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Review article

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ACCIDENT INVESTIGATIONS IN THE MERCHANT MARINE

A survey of total loss accidents in the merchant marine over a period of 30 years has shown that these accidents can be arranged in the following order: stranding, fire, water-leaks, gales and collision; other accidents have also been taken into consideration. The analysis covers ships over 500 GT flying different flags and plying any route of navigation.

At the beginning, a sample of 500 merchant ships - of different types and tonnage - and flying 15 different flags has been analyzed to determine the age and type of ship, as well as the causes of accidents.

In the second analysis, the same ships flying 15 flags are considered, but now over a wider range and on a sample totaling 1,500 merchant ships. The results of both the analyses have been compared. It resulted that all collisions, together with gales, amount to 25% of the maritime casualty returns -in the total loss lists- while stranding and collision take more than 40% of the toll.

Key words: maritime casualty, safety at sea

1. INTRODUCTION

Maritime accidents fall into one of the following groups due to several circumstances: those caused by weather conditions, such as gales, reduced visibility [1], ice, etc; or those due to pilot navigation error, narrow [2] and/or congested [3] waters, collision with unknown objects, ship lying at anchor or moored at buoys with strong currents, manoeuvring at close quarters or with limited space and adverse conditions in the port. Cargo related accidents occur through the carriage of dangerous goods, cargo on deck, heavy cargo, or cases relevant to the ship's seaworthiness. Failure in the steering system [4], main engine, different devices, war, terrorism, piracy, collision and misinterpretation in communications at sea, etc [5,6,7] can all lead to accidents.

Accidents by collision have significantly decreased, where a maritime traffic management service or, at least, a Traffic Separation Scheme (TSS) has been implemented. Currently, a worldwide maritime traffic management system is being contemplated [8].

The SOLAS (Safety of Life at Sea) convention rules the safety of navigation in sea

trade, in shipbuilding and fire-resistant bulkheads, life-saving appliances and facilities, radio communications, grain in bulk and dangerous goods transportation. These international provisions make it compulsory for sea-time training on board merchant ships, and for fire and abandon-ship drills.

Fire aboard merchant ships is serious, sometimes leading to total loss of the ship and/or her cargo, to gross damage, and to loss of life. In the past, when merchant ships were built out of wood and propulsion was achieved by wind action on the sails, lighting was achieved by means of oil or paraffin lanterns; tragic fires happened far too often, due mainly to the ship's rolling and the subsequent falling and breaking of the lanterns. In this day and age, flame lights are not allowed on board, or are prohibited by their inefficiency and danger. Nevertheless, fire still poses a high risk for several other reasons.

The stranding of merchant ships can result in fire and explosions, particularly when large tankers engaged in the crude oil trade are involved. Such was the case with the 'Torrey Canyon' in 1967, when a series of explosions and fires after her stranding in the Scilly Isles (Seven Stones, Pollard Rock) caused an all-time record in sea pollution. Probably petroleum products, shipped in bulk, present the highest risk, when errors occur, but we have other substances such as coal, a number of ores, feeding stuff, fertilizers, fish meal, etc. which are apparently harmless - when one is not acquainted with case histories - but which are liable to produce a spontaneous combustion.

Accident investigations show that fire leads to serious consequences not only in the carriage of dangerous goods, but also poses a risk to other goods which otherwise would not be dangerous and would not create a hazard during the sea passage - such as sugar, walnuts, cotton, and the like which can readily be stowed with no apparent fire risk. This kind of cargo burns easily and can become a risk if neighbouring hot work or a faulty mains line causes fire to break out in the cargo hold. Extinguishing this fire will prove difficult, once it has gained a hold and it will spread quickly if there is sufficient oxygen.

The paper aims at analyzing various maritime accidents during a 30-year period. On samples of 500 ships or more, it has been found that stranding and fire aboard, taken together, amounted to 50 % of the constructive total losses.

