a fixed reduction ratio

For a direct driven installation (rpm reduction ratio between prime mover and thruster is 1) an optimum thruster was found as described in example sheet 30. Following prime mover selection procedure 2, 3 suitable prime movers were found in the database. The prime mover selection area, together with the lay-out-fields of these 3 prime movers are displayed in figure 10. The selection criterion for finding an mcr point in the overlap area was minimizing the fuel oil consumption. The rpm values, for csr condition, of the prime movers and the already found optimum thruster don't match anymore. As a result of this the thruster has to be redesigned for each prime mover choice. Also the transmission(s) between the thruster and prime mover must be redesigned if they were already selected from the database. Their selection criteria, torque and rpm resulting from the optimum thruster design, changed due to the selected prime mover's mcr power and rpm values. The resulting thrusters are described in example sheet 32.

Optimum thruster description

component:		*propeller*	
type	:	Wageningen B-series	
diameter	:	6.90	m
pitch/diameter ratio	:	1.34	
number of blades	:	4	
blade area ratio	:	0.52	
shaft rpm	:	70	1/min
open water efficiency	:	0.70	

example sheet 30: the optimum thruster

As can be seen in example sheet 32 the most fuel efficient propeller-prime mover combinations are different for the 3 selected engines. Consequently the 3 engine selections have led to 3 alternative propulsion systems. It will be clear that the 6-cylinder solution incorporates the plant with the lowest first cost. The 7- and 8-cylinder solutions might be interesting because of their 3.3% and 4.9% lower fuel consumption at csr condition.

Prime mover description

alternatives:	*1*	*2*	*3*
type	LOF	LOF	LOF
make	SULZER	SULZER	SULZER
series	RTA62	RTA62	RTA62
number of cylinders	6	7	8
2 or 4 stroke	2	2	2
mcr power [kW]	10609	10307	10284
mcr rpm [1/min]	98.7	82.2	76.0
csr power [kW]	**9548**	**9276**	**9256**
csr rpm [1/min]	**95.3**	**79.4**	**73.4**
engine margin	0.90	0.90	0.90
csr fuel oil consumption [t/day]	39.1	37.8	37.2

example sheet 31: prime mover design results

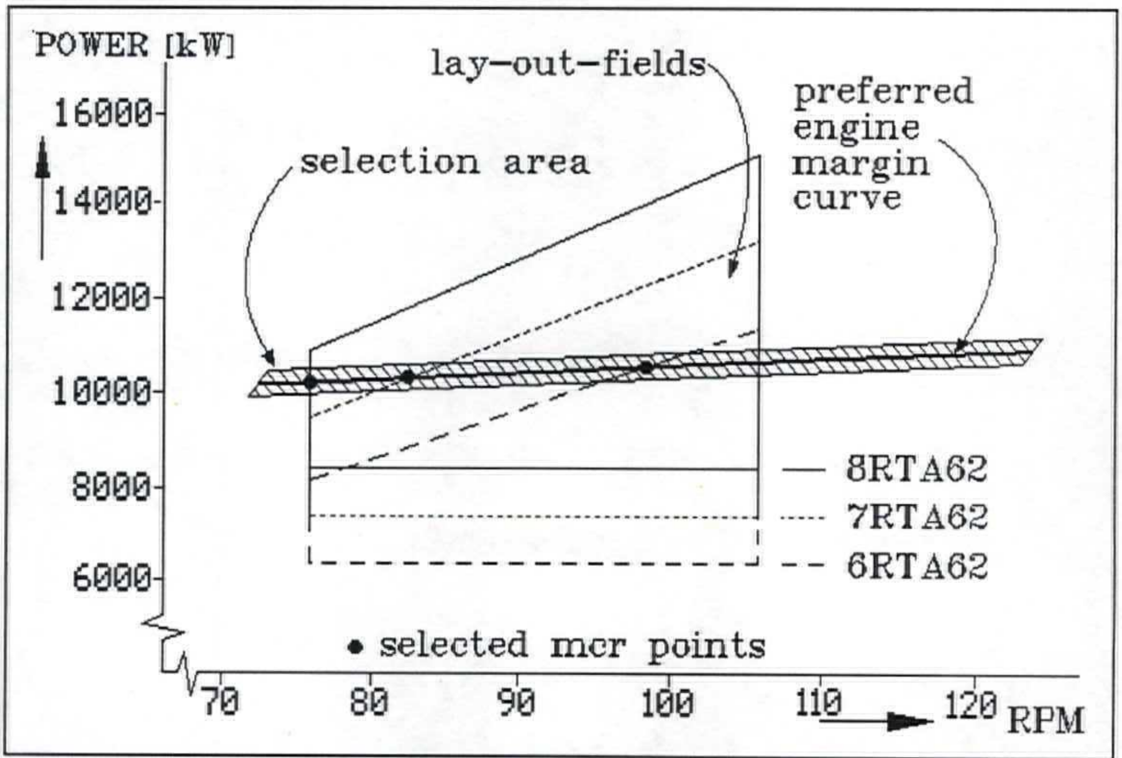


figure 10: selection of mcr point for selected prime movers in example 1

Optimum thruster description

Alternative:	*1*	*2*	*3*
type	Wagen.-B	Wagen.-B	Wagen.-B
diameter	6.54	6.90	6.90
pitch/diameter ratio	0.98	1.11	1.24
number of blades	4	4	4
blade area ratio	0.55	0.52	0.52
shaft rpm	**95.3**	**79.4**	**73.4**
open water efficiency	0.69	0.70	0.70

example sheet 32 : thruster design results for selected prime movers

---

PROSEL programma's

PROSEL bestaat uit een aantal programma's:

```
PROINP  - user interface program
PROBLD  - composition of installation alternatives
PROEVA  - installation evaluation
SELSOR  - sorting and selecting interesting alternatives
PRESENT - present installation description
PRESSHT - present general installation data
SETUP   - generate a default setup file in the working directory
```

PROINP is een door MARIN aangeleverd programma. Gedetaileerde informatie over datastructuur, subroutines, bibliotheken en het linken kan worden ingewonnen by F. Verbaas. PROINP zal daarom hier niet verder worden behandeld.
Alle programma's zijn aparte executables vanwege de beperkte PC geheugen capaciteit. (misschien is via het gebruik van overlays een geintegreerd pakket te verkrijgen). PROINP maakt voor schermopbouw en in/uitvoer gebruik van MIMER schermen. Voor PROBLD en PROEVA is een eigen schermopbouw en invoer/uitvoer programmadeel ontworpen, met de subroutines in de bibliotheek OUTPUT.LIB (zie bibliotheken).
De programma's SELSOR, PRESENT en PRESSHT maken voor hiervan nog geen en dienen hiervoor nog aangepast te worden. Deze programma's zijn ook nog niet geschikt voor communicatie met de andere programma's via lezen en schrijven van installatie identiteit gegevens in de setup file.
Met SETUP kan een default setup file PROSEL.SUP worden gegenereerd, die eventueel door de gebruiker kan worden bewerkt met een gewone text editor.

Setup PROSEL

PROSEL.SUP is een setup file die aan het begin van een programma executie wordt uitgelezen voor toewijzen van:

- locaties van datafiles
- identiteit van laats behandelde installatie
- kleur of zwart-wit scherm

Het is een leesbare sequentiele file, die aanwezig moet zijn in de directory van waaruit PROSEL wordt gestart. De file locatie gegevens moeten bekend zijn voordat executie van de PROBLD en PROEVA kan plaatsvinden. D.m.v. het programma SETUP kan een default setup file worden gegenereerd, die door de gebruiker naar zijn eigen wensen kan worden bewerkt. De locatie gegevens (regel 1-5) bevatten een locatie beschrijving van 16 posities lang die rechts(!!!) uitgevuld moet zijn. Een automatische uitvulling hiervan is nog niet ingebouwd. Spaties tussen de locatie en positie 17 zullen resulteren in een melding 'file not found'.

Beschrijving PROSEL.SUP

locaties datafiles:
regel 1: locatie voor installatie beschrijvende files
regel 2: locatie voor 'packed' installatie opslag en resultaat files
regel 3: locatie voor prime mover database files
regel 4: locatie voor transmission database files
regel 5: locatie voor prosel source files

identeit laatst behandelde installatie:
regel 6: naam schip
regel 7: versie schip
regel 8: optie design demand package
regel 9: optie operational condition
regel 10: titel design demand package
regel 11: titel operational condition
regel 12: nummer installatie
regel 13: optie operational profile

kleur schermuitvoer:
regel 14: kleur (1) of zwart-wit (0) schermoutput

File beschrijving

Er zijn binnen PROSEL een aantal soorten files:

- installatie beschrijvende files
- 'packed' installatie opslag en resultaat files
- prime mover database files
- transmission database files
- prosel source files

De installatie beschrijvende files bevatten de data representatie van de installatie layout, de scheepsgegevens, de gebruikers preferenties, de keuzes voor componenten uit de database; gebruikers eisen en alle gegenreerde installaties binnen die eisen. Deze structuur wordt aangemaakt met PROINP, en bestaat uit verschillende files. De files bevatten de record tabellen zoals beschreven in het PROSEL rapport van 19-12-90. Het is de bedoeling dat de files worden 'packed' en 'unpacked' door ze te schrijven naar/lezen uit een niet ASCII sequentiele opslag file. Deze file wordt 'unpacked' a.h.v. een door de gebruiker opgegeven installatie identiteit, zie setup file) als het een bestaande installatie is. Is dit niet zo dan moet met PROINP een nieuw beschrijving worden aangemaakt, die deze aan het einde 'packed'. Dit systeem functioneert momenteel bij de PROBLD en PROEVA programma's.
PROINP wordt hiervoor geschikt gemaakt door MARIN. De PRESENT, PRESSHT en SELSOR programma's moeten worden aangepast. Deze werken nu alleen bij een 'unpacked' data representatie.
Resultaten van een evaluatie met PROEVA worden opgeslagen in een leesbare file, die dezelfde naam heeft als de betreffende 'packed' datafile, met alleen een andere letter in de extensie (f=packed datafile,p=één punts evaluatie,m=speed range evaluatie,o=operatie profiel evalutie).
De transmissie en prime mover database files zijn leesbare files waarin de catalogi van verschillende dieselmotoren, tandwielkasten en koppelingen zijn opgeslagen.

Huidige directory structuur op PC

```
- fortran source files  : c:\coen\subs
- fortran include files : c:\coen\incl (niet variabel in source code
                                         via setup file)
- ontwikkelgereedschap  : c:\coen\tools
- executables           : c:\coen\exe
- storage files         : c:\coen\result
```

Compileren

---

zonder debug (Microsoft Codeview) informatie:

gebruik batch file FORC.BAT: FORC 'filenaam' (zonder extensie)

```
FORC.BAT
inhoud  :  FL /c /Od /FPi87 /4Ybd /G2 %1.FOR
           (voor beschrijving opties zie compiler manual)
locatie :  c:\coen\tools
```

met debug (Microsoft Codeview) informatie:

gebruik batch file FORD.BAT: FORC 'filenaam' (zonder extensie)
bij linken dient link optie /CO gebruikt te worden!

```
FORD.BAT
inhoud  :  FL /c /Zi /Od /FPi87 /4Yd /G2 %1.FOR
           (voor beschrijving opties zie compiler manual)
locatie :  c:\coen\tools
```

Bibliotheken

De objectfiles voor het PROBLD programma zijn gegroepeerd in 6 bibliotheken.

```
DISTRI.LIB - files gebruikt voor DISTRI programmadeel
SELECT.LIB - files gebruikt voor SELECT programmadeel
ADJUST.LIB - files gebruikt voor ADJUST programmadeel
PROSEL.LIB - datafile lees/schrijf routines + algemeen
NEWFIL.LIB - storage/result files lees en schrijf routines
OUTPUT.LIB - schermuitvoer routines
PIL.LIB    - MARIN PIL routines
```

Locatie van deze bibliotheken is: c:\coen\subs

Batch files voor aanmaken:
Voor het aanmaken van elke bibliotheek is een batch file aanwezig in c:\coen\subs. Gebruik van deze batch files dient plaats te vinden in deze zelfde directory. De namen zijn:

```
DISLIB.BAT voor DISTRI.LIB
SELLIB.BAT voor SELECT.LIB
ADJLIB.BAT voor ADJUST.LIB
PROLIB.BAT voor PROSEL.LIB
NEWLIB.BAT voor NEWFIL.LIB
OUTLIB.BAT voor OUTPUT.LIB
PILLIB.BAT voor PIL.LIB
```

De inhoud van deze bibliotheken:

```
DISTRI:  DEDVAR+DISTRI+PAMDED+TALDED+VARDET+VAREVA

SELECT:  SELECT+ADDPMC+CSADED+PMFIT1+PMFIT2+PMFIT3+PAMPRE+PAMSEL+
         EXHDET+FOCDET+MAXMMA+TRASEL+ADDTAM+PTOSEL+BSERI +GADPAP+
         KELBAR+SELPAP+THPERF+THANEW+THAPFN+THAPFV+THASEL+WAK    +
         THTD  +PSWAPS+PSTHPS+APWPPS

ADJUST:  ADDCOM+ADDINS+ADDLNK+ADDPAC+ADDTHA+ADDTRA+ADDTAA+NEWLNK+
         RESLNK+ADJPAM+ADJTHA+ADJTRA+ADJAAS+ADJUST+RESTRA

PROSEL:  SELCOM+SELEX2+SELFP1+SELFP2+SELINS+SELLNK+SELLAC+SELPMC+
         SELPMP+SELPRO+SELSHP+SELTHC+SELTHP+SELTRA+SELTAP+SELTAA+
         WAICOM+WAIINS+WAILNK+WAILAC+WAIPMC+WAIPMP+WAIPRO+WAITHC+
         WAITRA+WAITAA+SELPMG+SELMCA+SELFC1+SELFC2+CHECOM+INITIA+
         INSDAT+SELSUP+WAISUP+WAERA

NEWFIL:  NEWFIL +PROAEA+PROSTA+IDFILL

OUTPUT:  MAISCA+SCAENO+PREPMP+PRETHP+PRETAP+SCAINI+CONTIN+EFFDET+
         PAILIN+REFASH+THSCA1+TASCA1+YESNO +SELSCA+RESTAI+PREDBN+
         EAADBN+UPDSCA

PIL   :  EENDUD+INTPOL+LINSPL+MAXMI+SPLIN1+SPLINE+VOHINT
```

```
-----------------------------------------------------------------------
Linken
-----------------------------------------------------------------------

Programma PROBLD - 'composition of installation alternatives'

 * Response file: PROBLD.LNK (normaal)
                  PROBLD.DBG (linken met Microsoft Codeview informatie)
                  beide te vinden in 'c:\coen\tools'

 * PROBLD.OBJ wordt gelinkt met
   Object files:  -
   Bibliotheken:  DISTRI+SELECT+ADJUST+PROSEL+NEWFIL+OUTPUT+PIL
                  alle te vinden in 'c:\coen\subs'


Programma PROEVA - 'installation evaluation'

 * Response file: PROEVA.LNK (normaal)
                  PROEVA.DBG (linken met Microsoft Codeview informatie)
                  beide te vinden in 'c:\coen\tools'.

 * PROEVA.OBJ wordt gelinkt met:
   Object files:  EVALU1+EVALU2+EVALU3+COMEVA+PRMEVA+PMEVSC+PRMPOS+
                  LOCDET+SELLOC+SELOFD+TRAEVA+TREVSC+THREVA+THEVSC+
                  THRINI+NEWCUR+STORAR+READAR+ADDARR+SELRAR+WRIRAR+
                  RESLNK+THRMTX+LNKMTX+EVACHO+EV3INI+EVA3SC+INTMTX+
                  FOCDET+EXHDET+BSERI +PSEPPS+CAVI  +WAK   +THTD  +
                  PSWAPS+PSTHPS
                  alle te vinden in 'c:\coen\subs'
   Bibliotheken:  DISTRI+PROSEL+OUTPUT+NEWFIL+PIL
                  alle te vinden in 'c:\coen\subs'


Programma SELSOR - 'sorting and selecting interesting alternatives'

 * Response file: SELSOR.LNK
                  te vinden in 'c:\coen\tools'

 * SELSOR.OBJ wordt gelinkt met:
   Object files:  SORT+SELINS
                  beide te vinden in 'c:\coen\subs'
   Bibliotheken:  -
```

Programma PRESENT - 'present installation description'

* Response file: PRESENT.LNK
  te vinden in 'c:\coen\tools'.

* PRESENT.OBJ wordt gelinkt met:
  Object files: SCRINI
  te vinden in 'c:\coen\subs'
  Bibliotheken: PROSEL+OUTPUT
  beide te vinden in 'c:\coen\subs'

Programma PRESSHT - 'present general installation data'

* Response file: PRESSHT.LNK
  te vinden in 'c:\coen\tools'.

* PRESSHT.OBJ wordt gelinkt met:
  Object files: -
  Bibliotheken: PROSEL
  te vinden in 'c:\coen\subs'

Draaien op dit moment (20 december 1990)

1.
Als de PROSEL executables worden verplaatst van de huidige directory 'c:\coen\exe', wijzig dan ook het pad in de autoexec.bat file.

