CRITICAL REVIEW OF AFRAMAX TANKERS INCIDENTS

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ABSTRACT

The paper presents detailed results of a comprehensive analysis pertaining to AFRAMAX tanker incidents occurred in the last 25 years, enabling a thorough review of accidental database information, the identification of significant trends with respect to the impact of ship design, of human and a variety of other factors and the drawing of conclusions on AFRAMAX tanker incidents and of tankers in general, for further exploitation.

1. Introduction

A rational database of AFRAMAX tankers was set up in the framework of the EU funded project POP&C [1] to enable the full exploitation of the raw incidental data compiled and which was commercially available by Lloyd’s Marine Information Service (LMIS) [2]. The textual information presented in the incidental data were re-analysed by a team of the POP&C project partners and were introduced in the newly developed database to produce appropriate incidental statistics.

The analysis was mainly focused on six major incident/accident categories, namely Non-Accidental Structural Failure, Collision, Contact, Grounding, Fire, and Explosion. Whilst, on one hand, the analysis made an attempt to identify basic events leading to these major casualty categories, on the other hand, factors related to consequences such as the degree of incidents’ severity, event location and ship operating condition at the time of incident, loss of watertight integrity, weather impact, loss of life/injury, oil spill occurrence and the final outcome of incidents were also investigated.

2. Marine Accidents

Although the ship appears by statistics to be the safest mode of transportation, marine incidents always happened and will continue to. The prime concern of ship safety is not to totally eliminate the incidents/accidents, because the probability of occurrence always exists, but to minimise the probability of occurrence and to mitigate the serious consequences of an incident/accident. Investigations into some tragic tanker and other ship accidents have provided an in-depth knowledge and experience to change the safety regime in the past years. Significant outcomes of some catastrophic casualties that were investigated, led to improvements of IMO’s regulatory framework and eventually of marine safety and operation.

As far as the Tanker Fleet is concerned, some serious casualties led to the adoption of new regulations or/and amendments of the existing ones. Some spectacular tanker casualties are stated below:
The grounding of “Torrey Canyon”, in 1967, led to the biggest marine pollution in history at that time. The results of this investigation contributed to MARPOL 1973, STCW 1978 and SOLAS 1974 (fire safety provisions for tankers).

The grounding of “Argo Merchant”, in 1976, contributed to the development of Protocol 1978 of MARPOL.

The grounding of “Amoco Cadiz”, in 1978, led to the implementation of MARPOL 1978 Protocol.

The “Exxon Valdez” casualty, in 1989, led to the adoption of the first regional agreement (application in US waters), OPA 90.

The “Erika” disaster, in 1999, contributed to the revision of MARPOL 73/78 (Reg. 13G) which regulated a new phase-out for single hull tankers (MEPC - IMO). Furthermore, this particular accident led the European Union to the adoption of the ERIKA I and ERIKA II EU Marine Resolutions.

Following the “Prestige” accident in 2002, the European Union adopted Regulation 1726/2003 (accelerated single hull tanker phase-out, carriage of heavy grade oils in double hull tankers, enhanced hull condition assessment). This regulation took effect within EU on 21 October 2003. The IMO’s Marine Environment Protection Committee (MEPC) adopted amendments to Regulation 13G and produced Regulation 13H to Annex I of MARPOL on 4 December 2003 [Resolution MEPC.111(50) and Resolution MEPC.112(50)].

3. Methodology of work

3.1 Source of Data

The basic information was a comprehensive set of incidental records, provided by INTERTANKO [3] who had originally obtained most of this data from LMIS Ltd [2], concerning all subtypes and sizes of tankers and covering the period 1978 to early 2004.

Since the POP&C project has used the AFRAMAX size tankers to demonstrate the applicability of the developed risk based methodology, the analysis of past incidents was also focused on records pertaining to AFRAMAX tankers. The selection of the particular tanker ship size, namely AFRAMAX, was based on DWT size segment 80,000 – 119,999. In addition to the size, the basic AFRAMAX subtypes were also selected, namely Oil Tankers, Crude Tankers, Shuttle Tankers, Product Carriers and Chemical/Oil Tankers. OBOs and chemical tankers were excluded from the analysis since these tanker subtypes have special design features and layout, which are not representative of the whole AFRAMAX class of tankers. Out of all the available records, 1294 incident records were finally extracted with respect to size and particular tanker subtypes covering the period 1978 to early 2004.

