SUB-COMMITTEE ON FIRE PROTECTION
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Agenda item 6

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MEASURES TO PREVENT EXPLOSIONS ON OIL AND CHEMICAL TANKERS TRANSPORTING LOW-FLASH POINT CARGOES

Follow-up study of the cost benefit assessment on application of requirement of Inert Gas Systems to tankers of less than 20,000 DWT

Submitted by Japan

SUMMARY

Executive summary:	This document provides the results of the follow-up study of the cost benefit assessment on application of requirement of IGSs to tankers
Strategic direction:	2.1
High-level action:	2.1.1
Planned output:	2.1.1.1
Action to be taken:	Paragraph 6
Related documents:	FP 51/10/1, FP 52/INF.2, FP 53/5/3 and FP 53/23

Background

1 The Maritime Safety Committee, at its eighty-first session, considered reports on incidents of explosions on chemical tankers and product tankers (MSC 81/8/1 and MSC 81/INF.8), which recommended that the Committee should give consideration to amending the 1974 SOLAS Convention to provide for the application of inert gas systems (IGSs) to new chemical tankers and new product tankers of less than 20,000 DWT (MSC 81/25, paragraph 8.22). The Committee also noted the view that the FSA study and cost/benefit analysis should be carried out before decisions were made (MSC 81/25, paragraph 8.23), and the Committee agreed to refer to the issues related to the proposals on IGSs to the Sub-Committee (MSC 81/25, paragraph 8.30).

2 Following the decision by the Committee, Japan carried out FSA studies on the application of requirements of IGSs to tankers in size categories of 4,000-8,000 DWT and 8,000-20,000 DWT and presented the study results to the Sub-Committee (FP 51/10/1 and FP 52/INF.2).

3 In these FSA studies, a comparison of risks to loss of life – due to accidents involving fire and/or explosion in cargo tanks of tankers of 20,000 DWT and above – was made between the period from 1978 to 1983, during which most of such tankers were not provided with IGSs, and the period from 1990 to 2005, during which such tankers were provided with IGSs under the requirements of chapter II-2 of the 1974 SOLAS Convention. In the studies, the Gross Costs of Averting a Fatality (GCAF) and the Net Costs of Averting a Fatality (NCAF) were calculated for the comparison.

Summary of the follow-up study

4 For the purpose of analysing the previous FSA studies in more detail, the follow-up study was conducted to assess the cost-effectiveness of IGSs for tankers, taking into account that oil tankers and chemical tankers need different types of IGSs. In general, oil tankers require conventional IGSs (CO_2 IGSs), while chemical tankers require N_2 IGSs. Differences of costs relating to different types of IGSs are reflected in the follow-up study. Also, the follow-up study includes the analysis of cost-effectiveness of IGSs conducted for more size categories; 0-2,000 DWT, 2,000-4,000 DWT, 4,000-6,000 DWT, 6,000-8,000 DWT and 8,000-20,000 DWT. Again, the GCAF and NCAF are calculated for each size category. The results of the follow-up study are set out in the annex to this document.

5 The results of the follow-up study indicate that the mandatory application of the requirement of IGSs to 0-8,000 DWT oil tankers and 0-20,000 DWT chemical tankers cannot be justified from GCAF and NCAF standpoints. Also, this study shows that the mandatory application of the requirement of IGSs to 8,000-20,000 DWT oil tankers can be justified from NCAF standpoint, but from GCAF standpoint it is not considered cost-effective.

Action requested of the Sub-Committee

6 The Sub-Committee is invited to note the information set out in the annex.

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ANNEX

FOLLOW-UP STUDY OF COST BENEFIT ASSESSMENT ON THE APPLICATION OF REQUIREMENTS OF INERT GAS SYSTEMS TO TANKERS OF LESS THAN 20,000 DWT

1 General

1.1 In order to calculate risks of fire and explosion based on Lloyd's Register Fairplay (LRFP) database, vessels relating to the study were grouped together. Then, for calculation of Gross Cost of Averting a Fatality (GCAF), Net Cost of Averting a Fatality (NCAF) and Gross Cost of Averting one Ton of Oil Spilled (CATS), tankers are divided into two ship type categories based on types of inert gas systems required; in general, oil tankers require conventional IGSs (CO_2 IGSs), while chemical tankers require N_2 IGSs. These two ship types are considered for five deadweight categories of 0-2,000 DWT, 2,000-4,000 DWT, 4,000-6,000 DWT, 6,000-8,000 DWT and 8,000-20,000 DWT.

