Micro-internship at Lloyd's Register Foundation – December 2020

Laura Hurford – Fire at sea

LITERATURE REVIEW

The project I took part in, along with two other interns, as part of my micro-internship, was part of a bigger initiative to use sources available in the Heritage and Education Centre archives to help inform us on the biggest safety challenge areas that Lloyd's Register Foundation have identified. I have chosen to focus my hindsight project on fire safety on vessels and offshore structures and how this has changed throughout the past. Fires at sea have taken and continue to take many lives, cause great environmental damage and great cost to companies. However, there has been a significant increase in the understanding of fires and how they can act at sea over time and changes in safety rules and recommendations in response. A greater understanding of the history of fire safety could help us answer questions including what are the most effective ways of implementing fire safety recommendations? What are the different outcomes when different organisations implement a change of guidelines or rules? What types of recommendations have been most effective? Ones surrounding education, materials, technology or other areas? We could also gain wider perspective on how decisions in fire safety are made and what factors have been of influence on its developments. This could also provide an interesting way of studying how Lloyd's Register's role in promoting fire-safety at sea has varied over the years in its relationship to international conventions and the role of the IMO. This furthered understanding of fire safety would link into Lloyd's Register Foundation's work in their key challenge areas of improving safety at sea, the safety of physical infrastructure, skills for safety and public understanding of risk.

My role has been to explore the collections available in the HEC library for sources that could offer insight into fire safety and what these sources might be able to tell us. As I have been doing this internship remotely, I was using the HEC Library and other sources all online. This allowed me to search for key terms that I thought would bring up relevant documents quite efficiently, but also meant I did not have access the majority of sources as they are in the process of being digitised. This was not so much of a problem because most documents had an abstract available which meant I could gauge a brief understanding of what each document entailed. I noted down sources that might be of use in building this history of fire safety based on relevant titles and abstracts.

At the beginning of my project I was also given access to some digitised documents in the Dropbox. Here I found **Lloyd's Register Technical Association's Fire Test Procedures document, by P. Mather, from 1989-90.** This document was one of the first I tried to skim through. I definitely struggled a bit working my way through this source, and many other sources, due to my lack of technical or scientific background. However, I was able to appreciate that this source would be of great use to a historian trying to discern contemporary approaches to fire safety. The source is a good introduction into the different safety standards for fire tests set out by different entities, including the British government, the International Maritime Organisation (IMO) and more. This could therefore be a good source into the relationship between Lloyd's Register and classification societies and international, and national, requirements. Moreover, as a part of my internship I was given the chance to speak to an expert on fire safety on offshore structures who explained to me the impact the Piper Alpha disaster in the North Sea in 1988 had on fire safety. This source can be seen as an example of action taken in knowledge of that disaster, as it notes the importance of structural fire protection "particularly in the light of recent events in the North Sea the public, as well as the marine professions, are well aware of the dangers and consequences of a maritime fire if it is not contained and extinguished". This reference to public attitudes might make this source a useful

insight into public perceptions of risk and how this is dealt with by organisations including Lloyd's Register. The source also provides opportunity to contrast it with later documents as it has a section about the problems the future might pose due to a "trend it seems will continue unabated for the foreseeable future" in "the building, conversion to and upgrading of cruise liners". If I had more time on this project, I might contrast the fears expressed in this document surrounding the "preference for large open areas for public spaces" and unsuitable materials with a document that has actually dealt with the building of these liners and consider whether these challenges have been overcome.

In the Dropbox I also had access to the ***Guidance Notes for Risk Based Analysis: Fire Loads and Protection*** by Lloyd's Register in August 2014. This source is useful for showing much more current understanding of fire safety. This source gives a lot of detail to different types of fires and the science behind them, this might reflect ever evolving research into fire loads and its incorporation into fire safety. This document is heavily based on the use of design and materials to bring about fire safety and could therefore be compared with other older documents I have identified as focusing on these themes that I found in the HEC Library collection.

I also found in the Dropbox a section in the ***Group Review*** from 2009 detailing Lloyd's Register's work "with the UK P&I Club to develop the Marine Fire Safety Pocket Checklist". This was an interesting example of where training and education was used to encourage fire safety, as "the checklist, which is available for free from our website, can help with" ensuring "crew members are appropriately trained to inspect, maintain and operate fire safety equipment". My brief scan of the literature seems to show that most available documents focus more on structural or design changes along with the use of technology to improve risk assessments to bring about more secure fire safety, and less focus on changing human behaviour. However, some of the sources I have found seem to focus a bit on training and education, as I will discuss below. Understanding the impact of education in improving fire safety will be of interest to Lloyd's Register Foundation as they have recently been funding FEEFA (Fire Engineering Education for Africa) to establish the first post graduate courses in fire engineering in Africa.[1]

I then began my search on the HEC Library by searching the terms "ship fire". This then brought up 243 results. To try and get an initial understanding of what sorts of sources I would find in these archives and what insight they could actually offer I scrolled through the titles, authors, dates and abstracts for the first page of results in the archive. For the documents that I thought might be of use to this project I noted down their name, author and date, along with any parts of their abstract that I thought might summarise why they were useful. I also noted down what I think the key themes covered in each respective document seemed to be. Themes included technology, materials, modelling, simulating, policy, international convention, education, training, passengers, SOLAS, evacuation, design, fuels, cargoes, case studies, efficiency, costs, crew, skills, data, statistics, construction, oil, gas, detection, risk-assessment, plastics, environment and more. I then used these key themes to narrow down my subsequent searches. I tried a few different search terms. I have detailed at the end of this report the searches I made, how many results they generated and how many I found to be of relevance. There were some documents that didn't come up under certain search terms, like "material" for example, despite the abstract suggesting they might be of use in this area. I therefore noted down when this was the case.