2. METHOD AND RESULTS

The method followed in this research on maritime casualties includes the analysis of the total losses of merchant ships flying different flags, with a gross tonnage of 500 GT or more, throughout 30 years. The accidents data were taken from the "Maritime Casualty 1963 - 1996" [6], which lists disasters alphabetically by the ship's name. To obtain useful or reliable results for a given flag, it is necessary to consider a group of 100 ships for each flag. To quantify causes, ages, and class-type under different flags, a sample of 500 ships [8, 9] is needed. A total of 500 merchant ship losses, flying 15 flags, was analyzed first, in order to establish the ship's age when lost and the trade she was on (class or type of goods transported). The number of ships and the total gross tonnage per flag was recorded, and the data obtained are shown in Table 1.

Whilst a sample of 500 accidents is sufficient to establish the causes of, it is not a large enough sample to discriminate the behavior between different flags. In the next two tables,

Table 3 and Table 5, the same particulars have been analyzed, but the number of ships has been increased to a total of 1,500.

The reasons for these accidents have been analyzed and quantified in Table 2, both as numbers and as a percentage of the total.

2.1 Age estimation

In the analysis of the “15 flags - 500 ships” (Table 1), the losses have been separated into four periods of a ship’s active service – the first period covering 0-5 years, the second 6-12 years, the third 13-20 years, and the fourth overrunning 21 years of ship’s service. In Table 1, the sum of the losses in the first two periods, 38+72, amounts to 110 ships, meaning 22% of the 500 ships analyzed. The losses in the third and fourth period, 185+205=390 ships, make 78% of the total number analyzed. The first particular to consider is that losses in ships over 13 years outnumber the others, and are 3.5 times more frequent than in new and middle-aged ships; but it is also true, that the over-ageing of the world shipping, in the 30 years under survey, is a trend to consider. The 205 ships in the table, aged over 21 year, amount to 41% of the 500 sampled ships flying 15 different flags, and only Japan looms as a younger fleet.

2.2 Trade

Regarding ships classified by trade, those carrying general cargo (break-bulk or conventional cargo) are the majority, making a total of 333 units, meaning 66.6% of the total; dry bulk cargo ships come to 51 ships with 10.2%; tankers number 55 with 11%; and the rest of the ships make a total of 61 units, coming to 12.2% of the 500 ships analyzed. The total gross tonnage amounts to 3,941,360 which, divided by the 500 ships, comes to a mean of 7,883 GT per ship.

2.3 Cause

Table 2 shows 15 different flags and 500 merchant ships, entering the nine most frequent circumstances in maritime accidents, resulting in total losses confirmed by the ships’ classification societies. The results of the table place “stranding” as the leading maritime casualty - in fine weather, reason unspecified - followed by stranding in heavy weather, a total of 146 being entered with 29.2% of the 500 ships involved in accidents. Ranking second is “fire”; fire in the engine room is the most common cause, with 61 cases forming 55% of the total accidents caused by fire. The total number of accidents caused by fire amounts to 111 ships and represents 22.2% of the total. The third cause of a total loss is attached to “water-leaks” with 72 cases and 14.4% of the total. The fourth cause is represented by “gales”, affecting 70 ships and a share of 14%. The fifth place is held by “collisions” with 48 cases and a 9.6% share.

The remainder of the total losses, having a less frequency impact in this table, stands in the following order: explosions, faults in cargo, war, and striking unknown floating objects.

2.4 Ship losses

In Table 3 the same 15 flags are analyzed, increasing the number of merchant ships - in total loss casualties - to 1,500 of 500 GT and over, the results being entered according to the ship's age, class of ship and gross tonnage. In the first nine flags with 100 or more ships, the ship's ages are analyzed separately, the type of ships involved in the casualties, on an average per flag and on a total average. For the analysis and quantifying of ships, the same four periods out of Table 1 are maintained.

Taking into consideration the first two periods - new and middle-aged ships on one hand - and the two second periods - too long in service and old ships on the other hand - and if the ratio of the former over the latter is greater than the unity, the flag of that merchant fleet can be assumed as being of a new construction. For a valid comparison in making the estimation, we need to have 100 or more ships per flag:

- Japan has a ratio greater than 2 [$(39+50) / (31+7) = 2.342$]
- Greece has the lowest ratio, [$16/134 = 0.119$], indicating the oldest fleet;
- Cyprus [$19/131 = 0.145$] turns out to be the second oldest flag, followed by Panama with 0.154, the Philippines with 0.174, Italy with 0.244, the U.K. with 0.250, Liberia with 0.363 and Spain with 0.887.