The definitions of GCAF, NCAF and $CATS_{-Norway}$ are:

GCAF = $\Delta C / \Delta R$
NCAF = $(\Delta C - \Delta B) / \Delta R$
$CATS_{-Norway} = \Delta C / \Delta RE$ c.f. Norwegian FSA study in FP 53/5/3

where:

- ΔR: safety risk reduction, i.e., reduction of loss of lives over the lifetime of a tanker by the installation of IGSs;
- ΔC: additional costs for the installation of IGSs over the lifetime of a tanker;
- ΔB: economic benefit derived from the installation of IGSs over the lifetime of a tanker, e.g., costs for repair of ships, compensation of lives lost and clean-up of sea pollution, which are thought to be incurred if IGSs were not equipped; and
- ΔRE: environmental risk reduction, i.e., reduction of ton of oil spills over the lifetime of a tanker by the installation of IGSs.

2 Risk Reduction of IGSs (ΔR)

2.1 Table 1 shows the results of the risk analysis for "*all tankers*" (oil tankers and chemical tankers) in size categories of 0-2,000 DWT, 2,000-4,000 DWT, 4,000-6,000 DWT, 6,000-8,000 DWT, 8,000-20,000 DWT and >20,000 DWT, for two separate periods of 1978-1983 and 1990-2007.

2.2 The potential loss of lives (PLL) on "*all tankers*" > 20,000 DWT for the 1990-2005 period was about 18.9 % of that for the 1978-1983 period; the reduction ratio of PLL between these periods is 81.1 % as shown in Table 2. It seems clear that the reduction of PLL was achieved mainly by the installation of IGSs, while such significant reduction of PLL could be attributed to various safety measures implemented after the former period.

2.3 The risk reduction potential of 81.1% is converted into ΔPLL/ship lifetime (ΔR), where lifetime is assumed to be 25 years, for oil tankers and chemical tankers in Tables 3-1 and 3-2, respectively.

3 Gross Cost of IGSs (ΔC)

3.1 The costs of IGSs consist of the initial cost for installation and annual cost for maintenance. Furthermore, the initial cost consists of IGSs equipment prices, installation expense and others (ex. additional generators). Equipment prices differ depending on capability of delivering inert gas to a cargo tank by the requirement of FSS code. Tables 4-1 and 4-2 show lifetime cost (ΔC) of conventional IGSs (CO_2 IGSs) for oil tankers and N_2 IGSs for chemical tankers based on the investigation at shipyards in Japan.

4 Economic Benefit of IGSs (ΔB)

4.1 Elements of Benefit

The economic benefit of IGSs consists of the costs for repair, compensatory payments for lives lost and the costs for clean-up of sea pollution, which are thought to be incurred by cargo tank fire/explosion accidents if IGSs were not fitted. These costs were estimated based on experts' views of shipyards and shipping companies.

4.1.1 Costs for Repair

The repair costs of respective cargo tank fire/explosion accidents are estimated taking into account the brief explanations on damage to ships caused by the accidents in the LRFP database.

4.1.2 Compensatory Payments for Lives Lost

Compensatory payments for lives lost are calculated based on the numbers of lives lost at the respective cargo tank fire/explosion accidents, under the assumption that the compensatory payment is equally 20 million yen per person.

4.1.3 Costs for the Clean-up of Sea Pollution

The cargo oil spill quantity of respective cargo tank fire/explosion accidents is estimated by LRFP database. If any data of ship sunk caused by the accidents is absent in LRFP database, the average oil spill quantity is calculated by taking 5.7% of the deadweight in the same way as the Norwegian study in document FP 53/5/3. Based on the cargo oil spill quantity, the costs for the clean-up of sea pollution are calculated in accordance with the methodology of CATS thresholds (Norwegian study and Japanese proposal) as follows:

- $Cost_{-Norway}$ [US$] = W*6,0000 c.f. FP 53/5/3
- $Cost_{-Japan}$ [US$] = $W*(2{,}5441*W^{-0.34})$ c.f. MEPC 58/17/1 and MEPC 59/17

where:

W: weight of oil spill quantity [ton]

4.2 Lifetime Economic Benefit

Table 5-1 and Table 5-2 show the lifetime economic benefit (ΔB) of IGSs for oil tankers and chemical tankers, respectively.

5 Cargo Oil spill Risk of IGSs (ΔRE)

5.1 Table 6-1 and Table 6-2 show lifetime cargo oil spill risk (ΔRE) of IGSs for oil tankers and chemical tankers, respectively, obtained by the calculation of the costs for clean-up of sea pollution in economic benefit (ΔB).