2.
Ga naar de werkdirectory 'c:\coen\instbs'. Indien een andere werk directory gewenst is zorg er dan voor de files met extensie .DAT en .DMP vanuit 'c:\coen\instbs' te copieren naar de nieuwe werkdirectory. De reden hiervoor is dat PROINP een voorlopige versie is die initieel leest vanuit een dumpfile, waarin de gegevens van een bestaand schip zijn gedefinieerd. (zie voor de verschillende file soorten die PROSEL gebruikt, het hoofdstuk file beschrijving)
Nieuwe schepen en installaties kunnen met PROINP derhalve alleen worden gedefinieerd door een bestaande te laden, de beschrijving te wijzigen/verwijderen, en van hieruit de PROSEL datarepresentatie te genereren.
PROINP wordt nog omgebouwd naar een versie die geen dumpfiles nodig heeft en die bij een nieuw schip ook nieuwe files genereert.

3.
Voer PROINP uit. Bestaande scheepsnaam is 'ATA', bestaande opties zijn 1-9 (Hiervan bestaan dus dumpfiles die zich in de werkdirectory moeten bevinden). Een datarepresentatie van de installatie wordt nu aangemaakt door het uitvoeren van de menuopties. De datarepresentatie is nodig voor PROBLD en PROEVA

4.
De overige PROSEL programma's kunnen worden uitgevoerd.

PROSEL - BUILDING A PROPULSION ARRANGEMENT

TO DO   21 December 1990

»1. Selection of lay-out-field dieselengines with the use of the maximum and minimum engine margins. At this moment only the preferred engine margin is used in the subroutines PMFIT2 and PMFIT3.

»2. Let the user choose the lay-out-field dieselengine selection criterion: light weight installation, or lowest fuel oil consumption (present).

»3. Build in avoiding the calculation of a thruster when there is a similar one present in the installation with the same thruster preferences and thrust percentage (subroutine THRCOP)

»4. For prime mover selection in a multiple prime mover installation it must be possible to combine only engines of the same make and/or type.

»5. Build in the MARIN supplied new thruster design module.

»6. Make the horizontal shaft distance for a twin input gearbox a selection criterion. Let the user specify the minimum distance between engines (positioning of air/gas ducts) so the program can calculate the shaft distance.

»7. Make a discrete step reduction ratio gearbox selection possible (e.g. ZF gearboxes)

»8. Complete prime mover database with cost data, economy versions, efficiency booster/tcs data, cooling water data, expand to more prime movers

»9. Make exhaust gas determination module for lay-out-field dieselengines.

»10. Complete subroutine comments.

»11. Build in shaft dimension, weight and cost calculation modules (according to classification prescriptions) (marin PSSHPS)

»12. Build in coupling dimension, weight and cost calculation modules. (subroutines PSCOPS, SELCOU)

»13. Complete fuel oil optimization module with lay-out-field dieselengine selection procedure PMFIT2.

»14. Extend PROSEL to gasturbines

»15. Extend PROSEL to waterjets

»16. Build in MARIN supplies Ka-series propeller polynomials

»14. Change lower calorific values in fuel oil consumption tables to the lowest allowed value for the engines (LOFFOC and MCRFOC). At the moment it is the value for which the sfoc is valid

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Global Design

ir. C.C.P.J.M. Landa TU Delft Marin

1. Introduction

PROSEL is a propulsion installation selection program. It will help to select a propulsion installation within the designers demands. Heat and electric power generation systems design will also be offered. To find the optimal installation within the demands an evaluation on different feasible installations can also be executed with PROSEL.
The main goals of PROSEL are shortening the time needed for design and offering extensive evaluation possibilities to find the optimal installation.
This document is the basis for the development of the PROSEL propulsion selection program. PROSEL will be developed as a part of the MARDES II design system of TU DELFT and MARIN WAGENINGEN. Besides that it must be capable of acting as a stand alone program.
In this document the several program modules will be distinguished, which are representing the main functions that have to be performed. The global design forms a mutual base from which the several modules can be developed.

2.plan of approach

In this plan of approach a short introduction will be given by defining the PROSEL project. The starting points for the development will be given. Those are the requirements of the system's functions. The activities that have to be carried out are specified. A short schedule will be stated. At the end of the report a more detailed version will be available. In the project several experts are involved. These persons are mentioned and also the project organisation is described.

2.1.starting points

Starting point for PROSEL is to create a flexible propulsion installation design tool that can be used in the preliminary ship design stage. As less restrictions as possible must be there concerning numbers, dimensions and combinations of components. The system must have a strongly modular structure. All functions can be represented by a program module. In this way a complete system design can be made in which the modules can be developed according to their priority.

Other more technical starting points are the following ones:

- the PROSEL program will be a part of MARDES II as well as a stand alone module
- the source code will be Fortran 77
- the program will be developed on an AT-type DOS personal computer and Sun workstations using the UNIX operating system. The main goal is a system as hardware independent as possible
- the program must be suitable for the design of installations from ships that have a dieselengine, gasturbine or steamturbine, and PROSEL has to be prepared for future extensions to other types of prime movers e.g. a nuclear powered propulsion installation
- MIMER database handling and interface design will be applied when working in the MARDES II environment (not on the PC-version)
- There must be as less limitations as possible to propulsion plant configuration
- Four types of main propulsion arrangement components are being considered: prime mover, transmission, thruster and power take off
- Prime movers can be diesel engines, gasturbines, steamturbines and nuclear installations
- Transmissions in the program context are reduction gearboxes, electrical or hydraulical transmissions, and shafting systems.
- Thrusters can be propellers, waterjets or propellers in nozzles
- A power take off can be a generator or a direct drive for a pump, a compressor etc.
- An installation with a given configuration can be in different operational conditions. For a given condition it must be possible to specify which components of the installation are in active operation and which are not
- The installation design will concern the total energy generating plants for propulsion, electric power and heating
- The auxiliary system design involves cooling, fuel oil, lubrication oil and compressed air systems

- The system must be capable of performing a technical or economical evaluation on installations that are designed

2.1.1.main system functions

The main system tasks are to support the designer with:
- building a model of an installation.
  In this part the propulsion arrangement[1] will be considered. First the designer specifies his demands. Subsequently all possible installations, built up from database components, that meet this demands are generated.
- designing electric power, heating and auxiliary systems
- evaluating an installation.
  A specific installation can be evaluated technically and economically.

To compose an installation the system must have the disposal of a database with component data. In this database performance data, dimensions and weights are given for each component.
The program will communicate with:

1. the designer
   - design demands
   - installation selection
   - designing auxiliary systems
   - evaluation
   - presentation of results

2. the MARDES II environment
   - reading ship data
   - data output for interaction with MARDES II

3. the component database
   - component information

2.1.2.system design

The main functions of PROSEL, building and evaluating a propulsion installation and e.h.a.-systems (electric power, heat and auxiliary systems) will be worked out in the following paragraphs.

2.1.2.1.building a propulsion arrangement

The ship, for which the installation has to be developed, has to be identified from the MARDES II environment or directly from the designer in the stand alone version. The installation building phase begins with the designer giving the installation configuration with undimensioned blocks, this means blocks

---

[1] By propulsion arrangement the installation is meant which main task is converting the thermal energy in the fuel to a delivered thrust and ship speed.

representing a thruster, a prime mover, a transmission or a power take off.
Each installation component will be characterized by a describing list of parameters. In the component database existing components are described by such a list. In this database list all the parameters have a value or a range of possible values. Components in the design installation will be selected from these database according to the design demands.
After defining the configuration the designer can state his preferences for each component by giving a value to some or all of the parameters in the undimensioned block that describes the component. He can for instance specify a preference for a prime mover of make Sulzer by giving the 'make' parameter the value "Sulzer". When all the describing parameters of the components in the installation have been given a value by preference, and these values are consistent, then one specific component can be found in the database that meets this preferences and the component will already be selected.
Another design demand concerns the operational conditions for which the installation has to be designed, this means ship speed, draft, trim and sea margin.
Subsequently the system can get started to link the installation blocks together by selecting components and matching them. When doing this fitting components have to be found in the database. The component blocks are given in figure 1, together with the ingoing and outgoing parameters by which the components have to be linked together.
Therefore a possible installation is completely defined by it's component's describing parameterlists and the configuration. The matching and selecting will be governed by the automatic installation list completion algorithm.

2.1.2.2.electric power, heating and auxiliary systems (e.h.a.)

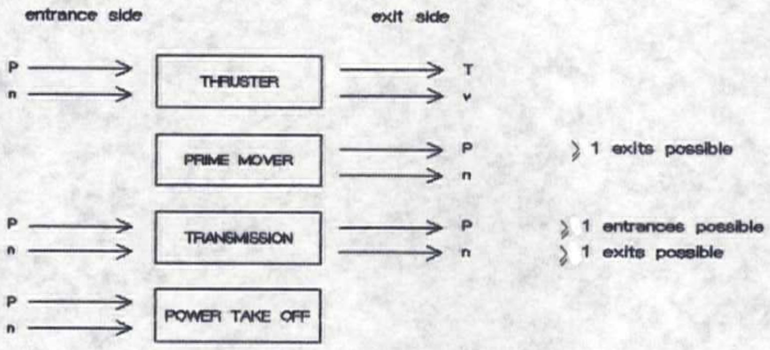
When a total energy system is to be designed the design of electric power, heating and auxiliary systems must be integrated. Auxiliary systems incorporate cooling, fuel oil, lubrication oil and compressed air systems. Besides that these systems are linked to the main propulsion arrangement these systems can be related to eachother. The designer must be offered the possibility to make use of these relations and design tailor made systems, that make optimal use of the energy that is being generated.

2.1.2.3.evaluating an installation

A model of a propulsion installation that has been built is serving as the input for the evaluation phase. Such an installation can be evaluated in a technical and an economical way.
In the technical evaluation the existing installation can be submitted to a performance calculation for a change in operational conditions (off design conditions), a reliability analysis, or a fine tuning of the thruster can be executed.

figure 1: components and the way they are linked

P = POWER
n = NUMBER OF REVOLUTIONS
T = THRUST
v = SPEED



COMPONENT	CAN BE COUPLED TO
THRUSTER ENTRANCE	PRIME MOVER EXIT TRANSMISSION EXIT
PRIME MOVER EXIT	THRUSTER ENTRANCE TRANSMISSION ENTRANCE
TRANSMISSION ENTRANCES	PRIME MOVER EXIT TRANSMISSION EXIT
TRANSMISSION EXITS	THRUSTER ENTRANCE TRANSMISSION ENTRANCE PTO ENTRANCE
PTO ENTRANCE	PRIME MOVER EXIT TRANSMISSION EXIT

For a given installation the main technical data can be given in the presentation mode. These are data concerning the installation weight, dimensions, costs, the maximum shipspeed, the fuel oil consumption etc.
Economical evaluations concern calculating economic parameters like e.g. internal rate of return, pay out period or present worth.

2.2.activities to carry out

The general system layout must be determined. A logical structure must be developed in which the program is subdivided. Each subdivision complies with a program function that has to be fullfilled. This will be achieved by translating the functions into program blocks. These blocks will consist of subblocks representing subfunctions etc. Every block has to be specified in functional and technical terms in such a way that it can be developed independently of the other blocks.
The organisation of data structures must be developed.
Where communication with elements outside the program takes place, an interface has to be designed. The screens layout from the user interface have to be ready at the end of the global design phase.

2.3.deployment of expertise

- Verbaas	Marin
- Klein Woud	TU Delft
- Aalbers	Yssel-Vliet combinatie

2.4.project organisation

Main design	:	ir. C. Landa		fulltime
Assistence	:	prof. ir. J. Klein Woud,	TU Delft	***
		ir. F. Verbaas,	Marin	***
Location	:	Marin Wageningen		thu, fri
		TU Delft		mon, tue, wed
Runtime	:	1-10-89 until 1-11-90		

3. future working environment

The system will be used as a stand alone program or as a module of the MARDES II designing environment. The user will likely be a member of the ship design department of a shipyard, a shipping company or a design agency. He will be expected to have a sound judgement in composing ship propulsion installations. The main goal of the PROSEL system is speeding up the composition and evaluation of an installation. In this way a greater number of possible installations can be compared before a selection is made and the optimal installation can be found.

4. specification of basic data structures

When the task of the system is considered it will be clear that the main system data concerns describing an installation with it's components and the links between them. An installation has to be composed by the system within the designer's demands.
To decide in which way an installation could be described it must be known how the installation components are defined. Four types of basic components are distinguished of which an installation is built up: prime movers, transmissions, thrusters and power take offs.
The data structure of an installation will be as given in figure 2.

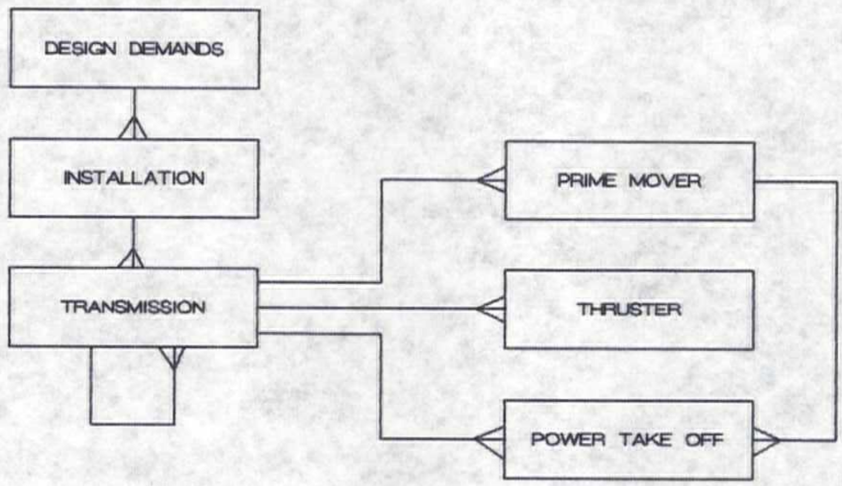


figure 2: data structure for the propulsion arrangement

5.specification of functions

Starting point for the specification of functions are the main task of the program as described in the conceptual design in paragraph 2.1.1. These main functions are:

- building a propulsion arrangement
- designing electric power, heating and auxiliary systems
- evaluating an installation
- selecting a propulsion installation

The last function will be needed for selecting a propulsion arrangement from the list of installations that are all feasible within the design demands.
The program functional layout will be described in the following paragraph with the help of the schematic display of the program in appendix 1. Each block will be described. The blocks are given a number, which will be pointed at in the concerning paragraph.

6.functional layout

(appendix 1, block 0)
The system layout is given in block 0 of the appendix.
The list of feasible installations is generated by the 'building a propulsion arrangement' block and contains a description of all installations that are feasible within the designer's demands. The selection function can be used to pick out one of these. For such an installation an auxiliary system design or an evaluation can be performed. The data flow between the main program blocks is given in a separate scheme.

6.1.building a propulsion arrangement

(appendix 1, block 1)
The program offers the possibility of generating automatically a number of installations within the design demands, as specified by the designer. The installation is composed by combining and matching together the components of which it is being built up. Data of actual dieselengines and gasturbines, gearings and thrusters are stored in a database.
The function of building a propulsion arrangement consists of two sub functions; specifying the design demands and automatical installation composition.

6.1.1.specify design demands

(appendix 1, block 1.1)
When specifying the design demands five steps have to be taken by the designer. The ship's identity, the operational conditions, the installation configuration, the component preferences and the design demands package name have to be made clear to the system before a feasible installation can be composed by the program.
When the ship's identity, the operational conditions and the configuration are known, these specifications are the input for determination of the ship's resistance, wake fraction(s), thrust deduction factor(s) and relative rotative efficiencies.

6.1.1.1.ship identification

(appendix 1, block 1.1.1)
When working in the MARDES II environment PROSEL will be activated when the designer is working on a specific ship. The ship identity will be known to the program in this case. Only a confirmation will be asked. When working in a stand alone version the ship's identity will have to be given, together with the location where the ship data can be found by the program. Which ship data are wanted is given in the next paragraphs.

6.1.1.2.operational conditions

(appendix 1, block 1.1.2)
The installation will be designed for one single operating point. This point is being recorded by the following data that have to be specified by the designer.

- speed
- sea margin

Only when working in the MARDES II environment it will be needed to specify the:

- hull position in the water (draft, trim)

This last specification is needed to calculate the ship's resistance by means of the resistance data in the database.

6.1.1.3.configuration

(appendix 1, block 1.1.3)
The propulsion arrangement consists of prime movers, transmissions, thrusters and power take offs being linked together. Specifying a configuration takes place by choosing component types, giving them a name and linking them together. For each component it has to be indicated wether it is active or inactive for the given operational condition. This feature is needed when for example a father-son installation is being designed for different operational conditions.
The following distributions have to be given by the designer:

- When more then one thruster per propulsion unit[2] is used then the thrust distribution has to be specified by the designer. A propulsion unit is a set of components that physically are or can be coupled to eachother
- When more then one shaft is fitted to the ingoing side of the transmission then the power distribution has to be given.
- When more then one propulsion unit is being applied, the thrust percentage per unit has to be given by the designer.

If no distribution is being specified, default values are being applied, giving an equal distribution. These default distributions are overruled when they can be directly deducted from the component preferences that are specified by the designer.

6.1.1.4.resistance and propulsion data

(appendix 1, block 1.1.4)
For composing a propulsion installation the required thrust is needed, as well as the wake fraction and the relative rotative efficiency, for every thruster. For propeller design also the maximum allowed propeller diameter must be known.

---

[2] A propulsion unit is a set of components that physically are or can be coupled to eachother

6.1.1.4.1.determine thrust per thruster
(appendix 1, block 1.1.4.1)
The required thrust per thruster in the design point can be calculated from the total ship's resistance, the thrust distribution and the thrust deduction factor per thruster. The thrust distribution is only relevant when more then one thruster is applied. The distribution has been given by the designer in the configuration specification.