The existing information of the initial records covered the followings:

- Ship basic characteristics (LR/IMO Number, Ship Name, Ship Type, Built Year and DWT)
- Type of incident according to LMIS coding, namely “Hull & Machinery”, “Collision”, “Grounding”, “Fire/Explosion” and “Miscellaneous”.
- Year and Location (MARSDEN grid) of incidents’ occurrence.
- Degree of severity of each incident, according to LMIS coding.
- Basic information concerning environmental pollution (quantity and units).
- Number of killed and missing persons and the case of Dead ship condition.
- Complementary texts with raw description of the incident concerning the causes, the ship operating condition at the time of incident, the location, environmental pollution and the outcome of the incident concerning the resulting ship’s condition.
3.2 POP&C Database

The initial selected records were imported into a database designed by NTUA-SDL to enable a comprehensive analysis of the data. The POP&C Tanker Incidents Database has been set-up in MS ACCESS 2000 format and can run at any PC computer employing MS Office 2000 (or later versions) [4].

The database was further developed in order to register the information of the complementary texts in a proper manner (using checklists, pull-down menus, etc.) so that the information could be easily retrieved and systematically analysed. The registered information was constructed such that the POP&C Risk Contribution Fault Trees (FTs) and Event Trees (ETs) developed by the project could be populated partially or completely. Synoptically, the following considerations were included into the new version:

- New major categories of incident types were predefined, namely: Non-Accidental Structural Failure, Collision, Contact, Grounding, Fire, Explosion, Failure of Hull Fittings, Machinery Failure and Unknown Reasons.
- Each incident category was further described by subcategories or/and descriptions of causes and exact ship’s location. Basically, the following considerations were defined in order to follow the POP&C Risk Contribution Fault-Trees.
  1. Non-Accidental Structural Failure occurrence: due to “Structural degradation”, due to “poor design/construction” or due to “excessive loading”.
  2. Collision occurrence because of: “failure to supervise route” or “failure of avoidance manoeuvring”.
  3. Contact: “contact with floating object” or “contact with fixed installation”.
  4. Grounding: “Drift Grounding” or “Powered Grounding”.
  5. Fire: as initiative event due to “internal source”, “external source” (piracy, spread of fire from other ship) or due to “atmospheric conditions” (lightning) along with further description on ship’s main location and ignition source.
  6. Explosion: as initiative event in cargo/slop tank, in aft area, on deck or in ballast tank/void spaces, along with ignition source information.
- Enhanced oil spill information concerning the location, proximity to shore, total oil spill quantity and the amount recovered.
- Information on fatalities/injuries, namely: number of serious injuries, non-serious injuries, fatalities and missing persons.
- Definition of event location and ship’s operating condition according to IMO relevant descriptions [5]. Basic information on the environmental condition at the time of incident.
- Outcome of incident with respect to the ship’s condition after the incident such as: “Remains Afloat”, “Total Loss”, “Sailed by her means” or “Towed Away”, “Loss of watertight integrity”, “Minor” or “Major” Repairs, “Sold for Demolition”, “Broken Up”, “No Damage Reported or Sustained”.
- Finally, information regarding the hull type of ships involved in the incidents was provided by Lloyds Register [6] and was input to the database.

3.3 Population of POP&C Database

The process of populating the POP&C database was carried out by the authors. Each partner organisation undertook the task of studying the accompanying complementary textual information for each incidental record and entering the relevant information in the format specified above. Because of the fuzzy character of the majority of the available information of the incidental records and also for ensuring the non-biased assessment of the incidental records to the extent feasible, a second round review of all records was conducted, by exchanging the records between the analysts. It should be
noted that when the raw record data were poor, requesting the personal judgement of the analysts for proper population of the database, a slightly different degree of ‘strictness’ was observed in relation to the assumptions made. The final control and assessment of all database input as well as the analysis of data [7] was the responsibility of the database developer.

4. Review of Results

The overall distribution of the initial 1294 records pertaining to AFRAMAX tankers, after the POP&C population process, is presented in Table 1.

Since the scope of POP&C project is to evaluate incidents that led directly to ship’s loss of watertight integrity (LOWI), the analysis of data was focused on the six major incident types, namely Non-Accidental Structural Failure, Collision, Contact, Grounding, Fire, and Explosion incidents.

Although significant proportion of the incidents were due to Machinery Failure and Failure of Hull Fitting (26% and 11% respectively), these particular categories were not considered in the analysis because they do not lead directly to loss of watertight integrity. When incidents in the above categories subsequently result in grounding, contact, etc, they are accounted for in the appropriate resulting event categories. Also, incidents characterised by Unknown Reasons were also excluded because of their insufficient information.

