SSPA HIGHLIGHTS

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PHOTO: DAVID JEFFREY/THE IMAGE BANK

Design for next millennium

Titanic has once again been the ”talk of the town” around the world, the reason this time not another catastrophe, but a popular movie.

When considering the impact of an ice-berg, it is with great satisfaction we notice that the environmental and safety concern is now penetrating the design process. Redundance is a key factor. Double engine rooms, double propellers and rudders give enhanced safety. If you, furthermore, secure that the required manoeuvrability will exist also at a failure of one of the systems, a large step forward has been taken. In this issue of SSPA Highlights we present projects using the most modern technology and knowledge to design ships for harsh climate, hard winds and hazardous cargo.

Hans Broberg
PRESIDENT

Are you still designing your ships' hull form only to achieve minimum power consumption and just to fulfil IMO's regulations?

Many shipowners today set their goal much higher than that. ARCO Marine Inc., a wholly owned subsidiary of AtlanticRichfieldCompany, now building its new generation tankers at Avondale, is definitely one of them. SSPA's key words Safety – Economy – Environment could also be the key words for its new design, the Millennium Class Tanker.

In late 1996 ARCO Marine assigned SSPA to carry out the hull form design and the model testing for its new Millennium Class Tanker. After the very first discussions with the manager Robert Levine it was clear to everyone involved at SSPA that ARCO Marine's intentions regarding the development work for its new ships reached far above the average. When signing the contract both parties had put in a significant number of working hours to form a development programme. The staff at SSPA felt both pride and enthusiasm for winning the confidence of ARCO Marine and for being chosen to participate in developing this new generation of tankers.

A redundant design

The Millennium Class Tanker is a twin-screw, twin-skeg, double hull tanker intended for service between the Trans-Alaska Pipeline terminal located at Valdez, Alaska, and US West Coast ports in Washington and California. The primary route is through the environmentally sensitive Puget Sound to Cherry Point in Washington as well as through Prince William Sound in Alaska. The ship will be built for 30 years of fatigue life, and is the first crude oil tanker to be built in the U.S. following the Oil Pollution Act of 1990. The double hull completely protects the cargo (crude oil) area and other tanks. The distance between the inner and outer hulls is even 50% greater than the regulatory minimum.

The ship will have to sustain long-term exposure to extreme weather conditions, and is being designed following the new redundancy requirements of the American Bureau of Shipping (ABS). The twin-skeg design allows the ship to have two completely independent engine rooms, each containing a low-speed diesel engine of 11.06 MW (15 015 hp). Also the two rudders can be operated independently from each other. The ship has extraordinarily good manoeuvrability. Using the 3 000 hp bow thruster and the two CP propellers, the ship can turn 360 degrees within its own length at slow speed.

Impressive navigational equipment

ARCO Marine has also engaged SSPA in the construction of the navigational system. This new ship will be equipped with two automatic plotting collision radars, Global Marine Distress and Safety System (GMDSS) and two Electronic Chart Display and Information Systems (ECDIS). For the latter system SSPA will deliver a Dynamic Position Predictor (DPP).

A DPP is a highly advanced navigation aid used for continuous dynamic position prediction. On the electronic chart, the bridge officers will see the ship's position 30 to 600 seconds ahead.

The DPP is customised for each individual ship, with an advanced mathematical model of the ship's hydrodynamics used for calculating the ship's predicted position. The ship's speed, position and draught, as well as water depth, wind speed and direction, are all used as input to the system's calculations.

Björn Allenström

Mr John Sullivan (left) and Mr Robert Levine (right), both from ARCO Marine, studying the wind tunnel model of their Millennium Class Tanker together with SSPA's Mr. Ted Rosendahl.

Artist's impression of ARCO Marine's 125 000 DWT Millennium Class Tanker. Main dimensions: Length overall 273 m, beam 46.2 m, draft 16.3 m. Ship speed (trial, 90% MCR) 16.5 knots.

