INFO-SPECIAL VOOR MARITIEME-EN OFFSHORE-TECHNIEK SCHIP EN WERF

SHIP PRODUCTION*

The Search for Specialization in Unique Product Manufacturing

by: Prof. Ir. S. Hengst**

SYNOPSIS

The shipbuilding industry is usually considered as unique product manufacturing, characterized by a labour intensive, custom built approach. The production process has, up till now, been improved by introducing new fabrication technologies, however, without changing the basic organization of the process. Cost savings were mostly realized by optimizing and improving certain stages in the production process such as numerically controlled processing of the prefabrication, panel-line assembly, pre-outfitting of blocks etc. Based on manhours per compensated gross ton the productivity of some European shipyards is comparable to Japanese yards.

At the same time new shipyards are emerging in the Newly Industrializing Countries, applying low labour cost in combination with advanced technologies, taking away from the Japanese yards that part of the international market, which was lost during the last decades, by the European yards. In strategical terms: new entrants in the market are not only a threat but also a fact.

A number of the factors which are preventing European yards to obtain an acceptable market position are not related to shipyard organization or productivity and cannot be influenced by the European shipbuilders anymore. The actually depressed market, in combination with the above mentioned increase in shipbuilding capacity, makes it particularly difficult for the European shipyards to survive without government support. As a result the shipbuilding capacity in Western Europe has been reduced drastically. The threat of this development is the loss of know-how on the middle-long term, which in combination with e.g. the loss of experience in shipmanufacturing and a reduction in efforts in the field of Research and Development will finally make Western Europe entirely dependent on the Far-East where it concerns the ship design and building, and even, on the longer term, ship operation, particularly where it concerns technology.

Which ways and means are available to change the process of ship production from the conventional manufacturing methods into 'advanced ship production'? In order to establish what will be required to change from conventional manufacturing methods to more sophisticated production techniques some differences in

- unique product manufacturing - is it still possible to
- series production - reduce costs
- mass production and - improve quality
- process industry and - realize shorter deliveries and
- will be discussed. - satisfy the customers' needs

by introducing basic changes in the construction and production methods, and organization of shipyards, using the same type of material and components? Or do we have to develop entirely new products, both from the point of view of materials as well as design. This paper will limit itself to the construction and production of ships with the same materials and components as applied today. First the market position will be discussed, then factors which influence the design by imposing manufacturing requirements will be analyzed leading to recommendations to establish the priorities for research and development.


** Delfts University of Technology, department of Maritime Technology.

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MARKET AND INDUSTRIAL COMPETITION

Among the many factors which are influencing the competition between companies, Porter (1) identified the following main driving industrial forces:

- the rivalry and competition between the companies,
- the potential entrants of new competitors into the market,
- the threat of substitute products or services,
- the bargaining position of the supplying industry,
- the bargaining position of the buyers (i.e. the shipowners).

As mentioned above also a new force entered into the competition: financial support by governments (fig. 1).

Considering these forces in the industrial competition Porter's theory confirms, among other things, what everybody in the ship's business knows i.e. that the loss of market of the European shipbuilding industry has been caused by the new entrants Japan and Korea.

What is the influence of the other forces, and how does the industry respond?

The supplying industry — to the shipbuilders — followed the shipowners, first to Japan and now to Korea, however, with the results that also they, in their own markets, are rapidly confronted with the threat of new entrants for their products from Japanese and Korean manufacturing.

Due to the very slow changing of the products (2) the threat of substitute products or services is growing gradually and slowly. An example is the development of Ro/Ro's and containerships. The selling of ships into the second hand market — ships which are not disappearing from the transportation market, are adding tonnage and at the same time creating a substitute service in the transportation sector — leads to new entrants coming into the market, stimulated by the sellers (shipowners) while they were buying larger, more economical and advanced ships.

- the introduction of economy of scale in research and development as well as in manufacturing,
- the search for the reduction of joint costs. An example is the intensifying of e.g. prefabrication or panel-line fabrication,
- improving the relationship between shipowners and shipbuilders in Europe with the aim to jointly develop new products on the long term.

The threat might be that advanced technologies are transferred to yards elsewhere in the world by the shipowners. This will require an appropriate answer by a joint operation from both suppliers and shipbuilders e.g. combined international spare part services and maintenance.

In Japan exists a very close cooperation between shipyard and shipyard suppliers. Subcontractors are working in a very close relationship with the shipyard and are assisting the shipyard in finding new techniques, ways and means to reduce costs (fig. 2). Japanese shipyards are also working in a captive market, where it concerns the home market and the barterdeal-market. As a result nearly all vessels for Japanese owners have been built by Japanese shipyards. Moreover, these shipowners form a part of the same industrial conglomerate as the shipbuilders. In this way the threat of new entrants and the development of substitute products or services is limited or controlled. Under these conditions competitive forces are not working freely, because non-Japanese firms have no possibility to compete. On the other hand the rivalry between the Japanese shipbuilders keeps the prices at competitive levels.

The situation in Europe (fig. 3) is entirely different: the industrial competition is spoiled by governmental subsidies which are — in many forms — supplied to shipowners, shipbuilders or even sometimes to sub-suppliers. The result is an industry where real industrial competition does not exist anymore and where possible opportunities to make new entries in the market are kept hidden or remain unused. Some of these opportunities are:

- creation of captive markets
  - home market
  - barter deals
  (strong trade organizations are a part of industrial conglomerates)
- fierce "local" competition
  — market forces are working
- international competition is kept out of the game

- strong cooperation between shipyards and subcontractors
  - new technologies
  - cost savings

- powerful, large, diversified heavy industries

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**FORCES IN COMPETITION**

![Diagram](image)

**MARKET AND INDUSTRIAL COMPETITION**

**STRENGTHS OF THE FAR EAST**

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- powerful, large, diversified heavy industries
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The development of uniform European standards by shipowners, suppliers and shipyards leading to a reduction in costs of maintenance for shipowners, training of crews for 'high tech' installation, etc. The target is to limit the possibilities for the owners to switch too easily to other products, particularly when sophisticated equipment, in view of (unavoidable) reduced manning, has been installed onboard. The attention should be focussed on those items of ship's operation which are cost-sensitive. The problem for the industry is that product know-how or designs - the development of uniform European standards by shipowners, suppliers and shipyards leading to a reduction in costs of maintenance for shipowners, training of crews for 'high tech' installation, etc. The target is to limit the possibilities for the owners to switch too easily to other products, particularly when sophisticated equipment, in view of (unavoidable) reduced manning, has been installed onboard. The attention should be focussed on those items of ship's operation which are cost-sensitive.

The problem for the industry is that product know-how or designs can hardly be kept proprietary by applying patents or secrecy agreements. Moreover the importance of the geographical location of a shipyard (or even a shiprepair yard) is decreasing. Shipowners are similarly struggling in an international competitive industry and are not in a position to create a commercial advantage from an - apparently attractive - geographical location. Finally experience. The developments in Korea show that experience is - on the long term - not resulting in a strategic advantage for a shipyard, or a significant lead over the competition. An example: in 1969 the fastest containerships in the world, the SL-7's for SeaLand (33 knots 120.000 H.P.) were ordered in European shipyards. One of the major reasons was that the European shipbuilding industry with regard to quality and special construction techniques, ranked among the best in the world. Nowadays no shipowner would hesitate and entrust the same order to a Korean shipyard which is only existing since 1980. The conclusion is that if the European shipbuilding industry will have to create a chance to remain in the market, government subsidy will only be a short term solution, unless it will be accepted as a 'usual' way to keep an industry alive.

The actual national policies are probably described properly by: 'the doctors are stating that the operation was difficult but successful, while the patient is slowly dying, unnoticed'. On the long and middle long term other ways and means will have to be found to establish a shipbuilding industry which is competitive in the international market. Where the threat of new entrants cannot be avoided and the international competition is unlikely to be reduced, the search for revival-possibilities must be intensified. Areas of interest are:

- Improve or change the design of the ships in such a way that the threat of new products or substitutes becomes difficult to realize;
- Strengthen the relationship with the shipowners to an extent that high entry barriers are becoming a 'fact of life' for the competition;
- Create a strong relationship between suppliers and subcontractors on one side and the shipbuilding industry on the other side, thus providing a strong economical force;
- Change, or at least start working, into a direction, whereby the structure of the West-European shipbuilding industry will convert itself (on the long term) into an industry that is able to provide entry barriers for the competition.

Porter (1) describes some major sources for barriers to entry:

1. Economies of Scale
One aspect can be found in Japan and Korea where large conglomerates are providing a diversified production and manufacturing set-up containing many aspects of the Heavy Industry. However, economies of scale can be found in any functional area or part of a business. The ultimate goal of economy of scale is to reduce the unit cost of a product or a part of a product. So is vertical integration - i.e. successive stages of production or distribution are in one hand or combined - able to create entry barriers.

2. Product Differentiation
Product differentiation is described normally as 'brand identification' combined with a certain loyalty of the customer. Investments to set up a brand name are usually limited to the consumer market and hardly possible in the market of capital goods.

3. Capital Requirements
An entry barrier to the market can be provided when large capital requirements are necessary to enter into a market. This can be related to cost for research and development but also to major investments for the set-up of a manufacturing or fabrication site. The major companies in the shipbuilding industry located in the Far East are corporations having the financial resources to generate almost any investment. This means that the capital requirements will hardly provide for a very successful entrance barrier for the shipbuilding industry in Western Europe.

4. Switching Costs
Switching costs are related to one time costs which face the buyer if he is changing from one product to another. The relationship subcontractor-equipment supplier to the shipbuilding industry is in this case of great importance. Particularly when the shipowners will start to use advanced equipment in order to operate the vessel with minimum crew, the quality of the crew and training the crew to operate the ship will increase the need to supply the shipowner with identical operating systems making it possible to change crews without any operational problems. In case West European shipbuilders will not timely enter this type of market, the cost of switching may well be an argument against the application or use of European-built ships.

5. Access to Distribution Channels
It is clear that a good relationship with the owners is creating an entry barrier for the competition.
6. Cost Advantages Independent of Scale
Some aspects are:
- favourable access to raw materials,
- favourable geographical locations,
- proprietary product technology,
- learning or experience curves.

When analyzing these factors one may conclude that both the Japanese and Korean Heavy Industries are utilizing the advantages of some of these aspects with skill e.g. a strategic week – the need for raw materials – is in combination with:
1. the geographical location of Japan,
2. the potential of new technologies, transferred into a position, an element of strength and the possibility to organize large trade set-ups and barter deals in which products of the Heavy Industry are delivered to the trade partners, in a protected market.

7. Government Policy
The government policy can limit the competition and provide for entry barriers not only by applying taxes but also by restrictions applied to pollution standards, product safety, etc.

The shipbuilding industry is operating in an international global market. However, many conditions which are applicable for global markets can be found within the Common Market as well:
- The market circumstances in the various countries are different and the roles played by the governments are different.
- Labour cost can differ very much between countries.
- The influences and possibilities to influence foreign competitors are sometimes rather limited, because of the local governmental protection.

