(RDM-collectie Johan Journée)

A meditation on the Diesel engine in relation to the Royal Netherlands Navy*

by Prof. dr. ir. E. van den Pol DIC,
Captain (E) R. Neth. N.**

Introduction

At first glance it may appear rather paradoxical that the introduction of the gasturbine as the new prime mover for the new generation of frigates caused an increased application of the diesel engine in the Royal Netherlands Navy. In this respect it should be realised that in general the Dutch navy has never been very 'diesel-minded' like e.g. the German navy.

Before 1970 – with the exception of submarines and minesweepers – the warships were mainly steamdriven.

At sea electrical power was generated by turbogenerators, while in harbour when the boilers were shut down and no shore-supply was available (auxiliary) dieselgenerators were used although some of the commanding officers felt ill at ease with them. This feeling often caused a kind of vicious circle: occasionally the diesel engines remained too much idle and when they had to be used they did give trouble because e.g. some air was trapped in the fuel-system or the diesel stopped because the day-tank was empty, while the gauge-glass had clogged with sediment. This in turn strengthened the opinion that diesel engines were highly unreliable indeed! Things changed however remarkably when for ship's propulsion the gasturbine was introduced while at the same time the dieselgenerator was accepted for the electrical power supply, because of the relative more favourable part load performance of the diesel.

The history of Diesel engine propulsion

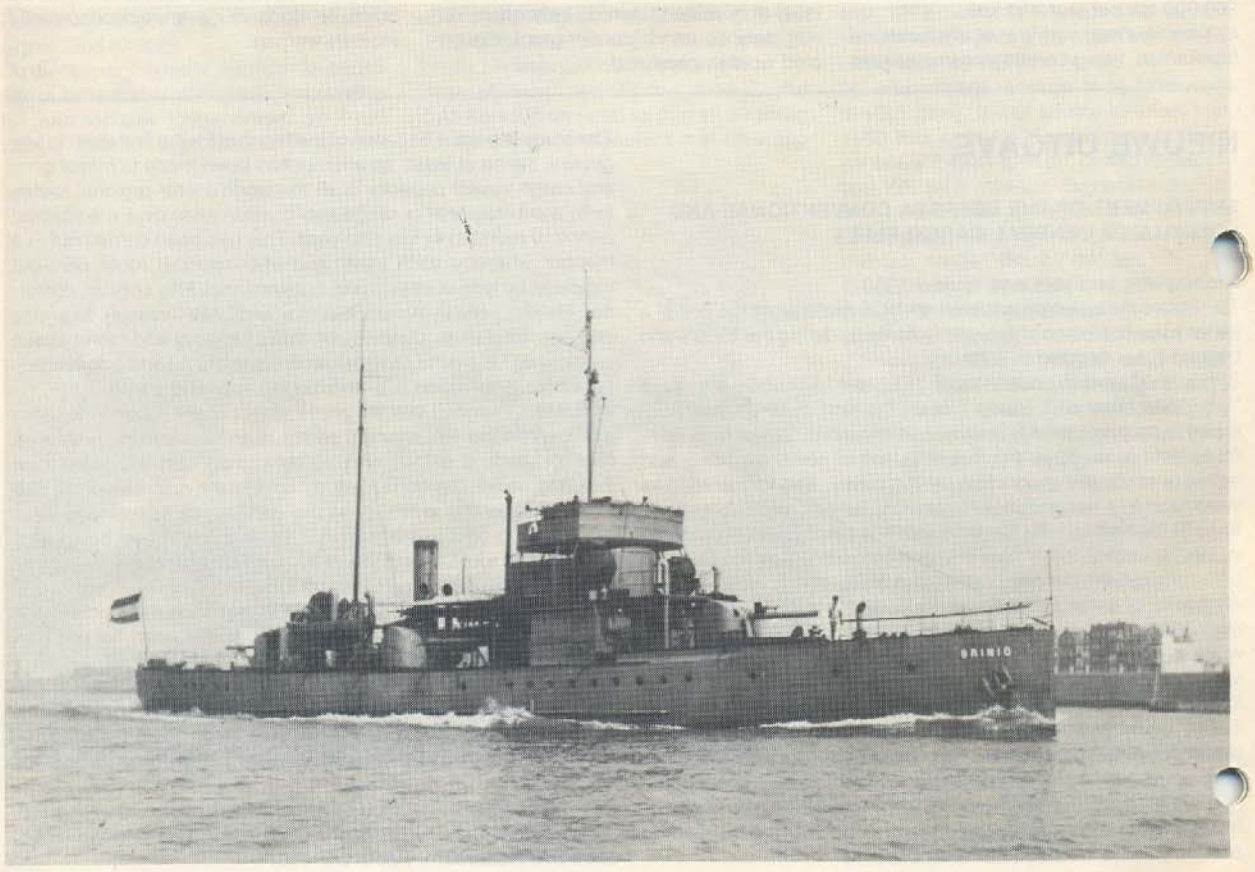
Before dwelling longer on the present situation, a look back over the shoulder seems not misplaced, for there have been some remarkable 'diesel high lights' in the Dutch navy, which are worth mentioning.