*Björn Allenström, Director Hydrodynamics Development He received his M. Sc. degree in Naval Architecture in 1976 at Chalmers University of Technology and has since then, except for two years, been employed at SSPA.
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Facts about twin-skeg designs

In 1943 the first twin-skeg afterbody hull was tested at SSPA on behalf of Götaverken Shipyard. Not until 1969 the next twin-skeg design was tested, now on behalf of Uljanik Shipyard in Yugoslavia. In the 70's and 80's, a number of twin-skeg designs were tested at SSPA, among them two of the biggest ships in the world; the French 550 000 DWT tanker Batillus (Chantier de l'Atlantique) and the Swedish 499 000 DWT Nanny (Uddevallavarvet). Also the 127 000 DWT tanker Stena Alexita (Tsuneishi), Japan's fist twin-skeg tanker, launched in 1998, was designed and tested at SSPA. Up to now, about 200 twin skeg hull configurations in over 100 projects have been tested at SSPA.

In general, it can be stated that it is definitely beneficial to use a twin-skeg afterbody on full hull forms, nevertheless also some very successful designs have been made for faster and slender ships. Especially when a low draught or a high beam-to-draught relation is wanted, the twin-skeg concept is advantageous. The major advantages of twin-skeg afterbodies can in general terms be described as follows.

– Lower propeller loads by using two propellers give increased propeller efficiency and decreased pressure pulses and vibrations (partly caused by less cavitation).
– Increased manoeuvrability by use of two rudders.
– Lower fuel consumption. For a full hull form, the twin-skeg design shows on an average 6% lower power consumption than a corresponding conventional single screw ship, and in some cases much lower. A comparison with conventional twin-screw ships shows even better figures.
– By placing the engines partly in the skegs, shorter engine room or longer cargo hold can be achieved. Completely separate engine rooms can be arranged improving the redundancy.
– Improved course-keeping stability.
– The skegs allow a more aft located centre of gravity, which enables a slenderer forebody.

The only disadvantage that could be mentioned compared with a conventional single-screw design is the costs due to a more complicated construction, double engines and higher steel weight.

The development of the ARCO tanker

Lars T. Gustafsson, Project Manager for the ARCO project, received his Master of Science in Naval Architecture at Chalmers University of Technology in 1993. After graduation he participated in a one-year job rotation programme and joined SSPA in 1994. He has mainly been working with model tests and CFD calculations and is from Jan. 1999 Marketing Manager at Ship Hydrodynamics Division.

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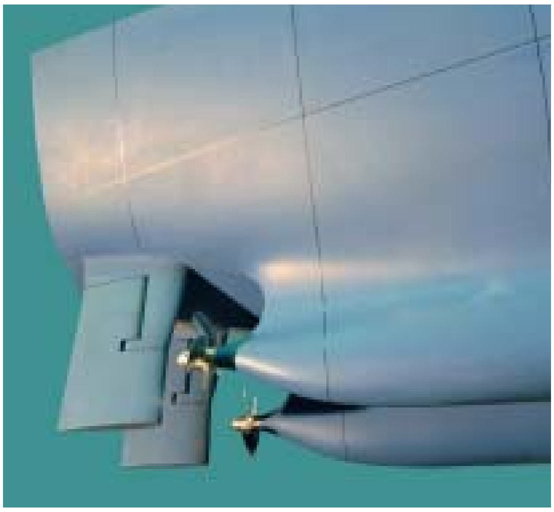
All efforts have been made in developing the ARCO Millennium Class tankers. The extensive analysis programme included testing in all SSPA's facilities, and from the results, predictions could be made showing very good overall efficiency, good course keeping stability, extraordinarily good manoeuvrability and low propeller induced pressure pulses.

Optimising the hull

CFD calculations were initially performed with the SHIPFLOW code for one hull form designed by SSPA and one hull form provided by the customer, which were both found to be of good design. After carefully viewing the results, the SSPA hull form was chosen due to smaller static and dynamic wetted surface, smoother pressure distribution in the forebody, lower wave heights along the hull side and smaller pressure difference between the inside and outside of the skegs. The SSPA hull was then further refined using information from pressure, speed and streamline plots.

