TITLE: **MILFORD HAVEN PORT AUTHORITY – EVENT STATISTICS**

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PREPARED BY: **LLOYD′S REGISTER EMEA CONSULTANCY SERVICES GROUP**

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16. Summary

LR has looked at high level statistics for accidents at Milford Haven and expressed them in easily understood terms for the general public. For incidents where the ship has been lost or broken up, and as such represents an incident large enough to potentially injure people nearby, we can come to the following high level statements.

- Experience of just a fire on the ship large enough to potentially injure people nearby is as likely per year as being struck by lightning
- Experience of just an explosion in the Ship large enough to potentially injure people nearby is as likely per year as being struck by lightning
- Fire and Explosion (or Explosion and Fire) – No comment as included below
- A pool fire large enough to potentially injure people nearby is as likely per year as being killed by lightning
- Any fire (including explosion) large enough to potentially injure people nearby is only slightly more likely per year as being struck by lightning
- Any Explosion (including fire) large enough to potentially injure people nearby is only slightly more likely per year as being struck by lightning
- The likelihood of an LNG incident is extremely low. There has never been a recorded incident of a major release of LNG from a ship to external atmosphere. Similarly no member of the public has ever been injured by LNG from a ship.

These values can then be linked into the event types that may be seen at Milford Haven.

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1. OVERVIEW

Milford Haven Port Authority has requested Lloyd's Register EMEA (LR) to provide information on the relative likelihood of various accidents occurring at Milford Haven Terminal. These likelihoods are to be expressed in terms that can be readily understood by people unfamiliar with statistics or the marine industry.

LR has conducted high level research of the number of incidents that have occurred worldwide over the period start 1995- end 2004. This has been carried out using LR Fairplay's data. This databank is a collection of publicly available information on incidents and represents the most comprehensive source available. However the way that this data is stored limits the extent to which a high level analysis can be carried out. Statistics can only be gathered in certain categories and so full statistical analysis of all specific scenarios envisioned is not possible. Please note that the difference between a cargo tank explosion, BLEVE and an unconfined vapour cloud explosion are not recorded. Hence these events have been recorded only as "explosion".

The method of analysis involved identifying the total number of ships operating in a particular segment and comparing this number against the number of incidents worldwide. This provided a probability of an incident per year per ship. This has been split up into size of event to give an indication of whether the incident is just minor with negligible consequences, or whether it is major with the potential for significant loss of life, environmental damage or commercial loss.

These results must be factored to allow for the likelihood of the ship being at Milford Haven when the incident takes place. This is carried out by comparing the number of visits that are made to Milford Haven against the total number of visits carried out by tankers worldwide. Note due to lack of recorded data, a pessimistic assumption has been made on the average number of visits made worldwide.

There is a moderate level of error in these results due to the high level nature of the analysis, and the subsequent transfer to readily understandable terms. More detailed research can be carried out to address the specific risks associate with Milford Haven (specific shipping, navigation risks, environmental factors, human error etc.) and to provide a more confidence in the answer.

General results are as follows.

2. ANALYSIS

Table 1 indicates the number of tankers in operation between 1995 and 2004

Tanker Time Series 1995 - 2005							
Year	**Chem. /oil**	**crude**	**LNG**	**LPG**	**Oil Prod**		**All**
1995	869	1643	88	872	5112		**8584**
1996	889	1653	92	898	5121		**8653**
1997	1004	1681	103	935	5238		**8961**
1998	1100	1748	108	958	5220		**9134**
2000	1266	1780	127	997	5224		**9394**
2001	1333	1782	128	1022	5205		**9470**
2002	1416	1764	136	1022	5158		**9496**
2003	1560	1832	164	1027	5160		**9743**
2004	1631	1859	174	1027	5077		**9768**

Table 1: Tankers in operation between '95 and '04

On average (mean) this represents **9245** tankers operating each year between 1995 and 2004, and

Table 2 show the number of incidents that have been experienced for each type over the 1995 - 2004 period. (Appendix A shows the full year by year results)

Notes

1. The extract is based on all seagoing merchant propelled ships of 100 gross tons and above where there is a casualty to the ship or a casualty resulting in a demolition and where there is a fire or explosion or both in the same incident, or a pool file/ vapour cloud explosion. The ship types included are: Oil tankers, oil/chemical tankers and gas tankers.