6.1.1.4.1.1.determine the total ship resistance
(appendix 1, block 1.1.4.1.1)
The ship's resistance can be determined by means of earlier specifications of ship speed, draft and trim (paragraph 6.1.1.2), when working in the MARDES II environment.
When PROSEL works in stand alone mode the resistance has to be entered directly by the designer.

6.1.1.4.1.2.determine thrust deduction ratio per thruster
(appendix 1, block 1.1.4.1.2)
The thrust deduction ratio is considered as being a function of the thruster position coordinates only, when working in design point conditions. When working in the MARDES II environment the value of the ratio is being returned when the position coordinates are given by the designer (three coordinate values).
When PROSEL is used in stand alone mode the thrust deduction ratio has to be given by the designer directly.

6.1.1.4.1.3.calculate thrust per thruster
(appendix 1, block 1.1.4.1.3)
The calculation of required thrust per thruster will be done automatically by the program as soon as the required data are known. These data are the total required thrust, the thrust deduction ratio for every thruster and the thrust distribution among the thrusters.
For an installation with a number of thrusters N, the required thrust per thruster T_i ($1 \le i \le N$) can be calculated by solving a set of N equations. This is needed because:
- the designer will specify a thrust distribution and not a resistance distribution among the thrusters when N>1
- the thrust deduction ratio is not necessarily equal for each thruster. This makes that the thrust distribution does not have to equal the resistance distribution among the thrusters.

The part of the total resistance that is being taken care of by thruster i, R_i, can be written as follows:

$$R_i = (1-t_i)*T_i$$

in which t_i is the thrust deduction ratio for thruster 'i' that

can be determined. The sum of these R_i's must equal the total ship's resistance R_{tot}, which is also known.
This results in the first equation.

$$\Sigma_{i=1}^{N} R_i = R_{tot} \qquad (1)$$

The other N-1 equations can be deducted from the thrust distribution among the N thrusters. The thrust T_i that has to be delivered by thruster i can be written as a factor f_i of the total required thrust T_{tot}:

$$T_i = f_i * T_{tot} \qquad (2-N)$$

with $T_{tot} = \Sigma_{i=1}^{N} T_i$

<u>6.1.1.4.2.determine wake fraction per thruster</u>
(appendix 1, block 1.1.4.2)
The wake fraction has to be gathered from the ship's database when working in the MARDES II environment. The wake fraction is being considered as a function of the thruster position coordinates in design point calculations. When working on a PROSEL stand alone version the wake fraction has to be entered directly by the designer.

<u>6.1.1.4.3.determine relative rotative efficiency per thruster</u>
(appendix 1, block 1.1.4.3)
For the relative rotative efficiency an estimation will be made depending on the number of thrusters.

<u>6.1.1.4.4.determine maximum diameter per thruster</u>
(appendix 1, block 1.1.4.4)
For every thruster the maximum allowed diameter has to be determined. It is a function of the thruster's position coordinates and it's being limited by the ship's size and by the ship's draft. The thruster's position coordinates always have to be given a value by the designer. When working in the MARDES II environment the maximum diameter can be deducted from the database containing the ship's hull description. The designer can further specify a minimum tip clearance from the base, the side and the hull. Another limitation is the draft percentage that the thruster must be below the water surface.
When working in stand alone mode the diameter must be entered as an input value.

6.1.1.5.component preferences

(appendix 1, block 1.1.5)

After all of the components have been given a name in the configuration specification, selection preferences can be stated per component. A component is described by a list of parameters that depends on the component type (prime mover, transmission, thruster or power take off). When all parameters of such a list have been given a value, the component selection is completed and it is fully described. In the parameterlist the designer can give a value to certain parameters to specify his preferences. The designer can also pick a component out of the database catalogue, thus giving all parameters a value. Examples of these parameters are the make and number of cilinders of a dieselengine, the number of blades of a propeller, the make of a transmission etc.

6.1.1.6.design demands package naming

(appendix 1, block 1.1.6)

The package of design demands gets a unique name. This name can be specified by the designer but it is also possible to accept a program initiated default name, consisting of the ship identification and a number.

6.1.2.automatic installation composition

(appendix 1, block 1.2)

After the design demand specification the system will have to compose one or more feasible installations that are built up from actual components. The data of these components are stored in a databank.

The components must be selected and matched. An algorithm for composing an installation will steer the selecting and matching. Input for the selection are the design demands, output is a list containing the feasible installations.

6.1.2.1.selection of components

(appendix 1, block 1.2.1)

The designer has given his preferences so certain parameters do already have a value. Component selection means finding a value for the remaining parameters that were not given a value by preference. For power take off no selection has to take place. It's parameters all have to be given during the component specification by the designer. The 'filling-in' of the power take off can be an electric power generator, or a direct driven pump or compressor etc.

6.1.2.1.1.selection of thruster and thruster performance
(appendix 1, block 1.2.1.1)

The selection and performance calculation of thrusters takes place using wageningen B-series for propellers (see chapter 9). For propellers in nozzles and waterjets also wageningen series and programs will be used. The B-series propeller selection module determines the optimal propeller, this means with the highest open water efficiency sofar as the preference parameter values will permit.

When a propeller has to be chosen there are a number of thruster parameters that must have a value before selection can take place. These parameters are the maximum allowed diameter, the required thrust, the wake fraction, the number of blades and a cavitation criterium.

Besides these required thruster parameters above there are four other parameters that determine whether a selection or a performance calculation has to be made. Those parameters are the delivered power, the number of revolutions, the delivered thrust and ship speed or the propeller diameter.

The following examples are given to explain the feature that, depending on these parameters having a value or not, a selection or a performance calculation will be made. When e.g. the actual diameter, the delivered power and the number of revolutions already have a value, then obviously a performance calculation is needed which results in a delivered thrust and a ship speed. When e.g. the number of revolutions only have been given a value, then the program will select a propeller with the optimal diameter, which deliveres the required thrust with the required speed.

6.1.2.1.2.selection of prime mover
(appendix 1, block 1.2.1.2)

For prime mover selection a catalogue is used in which all relevant prime movers are described by means of filled-in parameterlist. Selection takes place in first instance by the preference parameters. After this is completed feasible prime movers are selected on the basis of required maximum continuous rating only, or required maximum continuous rating and number of revolutions. Dieselengines with one or several mcr-points (ecr-engines) or layout fields are present in the database.

6.1.2.1.3.selection of transmission
(appendix 1, block 1.2.1.3)

Transmission selection takes place according to the number of ingoing and outgoing shafts, the reduction ratio(s), the numbers of revolutions, the transmitted power(s), and the distances between de shafts that are found. The transmission databank consists of actual deliverable transmission configurations. For complex tailor made transmissions a rubber transmission will be applied, i.e. a virtual transmission with reduction ratios and efficiencies, but no actual dimensions and weights. It will be considered to involve a dimension, weight and cost estimation.

6.1.2.2.matching of components
(appendix 1, block 1.2.2)
The links between components have been given during the configuration specification. A link between components means that the corresponding parameters have the same value (corresponding parameters are showed in figure 1 on page 5). If this is the case and for all components there has been found a satisfying sample in the database then a feasible installation has been composed.

6.1.2.3.automatic installation naming
(appendix 1, block 1.2.3)
Each feasible installation that has been generated has to have a unique identity. Because generation takes place automatically the namegiving will also be automated. The name will consist of the shipname, the design demand package name, and a sequential number.

6.2.selecting an existing installation
(appendix 1, block 2)
An existing installation is an installation that has been built up with the 'building a propulsion arrangement' block. By default an installation will be selected from the latest feasible installations list. A selection from lists belonging to earlier formulated design demand packages can be made if the name of the package is entered by the designer.
Selection from a file must be possible by name and by criterion. After selection an installation can be looked at by means of the show module.

6.2.1.selection by name
(appendix 1, block 2.1)
The installations that result in the feasible installation list have a unique name. The designer can look at the list directory which installations are in the list and the wanted installation can be selected by it's name.

6.2.2.selection by criterion
(appendix 1, block 2.2)
The second possibility consist of selection by criterion. Several selection criteria must be offered. It will be possible to combine the separate criteria by means of a merit function and weighting factors. Those factors have to be given by the designer and the program will select the desired installation.

6.2.3.show the installation

(appendix 1, block 2.3)
After an installation has been chosen it can be looked at if the designer wishes to. Four types of information can be considered: ship data, operational conditions, configuration and component parameter descriptions. In this mode the information can't be changed, only looked at.

6.2.4.installation list selection

(appendix 1, block 2.4)
Because it must be possible to select an installation that has been generated with a different design demand package than the current one, the designer is abled to change the list of feasible installations by specifying the name of the demand package.

6.3.electric power, heating and auxiliary systems

(appendix 1, block 3)
Besides the propulsion arrangement also the electric power generation, the heat generation and the engine auxiliary systems have to be designed.

6.3.1.waste heat utilization exploration

(appendix 1, block 3.1)
The waste heat of the main/auxiliary engines can be utilized in different ways. In this paragraph a module is described to explore the possibilities of waste heat utilization. The results are giving guidelines for the auxiliary system design.

6.3.1.1.exhaust gas heat

(appendix 1, block 3.1.1)
By means of the exhaust gas boiler predesign it can be evaluated wether the waste heat amount is large enough to cover the requested steam generation or thermal oil heating.
For the different heating purposes (e.g. bunker heating, fuel preheating, separator preheaters etc.) the demand must be specified by the designer. If necessary a simple estimation can be offered.

6.3.1.2.cooling heat from dieselengines

(appendix 1, block 3.1.2)
When dieselengines are applied several cooling systems can be exploited for heat extraction. Those systems are charge air cooling, high temperature cooling water and lubrication oil systems.

6.3.1.2.1.charge air
(appendix 1, block 3.1.2.1)
The charge air heat can be used for preheating the steam boiler feedwater. It can also be used for other heating purposes where a rather high temperature (120°C) is needed.

6.3.1.2.2.high temperature cooling water
(appendix 1, block 3.1.2.2)
The waste heat in the high temperature cooling water can be used for accomodation heating, freshwater heating and freshwater generation.

6.3.1.2.3.lubrication oil system
(appendix 1, block 3.1.2.3)
This system concerns the lubrication of prime movers and, if present, the engines that drive electic power generators. A cleaning, transport and feed system must be designed.

6.3.2.design of heat, electric power and auxiliary sytems
(appendix 1, block 3.2)
After an inventarisation of waste heat utilization has been made the actual e.h.a.-system designs can take place. In this way an optimal fullfillment of the total energy demand (propulsive power, heat and electric power) can be realized.

6.3.2.1.heat system
(appendix 1, block 3.2.1)
The heat flow between engineroom installations is shown in figure 3. The distribution of the generated waste heat has been chosen during the waste heat utilization exploration. If the waste heat does not cover the total required heat, then an additional boiler will have to be installed.
In this module the boiler arrangement will be designed. The prime mover and/or auxiliary engines can be used as heat sources by means of exhaust gas boilers but in this case donkey boilers will also have to be applied for covering the demand when the engine's heat output is too low or absent (partly loaded, switched off).
Also heat can be extracted from the cooling and lubrication oil systems of prime mover and/or auxiliary engines.
The heat demand will be considered input data for PROSEL. This means that PROSEL does not offer a heat demand determination module. It will be considered to offer a simple heat demand estimation program.

6.3.2.1.1.steam generation
(appendix 1, block 3.2.1.1)
When steam heating is being applied the heat demand must be converted to required steam quantities and qualities. Saturated and superheated steam must be distinguished.
The waste heat utilization exploration module has given an idea about the requirements of an exhaust gas boiler. This will be the input for the actual steam system design.
When the waste heat in the exhaust gasses of prime movers and auxiliary dieselengines is being used for steam generation a basic exhaust gas boiler design will be offered by the system.
Feedwater preheating can be applied.
The program offers an oil fired boiler selection. A database of boilers requirements that can be met will be exploited.

6.3.2.1.2.thermal oil heating
(appendix 1, block 3.2.1.2)
Like with the steam system the heat demand has to be converted to thermal oil temperatures and quantities. The thermal oil heating can make use of an exhaust gas heater and/or an oil fired boiler.

6.3.2.2.electric power
(appendix 1, block 3.2.2)
The electricity generation module needs an input in the shape of an electric power demand and through what type of installation it has to be delivered. Four alternatives are taken into account by this program. First a generator can be driven by a main engine power take off (power and rpm already specified with propulsion arrangement design). Second auxiliary diesel generatorsets can be applied. The third alternative is a steam turbogenerator which is fed by steam that is generated by an exhaust gas/auxiliary boiler (steam quality and quantity already specified with heat system design). The last applicable is an exhaust gas turbogenerator. Combinations of these four options are also possible.

6.3.2.2.1.power take off generator
(appendix 1, block 3.2.2.1)
An electric power demand can be fulfilled by using a power take off that must already be specified in the propulsion arrangement design. For the required electric power a generator has to be selected from the database or ordered from the manufacturer if a tailor made solution is whishfull.

6.3.2.2.2.auxiliary diesel generator
(appendix 1, block 3.2.2.2)
When electricity has to be generated by separate diesel generator sets the program offers the possibility to select these gensets. The input to the program is a power demand and the number of installations that are wanted. Component preferences can also be supplied by the designer. The installation will be built up from catalogue components. Auxiliary systems for the dieselengines like e.g. cooling, fuel and lubrication systems will be taken into account in the auxiliary systems design (paragraph 6.3.2.3)

6.3.2.2.3.steam turbogenerator
(appendix 1, block 3.2.2.3)
A steam turbine in combination with an exhaust gas and/or auxiliary boiler can be used to drive a generator.
The program offers two kinds of designing this steam turbogenerator.
The first way is selecting a generator and steam turbine for a given electric power demand. The designer has to specify the electric power that has to be delivered by the generator. The system will select a steam turbogenerator from the catalogue. Thus the required amount of steam will output.
The second way is selecting a turbogenerator for a given steam supply. The result will be an electric power generation.
Another way of describing those two ways is, the first finding a required steam supply with a given electricity demand, the second finding a maximum electricity generation with a given steam supply.
The designer can also specify component preferences.

6.3.2.2.4.exhaust gas turbogenerator
(appendix 1, block 3.2.2.4)
With some dieselengines it is possible to apply a turbine driven generator in the engine exhaust gas flow.
The design of this exhaust gas turbogenerator is depending on the type of prime mover that has been chosen. The electric power that can be generated in this way is therefore a value that can be attached to a specific engine. The design will not be seperated into a separate program module.

6.3.2.3.auxiliary systems
(appendix 1, block 3.2.3)
The auxiliary systems consist of a fuel oil system, a lubrication oil system, a cooling system and a compressed air system. These system designs are described in the following paragraphs.

6.3.2.3.1.cooling system

(appendix 1, block 3.2.3.1)
An engine manufacturer prescribes the heat that has to be dissipated, the temperatures and the required cooling water flows. Also one or more configurations will be proposed.
Within certain limits a designer must be able to compose a coolingwater system that satisfies the engine requirements and the designer's specific wishes. He can make choices between several system configurations concerning salt water and high and low temperature fresh water. He can build up an installation consisting of pumps, heat exchangers, heat sources and heat users.
Waste heat utilization can be coupled to the system. This means fresh water generation, charge air cooling with boiler feedwater, accomodation heating and freshwater heating by means of heat exchanger couplings.

6.3.2.3.2.fuel oil system

(appendix 1, block 3.2.3.2)
With the fuel system several subsystems can be distinguished: fuel transport, fuel boosting, fuel cleaning, fuel blending, fuel feeding. Depending on the requirements of the engines that need the fuel a system can be composed by the designer, consisting of basic elements like pumps, heaters, valves, separators, filters, flow meters, viscoraters blending units, and tanks.

6.3.2.3.3.lubrication oil system

(appendix 1, block 3.2.3.3)
For the lubrication oil system more or less the same lay out can be handled as is done for the fuel oil system. A transport, cleaning and circulation system can be distinguished. The system consists of pumps, filters, valves, separators, heaters and tanks.

6.3.2.3.4.compressed air system

(appendix 1, block 3.2.3.4)
The compressed air system has to meet the requirement of the prime movers and auxiliary engines that are applied. Besides these requirements compressed air is also needed for regulating purposes. Basic components will be chosen for the system.

6.3.2.4.saving of the e.h.a. system design

(appendix 1, block 3.2.4)
When an e.h.a. system has been designed it must be possible to store this design. The design is coupled to a specific propulsion arrangement. The name of this arrangement will be displayed and

can be confirmed. Because different e.h.a. system designs are possible for the same propulsion arrangement the designer has to specify which version of the total installation design the e.h.a. system belongs to.

6.4.evaluation and final selection

(appendix 1, block 4)
A given propulsion arrangement can be evaluated in a technical and an economical way. Also the main installation data will be presented in the technical presentation mode. The results of each evaluation are stored per installation. Different installations can be compared by comparing these results. If the optimal installation has been found a final selection can be made.

6.4.1.technical evaluation

(appendix 1, block 4.1)
The technical evaluation incorporates fitting the installation into the engineroom, a reliability analysis, fine tuning the thruster and a performance evaluation for changes in the operational conditions.

6.4.2.economical evaluation

(appendix 1, block 4.2)
In the economical evaluation capital investment, pay back periods, interest rates etc. can be considered for the given installation. The program will calculate and present the relevant ecomical/financial data.

6.4.3.technical presentation

(appendix 1, block 4.3)
In this technical presentation the main installation data are given e.g. fuel oil consumption, machinery weight, installation costs, maximum speed etc.

6.4.4.final selection

(appendix 1, block 4.4)
When more then one installation has been evaluated the evaluation results can be compared. An appropriate installation can be chosen on the basis of these comparisons. An optimalization procedure can be applied for the selection.