The whole 15 flags show an average ratio for the 1,500 ships of $(140+251) / (483 + 626) = 0.352$. From the total number of ships in casualty 9.3% are under 6 years and 41.7% are over 21 years old. These results do not mean that ships had a casualty for the reason of being very old, but, rather, that the world fleet in the 30 years under survey is quite old. It doesn't mean either that Japanese casualties occur mainly on board its new ships, but, rather, that its fleet is a new one.

As in Table 1, two letters have been entered at the head of the columns, for readily identifying the ship's class: GC = general cargo, BC = bulk carrier (dry-bulk carrier), etc. The total contribution of the GC ships is 1,034 units, a share of 69% of the total amount. The next column includes BC carriers with 121 ships and an 8.1% share, followed by 193 tankers or 12.9% of them employed in the carriage of crude oil or oil products. The rest of the ships (all columns to the right) entered in the same line (G total), amounting to 152 ships or 10% of the total. The average gross tonnage of the first four columns with 150 ships per flag is the highest for Liberia with $3,524,820 \text{ GT}/150 = 23,499 \text{ GT}$. This figure, representing less GC ships and several BC and TA for the same number of ships, means a higher tonnage average. On the contrary, Panama, with a higher number of GC ships and few BC and TA, has the lowest tonnage average of the four analyzed with $874,780/150=5,832 \text{ GT}$. The total average (15 flags) amounts to $12,472,710 / 1,500 = 8,315 \text{ GT}$.

Comparing Table 1 and 3, the total tonnage average per ship is only of $8,315-7,883 = 432 \text{ GT}$. Ships' age in each table keeps a similar ratio, and only the 13-20 year column shows a difference as high as 4.8%. Regarding the types of ships, the highest difference between the tables does not surpass 2.4%. In Table 5 we have arranged the accidents of the 15 flags in 10 columns, for allocating 1,500 ships per flag and their casualties under their corresponding entries and headings. "Stranding" is still the first reason for accidents, totaling 455 cases and representing 30.3% of the total number. "Fire" ranks second involving 304 ships with 20.3% of the losses; fire in the engine room has the highest rate in this category, with 165 accidents.

The third position is occupied by “water-leaks”, with 202 total losses or 13.4% of the total number. The fourth placed accident refers to “gales” with 157 ships and 10.5%. “Collisions”, with 149 ships and 9.9%, are placed fifth. Finally, the remaining five casualty reasons come to 233 total losses or 15.6%.

Analyzing individually the first nine flags in this table, with 100 or more ships in casualty per flag, Greece and Spain have reached the highest rate in their total losses because of “fire aboard”. On the contrary, Japan is the country with the lowest rate of losses by fire, with only five cases out of the 127 total losses, the most important accidents on record being “collisions”.

3. CONCLUSIONS

While analyzing the total loss accidents, on a sample of 500 and 1,500 ships of over 500 GT flying 15 different flags, in a 30 year period, the following order for the leading maritime casualties in the merchant fleet has been registered: stranding; fire; water-leaks; gales; and collisions. Other five accident causes were entered, but had little impact. In the reckoning of the ships of both models, fire was the second most frequent cause of the accidents and, together with stranding, represents more than 50% of the maritime casualty returns and, if we include explosions in the column of fire, these latter items (explosion + fire) would add up to 25% of the casualties. Taking into consideration one by one flag that over 100 ships are flying, Greece and Spain are the flags where the highest number of accidents caused by fire is to be found, while Japan is the lowest one. In the latter case, “collision” is the leading accident cause, ending in a casualty eventually.

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Table 1. *Ships' Age and Class of 500 Ships Flying 15 Different Flags*

GC=General Cargo; BC=Bulk Carrier; TA=Tanker; OB=Ore Bulk Oil; GA=Liquefied Gas;
 CH=Chemical tanker; RR=Roll on, Roll off; CO=Container ship; PF=Passenger or Ferry;
 OT=other ships