6 Gross CAF, Net CAF and CATS

6.1 Table 7-1 and Table 7-2 show GCAF, NCAF and CATS (based on Norwegian methodology) of IGSs for oil tankers and chemical tankers, respectively. The values of GCAF for both 0-20,000 DWT oil tankers and chemical tankers are higher than the threshold of 3 million US$. The values of NCAF for 0-20,000 DWT chemical tankers and 0-8,000 DWT chemical tankers are higher than the threshold of 3 million US$. The values of CATS for both 0-20,000 DWT oil tankers and chemical tankers are lower than the Norwegian CATS threshold of 0.06 million US$.

6.2 Thus, the mandatory application of the requirement of IGSs to 0-8,000 DWT oil tankers and 0-20,000 DWT chemical tankers cannot be justified from GCAF, NCAF and CATS standpoints. Also the mandatory application of the requirement of IGSs to 8,000-20,000 DWT oil tankers cannot be justified from GCAF and CATS standpoints, but from the NCAF standpoint it is considered cost-effective.

Table 1: PLL Calculations for "*All tankers*"

Period	DWT	Population [shipyears]	No. of Accidents	Accident Frequency [/shipyears]	No. of Lives Lost	PLL [/shipyears]
1978-1983	0-2,000	7,148	8	1.12×10^{-3}	3	4.20×10^{-4}
	2,000-4,000	5,156	6	1.16×10^{-3}	18	3.49×10^{-3}
	4,000-6,000	3,484	5	1.44×10^{-3}	31	8.90×10^{-3}
	6,000-8,000	991	3	3.03×10^{-3}	5	5.05×10^{-3}
	8,000-20,000	3,296	7	2.12×10^{-3}	10	3.03×10^{-3}
	>20,000	16,869	51	3.02×10^{-3}	328	1.94×10^{-2}
1990-2005	0-2,000	22,808	12	5.26×10^{-4}	29	1.27×10^{-3}
	2,000-4,000	18,703	18	9.62×10^{-4}	29	1.55×10^{-3}
	4,000-6,000	13,091	12	9.17×10^{-4}	11	8.40×10^{-4}
	6,000-8,000	6,728	9	1.34×10^{-3}	13	1.93×10^{-3}
	8,000-20,000	11,416	17	1.49×10^{-3}	46	4.03×10^{-3}
	>20,000	42,071	63	1.50×10^{-3}	155	3.68×10^{-3}

Table 2: Potential Risk Reduction of IGSs for "*All tankers*" of > 20,000 DWT

DWT	PLL 1978-1980 (A) [/shipyears]	PLL 1990-2005 (B) [/shipyears]	PLL reduction ratio (B/A) [%]	Risk reduction potential (1-B/A) [%]
>20,000	1.94×10^{-2}	3.68×10^{-3}	18.9%	81.1%

Table 3-1: ΔR of IGSs for Oil Tankers of < 20,000 DWT

DWT	Population [shipyears]	No. of Accidents	Frequency [/shipyears]	No. of Lives Lost	PLL [/shipyears]	Risk reduction potential	ΔPLL - 25years (ΔR)
0-2,000	18,318	6	3.28×10^{-4}	15	8.19×10^{-4}	81.1%	0.0166
2,000-4,000	13,691	10	7.30×10^{-4}	22	1.61×10^{-3}	81.1%	0.0326
4,000-6,000	10,452	7	6.70×10^{-4}	4	3.83×10^{-4}	81.1%	0.0078
6,000-8,000	2,859	3	1.05×10^{-3}	6	2.10×10^{-3}	81.1%	0.0426
8,000-20,000	5,100	9	1.76×10^{-3}	37	7.25×10^{-3}	81.1%	0.1470

Table 3-2: ΔR of IGSs for Chemical Tankers of < 20,000 DWT

DWT	Population [shipyears]	No. of Accidents	Frequency [/shipyears]	No. of Lives Lost	PLL [/shipyears]	Risk reduction potential	ΔPLL - 25years (ΔR)
0-2,000	4,490	6	1.34×10^{-3}	14	3.12×10^{-3}	81.1%	0.0633
2,000-4,000	5,012	8	1.60×10^{-3}	7	1.40×10^{-3}	81.1%	0.0284
4,000-6,000	2,639	5	1.89×10^{-3}	7	2.65×10^{-3}	81.1%	0.0537
6,000-8,000	3,869	6	1.55×10^{-3}	7	1.81×10^{-3}	81.1%	0.0367
8,000-20,000	6,316	8	1.27×10^{-3}	9	1.42×10^{-3}	81.1%	0.0288