The first Dutch warship with diesel-propulsion was the submarine '02', commissioned in 1911, in which one 6 cylinder MAN two stroke engine was installed. The armoured gunboat 'Brinio' (fig. 1) the first of a class of three sisterships, commissioned in 1914, was the first diesel engined 'surface'-ship of the Royal Netherlands Navy. These last ships were notorious however for their eternal engine-trouble. Before world-war II the Dutch submarines, which already had an established reputation in the world of naval architecture and e

* Opinions expressed or statements put forwar in this article do not necessarily represent or reflect the official attitude of the Neth. Naval Authorities.

** Advisor Director Material R. Neth. N., Professor 'Internal Combustion Engines' Tech. Univ. Delft & Royal Neth. Naval College Den Helder.

fig. 1 Hr. Ms. Brinio, a diesel engined gunboat of 1914 (foto Kon. Marine)



Schip en Werf, 1981, blz. 176.

fig. 2 Hr. Ms. 021, one of the first snorting submarines (foto Kon. Marine)

gineering, were propelled mainly by MAN or Sulzer diesel engines.
In 1926 the submarine 'K XIII' put out to sea and went unescorted from Holland – via the Panama canal – to the Dutch East Indies (now the Republic of Indonesia), which was repeated by 'K XVIII' in '34/'35.
In those days quite a feat.

The first snorting submarine

An absolute Dutch innovation in submarine engineering is pictured in fig. 2: Her Netherlands Majesty's submarine '021' *snorting* (and steaming!) near Flushing before the outbreak of world war II!

From time to time however and contrary to the acknowledged facts other countries do claim the snorkel as their invention as well, for a recent example: see Kruska (1) in his commemoration of the late redoutable Prof. Hellmuth Walter.
Starting with '019', commissioned in 1939, the submarines were fitted with the first, real operational snorting system in the world.
These snort- or schnorkel submarines were propelled by two very powerful, two stroke Sulzer engines of type 7 QD 42/50, which gave these boats a surface speed of nearly 20 knots. (In this respect it is rather surprising that – as far as I know – Sulzer never exploited the fact that the first snorting system in the world was built around one of their products).

