The Federation of European Marine Associations of Surveyors and Consultants

FEMAS NEWSLETTER

Spring 2010

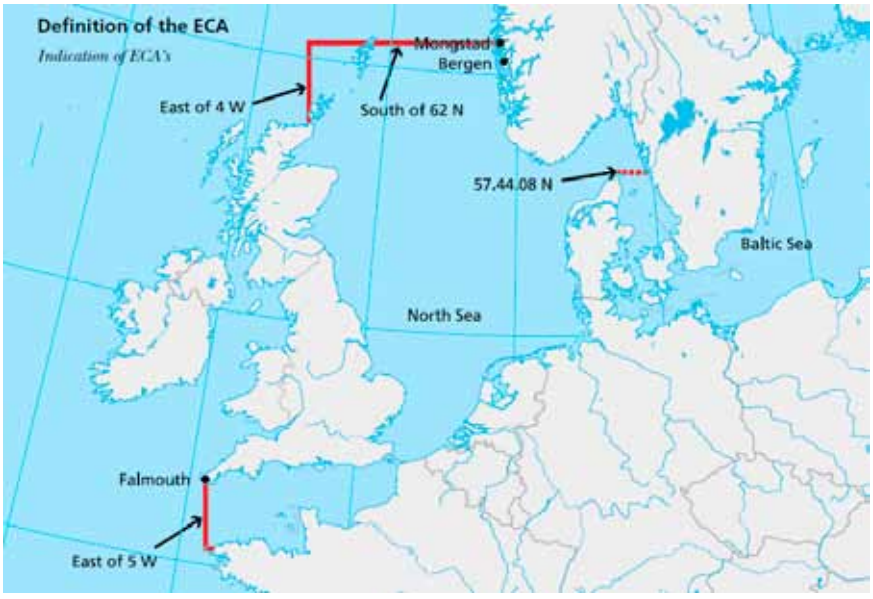
Implementation of Low Sulphur Fuels in sea-going and inland shipping in the EU

By Henk Arntz, NIVRE

The European Union adopted directive 98/70/EG dealing with reduction of emissions, especially where inland shipping exhaust gas emissions are concerned. This directive together with EU Directive 1999/32/EC and 2005/33/EC amendments required reduction of gas oil sulphur level to a maximum of 10 ppm as per 1st of January 2010 for coastal waters, ports and inland navigation. EU Directive 2009/30/EC of 23rd April 2009 however resulted in postponement of implementation of low sulphur gas oil with a sulphur level of maximum of 10 ppm for inland navigation until 1st of January 2011.

Originally the European Committee in improving emission of inland navigation a few years ago intended to introduce one type of low sulphur fuel spec, being the EN590. However, this was let loose and the final directive only gives limits to the maximum sulphur content in gas oil for inland shipping being maximum 10 ppm or 0.1 % m/m.

Seagoing vessels will, as per 01-01-2010 due to various international and regional legislation by the European Union directive 2005/33/EC, the California Code of Regulations title 13/17 and MARPOL (the International Convention for the Prevention of Pollution from Ships 1973) Annex VI, be required to apply to low sulphur fuel requirements in the Sulphur Emission Control Areas (SECA). The indication of this area in the European region is show on below map.



The new directives require the following with respect to low sulphur fuels;

low sulphur of any grade of fuel used in EU community ports, at berth, means sulphur less than 0.1% after 01-01-2010

low sulphur MDO under Californian regulations means sulphur less than 0.5% (0.1% after 01-01-2012)

low sulphur MGO under Californian regulations means sulphur less than 1.5% (0.1% after 01-01-2012)

low sulphur of any grade in IMO-regulated Emission Control Areas (ECA) means sulphur less than 1.50% prior to 01-07-2010

low sulphur of any grade in IMO-regulated Emission Control Areas (ECA) means sulphur less than 1.00% after 01 -07-2010

low sulphur of any grade in IMO-regulated Emission Control Areas (ECA) means sulphur less than 0.10% after 01-01-2015

The impact for seagoing vessel with respect to changing over to low sulphur fuel in the SECA areas is much more extensive than for inland vessels which per 01-01-2010 have to change to fuel with a maximum sulphur level of 0.2 to 0.1 % m/m, but are not confronted in having to change over frequently from different types of fuel due to the area they operate in.

Ships using separate fuel oils are required when entering or leaving an Emission Control Area to carry a written procedure showing how the fuel oil changeover is to be done, allowing sufficient time for the fuel oil service system to be fully flushed of all fuel oils exceeding the applicable sulphur content prior to entry into an Emission Control Area. Change over procedures need to be documented in a logbook. In the logbook volume of low sulphur fuel oils in each tank, date and time, ship's positions at the start and completion of changeover must be recorded.

Change-over between heavy fuel oil grades is standard practice and so is change-over from heavy fuel oil to marine diesel oil in connection with e.g. dry-dockings.