   Again please note that the difference between a cargo tank explosion, BLEVE and an unconfined vapour cloud explosion are not recorded. Hence these events have been recorded only as "explosion".

2. The categories considered in the search are:

   A) Just a fire (no other incident);
   B) Just an explosion (no other incident);
   AB) Both fire and explosion reported in the event sequence so threat from two sources of harm
   C) Pool/vapour fire
   D) Any fire (including those associated with explosions), (= category A and category AB)
   E) Any Explosion (including those associated with fires), (= category B and category AB)

Note on categories D and E. To get a true understanding of the risk from fire we must include incidents involving just a fire by itself, and incidents that have a fire followed/preceded by an explosion. Similarly to understand how many explosion events people are exposed to we must include incidents recorded as just an explosion plus those incidents where there was both a fire and explosion. This is what categories D and E represent.

3. The Events in terms of severity are defined as follows:

- Event Size 1. Minor incident which has occurred without adversely affecting the structure of the ship or interrupting the ships service schedule. Dealt with by the ship's staff or shoreside staff. No loss of life or pollution reported

- Event Size 2. Serious incident. Structural damage and interruption. Loss of life and/or pollution

- Event Size 3. The ship has been lost or broken up as a result of the incident

Totals all years		Event Size 1	Event Size 2	Event Size 3	Totals
Just Fire on the Ship (A)	No of Incidents	56	76	15	147
Just Explosion in the Ship (B)	No of Incidents	9	23	7	39
Fire and Explosion (or Explosion and Fire) (AB)	No of Incidents	1	40	21	62
Pool Fire (C)	No of Incidents	0	0	1	1
Any fire (including explosion event) (D)	No of Incidents	57	116	36	209
Any Explosion (including fire events) (E)	No of Incidents	10	63	28	101

Table 2: Total Worldwide Number of Incidents '95 – Mar '05

(Note that category D = A + AB, and category E = B + AB)

Hence from Tables 1 and 2 the likelihood of an incident occurring per ship, per year may be calculated. This has been done by taking the average (mean) number of incidents over the 9 year period and dividing by the value for the average (mean) number of ships in operation. (this assumes one incident per ship per year). These results are shown in Table 3.

	Event Size 1	Event Size 2	Event Size 3	Totals
Fire on the Ship (A)	6.73E-04	9.25E-04	1.92E-04	1.79E-03
Explosion in the Ship (B)	1.08E-04	2.76E-04	8.41E-05	4.69E-04
Fire and Explosion (or Explosion and Fire) (AB)	1.20E-05	4.81E-04	2.52E-04	7.45E-04
Pool Fire (C)	0.00E+00	0.00E+00	1.20E-05	1.20E-05
Any fire (including explosion event) (D)	6.85E-04	1.39E-03	4.33E-04	2.51E-03
Any Explosion (including fire events) (E)	1.20E-04	7.57E-04	3.37E-04	1.21E-03

Table 3: Likelihood of an Incident Occurring per Ship, per Year

It is normally expected that frequency will go down when the severity goes up. This is true of things like fire, where you can have a small incident without too much damage. Generally fires (category A) start small and escalate to larger sizes. Emergency response can be implemented, reducing escalation and as would be expected, lowering the occurrence of larger, more damaging fires such as covered by Event Size 3.

However explosions (Category B) by themselves (no fire) tend to immediately cause an intermediate amount of damage – event size 2. Unlike fire there is no escalation from small explosions to large ones. When there are no associated secondary consequences such as fire (and the low occurrence of other incidents such as sinking) the impact does not escalate and is limited to the intermediate category.

The category AB includes incidents where you have both a fire and explosion. These tend to be much worse than just a fire or just an explosion. To have both a fire and explosion implies escalation, problems with incident control, and probably a major event to begin with etc.. Hence when we collect data on such incidents, the larger more serious incidents come out in the results, and there are fewer small incidents.