The post World War II period

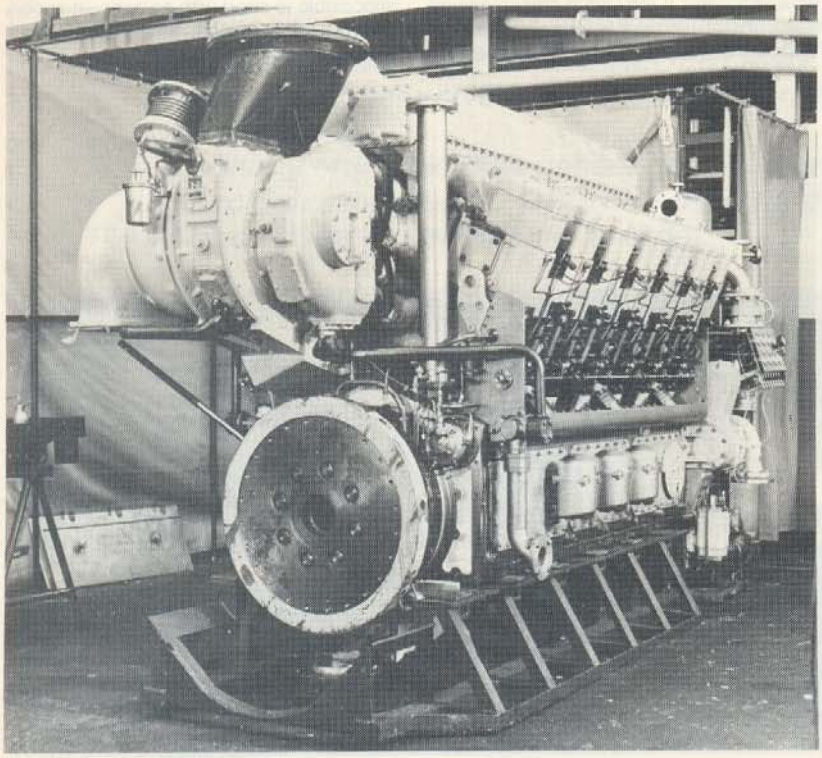
After world war II the Dutch navy received many (motor-)ships of US -origin under the 'Mutual Defense Aid' and consequently the wellknown General Motors (Cleveland) 278A engine dominated our naval diesel field.
The author of this article cannot resist depicting, as a typical example of one of the American ships, Hr. Ms. 'Walrus' (the former USS 'Icefish') because in his younger days his well-being was for some time intensely related to this boat and therefore also to its four sixteen cylinder GM 278 A(S) engines, (fig. 3).
This two stroke diesel turned out to be a highly reliable, cleverly designed engine without any significant supercharging.
Striking was the absolute firm quality control the manufacturers seemed to have achieved, because it was extremely seldom that a sparepart didn't fulfill its specification.
Sometimes one wonders why such an engine had to give way to a newer product. It is true most of the time that the latter incorporates a higher power to mass ratio but what about reliability?
The first post-war new construction program of the Dutch navy allowed the diesel engine as prime mover only to be installed in minesweepers and submarines, the latter of triple hull design.
For the minesweepers the Stork-Werkspoor RUB 215 and 160 together with the MAN 22/30, all partly of non-magnetic alloys, were chosen.
The submarines received only the latter in normal, twelve cylinder V-configuration (2 engines/boat).
Interesting to mention is that in those days (1960) it was said in some circles that it was impossible to snort with an exhaust supercharged diesel; the MAN 22/30 V6V appears to have belied this, however. . .

fig. 3 Hr. Ms. Walrus (foto Kon. Marine)

Schip en Werf, 1981, blz. 177.

fig. 4 Hr. Ms. Kortenaer, the first of a series of 12 S class frigates, built in the Netherlands by RSV Shipyards (foto Kon. Marine)

fig. 5 A Stork Werkspoor, type RUB 215 diesel engine, built by Brons Industrie for the 'Tri partite' MCM vessels (foto Huizinga)



Gasturbine propulsion

Turning our attention now to the present situation it should be clear that as far as th frigates are concerned the gasturbine is well established at the moment.

These frigates – (fig. 4) represents a typical example of the S-class – all have two Rolls Royce 'Tyne' turbines for cruising and two R.R. 'Olympus' engines for high speeds.

To a large extent future application of the gasturbine will not only depend on an improved part-load performance – i.e. the specific fuel consumption – but particularly on its ability to consume modern low grade fuels.

In this respect advanced steamplants with pressurized fluidized-bed combustors may turn out to be a real alternative.

Returning to the diesel, electrical power aboard our new frigates is generated by the use of four Pielstick PA-4-200 VG eight cylinder engines.

It is a pity that at the time these frigates were designed the Dutch diesel industry was n longer in a position to put forward a diesel engine of suitable power and dimensions.

Modern Diesel engine propulsion

For every 'diesel-addict' – like the author – it was therefore a gratifying affair that recently in connection with the socalled 'tri-partite' minehunter (a joint project of the French, Belgian and Dutch navy) the rebirth of the improved, non-magnetic version of the Stork Werkspoor RUB 215 by Brons Industrie at Appingedam, could be witnessed, (fig. 5).

In the meantime this engine has witstood rather stringent shock & magnetic tests and gives every promise of a highly reliable, trouble-free engine. The special know-how, obtained in the fifties, when – for the first time in this country – non-magnetic materials were used in diesel engines could be applied again and so a rare engineering speciality was established once more. A little bit overshadowed by the dashing appearance and performance of the new gt-frigates are two additions to the fleet, which are from the point of view of the diesel engine certainly worth to be mentioned.

In the first place the fleet tanker & replenishment ship Hr.Ms. 'Zuiderkruis', (fig. 6), propelled by two sixteen cylinder SWD-TM 410 medium speed four-stroke diesels, while four Pielsticks PA-4-200 take care of the electrical power supply.