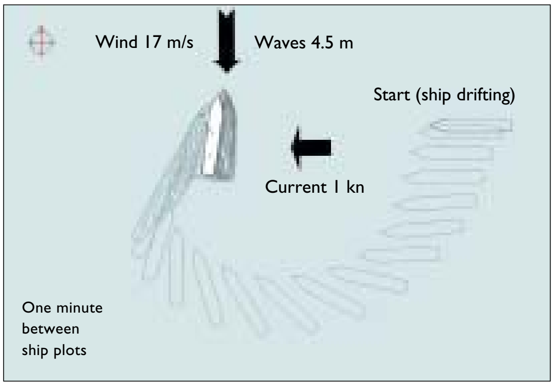
An initial manoeuvring study was performed in order to determine the rudder type and size, and bow thruster power. It was decided to use oversized conventional semi-spade rudders instead of any type of high-lift rudders. The rudder area was chosen to be 3.66 % of the lateral submerged hull area as compared with the DNV requirements of 2.02 %. The oversized Mariner rudders are expected to give excellent manoeuvring combined with the benefits of lower cost and easier maintenance.



The tested hull form was compared with other twin-skeg tankers of similar dimensions and fullness stored in the SSPA database. The present hull was found to be significantly better than average regarding both resistance and propulsive power.

Test	IMO requirements	Normal operation	Single screw/rudder port/stb.
Advance/Lpp	4.5	2.87	2.90/4.32
Tactical diameter/Lpp	5.0	3.11	3.16/4.62
10/10, 1st overshoot (deg.)	20	6.0	8.7/7.7
10/10, 2nd overshoot (deg.)	35	10.4	18.4/18.7
20/20, 1st overshoot (deg.)	25	12.6	19.6/10.7
20/20, 2nd overshoot (deg.)	n/a	15.7	17.4/27.0

The compliance with the IMO manoeuvring requirements was checked and showed that the tanker meets the requirements even with a propeller/rudder failure with the failed rudder to 45 degrees hard over.



In order to check the compliance with the ABS R2-S+ redundancy requirements, simulations including wind, wave drift forces and first order wave motions were performed with a single propeller and rudder working, trying to maintain position. Compliance with the requirements was achieved without any help from the bow thruster.

Verification in the towing tank

The computer optimised hull form was tested in the towing tank where resistance, self propulsion and wake tests at two drafts were followed by a paint flow test. The hull form was found to be significantly better than average regarding both resistance and propulsive power. However, the wake tests showed negative values in the lower part at inner radii. Minor modifications were introduced in the stern to improve the wake and reduce the flat surfaces at the stern that may have been vulnerable to slamming from following seas while in ballast. The hull form was then fully re-tested, verifying that all objectives were achieved.

Propeller design and cavitation testing

SSPA designed a first set of propellers, which later served as design benchmarks for the propeller vendor regarding propulsive qualities, as well as cavitation pattern and pressure pulses. The SSPA design propellers worked well in both loaded and ballast conditions and showed a 4 % lower delivered power demand than the stock propeller.

Cavitation tunnel tests were performed in SSPA's large cavitation tunnel, where the propellers work behind the complete ship model. Pressure pulse measurements and cavitation tests were performed with the SSPA design propellers. Two loading conditions, considered as the worst possible realistic cases, were tested representing design and ballast draft with 70 % sea margin. Despite the severe loading conditions, the pressure pulses at blade frequency were rather low, and the predicted vibration velocity complied with the ISO6954 norm as fully acceptable. Performance with the vendor's propellers was also verified.

Survival tests were carried out in head seas with a significant wave height of 13 m (Jonswap spectrum) at a forward speed of 5 knots. The high forecastle and flare at the forebody was suitably shaped to keep the deck dry in all conditions tested except for the severe storm in head seas where, not surprisingly, bottom slamming also occurred.

Wind tunnel tests

In order to study the wind loads and examine the exhaust gas dispersal from tank ventilators and stacks, wind tunnel tests were conducted. Air intake locations to accommodation and engine rooms were also considered. Different stack and pipe arrangements were tested and, among others, it was found that exhaust pipes angled astern raised the plume higher than straight pipes did. Introducing deflectors on the top of the navigation house reduced the amount of exhaust gases from the stack noticed on poop deck.