My research was not just limited to the HEC library, I also was given access to a database of LR Publication Articles. Here I searched the term "fire" to bring up 22 results which I then scrolled

[1] Engineering Fire Safety In South Africa, 2020, retrieved at: https://www.lrfoundation.org.uk/en/impact-stories/feefa-engineering-fire-safety-in-africa/

through, read the abstracts and noted down the relevance and key themes of each one. I did not find that many documents in this database seem to be relevant but the ones I did find seem to be particularly useful for some case studies of fires at sea. The majority of these sources are from *100A1*, Lloyd's Register's technical publication for staff and clients, and gives an insight into how international Lloyd's Register's reach was.

One area which might be of interest for further exploration that I think the archives would support would be in how safety regulations have developed alongside rapidly developing new shipping technologies. For example, searches for "ship fire material" seem to have brought up a few relevant documents about ships using carbon fibre reinforced plastics (CFRP). There are documents ranging in date from the year 1976[2] until the year 2000[3] involving considerations of how fire safety has to be adapted to vessels using alternative materials. What might also be of interest in further study here could be contrasting the role of classification societies such as Lloyd's Register as presented in the archives with the role of the IMO and the Safety of Life at Sea convention. As part of my internship, I was put in touch with an expert within Lloyd's Register on marine fire safety and one role of LR and other classification societies that he stressed to me was their ability to approve designs that might not be covered by the prescriptive requirements of the SOLAS convention. A study of published amendments to the SOLAS convention or IMO recommendations on fire safety with new technologies or materials being used in shipping, compared to published reports or guidelines by classification societies may be an interesting way to look at the different speed of responses to changes in the industry.

Another interesting area I came across while searching the HEC library, archives and the LR Publication Articles was the use of case studies and examples of particular accidents provoking changes in fire safety rules and regulations. The expert I was given the opportunity to talk to who specialised in fire safety on off-shore structures gave me an insight into how the Piper Alpha disaster in 1988 initiated a large research project into the physics of fires which led to a whole new understanding of the fire loads of hydrocarbon fires. This disaster also later led to a shift in the levels of responsibility oil companies and national authorities chose to take in safety standards which could maybe be further explored through an analysis of corporate publications and recommendations and conventions.

The expert also said the Piper Alpha disaster contributed to a growth in the study of risk-assessment and the incorporation of risk-assessment and risk-management into engineering education. As I mentioned earlier, the history of the development of new programmes of education might be something that the foundation be interested in as they have recently been funding FEEFA (Fire Engineering Education for Africa) to run postgraduate courses in fire engineering in Africa. The documents I found to be relevant when searching for "ship fire training" might be useful for this. If I had more time to complete this project I would spend time searching the archives with the names of incidents of fires at sea and would try look at patterns of updated rules and regulations occurring in the aftermath of incidents. This might be interestingly linked to an exploration of archives that could show public reaction to incidents, perhaps in newspapers, to increase our understanding of public perceptions of risk. A quick search of "Piper Alpha" in the HEC Library collection brings up 78 results and the first document, "A critical review of post-Piper Alpha developments in explosion science for the offshore industry", by D Bull and P Renwick, 2000, seems likely to be of great use when studying the impact of that significant event.

[2] D. Bailey, Fire Reinforced Plastics and their Application in the Marine Environment, 1976
[3] A. Loennoe, The Visby Class Corvette- the World's Biggest CFRP-sandwich ship, 2000

As part of my project, I also searched Lloyd's Register's website to gather sources to give insight to more recent and ongoing developments in fire safety. I searched "fire", which brought up 79 results. I found many articles to be focused on investments in new technology that could improve many aspects of fire safety, from detection of pre-fire conditions in shipping vehicles to cutting the maintenance time and cost for fire detectors. If I was to spend longer on this project, I would have enjoyed looking at how effective these new technologies have actually been in preventing fires. A report I read by Allianz documents that by 2019 the capacity of container-carrying ships has increased by almost 1,500% since 1968.[4] Since 2006 this capacity has increased from approximately 11,000 teu to 24,000 teu in 2019.[5] Allianz's report argues that "fire-fighting capabilities on board have not necessary kept pace with the increasing vessel size". Developments in technology have been allowing shipping to change constantly and thus it would be interesting to study whether fire safety on vessels has been as heavily researched and developed alongside. An interesting approach this project could take is studying how fire safety recommendations and regulations have changed at times in response to fires at sea taking place or near misses and at other times have developed alongside changes occurring in the industry.

SEARCHES

I have given the search I made, and then recorded the title, author and date of any documents I considered relevant under this search. I also noted down any parts of the abstract that might explain the document's significance. I also added the list of key themes to every relevant document I found. If the document had come up in a previous search then I just noted the title, author and date again but did not repeat the abstract or key themes.