The other interest concerns the hydro- and oceanographic research vessel 'Tydeman', (fig. 7). Three SWD F 240 engines drive each a 850 kW generator (fig. 8), supplying the electrical propulsion power for the main electromotor. These SWD-engines (TM 410 & F 240) are interesting from a naval point of view, because they ar relatively heavy and large, but also wit proven modern fuel capability, I will comment on this later.

Schip en Werf, 1981, blz. 178.

fig. 6 Hr. Ms. Zuiderkruis, built by RSV (Verolme Alblasserdam) (foto Kon. Marine)

fig. 7 Hr. Ms. Tydeman, built by 'De Merwede' at Hardinxveld (foto Kon. Marine)

The modern submarines

Returning to an old Dutch speciality the submarines of the 'Zwaardvis' class should be mentioned (see fig. 9).

Rather large, ocean going boats of 'tear drop' design, submerged highly manoeuvrable in both the vertical and horizontal plane, fitted with the last examples (three/boat) of the RUB 215, built by Stork Werkspoor around 1970, after which the production was stopped.

These twelve cylinder V-type, four-stroke engines incorporate a Ricardo-type combustion chamber in the cylinder-heads and are equipped with Napier turbochargers.

Snorting on all three engines at the same time is possible and gives no apparent, operational problem.

At the moment of writing two new submarines of the 'Walrus' class, which in external appearance will be similar to the previous 'Zwaardvis' class, are under construction.

A few years ago when the decision, regarding the diesels had to be made, the Pielstick PA-4-200-VG was chosen, because at that time there seemed to be no real alternative.

New developments

In this respect it should be realised that because of a more stringent snort-specification it was felt in the end that only a mechanically driven supercharger could do the job. Recently however, it came to my knowledge that MTU is developing a special version of their 396 V-type diesel with a MTU-designed turbocharger, which they claim, satisfies every snortingspecification excisting at the moment (2).

Exciting news indeed, because from the point of view of energy-utilisation exhaust super-charging should be preferred, on the other hand engine-reliability aboard submarines often turns out to be quite a different affair. Experience has given me the feeling that the diesel situation in a modern snorkel submarine gives rise to some nearly contradictory phenomena, for which there seems to exist no real solution especially when turbochargers are applied.

Increased back-pressure goes hand in hand with atmospheric depression in the boat, both resulting in a decrease in air-receiver pressure.

In order to maintain the latter on the highest possible level one tends a.o. to reduce the valve-overlap.

In general however, a supercharged diesel

Schip en Werf, 1981, blz. 179.

badly needs the valve-overlap in order to scavenge the cylinder and especially to cool the exhaust valve(s) and the walls of the combustion chamber sufficiently. This applies most particularly in the case of a submarine-engine when turbo-charged, although some diesel-manufacturers derate their product in order to achieve a more or less satisfying optimum. If one wants to evade the chance of frequent engine trouble in submarines, then – in my opinion – there is much to say for naturally aspirated diesels, for it simplifies the total snorting problem considerably. Of course the penalty is lower total engine efficiency and more engine-space is needed.

The future Diesel fuels

If the Dutch navy is forced in the near future to change from the light – like gasoil – to the middle destillates and later on maybe to blended fuels, because of the coming changes in refinery processing, this will impose rather severe constraints on our present mainly high speed diesel equipment. A not impossible future change over to e.g. Marine Diesel Fuel B2 (which may be blended up to 15% with residual oil) might lead to a reduction in maximum output and speed in order to obtain acceptable lifetimes of wearing components, not withstanding the reassuring noises made by the diesel-manufacturers.

Very often they are not sufficiently aware that the 'load profile' of a diesel engine in a modern warship is a rather erratic one. On the other hand we should get rid of a general 'naval disease' namely: always wanting – for obvious reasons of course – the highest number of kilowatts per kg engine mass, because most of the time this – as it often turns out – seems not to be compatible with increased reliability. It is my firm conviction that with the present state of the art in high speed diesels with direct injection in relation to warships which have no fast engine exchange facilities one should not go beyond 0,2 kW/kg and preferably stay in between 0.1 and 0.15 kW/kg.