Table 1 – Distribution of major incident types according to POP&C analysts, Covered period 1978 to early 2004

<table>
<thead>
<tr>
<th>POP&amp;C Incident Type</th>
<th>No. of Incidents</th>
<th>All Categories Percentage</th>
<th>Six major types Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collision</td>
<td>233</td>
<td>18%</td>
<td>29%</td>
</tr>
<tr>
<td>Grounding</td>
<td>194</td>
<td>15%</td>
<td>25%</td>
</tr>
<tr>
<td>Contact</td>
<td>126</td>
<td>10%</td>
<td>16%</td>
</tr>
<tr>
<td>Non-accidental Structural Failure</td>
<td>121</td>
<td>9%</td>
<td>15%</td>
</tr>
<tr>
<td>Fire</td>
<td>79</td>
<td>6%</td>
<td>10%</td>
</tr>
<tr>
<td>Explosion</td>
<td>39</td>
<td>3%</td>
<td>5%</td>
</tr>
<tr>
<td>Total of six major types</td>
<td>792</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Machinery Failure</td>
<td>337</td>
<td></td>
<td>26%</td>
</tr>
<tr>
<td>Failure of Hull Fittings</td>
<td>137</td>
<td></td>
<td>11%</td>
</tr>
<tr>
<td>Unknown Reasons</td>
<td>28</td>
<td></td>
<td>2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1294</strong></td>
<td></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

With respect to the whole analysis process and the given statistics of accidents, it is noted that records with partly missing relevant information, indicated as “unknown” in the original LMIS taxonomy, were not separately classified, but embedded in records with known information, except for the category ‘unknown reasons’, that was kept separate from the others.

4.1 Review of Non-Accidental Structural Failure incidents

In total, 121 incidents were caused by Non-Accidental Structural Failure (see Table 1). *Structural Degradation* was found in 17% of the particular sample, 66% was as a result of *Excessive Loading* and 17% was due to *Poor Design/Construction*.

Event Location and Ship operating condition
The majority of Non-Accidental Structural Failure incidents were found to have taken place in Open Sea. Specifically;
68% took place in Open Sea
18% took place at Berth
9% took place at Port and Port Approach
3% took place in Coastal Waters, 1% in River and 1% at Anchorage.

At the time of the Non-Accidental Structural Failure incidents, ships were under the following operating conditions:
75% were En-route, 18% were: Discharging (9%), Loading (5%) & Ballasting (4%), 4% were: at Berth (3%) or in Port (1%) and 3% were: Manoeuvring (1%), Towed (1%) or Mooring (1%).

Environmental Condition at the time of incident
39% (47 incidents) of the Non-Accidental Structural Failure incidents were affected by heavy weather conditions.

Oil Pollution
84% (102 incidents) of the Non-Accidental Structural Failure incidents did not lead to environmental pollution. With respect to the incidents that caused pollution, the following conclusions can be drawn:
37% took place in Open Sea, 37% took place at Berth, 13% took place at Port and 13% during Port Approaching

Outcome of incident
- In 9% of the Non-Accidental Structural Failure incidents, no damage, if any, was reported.
- 27% sustained damage requiring minor repairs.
- 61% of the Non-Accidental Structural Failure incidents led to major repairs to ships.
- 3% led to the vessel’s total loss (Total loss, Sold for Demolition & Broken Up).

4.2 Review of Collision incidents

In total, 233 incidents were caused by collision (see Table 1). In 80% of the collision incidents, the ship had failed to do an Avoidance Maneuver and in the rest of the cases the ship’s crew had failed to Supervise Route.

Event Location & Ship operating condition
The majority of collision incidents were found to have taken place within confined waters, namely Coastal, Restricted Waters, Port, Berth and Anchorage. This could be expected due to the fact that these places have heavy traffic rate. More specifically,
- 40% took place either in Port (19%), or at Anchorage (12%), or at Berth (7%) or during Port Approach (2%).
- 36% took place in Coastal (33%) and Restricted Waters (3%).
- 13% took place in Open Sea.
- 10% took place in Canals (2%), Rivers (7%) or Inland waters (1%).
- 1% took place at Drydock.

At the time of the collision incidents, the following holds for the operating condition:
63% were En-route, 15% were: at Berth (6%), Anchoring (5%), Towed (2%) or Mooring (2%), 11% of the collision incidents happened during Manoeuvring, 10% took place during Discharging (8%), Bunkering (1%) and Loading (1%) and 1% was Under Repair.