Excellent manoeuvring

A second, smaller model of the final hull lines was prepared for the manoeuvring and seakeeping tests. Free sailing manoeuvring tests were conducted for various load cases and speeds. Extensive captive tests were also performed with the self propulsion model fitted with a working model of the bow tunnel thruster and movable rudders. With this model configuration, propeller un-symmetry tests with one propeller/rudder failure, crabbing force measurement and bow thruster efficiency tests were performed.

With data from the free sailing, crabbing and wind tunnel tests the simulation model was considerably improved and ordinary manoeuvring tests as well as different failure modes could be simulated.

The ABS R2-S+ redundancy requirements state that the ship, after a single failure, shall withstand adverse weather conditions without drifting. Hence it should be possible to maintain position in all weather conditions up to a wind of 17 m/s and a significant wave height of 4.5 meters. With one propeller and one rudder failure, the rudder fixed at port 45 degrees, the simulation showed that the vessels will comply with the requirements.

The ship in waves

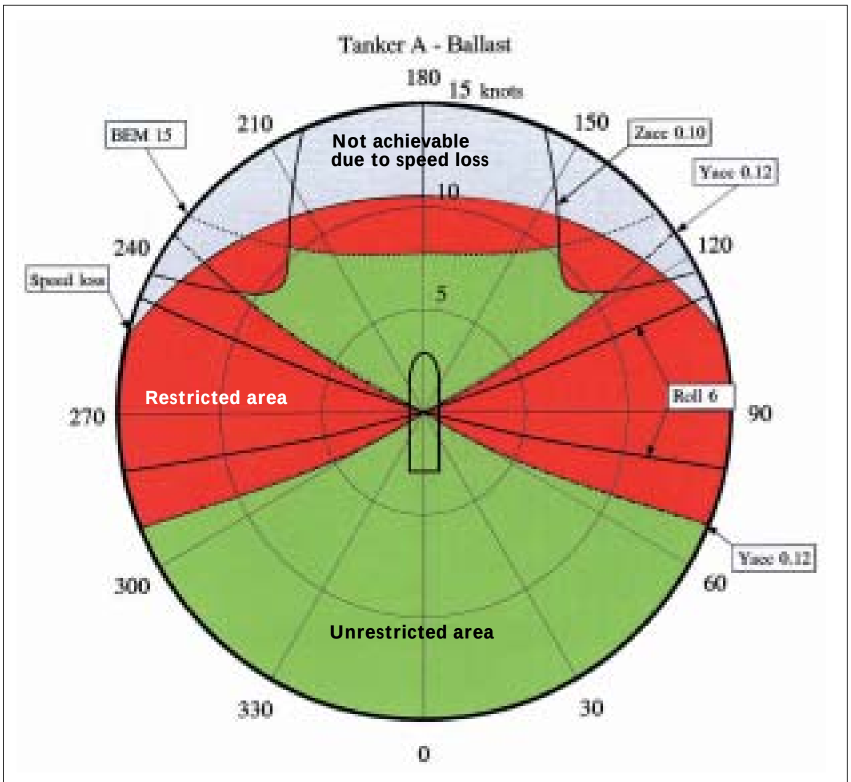
The key objectives of the seakeeping programme were to measure and observe the seakeeping performance to determine the operability in seas characterised by a 5.5 m significant wave height and to verify survivability behaviour in head seas characterised by a 13 m significant wave height.

It was also important to collect data that would be useful in verifying analytical tools to be used for operability analysis and ship structural design. Seakeeping tests were performed in regular as well as irregular waves, the latter with two wave spectra generated simultaneously and perpendicular to each other.

Sailing the year 2000

After a year of extensive testing all expectations were met. The first ship will be launched in 1999 and will be delivered during 2000. SSPA now looks forward to working in the evaluation of a most extensive sea trial programme.

