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SYSTEM OF PREVENTING MARINE ENVIRONMENT POLLUTION FROM DAMAGED TANKERS

Abstract: Tanker casualties that happen from time to time in the world cause serious environment with disastrous effects. Baltic Sea being closed sea is particularly vulnerable to such casualties, and if it happens the whole life in the sea could be destroyed. Risk of tanker casualty in the Baltic Sea is rather high. It is essential to be prepared for such a casualty and a system of salvage operation should be developed that may be used in case of emergency. The paper describes proposal of the lay-out of such system and summarizes important problems that are relevant for development of particular tasks related to the system. Currently the system is under consideration by the Foundation and actually one of its important elements, methodology of prediction of the path of damaged tanker has been already developed. This is described in more detail.
Keywords: Tanker casualties, drift of ships, marine pollution

1. INTRODUCTION

From time to time the public opinion is shocked by the information that somewhere in the world there was serious shipping accident where damaged large crude oil tanker caused disastrous pollution of the sea environment. In consequence hundreds kilometers of the seaside were polluted and were of no use for tourism, recreation and for fishery, sea life was damaged for a long time and resulting cost of recovery was counted in hundreds of millions of US dollars. The first catastrophic disaster happened in 1967 where large tanker TORREY CANYON went aground in the British Channel spilling more than hundred thousand tons of oil polluting large length of shoreline caused strong reaction of the International Maritime Organization (UN agency) and maritime authorities. New international design rules for tankers were hastily drafted and more stringent safety requirements agreed upon.

2. IMPORTANT OIL SPILLS AND LESSONS LEARNED

The first serious tanker casualty that happened in European waters happened in 1967 when the supertanker Torrey Canyon because of the master fault hit the Seven Stone rocks near the Scilly Island, the hull of the tanker was ruptured and spilled oil caused the most serious ecological disaster. Several other serious tanker casualties happened in the years 1967 to 1977 as shown in the table 1 and the casualties stirred public opinion and maritime authorities and as a result extraordinary conference was organized by the International Maritime Organization (IMO) in 1978 that adopted Protocol to SOLAS and MARPOL Conventions that included important amendments to those conventions related to tanker safety (IMO 1978). New international design rules for tankers were hastily drafted and more stringent safety requirements agreed upon

This conference almost coincided with the most serious disaster of the tanker AMOCO CADIZ in 1978 close to shores of Normandy that was caused by rudder gear failure and resulting drifting of the disabled ship towards the rocks where the hull was eventually split into two parts and more than 200 000 tons of oil transported spilled into the sea.

In spite of enhanced international safety rules adopted regarding construction of tankers during the last period, where double hull, segregated ballasts, duplicated rudder gear amongst other measures are required, tanker casualties happen with resulting oil spill, sometimes as large as more than hundred thousands tons. The most serious tanker casualties that happened during the years 1967 to 2008 are shown in the table 1.

Table 1.

Most serious pollution from tankers in the years 1967-2004

Month/Year	Ship's name	Place	Oil spill/sunk ($t \cdot 10^3$)
03/1967	Torrey Canyon	Scilly Isles	119
01/1977	Nakhodka	Japan Sea	6
03.1978	Amoco Cadiz	Brittany, France	223
11.1979	Independent	Bosphorus	95
07.1979	Atlantic Express	Tobago, West Indies	287
08.1983	Castillo de Bellveder	South Africa	252
03/1989	Exxcon Valdez	Alaska	37
05/1991	ABT Summer	Angola	260
02/1996	Sea Empress	Milford Haven	72
12/1999	Erika	Brittany, France	20
11/2002	Prestige	Galicia, Spain	76
11/2003	Tasman Spirit	Karachi, Pakistan	28
12/2007	Hebei Spirit	South Korea	10.5

The most often causes of tanker disasters are collisions with other ships, groundings on the rocks and hull breaking.

Casualties of the Russian tanker NAKHODKA in 1997 that was broken into two parts in Japan sea, of the tanker ERIKA in1999 that was also broken into two parts near Brest and in particular of the tanker PRESTIGE in 2002 in the Atlantic Ocean close to Spain, where attempts to tow the disabled ship failed and during the stormy weather the ship was broken down in the middle as shown in fig. 1, spilling oil and causing the most severe pollution of the Spanish coast, stirred public opinion and the authorities were under pressure to react.

The consequences of such large oil spills are disastrous for the sea life (birds, animals and fish) for the economy (fishery, tourism, recreation) and cleaning operations costs usually many millions euro.

Understanding that such disasters, in spite of prohibitive measures that are taken, are unavoidable, people realized that it would be necessary to develop a system to prevent or mitigate consequences caused by spilled oil if such casualty happens. This was done for the first time after the NAKHODKA disaster, where in Japan important project of this type was installed under the leadership of professor Hara. This was reported in several places, e.g. (Hara 2000; Hara et al 2004). Attempts to develop certain tools designed to help the salvage organization to deal with the consequences if similar disasters were undertaken after the ERICA and PRESTIGE disasters.