Environmental Condition at the time of incident
Only 6% (14 incidents) were affected by heavy weather conditions.
Oil Pollution
96% (223 incidents) of the collision incidents did not lead to environmental pollution. With respect to the few incidents (10) that caused oil pollution, the following conclusions could be drawn (bearing in mind however the very small size of the statistical sample here):
56% took place in Coastal Waters, 22% took place at Port, 11% took place in Anchorage and 11% was in Open Sea.
In relation to the event location, environmental pollution caused by collision incidents, occurred primarily in confined waters.

Outcome of incident
- In 30% of the collision incidents, no damage, if any, was reported.
- 59% sustained damages requiring minor repairs or no damage at all.
- 11% of the incidents led to major repairs to ships.

4.3 Review of Contact incidents

In total, 126 incidents were caused by Contact, Table 1. Almost half (45%) of the contact incidents refer to contact with a floating object and the rest (55%) to contact with a fixed installation.
Concerning contact with floating object, in 64% of the cases, the object was detected but it could not be avoided, because of either Manoeuvring Avoidance Error (33%) or Steering System Failure (67%).
In the rest of the cases (36%), the object was simply not detected.
Regarding the incidents involved in contact with fixed installation, in almost all cases (97% of the particular incidents) the object was detected but it could not be avoided, due to Manoeuvring Avoidance Error (82%), due to Steering System Failure (9%) or due to Bad Environmental Condition (9%).

Event Location and Ship operating condition
Contact incidents occurred primarily in confined waters, as could be expected due to the nature of the incident, like Collision incidents. Specifically,
- 37% took place at Port (36%) or during Port Approach (1%)
- 23% took place in Coastal (20%) or Restricted Waters (3%)
- 16% took place at Berth
- 13% took place in Rivers (9%), Canals (3%) or Inland waters (1%)
- 7% took place in Open Sea
- 4% took place at Drydock (3%) & Shipyard (1%).

At the time of the contact incidents, the following holds for the operating conditions:
48% were En-route, 36% took place during Manoeuvring and 16% were at Berth (8%), while Towed (3%), Mooring (3%), at Port (1%) or while Discharging (1%).

Environmental Condition at the time of incident
Only 2% (3 incidents) of the contact incidents were affected by heavy weather conditions.

Oil Pollution
89% (112 incidents) of the contact incidents did not lead to environmental pollution. With respect to the 14 incidents that caused pollution, the followings statistics apply:
51% took place in Port, 14% took place in Rivers, 14% took place in Coastal Waters, 7% took place in Canals, 7% took place at Berth and 7% took place in Open Sea.
In relation to the event location, environmental pollution caused by contact incidents, occurred primarily in confined waters (as is the case for collision incidents).

**Outcome of incident**
- In 16% of the contact incidents, no damage, if any, was reported
- 74% sustained damages requiring minor repairs or no damage at all
- 10% of the incidents led to major repairs.

4.4 Review of Grounding incidents

In total, 194 incidents were caused by Grounding, Table 1. The majority (90%) of the grounding incidents were characterised as *Powered grounding* and the remaining 10% as *Drift grounding*. In *Powered grounding* incidents, 83% were attributed to “Squat Effect”. *Drift groundings* were caused due to *loss of propulsion* (40%), whereas the remaining 60% were due to *loss of steering*.

**Event Location and Ship operating condition**
Grounding incidents primarily took place in shallow waters.
- 33% took place in Coastal Waters
- 28% took place in Rivers and Inland Waters
- 21% took place in Canals
- 14% took place at Port and Port Approaches
- 3% were at Anchorage (2%) or Berth (1%), and
- 1% took place in Open Sea.

At the time of the grounding incidents, the following holds for the operating conditions:
90% were En-route, 4% were during Anchoring, 4% were at Berth (2%) or in Port (2%), 1% was during Discharging and 1% was while being Towed.

**Environmental Condition at the time of incident**
Only 8% (16 incidents) were affected by heavy weather conditions.

**Oil Pollution**
91% (176 incidents) of the grounding incidents did not lead to environmental pollution. With respect to the 18 incidents that caused pollution, the following statistics apply based on this limited sample size: 28% took place in Coastal Waters, 24% took place in Rivers, 12% took place at Ports, 12% took place in Canals, 12% took place in Open Sea, 6% took place at Berth, and 6% took place during Port Approach.
In relation to the event location, environmental pollution caused by grounding incidents occurred primarily in shallow waters that are close to the land.

**Outcome of incident**
- In 37% of the grounding incidents, no damage, if any, was reported
- 42% sustained damages requiring minor repairs or no damage at all
- 16% of the incidents led to major repairs to ships
- 4% were sold for Demolition and Broken Up
- 1% was Total Loss/ Capsize.