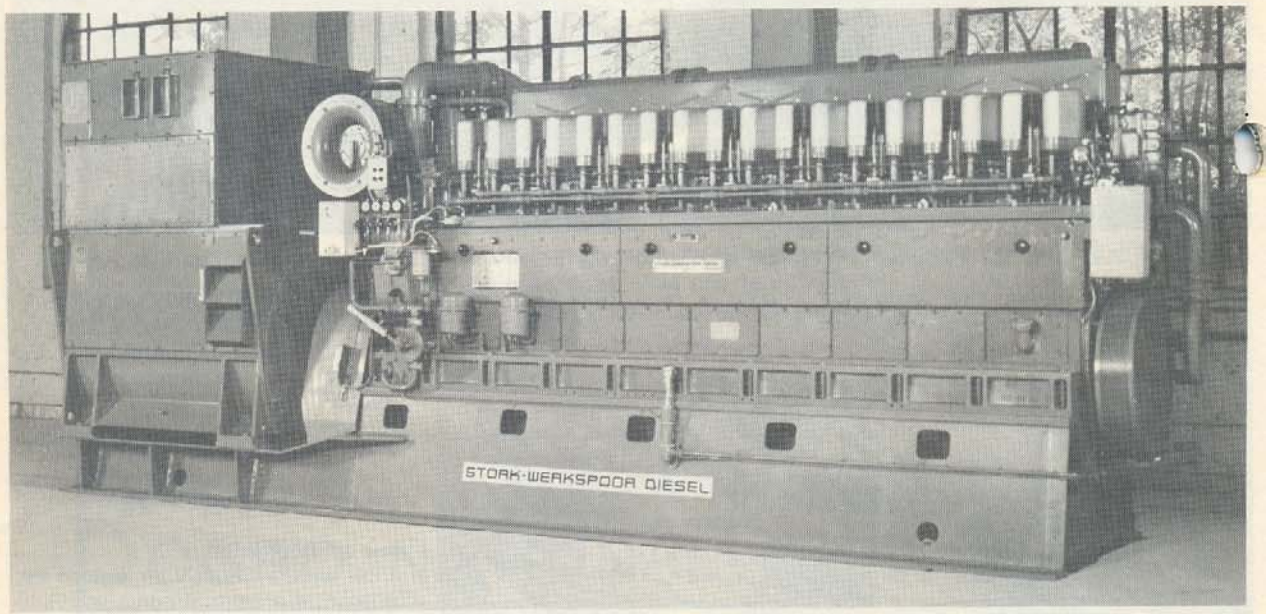
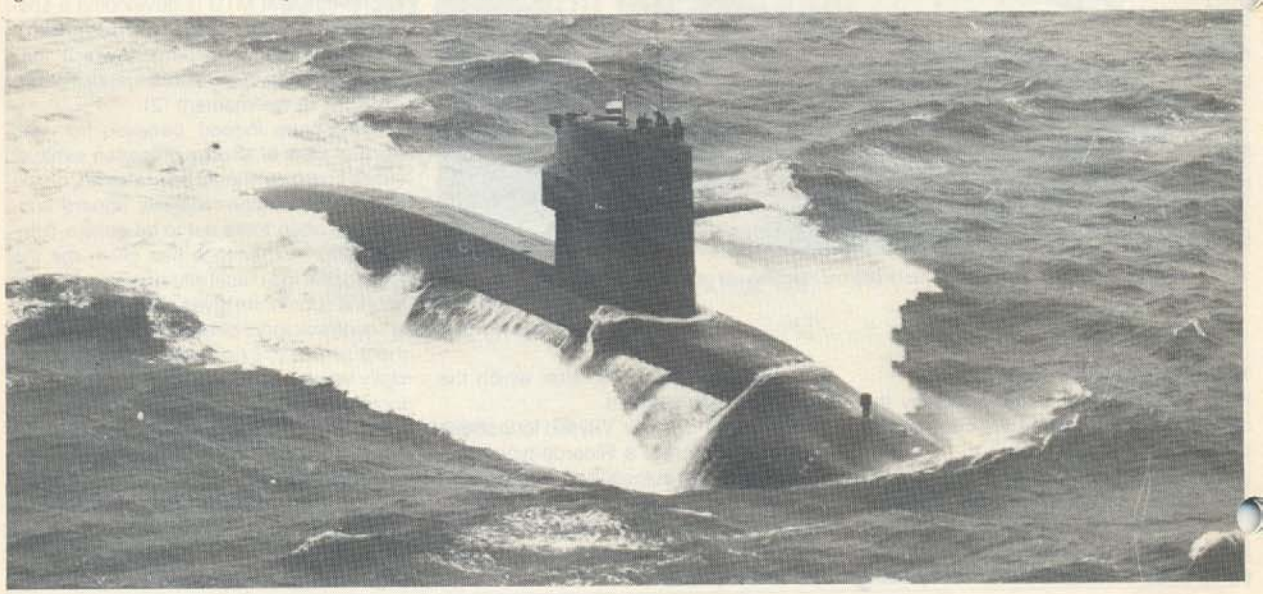