Lars T. Gustafsson



To provide the masters with guidance and relevant data to facilitate decisions leading to an optimum ship operation in different weather conditions, an operability analysis was made. The analysis is based on results from model tests and theoretical calculations of wave induced motions, accelerations and vertical bending moment amidships and assumed criteria for operation.

BEM=Bow emergence each 3rd minute
Roll 6=Roll angle exceeds 6 deg. (rms)
Zacc 0.10=Vert. acc. at FP exceeds 0.10g (rms)
Yacc 0.12=Lat. acc. at bridge exceeds 0.12g (rms)
VBM 115=Vert. bend. mom. exceeds 115 000 tonm (rms)

Tanker safety and oil spills

Björn Forsman, Project Manager, M. Sc. in Mechanical Engineering, graduated from Chalmers University of Technology in 1979. In 1980 he joined SSPA where he has worked with development of oil spill recovery equipment, arctic offshore engineering, model testing and simulation of ship manoeuvring, and been responsible for leading and co-ordinating commercial projects in the area of marine environment. He has also been programme manager for a number of advanced international and regional training programmes on Coastal and Marine Environment Pollution Prevention and Maritime Safety Management.
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Right now about 100 million tonnes of crude oil and oil products are under transportation by ship over the oceans. Most of it in safe ships with skilled crew under competent management. But still a few of the ships are in doubtful condition and do not comply with today's standards of safety and thus impose threats to the lives of their crew and to the environment. Significant improvements have been gained by international co-operation, and oil spill statistics over the past few decades indicate some positive trends, but there is more to be done.

The environmental threats

Accident statistics over the past 25 years show a significant reduction in the number of large-scale oil spills. A clear drop is recorded from about 1980 for spills over 700 tonnes. This coincides with the introduction of the MARPOL 73/78 convention, but also with a drop in the total transported oil volumes.

Major oil spill accidents may cause severe local impacts and contaminate hundreds of kilometres of shoreline, but we must not forget that the large number of small-scale spills also constitute serious environmental threats in many areas. If the spill size interval is extended to include also small-scale, so called operational spills, the figures do not demonstrate a clear-cut decrease. Even though many of the provisions of MARPOL are aimed at reducing and regulating all operational discharges of oil and oil contaminated water, illegal operational spills are still frequently reported. Along the Swedish coast, for example, the operational spills are a regular nuisance, killing thousands of birds every year and costing large amounts for clean-up.

What has been done to reduce the number of accidents?

Analyses of the reasons behind tanker accidents often end up in a chain of causes involving aspects frequently attributed to human element. This was recognised as a key factor, when the International Maritime Organization, IMO outlined the ISM (International Safety Management) Code and the new 1995 amendments to the STCW convention (Standards of Training, Certification and Watchkeeping). The ISM Code became mandatory for all tankers in July 1998, and the STCW 95 is also effective from 1998. The flag states have the responsibility that the certificates are more than only papers and signatures and some flagrant non-conformities have been reported. More and more of the flag state responsibilities are today delegated to the classification societies and of course the societies also have an important role in the implementation of the new safety regimes.

Most of the tanker accidents occur in confined waters and often only a close to or at the loading/unloading terminals. This highlights the importance of the ship – port interface with its navigational conditions and supporting tug , pilotage and VTS services. The increasing use of simulators for training of masters and pilots and for reconstruction and design of safe fairways and adequate navigational aids also contributes to enhanced safety.

Together, the new legal regimes and other measures initiated by the increased awareness and technical advances have most likely reduced the risks of tanker accidents significantly

Further safety enhancement

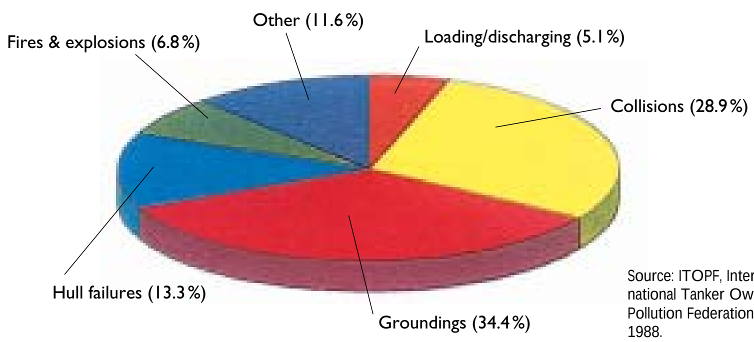
Even if tanker safety has improved a lot over the past few years, accident risks are not eliminated and the fundamental concept must be to consider all our common safety