4.5 Review of Fire incidents
In the LMIS database Fire and Explosions are considered as a single category. Upon examination of the location and also consequences of the fire and explosion incidents, there was a clear difference between the two. Therefore, it was decided to investigate these incidents separately.

In total, 79 incidents were caused by Fire, Table 1. Based on the analysis of POP&C database, in 4% of the investigated fire incidents, an explosion followed as a second major event. As far as the nature of the source is concerned, the great majority (97%) were caused by “Internal Source” and the remaining 3% by “External Source”.

Regarding the incidents for which Fire was caused by “Internal Source”, the following can be indicated: 83% took place in ship’s Aft Area, 16% took place in Cargo/ Slop tanks and 1% took place in Ballast Tanks/Void Spaces.

Focusing on the incidents which occurred in the ships’ Aft Area:
- in 83% of these incidents, the fire started in the area of Machinery Spaces, below the main deck namely:
  - the fire started from the Engine Room in 83% of the incidents
  - the fire started from the Pump Room in 17% of the incidents
- in 17% of the incidents in ship’s aft area the fire started On Superstructure.

Focusing on the fire incidents initiated On Superstructure, 83% of them started in Accommodation area, whereas the remaining 17% started in Bridge area.

Given the small sample of information concerning the Ignition Source (34 incidents), the following distribution is given: 43% were due to Hot Works, 24% were due to Electrical Faults, 18% were due to Equipment Failure, 9% were due to Remains of Crude Oil, 3% (i.e. 1 incident) were due to Prohibited Transfer of crude oil to bunkers and 3% were due to Heating Equipment (Boiler & Preheater).

Event Location and Ship operating condition
Many fire incidents occurred in Port and Port Approaches. Also, a considerable percentage was found to have taken place in non-confined waters (Open Sea).
- 44% took place in Port (41%) & Port Approaches (3%)
- 23% took place in Open Sea
- 11% took place in Coastal Waters
- 15% took place in Shipyard (11%) or Drydock (4%)
- 5% took place at Berth, and
- 2% took place in Canals (1%) and Rivers (1%).

At the time of the “Fire” incidents, the following holds for the operating conditions: 45% were En-route, 28% were Under Repair (26%) or during Ship’s Construction (2%), 11% were at Berth, 9% were during Discharging (7%) or Bunkering (2%), and 7% took place while Mooring.

Environmental Condition at the time of incident
Only 3% (2 incidents) of fire incidents were directly affected by the heavy weather conditions.

Oil Pollution
Only 1 incident led to oil pollution to the environment while the vessel was At Berth; the fire started in Engine Room.

Outcome of incident
In 38% of the “Fire” incidents, no damage, if any, was reported
43% sustained minor repairs (39%) or no damage at all (4%)
15% of the incidents led to major repairs to the ship
4% were sold for demolition (1%) or to be broken up (3%).

4.5.1 Review of fire incidents initiated in Engine Room
Focusing on the fire incidents initiated in the Engine Room,
- 39% of the incidents had a serious degree of severity, 3% led to ship’s total loss and 58% of
  the incidents had a non-serious degree of severity. The above percentages indicate that Fire
  incidents caused in the area of Engine Room need special attention as they often lead to
  severe consequences.
- In relation to the Ignition Source (information on 12 incidents): 50% of the incidents were
  due to Electrical Faults (6 incidents), 25% due to Equipment Failure (3 incidents), 8% due
  to Heating Equipment (1 incident), 8% due to Prohibited Transfer of crude oil to bunkers (1
  incident) and 8% due to Hot Works (1 incident).
- In 3%, explosion followed as a second major event.

It should be noted however that the basis of all the above percentages are small numbers.

Event Location and Ship operating condition
- 36% took place in Port (30%) or Port Approaches (6%)
- 30% took place in Open Sea
- 22% took place in Coastal Waters
- 9% took place at Berth (6%) or in Shipyard (3%), and
- 3% were in Rivers.

At the time of the fire incidents initiated in Engine Room, the following holds for the operating
conditions: 72% were En-route, 12% were at Berth, 12% took place during Discharging or Bunkering,
and 4% took place when the vessel was under construction/repair.

Outcome of incident
- In 47% of the fire incidents initiated in Engine Room, no damage was reported.
- 30% of the incidents sustained minor damages
- 20% of the incidents led to major repairs
- in 3% of the incidents, ship was broken up.

4.5.2 Review of fire incidents initiated in Cargo/ Slop Tanks (12 incidents)
Focusing on the area of Cargo/ Slop tanks,
- Only in one (1) incident, the fire was followed by an explosion.
- All of the particular incidents had non-serious degree of severity.
- The majority (10 out of 12) of the particular incidents were caused due to “Hot Works”.