Searches in the HEC Library collection, online:

Searching "ship fire", 243 results:

- International symposium on fire safety of ships Vol. 1, written by the IMO, 1990
    - key themes: technology, conventions, SOLAS, passengers, materials
- The application of fire and evacuation simulation in ship design, Edwin R Galea, Steve Gwynne, Peter J Lawrence et al., 2003
    - The maritimeEXODUS ship evacuation and the SMARTFIRE fire simulation model are described… by combining detailed fire simulation with evacuation simulation it is possible to obtain detailed insight into the performance of both man and machine under emergency conditions involving fire. This insight can be used to investigate the success of the procedures on board the impact of the specified fire scenarios and to suggest potential solutions to these problems. In this way the ship of the future will be safer by design
    - Key themes: evacuation, simulation
- Post-fire flexural response of GPR composite ship panels, C P Gardiner, A P Mouritz, Z Mathys et al., 2001

[4] Allianz, Industry's Struggle with Container Ship Fires Continues, retrieved at: https://www.agcs.allianz.com/news-and-insights/expert-risk-articles/container-ship-fires.html

[5] Allianz, Safety and Shipping Review 2018, retrieved at: https://www.agcs.allianz.com/content/dam/onemarketing/agcs/agcs/reports/AGCS-Safety-Shipping-Review-2018.pdf

    - Degradation to the flexural strength and stiffness of glass reinforced polyester (GRP) ship panels due to fire is investigated in this paper
    - Key themes: materials
- Monitoring and limitation systems of fire products generation of fire on a ship, Z Sychta, T Graczyk, T Jastrzebski et al., 1995
    - “in order to estimate comprehensively ship safety at the design stage it is necessary to know dynamics of fire development and characteristics of natural and forced flows of gases streams and of factors determining these flows.
    - Key themes: dynamics of fire development
- Ship Fire Prevention, A J S Bennett, 1964
    - “The subject matter is divided into two parts. Part one deals with Material and Methods, and covers: Details of Fire-fighting equipment; Fire Pumps; the effect of free water on ship stability; Extracts from rules and regulations. Part two is on Engineering Aspects, and covers: anti-fire data for fuels; protection of steam raising plant; prevention of explosions; and ships in port
    - key themes: Materials, Fuels.
    - This is a big, collection on fire safety so might be quite important, and its from 1964 where I’ve not seen many sources.
- Fire Service Operations (Fire Service Manual) (V.2), Her Majesty’s Fire Service Inspectorate, 2000
    - This book looks initially at ship construction in general and describes the principal types of ship which firefighters are likely to encounter.
    - Key themes: Fire-fighting strategy on ships, dangerous cargoes, different locations like inland waterways, marinas etc.
- The Fire-proof Ship, E F Spanner, 1934
    - “measures necessary to ensure safety against fire on board ship…. Section two provides detailed information relating to actual fires. It contains extracts from a few published reports, expressions of opinion, and statements of fact from well-known experts.
    - Key themes: case-studies, expert opinion
    - This is quite an old document and could be an early example of how fires and disasters inspired reconsiderations of fire-safety. The published reports that this references might be useful sources too.
- Manual of firemanship. A survey of the science of fire-fighting: part 7- Fireboats and ship fires, Home Office- Fire Department, 1972
    - key themes: Fire fighting
- Modelling of fire smoke propagation in ship with multiple compartment using combined field and zone model, Wang Jian; Hua Jinsong, Kurichi Kumar, 2003

    - “the combination of the two models achieved a much more accurate prediction of fire smoke movement in multi-rooms than with the zone model alone and requires less computational resource and computing time than with the field model alone”
    - Key themes: simulation, efficiency, technological innovation
- Training and Preparation for fire at sea, J E Kjaerulff, 1995
    - “Although many shipboard fires are prevented due to innovations in the science of fire domination when a fire does erupt abroad ship extinguishment depends on successful application of fire-fighting knowledge. Training crews in the knowledge and science of fire domination is a necessity. Training seafarers in fire-fighting takes place on two levels - training at a fire training school or academy and training conducted aboard the seaman's own vessel. Both levels are needed for effective fire training. These issues are discussed in detail. Saving lives and ships takes hard work and realistic training supported by realistic drills.”
    - key themes: training, education, personal (about the crew’s responsibility)
- Marine Fire studies, Pat G Cox, 1997
    - “this book is intended to provide an introduction to the subject of fire safety and fire-fighting on board ships. This cannot be done without an appreciation of the Safety of Life at Sea convention and some of the basic concepts of design, flotation, stability and construction…. the role of classification societies and other maritime agencies and organisations…
    - key themes: overview, SOLAS, the role of LRF
- Fire still the number one enemy, F Rushbrook, 1984
    - “available data on the occurrence of shipboard fire are analysed in order to discuss: total and partial ship losses due to fire; comparison with other causes of ship loss; age of vessels lost; national flag of vessels suffering casualty; location of outbreak of fire; injury and loss of life through shipboard fire. Main causes characteristics and typical problems associated with fires seated in accommodation machinery spaces and cargo holds are examined. Guidance for appropriate action in the event of discovering fire at sea is given.
    - Key themes: data, statistics, causes, locations, loss of life
    - An interesting document about the occurrence and the main damage caused by fires at sea. It would be interesting to see if there was any response to this data by anyone
- The role of the shore fire brigade, P Hartbottle, 1998:
    - The Brigade Training Officer of the Tyne & Wear Metropolitcan Fire Brigade examines the role of the on-shore fire brigade in fighting shipboard fires… in port incidents appropriate training is detailed with reference to the specialsied training centres and marine courses available
    - Key themes: fire-fighting, training