Environmental impact from single hull oil tankers

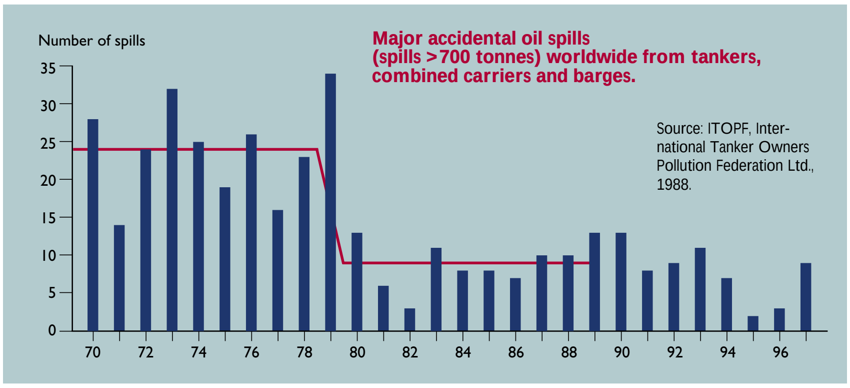
The European Commission, DG VII Transport, has awarded a contract to SSPA to carry out a study on the environmental impact of single hull oil tankers. Accidental and operational risks for oil spills will be compared for single hulled pre-MARPOL tankers versus tankers built with protectively located segregated ballast tanks or double hull. The output of this comparative risk study will provide the Commission with data defining the character of the risks and proposals on possible adequate measures for risk reduction. The study is based on a Formal Safety Assessment approach and IMO's guidelines for FSA in the rulemaking process is used in applicable parts. The study will be completed in mid 1999.

Relative relations of the causes for tanker accidents with large-scale oil spills. Groundings and collisions are generally the dominating causes for tanker accident with large oil spills. For small spills, the causes are most frequently attributed to cargo handling operations. Consequently, both large and small spills most likely occur near the ports or in coastal areas with limited depth and dense traffic.

Accidental spills <700 tonnes, 1974–1997



Source: ITOPF, International Tanker Owners Pollution Federation Ltd., 1988.



Number of large oil spills per year. The number of large scale accidents has been constant from the early 80's even though the total transported quantities have increased during this period.