Event Location and Ship operating condition
- 75% took place in Shipyards & Drydock
- 17% took place in Port, and
- 8% took place at Berth

At the time of the fire incidents initiated in Cargo/ Slop Tanks, the following data can be mentioned:
83% was under repair and 17% was at Berth.
The event location, as well as the ship operating condition at the time of incident, indicates that
these incidents were mainly caused by human error.

Outcome of incident
In 25% of the fire incidents initiated in Cargo/ Slop tanks, no damage, if any, was reported. In 25% of these incidents, no damage was sustained. 50% of the fire incidents initiated Cargo/ Slop tanks sustained damages requiring minor repairs.

4.6 Review of Explosion incidents

In total, 39 incidents were caused by Explosion, Table 1. Based on the analysis of the database, in 41% of the investigated explosion incidents, fire followed as a second major event. Concerning the location of the initiation of the explosion incidents, the great majority (62%) started in the ship’s Aft Area, 24% in the Cargo / Slop Tanks, 11% on Deck and 3% in ship’s Ballast Tanks / Void Spaces.

Given the small sample of information concerning the Ignition Source (9 incidents), the following distribution is given: 56% were due to Hot Works, 22% were due to Electrical Faults, and 22% were due to Electrostatic Charges.

Event Location and Ship operating condition

A considerable percentage of the Explosion incidents occurred outside confined waters as well as a considerable percentage of occurrences taking place at Port. Specifically

- 40% took place in Open Sea and Archipelagos
- 35% took place in Port
- 14% were in Shipyards (11%) or Drydock (3%)
- 5% took place in Coastal Waters
- 3% were at Anchorage and 3% in Rivers.

At the time of the explosion incidents, the following holds for the operating conditions: 43% were En-route, 33% were Under Repair, 14% were in Port (7%) or during Anchoring (7%), and 10% took place during Discharging.

Environmental Condition at the time of incident

There is no indication that weather had an impact on the particular incidents.

Oil Pollution

5% of the explosion incidents (2 incidents) led to environmental pollution.

Outcome of incident

- In 30% of the explosion incidents, no damage, if any, was reported.
- 31% sustained damages requiring minor repairs or no damage at all
- 18% of the incidents led to major repairs to the ship
- 13% were sold for demolition and were broken up, and
- 8% were Total Loss/ Capsize.

4.6.1 Review of explosion incidents initiated in Cargo/ Slop Tanks

Focusing on the area of Cargo/ Slop tanks where there are 9 incidents recorded:

- 1 incident happened during tank cleaning.
- 1 incident happened although tanks were degassed.

4.6.2 Review of explosion incidents initiated in Aft Area

Focusing on the incidents initiated in the Aft Area the following can be stated:
65% of the incidents started in Engine Room, 20% started in Boiler Room, and 15% started in Pump Room.

5. Discussion

5.1 Incident Categories

Fig. 1 presents the distribution of all incident categories for the range of years 1978-2003, as derived from the POP&C Database, (see also Table 2).

![Annual Distribution of Incident Types in ARAMAX Tankers Database in the period 1978-2003](image)

**Fig. 1 – Distribution of major incident types, POP&C Database, period 1978 – 2003.**

### Table 2 - Number of incidents, POP&C Database, period 1978 – 2003

<table>
<thead>
<tr>
<th>Year</th>
<th>Structural Failure</th>
<th>Collision</th>
<th>Contact</th>
<th>Grounding</th>
<th>Fire</th>
<th>Explosion</th>
<th>Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>4</td>
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<td>5</td>
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</table>
As can be seen from the table, an increase of incidents is noted in years 1979 and 1981, as well as within the period 1988-1991. Afterwards, there is a clear tendency of reduced numbers of incidents for all incident categories presented, particularly after the early 90ties. This could be attributed to the adoption and implementation of enhanced regulations concerning ship’s safety and pollution (e.g. OPA 90, MARPOL), as well as operation, and also to the increased safety awareness and safety culture amongst ship owners and operators.

5.2 AFRAMAX tankers vs. All Tankers

Fig. 2 presents the number of incidents concerning AFRAMAX tankers within the period 1980-2003 (POP&C database), as well as the total number of incidents for All Tankers (Source: INTERTANKO) for the same time period. Actually no data for all tankers were available for pre-80.