Table 4-1: ΔC of CO_2 IGSs for Oil Tankers of < 20,000 DWT

DWT	Initial Cost [M$]	Annual Cost [M$]	Cost -25years (ΔC) [M$]
0-2,000	0.2586	0.0681	0.3267
2,000-4,000	0.3690	0.0681	0.4371
4,000-6,000	0.4693	0.0681	0.5374
6,000-8,000	0.5595	0.0681	0.6276
8,000-20,000	0.7807	0.0681	0.8488

[M$] : USD in Millions. (@USD/JPY110)

Table 4-2: ΔC of N_2 IGSs for Chemical Tankers of < 20,000 DWT

DWT	Initial Cost [M$]	Annual Cost [M$]	Cost -25years (ΔC) [M$]
0-2,000	0.5512	0.0681	0.6193
2,000-4,000	0.6180	0.0681	0.6861
4,000-6,000	0.7613	0.0681	0.8294
6,000-8,000	0.8902	0.0681	0.9583
8,000-20,000	1.2062	0.0681	1.2743

[M$] : USD in Millions. (@USD/JPY110)

Table 5-1: ΔB of IGSs for Oil Tankers of <20,000 DWT

DWT	Average Cost [M$]	Population [shipyears]	No. of Accidents	Risk reduction potential	Cost-25years [M$]	ΔBenefit - 25years (ΔB) [M$]
	Repair					
0-2,000	6.9697	18,318	6	81.1%	0.0463	
2,000-4,000	5.0909	13,691	10	81.1%	0.0754	
4,000-6,000	9.0909	10,452	7	81.1%	0.1234	
6,000-8,000	8.1818	2,859	3	81.1%	0.1741	
8,000-20,000	12.8283	5,100	9	81.1%	0.4590	
	Lives lost					
0-2,000	0.1818	18,318	15	81.1%	0.0030	
2,000-4,000	0.1818	13,691	22	81.1%	0.0059	
4,000-6,000	0.1818	10,452	4	81.1%	0.0014	
6,000-8,000	0.1818	2,859	6	81.1%	0.0077	
8,000-20,000	0.1818	5,100	37	81.1%	0.0267	
	Clean-up (Norway)					
0-2,000	45.1686	18,318	2	81.1%	0.1000	0.1493
2,000-4,000	8.6646	13,691	2	81.1%	0.0257	0.1070
4,000-6,000	17.3958	10,452	2	81.1%	0.0675	0.1923
6,000-8,000	21.1151	2,859	1	81.1%	0.1497	0.3315
8,000-20,000	41.1415	5,100	3	81.1%	0.4907	0.9764
	Clean-up (Japan)					
0-2,000	1.7810	18,318	2	81.1%	0.0039	0.0532
2,000-4,000	0.6751	13,691	2	81.1%	0.0020	0.0833
4,000-6,000	1.0730	10,452	2	81.1%	0.0042	0.1290
6,000-8,000	1.2195	2,859	1	81.1%	0.0086	0.1904
8,000-20,000	1.8757	5,100	3	81.1%	0.0224	0.5081

[M$] : USD in Millions. (@USD/JPY110)

Table 5-2: ΔB of IGSs for Chemical Tankers of <20,000 DWT

DWT	Average Cost [M$]	Population [shipyears]	No. of Accidents	Risk reduction potential	Cost-25years [M$]	ΔBenefit - 25years (ΔB) [M$]
	Repair					
0-2,000	5.8333	4,490	6	81.1%	0.1580	
2,000-4,000	4.0682	5,012	8	81.1%	0.1317	
4,000-6,000	6.7273	2,639	5	81.1%	0.2584	
6,000-8,000	6.4394	3,869	6	81.1%	0.2025	
8,000-20,000	16.7614	6,316	8	81.1%	0.4304	
	Lives lost					
0-2,000	0.1818	4,490	14	81.1%	0.0115	
2,000-4,000	0.1818	5,012	7	81.1%	0.0051	
4,000-6,000	0.1818	2,639	7	81.1%	0.0098	
6,000-8,000	0.1818	3,869	7	81.1%	0.0067	
8,000-20,000	0.1818	6,316	9	81.1%	0.0053	
	Clean-up (Norway)					
0-2,000	3.8920	4,490	1	81.1%	0.0176	0.1871
2,000-4,000	14.7600	5,012	1	81.1%	0.0597	0.1965
4,000-6,000	19.7779	2,639	1	81.1%	0.1520	0.4202
6,000-8,000	23.5296	3,869	1	81.1%	0.1233	0.3325
8,000-20,000	30.2552	6,316	2	81.1%	0.1942	0.6299
	Clean-up (Japan)					
0-2,000	0.3995	4,490	1	81.1%	0.0018	0.1713
2,000-4,000	0.9628	5,012	1	81.1%	0.0039	0.1407
4,000-6,000	1.1680	2,639	1	81.1%	0.0090	0.2772
6,000-8,000	1.3098	3,869	1	81.1%	0.0069	0.2161
8,000-20,000	1.2803	6,316	2	81.1%	0.0082	0.4439