Changeover from heavy fuel oil to marine gas oil is however completely different and clearly not common standard. If gas oil is mixed in while the fuel temperature is still very high, there is a high probability of gassing in the fuel oil service system with subsequent loss of power.

The experience in terms of low sulphur residual (or heavy) fuel oil blending is varying. Indications are seen that the blending of low sulphur fuel oils may lead to additional quality problems such as instability, incompatibility, ignition and combustion difficulties and an increase of Aluminium and Silicon levels due to use of different low sulphur blend components. Regrettably one has also seen cases where chemical waste has been introduced in such fuel. In light of the required demand for low sulphur fuel oils, there have also been concerns over the potential increase of sulphur content in high sulphur fuel oils.

Ship operators should assure that the LSFO (Low Sulphur Fuel Oil) oil is compatible with the HSFO (High Sulphur Fuel Oil) by sending a representative sample of each fuel oil quality to a fuel oil testing company. Blending high-density fuel oil with low-density fuel gives the highest risk of incompatibility, while blending two low-density fuel oils represents the lowest risk. The blending ratio should in any case be as small as possible.

The consequence for seagoing vessels has not only an impact on changeover procedures but also on use and choice of lube oil TBN level and the technical consequences thereof.

High total base number (TBN) lube oil in combination with low-sulphur fuel increases the risk of scuffing on the cylinder liner. The deposits are more solid when less oil TBN additives are neutralised by sulphuric acid. Therefore careful monitoring of the cylinder liner condition when operating on low sulphur fuel oil, and if necessary change to low TBN cylinder oil or reduce the feed rate in accordance with the engine makers recommendations will be required.

Apart from consequences for the propulsion installation also boilers and exhaust gas cleaning systems on board seagoing vessels will be affected by the use of low sulphur fuel and will require technical adaptations as well as review of cleaning and maintenance procedures in order to avoid increase of damage risks.

Boilers are the component most at risk when switching over from HFO to use 0.1 % sulphur Medium Diesel Oil (MDO). Boilers on board can be divided in 3 categories: “small”; “large” boilers and boilers used for propulsion.

Small boilers are installed on board all types of vessels and can run purely on MDO. However an assessment for each boiler is advisable and most probably modification will be required.

Large boilers are commonly installed on tankers to produce steam for cargo operations. As for all other boilers, individual assessments will be also needed before modifications.

Boilers used for main propulsion, shipboard electricity generation and cargo operations. This type of boiler is commonly fitted on board LNG carriers. These also will require extensive modifications in order to be able to run on low sulphur fuel without increasing wear and damage risks.

From research carried out it can be concluded that:

Due to the hydrodesulphurisation (HDS) process for reducing the sulphur level from the basic crude oil in the refinery process, the lubricity is reduced. This reduction in lubricity properties is compensated by adding lubricity additives during the refinery process. Low sulphur fuel should have an anti friction property indicating a wear scar diameter of less than 460 μm at 60°C under the condition of test, in order to guarantee a fuel lubricity which is satisfactory for use with old and new fuel pumps.

Elastomeric compatibility of low sulphur gas oil is slightly different. Basically sulphur free gas oil has a lower impact on the elastomers which might result in some fuel system seals in some engines which have always been running with higher sulphur grades gasoil might pose a problem when switching to sulphur free gas oil.

The typical engine wear issues of cylinder liner lacquering and bore polishing are expected to improve with the use of low sulphur gas oil due to the more complete combustion. The sensitive balance between operation conditions and lubrication oil in preventing this phenomena, as experienced in several engines, may need a new adjustment by testing other engine oil or cylinder oil formulations.

The switch to low sulphur gas oil will have an impact on the average fuel density. As a consequence fuel consumption will increase by some 0.5 % and maximum power output will be reduced by some 0.5 %.

On 4-stroke engines reduced density results in reduced energy content per stroke of fuel pump, reduced output at any fuel rack position. Depending on the 4-stroke engine type, the actual difference in output between LFO and HFO can typically be approx. 6-15 %, considering also the leakage due to low viscosity. This tendency may be further aggravated in older engines due to wear in the injection pumps.

On 2-stroke engines in general, pump index limitations are not an issue regarding application of different fuel qualities. But when running on distillate fuel a slightly higher pump index can be expected compared to HFO operation. This adaptation is made automatically by the speed governor. The injection pumps as well as torque limiter and charge air limiter however have sufficient margin for safe engine operation. However, during exceptional conditions, such as a combination of an old engine with worn injection pumps, inappropriate adjustments, extreme weather and distillate fuel, these limiting devices may limit the available power. In case of doubt it is prudent to check the engine in case operation on distillate fuel in rough sea areas is foreseen (especially in case of small container ships).

On smaller 4-stroke engines most frequently used in the inland navigation, the “modern” engines with common rail systems low density will have only limited effect on the engines output. This will however in the older types be more of an issue.

The blending of up to 5% or even 7% V/V Bio fuel which

most probably will be the case in inland shipping fuel and which is common practice in automotive diesel, will increase fuel consumption by another 0.5 % and require additional maintenance discipline to prevent fuel system fouling and deposit formation.