Reviewing the above one could say that the Japanese Heavy Industry, being followed by the new entrant Korea which is basically applying the same policies as the Japanese Industry, created in the world market a number of major (re)entry barriers for the competition, which, in combination with a highly efficient production system, will be difficult to beat. For the European shipbuilder some (rather limited) possibilities remain to stay in the market on the long term. The intensifying competition in the transportation market makes it also for the European shipbuilders more and more difficult to compete. One of the stronger items which remains in the European market is the access to distribution channels for both shipowners and shipbuilders, which combined with an European Government policy, might enable this part of the industry to regain that part of the market which controls one of the major economical strategic elements of the European community:
a reliable maritime transportation and distribution system which is able to operate independently.

THE ORGANIZATION OF A SHIPYARD AND SHIPYARD PRODUCTION
When we are defining how a business will remain in competition the objectives of profitability, the market share, the operating conditions for the company under the prevailing market circumstances etc. shall be adequately defined. This is the reason that some attention has been paid to the global and European scenery. Very little has been published about the possibilities for companies which are operating in the markets of the Heavy Industry to adapt themselves to a changing environment and the importance of these companies for an economy. Christensen and Andrews (3) formulated and investigated the concept of an explicit strategy for a company. The combination of 'objectives' and 'means' is defining the relationship between the formulation of a strategy and the operational attitude of the management. The means to realize the objectives are, according to Christensen and Andrews:
- target-markets for products and product development,
- products which the company will have to develop or actually is producing,
- research and development which is related to product or production development,
- marketing which is one of the major preparatory functions for product development,
- sales,
- manufacturing,
- the availability of labour,
- purchasing,
- finance and control.

The specific articulation of the operational means by the management will depend on the nature of the business. Again very little can be found in the literature about the shipbuilding industry. Not much is being said either about the differences which occur between the various types of industries. Generally it is said that 'the organization will depend on the nature of the business' and that management may be more or less specific in defining the key operating policies and from there-on shape the organization to the purposes of the company.

A very useful differentiation is made by Drucker (4), who defines:
- unique product manufacturing,
- series production,
- mass production and
- process industry.

Drucker describes very carefully how one can recognize the differences in production systems and also what the consequences are for the organization, the quality of the people, the market approach and last but not least the management of an organization. As Drucker explains:
'Production is not the application of tools to materials. It is the application of logic work. The more clearly and rationally the right logic is applied, the less of a limitation and the more of an opportunity production becomes.'

Drucker developed principles of production i.e. some basic models with rules, requirements and characteristics. He describes for each system of production which competence, skill and performance are required.

The systems described by Drucker are:
- unique product production
- rigid mass production
- flexible mass production
- process or 'flow' production.

At the time Drucker gives two general rules to improve production performance and — even more important — pushing back certain limitations.

Those rules are:
1. by applying the principles of the system in use, limitations on production can be pushed back further and faster, the more consistently and thoroughly those principles are applied.
2. the systems represent different degrees of complexity. Unique product production is described as the least complex and process (flow) production the most complex production system.

By developing – and learning to know – the specific application possibilities, requirements and limitations of each system one will be able to organize (parts of) the production efficiently. By organizing parts of production the principles of each system (and learning how we can apply and harmonize those systems within a production process) it should be possible according to Drucker to advance the whole process.

Recognizing the type of process is therefore one of the most important factors in organizing the production. Organizing the production means then also organizing marketing, sales, manufacturing, purchasing, finance and control etc.

Unique product manufacturing can be recognized by the organiza-
... tion of the work by homogeneous stages. This means that the production organization is dependent on:
- the type of product,
- the application of standardized tools,
- the use of standardized materials.

The shipbuilding industry showed this approach in the division of the work which consisted of:
1. building the hull,
2. installation of equipment,
3. outfitting.

The specific requirements for specialized craftsmanship were depending on each stage. Even the building of large series of ships in the U.S. during the second world war was an example of well organized unique product production.

Examples of unique product production are:
- the building of a ship
- the building of offshore platforms at sea
- the building of a refinery.

The characteristics of mass production are usually related to the organization of the work around line production. However, both rigid and flexible mass production are based on the application of standardized parts, next to the application of standardized tools and materials.

The application of mass production principles requires a systematic analysis of the product with the aim to find a common pattern which has no relation with the available tools (or even materials). Diversification is the result of intelligent assembly methods rather than fabrication methods. The possibilities of flexible mass production have not been investigated in depth with the help of systematic research in the shipbuilding industry. This is understandable if one considers the variety of ships, the large number of variables which can be used for the design of ships for an identical service and the relatively small number of sea-going vessels. Yet this is not the main reason which should be found in the 'individual approach' of...
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For the last step we have probably to go back to 1912 to F. W. Taylor and his Scientific Management. Any step to improve production facilities or systems will demand an analysis of methods and systems as applied today, into the smallest detail. The research to be done in this field is gigantic, because at practically each shipyard methods and ways of working are—although superficially identical—basically different, most of the time.

Going back to time and motion studies is probably one of the ways to obtain insight in how shipyard production can be organized faster and better. These studies should not be academic but carried out 'on the spot and on the site'.

Taking into consideration that the industrial production processes are developing from unique product manufacturing into mass production and further to process industry, we can develop some specific requirements for shipyards how it will be possible—on the long term—to realize a similar development. It means a step by step analysis of the production process:

- from marketing and sales, design and engineering, through purchasing, material handling and distribution, prefab, plate and profile assembly, panel-line production, etc., up to the final assembly of the ship. Even testing, trials, delivery and after service shall then be considered as a part of a production process.

In analyzing the different parts of the process, we find that based on criteria mentioned earlier, the parts of the production process have different characteristics and can be considered as unique production or process industry. Attention must be given to the level of complexity of the ship as a total unit going down to the individual components or part of components.

Considering these factors some questions should be posed, e.g.:

- 'What are the main functions of a shipyard?' (Marketing, Design, Engineering, Assembly?)
- 'What are the functions necessary to keep the main functions going?' (Transport and Distribution of Material, Purchasing, etc.)
- 'What are the supporting functions, which could be done elsewhere?' (Prefab, panel-line assembly, block assembly)
- 'Does the management and type of control of some parts of the process need to remain in one location or should the different parts which require different type of management be separated?'

By posing us questions like these we must realize that we start restructuring an industry, and that was not the purpose of this paper.

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A NEW APPROACH TO SEMI-SUBMERSIBLES

by: Dr. Ir. M. Goldan**

I. INTRODUCTION
This paper presents a new approach for designers and builders of semi-submersible platforms with the intention to extend and improve the possibilities of performing their tasks in a more efficient way and at reduced costs. These tasks are included in a design process and a building process. The design process is concerned with the conversion of the client's objectives into a design solution which complies with all applicable rules, regulations and other possible constraints. The building process is concerned with the conversion of a design solution into the 'reality', to the satisfaction of client and authorities.

To obtain cost-efficient combinations of design solutions and building processes, alternatives have to be evaluated (fig. 1). Complex structures such as semi-submersible platforms make the process of evaluation laborious, time-consuming and expensive. To overcome this it is necessary that:

1. generation and evaluation of information and alternatives, performing of calculations, etc. should be done efficiently in terms of time and costs;
2. the conditions of building locations form a part of the search for the optimal solution to client's objectives;
3. the relation between design solution and costprice must be sensitive to variations in design- and building parameters.

These are the objectives of the new approach. The scope of this paper will be limited to the structure of semi-submersible platforms.

2. PROBLEM ANALYSIS
The objectives involve two different levels of application:

1. a high level concerning the interaction between design and building so that design objectives and capacities at a building location can be better matched;
2. a low level concerning the methods and models necessary in the design process as well as the incorporation of the results of 1. in this process.

In general, design solutions are concerned with the location and function of all components within the platforms; the identity and specification of these components is given by:

a. the external geometry, here defined as the geometrical design solution; this is related to platform's dimensions, shapes, etc.;

b. an internal geometry, here defined as the structural design solution; this concerns the arrangement of steel structures and their patterns throughout the platform;

c. an arrangement of machinery, equipment, outfit, etc.

The identity and specification of components within (c) above are mainly determined by client's objectives and to a limited extent by the geometrical and structural design solutions. On the other hand there is a great deal of dependence and interaction between the geometrical and the structural design solutions (Oo and Miller, 1981; Masaru Mokumaka et al, 1985; Haslum and Fylling, 1985). These solutions are generated by means of combinations of

![Table I](Attached)

<table>
<thead>
<tr>
<th>STRUCTURAL LEVEL</th>
<th>COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIMARY</td>
<td>floater structure, column structure, deck structure</td>
</tr>
<tr>
<td>SECONDARY</td>
<td>external (shell) panel, • horizontal: deck, bottom, • vertical: side shell, internal panel, • horizontal decks, • vertical bulkheads</td>
</tr>
<tr>
<td>TERTIARY</td>
<td>web-frames, brackets, stiffeners, crossties</td>
</tr>
</tbody>
</table>

Table I
Structural levels in semi-submersible platforms

components from an assortment which is usually divided over three levels of complexity (table I):

- the primary level which consists of volume components related to the external geometry of platform; these components are the floaters, the columns and the deck structure;
- the secondary level which consists of

![Fig. 1](Attached)

Fig. 1: Alternative combinations design/building solutions.
two-dimensional components related to the structural composition and patterns of primary components; in general, the secondary level consists of an assortment of flat panels;  
- the tertiary level which consists of elementary components related to the structural composition of secondary components; the tertiary level consists of an assortment of plates, stiffeners, webframes, brackets, etc.

The characteristics of all components are determined by geometrical and structural variables such as length, width, shape, spacings, thickness, sectional areas, etc. A vast assortment of components implicates a large number and variety of variables. Since the computational effort concerning a design process depends on the number and variety of variables, a primary objective at the low level of application will be to simplify and order the assortment of components on the basis of a limited number of variables.

### Fig. 2: Separate processes of design and building

The general practice at the high level of application is shown in fig. 2. Design and building are kept separated; material and labour costs are accepted as a consequence of the design solution. The conditions at the building location which should be involved in the design process are production means, methods and performances; if these and all handlings and processes involved in the building of the platform are known, the sequence of activities which form the building procedure for each design solution can be established.

The possibility to quantify the amount of labour effort and cost will depend on the following conditions (fig. 3):
- the possibility to determine the work content of the structure in relation with the structural design solution;
- the possibility to establish a relation between work content and labour effort, the latter being usually given in manhours;
- the possibility to establish the costprice of one manhour.

Investigations on the matter of work content have indicated a number of parameters such as the weight of weld metal deposited, the number of parts and the length of joints or line connections between structural components (Hewitt, 1976). Further investigations have indicated that a accurate definition of work content in relation with the structural solution is obtained by considering in addition to line connections also the so-called point connections (Goldan, 1985); these involve two or more structural components and a relatively short joint length (bracket/cross ties connections, etc.).

The link between work content and labour effort is given by production performance data; production performance can be defined as a measure of merit for the accomplishment of a production facility, given by the ratio:

$$ T_p = \frac{T_f}{U_p} $$

where:
- \( T_f \): production performance, per unit of production
- \( T_f \): input of labour effort
- \( U_p \): units of production.

Labour effort input is usually given in manhours. Production output can be defined by various parameters such as weight of steel, panel area, the number of connections, etc. The choice of a particular parameter is judicious; however, the linking role of production performance requires that the corresponding parameters are compatible with parameters defining work content. Methods for calculating manhour costs or tariffs were investigated by the Netherlands Shipbuilding Industry Foundation (1970), Hewitt (1976) and others. In principle, the methods base the calculation of tariffs on contributions from wages, variable and fixed overheads. As known hourly tariffs, the total labour costs can be calculated.