7.specification of the interfaces

PROSEL needs to collect data for operation. The main source of these data will be the designer who is operating the program. Depending on the fact wether the program is working in the MARDES II environment or not there will be need for other interfaces.

7.1.ship data from database

The installation is being composed for a certain ship from which the hull is already defined. Primarily hull resistance data, thrust deduction ratio, wake fraction, relative rotative efficiency and maximum allowed thruster diameter must be known to determine the propulsion installation. Secondly when fitting the installation into the engineroom the engineroom dimensions must be known. When working in a stand alone version the designer will have to enter these data directly by hand. In the MARDES II environment these data will be collected from the MARDES II database.

7.2.component data from database

The installation will be built by selecting and matching components that are described in the component database. The selection must be possible by specifying values for certain parameters. These parametervalues represent the design requirements. Components in the database that meet these demands will be selected. Database handling and selection procedures must be developed for the stand alone version as well as for the MARDES II version.

7.3.user interface

Communication with the designer takes place in several ways. The main issues are:
- specifying installation design demands
- selecting an installation
- specifying an evaluation mode
- interpreting design results

The user interface screen lay-outs are given in appendix 3. When working in the MARDES II environment there can be made use of the MIMER database handling and interface design.

8.technical system structure

PROSEL primarily will be developed on a personal computer (AT-type) with DOS operating system and on Sun workstation with the Unix operating system. In principle PROSEL must be hardware independent.
The following hardware will be made available for system development:

- PC type AT:	by:	- TU Delft - Marin
- Sun workstation:	by:	- TU Delft - Marin

The programming language that will be applied will be Fortran 77 according to MARDES II language.

9.development priority list

In order to get a workable version before 01-11-90, when the first PROSEL development phase will end, priorities will have to be given to the parts of the program. All elementary blocks can more or less be developed separately. Among the main program functions are selection, auxiliary system design and evaluation. To do these three functions a description of a propulsion arrangement is needed. Therefore the propulsion arrangement building block has priority number 1.
Considering the application of the program a choice has to be made for which kind of components the program will be suitable in the first instance.

- The prime mover component with the highest priority will be the dieselengine. Gasturbine, nuclear installation and steamturbine will be added later.
- As thruster components Wageningen B-serie propellers will be used. Propellers in nozzles and waterjets will be added later.

After the propulsion arrangement building block has been completed, the installation selection block will be developed. Electric power generation and heat system have the next priority. The technical presentation and technical evaluation phase will complete the PROSEL version 1.
Auxiliary system design and extension to other types of prime movers, thrusters and transmissions will take place in a later PROSEL version.

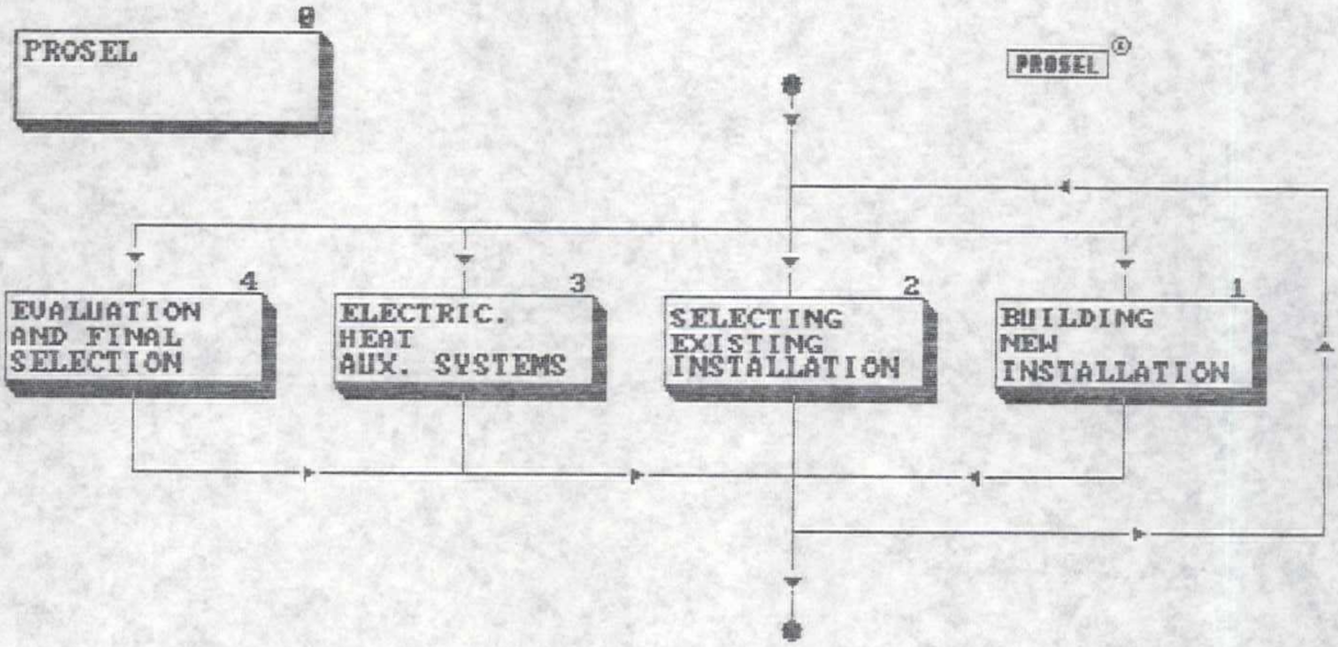
10.acceptation testing plan

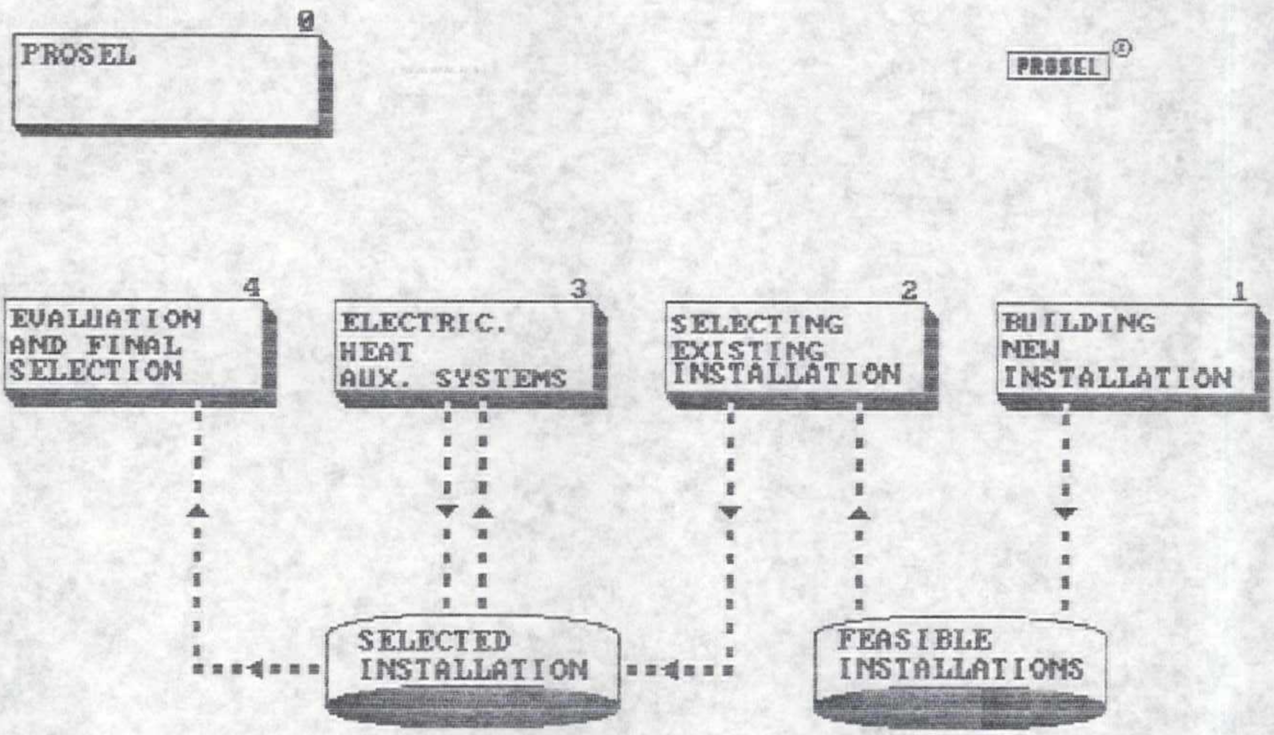
Per program block there will be made a test program. The block will be submitted to extremities. All error situations must be distinguished during the detailed design phase. For all the situations in which these errors occur the program must be run and react according to the specifications.

11.detailed project plan

subject	duration	ending
definition study/global design	10 weeks	10-11-89
building a new installation		
- detailed design	4 weeks	08-12-89
- technical design	6 weeks	02-02-90
- testing	2 weeks	16-02-90
selecting an installation		
- detailed design	1 week	23-02-90
- technical design	2 weeks	09-02-90
- testing	1 week	16-02-90
heat system		
- detailed design	3 weeks	06-04-90
- technical design	3 weeks	27-04-90
- testing	1 week	04-05-90
electric power system		
- detailed design	2 weeks	18-05-90
- technical design	2 weeks	01-06-90
- testing	1 weeks	08-06-90
technical presentation		
- detailed design	3 weeks	29-06-90
- technical design	3 weeks	17-08-90
- testing	1 weeks	24-08-90
technical evaluation		
- detailed design	4 weeks	05-10-90
- technical design	4 weeks	26-10-90
- testing	1 weeks	02-11-90

appendix 1: PROSEL block scheme


PROSEL
0
PROSEL ©
EVALUATION AND FINAL SELECTION
4
ELECTRIC. HEAT AUX. SYSTEMS
3
SELECTING EXISTING INSTALLATION
2
BUILDING NEW INSTALLATION
1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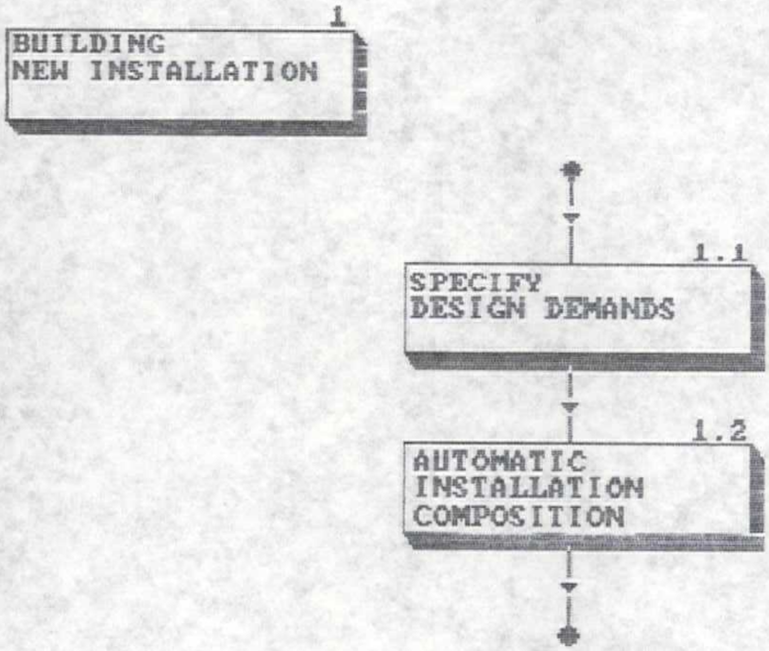
PROSEL ©
EVALUATION AND FINAL SELECTION
4
ELECTRIC. HEAT AUX. SYSTEMS
3
SELECTING EXISTING INSTALLATION
2
BUILDING NEW INSTALLATION
1
SELECTED INSTALLATION
FEASIBLE INSTALLATIONS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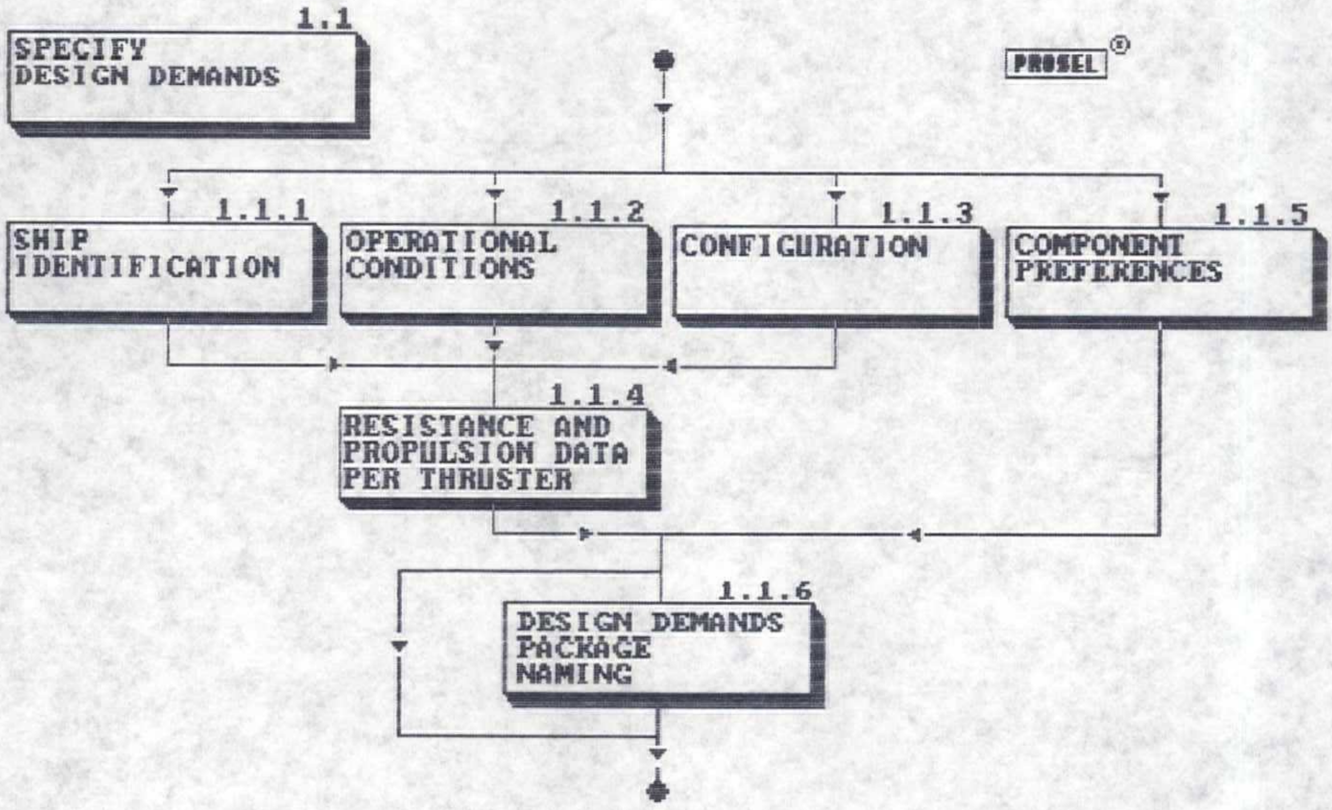
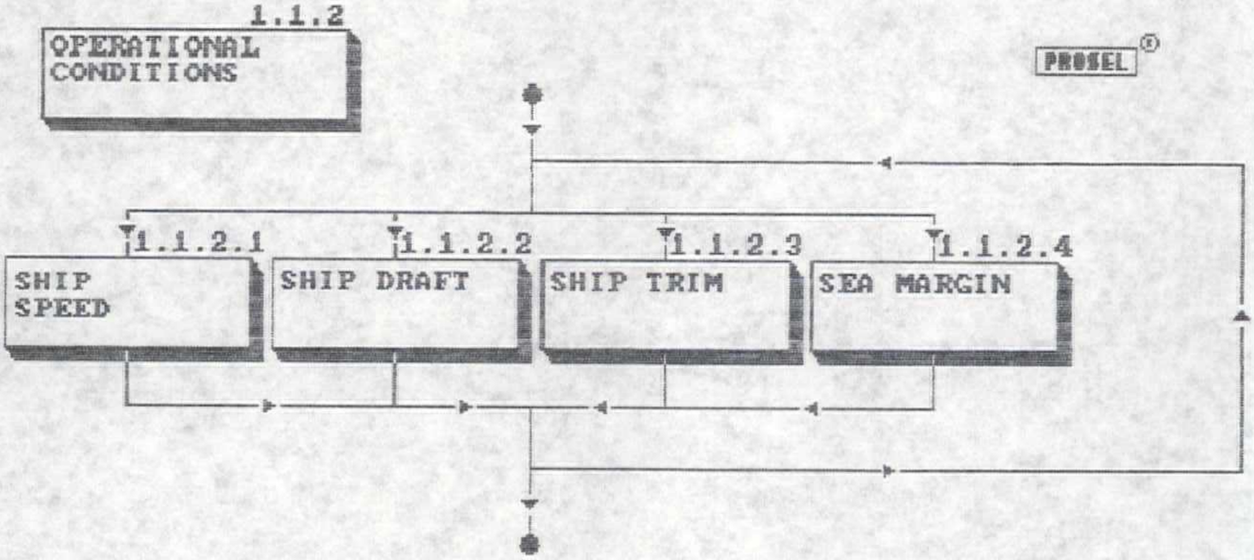
BUILDING
NEW INSTALLATION
1.1
SPECIFY
DESIGN DEMANDS
1.2
AUTOMATIC
INSTALLATION
COMPOSITION