Bio fuel blend might also cause problems for onboard heating systems. Problems such as with seals, hoses and deposit formation. This can lead to a safety problem.

Low sulphur gas oil will, due to its low flashpoint, on seagoing vessels have a negative impact on boiler burner flame pipes. These require to be replaced by ceramic pipes to avoid "metal dusting". Metal dusting is a severe form of corrosive degradation of metals and alloys at high temperatures (300-850°C) in carbon-supersaturated gaseous environments. Fe, Ni and Co, as well as alloys based on these metals are all susceptible. The corrosion manifests itself as a break-up of bulk metal-to-metal powder - hence the term, metal dusting. Also, when low flashpoint fuels are being atomised with the help of steam, there is a chance that the fuel will evaporate before entering the boiler because of the steam temperature. Condensation of the atomizing steam may also be experienced when the steam gets in contact with cold MGO. This may lead to poor combustion, an irregular burner flame or even flame extinction.

In general, low sulphur fuel will result in a cleaner combustion and emission, a cleaner engine, a somewhat higher fuel consumption and risk of fuel system components wear for older engines if fuel without lubricity additives is used, there is a possible risk of clogging in fuel systems when mixing with bio fuel and risk of fuel system seals leakage. None of these should result in severe problems when care and attention is paid to the implementation of low sulphur fuel, its quality, correct modification of fuel systems of "older" engines, correct adjustment of lube oil specification and adjustment of change over procedures.

More detailed information on this subject can be found on the IVR website www.ivr.nl

Erika - The Continuing Story

As President of UPEM, I'm very pleased to introduce the very interesting article written by our friend Henry Monasterolo in the continuation of the Erika's judgments.

Henry is a 1st Class Marine Engineer and holder of Master degree in Maritime Law as well. We are now waiting with curiosity the next step of this saga with the sentence expected from the Court of Appeal in 2010 and indeed the acute comments from Henry Monasterolo.

Frédéric Beaugrand
President of UPEM

A few words about the latest ERIKA sentence : Decision n° 1317 of 17th December 2008 by the Supreme Court, Third Common Chamber

By Henry Monasterolo, UPEM

Foreword

A copy of the documents in the French language cited hereafter may be emailed on request. They may also be found written in a number of languages on the Web Site http://eur-lex.europa.eu/fr/index.htm (*replace /fr/ with your own language*).

- The Court of Appeal is an intermediate Court in the French Justice Organisation. Its sentences rely on facts and evidences.

- The Supreme Court is the ultimate one. Its decisions do not rely on facts and evidences, but on whether the sentences of the lower Courts are in conformity with the French Laws.

- Cour de Justice des Communautés Européennes **CJCE** : Court of Justice of the European Com- munities. This Court is the ultimate Authority to "say the law" in the conflicts which may arise between the Union Members, or within an Union Member in such claims that could infringe The Union Rules or the European Convention of Human Rights. It may also give its advice (article 234 CE) when questioned by a national judge about how to consider a Rule BEFORE giving out a valuable judgement (which is indeed the case in the present sentence).

- The study presented in the first issue of FEMAS Newsletter, which commented the judgement of Tribunal de Grande Instance de Paris on 16th January 2008, concerned a different aspect of the ERIKA case.

The Actors

- City of COSQUER, Plaintiff, which claimed that TOTAL (both Seller and Charterer in two different Companies) should indemnify the costs generated by cleaning and de-polluting the City territory.

- TOTAL Oil Companies, Owner of fuel oil and Charterer of ERIKA.

- Supreme Court of France, which submitted the problem to CJCE - Court of Justice of the European Communities CJCE.

- Court of Appeal of RENNES which rendered on 13th February 2002 the sentence objected by the City of Cosquer (the Court dismissed the claim, considering that the heavy fuel was NOT a waste).

The questions before rendering its decision, the Supreme Court requested the interpretation of CJCE on the questions put to it by the City of Cosquer :

- Should the Heavy Fuel carried by M/T "ERIKA" be considered as waste after it was spread over the waters in consequence of sinking? - If the Heavy Fuel became a waste at that moment, should the liability of the holder of this waste be admitted?

- Henceforth should TOTAL, who was Owner of the Waste and Charterer of the tanker, be condemned to indemnify the claimant?

The Legal Ground

Convention on civil liability for damages due to oil pollution (Brussels 29th November 1969, London Protocol 27th November 1992). Convention for an International Fund to indemnify the damages due to oil pollutions (Brussels 18 December 1971, London Protocol 27th November 1992) FIPOL.

Directive 75/442/CEE of the Council of 15th July 1975 regarding the wastes. Decision 96/350/CE of the Commission of 24th May 1996 on the same subject. Annexes IIA and IIB amending the Directive 75/442/CEE of the Council. French law nr 75-633 of 16th July 1975 regarding the wastes, now included in the Environment Code art. L 541-2.