Baltic Sea is a closed sea particularly vulnerable to pollution. If disaster of a large tanker, such as described above, happens in the Baltic the results would be catastrophic to the countries surrounding Baltic Sea. In the extreme case the whole life in the Baltic might be destroyed and the beaches made unusable for the long time. Fortunately, such disaster did not happened yet, but the risk that it may happen in future is rather high because in Baltic Sea there is dense sea traffic and about 55 000 ships pass the Danish Strait every year, with 6 000 of them being large or medium size tankers carrying dangerous goods.

Fig.1. Damaged tanker Prestige drifting in the Atlantic Ocean

More than 50 ferry routes cross the Baltic Sea. Collision and grounding may easily happen. Some indication what may happen was shown in December 2009, when bunker ship ROMANKA lost manoeuvrability, drifted towards the Latvian coast and grounded. The ship was without cargo and on the sandy beach hull was not ruptured (Anonym 2009).

It is extremely important to be well prepared for the possibility such accident may happen. The stock phrase “Pole is wise after harm is done” must not be true. International safety requirement related to the construction of tankers reduce risk of pollution even if the ship is damaged, but they do not eliminate the risk completely, in particular because serious pollution was often the result of negligence, incapacity and inefficiency of salvage companies. Therefore it is essential to develop a system for prevention of pollution the sea and coast from damaged tankers

3. THE ENVIRONMENT POLLUTION MITIGATION SYSTEM FROM DAMAGED TANKERS (EPM System)

The system developed by Japanese (Hara et al 2004) was the result of 5 years project installed after NAKHODKA disaster and was named Optimum Towing Support System (OTSS). Unfortunately, only short publications that include description of the system and some results of the model test of damaged tankers are available, and access to the system that is owned by Japanese authorities is not possible. Moreover the system is geared to the local conditions in Japan and model tests comprise damage cases that do not include cases that happened in PRESTGE or ERIKA casualties.

The system developed should be for use in the Baltic, therefore is should be tailored to local conditions. It should take into consideration types and sizes of tankers operating on Baltic routes and local environmental conditions. The cost/benefit consideration of developing such a system poses also an important problem. Therefore the system should made use of the Japanese experience, but will not necessarily be modeled in the same way.

In order to accomplish aims of the EPM system the following tasks have to be undertaken:

Task 1: Identification of the condition and important parameters of the disabled ship

Task 2: Identification and prediction of the hydro-meteorological condition in the area of casualty

Task 3: Prediction of the path of drifting damaged vessel

Task 4: Developing of the optimum towing system of the damaged vessel to the safe place

Task 5: Developing optimum system of containment of the pollution and removal spilled oil.

Task 6: Developing user friendly fast computer code for the use of salvage organization'

The important element of the system is prediction of the path of damaged ship drifting under he action of wind, wave forces and sea current (Task 3). This task has been actually completed. It is very important to know, even approximately, predicted position of the damaged ship in order to reach this position by salvage ships as soon as possible.

Task 1 comprises tools for identification of the most important parameters of the damaged ship that may be used for further calculations, first of all for prediction of drift path. As a rule, when the information about the casualty reaches salvage coordination centre, only approximate condition and few parameters of the disabled ship will be known. Having available those data all relevant data for calculations to be performed within the system must be estimated. This is an important task and the methods employed may use neural network based on statistical data for a population of tankers.