PROSEL®


1.1
SPECIFY
DESIGN DEMANDS
PROSEL®
1.1.1
SHIP
IDENTIFICATION
1.1.2
OPERATIONAL
CONDITIONS
1.1.3
CONFIGURATION
1.1.5
COMPONENT
PREFERENCES
1.1.4
RESISTANCE AND
PROPULSION DATA
PER THRUSTER
1.1.6
DESIGN DEMANDS
PACKAGE
NAMING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SHIP DRAFT
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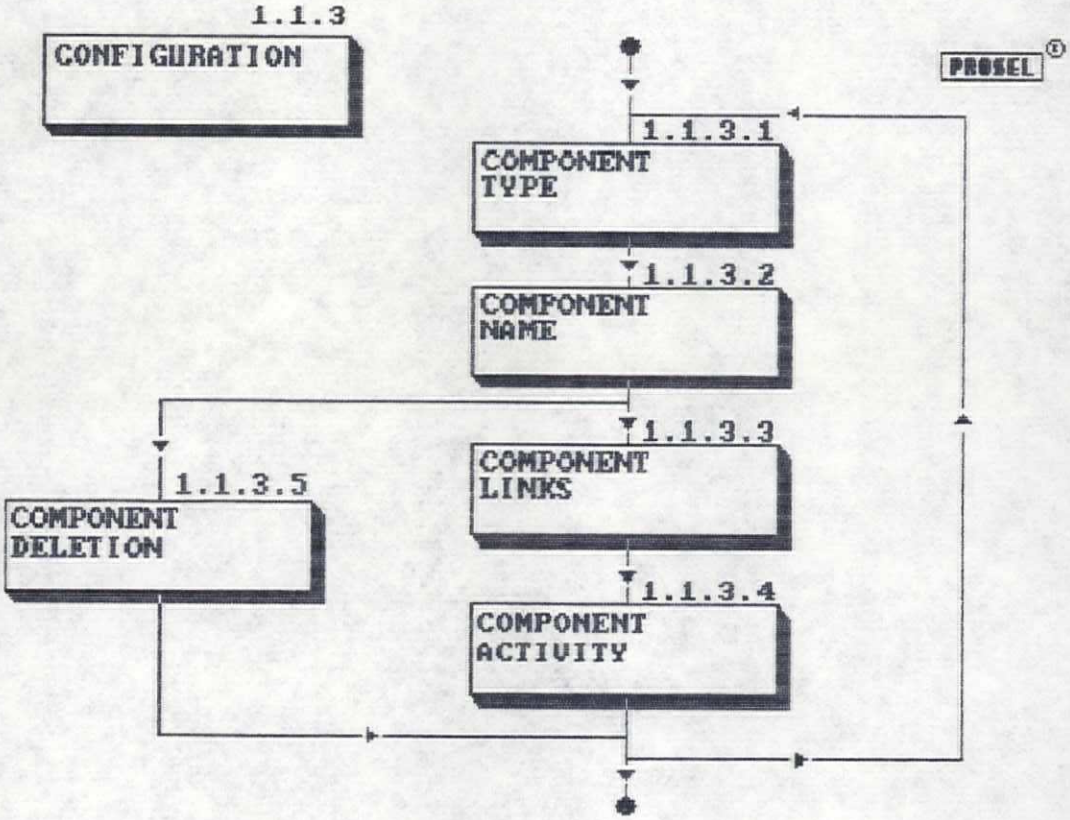
SEA MARGIN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CONFIGURATION
PROSEL
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COMPONENT TYPE
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COMPONENT NAME
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COMPONENT ACTIVITY
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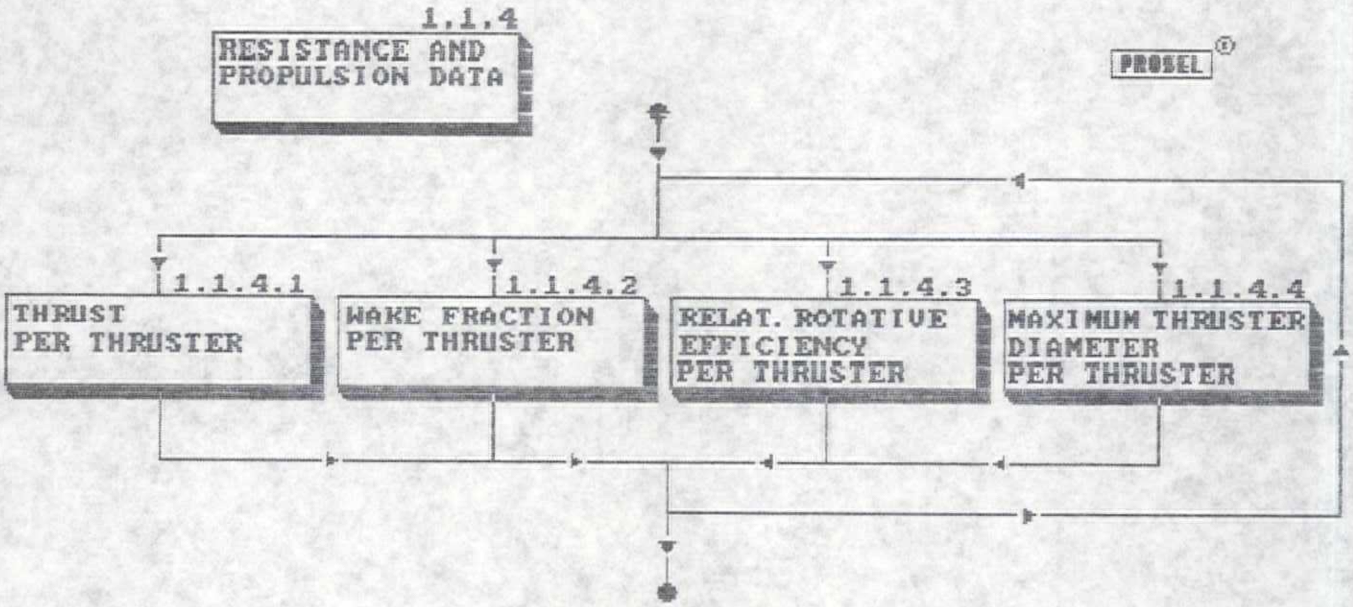
COMPONENT DELETION



1.1.4
RESISTANCE AND PROPULSION DATA
PROSEL ®
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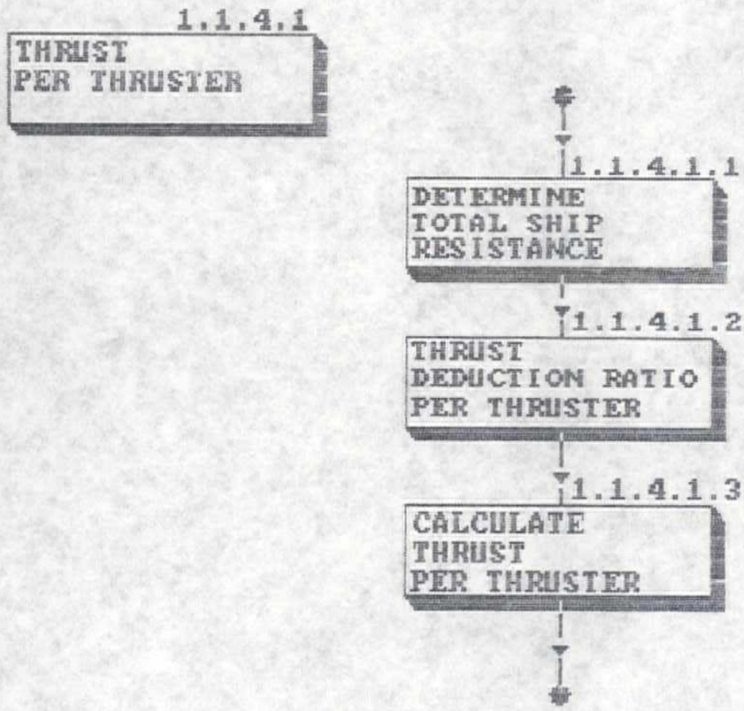
THRUST PER THRUSTER
1.1.4.2
WAKE FRACTION PER THRUSTER
1.1.4.3
RELAT. ROTATIVE EFFICIENCY PER THRUSTER
1.1.4.4
MAXIMUM THRUSTER DIAMETER PER THRUSTER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THRUST
PER THRUSTER
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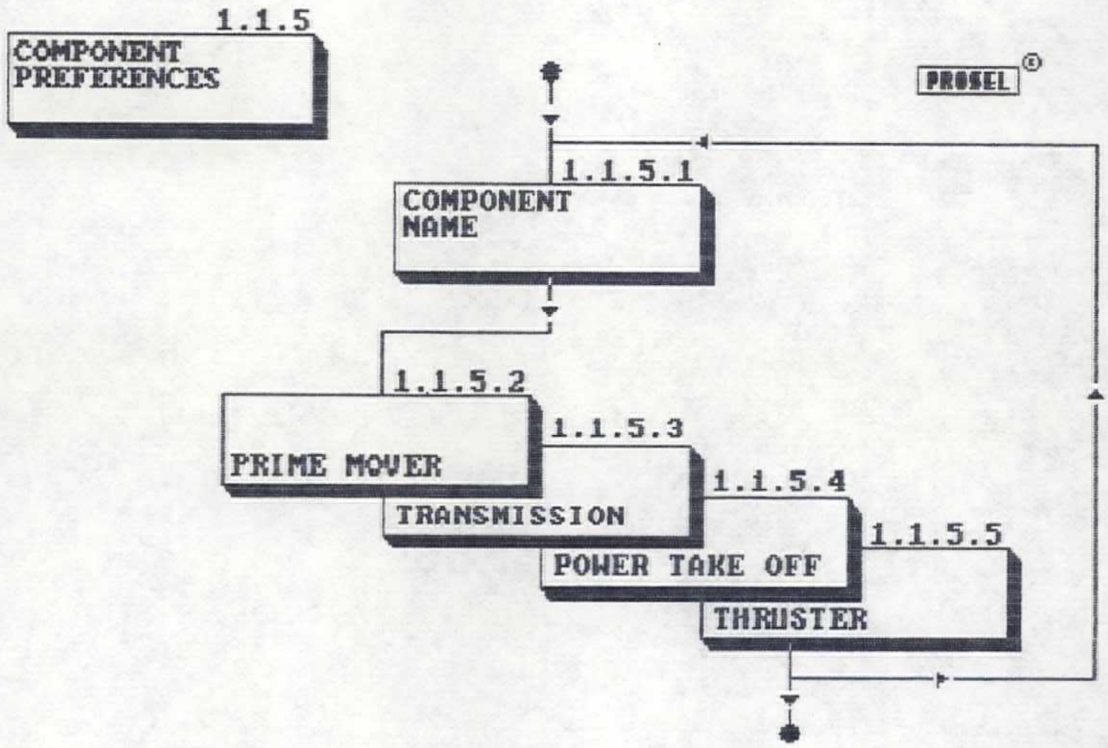
DETERMINE
TOTAL SHIP
RESISTANCE
1.1.4.1.2
THRUST
DEDUCTION RATIO
PER THRUSTER
1.1.4.1.3
CALCULATE
THRUST
PER THRUSTER

PROSEL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COMPONENT PREFERENCES
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COMPONENT NAME
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PRIME MOVER
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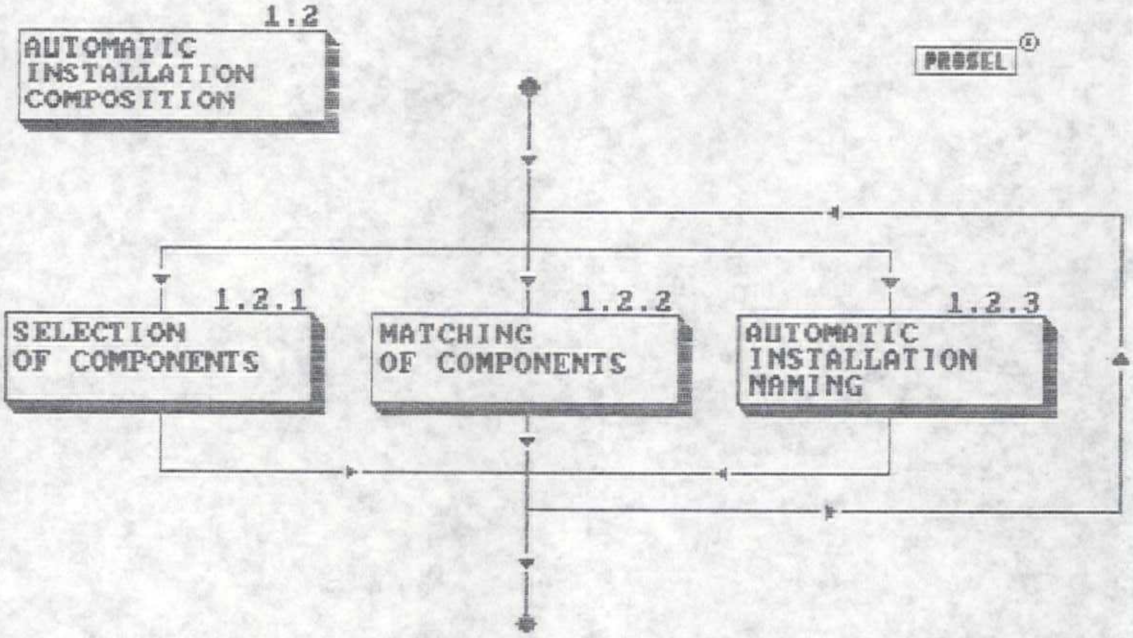
TRANSMISSION
1.1.5.4
POWER TAKE OFF
1.1.5.5
THRUSTER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AUTOMATIC INSTALLATION COMPOSITION
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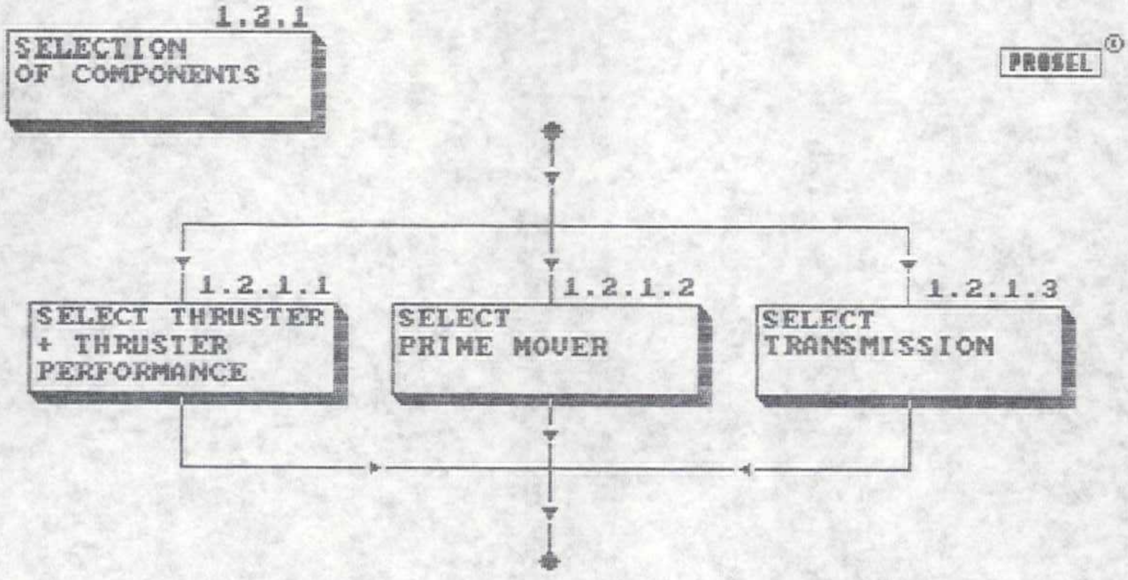
1.2.2
MATCHING OF COMPONENTS
1.2.3
AUTOMATIC INSTALLATION NAMING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SELECTION OF COMPONENTS
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SELECT THRUSTER + THRUSTER PERFORMANCE
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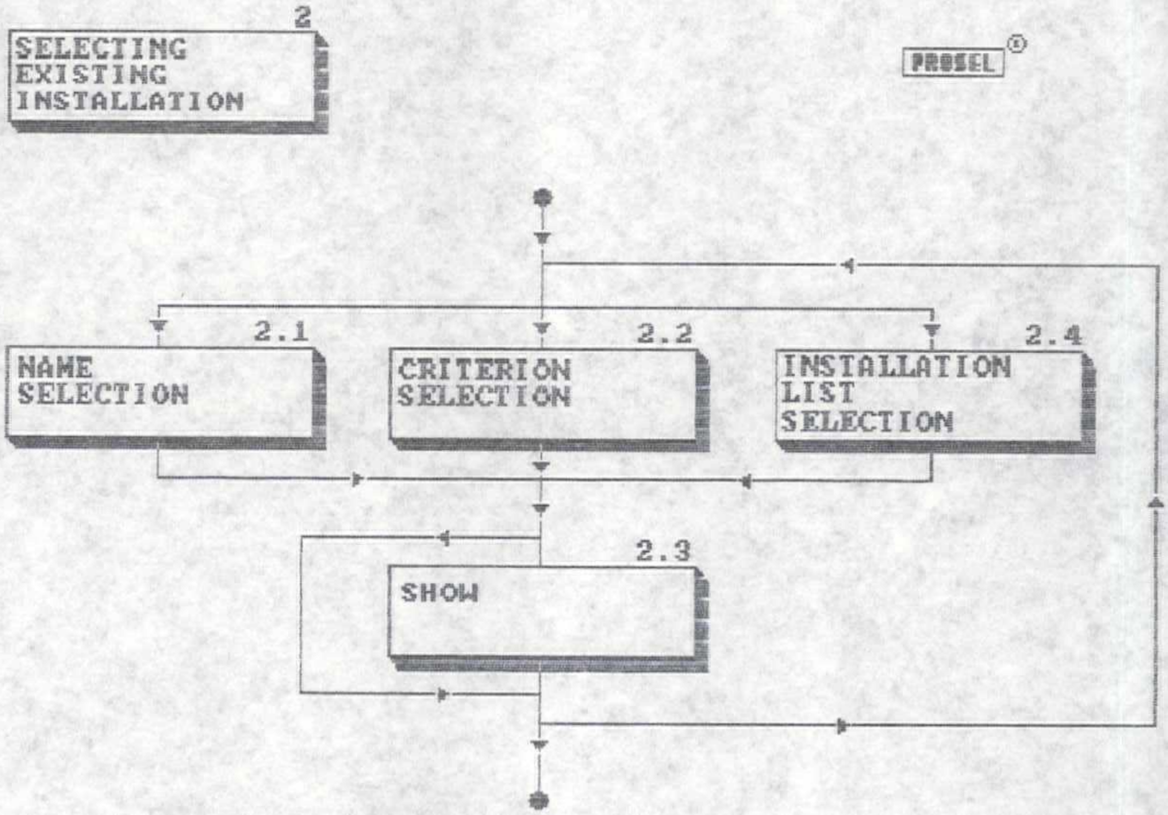
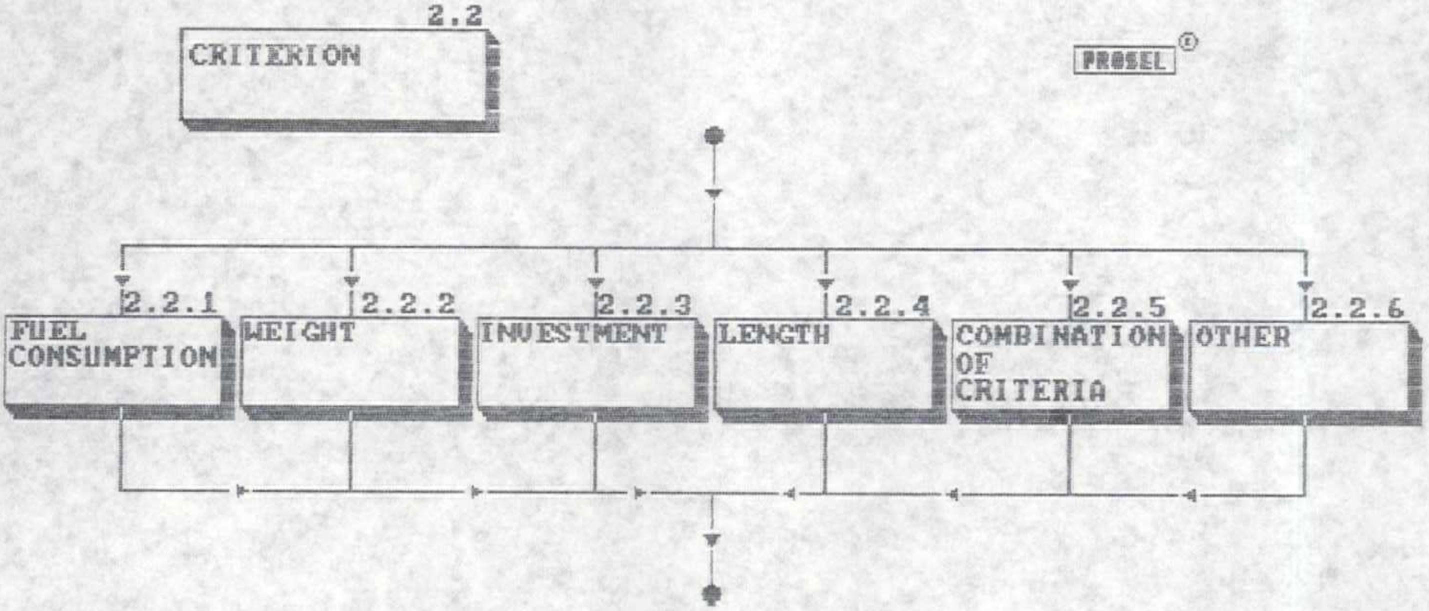
SELECT PRIME MOVER
1.2.1.3
SELECT TRANSMISSION