A - Court of Justice of the European Communities

On 17th December 2008 the precautionary questions of the Supreme Court were given the following answers by CJCE (comments which follow have been considerably shortened to remain within the frame of this Newsletter) :

1 - CJCE first considered the objection of TOTAL, which contended that the City of Cosquer was not entitled to proceed with the claim since it had already been indemnified by FI- POL. CJCE admitted that it was the responsibility of the national Authority to appreciate this point. Since the questions were connected to the "ERIKA" event, CJCE could not refuse its advice.

2 - CJCE then opined that a heavy fuel sold as merchant fuel could not be considered as a waste, since it may be a source of profit for the seller and does not need a prior treatment. CJCE further declared that a Waste is a substance enumerated in Annex I of the Directive 75/442, that the holder plans to, or is compelled to get rid off. The difficulty remains to understand the lawful meaning of "getting rid off", both within the context and within the environmental rules.

3 - CJCE also considered that petroleum oils accidentally released at sea as a result of a vessel sinking become Wastes in the light of article 1-a of Directive 75/442 since they are no longer merchant fuel unless re-treated. Also, such oils shall be then considered after the sinking, as substances that their holder, even though having no intention to generate them, is getting rid off and are subsequently Wastes as per Directive 75/442. Ultimately it does not matter if the sinking occurred in the economical area of a Member State, since the oil drifted and settled on the coastal territory of this State.

4 - Ultimately CJCE stated that, giving due consideration to article 15 of Directive 75/442 dealing with accidental oil pollution at sea resulting in coastal oil pollution of a Member State :

- The national Judge may designate the Seller of the Fuel and the Charterer of the vessel as Producer of the waste, which means in turn "prior Holder", **under** the **condition** that this Seller-Charterer contributed to the pollution, in particular if he failed to take every pertinent measure to prevent the incident by selecting an appropriate vessel. Said CJCE : the national Judge is the only Authority able to conclude in that way in the light of the evidences in hand.

- If the costs of eliminating the waste is not covered by FIPOL or is beyond the contractual indemnity AND if the national Right of a Member State prevents the Ship Owner or Charterer to be charged with these costs even though they are said "Holder" according to Directive 75/442, then that Right should allow to charge these costs to the Producer of the Fuel which generated the waste, **under** the same **condition** as above.

B - Decision of the Supreme Court

The position of CJCE on the precautionary questions put forward by the Supreme Court served the latter to render its decision as follows :

1 - The Court agreed that the Heavy Fuel carried by ERIKA was not a waste fuel.

2 - The Court confirmed that the oil cargo was held by the Owner of ERIKA as soon as it was loaded on board. Therefore TOTAL was no longer the responsible Holder and the article 1384 of the French Civil Code was inapplicable (*this article deals with the liability borne by the Holder of a thing*).

3 - The Court was satisfied that the objectives of Directive 75/442 were also those of the article L 541-2 of the French Environment Code, in particular where it is clear that the Holder of waste stuff detrimental to Human health and Environment, should stand the costs of eliminating every consequence of the pollution by the waste.

At that stage the Supreme Court referred to the sentence of the Court of Appeal of Rennes, which declared that TOTAL could be considered as neither Producer nor Holder of the oil waste, for it sold a fuel which became waste as a result of its transportation. It appeared to the Court that the sentence omitted to consider whether TOTAL as Seller/Charterer, did not fail to take every pertinent measure to prevent the pollution by selecting an appropriate vessel and if so, if it did not become the prior Holder of the waste.

Such an omission was a sufficient reason to declare that the **sentence** was **wrong**, but only when it ungroundly concluded that TOTAL was not the Holder of the Heavy Fuel and dismissed the City of COSQUER on this unverified ground. As a result, the Supreme Court sent the Parties before the Court of Appeal of Bordeaux, in order to be judged again in the light of its own conclusions.

C - Temporary conclusion

The sentence expected from the Court of Appeal shall be commented as soon as it is known, likely during 2010. Already the opinion of CJCE may be considered as a half good new by all substance Producers and Charterers, who shall bear the costs of removing every pollution caused by their stuff after it became a waste according to EU Directives and national Laws, ONLY if they contributed to the pollution. And here begins the problem : define contribution !

We shall learn from the expected sentence how TOTAL

failed to prevent the pollution. But the following question must be first answered : which TOTAL failed ? It cannot be TOTAL Producer since the Courts agreed that the quality of the heavy fuel was fair and could not contribute to the vessel sinking. Then it can be TOTAL Charterer who selected a vessel whose improper condition contributed, if not generated, to the sinking.

In that latter case, TOTAL was party to that infringement to a safe carriage of goods and should be condemned together with the Owner. The previous judgment of Tribunal de Grande Instance of 16th January 2008 did it and added "*in solidum*". This practically means that TOTAL should pay ALL expenses... See the comments about *deep pocket* in FEMAS Newsletter nr 1.