Likelihood

To understand the likelihood of an incident taking place at Milford Haven the proportion of time that the terminal is exposed to the ship must be calculated. Incidents take place in a variety of circumstances and locations. However it has been pessimistically assumed that all incidents take place when a ship is in the port or entrance channel areas. This is defined as a ship movement.

Ideally a calculation would be made based upon the number of movements at Milford Haven, compared to the total number of ship movements per year. However the total number of ship movements per year is not a readily available figure, hence it has been pessimistically assumed to be on average 30 voyages per year made up of 60 movements (1 terminal at either end of each voyage).

Hence with an average of 9245 tankers this results in an assumed figure of 554700 movements per year worldwide. It is known that Milford Haven has 2747 tanker movements per year. Hence the likelihood of a tanker being at Milford Haven during a movement is:

$$\frac{2747}{554700} = 0.00495$$

Thus the value we are looking for is the likelihood of both an incident taking place, and also the likelihood of a ship being in Milford Haven. To reach this the results in Table 3 are each multiplied by the above value to provide the likelihood of an incident occurring in the Milford Haven area per year. This is show in Table 4.

	Event Size 1	Event Size 2	Event Size 3	Totals
Fire on the Ship (A)	3.33E-06	4.58E-06	9.52E-07	8.86E-06
Explosion in the Ship (B)	5.35E-07	1.37E-06	4.16E-07	2.32E-06
Fire and Explosion (or Explosion and Fire) (AB)	5.95E-08	2.38E-06	1.25E-06	3.69E-06
Pool Fire (C)	0.00E+00	0.00E+00	5.95E-08	5.95E-08
Any fire (including explosion event) (D)	3.39E-06	6.90E-06	2.14E-06	1.24E-05
Any Explosion (including fire events) (E)	5.95E-07	3.75E-06	1.67E-06	6.01E-06

Table 4: Likelihood of an Incident Occurring in the Milford Haven Area per Year

These values have then been transferred into readily understood comparisons.

3. LIKELIHOODS IN LAYMAN'S TERMS

In 2001 the UK's Health and Safety Executive (HSE) published a report entitled "Reducing Risk Protecting People". Within this report guidance is provided on the average annual risk of death (note not injury) from a variety of events. This table is reproduced in Table 5.

Cause of Death	Annual Risk	Statistic	Basis of risk and Source
Cancer	1 in 387	2.58 E-3	England & Wales 1999 [1]
Injury & Poison	1 in 3,137	3.19 E-4	UK 1999 [1]
General Accident	1 in 4,064	2.46 E-4	UK 1999 [1]
Road Accident	1 in 16,800	5.95 E-5	UK 1999 [1]
Lung cancer (from Radon in dwellings)	1 in 29,000	3.45 E-5	England 1996 [2]
Gas incident (all sources)	1 in 1,510,000	6.62 E-7	GB 1994/95-98/99 [3]
Lightning	1 in 18,700,000	5.35 E-8	England & Wales 1995-99 [4]

Table 5: Annual Risk of Death for Various Causes Averaged Over the Entire Population

[1] Annual Abstract of Statistics (2001)
[2] National Radiological Protection Board (1996)
[3] Health and Safety Executive (2000)
[4] Office of National Statistics

To this can be added the general statistics of

- Being scalded at home – 1 in 610 or 1.64 E-3 [6]
- Winning the lottery - 1 in 13,983,815 or 7.15 E-8 [7]
- Being struck by lightning – 1 in 1,870,000 or 5.35 E-7 [5] [6]

[5] US National Oceanographic and Atmospheric Administration
[6] HSE Reducing Risks Protecting People
[7] Lloyd's Register calculation

Although statistics on meteors can be included the likelihood of being hit by one varies hugely depending on the size of the meteor. Secondly the likelihood of injury by a meteor doesn't necessarily require a person to be hit. As such this comparison has not been included.

It should be noted that these comparisons have been included to give an understanding of the likelihood of an incident in readily accepted terms. They are not there to demonstrate that the risks are acceptable or not.