2
SELECTING
EXISTING
INSTALLATION
PROSEL
2.1
NAME
SELECTION
2.2
CRITERION
SELECTION
2.4
INSTALLATION
LIST
SELECTION
2.3
SHOW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CRITERION
PROSEL ©
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FUEL CONSUMPTION
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WEIGHT
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INVESTMENT
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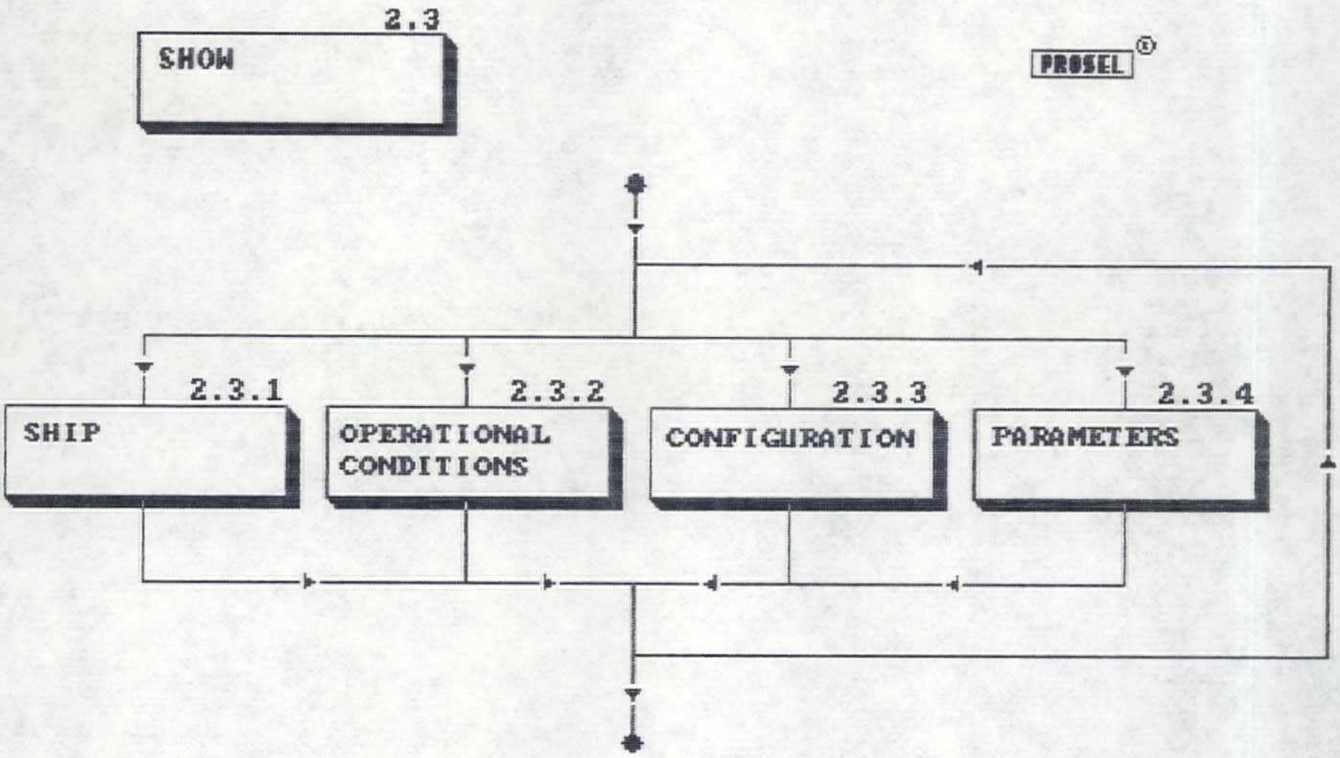
LENGTH
2.2.5
COMBINATION OF CRITERIA
2.2.6
OTHER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SHOW
PROSEL ®
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SHIP
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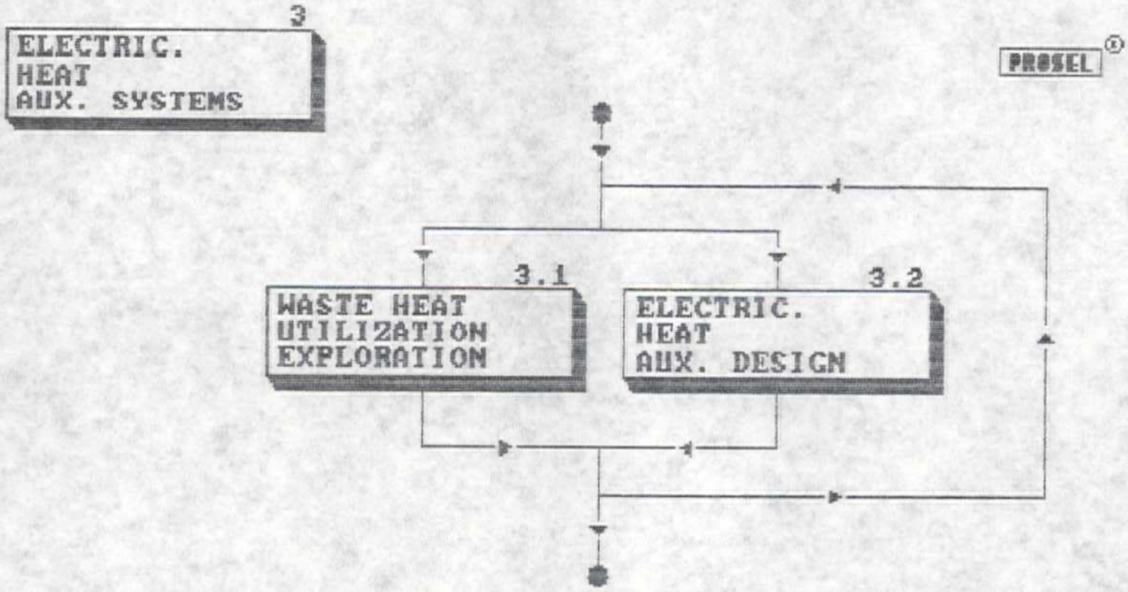
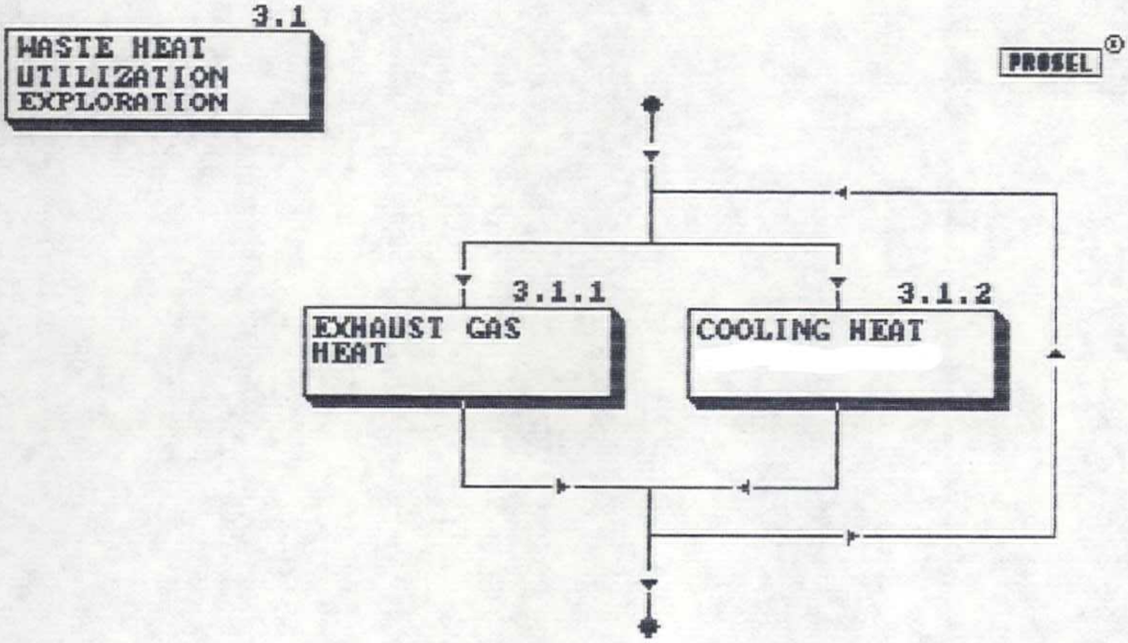
OPERATIONAL CONDITIONS
2.3.3
CONFIGURATION
2.3.4
PARAMETERS


3
ELECTRIC.
HEAT
AUX. SYSTEMS
PROSEL
3.1
WASTE HEAT
UTILIZATION
EXPLORATION
3.2
ELECTRIC.
HEAT
AUX. DESIGN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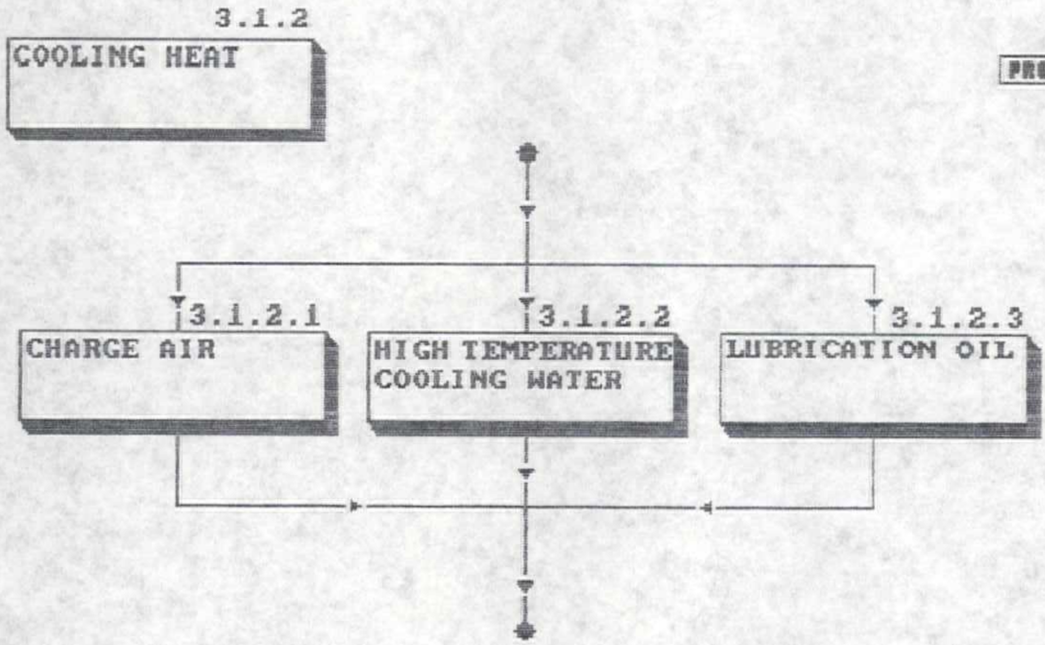
UTILIZATION
EXPLORATION
PROSEL
3.1.1
EXHAUST GAS
HEAT
3.1.2
COOLING HEAT


3.1.2
COOLING HEAT
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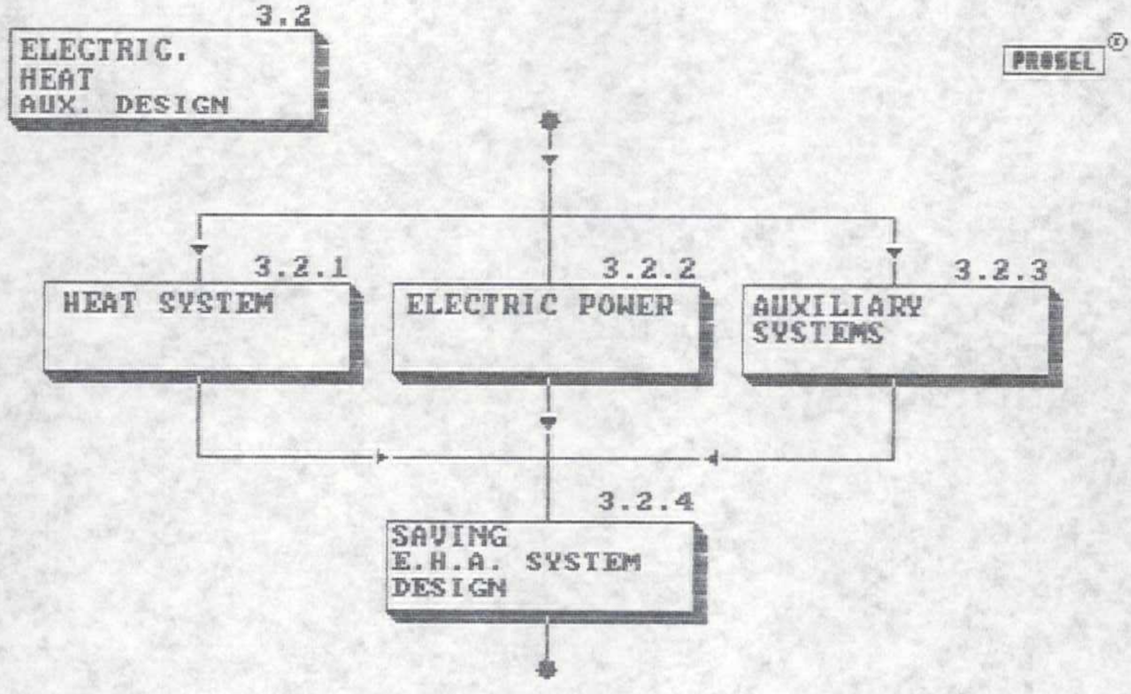
CHARGE AIR
3.1.2.2
HIGH TEMPERATURE COOLING WATER
3.1.2.3
LUBRICATION OIL