Digging further into the concept of liability leads to ask whether TOTAL Charterer knew the improper condition of the tanker or ignored it. If it knew it and nevertheless chartered it willingly, then it committed a gross negligence and should indemnify all victims; here the due indemnities are NOT limited by whatever international Convention including FIPOL; TOTAL may also be suited before a criminal Court. Adversely if it ignored that the tanker was improper for carriage, it committed a professional fault and should again indemnify the victims; this time the due indemnities may be limited by the international Convention and FIPOL.

If this is the sentence to come from the Court of Appeal, it shall be interesting to check whether the indemnities already paid by FIPOL to City of Cosquer, which accepted them against dismissing of their claim, are taken into consideration. If not, the sentence shall threat the foundation of the Convention and FIPOL limitation of indemnities, for no Carrier (Producer, Charterer, Owner) and no Insurer shall be able to safely include in their schedules and accounts such an unlimited risk, since all substances carried by sea are susceptible of becoming waste.

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What is presently a "Market Value" for Container Vessels?

By Dipl.-Ing. Gerd Weselmann, (VDKS)
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Until October 2008 estimating the value of a ship was mainly based on recent sales being concluded and on the time charter development, the earning possibilities of the vessel. For all types of vessels there was an open market between "willing buyer" and "willing seller" with enough comparable sales.

Since autumn 2008 the market, especially for bulk carriers and container vessels has collapsed. As during the recent months time charter rates for bulkers and consequently also the values have slightly recovered, for container vessels the situation is still terrible, with the only hope that at least the bottom has been reached.

Due to this very poor earning possibility presently there are almost no sales and purchase activities and with no open and active market existing between "willing buyer" and "willing seller" as on the present level there is definitely no "willing seller".

Since January 2009 until now only 24 container vessels younger than 10 years have been sold, whereof only 7 vessels were above 2.000 TEU capacity. It can be assumed that all these sales have not been concluded voluntarily, but that all sellers had been forced to sell by banks, cash flow problems etc.

Presently the possible time charter rates for container vessels are sometimes below OPEX cost. Taking the level mid 2008 as 100 % - beginning of 2010 time charter rates for small vessels below 2,000 TEU have dropped to as low as 35-40 % and for vessels above 2,000 TEU to even 20-25 %.

How shall an appraiser or broker presently estimate the market value of a container vessel, knowing that there is no open sale and purchase market existing but also considering that financing banks are requesting a value which could be achieved on such an open market. Should a value eventually be estimated according to the extremely low level of the time charter rates? This would definitely lead to a collapse of the shipping industry as at all banks the loan to value ratio would immediately request fresh money from the owners, which definitely would cause big problems.

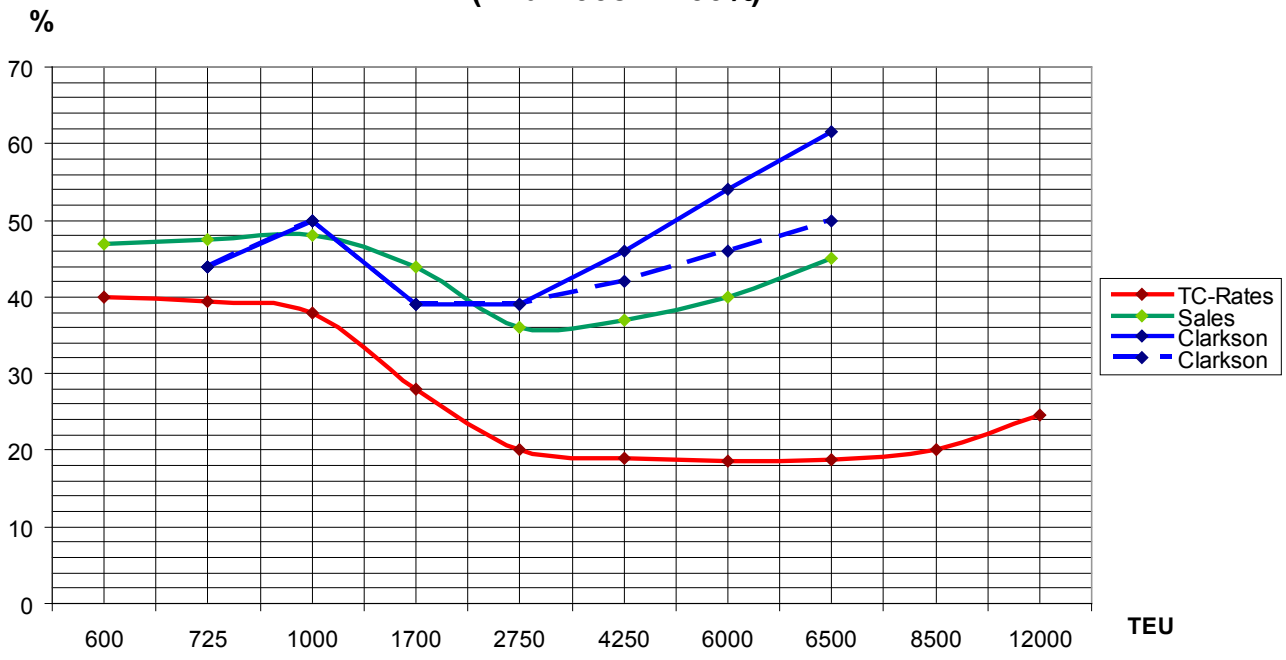
Development of Time Charter Rates and Market Values