Hence Table 4 can be further modified as shown in Table 6

Event (note not injury or death)	Event Size 1	Event Size 2	Event Size 3	Totals
Fire on the Ship (A)	74 times more likely to be killed in a road accident	54 times more likely to be killed in a road accident	the same likelihood as being struck by lightning	28 times more likely to be killed in a road accident
Explosion in the Ship (B)	the same likelihood as being struck by lightning	179 times more likely to be killed in a road accident	the same likelihood as being struck by lightning	106 times more likely to be killed in a road accident
Fire and Explosion (or Explosion and Fire) (AB)	the same likelihood as being killed by lightning	103 times more likely to be killed in a road accident	197 times more likely to be killed in a road accident	67 times more likely to be killed in a road accident
Pool Fire (C)	negligible	negligible	the same likelihood as being killed by lightning	the same likelihood as being killed by lightning
Any fire (including explosion event) (D)	17 times more likely to be killed in a road accident	9 times more likely to be killed in a road accident	Slightly more likely than being struck by lightning	More likely to die in a road accident
Any Explosion (including fire events) (E)	the same likelihood as being struck by lightning	16 times more likely to be killed in a road accident	Slightly more likely than being struck by lightning	10 times more likely to be killed in a road accident

Table 6 : Comparative Likelihood of an Incident Occurring at Milford Haven per year (Note Comparisons are also Per Year)

If we just look at Event Sizes 3 which covers incidents where the ship has been lost or broken up then this represents an incident large enough to potentially injure people nearby. As such we can come to the following high level statements.

- Experience of just a fire on the ship large enough to potentially injure people nearby is as likely per year as being struck by lightning
- Experience of just an explosion in the Ship large enough to potentially injure people nearby is as likely per year as being struck by lightning
- Fire and Explosion (or Explosion and Fire) – No comment as included below
- A pool fire large enough to potentially injure people nearby is as likely per year as being killed by lightning

- Any fire (including explosion) large enough to potentially injure people nearby is only slightly more likely per year as being struck by lightning
- Any Explosion (including fire) large enough to potentially injure people nearby is only slightly more likely per year as being struck by lightning

Further conclusions that can be made from worldwide data include:

- The likelihood of an LNG incident is extremely low. There has never been a recorded incident of a major release of LNG from a ship to external atmosphere. Similarly no member of the public has ever been injured by LNG from a ship.

These values can then be linked into the event types that may be seen at Milford Haven.

APPENDIX A :
FULL YEAR BY YEAR INCIDENT STATISTICS
(1995 – March 2005)

Fire and Explosion and Releases of Liquid or Gas resulting in Pool Fires or Vapour Cloud Explosions

Year 1995		*Event Size 1*	*Event Size 2*	*Event Size 3*	***Totals***
Fire on the Ship (A)	No of Incidents	14	4	2	20
	DWT	845805	48447	277676	1171928
Explosion in the Ship (B)	No of Incidents	0	1	0	1
	DWT	0	25935	0	25935
Fire and Explosion (or Explosion and Fire) (AB)	No of Incidents	0	2	2	4
	DWT	0	3404	35015	38419
Pool (C)	No of Incidents	0	0	1	1
	DWT	0	0	1660	1660

Year 1996		*Event Size 1*	*Event Size 2*	*Event Size 3*	***Totals***
Fire on the Ship (A)	No of Incidents	9	5	0	14
	DWT	600758	182842	0	783600
Explosion in the Ship (B)	No of Incidents	3	4	0	7
	DWT	63282	487231	0	550513
Fire and Explosion (or Explosion and Fire) (AB)	No of Incidents	0	5	3	8
	DWT	0	23896	21100	44996
Pool (C)	No of Incidents	0	0	0	0
	DWT	0	0	0	0

Year 1997		*Event Size 1*	*Event Size 2*	*Event Size 3*	***Totals***
Fire on the Ship (A)	No of Incidents	10	10	4	24
	DWT	722827	534464	16389	1273680
Explosion in the Ship (B)	No of Incidents	0	4	0	4
	DWT	0	184161	0	184161
Fire and Explosion (or Explosion and Fire) (AB)	No of Incidents	0	11	4	15
	DWT	0	1038733	194196	1232929
Pool (C)	No of Incidents	0	0	0	0
	DWT	0	0	0	0