PROSEL©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ELECTRIC.
HEAT
AUX. DESIGN
PROSEL
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ELECTRIC POWER
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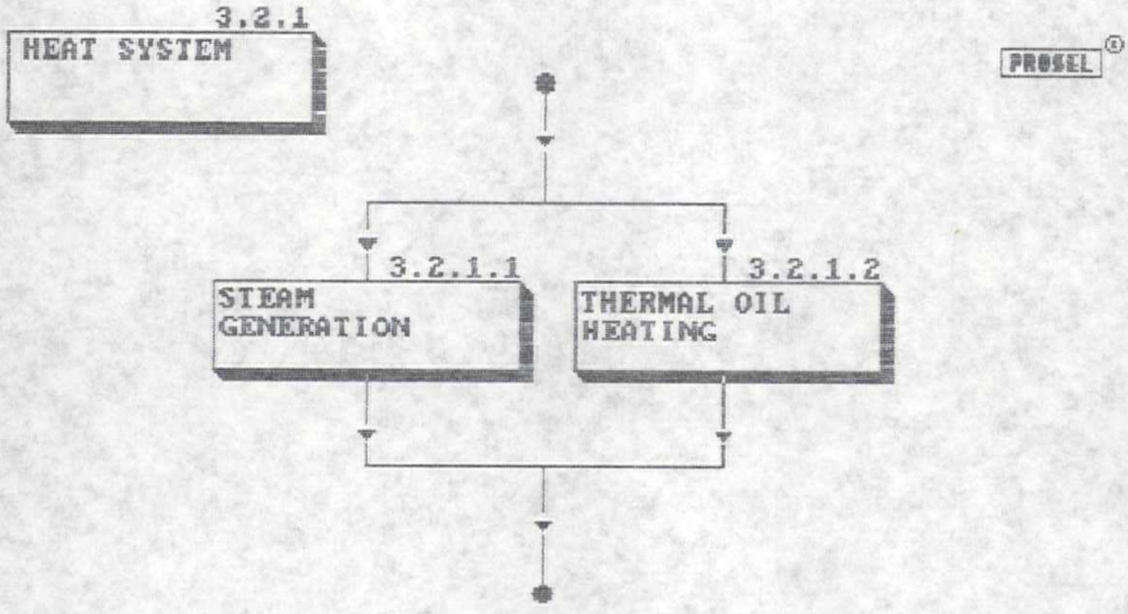
AUXILIARY
SYSTEMS
3.2.4
SAVING
E.H.A. SYSTEM
DESIGN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STEAM GENERATION
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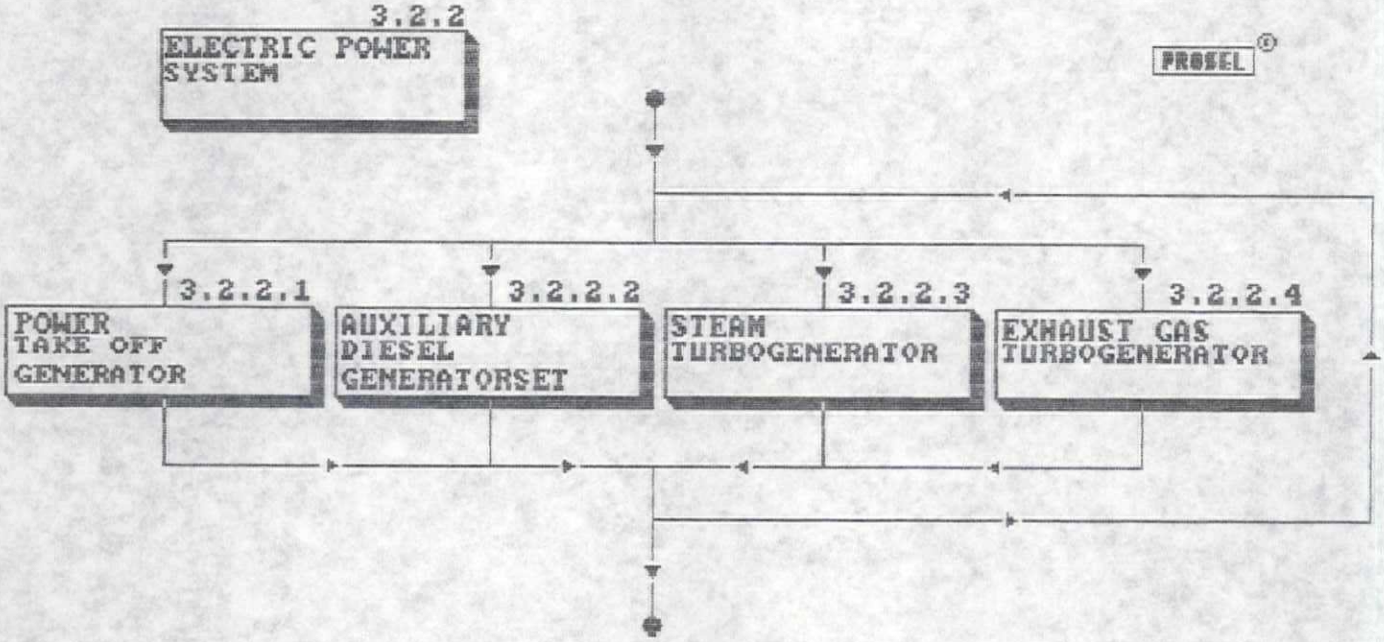
THERMAL OIL HEATING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POWER TAKE OFF GENERATOR
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STEAM TURBOGENERATOR
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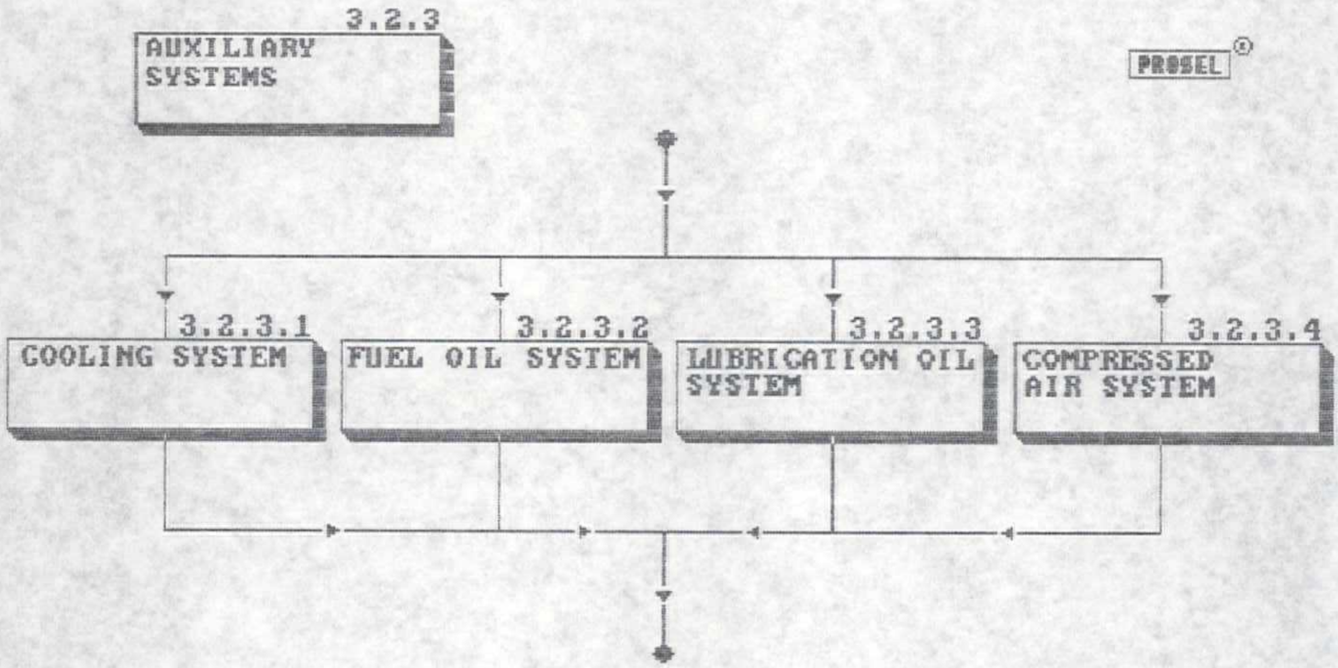
EXHAUST GAS TURBOGENERATOR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AUXILIARY SYSTEMS
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3.2.3.2
FUEL OIL SYSTEM
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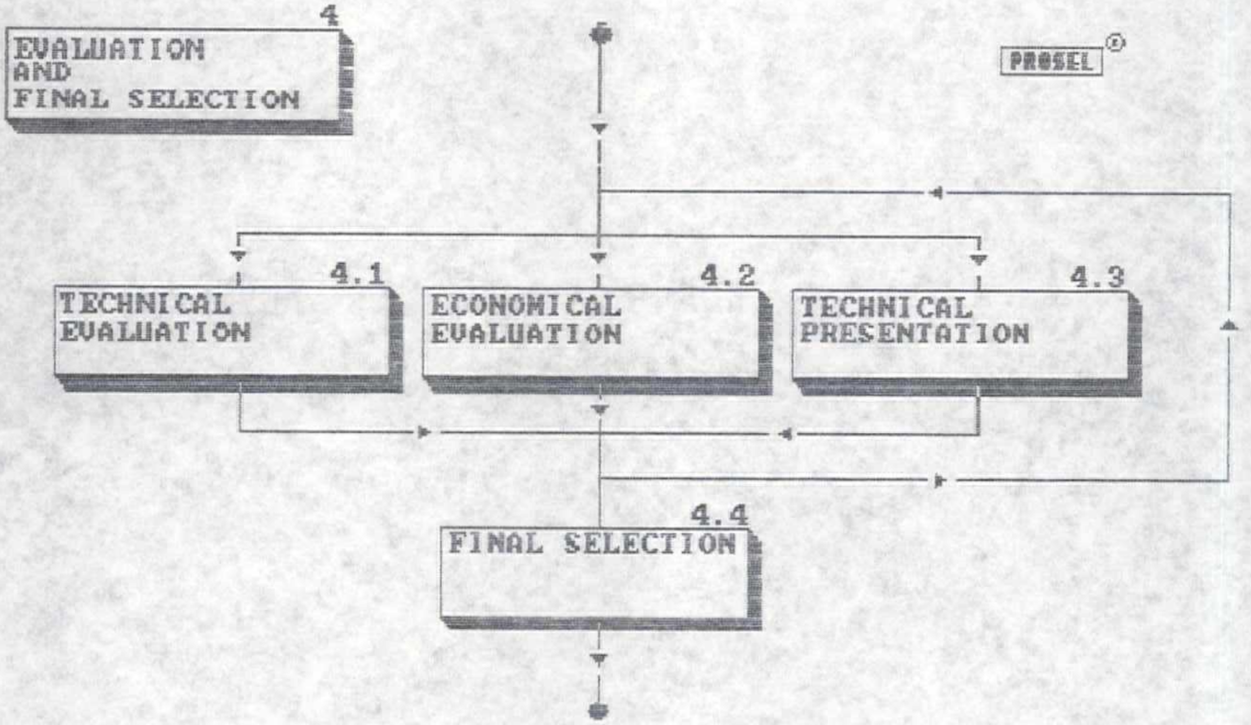
LUBRICATION OIL SYSTEM
3.2.3.4
COMPRESSED AIR SYSTEM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EVALUATION
AND
FINAL SELECTION
PROSEL®
4.1
TECHNICAL
EVALUATION
4.2
ECONOMICAL
EVALUATION
4.3
TECHNICAL
PRESENTATION
4.4
FINAL SELECTION

appendix 2: PROSEL user interface screens

PROSEL

propulsion selection program

Page ******	installation ********	ship ********

message field for program level

---

menu or data field

---

explanation field for interface design (not visible for user)

Page 0

MAIN

```
0 - End PROSEL
1 - Build a propulsion arrangement          1
2 - Select an installation                  2
3 - Electric power, heat and                3
    auxiliary systems
4 - Evaluation                              4


your choice = ********
```

after ending exit program
this page is dynamic, unallowed choices will not be displayed

Page 1.

BUILD A PROPULSION ARRANGEMENT

0 - End building a propulsion arrangement

1 - Specify design demands 1.1

2 - Automatic installation composition 1.2

your choice = ********

after ending go to page 0

Page 1.1. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS

---

0 - End specify design demands		
1 - Ship identification	1.1.1	
2 - Design demand package naming	1.1.2	
3 - Operational conditions	1.1.3	
4 - Configuration	1.1.4	
5 - Resistance and propulsion data	1.1.5	
6 - Component preferences	1.1.6	

your choice = ********

after ending go to page 1

Page 1.1.1.

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS -
SHIP IDENTIFICATION

```
ship identity          ********

ship data              ********
                       ********
                          --



     confirm [Y/N]     ********
```

if confirmation [Y] read data and go to page 1.1
if confirmation [N] go to page 1.1

```
Page 1.1.2.                                                   ship ********
-----------------------------------------------------------------------------
BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS -
OPERATIONAL CONDITIONS
-----------------------------------------------------------------------------
 draft                ********
 trim                 ********

 speed                ********

 sea margin           ********



       confirm [Y/N]  ********
-----------------------------------------------------------------------------
 if confirmation [Y] read data and go to page 1.1.
 if confirmation [N] go to page 1.1.
```

Page 1.1.3. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION

---

0 - End configuration

1 - Define configuration 1.1.3.1

2 - Change configuration 1.1.3.2

your choice = ********

after ending go to page 1.1.

Page 1.1.3.1.	ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION - DEFINE CONFIGURATION

---

0 - End define configuration	
1 - Component definition	1.1.3.1.1
2 - Activity specification	1.1.3.1.2
3 - Link definition	1.1.3.1.3
4 - Thruster position	1.1.3.1.4

your choice = ********

after ending go to page 1.1.3

Page 1.1.3.1.1. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION - DEFINE CONFIGURATION - COMPONENT DEFINITION

component type	********	component name	********
component type	********	component name	********
component type	********	component name	********
component type	********	component name	********
component type	********	component name	********
component type	********	component name	********
component type	********	component name	********
component type	********	component name	********
component type	********	component name	********

confirm [Y/N] ********

if confirm [Y] read data and go to page 1.1.3.1.
if confirm [N] go to page 1.1.3.1.

Page 1.1.3.1.2.			ship ********
BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION - DEFINE CONFIGURATION - ACTIVITY SPECIFICATION			
component name	********	active [Y/N]	********
component name	********	active [Y/N]	********
component name	********	active [Y/N]	********
component name	********	active [Y/N]	********
component name	********	active [Y/N]	********
component name	********	active [Y/N]	********
component name	********	active [Y/N]	********
component name	********	active [Y/N]	********
component name	********	active [Y/N]	********
confirm [Y/N]	********		
if confirm [Y] read data and go to page 1.1.3.1.			
if confirm [N] go to page 1.1.3.1.			

Page 1.1.3.1.3.	ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION - DEFINE CONFIGURATION - LINK DEFINITION

component name ********

linked to:

ingoing component 1	********	outgoing component 1	********
ingoing component 2	********	outgoing component 2	********
ingoing component 3	********	outgoing component 3	********
ingoing component 4	********	outgoing component 4	********
ingoing component 5	********	outgoing component 5	********
ingoing component 6	********	outgoing component 6	********

confirm [Y/N] ********

if confirm [Y] read data and go to next component
if confirm [N] go to page 1.1.3.1.
this is a dynamic page, depending on the type of component the number of ingoing and outgoing component names will be adapted

Page 1.1.3.1.4. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION - DEFINE CONFIGURATION - THRUSTER POSITION

---

thruster name	********	x coordinate	********
		y coordinate	********
		z coordinate	********

confirm [Y/N] ********

---

if confirm [Y] read data and go to next thruster
if confirm [N] go to page 1.1.3.1.

Page 1.1.3.2. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION - CHANGE CONFIGURATION

0 - End change configuration	
1 - Addition of component	1.1.3.2.1
2 - Deletion of component	1.1.3.2.2
3 - Addition of link	1.1.3.2.3
4 - Deletion of link	1.1.3.2.4
5 - Thruster position	1.1.3.2.5

your choice = ********

after ending go to page 1.1.3

Page 1.1.3.2.1.	ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION - CHANGE CONFIGURATION - ADDITION OF COMPONENT

component name	********	component type	********
		active [Y/N]	********
linked to:			
ingoing component 1	********	outgoing component 1	********
ingoing component 2	********	outgoing component 2	********
ingoing component 3	********	outgoing component 3	********
ingoing component 4	********	outgoing component 4	********
ingoing component 5	********	outgoing component 5	********
ingoing component 6	********	outgoing component 6	********
confirm [Y/N]	********		

if confirm [Y] read data and go to page 1.1.3.2.
if confirm [N] go to page 1.1.3.2.

Page 1.1.3.2.2. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION - CHANGE CONFIGURATION - DELETION OF COMPONENT

---

component name ********

confirm [Y/N] ********

if confirm [Y] read data and go to page 1.1.3.2.

if confirm [N] go to page 1.1.3.2.