- Fire on Board the Panamanian Passenger Ship Universe Explorer in the Lynn Canal near Juneau Alask July 271996, National Transportation Safety Board, 1996
    - This report explains the fire on board the Panamanian cruise ship Universe Explorer in the Lynn Canal, Alaska, on July 27, 1996. From its investigation of this accident, the Safety Board identified the following safety issues: the adequacy of shipboard communication; the adequacy of fire prevention, detection and control measures; the adequacy of emergency procedures; and the adequacy of oversight.
    - Key themes: case study, communication, inadequate measures, emergency response, oversight
- Ship stability during fire sighting, F G M Evans, D G Eves, J Spiers, 1980
    - Key themes: construction, fight fighting, emergency drills
- Safety first project- a step forward in passenger ship safety design, Alessandro Maccari; A Vergine, 2003:
    - The major achievements of the Safety First project are outlined… after some introductory information the fire safety project is described and some case studies are looked at. Next attention is given to methodology for the fire engineering analysis.
    - Key themes: case studies, guidelines, engineering analysis
- Dealing with an on-board fire, J Noble, 1998
    - Particular problems of fighting shipboard fires when the ship is away from shore and immediate sources of outside help are examined. An overview of the causes and main characteristics of the most common types of shipboard fire is presented and includes: cargo fires (caused both by external sources and by spontaneous combustion in cargos such as coal and cotton) machinery space fires accommodation block fires fires resulting from incidents such as collision and fires set deliberately: the aggravation of fire caused by poor response and inadequate crew competency is included. Appropriate onboard priorities and actions are discussed with attention to: the foremost need to save life; the limitations of shipboard fire fighting equipment crew numbers and crew training; when to summon assistance from passing ships salvors and onshore fire brigades; the importance of documentation and when to abandon ship.
    - Key themes: emergency procedure, causes of fires, poor responses and inadequate crew competency, onboard priorities
- Fires on board ship, F R Lindley, 1932
    - Typical causes of fire on board passenger vessels cargo ships and oil tankers are discussed with details of- techniques and equipment for fire/smoke detection and control; personnel training; structural design for fire safety; fire risks associated with coal and oil firing; and incidence of fire in casualty returns for July 1932
    - Key themes: causes, oil, detection, training, design, statistics
- Fire spread by heat transmission through steel bulkheads and decks, R L Darwin, J T Leonard; J L Scheffey, 1994

    - the effect of shipboard compartment flashover on the thermal conditions and fire threat in adjacent and overhead compartments was studied in a US Navy Test Programme on the fire test ship USS Shadwell. Results include time-temperature data for air deck and bulkheads in all nearby locations. Discussions concentrate on the post flashover fire threat to these locations and consider the fire safety implications for ship design and construction.
    - Key themes: design, construction, data

- Standards mapping in support of fire safety certification, Jan Jarvis, 2006
    - Fire safety for both ship and submarine represents a significant danger with potentially severe consequences. Fire is therefore defined as one of the 'key hazard' areas. As such the SSB (Ship Safety Board) requires particular safety assurance by means of Naval Authority safety certification and MESH IPT is the certifying section for fire safety. In order to fulfil its role the IPT applies current risk assessment techniques with reference back to the relevant fire-related Defence Standards and also the fire-related clauses of the commercial standards. The development of a cost-effective software tool that significantly increases the ability of MESH IPT in meeting its objectives is presented. MESH IPT has already begun to use this software in order to help its navigation of the commercial standards. The benefits will increase with time as the database comes to hold larger amounts of information.
    - Key themes: policy, technological developments, modelling, risk-assessment, efficiency

Searching “ship fire material”, 10 results, 9 relevant:

- Ship Fire Prevention, A J S Bennet, 1964
- Post-fire flexural response of GPR Composite ship panels, C P Gardiner, A P Mouritz, Z Mathys et al., 2001
- The Visby Class Corvette- the world’s biggest CFRP-sandwich ship, A Loennoe, 2000
    - The Visby Class Corvette launched in June 2000 is the largest carbon fibre reinforced plastic (CFRP) ship to date. The role of the composite material behaviour and limitations of the CFRP sandwich material concept were studied and load and strength calculations were made. Experiences and difficulties faced in the design and construction of the vessel are described. Production of the vessel and fire safety are also outlined. The background to the project problems faced and future projects for the Swedish Navy are discussed.
    - key themes: materials, technological innovation, case study, design, construction
    - This is about developments in materials (carbon fibre reinforced plastic), and how this implicates fire safety.
- Use of FRP sandwich panels for large ship superstructures: technological implications and normative aspects, A Maccari, M Dogliani, 1994
    - Objectives methodologies and findings of the Project BREU 0178 COMAST Composite Materials for Marine Structures and Components are presented in respect of the application of Fibre Reinforced Plastics (FRP) materials to large ship

superstructure panels. The research programme is outlined linked tasks include: definition of structural typologies and governing regulations (SOLAS Class A and B panels); selection of standard material; correlation of experimental tests with theoretical predictions; fire resistance; design guidelines; and cost evaluation.

    - key themes: plastic, materials, technological innovation, design, modelling, costs.
    - Could LINK THIS to the Visby Class Corvette- similar topic but what changed in 6 years?