fig. 8 A 850 kW dieselgenerator set driven by a Stork Werkspoor Diesel engine type F 240

fig. 9 Hr. Ms. Zwaardvis, built by the RSV Rotterdam Dockyard (foto Kon. Marine)



Schip en Werf, 1981, blz. 180.

Experience shows that light-weight engines exhibit too often after some 4000 running hours frame-deficiencies, cracks in cylinder-heads and pistons because of a too optimistic construction-philosophy.
The above quoted figures may appear conservative but might turn out to be more justified when – in the future – fuels will become more aromatic of nature and consequently the ignition more delayed and partly more explosive while the temperature-level during combustion will be higher.
In the foregoing, starting with a historic 'stepping stone' in which some diesel high lights were mentioned, a sketchy review was given of the present, expanding diesel situation, while at the same time some problems were touched on rather lightly.
Now one could therefore raise the not unlogical but intricate question: how is the Dutch navy going to cope with the diesel engine in the future? At the moment the overhaul of our diesels is done partly on contract by the manufacturers and partly by the mechanical engineering department of the Naval Dockyard at Den Helder.
If this routine is to continue the facilities of the latter – including the accompanying organisation – should be enlarged and modernised in order to face the increasing demand for overhaul, due to the greater number of engines and their enhanced use.
In the meantime, in order to exercise a strict configuration control a 'Bureau of Dieselengines' has been created in our Engineering department of the Ministry of Defense recently.
In case of an engine trouble, based on the mechanical failure of a diesel component, the expertise of the naval metallurgic laboratory is available and can be called upon. The ability of the latter is demonstrated in fig. 10, dealing with a cast-iron engine component that – in a certain type of diesel – has suddenly fractured.
A precise investigation learned a.o. that instead of the specified nodular cast-iron configuration the latter was partly of lamellar (and weaker) structure.
Having such a facility at one's disposal gives the navy a very powerful tool indeed, for it allows in the shortest possible time an analysis, as good as is possible in the given circumstances, of the failure of a diesel component and contributes therefore considerably to the operational readiness of the fleet.

fig. 10 A Undisirable structure of a diesel component.

Naval research on Diesel engines

In relation to the future the world-wide availability of suitable fuels is giving rise to increased concern of the naval authorities. It is felt in this respect that a frequent dialogue with the oil-companies and the eligible manufacturers is necessary but probably not sufficient, especially in the case of fuels, having a substantial fraction of oils of artificial molecular structure due to thermal and catalytic cracking.
Therefore – and also to be a better partner in such discussions – the Director Material feels it as desirable that the Dutch navy should start its own combustion experiments with modern, low grade fuel in a naval environment.
To realise this the navy intends – if the funds can be raised – to build near the Royal Netherlands Naval College at Den Helder a modern test-facility for two diesel engines.
In principle this project will be open to everyone who feels he might benefit from it and as a matter of fact the Dutch industry will be kindly invited to participate.
Moreover it will be tried to establish formal links with the new Maritime Research Institute Netherlands (MARIN), which originates from the merging of the internationally well known Netherlands ShipModel Basin (NSMB) in Wageningen and the Netherlands Maritime Institute (NMI) in Rotterdam. By doing so the Royal Netherlands Navy not only serves her own interests, but may stimulate the Dutch industry as well which can be interpreted today as a part of her peace-time task.
In conclusion it can be said that in the Netherlands navy the diesel engine is not only very alive but furthermore that clearly steps are being taken to assure that the Royal Netherlands Navy will soon be very 'diesel minded' indeed!

References

1. Kruska, E. In commemoration of Prof. Hellmuth Walter, Marine-Rundschau 2/1981, S.127.
2. Jost, Volker M.W. Private communication. Motoren- und Turbinen-Union, Friedrichshafen.

Schip en Werf, 1981, blz. 181.