Year 1998		*Event Size 1*	*Event Size 2*	*Event Size 3*	***Totals***
Fire on the Ship (A)	No of Incidents	6	6	1	13
	DWT	326081	174651	31086	531818
Explosion in the Ship (B)	No of Incidents	1	3	1	5
	DWT	1821	123534	5794	131149
Fire and Explosion (or Explosion and Fire) (AB)	No of Incidents	1	2	0	3
	DWT	3261	97716	0	100977
Pool (C)	No of Incidents	0	0	0	0
	DWT	0	0	0	0

Year 1999		*Event Size 1*	*Event Size 2*	*Event Size 3*	***Totals***
Fire on the Ship (A)	No of Incidents	5	6	1	12
	DWT	411275	136048	30687	578010
Explosion in the Ship (B)	No of Incidents	0	2	1	3
	DWT	0	38988	32737	71725
Fire and Explosion (or Explosion and Fire) (AB)	No of Incidents	0	6	5	11
	DWT	0	263019	119076	382095
Pool (C)	No of Incidents	0	0	0	0
	DWT	0	0	0	0

Year 2000		*Event Size 1*	*Event Size 2*	*Event Size 3*	***Totals***
Fire on the Ship (A)	No of Incidents	2	3	0	5
	DWT	180631	24131	0	204762
Explosion in the Ship (B)	No of Incidents	0	1	1	2
	DWT	0	44993	8366	53359
Fire and Explosion (or Explosion and Fire) (AB)	No of Incidents	0	1	0	1
	DWT	0	2207	0	2207
Pool (C)	No of Incidents	0	0	0	0
	DWT	0	0	0	0

Year 2001		*Event Size 1*	*Event Size 2*	*Event Size 3*	***Totals***
Fire on the Ship (A)	No of Incidents	4	11	2	17
	DWT	392328	602269	2903	997500
Explosion in the Ship (B)	No of Incidents	1	2	3	6
	DWT	91821	11040	252278	355139
Fire and Explosion (or Explosion and Fire) (AB)	No of Incidents	0	6	3	9
	DWT	0	435657	327114	762771
Pool (C)	No of Incidents	0	0	0	0
	DWT	0	0	0	0

Year 2002		*Event Size 1*	*Event Size 2*	*Event Size 3*	***Totals***
Fire on the Ship (A)	No of Incidents	3	7	3	13
	DWT	24460	575711	85755	685926
Explosion in the Ship (B)	No of Incidents	2	2	0	4
	DWT	3833	303395	0	307228
Fire and Explosion (or Explosion and Fire) (AB)	No of Incidents	0	1	0	1
	DWT	0	5353	0	5353
Pool (C)	No of Incidents	0	0	0	0
	DWT	0	0	0	0

Year 2003		*Event Size 1*	*Event Size 2*	*Event Size 3*	***Totals***
Fire on the Ship (A)	No of Incidents	2	7	0	9
	DWT	89481	458052	0	547533
Explosion in the Ship (B)	No of Incidents	2	2	0	4
	DWT	48717	17445	0	66162
Fire and Explosion (or Explosion and Fire) (AB)	No of Incidents	0	4	1	5
	DWT	0	184838	5229	190067
Pool (C)	No of Incidents	0	0	0	0
	DWT	0	0	0	0

Year 2004		*Event Size 1*	*Event Size 2*	*Event Size 3*	***Totals***
Fire on the Ship (A)	No of Incidents	1	17	2	20
	DWT	96765	811871	2414	911050
Explosion in the Ship (B)	No of Incidents	0	2	1	3
	DWT	0	57072	6880	63952
Fire and Explosion (or Explosion and Fire) (AB)	No of Incidents	0	2	3	5
	DWT	0	57050	68327	125377
Pool (C)	No of Incidents	0	0	0	0
	DWT	0	0	0	0