Furthermore, if the amount of steel materials can be determined in relation with any structural design solution, material costs and the costprice of the steel structure can be calculated. A primary objective at the high level of application will be to determine, in relation with the structural solution, the work content, the required labour effort at a particular building location and the labour and material costs.

### Fig. 3: Integrated process design/building

#### 3. THE NEW APPROACH

#### 3.1 General

A possible way to simplify the design process is to standardize the assortment of components used in the generation of design solutions; this can be achieved if the number of variables which determine the characteristics of components at all levels of complexity within the assortment is reduced; the possibility to reduce the number of variables concerns:
- at the third level; the shapes, main dimensions (length, width, height) and characteristic dimensions (thickness, sectional area, etc.) of plates, stiffeners, webs, etc.;
- at the secondary level; the dimensions and structural patterns of panels;
- at the primary level; the shape and dimensions of volume elements.
By limiting the number of variables a new and more limited assortment of standard components is obtained. The scope of this paper is limited to standardization of components at the secondary and primary structural levels.

3.2. Standardization at the secondary level
The structural pattern concerns the configuration of panel stiffening elements determined by the ratio $S/s$, respectively the spacing between transverse and longitudinal stiffening elements. Standardization of patterns implies the adopting of a constant ratio $S/s$ for all panels throughout the entire platform (fig. 4). The value of the ratio $S/s$, in combination with $s$ (or $S$) will affect the structural design solution but also the work content and material costs.

Panel dimensions concern length and width; standardization of these dimensions throughout the entire structure implicates the breakdown of first-level components in a manner which yields the minimum possible variation in panel dimensions. The outcome of this breakdown will depend on factors related to:

a. the design solution; this concerns the dimension of primary components and the internal arrangement of horizontal and vertical bulkheads;

b. the conditions at the building location; this concerns the capacities of production facilities.

3.3. Standardization at the primary level
In general, floaters and columns consist of circular or rectangular cylinders of similar dimensions and sectional areas (table 2 for drilling platforms). For boxtype decks it is possible to break down the structure into an assortment of cylindrical elements of rectangular cross-sections and lengths corresponding with those of floaters and columns providing that due consideration is given to the arrangement of longitudinal and transverse bulkheads within the deck structure (fig. 5). If all cylinders throughout the platform can be brought to a standard with respect to shape and sectional dimensions, a common structural system can be developed for floaters, columns and decks in terms of a unique cylindrical component.

Furthermore, by choosing a suitable length, standardization of first-level components can be obtained for the entire structure. The required dimensions of floater, column and deck structures as well as those of the entire platform are obtained by combining a number of these components (fig. 6). An important aspect here is the transition and alignment of structural elements in connections because of the distribution of loads throughout the structure. Effec-

<table>
<thead>
<tr>
<th>FORM OF CROSS-SECTION</th>
<th>DIMENSIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRCULAR</td>
<td>RECTANGULAR</td>
</tr>
<tr>
<td>FLOATERS</td>
<td>COLUMN</td>
</tr>
<tr>
<td>DECK STRUCTURE</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 2. Characteristic geometries of first-level components in semi-submersible drilling platforms

Fig. 4: Second-level module, standard structural pattern

Fig. 5: First-level module in deck structure

Fig. 6: Modular semi-submersible structure
UIT VOORRAAD HELMOND LEVERBAAR

- rvs gelaste en naadloze buizen
- rvs naadloze precisie buizen, instrumentatie en hydrauliek buizen
- rvs hittebestendige buizen
- rvs machineplijp
- rvs vierkante en rechthoekige buizen
- rvs lasfittingen en beugels
- rvs BSP draadfittingen 150 lbs
- rvs NPT en SW fittingen 3000 lbs
- rvs snijringkoppelingen

- rvs twin ferrule fittingen
- rvs snelkoppelingen
- rvs flessen DIN en ANSI
- aluminium flessen en rvs boordringen
- rvs kogelafsluiters
- rvs schuifafsluiters
- rvs klepafsluiters
- rvs terugslagkleppen
- rvs hoge druk kogel- en naaldafsluiters
- rvs vlinderkleppen

ROESTVRIJSTALEN HOGEDRUK KOGELAFSLUITERS PN 400

Maximale druk 400 BAR
Kwaliteit huis en kogel 316Ti
Afdichting PTFE
Verbindingen: - NPT/BSP binnen-/buitendraad
- snijring volgens DIN 2353
- twin ferrule
- lasindien
Afmetingen: 1/8" t/m 1"

ROESTVRIJSTALEN SNIJRINGFITTINGEN

Werkdruk tot 630 BAR.
Uitvoering volgens DIN 2353
BSP draad
Kwaliteit 316Ti
Van 6 mm t/m 38 mm

ROESTVRIJSTALEN TWIN FERRULE FITTINGEN

Werkdruk tot 700 BAR
Kwaliteit 316
Metrische en inch-afmetingen
Afmetingen: 6 mm t/m 25"
1/4" t/m 1"
3.4 The interaction between design and building
The conditions necessary to link design and building were discussed in par. 2. In the first place it is required to determine work content in relation with a structural design solution; the latter depends on the internal arrangement of bulkheads and the structural patterns. Once the internal arrangement has been established, the structural design solution is mainly determined by the structural pattern of all panels; any variation in the structural pattern will:

a. alter the characteristic dimensions of third-level components (plate thickness, sectional area's, etc.); this results in a change of the type of connections or weld-type (I-weld to V or X-weld, increase of throat thickness for fillet-welds, etc.);
b. alter the number of third-level components (sections, webframes, brackets, etc.); this results in a change of the amount of line and point connections.

If information concerning (a) and (b) is available, an accurate definition of work content in relation with the structural pattern can be established; a necessary condition is that structural patterns throughout the platform are known. The use of standard components and structural patterns enable to define accurately all connections throughout the structure; any change in structural patterns and dimensions of components will directly affect the type and amount of connections. Hereby, a relation between the structural design solution and the work content can be established.

The distinction between line and point connections enables to identify and associate technology and work methods to a particular type of connection (Goldan, 1985). If the labour effort necessary to effectuate one unit of connection is established by estimates, time measurement, etc. at a particular building location, a relation between the design solution and the required labour effort at that particular building location can be established.

Furthermore, if the labour effort is necessary to produce one unit of connection \( T_{Pi} \) of type \( i \) is known, the total labour effort \( T_i \) is found from:

\[
T_i = \sum (T_{Pi} \times N_i),
\]

where

\( N_i = \) number of connections of type \( i \).

If the unit price of one manhour (tariff) \( R \) at a particular building location is known, the labour costs \( C_L \) at that location are:

\[
C_L = T_i \times R.
\]

The amount of steel materials is proportional with the characteristic dimensions and numbers of third-level components; these are determined by the structural pattern. By using standard patterns, the amount of steel materials can be determined in relation with any structural design solution.

The cost of steel materials can then be determined as follows:

\[
C_m = \sum (W_i \times P_{mj}),
\]

where:

\[
C_m = \text{total material costs}
\]

\[
W_i = \text{weight of } i \text{-type steel materials}
\]

\[
P_{mj} = \text{number of } j \text{-type steel materials}.
\]

Finally, the costprice of the platform \( C_p \) in relation with any structural design solution can be determined:

\[
C_p = C_L + C_m.
\]

Several possible applications of the new approach are demonstrated below.

4. APPLICATIONS
4.1 Generation of geometrical solutions
Some important characteristics derived from the geometrical design solution are the behaviour in waves and the stability. Since these characteristics impose contradictory requirements to the underwater geometry of the platform (Oo and Miller) it is important to establish the boundaries of feasible geometrical solutions at an early design stage. By using first-level standard components, the number of geometrical design variables is reduced; this simplifies the geometrical design process and enables to establish boundaries of feasible solutions in a more efficient way.

4.2 The choice of a structural pattern for panels
Lateral pressure is a dominating factor in determining the scantling of most primary components such as floaters, columns and deck (Bainbridge, 1984). These components consist mainly of second-level structures, i.e. panels. Panel design is, thus, a major activity within the structural design and includes the determination of characteristics such as structural patterns and the scantling of plating, stiffeners and webs.

The use of standard structural patterns reduces the number of variables and simplifies panel design process; hereby, reference data for a large range of lateral loadings and stiffener spacing, s, can be prepared.

4.3 Weight- versus cost-efficiency
An important aspect governing the design process is that of weight- versus cost-efficiency of the steel structure. Designers and builders may adopt different views on this matter; a light construction may be advantageous in terms of payload capacity but may have a negative influence on the costprice (Moe and Lund, 1963; Caldwell and Hewitt, 1975; Kuo et al, 1983; and others).

The governing problems related to this aspect are:

- accurate estimate of steelweight,
- establishing the amount of labour required to build the structure which is sensitive to variations of design variables and the performances at a particular building location (see also par. 2.)

The possibilities to overcome these problems by using standard components were discussed in par. 3.4. In this principle, this aspect concerns the matching of conditions at building locations with design objectives so that a range of alternatives can be provided for clients, designers and builders, which represents the existing market conditions in terms of material prices and cost of labour.

4.4 The industrialization of the building process
The building process of marine structures is labour-intensive and consists mainly of assembly processes at various levels of structural complexity; the introduction of some mechanized and automatic facilities in the past years has not resulted in a basic change of this building process. A real breakthrough towards industrialization in marine constructions requires a different approach to both design and building; in this respect, much can be learned from other enterprises with regard to:

1. design simplification by using pre-determined standard components and structural patterns;
2. advanced mechanization and automation in manufacturing of components and assembly of the final product;
3. increased efficiency in the entire building process due to 'learning effects' associated with standardization of components and patterns.

Some aspects related to aspect 1. above have been studied in connection with the design process. Regarding the building process, the new approach results in a structure consisting of a limited number of component series, at various levels of complexity. The hereby created possibilities for advanced mechanization and automation are not dealt with in this paper.

The matter of 'learning effects' in ship-building has been studied by Couch (1963), Kriemeyer (1967), McNeal (1969), Svedrup (1982) and others. These studies were however directed towards the complete structure. The approach presented here creates conditions for introducing 'learning effects' in building phases prior to the final assembly of the structure. This is of particular importance for the semi-sub-
Goede uitvindingen komen nooit te vroeg. ESAB bewijst dat al vele jaren. ESAB-ontwikkelingen zijn daarmee normstellend geworden voor de laswereld.
Wie niet wachten wil op gemeengoed, maar wil profiteren van voorsprong in technische innovatie, kiest ESAB.
Zeker als dat voordeliger uitpakt. Of 't nu gaat om automatisering, apparatuur of lasmateriaal: ESAB blijft als wereldconcern toonaangevend in technische vooruitgang.
Wie de ontwikkelingen volgt, weet waarom.
mersibles’ market which is governed by ‘one-offs’ and/or small series’ building.

5. NUMERICAL EXAMPLES
Several numerical examples regarding the possibilities for application of the new approach in the design and building of semi-submersible platforms are given below. In general, the examples concern a semi-submersible drilling platform of which the main parameters are given in table 3.