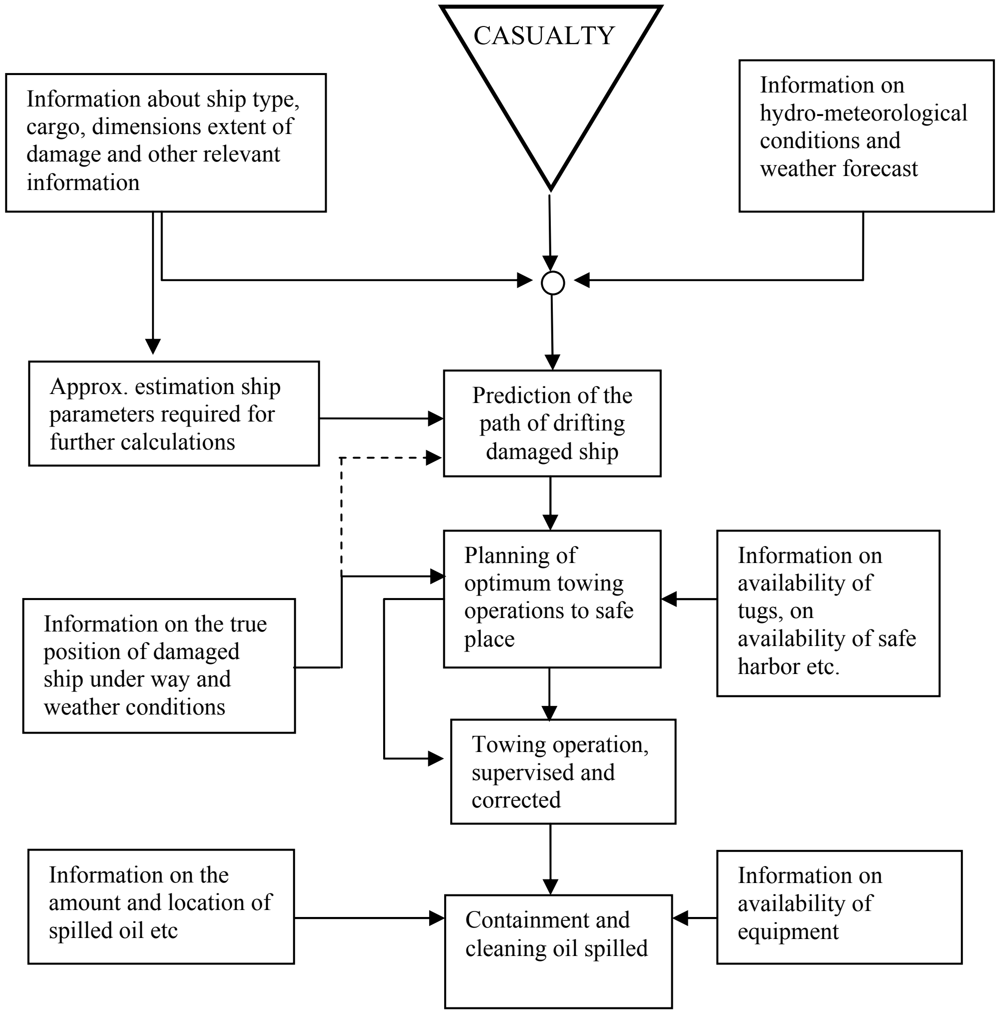

Fig.2. Block diagram of the EPM system

Developing of an optimum towing system of damaged tanker (Task 4) is now under consideration. For his purpose it would be necessary to estimate forces required to tow the ship in different weather conditions and the method of towing in order not to lose the ship. Large model of damaged ship may be used for this purpose.

Task 5 requires expertise of salvage organization having experience in performing cleaning and containment operations of oil spilled at sea. Salvage organization must have also available fast reliable and user friendly computer code (Task 6)helping in organization of salvage operation that will include all previously mentioned tasks.

4. CURRENT WORK ON THE SYSTEM – PREDICTION OF PATH OF DAMAGED VESSEL

From the tasks mentioned above, task 3 is virtually completed and the results are published elsewhere (Kobylinski et al 2010). The methodology of prediction path of drifting damaged tanker was developed. The method is based on hydrodynamic model of drifting ship under action of forces of wind, waves, hydrodynamic forces acting on the submerged portion of the hull and Coriolis forces. The available data (Dand 1981) as well as preliminary model test did show that the drifting path of the ship without propulsion consists of two parts: short initial part where the dynamically acting external forces cause the ship drifting and rotating until it reaches quasi-static equilibrium position and further part where the ship is drifting in the quasi static position as long as external conditions did not change. As observations of the behaviour of real ship show, the initial part is counted in term of minutes rather than hours (US Coast Guard) and from the point of view of path prediction on long term could be neglected. Obviously, when external conditions change, the new equilibrium position should be taken. Bearing that in mind prediction of the path of drifting ship could be calculated the path.

Because changes of the environmental conditions are rather slow, and their periods are much greater than period of yaw then in the short period of time those conditions may be assumed as stationary (Dand 1981a, Dand & Read 1981). When they change, the ship after short transitional period reaches another stationary situation. Thus the drifting path could be divided in a number stationary situations and in each of them the equations (1) could be applied. Adoption of this assumption simplified the calculations apparently without any loss of accuracy and the computer code for calculation of predicted path was developed on this basis.