- Damage Control. A manual for naval personnel, Thomas J Kelly, 1944
    - This book assembles a large variety of information regarding damage control and its practical application… fire fighting… principles of stability; buoyancy and stability in damaged condition; repairing damage in action.
    - Key themes: stability, damage control, overview
- Global Safety approach, V Farinetti, L Grossi, A Gazzo, 1997
    - The most important threats to vessel safety are hull damage fire and failure of on-board systems. However, these three areas should not be considered separately; for optimal results an integrated approach is needed. Such an approach has been taken by Fincantieri in the design of their new high peed roll-on roll-off (ro-ro) passenger vessels MDV 1200 Pegasus and Superseacat. Brief details are given in relation to damage stability assessment reliability of components and material selection.
    - Key themes: materials, case study
- Design of structural composites, J Cadei, 1999
    - A methodology for the design of primary structures in fibre reinforced composite materials for the offshore oil and gas industry is presented which uses the limit state approach. Aspects considered include material selection safety failure criteria mechanical properties and the effects on environment durability dynamic effects impact energy and fire performance. The structural form of the beams and decks fibre architecture and cost-effectiveness of composite use are discussed.
    - Key themes: materials, technological advancement, carbon fibre, gas and oil, environment, efficiency, costs
    - Maybe link the carbon fibre articles
- Risk analysis for the enhancement of riser safety, L H Katteland, 1996
    - Riser (the vertical pipe for the upward flow of liquid or gas) accidents can lead to critical situations the worse case being the Pipe Alpha disaster. Four possible riser failure modes are considered: external forces such as fire, dropped objects or ship impact, corrosion, structural failures and material failures. A methodology for evaluating the probability of accidental events is presented. Risk reducing measures based on a risk analysis approach are presented through four case studies: a tension-leg platform designed for the Heidrun Field, a jacket with a steel riser either inside or outside a concrete gravity-based structure and a floating production system.

    - Key themes: oil , case study, Pipe Alpha, materials, risk assessment

- Code of Safe Working Practices for Merchant Seamen, Department of Trade, 1978
    - This code provides information and guidance on procedures to be followed and measures to be adopted for improving the safety and health of those living and working on board ship. Contents include; general; fire precautions, emergency procedures…
    - key themes: government, guidance, precautions

Searching "ship fire case studies" in HEC Library, you get 4 results, 2 I think are useful:

- Fire Safety, MER, 1997
    - A series of articles on fire safety include: regulations are plentiful but do they address every conceivably fire scenario? – a warning from the Institute of London Underwriters about the high number of passenger ship fires; the Borrenmill tragedy- a case study of the fatal fire onboard the general cargo vessel Borrenmill; Fuel vapour can be an unseen hazard- the dangers of oil fuel vapour leakage in machinery spaces are discussed in light of the engine room fire onboard the ro-ro passenger ferry Sally Star; The management of life - a discussion of life safety management systems on board the Oriana; Water fog gets the thumbs up - a discussion of water mist / fog extinguishing systems; and Smoke control systems on the cards - a discussion of controlling the ventilation systems.
    - Key themes: Borrenmill, case study, oil, different scenarios, methods of extinguishment
- Formal Fire Safety assessment on passenger ships: application of cost-benefit analysis and decision-making approach, Soo-Woong Jim; Hyun-Jin Lee; Young-Sub Kwon, 2006
    - The application of FSA (formal safety assessment) to passenger ships is discussed. Passenger ship accident statistics are considered. An analysis of passenger ship characteristics and a proposed formal safety assessment methodology are presented. Five interlocking steps are described to construct a safety model including novel risk assessment cost-benefit analysis and decision-making approaches. A case study is carried out in order to show the demonstrate methodology. Finally further development in formal safety assessment in the context of passenger ship safety is discussed in detail.
    - key themes: modelling, risk assessment, evaluation, efficiency, case study, passengers, statistics

Search "ship fire cost", 18 results, 16 relevant:

- Formal fire safety assessment on passenger ships: application of cost-benefit analysis and decision-making approach
- Proceedings of the International Maritime Defence Conference- 'Creating the Naval Task Force' London 28-31 March 1995 Volume 3, 1995

    - Proceedings of the International Maritime Defence Conference… includes papers relating to… fire-safe materials R & D for Canadian ships… papers relating to cost effective requirements
    - key themes: cost, materials, research
- The all-aluminium naval ship- the way to affordable naval ships, Thomas Lamb; Nathaniel Beavers, 2010
    - In a previous paper it was shown that even though the cost of an aluminium ship structure is 40% more than an equivalent steel structure the aluminium naval ship can be built within just 7.5% of the acquisition price of the steel ship. This is possible because of the benefits of the aluminium ship's significantly lighter weight. Based on these findings it was suggested that the use of aluminium ships be broadened beyond its current use today. This paper reports on additional design effort carried out by the authors that validate the structural and fire insulation weight estimates used in the earlier paper for the aluminium ship design.
    - Key themes: materials, costs, aluminium
- Ventilation and air conditioning- planning and layout aspects, B Lindberg, H Svensson, 1988
    - Proper planning of the ship and ventilation plant has a vital impact on the total cost and the operation of the ship as well as on the complexity of the fire and safety system. This planning calls for cooperation and concerns not only the division of fire zones and the position of the main fire bulkheads but also the position of fan rooms vertical ventilation trunks air intake and outlets etc. Three different fan room arrangements are presented and discussed in this paper.
    - Key themes: structure, construction, design, ventilation, cost, divisions
- Standards mapping in support of fire safety certification, Jan Jarvis, 2006
- Ship Safety- series of short article, MER, 1992
    - This series of short articles covers - Counting the cost - the grim toll of casualty statistics Fire casualties - the burning questions Making the most of materials Putting a damper on fires Fire control systems - getting to the heat of the matter Taking a scientific look at ship safety First black box recorder makes debut.
    - Key themes: cost, casualties, materials, systems, overview
- A review of practices and regulations in the LNG shipping industry, E G Tornay, 1996
    - Features and characteristics of LNG ships are examined and regulatory requirements with respect to whether they are cost effective in terms of maintaining operational performance and flexibility as well as safety are considered. Safety features of LNG ships are required by internationally accepted regulations referred to as the Gas Code. Reviews of cargo tank filling level cargo tank relief valves and fire fighting equipment are give
    - key themes: gas, fuel, dangerous cargo
- Use of FRP sandwich panels for large ship superstructures: technological implications and normative aspects, A MAccari, M Dogliani, 1994