### Table 3. Design parameters for semi-submersible platform

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement V</td>
<td>22000 m³</td>
</tr>
<tr>
<td>Variable deckload</td>
<td>3000 T</td>
</tr>
<tr>
<td>Natural period heave Tₜ</td>
<td>22 sec</td>
</tr>
</tbody>
</table>

5.1 Generation of geometrical solutions
Geometrical solutions were generated for the platform data shown in table 3. The de-tuning method was used to control the heave motion. Design parameters were the underwater volume V and the natural heave period Tₜ. The independent and dependent design variables are given in table 4. A closed directing model was used (Deetman, 1984) which enabled to incorporate motion and stability constraints in the design process; a simplified flowchart is shown in fig. 7; the results are presented in table 5.

### Table 4. Design variables for modular semi-submersible platform

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of columns m</td>
<td></td>
</tr>
<tr>
<td>Column height H₀</td>
<td></td>
</tr>
<tr>
<td>Ratio submerged column height Hₛ/H₁</td>
<td></td>
</tr>
<tr>
<td>Ratio first-level module width b/h</td>
<td></td>
</tr>
<tr>
<td>Moment heeling arm cmₚ</td>
<td></td>
</tr>
<tr>
<td>Metacentric height CM</td>
<td></td>
</tr>
<tr>
<td>Centre of gravity KG</td>
<td></td>
</tr>
</tbody>
</table>

### Table 5. Geometrical solutions for modular semi-submersible platforms

<table>
<thead>
<tr>
<th>m</th>
<th>b/h</th>
<th>b</th>
<th>L₁</th>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>1.75</td>
<td>13.8</td>
<td>73.0</td>
<td>54.6</td>
<td>54.6</td>
</tr>
<tr>
<td>2.00</td>
<td>15.2</td>
<td>67.5</td>
<td>52.6</td>
<td>52.6</td>
<td></td>
</tr>
<tr>
<td>2.25</td>
<td>16.5</td>
<td>63.0</td>
<td>60.9</td>
<td>60.9</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1.75</td>
<td>11.3</td>
<td>109.3</td>
<td>65.7</td>
<td>53.6</td>
</tr>
<tr>
<td>2.00</td>
<td>12.4</td>
<td>101.3</td>
<td>63.3</td>
<td>51.7</td>
<td></td>
</tr>
<tr>
<td>2.25</td>
<td>13.5</td>
<td>94.5</td>
<td>61.3</td>
<td>50.0</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>1.75</td>
<td>9.8</td>
<td>146.0</td>
<td>71.2</td>
<td>53.0</td>
</tr>
<tr>
<td>2.00</td>
<td>10.7</td>
<td>135.0</td>
<td>68.6</td>
<td>51.1</td>
<td></td>
</tr>
<tr>
<td>2.25</td>
<td>11.7</td>
<td>126.0</td>
<td>66.5</td>
<td>49.5</td>
<td></td>
</tr>
</tbody>
</table>

5.2 The choice of a structural pattern for panels
A study to obtain reference data for design and building of second-level standard components subjected to uniform lateral loadings was performed. Structural design criteria were taken in accordance with the Rules for the Classification of Mobile Offshore Units (Det norske Veritas, 1983). Design parameters were panel dimensions, criteria for structural strength and basic steel prices. The independent variables are given in table 6.

### Table 6. Design variables for panels

<table>
<thead>
<tr>
<th>Design variable</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stiffener spacing</td>
<td>s</td>
</tr>
<tr>
<td>Ratio S/s</td>
<td>k</td>
</tr>
<tr>
<td>Lateral pressure</td>
<td>P</td>
</tr>
<tr>
<td>Hourly tariff</td>
<td>R</td>
</tr>
<tr>
<td>Basic steel prices</td>
<td>Pₘₙ</td>
</tr>
</tbody>
</table>

**Fig. 7: Flowchart geometrical design process**

**Design Input Data**

**Directing Model Phase 1**

**Design Model with Motion Constraints**

- 3 Free Variables
- 2 Dependent Variables
- 2 Satisfying Conditions

**Input Data Stability Design Model**

**Directing Model Phase 2**

**Design Model with Stability Constraints**

- 1 Free Variable
- 6 Dependent Variables
- 5 Satisfying Conditions
- 1 Inequality Constraint

**Complete Geometry**
5.3 Weight-versus cost-efficiency
A study on the weight versus cost-efficiency was performed for a complete platform. For a given geometry, material prices and manhour tariffs, the total building costs were calculated at various values of the stiffener spacing, s. The results are shown in fig. 9.

The calculations were repeated for different values of manhour wages; at each level of wages, the lowest total cost and the corresponding structural solution given by the spacing s were established. The relation wages-structural solution at minimum total costs is shown in fig. 10. Manhour tariffs were calculated according to the NSIF (1970). Hereby, the possibilities to match economical conditions with design variables in the course of the design process are demonstrated.

5.4 Industrialization of the building process
The effect of learning effects associated with the new approach in the building of semi-submersible platforms is demonstrated in fig. 11. The platform was broken down in series of second and first-level modules. Learning figures were assumed following general principles in industrial processes (Joustra, 1982; 't Veld). The results from fig. 11 concern:
1. case 1, where the effects of learning were not included
2. case 2, where the effects of learning were included.

The calculations were performed for different values of the stiffener spacing s.

6. Conclusions
A new concept in design and building of semi-submersible platforms was presented. Following this concept, the platform consists of a limited assortment of standard components. Standardization is obtained through uniformity of dimensions and shapes at two levels of structural components.
plexity. A standard structural pattern is adopted by assuming a constant ratio between transverse webspace $S$ and stiffener spacing $s$ for the entire platform. Hereby, the number of geometrical and structural variables is reduced and the information regarding the steel structure with respect to weight and work content can be determined accurately.

With respect to possible applications of this concept it should be mentioned that realization of objectives in design and building of semi-submersible platforms requires input from both disciplines. In the first place the concept presented in this paper can be used as a tool of design for:

- generation of geometrical design solutions; this enables to evaluate the effect of geometrical design variables and to establish boundaries for feasible geometrical solutions;
- generation of structural design solutions; this enables to evaluate the effect of structural design variables on the design.

The concept is even more a useful tool in matching design solutions with the capabilities of builders; hereby, a range of alternatives is provided which can be used by the client in the search for an optimum technical/economical solution to his objectives. The concept can also be used as a tool of management by builders enabling to evaluate their position with respect to altering market conditions in terms of material prices and cost of labour.

Finally, the concept enables the industrial approach to the building process of unique products which yields a reduction of labour effort and cost due to learning effects associated with series fabrication of components.

References
- Couch J. C. (1963); The Cost Saving of Multiple Ship Production; International Shipbuilding Progress.
- Krietemeyer J. H. (1976); Standardization and Series-Production in the Shipbuilding Industry, Europort Amsterdam.
- McNeal J. K. (1965); A Method for Comparing Costs of Ships Due to Alternative Delivery Intervals and Multiple Quantities, Transactions SNAME.
- Moe J., Lund S. (1968); Cost and Weight Optimisation of Structures with Special Emphasis on Longitudinal Strength of Tankers, Transactions RINA.
- NSIF (1970); Uniform Administration for the Shipbuilding Industry (in Dutch), Netherlands Shipbuilding Industry Foundation.
- Det norske Veritas (1983); Rules for the Classification of Mobile Offshore Units.
- Sverdrup C. F. (1982); Considerations Regarding Improved Productivity Based upon Experience of Series Production of Merchant Ships, Proceedings IREAPS Technical Symposium, San Diego California.
- In 't Veld J. G.; Production Organizations (in Dutch), Lecture Notes b64, Delft University of Technology.
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de Noord te Krimpen.

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Vestigingen te Dintelmond en Vlissingen.
OPTIMISATION OF SEMI-SUBMERSIBLE DESIGN WITH CONSTRAINTS ON MOTIONAL BEHAVIOUR AND FABRICATION

By: Ir. G. J. Schepman and Ir. J. L. A. M. van der Hoorn**
H. Isshiki and T. Nakajima***

I. INTRODUCTION

Although semi-submersibles have been in existence for over two decades as versatile mobile offshore units, it is still considered worthwhile to discuss their motional behaviour. Especially in today's technology, motional behaviour is better understood and optimisation has resulted in all kinds of hull forms, e.g. introduction of sponsoons and bulges to improve on heave motions in head waves. Penalties on other aspects as construction, stability and inspection and maintenance are often not considered and could easily lead to 'unbalanced' designs. In the early 80's, MSC developed the four column design with special emphasis on simple construction and ease of inspection and maintenance. An example was the 'Stena Conqueror' (type DSS-24, see ref. 1).

The four column semi-submersible design is composed of a limited number of construction elements, (see figure 1.):
- two floaters
- four columns
- one buoyant, self-supporting upper hull structure
- two or four horizontal braces.

This lay-out has also been the basis for the design of the fourth generation drilling semi-submersible DSS-40. In the development of the semi-submersible DSS-40, Sumitomo Heavy Industries (SHI) and Marine Structure Consultants (MSC) opted for optimisation of the rigs' overall performance considering important factors as:
- motions
- capacity (Variable Drilling Load/Total Variable Load)
- construction (system and costs)
- stability.

The design requirements of a semi-submersible can be split up into owner's and shipyard requirements. Owner's requirements are mostly related to operational aspects, such as:
- environmental conditions (wind, wave and current) for operations and survival
- Variable Drilling Load
- Total Variable Load in transit
- motional behaviour limitations e.g. heave and seastate for operating conditions
- stability
- equipment specification.

Shipyard requirements are mainly related to the construction:
- optimum use of shipyard fabrication system from panel dimensions up to assembly
- maximum construction width due to building dock facilities or waterway restrictions.

To establish the particular set of main dimensions fulfilling the design criteria in a well-balanced manner, MSC applies an optimisation program, developed in house, as an important tool in the concept stage. The advantages of this procedure are:
- parametric studies can be carried out quickly to determine the influence of design requirements changes
- such a degree of accuracy is obtained...
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Total communication, guidance, navigation and survey
In the optimisation program, as many parameters as needed are included to obtain a well balanced design. The program does not calculate only geometry stability and weights, but will also define a unit with a predicted and pre-engineered motional behaviour at minimum steel weight.

2. OPTIMISATION PROGRAM

2.1. General description

The use of optimisation techniques requires a clear distinction of the variables involved, being:
- free variables
- parameters
- constraints
- objective function.

Free variables can be changed by the program during its search for an optimum solution, while parameters are fixed values defined in a separate input file remaining constant during the optimisation process. Constraints are the requirements to be fulfilled, while the objective function will be optimised.

As the objective function can be very complicated the optimisation technique must be a powerful algorithm to find the optimum value. At MSC, the general reduced gradient method is selected and incorporated in the optimisation routine GRG.

2.2. Free variables

The present optimisation program is based on four column semi-submersible designs assuming a square upper hull and square columns. In addition the height of the upper hull is selected by the designer based on the equipment to be installed. So the following six free variables will define the unit’s main dimensions (see figure 4):
- upper deck: width
- columns: width, height
- floaters: width, height, length.

2.3. Parameters

The parameters can be split into two groups, being parameters related to the construction system and parameters defined by the owner. The construction parameters are height of the deck box and number and diameter of bracings. Owner’s requirements are concentrated on Variable Drilling Load, Total Variable Load in transit and environmental conditions. This latter one refers to the required air gap in maximum operating conditions. Approximate formulae are used to establish the required air gap, based on extensive model test results of similar designs.

2.4. Constraints

The constraints refer to owners requirements and some construction aspects. The owner’s requirements are:
- stability
- environmental conditions: maximum operating conditions.