It is noted that the initial LMIS incident category “Hull & Machinery” (Fig. 2: 6735 incidents) is herein compared with the three (3) relevant POP&C incident categories, namely “Failure of Hull Fitting”, “Non-Accidental Structural Failure” and “Machinery Failure” (Fig. 2: 501 incidents). Similarly, the unified LMIS category “Fire and Explosion” is compared with the sum of POP&C categories “Fire” and “Explosion”.

<table>
<thead>
<tr>
<th>Incident Type</th>
<th>AFRAMAX incidents as a % of all tanker incidents (Fig. 2)</th>
<th>Number that corresponds to the 19% of incidents of All Tankers involved</th>
<th>Actual # of AFRAMAX incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hull/Struct/Machinery</td>
<td>7.4</td>
<td>[6735*0.19] = 1280</td>
<td>501</td>
</tr>
<tr>
<td>Collision</td>
<td>6.3</td>
<td>[3202*0.19] = 608</td>
<td>200</td>
</tr>
<tr>
<td>Contact</td>
<td>8.5</td>
<td>[1324*0.19] = 252</td>
<td>113</td>
</tr>
<tr>
<td>Grounding</td>
<td>7.8</td>
<td>[2130*0.19] = 405</td>
<td>166</td>
</tr>
<tr>
<td>Fire/Explosion</td>
<td>8.9</td>
<td>[1181*0.19] = 224</td>
<td>105</td>
</tr>
</tbody>
</table>

Incidents of AFRAMAX tankers correspond to 6.3-8.9 % of incidents of all tankers, Table 3, depending on the type of incident. The upper percentage (8.9%) refers to the Fire & Explosion Incidents and the lower one to Collision Incidents.

Table 3 - AFRAMAX vs. All Tankers, Period 1980-2003

![Fig. 2 – AFRAMAX vs. All Tankers, number of incidents per incident type](image-url)
The AFRAMAX Fleet corresponds to about 19% of the Total Tanker Fleet. This percentage is computed as the average value of the operating fleet within the period 1980-2003. From the last two columns of Table 3, it is evident that with respect to the ship size categorisation, the number of incidents that AFRAMAX tankers were involved is relatively low for the part of fleet they present.

5.3 Degree of severity

The following results are considered of major importance, Fig. 3:
- 19% of Non-Accidental Structural Failure incidents are characterised by serious degree of severity.
- 13-15% of Collision and Contact incidents have serious degree of severity and the case of ship’s loss could be considered as negligible.
- 19% of Grounding incidents are characterised as serious and in 4% of the particular incidents the ship was lost.
- 26% of Fire incidents are considered serious and in 4% of the particular incidents the ship was lost. Based on this consideration, Fire Incidents are characterised as the second most severe incident event, regarding this type of tankers.
- Explosion is the most severe incident event due to the fact that more than half of the explosion incidents are characterised by serious consequences (32% had serious degree of severity and 22% led to ship’s total loss, in total amounting to 54%).

![AFRAMAX, POP&C Database Degree of severity](image)

**Fig. 3 – AFRAMAX incidents, degree of severity, POP&C database**

5.4 Ship’s Loss of Watertight Integrity (LOWI)

Fig. 4 presents the number of incidents, per incident type, where Loss of Watertight Integrity has occurred.

The large percentage of incidents (29.8%) that underwent LOWI occurred due to Non-Accidental Structural Failure. LOWI occurred in between 17 to 24 percent of incidents in relation to Grounding, Contact and Collision incidents. Whilst only in 13% of Explosion incidents LOWI occurred, the occurrence of LOWI is considered almost negligible in Fire Incidents.

With respect to the ship’s loss of watertight integrity, Non-Accidental Structural Failure incidents are the most severe incident event.

\[1\] According to LMIS coding
5.5 Weather Impact

Fig. 5 shows the number of incidents where the environmental conditions had an impact on the incident noting the followings:

In 39% of the Non-Accidental Structural Failure incidents, the environmental condition appears to be a contributing factor to the incident. Comparing the data for the other incident types, it could be concluded that the Non-Accidental Structural Failure incidents are often caused (or at least, triggered) by bad weather, in contrast to the other incident categories for which the weather is much less of a contributory factor.

5.6 Oil Pollution Quantity

Fig. 6 presents the total oil spill quantity in tonnes, as derived from the POP&C database per incident type.