Flags	Years Old				Ships No	Class of Ships										DWT
	0-5	6-12	13-20	>21		GC	BC	TA	OB	GA	CH	RR	CO	PF	OT	
Greek			2		2	2					2					5,280
Panamanian	1	7	25	33	66	54	4	2			2	1		1	2	338,710
Liberian	7	12	37	29	85	36	21	17	6	1	3		1			1,680,190
Cyprus	1	8	23	32	64	53	4	2		1	1	1	1		1	234,880
UK	4	4	19	16	43	24	3	10	2	2				1	1	379,580
Japanese	6	9	11	1	27	16	2	4		1	1	1		1	1	146,850
Philippine	2	4	16	31	53	42		1					1	9		103,660
Italian	1	8	14	13	36	25	1	5		2	1		1	1		142,550
Spanish	6	6	6	11	29	17	2	6				1		1	2	310,630
Lebanese	1	1	5	17	24	20	2								2	65,750
Norwegian	4	4	8	1	17	11	2	2			1			1		200,470
Brazilian		6	5	6	17	14	3									80,240
USA	1	1	4	10	16	5	5	5						1		145,570
West German	4	1	7	3	15	11	1				1	1	1			53,920
Chilean		1	3	2	6	3	1	1							1	53,080
Total	38	72	185	205	500	333	51	55	8	7	10	5	6	15	10	3,941,360
%	7.6	14.4	37	41	100	66.6	10.2	11	12.2							100

Table 2. Causes of Maritime Casualties of 500 Ships Flying 15 Different Flags

S=Stranding, fine weather; SGF=Stranding in gale, fog or engine failure; FE=Fire in engine room; F=Fire, unspecified; FC=Fire in cargo; T =TOTAL; L= Leak; G=Gale; SC=Ship's collisions; E=explosion; MF=Machinery failure; T=Terrorism, piracy or war; CU=Collision with an unknown subject.

Flags	Stranding			Fire				L	G	SC	E	MF	T	CU	Ships No
	S	SGF	T	FE	F	FC	T								
Greek								1	1						2
Panamanian	15	5	20	5	5	1	11	14	10	2	2	3	2	2	66
Liberian	19	12	31	14	6	3	23	9	2	9	6	1	4		85
Cyprus	11	12	23	8	3	1	12	14	8	3		1	2	1	64
UK	8	4	12	7	2		9	3	8	3	2	1	2	3	43
Japanese	2	4	6					2	7	11	1				27
Philippine	7	6	13	6	5	4	15	7	11	14		3			53
Italian	7	4	11	5	2	2	9	5	5	2	1	1	1	1	36
Spanish	3		3	4	4	1	9	7	5	2	2	1			29
Lebanese	5	2	7	5	1	1	7	2	3	1			2	2	24
Norwegian	2	1	3	4	2		6	1	2	4	1				17
Brazilian	4	2	6	2	1	3	6	3	2						17
USA	3		3	1	1	1	3	2	3	3		1	1		16
West German	2	2	4			1	1	1	2	4		2		1	15
Chilean	4		4					1	1						6
Grand Total			146				111	72	70	48	15	14	14	10	500
%			29.2				22.2	14.4	14	9.6	3	2.8	2.8	2	100

Table 3. *Ship's Age and Class of 500 Ships Flying 15 Different Flags*

GC=General Cargo; BC=Bulk Carrier; TA=Tanker; OB=Ore Bulk Oil; GA=Liquefied Gas;
 CH=Chemical tanker; RR=Roll on, Roll off; CO=Container ships; PF=Passenger or Ferry;
 OT=other ships

Flags	Years Old				Ships No	Class of Ships										DWT
	0-5	6-12	13-20	>21		GC	BC	TA	OB	GA	CH	RR	CO	PF	OT	
Greek	4	12	63	71	150	104	13	24	2	1		1		4	1	1,608,720
Panamanian	2	18	53	77	150	117	14	7	1		2	1		2	6	874,780
Liberian	10	30	62	48	150	59	32	45	8	1	3		2			3,524,820
Cyprus	2	17	51	80	150	123	8	9	1	1	3	1	2	1	1	1,214,260
UK	11	14	50	50	125	71	9	22	4	2		5	1	5	6	1,013,070
Japanese	39	50	31	7	127	100	4	12		4	2	1		1	3	495,140
Philippine	3	13	33	59	108	79		8		3			1	17		285,280
Italian	7	13	35	47	102	67	5	18	1	2	3	1	1	3	1	597,010
Spanish	21	26	16	37	100	76	6	9			1	1	2	1	4	687,820
Lebanese	1	2	18	57	78	71	5								2	262,020
Norwegian	16	18	23	11	68	43	5	15		1	2			2		697,470
Brazilian	3	15	15	25	58	48	4	1	1	2				1	1	259,140
USA	2	3	13	40	58	18	12	20		1		1	2	2	2	608,510
West German	19	17	14	7	57	45	1	2			1	3	1		4	188,690
Chilean		3	6	10	19	13	3	1	1						1	155,980
Total	140	251	483	626	1,500	1,034	121	193	19	18	17	15	12	39	32	12,472,710
%	9.3	16.8	32.2	41.7	100	69	8.1	12.9	10							100