Figure 1: Fabrication scheme

Figure 2: Program structure
Wie de kwaliteit van afstandsbedieningen zelf in de hand wil hebben, komt tijdens Europort '87 naar stand E 302.

U maakt daar kennis met betrouwbare produkten van degelijke kwaliteit. Met een lange levensduur.

Wat daarmee in beweging wordt gezet, weet bij wijze van spreken van geen ophouden....
2.4.1. Stability

Based on the classification societies' rules and regulations, required stability for intact and damaged conditions should be regarded. Due to the buoyant upper hull structure, intact stability will be no problem, but the 15 degree heeling angle limit in damaged condition allows only a limited inflow of water. Based on MSC's experience in four column designs, this damaged condition can best be met by applying a double hull in the column. Thus the vessel's restoring moment has to counteract the inflow of water. The linear approximation (Restoring moment = Displacement times GM-value times angle) is sufficiently accurate up to the angle of upper hull submergence, which will be around 15 degrees. In this way the GM-value is selected as a valuable measure for definition of the stability in the operating condition.

2.4.2. Heave motions

Owner's requirements will certainly contain indications on workability or motional behaviour of the rig, by specifying maximum drilling conditions and maximum operating condition. By defining the allowable drill string compensator limit respectively the telescopic joint limit, the allowable heave response of the rig can be determined.

At MSC, research studies have been carried out to obtain an insight in the parameters defining the heave motions of a semi-submersible (see reference 2). The main conclusions are that heave motions are dependent on (see figure 5):

1. Natural heave period $T_h$
2. Submergence of the floaters $z_{fl}$

According to the following formulae:

\[ T_h = 2\pi \sqrt{\frac{A + AM}{\rho g A}} \]

\[ z_{fl} = e^{-kz_{fl}} \left( 1 + \frac{k z_{fl}}{1 - (\omega_0^2/\omega^2)^{1/2}} \right) \]

Where:
- $\Delta$ = operating displacement of the vessel
- $M$ = added mass, determined as a function of floater- and column dimensions
- $\rho$ = specific mass 1025 kg/m$^3$
- $g$ = gravitational constant 9.8 m/s$^2$
- $A$ = waterplane area
- $z_{fl}$ = heave response in regular waves
- $\omega_0$ = $2\pi/T_h$ = natural heavy frequency
- $k = \omega_0^2/g$ = wave number
- $\omega$ = wave frequency
- $z_{fl}$ = submergence of floaters.

The effects of selecting a natural heave period and/or a floater submergence are illustrated in figure 6. By specifying the natural heave period, $T_h$, and the second hump response value, $z_{fl}$, as constraints, the optimisation program will determine the shape of the unit fulfilling owner's motional behaviour requirements.

Figure 4: Free variables
- Total Variable Load in transit: required freeboard.

GM-value times angle
The advantage of including the motional behaviour as constraints is that design concepts can be compared while motions are always similar. In the past designs have been compared without regard to the similarity of motions.

2.4.3. Freeboard at transit draft
Besides defining the Total Variable Load in transit condition, the floater size depends on the freeboard in transit condition. Freeboard can be treated as a requirement for a positive freeboard or as a margin for weight increase during construction.

As freeboard depends on the owner's views, freeboard is considered as a constraint. One should realize that both selected freeboard and Total Variable Load determine the size of the floaters and consequently will have an important impact on the overall displacement of the vessel.

2.4.4. Construction aspects
The adopted design philosophy is to use flat panel shipyard practice construction systems. Some physical constraints in semi-submersible design are:
- Floater length should be equal or larger than the upper hull length, to avoid connection problems of floater to column
- Floater width should be equal to column width, to create a better continuation of the structural integrity and to reduce the number of longitudinal bulkheads in floaters
- Upper limits on the total width of the vessel due to the availability of existing building docks and/or repair docks.

2.5. Objective function
The overall performance of the semi-submersible should be optimised. It will usually be expressed in terms of investment costs. A typical cost breakdown of a semi-submersible (see figure 7) illustrates that the majority of costs is related to the drilling package and the machinery part. These items will be either owner furnished equipment or owner specified equipment, so these costs can not be influenced by the shipyard.

An other important cost item is the steel construction of the vessel, which can be fully controlled by the shipyard by an optimum use of their fabrication system (man-hours/ton) and by a minimum steel weight of the unit. Therefore, it has been concluded that the ultimate and most practical variable to assess the costs is the vessel's steel weight, and consequently the objective function is to minimise on steel weight.
**AFDELING: TECHNISCHE RUBBERARTIKELEN**

**Continental**

Chemicaliën- en oplosmiddelenbestendige slang
Olie- en benzinebestendige slangen, zoals tankwagenslang en haspelslang.
Bunkerslang uit voorraad leverbaar tot ∅ 200 mm

**Avery-Hardoll**

Dry-Break koppelingen
Refuelling Nozzles
Vloeistofmeters

**ELAFLEX**

Rubber compensatoren
Vulpistolen ZV en ZVA
Snelkoppelingen - type TW, ook in R.V.S.

**ROMAN SELIGER**

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**Perolo**

Laadarmen voor vloeistoffen
Toebehoren voor tankauto's en tankstations

**AFDELING: INTERN TRANSPORT**

**Climax**

Vorkheftrucks
Reachtrucks
Zijladers
Explosiebeveiligde heftrucks

Voorts:
Metaalbewerkingsmachines
Gereedschappen voor metaalbewerkingsmachines
3. CALCULATION PROCEDURE

In the optimisation process the design calculations are carried out in subroutine GCOMP (X,G) which is entered with a specified set of free variables (X-vector), and which calculates the values of constraints and objective function (G-vector). This calculation is shown in figure 8 and is regarded to be self-explanatory.

In the GRG subroutine first of all the constraints are checked. When the constraints are not fulfilled, the GRG method will change the X-vector(s) in an intelligent way and the GCOMP procedure will be repeated. Finally, the objective function is optimised in the GRG subroutine.

4. EXAMPLE OF OPTIMISATION PROGRAM

4.1. Introduction

In 1984 SHI and MSC decided to develop a fourth generation drilling semi-submersible vessel, called the DSS-40. The project team aimed for a development of a balanced unit with respect to operational as well as construction aspects.

For a better insight in the effects of design variables the optimisation program was developed and extensively used in the concept design stage. Also main design criteria have been varied to study their effect on overall size and shape of the unit. In this section the design process of the DSS-40 and results of the variation study will be discussed.

4.2. Concept design of the DSS-40

Based on a market review, the extensive discussions within the project team have led to select the main design criteria for the design, divided in owners and shipyard requirements.

Owner's requirements are:
- Variable Drilling Load in operational, survival and transit condition: at least 4,500 ton
- Total Variable Load in transit including mooring spread: at least 8,300 ton
- Workability in operational condition:
  - Drilling operation: up to 8 m significant waves
  - Riser disconnection: one year North Sea storm
- Workability in survival condition: 100 year condition, maximum waves 34 m
- Classification societies: DnV or LR or ABS
- National authorities: NPD or DEn.

Shipyard requirements:
- Optimise on construction with respect to:
  - Fabrication system (shipyard practice, flat panel)
  - Reduction of main connection numbers
  - Maximum construction width due to building dock: 74.0 m
  - Minimum steel weight.
Our congratulations to Anthony Veder and the crew from 'The Prince Willem van Oranje'

The HYDRALIFT MCV-type deck crane is a "ready to install", "plug-in" unit, self-powered by a built-in electro-hydraulic power pack ready for connection to the ships main power supply. The cranes are delivered with wire and hook, shotblasted and coated with zinc epoxy, tested and adjusted.

Control features

All motions are continuous. The controls may be operated at the same time.

We wish you a good sailing!

UMEC

VAN UDEN MARINE & ENGINEERING CONSULTANTS
Tlx 22024, tel. 010-436 33 00, Veerhaven 14, Rotterdam
From this set of design criteria workability in operation and survival conditions need to be translated to the motional behaviour input data (natural heave period and second hump heave response). The 8 m significant waves and the one year North Sea Storm (i.e. 11 m significant waves) criteria in operating conditions are combined with allowable strokes of the drill string compensator and the telescopic joint respectively. Presently available equipment has effective strokes of:
- 20 ft for the drill string compensator
- 45 ft for the telescopic joint.

The full set of input data for the concept design of the DSS-40 was:

1. Free variables
   60 m < deck width < 74 m (due to available building dock width)
   0 m < column height
   0 m < floater length
   0 m < floater/column width
   0 m < floater height.

2. Parameters
   VDL 4,500 ton
   TVL 8,300 ton
   Airgap 12 m
   Height of deck box 8 m
   Bracings: number 4
   diameter 2.5 m

3. Constraints
   GM operating = 4.00 m
   GM transient = 0.30 m
   Natural heave period = 20.5 s
   Second hump response = 0.46 m/m
   Transit freeboard = 0.50 m

The results of the final design, based on the optimisation program results, are shown in figure 10 and table I. Main characteristics of the design are its steel weight (11,500 ton), its operating displacement (39,200 ton) and its overall width (71.25 m).

4.3. Variation study of main input data versus steelweight
4.3.1 Owners requirements (VDL, TVL, workability and stability) Variable Drilling Load

In figure 11 the effect of VDL on steelweight is clearly shown: the larger the VDL, the larger the steelweight. Interesting parameter is the gradient of the curve defined by the increase of steelweight per ton increase of VDL, being 0.253 (ton/ton).
Korte levertijd is belangrijk
(vooral in scheepvaart en industrie)

Daarom hebben wij ruim 25 vooraanstaande merken filters en filterelementen op voorraad.
Voor een optimale service, leveren wij tevens filters volgens elk model in elk gewenst materiaal.

7 dagen per week, 24 uur per dag
In figure 12, this effect is shown, while the gradient is 0.191 (ton/ton).

Workability
In order to get an insight in the influence of required motional behaviour level on steelweight, the impact of the owner’s requirements will be discussed.

In the design process of the DSS-40 two operating conditions are specified, i.e. maximum drilling condition (8 m significant waves) and maximum operation (11 m significant waves). The selection of these two conditions combined resulted in design 2. \( T_n = 20.5 \) s and \( z/\zeta = 0.46 \) (see figure 13).