With respect to the oil spill quantity, Grounding incidents gave the larger total oil pollution quantity (see Fig.6 and Table 4). The highest number of incidents causing environmental pollution arises from Non-Accidental Structural Failure. The severity of the Explosion incidents is once again highlighted. For example, two Explosion incidents led to more pollution than nineteen Non-Accidental Structural Failure incidents.
Fig. 6 - Oil spill quantity in tonnes, AFRAMAX tankers, POP&C database

Table 4 - Incident Categories vs. Pollution Quantity, period 1978-early 2004

<table>
<thead>
<tr>
<th>Incident Type</th>
<th>Number of Incidents</th>
<th>Number of incidents causing pollution</th>
<th>Number of incidents w/o pollution</th>
<th>% of incidents with Oil Spilt</th>
<th>Total Oil Pollution Quantity per incident type, t</th>
<th>% of oil spill quantity, per incident type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Failure</td>
<td>121</td>
<td>19</td>
<td>102</td>
<td>15.70</td>
<td>96,370</td>
<td>23.38</td>
</tr>
<tr>
<td>Contact</td>
<td>126</td>
<td>14</td>
<td>112</td>
<td>11.11</td>
<td>7,878</td>
<td>1.91</td>
</tr>
<tr>
<td>Collision</td>
<td>233</td>
<td>10</td>
<td>223</td>
<td>4.29</td>
<td>20,934</td>
<td>5.08</td>
</tr>
<tr>
<td>Grounding</td>
<td>194</td>
<td>18</td>
<td>176</td>
<td>9.28</td>
<td>158,869</td>
<td>38.54</td>
</tr>
<tr>
<td>Fire</td>
<td>79</td>
<td>1</td>
<td>78</td>
<td>1.27</td>
<td>676</td>
<td>0.16</td>
</tr>
<tr>
<td>Explosion</td>
<td>39</td>
<td>2</td>
<td>37</td>
<td>5.13</td>
<td>126,260</td>
<td>30.63</td>
</tr>
</tbody>
</table>

Total Oil Pollution Quantity in POP&C Database, t = 412,253

Note that only 0.3% of total oil pollution quantity is coming from the other non-studied incident categories (i.e. categories of Machinery Failure, Failure of Hull Fitting and Unknown Reasons).

5.7 Injuries and Fatalities

There are no records of fatalities and injuries for the Non Accidental Structural Failure, Grounding and Contact incidents.
Regarding Collision incidents, the total number of fatalities amounts to 25 persons and the number of injuries is 2 persons.
In Explosion incidents, twenty-two (22) fatalities were recorded and four (4) persons were injured.
In the case of Fire incidents, there were 22 fatalities and 27 injuries.
The consequences in terms of safety of life confirm the severity of the explosion and fire incidents.

5.8 Quality of Data in Incident Databases

Accident databases such as the one utilized by POP&C are potentially important tools for gauging the safety and the environmental performance of the industry. They can be used to guide the regulatory process so that the regulations that are being produced may be focused so as to address the weakest links in the safety and environmental prevention chain, and also they can be used to provide alerts for areas of design, operation and training which may be in need of additional attention or of a new approach.
Whereas the recognition of the potential value of marine accident databases is not new, the databases that currently exist suffer from two basic and serious weaknesses that greatly diminish our ability to utilize this data. These two problems were faced by the analysts of the POP&C project, and whereas they could not be resolved within this project, the experience gained is certainly worthy of dissemination because until these problems start being resolved, accident data will remain mostly underutilized.

It might be argued that a lot of maritime accident records already exist in the public domain in the form of commercially available casualty databases (examples are: the old LMIS database, the LR-Fairplay database, and the Lloyd’s Marine Intelligence Unit database). Whereas these international databases contain a plethora of records of shipping casualties (and a plethora of records are certainly needed in order to arrive at statistically meaningful conclusions), they all tend to suffer greatly from the fact that the source of their information is more often than not, non-technical. And anyone who has worked with such data will probably confirm this serious limitation.

The second stumbling block to the utilisation of accident data arises from the way the information is categorised. Accidents are assigned a single category, such as Collision, Grounding, Fire/Explosion, Hull & Machinery etc. This one-dimensional categorisation ignores the basic fact that accidents are sequences of undesirable events, each of these having their own probability profile, as for example a fire can lead to loss of power or steering, which in turn can lead to grounding. Using a single code to define an accident takes away vital information for any subsequent analysis and in the days of computers is an unnecessary restriction. It should therefore be evident that accident categorisation (accident taxonomy) is in need of a rethink and a restructure.

6. Acknowledgements

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The European Community and the authors shall not in any way be liable or responsible for the use of any such knowledge, information or data, or of the consequences thereof.

7. References

2 LMIS, “Lloyd’s Maritime Information Service”.
3 INTERTANKO, “The International association of independent tanker owners for safe transport, cleaner seas and free competition”.
4 POP&C database (2005), version 1, 2-21-DATABASE-06-00-01 deliverable.