Vessels 3 years old

	1.700 TEU		2.750 TEU		4.250 TEU	
	TC-Rates $	Value $	TC-Rates $	Value $	TC-Rates $	Value $
1985		21.3				
2005	25,600	39.4	33,600	44.4	42,300	62.5
mid 2008	15.350	43.4	24,400	45.0	34,000	77.7
Jan. 2010	4,200	? ?	4,500	? ?	6,500	? ?
% drop	27%	11.7	18.5%	10.7	19 %	14.8
10-years average	14,750	27.25	21,200	37.9	29,500	51.7
sales		16-18.5		24-25		-

The table shows the development of values and 12-months time charter rates over several years until now. It also shows that estimating the value of a container vessel in relation to the present time charter rates is not possible and gives far too low figures.

Development from mid 2008 to January 2010
(mid 2008 = 100%)



This graph shows the development of time charter rates (red curve) and of the very few sales (green curve) in relation to the level of mid 2008.

As explained we consider these sales are "forced sales" as presently there is no open market existing between "willing buyer" and "willing seller".

Like almost all brokers we had suspended appraisal of container vessels from October 2008 as there was no market existing.

As the economy and shipping crises is lasting already since almost 1 ½ years a method at least to give an indication for the market value has to be found.

Since beginning January 2010 also Clarkson started again to publish values for container vessels. The blue curve in the graph is showing these figures and it makes clear that Clarkson is just estimating at the level of the very few concluded sales.

As these sales have not been agreed on an existing open market we think the expected future improvement of the market (it will definitely come, however nobody knows when and to which level) has not been taken enough into consideration.

Our opinion is that the concluded sales are representing "prices" but not "market values" of the vessels.

What kind of emergency tool can be used during the present situation where the traditional way of ship evaluation alone leads to misleading and sometimes destructive results?

One way is to take an additional look at the average value over the past 10 years. The boom years 2005-2008 are included but also the poor years 2001/2002. Using this way in 2010 it also includes the extremely low level of 2009.

Additionally during the recent months the Hamburg shipbrokers in cooperation with Pricewaterhouse-Coopers, appraisers and banks have developed the "Long Term Asset Value" (LTAV). It is an economy and investment calculation over the remaining life time of the vessel with certain assumptions for financing cost, OPEX and development of possible earnings. Presently the calculation assumption for the 12-months TC-rate is that it will remain on the present low level for the next 2 years, followed by slow increase to the average level of the past 10 years.

We know, and point it clearly out to all banks, ship owners etc. that this so calculated figure is not representing the market value of the vessel. As the LTAV is working with historical figures in the present depressed market the calculated results are definitely above market values, but during the boom years 2005-2008 the LTAV results would have been significantly below market values.

Both described emergency tools are not representing a method to estimate the market value but they are an additional help to the acting appraiser.

Only with his long year experience together with intensive market observation and investigation into future economy and shipping improvement presently a value for container vessels can be estimated, which however should definitely be above the present level of the very few concluded forced sales. How much it should be above this level is however depending on whether the appraiser is an optimist or pessimist.

Early Steamships

By Dimitri G. Capaitzis, HMTCA

Sail and Steam, Wood and Iron

The early 19th century saw some revolutionary changes in shipbuilding. Steam instead of sail started being used for propulsion and iron instead of wood for ships' hulls.

Some of the early successes were the 'Charlotte Dundas', a wooden tugboat with a Symington steam engine on the Clyde in 1801, Fulton's 'Clermont', a steam ferry on the Hudson River in 1807, Bell's 'Comet' ferryboat on the Firth of the Forth and Marc Brunel's 'Regent' on the London to Margate run, both in 1812. The American 'Demologos', a steam warship commissioned in 1816, with a paddle wheel on the inside between two wooden hulls and 26-32 pound guns, 153 feet long, 1450 tons displacement, 5.5 knots, never saw action in war. The 'Aaron Manby' a paddle steamer in 1820 was the first iron ship while the American 'Savannah' in 1819 and the Dutch 'Curacao' in 1824 both crossed the Atlantic, with part sail and part steam propulsion, respectively in 24 and 28 days.

The Greeks, then fighting for Independence, were among the pioneers in the use of steam and iron warships. In 1825 they ordered the 'Karteria' to be built by Brent at Deptford on the Thames and her steam engines by Galloway at Smithfield. She was completed in May 1826. On her voyage to Greece she sustained boiler breakdowns, put up in Sardinia for repairs and finally reached Nafplion in September 1826.