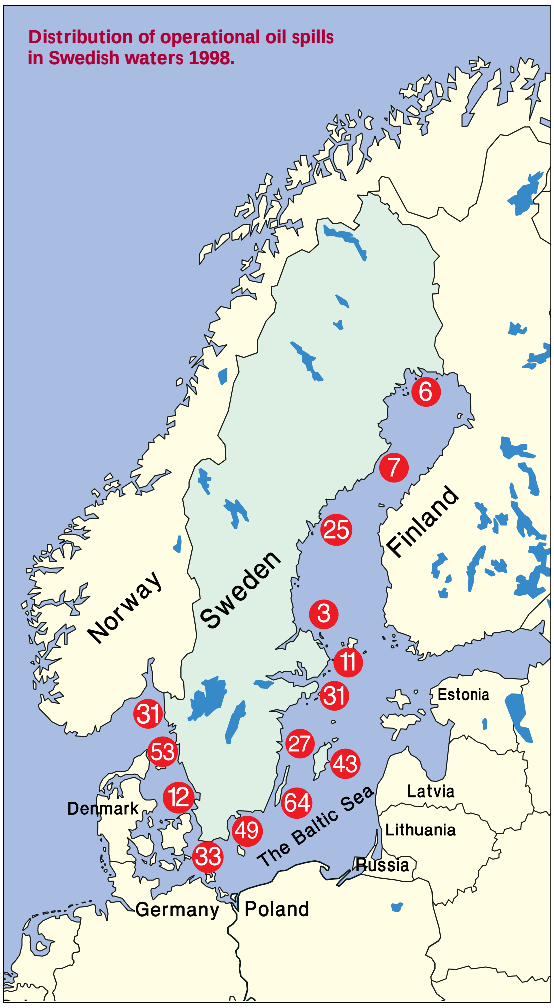
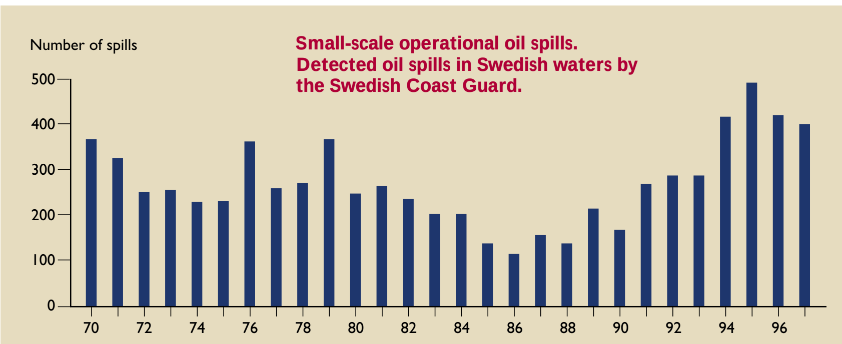
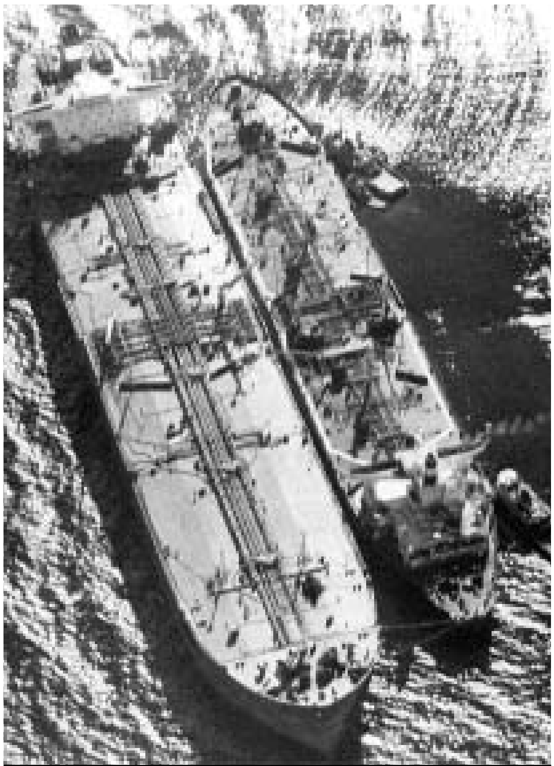


Diagram and map of the Baltic Sea indicating the number and distribution of operational oil spills in Swedish waters. Most of the recorded spills are small (90 % < 1 ton) and even if the polluters only on rare occasions are identified, it is considered that most of the spills origin from the discharge of bilge water and engine room waste. There are no indications that tanker vessels should be over represented. None of the spills in 1998 are referred to known accidents and all operational discharge of oil is prohibited in the area. Source: Swedish Coast Guard 1999.





Is this risk lower today than ten years ago?

In March 1989, the tanker Exxon Valdez ran aground on Bligh Reef, spilling large amounts of oil into the Prince William Sound, Alaska. PHOTO: PRESSENS BILD

efforts as a continuous process of enhancements. The authorities have adopted the proactive principles and the tanker industry is committed to implement the safety culture onboard as well as on shore. Also in the present situation with tough competition in the tanker market, safety and environment aspects become increasingly important competitive factors, and the prospects are good that sub-standard tanker tonnage will be pushed out of market.

The safety process for the next generation of tankers starts at the design office and is completed by a competent management and it involves a wide range of technical, environmental and operational aspects. The article on the previous pages highlights some aspects considered of primary interest by ARCO Marine and where SSPA's services were utilised to find adequate solutions. Over the past few years, SSPA has widened the scope of safety-related services, and today we offer tanker designers and operators services spanning from traditional hydrodynamic predictions to safety assessments and reliability analyses.