### Principal Dimensions:
- Length of Main Deck: 71.25 m (233.8 ft)
- Breadth to Main Deck: 71.25 m (233.8 ft)
- Depth to Main Deck: 43.00 m (141.1 ft)
- Depth to Flush Bottom Deck: 35.00 m (114.8 ft)
- Length of Lower Hull: 119.00 m (390.4 ft)
- Breadth of Lower Hull: 13.75 m (45.1 ft)
- Depth of Lower Hull: 9.00 m (29.5 ft)
- Length of Column: 13.75 m (45.1 ft)
- Breadth of Column: 13.75 m (45.1 ft)
- Column Space (Longi): 57.50 m (188.6 ft)
- Column Space (Trans.): 57.50 m (188.6 ft)
- Draft (Operating): 23.00 m (75.5 ft)
- Draft (Survival): 19.00 m (62.3 ft)
- Draft (Transit): 8.50 m (27.9 ft)

### Capacities:
- Bulk Mud & Cement: 800 m³ (28,250 bbl)
- Liquid Mud: 700 m³ (4,400 bbl)
- Drill Water: 2,440 m³ (15,350 bbl)
- Fuel Oil: 2,900 m³ (18,240 bbl)
- Potable Water: 420 m³ (2,640 bbl)
- Brine: 420 m³ (2,640 bbl)
- Sack Storage: 190 m² (2,040 ft²)
- Drill Pipe Storage: 390 m² (4,200 ft²)
- Casing Pipe Storage: 320 m² (3,440 ft²)
- Riser Storage: 600 m² (6,460 ft²)

### Variable Load (metric tons)
<table>
<thead>
<tr>
<th></th>
<th>Operating</th>
<th>Survival</th>
<th>Transit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck + Column</td>
<td>4,500</td>
<td>4,500</td>
<td>4,500</td>
</tr>
<tr>
<td>Lower Hull</td>
<td>5,500</td>
<td>5,500</td>
<td>5,500</td>
</tr>
<tr>
<td>Mooring</td>
<td>1,800</td>
<td>2,000</td>
<td></td>
</tr>
</tbody>
</table>

### Design Criteria
- Water Depth: 914 m (3,000 ft)
- Wind (1 min.): 70 knots
- Wind (1 hr.): 60 knots
- Sig. Wave Height/Period: 8 m (26 ft)/10 sec.
- Max. Wave Height: 15 m (49 ft)
- Surface Current: 2.5 knots
- Temperature: -20° C

### Table I: Technical specifications of DSS-40

<table>
<thead>
<tr>
<th>Machinery/Equipment/Fittings</th>
<th>Operating</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anchors</td>
<td>8 - 15 T</td>
<td></td>
</tr>
<tr>
<td>Mooring Lines</td>
<td>8 - 76 mm dia chain x 1,000 m plus 97 mm dia wire x 2,000 m</td>
<td></td>
</tr>
<tr>
<td>Cranes</td>
<td>2 - 60 T</td>
<td></td>
</tr>
<tr>
<td>Heli-deck</td>
<td>For chinook</td>
<td></td>
</tr>
<tr>
<td>Accommodation</td>
<td>For 100 persons in 2-persons cabins</td>
<td></td>
</tr>
<tr>
<td>Ballast Pump Room</td>
<td>Four (4)</td>
<td></td>
</tr>
<tr>
<td>Main Generators</td>
<td>6 - 2,500 kW</td>
<td></td>
</tr>
<tr>
<td>Azimuth Thrusters</td>
<td>4 - 2,200 kW</td>
<td></td>
</tr>
</tbody>
</table>

Rules and Regulations
Det norske Veritas
American Bureau of Shipping
Norwegian Maritime Directorate
U.K. Department of Energy
United States Coast Guard

Det norske Veritas
American Bureau of Shipping
Norwegian Maritime Directorate
U.K. Department of Energy
United States Coast Guard
HOEVER DENKT U TE KUNNEN KOMEN ZONDER VERKEERSBORDEN?

Om uw produktken efficiënt te kunnen laten expediëren moet u op een breed terrein over goede informatie beschikken. Wat voor soort transport moet u kiezen? Passen vertrek- en aankomsttijden in uw produktie-schema? Waar zijn er havencongesties te verwachten? En wat voor politieke ontwikkelingen kunnen uw import- of export beïnvloeden?

Vragen waarop het Nieuwsblad Transport u in extenso en op zeer actuele wijze antwoord geeft: maar liefst driemaal per week.

Nieuwsblad Transport geeft u de goede richting aan. Geïnteresseerd in deze nieuwe krant voor verlader en vervoerder?

Bel 010-4053130 voor een vrijblijvende kennismaking met dit nieuwsblad. Of schrijf naar:
Transportuitgaven B.V.
Beurs-World Trade Center
Postbus 30180
3001 DD Rotterdam
The operating conditions are varied as follows:
- keep one condition constant, i.e. maximum drilling
- vary the other one, i.e. maximum operating.

The influence of varying the maximum operating condition is shown in figure 13 by selecting the following conditions:
- maximum drilling condition constant (8 m waves at 10 s period)
- maximum operating condition
  - 11.7 m waves at 13.5 s period
  - 11 m waves at 13 s period
  - 10.8 m waves at 12.5 s period.

The major impact is shown in the steel-weight of the unit (105% to 97%). The reduction of maximum operating conditions allows for a lower second hump and heave period, which accounts for the steel-weight reduction. However, the disadvantage of reducing the maximum operating condition is that the probability of having to disconnect the riser will be some what higher. In this way the owner is able to quantify the pro (lower investment) and the con (lower workability in higher waves).

The other variation is by:
- maximum condition constant (11 m waves at 13 s period)
- maximum drilling condition:
  - 8.86 m waves at 11.75 s period
  - 8.0 m waves at 10 s period
  - 6.56 m waves at 9.5 s period.

The increase of the maximum drilling condition has a significant impact on steel-weight, while the advantage of workability is very minor. Thus, this is not the right direction. The decrease of the drilling condition has a significant advantage on steel-weight combined with a modest decrease of workability.

As a conclusion on the variation of owners operational requirements, one can see that the identification of two operational conditions will determine the required workability. Variation of either condition leads

### Table: Variation in maximum operating condition

<table>
<thead>
<tr>
<th>Designs</th>
<th>Condition</th>
<th>Waves</th>
<th>Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. 1</td>
<td>maximum operating</td>
<td>11.7 m</td>
<td>13.5 s</td>
</tr>
<tr>
<td>no. 2</td>
<td>maximum operating</td>
<td>11 m</td>
<td>13 s</td>
</tr>
<tr>
<td>no. 3</td>
<td>maximum operating</td>
<td>10.8 m</td>
<td>12.5 s</td>
</tr>
</tbody>
</table>

Combination of two conditions leads to the following:
- Natural heave period:
  - Design 1: 22 s
  - Design 2: 20.5 s
  - Design 3: 19 s
- Second hump response:
  - Design 1: 0.49
  - Design 2: 0.46
  - Design 3: 0.43
- Steelweight:
  - Design 1: 12.07 ton
  - Design 2: 11.518 ton
  - Design 3: 11.148 ton
- Difference to design 2 (%):
  - Natural heave period: 105%
  - Second hump response: 100%
  - Steelweight: 99.8%

### Table: Variation in maximum drilling condition

<table>
<thead>
<tr>
<th>Designs</th>
<th>Condition</th>
<th>Waves</th>
<th>Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. 4</td>
<td>maximum drilling</td>
<td>8.86 m</td>
<td>11.75 s</td>
</tr>
<tr>
<td>no. 5</td>
<td>maximum drilling</td>
<td>6.56 m</td>
<td>9.5 s</td>
</tr>
</tbody>
</table>

Combination of two operating conditions leads to the following:
- Natural heave period:
  - Design 1: 19 s
  - Design 2: 20.5 s
  - Design 3: 22 s
- Second hump response:
  - Design 1: 0.2
  - Design 2: 0.46
  - Design 3: 0.41
- Steelweight:
  - Design 1: 14.182 ton
  - Design 2: 11.518 ton
  - Design 3: 10.424 ton
- Difference to design 2 (%):
  - Natural heave period: 100%
  - Second hump response: 100%
  - Steelweight: 99.8%

Note: *) Workability figures are based on a one year Northsea scatter diagram.

FILARC Lastechniek B.V.
Neutronweg 11, 3542 AH UTRECHT
Postbus 8035, 3503 RA UTRECHT
Telefoon: 030-46 5911, Telex: 47302

*Trademark of Philips Export B.V. The Netherlands
Stability

In figure 14 the effect of the GM variation at operating draft is shown, with a gradient of 2.685 ton/cm. This GM value criterion can also be treated as an owners or builders margin in the design. Based on a 4 m GM, 10 percent equals 0.4 m variation resulting in a steel weight increase of 107.0 ton.

General conclusions from this part of the variation study are:
- the above parameters have a direct influence (linear increase) on the overall size of the design
- a 10 percent variation of owners requirements in:
  - VDL results in steel weight variation of 113 ton
  - TVL results in steel weight variation of 200 ton
  - GM results in steel weight variation of 107 ton.
- TVL is the most severe one.

Thus, the owner should be very cautious in setting his design requirements, as too high figures on some criteria are easily adding steel weight and consequently increase the size of the design and its investment.

4.3.2. Shipyard requirements

Ease of fabrication

This item can easier be regarded as a design philosophy than transferred in round figures of constraints. Ease of fabrication is realized by ship type flat panel construction of bulkheads, avoiding circular or curved members, reducing the number of main construction elements and continuation of bulkheads from floaters through columns to upper hull.

Construction width

The total allowable width of the rig can be dictated either by the building dock dimensions or by the available repair docks. In this way, it is very useful to obtain an insight on the effect of width versus steel weight. The variation of allowable width results in an optimum width of around 71.8 m as seen in figure 15. At this particular width, the design is best balanced with respect to floater, column and deck dimensions within the set of design criteria.

5. CONCLUSIONS

- The optimisation program is an effective and very useful tool in the concept design of a semi-submersible vessel.
- The results of the optimisation program are sufficiently accurate to enter the next design stages, without the danger of major modifications of the vessel.
- The optimisation program can also be used to study the impact of the design criteria and their effects on the overall dimensions of the rig.

- The variation study on design criteria showed clearly the effect of the Total Variable Load in transit and overall width versus total steel weight of the rig.
- In the optimisation program motional behaviour is treated as a constraint. When design requirements are varied, it is possible to develop designs with the same motional behaviour.
- As the optimisation program is relatively small, it lends itself easily to modifications meeting specific requirements of owners and/or builders, for instance varying the number of columns or designing accommodation/construction units.

Acknowledgement

The authors acknowledge the kind permission of the management of Sumitomo Heavy Industries and Marine Structure Consultants to publish results of the development of the semi-submersible drilling vessel, DSS-40.

References

One of the tastiest contracts we’ve won.

All manner of fruits, vegetables, meat and fish can now enjoy first class travel around the world and, to ensure a smooth passage, Anthony Veder B. V have selected BP to supply all the lubrication for the Prins Willem Van Oranje. The Dutch shipping industry is justifiably proud of this new ship and they can rest assured that in 300 ports around the world BP can serve her with the highest quality lubricants and expert technical advice.

It’s a partnership we hope will provide food for thought.
The first of two new 350,000 cbft. reefers, built by Yssel-Vliet Combinatie B.V. at their yard Ysselwerf

The principal dimensions of m.v. 'PRINS WILLEM VAN ORANJE' are:

- Length over all: 118.38 m.
- Length b.p.p.: 110.22 m.
- Breadth: 18.50 m.
- Depth to maindeck: 12.57 m.
- Free deckheight: 2.20 m.
- Max. draught: 8.08 m.
- Deadweight: 6885 metric tons
- Gross tonnage: 5966 ('69 convention)
- Hold capacity floor area:
  - Hold no. 1 - 2514 m³
  - Hold no. 2 - 2470 m³
  - Hold no. 3 - 2464 m³
  - Hold no. 4 - 2521 m³
  Total 4018 m²
- Fuel oil capacity 1027 t.
- Waterballast 880 t.
- Freshwater 62 t.
- Lub. oil 43 t.
- Service speed 18 kn.

m.v. 'PRINS WILLEM VAN ORANJE' is the first ship of a new series of two identical reefers to be completed for account of Anthony Veder Koelvaart Mij. B.V. at Rotterdam.