- Recent developments in composite technology for ship structures, N St John, 2002
    - Composite materials are well established in the construction of small naval vessels. Recent developments have focused upon weight-sensitive ship structures. However there are concerns about the use of composite materials for commercial passenger vessels and larger naval ship construction. These include concerns about quality damage tolerance and fire reaction and resistance. Recent technology developments aimed at addressing these concerns that have the potential to deliver more cost-effective and safer composites for ship construction are reviewed.
    - Key themes: MATERIALS (and this didn't come up when you search "materials"!!!), technological innovation, costs, evaluation
- The Motor Ship. A Special Survey 'Marine Automation and Remote Control', December 1967
    - Journal 'The Motor Ship'. Articles include.. 'The detection of fire in unattended machinery spaces'.
    - Key themes: detectors, technology
    - interesting as there is stuff about detection of fire in unattended machinery spaces all the time, this is a common problem, and 1967 is quite long ago so it's a good time to have this source
- Surviving technology for the 21st Century, M A Squires, D J Mattick, 1998
    - The role of technology in improving the recoverability of a warship and therefore improving survivability is described. The key issues for being able to recover from the longer term effects of a hit are flood, fire and smoke and damage to essential services, particularly electrical power, chilled water and fire main. Initiatives within the Directorate of Marine Engineering of the Ship Support Agency to evaluate new and existing survivability technologies for future Royal Navy platforms are discussed. Technologies include Platform Management Systems (PMS), fire-fighting and smoke clearance technologies. A measure of effectiveness analysis considering military effectiveness, risk, cost and statutory requirements showed that a basic Platform Management System is likely to be the most effective technology. The next most effective technologies are simple portable equipment such as wire free communications extended duration breathing apparatus and improving the zoning and control of ventilation. Technologies that rely on sensors and actuators did not perform well.
    - Key themes: technology, Platform Management Systems, ventilation, zoning, sensors, damage control
    - quite interesting and useful that this source seems to actually rank different effective technologies for limiting the damage from fires
- World Cruise Industry Review 1995, Douglas Ward, 1994
    - "This review has sections on… Safety of life at sea (marine safety on board ship, marine fire protection- water mist, photoluminescent escape route systems, low location lighting)"
    - Key themes: cruises, passengers

- Shipbuilding Technology International 1987 The International Review of Ship Design and Construction Technology, IRDCT, 1987
    - Int. Review of ship design and construction technology. Chapters are… fire protection…
    - Key themes: construction, design, evaluation, costs, technology
- Design of structural composites, J Cadei, 1999
- Structural use of polymeric composites in ships and offshore, A R Mableson, R J Osborn, J A Nixon, 1987
    - This paper considers how the lessons to be learnt from the use of GRP in the Navy can be applied to large commercial marine structures such as ship superstructures and oil rig modules. The resulting structures can be cost-effective and are able to provide adequate protection against the fire requirements of the oil industry. The applicability of other composite materials to the building of large structures within a commercial environment is also discussed. Much emphasis is paid to mine countermeasures vessels including MCMV and SRMH and covers the Hunt Class vessels.
    - key themes: MATERIALS (which it doesn't come up for when searching 'materials'), Cost effectiveness, efficiency, moving from naval to commercial structures, technology, also this is 1987 so it's a bit of a earlier one which is nice on composite materials
- International Maritime Defence 1993, Vol 1 of 2, Spearhead Exhibitions, 1993
    - Conference held 31 March- 1 April in Brighton UK. Papers are… prediction of ventilation and fire spread in shipboard compartments and machinery spaces…
    - key themes: prediction, modelling, risk assessment, ventilation, structures

Search "ship fire technology", 26 results, 22 relevant:

- Survivability technology for the 21st century, M A Squires, D J Mattick, 1998
- International symposium on fire safety of ship Vol. 1, Hellenic Institute of Marine Technology, 1989
- Recent developments in composite technology for ship structures, N St John, 2002
- Shipbuilding Technology International 1987 The International Review of Ship Design and Construction Technology, IRSDCT, 1987
- Shipbuilding Technology International 1988 The International review of ship design, construction technology and management, B Wilson, 1988
    - articles are… fire protection…
    - key themes: design, construction, technology, structures

- Promoting safe return to port (Cruise and Passenger Ship Technology Supplement), Shipping World & Shipbuilder, 2008
    - Claudio Abbate Head of RINA Operations in North and Central America and Vice-Chair of the IMO sub-committee on fire protection reports on the latest initiatives for passenger fire safety.
    - key themes: passengers, technology, methods
- Fire detection systems for the millennium, B S Rodricks, 2001
    - Addressed here are some new developments in the field of marine fire detection systems. Traditional fire detection principles have been advanced and new technologies such as smoke and flame detection using closed circuit television and optical fibre real time temperature sensing have been developed. Detection systems have also been enhanced using digital protocol knowledge based expert systems and multi-sensor detectors and alarm actions developed through the Operator Interface have become more advanced. The **use of new technology is becoming more widespread as ship operators increasingly use risk management based philosophies rather than relying on prescriptive SOLAS regulations to** protect their vessels.
    - Key themes: risk assessment, relationship with conventions, technology, detection, SOLAS
- Rules for Classification and Construction- Ship Technology 1 Seagoing Ships 1 Hull Structures, Germanischer Lloyd, 2007
    - these rules cover materials, design principles… structural fire protection on board seagoing ships…
    - key themes: design, structure, rules, materials.
    - Whose rules are they? It's a classification society.
- Technology and safe navigation, J A Paffett, 1981
    - Aspects of safety at sea are discussed including number of incidents; loss of ship; loss of life; spillage of dangerous cargo; causes of accident through engineering failure fire/expolosion and human error arising from problems with ergonomics, decision making, discipline and interaction with electronic information generating equipment. Constant hazard theory is considered.
    - key themes: technology, human error, crew, workers
    - interesting speaks of human use of technology and problems, this was quite early in 1981. This could therefore link into research on the importance of education and training for fire safety
- A technology demonstrator for a composite superstructure, R Dow, 1995
    - Glass-reinforced plastic (GRP) has been used successfully in the construction of mine countermeasure vessels (MCMVs). As a result a research programme is now under way at the Defence Research Agency (DRA) to demonstrate the use of GRP for steel-hulled ship superstructures. The programme has three main areas: structures