Maritime administrations and international organisations also increasingly engage SSPA's Consulting Division and SSPA Research for studies and analyses in the maritime safety sector. Our combined experience, from authorities and operators, ensure that we are well familiarised with the use of tools like FSA both in the rule making process and in the proactive ISM compliance process.

Björn Forsman

Short comments

Royal visit to ICZM seminar in Mozambique

His Royal Majesty the King of Sweden, CarlXVI Gustaf, visited SSPA's Regional follow-up seminar on Integrated Coastal Zone Management, held in Maputo, Mozambique, 2–13 November, 1998. The Swedish King's personal interest in coastal and marine environment protection is well documented and appreciated. During a State Visit to Mozambique, King Carl Gustaf together with the honourable Mozambiquean Minister of Environmental Action Coordination, Mr Bernardo Pedro Ferraz, actively participated in the seminar. Items like coastal erosion and coral reef protection were discussed during the visit.

The aim of the seminar was to broaden the perspectives and knowledge in the field of Integrated Coastal Zone Management. Former participants of the programmes on Coastal and Marine Environment Pollution Prevention, arranged by SSPA and funded by Sida (Swedish International Development Agency), were invited to the seminar together with other professionals in eastern and southern Africa. Totally, 24 delegates from 6 countries participated. The seminar, which also included a study visit to the Inhaca Island, was well supported by the local partner SEACAM. SSPA´s experts Mr Tim Greenhow and Mr Sixten Larsson headed the lecture team, which included also Dr Olof Lindén from Sweden and Dr Neil Malan, Deputy Director, Coastal Management, Dept of Environmental Affairs and Tourism in South Africa, among others.

Jim Sandkvist

Jim Sandkvist, Head of Consulting Division, SSPA (to the right) is here delivering information about the seminar to HRM King Carl XVI Gustaf and President Joaquim Chissano, (to the left) during the State Visit of the King and Queen of Sweden.

More twin-skeg testing at SSPA

Daewoo has performed model tests at SSPA for a 850,000 dwt twin-skeg Shuttle Tanker for British Petroleum. The vessel will be used by BP in the transportation of crude oil from the Schiehallion field west of Shetland to terminals in the North Sea basin.

The environmental forces are greater than in many other offshore fields, why specific requirements for good Dynamic Positioning (DP) operation were needed. The risk of slamming and green water on deck were some other specifically interesting topics to study in the extensive test programme, which consists of towing tank, cavitation tunnel, manoeuvring, seakeeping, DP and wind tunnel tests.

An article in a coming Highlights will present the model test programme and performance more comprehensively.

Hasse Olofsson

The BP Tanker Loch Rannoch will be exposed to extreme weather conditions. Not often does the sea be as calm as in this photo from the trial tests.

Long-term environmental effects from oil spills and clean-up operations

SSPA has been commissioned by the Swedish Rescue Service Board to investigate the long-term environmental effects from oil spills and clean-up operations.

The reason for and background of this project is the discussion about using soft methods instead of using traditional methods for clean-up operations. The investigation aims at giving an answer to the question whether more damage could be done to the environment during a traditional clean-up operation compared with soft methods or "no-action" alternatives.

An important part of the project is to compile the latest available information about bioremediation and biodegradation as a soft clean-up method. Another important part of the project is to suggest guidelines for clean-up strategies, as a tool for decision-makers in the local community.

Experience from national and international clean-up operations is also presented as well as available literature and documentation focusing on the topic.

Per Danielsson

New version of SIMNON

A new version, 3.0, of the software program SIMNON has recently been released by SSPA: SIMNON is a world-wide spread simulation tool, used by over 4000 people, both at universities and in the industry.

SSPA now looks forward to the market's response, not only on the features but also on the very competitive price, which for a single version is set to 99 Euro.

More information about SIMNON 3.0 is available on SIMNON's home page www.sspa.se/simnon, where a demo can be downloaded and orders can be placed.

Karl-Johan Raggl

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