The vessel is of a new generator reefer-vessel type, specially designed for transporting fruit and deepfrozen products. After the last reefer-vessel, built by the Yssel-Vliet Combinatie, which was a 3-deck vessel with a trunk of 0.6 B on top of it, the market was asking more cargohold volume.

In this new design the trunkdeck has been extended over the full breadth, resulting in a cargo section of four holds, each divided in four compartments with two open decks and one closed deck. This makes the vessel suitable for carrying eight different cargoes with eight different temperatures.

The hull form has been optimally designed to obtain sufficient stability at lowest propulsion power. The result will give the
Congratulations!
Prins Willem van Oranje

Construction No 230, built by Ysselwerf, by order of the Anthony Veder Group N.V.

Equipped with Mitsubishi diesel engine powered gen sets

News at the Europort’87
The Mitsubishi S6R series marine engines
Introduction on our stand No E 414

- 6 cylinder in line
- 820 Hp/1500 r.p.m.
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- Low price
- Low fuel consumption

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European sales and service subsidiary of Mitsubishi Heavy Industries-Engine Division-Japan.
P.O.Box 20, 3840 AA Harderwijk, The Netherlands. Phone (0)3410-13041.
Telex 47330. Telefax (0)3410-19060
Air refreshment:

Air circulation:

Walls and ceiling of high quality water resistant multiplex (betonplex) in white colour. Each hold is provided with air connection and high pressure cleaning connection for hot and cold water. The lower part of each cargo compartment has steel protection against forklift truck damage and is equipped with fittings for car transport. On 1st tweendeck level at starboard-side, each hold has a hydraulic operated side cargo door with a clear opening of 2.40 m. Each tweendeck hatch is provided with hydraulic operated banana hatch of 2.40 x 2.40 m. clear opening.

On the maindeck 48 TEU can be placed, of which 20 can be of the refrigerated type. For loading and unloading 4 special cargo cranes have been placed in such a way that each crane can reach two holds. Cranes are made Nor-Marine, type MVC 1610-7-18, with a capacity of 7 tons from 0 – 70 m/min. at an outreach of 18 m.

Holds are protected against fire by a CO₂ installation, which is situated in the forecastle.

Refrigeration installation

The design of the cargo refrigerating plant has been based on following conditions:

- Total hold capacity: 9970 m³
- Number of holds: 8
- Different temperatures: 8
- Cooling down time:
  - Bananas from +30°C to +12°C in 24 hrs.
  - Deciduous cool transport from +12°C to 0°C in 36 hrs.
  - Deepfreeze cargo from -20°C to 27°C in 36 hrs.
  - Above 0°C: 90/hr.
  - Deepfreeze: 45/hr.
- Air circulation:
- Air refreshment:
- Air circulating system:
- Temperature accuracy:
- Air delivery to change set points.
- Air delivery to scan all alarm reports.
- Air delivery to operate all in- and outputs of the local stations.
- Air delivery to special USDA reports from the hold temperatures.
- Air delivery for cool transport: approx. 0.1°C.
- Air delivery for freeze transport: approx. 0.5°C.

Cargo holds

All four cargo holds are equipped with hydraulic operated hatches on each deck. The length of the holds has been chosen in such a way that each hold will have about the same floor area. The holds are specially designed for pallet carrying with a minimum free height of 2.2 m. and strengthened for 2 t/m² deckload and suitable for forklift truck operation.

The second tweendeck is a closed deck with special designed aluminium gratings, same as for the tanktop floor. The first and third tweendeck are constructed as an open grating deck with hardwood planking.

The refrigerant liquid supply to the aircoolers have been placed, one on port-side and one on starboard. Above these aircoolers a number of axial ventilators have been placed with 2-speed electric motors. The finned aircoolers are automatically defrosted by hot gas. Necessary valves, magnetic solenoids and infra-red ice measurement has been installed. Below the aircooler special leak-trays are constructed with heated scupper pipes to the bilge wells in the double bottom.

The auxiliary diesel engine of make M.A.N., type 7L52/55B, with a continuous output of 6000 kW at 435 r.p.m.

Furthermore in the central control room has been placed a starter and control switchboard as well as a CO₂ measuring and registration plant.

Engineerroom

m.v. ‘PRINS WILLEM VAN ORANJE’ is propelled by a 4-stroke reversible turbocharged main diesel engine of make M.A.N., type 7L52/55B, with a continuous output of 6000 kW at 435 r.p.m.

Electricity is generated by 3 generator sets, make M.A.N., type 7L20/27, output 630 kW at 900 r.p.m. Each diesel engine drives a 600 kW Indar generator. The diesel sets are automatically started and equipped with loadsharing.

The auxiliaries are suitable to burn the same fuel as the main engine and are connected to the common uni-fuel system, consisting of pressurised mixing tank and

SCHIP EN WERF INFO-SPECIAL, NOVEMBER 1987
Grenco B.V. congratulates shipowner Anthony Veder on the MS Prins Willem van Oranje and wishes shipowner and crew a safe voyage.

Grenco Refrigeration supplied the complete refrigerating plant for the Prins Willem van Oranje.
The vessel has a refrigeration capacity of 2,580 kW and a total hold volume of 9,922 m³ (364,000 cuft), sub-divided into 8 temperature zones.
electronic viscorator.
The fuel is separated by two fully automatic Alcap separators, make Alfa-Laval, who also delivered the lub. oil separator for the main engine and auxiliaries.
Furthermore are installed: Atlas copco starting air and pilot air compressor, a Haworthy sewage installation, a Pasilac freshwater generator, a R.W.O. bilge water separator and Unitor high pressure cleaning units.
The cooling water system is designed for central cooling for main engine, auxiliaries and miscellaneous consumers. The system consists of HT and LT coolers, make Gea, with LT pumps, HT pumps and seawater pumps. The system is designed in such a way that in cold condition one or two pumps can be switched off to save energy.

Accommodation
The accommodation, divided over 4 decks and wheelhouse, is suitable for 16 persons. The maindeck layer is used for a messroom, an office, galley stores, a laundry and a changeroom. On the second deck the officers' mess and a number of crew cabins are situated. The third and fourth deck are used for officers' cabins.
All cabins are designed with their own toilet cabin arranged in such a way that optimum living and working space is created. All walls and ceilings are sound-insulated and conform to latest Solas requirements for safety and fire protection.
The accommodation is airconditioned with an A.C. installation, suitable for tropical conditions.
In the wheelhouse a central control desk with all navigation and manoeuvring equipment is situated.
Also the radio room is situated on the bridge deck and consists of main radio station and satcom.
For lifesaving equipment an aluminium free fall boat for 20 persons, make Verhoef, is installed. A hydraulic crane is also installed on the aftship for taking the boat out of the water. This crane is also used for storing and launching one of the two life rafts, which are also placed on the aftship.
The corrosion protection and paint system of the whole vessel is carried out with coatings of Hempel.
The navigation bridge consists of the following equipment:
- One 3 cm X-band automatic radar with Arpa, make Kelvin Hughes, type Radtrak.
- One 10 cm S-band relative motion radar, make Kelvin Hughes, type Radtrak-16.
- One slave indicator, make Kelvin Hughes, model KH-1600 with 12 inch high Milliana monitor.
- One satcom installation, make Elektrisk Bureau, type Satcom-3S, complete with monitor, telephone and teleprinter.
- One satellite back-up radiostation, make SP radio, 800 Watt.
- One facsimile receiver, make JMC, type FX 200.
- One/navtex receiver, make Lokator, type 2 NL.
- One direction finder, make Ramantem, type 982/RH.
- One satnav, make Furuno, type FSN-90 with interface to gyro and log.
- One Lorang-C receiver, make Furuno, type LC-90.
- One Decca navigator, make Navstar, type 601-D.
- One lifeboat radio, make Skanti, type TRP-1.
- Two EPIRB, make Burn dept.
- Two mariphones, make SP radio, type RT-144C.
- One echosounder, make Furuno, type FE-881 Mhz.
- One speedlog, make Ben Marine, type Athenie.
- One Robertson autopilot AP-9.
- One gyro compass, make Hikushin, type CM2-200, with 3 repeaters.
- One Robertson hand-control for follow-up and non follow-up rudder control.
- One magnetic compass, type MK 2, with sub unit MK-2.

The vessel is scheduled for delivery end of October 1987.
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MERCUUR

Built by: Royal Schelde in Vlissingen
Built for: The Royal Netherlands Navy

The 'Mercuur' is a ship especially built for the trail of torpedo's for the submarines and frigates of the Royal Netherlands Navy. The ship is based in Den Helder. The main characteristics are:
Lenth o.a. 64.80 m, Length b.p. 57.60 m, Width 12.00 m, Depth to maindeck 7.00 m, Draught (base line) 4.30 m, Draught (sonardome) 5.45 m, Displacement 1400 tons, Accommodation for 39 persons.
The ship's propulsion installation consists of 2 Brons/MAN diesels type 6L20/27 of 600 kW each driving two propellers. The electrical energy is produced by three dieselgenerator sets of 300 kW each.
The 'Mercuur' is equipped with torpedo launching tubes, a special slipway for picking up and transporting torpedo's. On board are several workshops for dismantling, cleaning and assembly of the torpedo's.
A full description of this 'torpedo trials vessel' has been published in a special issue of 'Ship en Werf' no. 16 of 7th August 1987.
In 1987 door ons gebouwd onder bouwnr. „416” „YE 172” „PIET HEIN” afm. 40 × 10 m. Voor rederij „Mieras” te Arnemuiden

In 1986 gebouwd: Theodora „WR 238” afm. 36 × 9 m voor de heer L. Kooi te Hyppolytushoef

Scheepswerf

PETERS

Kampen

Postbus 291
8260 AG Kampen (Holland)
Haatland Haven 1
Tel. (05202)-15023 Telex 42323 -15708
YE 172 'PIET HEIN'

Built by: Laan en Kooy in Den Oever
Built for: Mieras en Co. B.V. in Arnemuiden

The 'Piet Hein' is a special type of fishery ship specially built for the catch or 'harvest' of cockles in shallow water. The hull of the ship, which was built by Peters Scheepsbouw in Kampen, has a length of 40 meters, the breadth is 10 meters, the draught is only 0.50 meters. The engineroom installation consists of 2 Scania diesel engines type DS-11 with 218 kW each and 6 Valmet diesel engines for generators and pumps. The ship has an extensive fishing and fishprocessing installation. A full description of the vessel has been published in 'Schip en Werf' no. 18 of 4 September 1987.
AEG Technologie voor de offshore industrie:

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- energie-opwekking,
- energiedistributie,
- aandrijving,
- besturing,
- communicatie,
- dataprocessing,
- verlichting, enz. enz.

De documentatie wordt door ons projectgericht samengesteld, operators en crew door ons getraind. Onze dienstverlening staat dag en nacht voor u klaar (7 x 24 uur).

De wereldwijde en jarenlange ervaring van AEG en DEBEG op dit terrein hebben een schat aan know-how opgeleverd.Know-how die borg staat voor de hoogst mogelijke betrouwbaarheid en veiligheid.

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Telex 28822 adrd nl.
Automatiseren, regelen, bewaken en beveiligen van generator-aggregaten


Moeizaam samenstellen en inbouwen van meerdere losse componenten is nu niet meer nodig. AEG levert een compleet geheel, een unit waar alle functies – bedieningen en alarmen opzitten. Een perifere aansluitplaat met stekeraansluitingen staat borg voor een simpele – snelle montage. De opbouw en de verschillende mogelijkheden worden onderstaand nader uitgezet.