As there are no data available on the hydrodynamic forces and wave forces acting on drifting damaged ship, model tests were performed in order to estimate those forces. Model test were carried on in the towing tank owned by the Technical University of Gdansk of the dimensions: length L=30.00m, breadth B = 3.00m and depth h=1.5m. Model of the dimension suitable to the size of the towing tank of the tanker chosen was made in the scale 1:150. Model was divided in several compartments and prepared to be tested in four different damage states:

1. Model not damaged, in intact condition
2. Model with flooded forward tanks, trimmed to the bow, the bow submerged
3. Model broken down in the middle, both parts still holding together
4. Stern part of the model separated, floating vertically

The computer code developed used hydrodynamic coefficients and wave force coefficients for damaged ship estimated in this way, whether wind force and the effect of current were calculated in the traditional way. The results of calculations were verified by model tests of drift behavior of the large model (8 m long) of damaged tanker on lake Jeziorak (fig 3). Measured (dotted line) and calculated (solid line) drift track for one condition of the model is shown in fig 4. It shows that the computer code predicts track of the drifting model with reasonable accuracy. More information could be found in the paper by Kobyliński et al (2009).

Fig. 3. Drifting model broken in the middle during drift tests

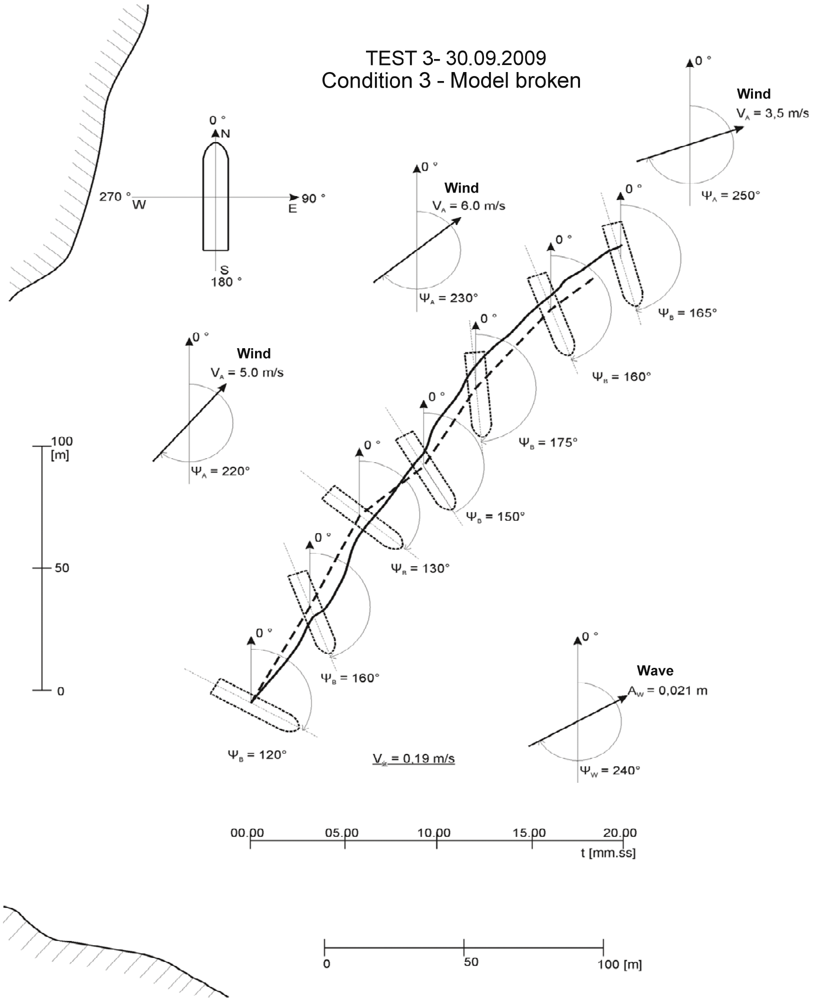

Fig. 4. Predicted and measured track of damaged tanker model

5. CONCLUSIONS

It is imperative that EPM system must be prepared, otherwise in case of tanker casualty in Baltic effects may be disastrous. Development of the system is realistic but it requires cooperation of scientific institutions salvage organizations, meteorological service and others.

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SYSTEM ZAPOBIEGANIA ZANIECZYSZCZENIU MORZA PRZEZ USZKODZONE ZBIORNIKOWCE

Streszczenie: Katastrofy zbiornikowców zdarzające sie od czasu do czasu na świecie powodują ogromne zanieczyszczenie środowiska morskiego. Morze Bałtyckie, jako morze zamknięte jest szczególnie narażone na skutki takich wypadków. Ryzyko katastrofy zbiornikowca na Bałtyku jest znaczne. Istotne jest aby służby ratownicze były dobrze przygotowane na wypadek takiej katastrofy i należy w tym celu przygotować odpowiedni system operacyjny dla tych służb. W referacie zaproponowano projekt takiego systemu i omówiono istotne problemy związane z jego realizacją. Obecnie system taki jest rozważany w Fundacji i prace nad jednym z ważnych elementów tego systemu, metodologią przewidywania drogi dryfującego uszkodzonego statku zostały zakończone.

Słowa kluczowe: katastrofy zbiornikowców, dryf statku, zanieczyszczenie morza