She was built at the instigation of the great English Philhellene Frank Abney Hastings, who inspired the design, helped in the construction and captained the ship on her passage and in war. The 'Karteria' took part in many successful battles at Oropos, Volos, Salona, Aitoliko and was the first ever steamship to do battle.

The 'Karteria' was rigged as a four masted schooner 126 ft long, 25 ft wide and 233 tons displacement. Her coal-fired boilers fed steam to her 2x85HP engines that ran at sixteen revolutions a minute driving port and starboard paddle wheels and a speed of 7 knots.. Her original armament was one thirty two pound gun forward and one aft, and one sixty eight pounder on each side. After a first shot from the bow, the ship could be turned in a tight circle by her paddle wheels for each gun to fire in turn with red hot shot, which was lethal for the enemy wood and sail ships. She moved usually under sail and the steam engines were used primarily in action. Her crew was about 180 men.

In 1833 the 'Royal William' was the first ship to cross the Atlantic on steam and paddle wheels alone, while the 'Archimedes' in 1838 was the first steamer driven by a propeller, which showed a gain on efficiency over paddle wheels. The concept of steam gunboats was adopted by the British Navy only in the Crimean War in the early 1850's.

These were the early days of discovery, invention and engineering. Individuals with vision and tenacity and with the tools of science and materials developing with the industrial revolution took it upon

themselves to coordinate and invent new things. In ships these new monsters or wild beasts, as many then called them, gradually developed into workable and efficient machines and vehicles that were to change the world.

Isambard Brunel and William Froude

These were times of new ideas, innovation and development. Iron and steam had started a revolution in ship design. It took the genius of a great engineer of the day to give it a significant boost and liberate it from the conventional wisdom and the very conservative attitudes of the establishment of the time.

Isambard Kingdom Brunel, whose bronze statue stands on the Thames Embankment next to the old Shell building, is the designer and builder of underwater tunnels, railways, bridges and ultimately the three great ships of the age.

The first in 1838, the 'Great Western', wooden built, 236 feet long, 1321 tons, with four boilers and one 750 horsepower steam engine driving 298 foot diameter paddle wheels, crossed the Atlantic on her maiden voyage from Bristol to New York in 14.5 days, an average 8 knots and with 24 first class passengers. She arrived only hours after the 'Sirius', 700 tons, 320 horsepower, that crossed from Cork to New York in 18.5 days, an average of 6.7 knots with forty passenger onboard.

The second in 1845 the 'Great Britain, an iron ship 322 feet long 3270 tons with a 1500 horse power steam engine driving one propeller crossed at an average 12 knots with 60 first class passengers in state rooms and a full complement of steerage passengers and 600 tons of cargo. Later she was used as a cargo and passenger ship to Australia, carrying on one voyage 600 passengers.