Page 1.1.3.2.3. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION - CHANGE CONFIGURATION - ADDITION OF LINK

---

component 1 name ******** component 2 name ********

confirm [Y/N] ********

if confirm [Y] read data and go to page 1.1.3.2.
if confirm [N] go to page 1.1.3.2.

Page 1.1.3.2.4. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION - CHANGE CONFIGURATION - DELETION OF LINK

---

component 1 name ******** component 2 name ********

confirm [Y/N] ********

if confirm [Y] read data and go to page 1.1.3.2.
if confirm [N] go to page 1.1.3.2.

Page 1.1.3.2.5. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - CONFIGURATION - CHANGE CONFIGURATION - THRUSTER POSITION

thruster name	********	x coordinate	********
		y coordinate	********
		z coordinate	********

confirm [Y/N] ********

if confirm [Y] read data and go to next thruster
if confirm [N] go to page 1.1.3.2.

Page 1.1.4. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - RESISTANCE AND PROPULSION DATA

With the data given in 1.1.1, 1.1.3 and 1.1.4 the system is now busy determinining

- required thrust
- wake fraction
- relative rotative efficiency
- maximum diameter

for every thruster

results [Y/N] ******** device [P/T/N] ********

if results [Y] then type result file
if results [N] then go to page 1.1.

Page 1.1.4.1. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS -
RESISTANCE AND PROPULSION DATA PER THRUSTER - RESULTS

thruster name	********	********	********	********
required thrust	********	********	********	********
maximum diameter	********	********	********	********
wake fraction	********	********	********	********
relative rotative efficiency	********	********	********	********

continue [Y] ********

if continue [Y] then go to page 1.1.

Page 1.1.5. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - COMPONENT PREFERENCES

---

0 - End component preferences

1 - Parameter specification 1.1.5.1

2 - Deletion of all parameters 1.1.5.2

your choice = ********

after ending go to page 1.1.

Page 1.1.5.1. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - COMPONENT PREFERENCES - PARAMETER SPECIFICATION

---

component name ********

confirm [Y/N] ********

after confirmation [Y] go to page (dependent of type):

prime mover	1.1.5.1.1.	thruster	1.1.5.1.3.
transmission	1.1.5.1.2.	power take off	1.1.5.1.4.

after confirmation [N] go to page 1.1.5.

```
Page 1.1.5.1.1.                                        ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS -
COMPONENT PREFERENCES - PARAMETER SPECIFICATION - PRIME MOVER
-------------------------------------------------------------------
 type                    ********  engine margin min    ********
 make                    ********                max    ********
 series                  ********
 rpm                     ********

 for dieselengines
 2/4 stroke              ********
 number of cylinders     ********
 brake power             ********

       confirm [Y/N]     ********  list feasibles [Y/N] ********

 if confirmation [Y] then read data, select feasible prime
 movers from the database and display list feasibles [Y/N]
 if confirmation [N] then go to page 1.1.5.
 if list feasibles [Y] then type feasible prime movers file
 if list feasibles [N] then go to page 1.1.5.
```

Page 1.1.5.1.2. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS -
COMPONENT PREFERENCES - PARAMETER SPECIFICATION - TRANSMISSION

---

make	********		
type	********		
linked components			
component name	********	rpm	********
component name	********	rpm	********
component name	********	rpm	********
component name	********	rpm	********
component name	********	rpm	********
etc.			
confirm [Y/N]	********		

if confirmation [Y] then read data and go to page 1.1.5.
if confirmation [N] then go to page 1.1.5.

Page 1.1.5.1.3. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - COMPONENT PREFERENCES - PARAMETER SPECIFICATION - THRUSTER

type	********
series	********
number of blades	********
blade area ratio	********
diameter	********
pitch	********
cavitation number	********

confirm [Y/N] ********

if confirmation [Y] then read data and go to page 1.1.5.
if confirmation [N] then go to page 1.1.5.

Page 1.1.5.1.4. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - COMPONENT PREFERENCES - PARAMETER SPECIFICATION - PTO

---

power ********
rpm ********

confirm [Y/N] ********

if confirmation [Y] then read data and go to page 1.1.5.
if confirmation [N] then go to page 1.1.5.

Page 1.1.5.2. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - COMPONENT PREFERENCES - DELETION OF ALL PARAMETERS

component name ********

confirm [Y/N] ********

if confirmation [Y] then read data and go to page 1.1.5.
if confirmation [N] then go to page 1.1.5.

Page 1.1.6. ship ********

BUILD A PROPULSION ARRANGEMENT - SPECIFY DESIGN DEMANDS - DESIGN DEMANDS PACKAGE NAMING

---

ship identity ********
demand package name ********

confirm [Y/N] ********

if confirmation [Y] read data and go to page 1.1.
if confirmation [N] go to page 1.1.

Page 1.2.   ship ********

BUILD A PROPULSION ARRANGEMENT -
AUTOMATIC INSTALLATION COMPOSITION

Please wait, the system is composing all feasible installations within your demands.

---

if completed go to 0

Page 2.

SELECT AN INSTALLATION

---

0 - End selection

1 - Name selection 2.1

2 - Criterion selection 2.2

3 - Show installation data 2.3

4 - Installation list selection 2.4

your choice = ********

after ending go to 0

Page 2.1. ship ********

SELECT AN INSTALLATION - NAME SELECTION

---

installation name ********

confirm [Y/N] ********

if confirm [Y] read data and go to page 2.
if confirm [N] go to page 2.
a list of available installations must be claimable

Page 2.2. ship ********

SELECT AN INSTALLATION - CRITERION SELECTION

---

0 - End criterion selection		
1 - Fuel consumption	2.2.1	
2 - Weight	2.2.2	
3 - Investment	2.2.3	
4 - Length	2.2.4	
5 - Combination of criteria	2.2.5	
6 - Other criteria	2.2.6	

your choice = ********

if confirm [Y] read data and go to page 2.
if confirm [N] go to page 2.

Page 2.3.	installation ********	ship ********

SELECT AN INSTALLATION - SHOW INSTALLATION DATA

---

0 - End of show	
1 - Ship data	2.3.1
2 - Operational data	2.3.2
3 - Configuration	2.3.3
4 - Parameters	2.3.4

your choice = ********

after ending go to page 2.

Page 2.3.1. installation ******** ship ********

SELECT AN INSTALLATION - SHOW INSTALLATION DATA - SHIP DATA

---

name	********	length	********
type	********	width	********
database	********	draft	********

etc.

continue [Y] ********

if continue [Y] then go to page 2.3

Page 2.3.2.	installation ********	ship ********

SELECT AN INSTALLATION - SHOW INSTALLATION DATA -
OPERATIONAL CONDITIONS

---

draft	********
trim	********
speed	********
sea margin	********
continue [Y]	********

if continue [Y] then go to page 2.3

```
Page 2.3.3.              installation ********    ship ********

SELECT AN INSTALLATION - SHOW INSTALLATION DATA -
CONFIGURATION
------------------------------------------------------------------
 component name        ********

 ingoing component 1   ********   outgoing component 1 ********
 ingoing component 2   ********   outgoing component 2 ********
 ingoing component 3   ********   outgoing component 3 ********
 ingoing component 4   ********   outgoing component 4 ********
 ingoing component 5   ********   outgoing component 5 ********
 ingoing component 6   ********   outgoing component 6 ********


      continue [Y]     ********

 if continue [Y] then go to page 2.3
```

Page 2.3.4.	installation ********	ship ********

SELECT AN INSTALLATION - SHOW INSTALLATION DATA - PARAMETERS

---

component name ********

confirm [Y/N] ********

---

after confirmation [Y] go to page (dependent of type):

prime mover	2.3.4.1.	thruster	2.3.4.3.
transmission	2.3.4.2.	power take off	2.3.4.4.

after confirmation [N] go to page 2.3.

Page 2.3.4.1.   installation ********   ship ********

SELECT AN INSTALLATION - SHOW INSTALLATION DATA -
PARAMETERS - PRIME MOVER

---

type	********	engine margin	********
make	********		
series	********	engine margin min	********
rpm	********	max	********

<u>for dieselengines</u>

2/4 stroke	********
number of cylinders	********
brake power	********
continue [Y]	********

if continue [Y] then go to page 2.3.

Page 2.3.4.2. installation ******** ship ********

SELECT AN INSTALLATION - SHOW INSTALLATION DATA -
PARAMETERS - TRANSMISSION

make	********		
type	********		
ingoing component 1	********	outgoing component 1	********
ingoing component 2	********	outgoing component 2	********
ingoing component 3	********	outgoing component 3	********
ingoing component 4	********	outgoing component 4	********
ingoing component 5	********	outgoing component 5	********
ingoing component 6	********	outgoing component 6	********
continue [Y]	********		

if continue [Y] then go to page 2.3
the number of ingoing and outgoing components that are displayed is adapted to the specific transmission

Page 2.3.4.3.	installation ********	ship ********

SELECT AN INSTALLATION - SHOW INSTALLATION DATA -
PARAMETERS - THRUSTER

---

type	********
series	********
number of blades	********
blade area ratio	********
diameter	********
pitch	********
cavitation number	********

continue [Y] ********

if continue [Y] then go to page 2.3

Page 2.3.4.4.	installation ********	ship ********

SELECT AN INSTALLATION - SHOW INSTALLATION DATA -
PARAMETERS - POWER TAKE OFF

---

power	********
rpm	********

continue [Y] ********

---

if continue [Y] then go to page 2.3

Page 2.4.

SELECT AN INSTALLATION - INSTALLATION LIST SELECTION

---

ship identity ********

design demands
package ********

confirm [Y/N] ********

if confirm [Y] read data and go to page 2.
if confirm [N] go to page 2.
a list of available installations must be claimable

Page 3.	installation ********	ship ********

E.H.A. SYSTEMS
(ELECTRIC POWER, HEAT AND AUXILIARY SYSTEMS)

---

0 - End E.H.A. systems

1 - Waste heat utilization exploration 3.1

2 - E.H.A. systems design 3.2

your choice = ********

after ending go to page 0

Page 3.1. installation ******** ship ********

E.H.A. SYSTEMS - WASTE HEAT UTILIZATION EXPLORATION

---

0 - End waste heat exploration

1 - Exhaust gas heat 3.1.1

2 - Cooling heat 3.1.2

your choice = ********

after ending go to page 3.

Page 3.1.1. installation ******** ship ********

E.H.A. SYSTEMS - WASTE HEAT UTILIZATION EXPLORATION - COOLING HEAT

---

0 - End cooling heat

1 - Charge air 3.1.1.1

2 - High temperature cooling water 3.1.1.2

3 - Lubrication oil 3.1.1.3

your choice = ********

after ending go to page 3.

Page 3.2.	installation ********	ship ********

E.H.A. SYSTEMS – E.H.A. SYSTEM DESIGN

---

0 – End E.H.A. system design

1 – Heat system 3.2.1

2 – Electric power system 3.2.2

3 – Auxiliary systems 3.2.3

4 – Save E.H.A. systems design 3.2.4

your choice = ********

after ending go to page 3.

Page 3.2.1.	installation ********	ship ********

E.H.A. SYSTEMS - E.H.A. SYSTEM DESIGN -
HEAT SYSTEM

---

0 - End heat system

1 - Steam system 3.2.1.1

2 - Thermal oil system 3.2.1.2

your choice = ********

after ending go to page 3.

Page 3.2.2.   installation ********   ship ********

E.H.A. SYSTEMS - E.H.A. SYSTEM DESIGN -
ELECTRIC POWER SYSTEM

---

0 - End electric power system

1 - Power take of generator   3.2.2.1

2 - Auxiliary diesel generator   3.2.2.2

3 - Steam turbogenerator   3.2.2.3

4 - Exhaust gas turbogenerator   3.2.2.4

your choice = ********

after ending go to page 3.

Page 3.2.3. installation ******** ship ********

E.H.A. SYSTEMS - E.H.A. SYSTEM DESIGN -
AUXILIARY SYSTEMS

0 - End auxiliary systems

1 - Cooling system 3.2.3.1

2 - Fuel oil system 3.2.3.2

3 - Lubrication oil system 3.2.3.3

4 - Compressed air system 3.2.3.4

your choice = ********

after ending go to page 3.

Page 3.2.4.	installation ********	ship ********

E.H.A. SYSTEMS - E.H.A. SYSTEM DESIGN -
SAVE E.H.A. SYSTEM DESIGN

---

installation
e.h.a. version ********

ship identity ********

design demand
package name ********

installation name ********

confirm [Y/N] ********

after ending go to page 3.

Page 4.	installation ********	ship ********

EVALUATION

---

0 - End evaluation	
1 - Technical evaluation	3.1
2 - Economical evaluation	3.2
3 - Technical presentation	3.3

your choice = ********

after ending go to page 0.

Page 4.1.	installation ********	ship ********

EVALUATION - TECHNICAL EVALUATION

---

0 - End technical evaluation	
1 - Fitting into engineroom	4.1.1
2 - Tuning of the thruster	4.1.2
3 - Off design conditions	4.1.3

your choice = ********

after ending go to page 4.

Page 4.2.	installation ********	ship ********

EVALUATION - ECONOMICAL EVALUATION

---

0 - End economical evaluation	
1 - Pay out period	4.3.1
2 - Internal rate of return	4.3.2
3 - Present worth	4.3.3

after ending go to page 4.

Page 4.2.1. installation ******** ship ********

EVALUATION - TECHNICAL PRESENTATION

---

installation weight ********
installation cost ********

maximum speed ********

fuel oil consumption ********

etc, etc.

continue [Y] ********

if continue [Y] go to page 4.2.

appendix 3: secundary heat utilization

Secundary heat utilization

The main heat system design is handled by the present PROSEL design. Besides the heat flows that are covered by the boiler system several other heat flows can be distinguished in figure 3.1:

- boiler feedwater preheating by using the heat that results from charge air cooling of a dieselengine
- heating fuel oil for transport, cleaning, injection and blending purposes with heat from the cooling system
- heating lubrication oil for cleaning and preheating purposes with heat from the cooling system
- heating other users by using the heat in the prime mover lubrication oil system
- heating other users by using the heat in the auxiliary engine lubrication oil system
- heating other users by using the heat in the prime mover cooling system
- heating other users by using the heat in the auxiliary engine cooling system

For these flows heat exchangers have to be designed that make part of the heat system as well as boiler, fuel oil, lubrication oil or cooling systems. Coupling the auxiliary systems heat exchange together automatically could be a proposal for further development of the PROSEL design system.

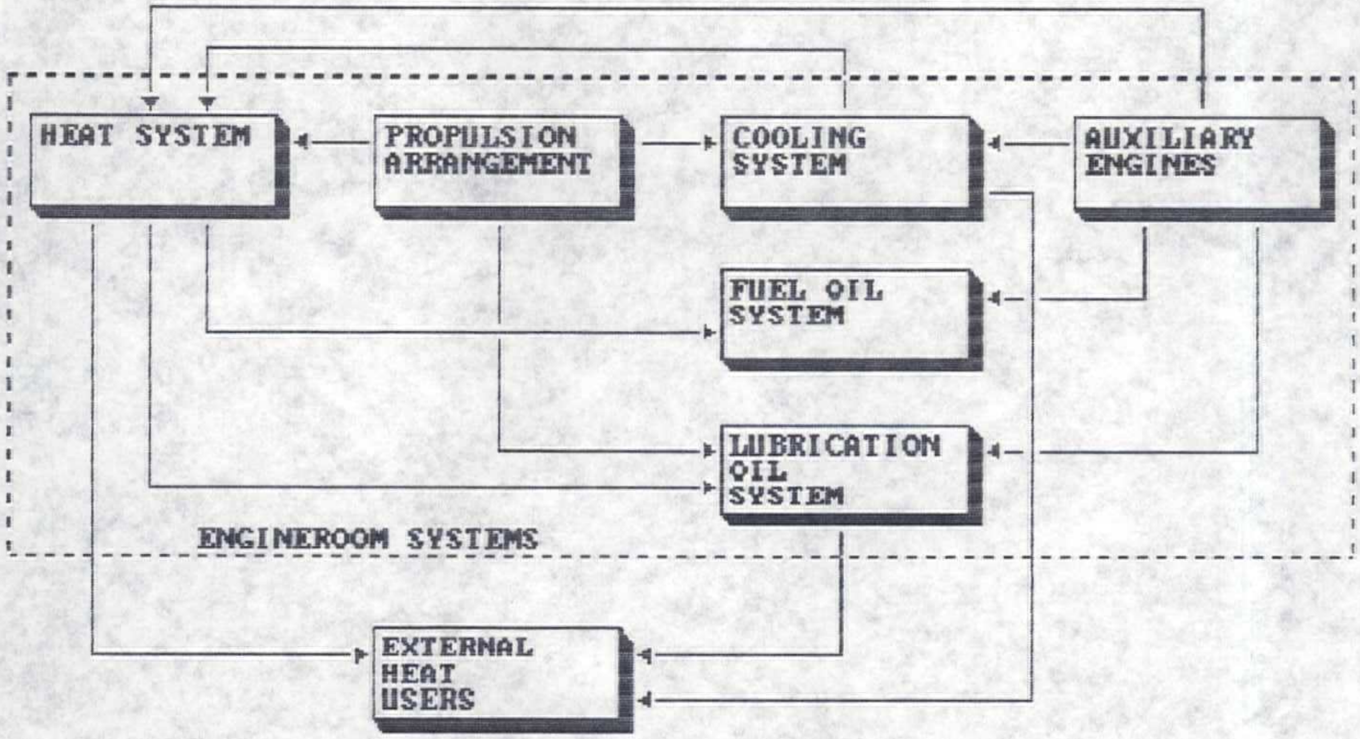

FIGURE 3.1: HEAT FLOWS