materials and industrial involvement. These areas are described and particular reference is made to blast loading electromagnetically compatible (EMC) screening and fire resistance. Vosper Thornycroft is providing industrial expertise to ensure that the design and manufacturing process are commercially viable.

    - key themes: materials (THIS DOESN'T COME UP IN MATERIALS), technology,

- Handbuch Schiffsbetriebstechnik (Handbook of ship operation and maintenance), Hansheinrich Meier-Peter; Frank Bernhardt, 2006

    - This book examines marine engineering, particularly the numerous recent technological changes. Sections of the book cover machinery, electrical systems and engineering, tools and control technology, supplies (such as drinking water systems) and disposal facilities, refrigeration and air conditioning (including ventilation), container facilities, manoeuvring devices, shipbuilding, fire extinguishing, security and rescue facilities, maintenance, issues relating to possible damage, regulations and conversion factors. Book is written in German.

    - Key themes: extinguishing, engineering, technological

    - This is in German

- Fibre reinforced composites in ship and boat building: the pros-cons and latest developments, Ian Crough, Adrian Mouritz, Nigel St John, 2003

    - The current state of technology in Australia's ship and boat building is considered. The latest developments in research and development are reported with particular attention to the areas of fire performance structural joints and impact damage. It is concluded that the composite fabricators within the marine industry continue to develop leading-edge products and new processes some of which are based on the outcomes of earlier defence-related R and D programs and acquired via natural technology diffusion.

    - Key themes: research, technology, development, composite fabrics, materials (THIS DOESN'T COME UP FOR MATERIALS)

- Shipbuilding Technology International 92 The International Review of Shipbuilding, Conversion and Repair, Sterling R Burnett, 1992

    - review of ship design construction technology and management. Papers are… water spray fire protection for machinery spaces

    - key themes: technology, developments, water spray

- Proceedings of the International Conference on Water Mist Fire Suppression Systems 4-5 November 1993, Swedish Nat Testing and research Inst, 1993

    - Conf held… papers are- developments of standards and test methods for water mists systems, Design of water mist fire suppression systems for shipboard enclosures, the efficiency of different water mists systems in a ship cabin, the potential of fine water sprays as halon replacements for fires in enclosures, perspectives on fine spray/ water mist technology at factory mutual research corporation. Extinguishing mechanisms of water mist, full scale water mist experiments. A fully integrated water mist fire suppression system for

telecommunications and other electronics cabinets suppression of compartment fires with a small amount of water. Approval of water mist systems on ships- consideration of equivalency to sprinkler and water spray systems

    - key themes: technology, water mist, extinguishing, design, testing,

- International Maritime Defence 1993, Vol 1 of 2, Spearhead Exhibitions, 1993
- Reliability and safety of LNG shipping- lessons from experience, B de Frondeville, 1977
    - Experience of 13 years commercial LNG shipping is reviewed with special reference to safety and reliability of ship and shore operations. Discussions refer to - ship and tank types/structures; containment technology; shipping records cargo loadings carriage unloadings; terminal operations storage sendout; spillage and handling of vapour clouds; flammability and fire protection; terminal and berth construction and operating permits; trade routes.
    - key themes: gas, fuel, cargo, experience, case studies
- Tightening the grip on passenger ship safety: the evolution of SOLAS, S Payne, 1994
    - An historical account examines in detail the development of International Conventions concerned with the Safety Of Life At Sea beginning with the first and largely unenacted SOLAS 1914 and the subsequent SOLAS 1929 which set fundamental aspects of safety in a Convention structure of chapters and articles and continuing through the provisions of SOLAS 48 and SOLAS 60 to SOLAS 74 which together with its Chapter II amendments is the basis of current safety. Major vessels built during this time are used to illustrate significant advances in safety technology particularly concerning life saving equipment fire safety systems and stability.
    - key themes: SOLAS, convention, law, history, development, technology, change, passengers
    - probably a useful document for some history of the changes in SOLAS
- Jane's underwater warfare systems, Bernard Blake, 1989
    - contents cover underwater weapons, submarine fire control systems…
    - key themes: submarines, underwater, systems
- The all-aluminium naval ship- the way to affordable naval ships, Thomas Lamb, Nathaniel Beavers, 2010
- Fibre reinforced plastics and their application in the marine environment, D Bailey, 1976
    - This report was partly sponsored by the Ship and Marine Technology Requirements Board and supported by the Department of Industry Research Requirements Branch. It covers fibre reinforced plastics (advantages and disadvantages, fire resistance and durability), uses of glass reinforced plastics and carbon, boron and other high performance reinforced plastics and economic considerations. Also, appendices on: laminated plastics, FRP production and joining methods, resins.
    - key themes: materials, FRP, development, carbon,