Table 4. Causes of Maritime Casualties of 500 Ships Flying 15 Different Flags

S=Stranding, fine weather; SGF=Stranding in gale, fog or engine failure; FE=Fire in engine room; F=Fire, unspecified; FC=Fire in cargo; T =TOTAL; L= Leak; G=Gale; SC=Ship's collision; E=explosion; MF=Machinery failure; T=Terrorism, piracy or war; CU=Collision with an unknown subject.

Flags	Stranding			Fire				L	G	SC	E	MF	T	CU	OT	Ships No
	S	SGF	T	FE	F	FC	T									
Greek	29	18	47	32	12	9	53	20	6	5	5	2	5	4	3	150
Panamanian	28	14	42	14	11	8	33	28	17	5	4	7	6	3	5	150
Liberian	29	19	48	21	11	4	36	17	8	15	10	2	9		5	150
Cyprus	26	20	46	23	9	4	36	30	12	5		3	12	1	5	150
UK	25	17	42	10	7	3	20	10	15	11	5	6	5	5	6	125
Japanese	14	17	31		2	3	5	16	26	38	7	4				127
Philippine	16	19	35	11	7	4	22	12	20	6	5	5	1	1	1	108
Italian	21	13	34	10	4	7	21	16	7	9	5	4	1	2	3	102
Spanish	11	9	20	9	10	4	23	15	10	14	4	9	2	2	1	100
Lebanese	22	12	34	10	1	2	13	9	6	3	2	3	4	2	2	78
Norwegian	7	6	13	9	6		15	7	7	12	5	6		1	2	68
Brazilian	14	11	25	3	1	5	9	9	3	6	2				4	58
USA	11	4	15	7	1	1	9	6	7	6	8	3	3		1	58
West German	9	5	14	5	1	1	7	5	9	14	1	5		2		57
Chilean	8	1	9	1	1		2	2	4		1			1		19
Grand Total			455	61	32	18	304	202	157	149	64	59	48	24	38	1,500
%			30.3				20.3	13.4	10.5	9.9	4.3	3.9	3.2	1.6	2.6	100

ISTRAŽIVANJA POMORSKIH NESREČA

SAŽETAK

Na osnovi prikaza svih pomorskih nesreća s potpunim gubitkom broda, koje su se dogodile unutar 30 i više godina, proizlazi da se uzroci tih nesreća mogu svrstati prema sljedećem redoslijedu: nasukavanje, požar, vodopropusni otvori, vrlo jaki vjetrovi i sudar, te drugi uzroci nesreća koji su također razmatrani. Analizom su obrađeni brodovi od preko 500 BRT koji plove pod različitim zastavama i koriste sve plovidbene putove.

Na početku je analizom obuhvaćen uzorak od 500 trgovačkih brodova, različitog tipa i tonaže, koji su plovili pod 15 različitih zastava, kako bi se utvrdila starost i tip broda, kao i uzroci nesreća.

Sljedećom su analizom uzeti u obzir isti brodovi, s time što je uzorak proširen na ukupno 1500 trgovačkih brodova. Rezultati dobiveni na osnovi i jedne i druge analize su uspoređeni i došlo se do zaključka da svi sudari, zajedno s vrlo jakim vjetrovima, čine 25% od ukupnog broja gubitaka brodova, po popisu nesreća s potpunim gubitkom broda, dok je nasukavanjem i sudarom obuhvaćeno više od 40% gubitaka.

Ključne riječi: gubitak broda uslijed pomorske nesreće, sigurnost na moru

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