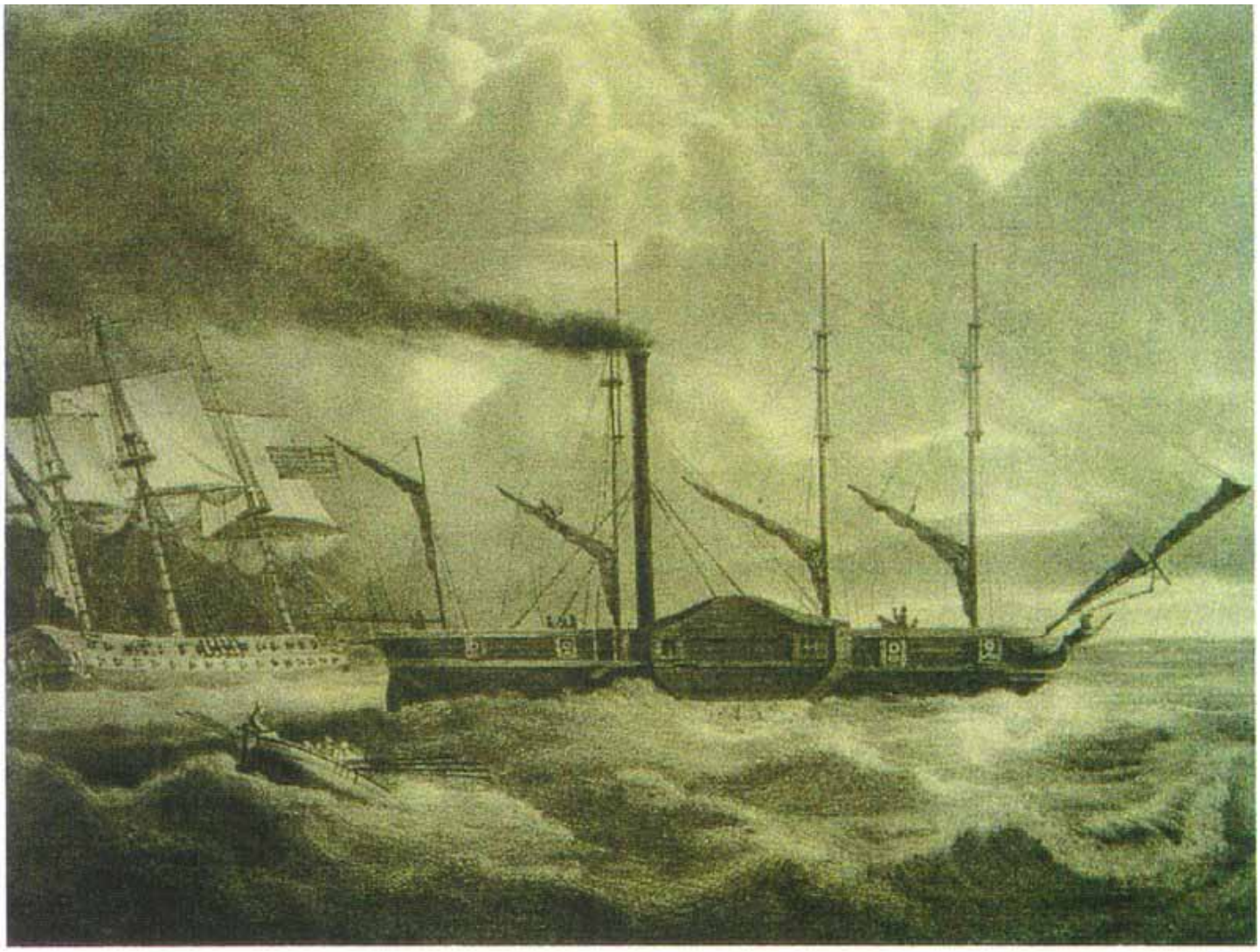
The third in 1858 the Great Eastern', an iron ships, 692 feet long, 82 feet beam, about 18,900 tons lightweight, and about 27,000 tons displacement, with two steam engines each driving port and starboard paddle wheels and one driving one propeller aft, she could reach a top speed of 15 knots on 300 tons of coal a day and carry 3000 tons of cargo and 4000 passengers or 10,000 troops. The ship was double skin, with cellular double bottoms, transverse subdivision bulkheads, great longitudinal strength and excellent manoeuvrability. All features that were adopted in shipbuilding ever since. She was by far bigger than any ship built to that date and it is only about 50 years later, in 1906, that she was surpassed by Cunard's 'Lusitania', 31,500 tons with four propellers and a speed of 24 knots.

The basic principle behind these spectacular increases in size was that power to propel a ship does not so much depend on size, weight and displacement, as on resistance to a ship's motion in water, caused by her hull surface or skin friction, eddies and wavemaking. William Froude had worked with Brunel and later developed his famous theories. It is in this new world of science and mathematics, combined with the use of iron and steam, that naval architecture came to relate size and shape of hull, engine power, efficiency of propulsion, quantity of fuel and cargo to the design of ships that had been traditional, empirical and with a cautious and conservative outlook.

Steam Engines / Paddle Wheels, Propellers

In warships steam was adopted seriously only with the introduction of propellers in the 1850s. Paddle wheels had been in the way of broadside guns and were too large a target for enemy fire. Even then steam was used only as an auxiliary and in conjunction with sails, which were only phased out in the 1880's. The transition came under various other forms. First broadside ironclads, then iron ships, then turret ships, then armored steel ships in the 1870's.

The steam engine concept goes well back in time to Heron of Alexandria in the 1st Century AD. It was however with Watt in 1769 that a practical machine was built, which pioneered around 1800 the steam engine for locomotives and ships. Low pressure single acting engines of up to 20 lb/in2 in the first half



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of the 19th century were followed by compounds of 60 lb/in2 in the 1860's and triple expansion engines of 120 lb/in2 in the 1870's. Drastic change only came about at the end of the 19th century, when Parson's 'Turbinia', the first steam turbine boat was presented in a spectacular manner to Queen Victoria and the Royal Navy at Spithead in 1897.

Steamers Prevail

Turner's painting the 'Fighting Temeraire' shows that 1798 built sailing warship of heroic action in Trafalgar, being towed to a breaking yard by a steam tug in 1838. An early omen of things to come that came. In the second half of the 19th century the industrial revolution, with ship technology as a spearhead, was ready for export. Engineering, metallurgy, propulsion, science and ballistics gave the West the tools to straddle the world, move the people and carry the goods fast and efficiently. Associated with all this is the opening of the Suez Canal in 1869. The London to Bombay sea miles were reduced to about half and the whole pattern of sea trade changed drastically. This was the age of European expansion worldwide and the emergence of global economy.

These years saw the consolidation of iron over wood and steam over sail. In the 1880's Bessemer steel started replacing iron. By 1900 it was nearly all steel, which was lighter and easier for construction. Steel benefited all ships. Warships and passenger ships benefited from both steel and steam turbines and went on to larger sizes and greater speeds, and in line with the commercial and military requirements of the times. The great transatlantic passenger liners and the dreadnoughts are legends of the age.

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