Automatische stroomverzorgingsysteem GEAPAS. Een volautomatisch bedrijf met verschillende generatoren kan worden gerealiseerd met het automatische stroomverzorgings-systeem dat door AEG in Hamburg is ontwikkeld. Afhankelijk van het gekozen installatieontwerp kan het systeem opgebouwd worden uit de volgende componenten:

- DSG 822: Dieselgenerator controle- en bewakingsunit
- WSG 822: Asgenerator controle- en bewakingsunit
- TSG 822: Turbogenerator controle- en bewakingsunit
- LSG 821/822: Belastingbewakingsunit. (De generatoren worden belastingsafhankelijk bij- of afgeschakeld.)

Bij veranderingen van de belasting kan het systeem automatisch generatoren bij- of afschakelen. Tevens worden zowel generatoren als het net bewaakt tegen storingen en in overeenstemming daarmee maatregelen getroffen om de stroomvoorziening zeker te stellen.

Hoofdfuncties zijn:

- start en stop van de aggregaten en hun bewaking.
- synchronisatie en bijschakelen van de aggregaten
- belastingverdeling
- generatorbewaking

De 'hardware' van de WSG 822 en TSG 822 is identiek met die van de DSG 822. De verschillen zitten in het programma en de aanduidingen op het front. De software is telkens aangepast aan de specifieke aggregaat-eigenschappen, met individueel instelbare parameters.

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Sinds de oprichting van FLOAT in 1980 heeft de onderneming zich in hoofdzaak geconcentreerd op de vervaardiging van reddingvlotten t.b.v. de watersport. Thans, in 1987, bestaat de serie uit 3 typen met capaciteiten van 4 t/m 10 personen. Als een der eerste fabrikanten in Europa heeft FLOAT in de door haar geproduceerde vlotten de resultaten verwerkt van de door het Engelse Maritime Institute uitgevoerde proeven m.b.t. de stabiliteit en bruikbaarheid van jacht-reddingvlotten.


Behalve de genoemde collars vervaardigt FLOAT eveneens z.g. floating bags met liftvermogens van 2,500 tot 15,000 Kg. en kleine fenders voor de watersport.

De FLOAT 505 hulpverleningsboot zal binnenkort worden geïntroduceerd. Het spreekt vanzelf dat FLOAT zich ook bezig houdt met het op deskundige wijze inspecteren van alle merken jacht-reddingvlotten en reddingvesten alsmede het onderhoud en reparatie van rubberboten en overlevingspakken. Sinds juni 1985 is er onder de naam SERVI-FLOAT tevens een 'steunpunt' aan de Noorderhaven 61 in HARLINGEN.
De naam OKAY/CEE staat voor een team enthousiaste medewerkers, die gezamenlijk voor de innovatie hebben gezorgd. Daarom haalt u voor uw electro-technische installatie altijd een expert in huis. Meer dan 60 specialisten staan voor u klaar waarbij hard werken ook buiten de kantooruren, trouwbaarheid en service tot de meest ouderwetse zaken behoren.

Ons bureau moest veelal bewijzen, dat de theoretische know-how in de praktijk moest worden gerealiseerd. Specifiek toen de activiteiten van het spu ren naar olie op het continentale plat en de exploitatie hiervan om meer geavanceerde technieken vroegen. Hiermee onderstrepen wij dat voor Uw probleem, waarvoor theoretische oplossingen zijn bedacht, onze engineers de praktische toepasbaarheid effectueren.

LEVERINGSPROGRAMMA:
- PLC besturingen,
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Giesselbach levert u niet alleen de oplossing voor uw elektrotechnisch vraagstuk van vandaag maar ook van morgen. Door de toepassing van nieuwe technieken is er al ervaring voorhanden op het gebied van micro-processing. Geprogrammeerde c.q. gestuurde elektrische installaties werden met volledig aangepaste systemen door ons geplaatst in de recycling- en bio-industrie. Doordat wij doorgaans z.g. maatpakken moeten leveren is ons werkterrein zeer veelzijdig. De off-shore branche biedt in deze overzichtsbrochure mogelijk de meest spectaculaire beelden, maar ook rekenen wij af met storingen in de meest eenvoudige installaties. Omdat wij geen vast leveringsprogramma hebben, kunnen wij u objectief adviseren welk produkt ons inziens de voorkeur geniet voor installatie. Dit kan van project tot project variëren.

Grenzeloze service

Hoewel het hoofdkantoor van OKAY bv Giesselbach Electro Engineering in Amsterdam is gevestigd, kent het werkterrein geen grens. Juist omdat veel opdrachtgevers uit de scheepvaart en offshore komen, gelden voor het OKAY/G.E.E.-team geen grenzen.
Smits Neuchâtel is de erkende specialist op het gebied van maritieme vloeren. Levert accommodatievloeren, buitendekbedekkingen, ruimvloeren en conserveringen.

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Graag zenden wij u uitvoerige documentatie plus certificaten, die stuk voor stuk een aanbeveling zijn.
Of wilt u meteen een gedegen advies voor een bepaald project? Wij zijn niet verder weg dan uw telefoon.

Smits neuchâtel bv
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scheepsdekkers
Scheepsdekkers stellen zeer specifieke eisen aan de afwerking, zowel in de accommodatie als daarbuiten. Smits Neuchâtel heeft hiervoor een breed scala van produkten en diensten.

Accommodatievloeren: van latex-ce­ment vloeren tot hoog gekwalificeerde vloerafwerkingen, brand- en geluidwe­rend, decoratief afgewerkt met p.v.c., li­noleum, tapijt, rubber of naadloze kunst­stof vloeren, dan wel met keramische of marmer tegels. Speciale afwerkingen worden daarbij niet uit de weg gegaan, zoals blijkt uit de interieur foto’s van de ferry ‘Koningin Beatrix’.

In Schip en Werf Info-Special, November 1987

Scheepvaartinspectie, en zijn goedge­keurd door vooraanstaande classificatie­bureau’s.

Buitendekken: hiervoor beschikt Smits Neuchâtel over kwalitatief hoogwaardige kunststofbedekking op basis van rubber, polyurethaan en epoxy. Zo werd onder andere voor de Koninklijke Nederlandse Marine het Hypox Dek­bedekkingssysteem ontwikkeld: een serie van op elkaar afgestemde produkten, waardoor dekken onder alle klimatologi­ sche omstandigheden een sterke, corrosiebestendige, brandwerende en antislip bescherming krijgen.

Alles wat op maritiem gebied gebouwd wordt kan door Smits Neuchâtel voor­ zien worden van dek- en vloerbedekkin­gen: booreilanden en andere off­shoreconstructies, supply-vessels, sche­pen voor de grote vaart, sleepboten, hektrawlers, binnenvaart-, kustvaart- en passagiersschepen, fregatten, onderzee­boten. De afwerkingen zijn grotendeels ontwik­keld in eigen laboratorium, in nauw overleg met TNO en de Nederlandse

Smits Neuchâtel heeft een jarenlange ervaring in de nieuwbouw- en renovatie­sector, ter land en ter zee.

En: Smits Neuchâtel is nooit verder weg dan de dichtstbijzijnde telefoon!
PROBLEEMLOOS LASSEN...

Smitweld heeft precies die elektroden en toevoegmaterialen die het meest geschikt zijn voor uw werk. Ga maar na: we maken bijvoorbeeld meer dan 80 verschillende elektroden, poeders en gevulde draden. Allemaal grondig getest en zeer constant in gedrag.

En mocht u toch een keer voor een probleem staan, dan adviseren wij u graag. Want dank zij gedegen research en rijke ervaring blijken we steeds weer in staat een oplossing te vinden.

Smitweld dus. Niet alleen als het gaat om de juiste elektroden, gevulde draden of poeders. Ook op het gebied van apparatuur kunnen wij u uitstekend van dienst zijn.

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SMITWELD

60 jaar laservaring

De naam SMITWELD klinkt velen die werkzaam zijn in de lasindustrie, vertrouwd in de oren. Dat is niet zo verwonderlijk, want dit Nijmeegse bedrijf is de grootste producent van laselctroden en -poeders in Nederland. En SMITWELD draait al zo'n zestig jaar mee. In West-Europa bezit het bedrijf een sterke positie op het gebied van lasstoevoegmaterialen voor speciale toepassingen; denk daarbij aan roest- en hittevast staal, duplex staal en cryogene installaties. In het begin van de jaren '80 ontwikkelden SMITWELD het EMR-Sahara concept: lasmateriaal met een bijzondere ongevoeligheid voor vocht.


Het in 1927 opgerichte bedrijf telt nu rond de vierhonderd medewerkers. Twintig procent daarvan is werkzaam in de sfeer van research & development. Dat percentage illustreert het grote belang dat SMITWELD hecht aan het vooruitlopen op nieuwe ontwikkelingen in de verbindingstechniek. Zo wordt de know how, opgebouwd in meer dan een halve eeuw, geconsolideerd en verder versterkt.

De recente geschiedenis van het bedrijf kenmerkt zich door modernisering, de ontvloeiing van nieuwe activiteiten en een toenemende oriëntatie op de internationale markt. In 1981 werd een nieuw fabriekscomplex geopend dat een van Europa's modernste laslaboratoria huisvest. Voor grondstoffenanalyse is onder andere een uiterst nauwkeurige emissiespectrometer beschikbaar. In hetzelfde jaar nam de produktie-afdeling een automatische menginstallatie in gebruik voor de aanmaak van de bekleding der laselctroden. De computer-besturing daarvan garandeert een constante en precieze reproduceerbaarheid. Behalve de fabrieken bevinden zich in Nijmegen ook de verkooporganisaties voor binnen- en buitenland; regionale kantoren zijn gevestigd in Amsterdam, Groningen en Barendrecht. In Duitsland en België opereren zelfstandige verkooporganisaties.

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Transport Efficiency B.V. is van huis uit leverancier van stalen scheepsluiken voor allerlei zeegaande schepen. De stap naar leveranties voor Ro-Ro schepen was jaren geleden een voor de hand liggende zaak. Als gevolg daarvan begon Transport Efficiency met het ontwerp, verkoop en het (laten) bouwen van zgn. Linkspans of wel Ro-Ro bruggen. De meest recente is de Ro-Ro brug voor Ford Engeland te Dagenham die de brug gebruikt voor de aanvoer van in speciale High-Cube Trailers verpakte assemblage onderdelen voor de bekende Ford-modellen.

De laatste ontwikkeling bij T.E. is de uitbreiding van de engineeringsafdeling. Deze uitbreiding houdt in, dat er nu mogelijkheden voor T.E. aanwezig zijn om naast de bovengenoemde activiteiten ook aan de scheepsbouw in het algemeen complete constructie tekeningen te kunnen leveren op basis van een ontwerp. Tevens wordt gewerkt aan Engineering op het gebied dat buiten de scheepsbouw ligt en de eerste stappen zijn reeds succesvol gebleken.

Ook is de verkoop van de lieren van Ten Horn Machine en Lierenfabriek B.V. bij T.E. ondergebracht sinds de toetreding van Ten Horn tot de Cono Industrie Groep te Groningen, waarvan ook T.E. met een zevental andere bedrijven deel uitmaakt.

Bij Transport Efficiency B.V. ziet men de toekomst dan ook met vertrouwen tegemoet.
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