[M$] : USD in Millions. (@USD/JPY110)

Table 6-1: ΔRE of IGSs for Oil Tankers of <20,000 DWT

DWT	Average Oil spill [t]	Population [shipyears]	No.of Oil spill accident	Risk reduction potential	ΔOil spill - 25years (ΔRE) [t]
0-2,000	753	18,318	2	81.1%	1.6669
2,000-4,000	144	13,691	2	81.1%	0.4265
4,000-6,000	290	10,452	2	81.1%	1.1251
6,000-8,000	352	2,859	1	81.1%	2.4963
8,000-20,000	686	5,100	3	81.1%	8.1816

[M$] : USD in Millions. (@USD/JPY110)

Table 6-2: ΔRE of IGSs for Chemical Tankers of <20,000 DWT

DWT	Average Oil spill [t]	Population [shipyears]	No.of Oil spill accident	Risk reduction potential	ΔOil spill - 25years (ΔRE) $[t]_{Norway}$
0-2,000	65	4,490	1	81.1%	0.2935
2,000-4,000	246	5,012	1	81.1%	0.9951
4,000-6,000	330	2,639	1	81.1%	2.5353
6,000-8,000	392	3,869	1	81.1%	2.0542
8,000-20,000	504	6,316	2	81.1%	3.2358

[M$] : USD in Millions. (@USD/JPY110)

Table 7-1: GCAF, NCAF and CATS of IGSs for Oil Tankers of <20,000 DWT

DWT	ΔR	ΔC [M$]	ΔB		ΔRE $[t]_{Norway}$
			$[M\$]_{Norway}$	$[M\$]_{Japan}$	
0-2,000	0.0166	0.3267	0.1493	0.0532	1.6669
2,000-4,000	0.0326	0.4371	0.1070	0.0833	0.4265
4,000-6,000	0.0078	0.5374	0.1923	0.1290	1.1251
6,000-8,000	0.0426	0.6276	0.3315	0.1904	2.4963
8,000-20,000	0.1470	0.8488	0.9764	0.5081	8.1816

DWT	GCAF (ΔC/ΔR) [M$]	NCAF ((ΔC-ΔB)/ΔR)		$CATS_{-Norway}$ (ΔC/ΔRE) $[M\$/t]_{Norway}$
		$[M\$]_{Norway}$	$[M\$]_{Japan}$	
0-2,000	19.6807	10.6867	16.4759	0.1960
2,000-4,000	13.4080	10.1258	10.8528	1.0249
4,000-6,000	69.8974	44.2436	52.3590	0.4776
6,000-8,000	14.7324	6.9507	10.2629	0.2514
8,000-20,000	5.7741	-0.8680	2.3177	0.1037

[M$] : USD in Millions. (@USD/JPY110)

Table 7-2: GCAF, NCAF and CATS of IGSs for Chemical Tankers of <20,000 DWT

DWT	ΔR	ΔC [M$]	ΔB		ΔRE $[t]_{Norway}$
			$[M\$]_{Norway}$	$[M\$]_{Japan}$	
0-2,000	0.0633	0.6193	0.1871	0.1713	0.2935
2,000-4,000	0.0284	0.6861	0.1965	0.1407	0.9951
4,000-6,000	0.0537	0.8294	0.4202	0.2772	2.5353
6,000-8,000	0.0367	0.9583	0.3325	0.2161	2.0542
8,000-20,000	0.0288	1.2743	0.6299	0.4439	3.2358

DWT	GCAF (ΔC/ΔR) [M$]	NCAF ((ΔC-ΔB)/ΔR)		$CATS_{-Norway}$ (ΔC/ΔRE) $[M\$/t]_{Norway}$
		$[M\$]_{Norway}$	$[M\$]_{Japan}$	
0-2,000	9.7836	6.8278	7.0774	2.1101
2,000-4,000	24.1585	17.2394	19.2042	0.6895
4,000-6,000	15.4451	7.6201	10.2831	0.3271
6,000-8,000	26.1117	17.0518	20.2234	0.4665
8,000-20,000	44.2465	22.3750	28.8333	0.3938

[M$] : USD in Millions. (@USD/JPY110)

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