    - this might be quite interesting because its 1976 which I could compare to later articles about the fibre reinforced plastics

- Development of pumps for the marine and offshore oil industries, A G Sheil, D M Manson, 1988
    - The paper reviews the background to and the changes that have taken place in fire pump system design philosophy and the currently installed alternative systems.
    - key themes: technology, extinguishing, pump, design, system
- The use of simulation to assess the evacuation of passengers from ships, N Hunt, 2001
    - Risk assessment is increasingly important in considering the safe evacuation of passengers. Traditionally assessment of evacuation/abandonment arrangements has focused on the physical layout of a vessel and its equipment. Simulation models have added additional factors such as the environment (fire smoke flooding heel trim and rolling etc) and human behaviour (age familiarity searching for relatives etc). The BMT (British Maritime Technology) Group can provide initial risk assessment use their ProModel simulator to examine vessels such as the Class V passenger ships and the Marine Exodus for larger vessels such as ferries and cruise ships. Both the ProModel and the Marine (Maritime) Exodus simulators are outlined. Includes copies of OHP slides.
    - key themes: simulation, modelling, risk assessment, human behaviour, passengers, evacuation

Searching “offshore fire” into HEC Library:

- Burning issues in the offshore industry- an overview of fire safety engineering offshore, S P Webb, 1996
    - The current status of fire safety engineering within the offshore industry is addressed. An overview of the research programmes and current issues relating to fire hazards offshore is provided. Specific attention is given to identifying the current issues and why they are the current issues determining the ongoing research programmes addressing these issues and looking at how this research work is being implemented. Also considered is where we are and how we can move forwards.
    - Key themes: overview, research
- Fire risks on offshore platforms, B Gowar, 1987
    - Aspects of fire risk and fighting on offshore platforms are discussed including; government legislation fire risk areas associated with crude oil/gas electrical equipment and carbonaceous materials and fire dectection and fighting equipment both fixed and portable using water and chemicals (Halon AFFF)
    - key themes: government legislation, detection, fighting
- Improving the knowledge about the DAL fire for offshore installations using state-of-the-art CFD tools in combination with existing QRAs, Joar Dalheim, Torunn Hiorth Marthinsen, Harvard Thevik et ak., 2002

    - A new procedure for predicting the DAL (design accidental load) fire more accurately on offshore platforms is presented. The new procedure combines results from state-of-the-art CFD (computational fluid dynamics) tools and conventional QRA (quantitative risk analysis) tools. The detailed information about the DAL fire can be used to carry out improved design of passive fire protection on process equipment fire walls and escape ways. It is argued that knowing more about the DAL fire will give a potential for both improved safety and improved cost effectiveness. The new procedure is used to predict the detailed effects of DAL fires for a major oil company on several of their offshore installations and the results from the improved DAL fire analysis of this field example are presented.
    - key themes: CFD, simulation, modelling, prediction, risk analysis, costs

- Novel fire detection technologies and products for the offshore oil and gas industry, E Jacobson, Y Spector, 2000
    - Various aspects associated with fire and flame detection on offshore platforms and FPSOs are addressed including: direct and reflected optical radiation from the flare stack sunlight projectors and artificial illumination and black body radiation from various heat sources. Technological solutions to these issues are discussed including Triple IR optical flame detection and CCTV imaging technologies. The results of a series of performance comparison tests on flame detectors carried out by BP exploration are presented.
    - Key themes: detection, technology, innovation

- Fire protection of offshore rigs, IFSSEC 1982, 1982
    - Int conf held 19-23 April 1982 in London Papers are the development of fire safety regulations applicable to offshore rigs meeting the fire safety requirements
    - Key themes: conference, international agreement, regulations
    - IFSSEC is the International Fire Security and Safety Exhibition and Conference

- A rational approach to fire safety of offshore installations, R Cassulo, C Murgia, F Ziliotto, 1992
    - This paper provides an overview of European fire safety programmes on offshore structures and highlights the need to integrate all aspects of safety management. A research project into a design approach to fire safety has been developed to cover three main areas which include the development of standardised fire hazard scenarios for topsides, development of tools for the cost / benefit optimisation of layout design with respect to fire safety, harmonisation of existing regulations and updating of guidelines.
    - Key themes: design, costs, Europe, regulations

- Fire Safety Engineering, ed. D N Smith, Gulf Publishing Company, 1989’
    - 2nd Int Conf on Fire Engineering and Loss Prevention in Offshore and Petrochemical Applications Papers are The new Institute of Petroleum code on area classification of hazardous areas in petroleum facilities The design of well control systems and production completions to limit fire and explosion damage on offshore platforms

Applications of nuclear power station design criteria to non-nuclear installations Safety through separation and simplicity Investigation of an explosion on a North Sea production platform Developments in deluge system design Experimental fire tests on offshore simulating rig for optimum design of foam/water spray systems Explosion resistance testing of high pressure hydraulic fluids Risk assessment and the major hazard industries with particular reference to offshore installations

  - key themes: Piper Alpha, risk assessment, engineering, design, case study
  - Published the year after Piper Alpha disaster, North Sea, Gulf

- Offshore Loss Prevention- a Systematic Approach, BRH Group, 1993
  - Conf held 3-5 March 1993 in Aberdeen UK. Papers are - The role of QRA offshore Quantified Risk Assessment of fire and explosion hazards on an offshore platform North Sea collision risk assessment Offshore earthquake hazard Consequence assessment - what do or don't we know Modelling the use of water sprays to combat fires on offshore platforms Safety system optimisation using fault tree analysis Total fire hazard management Safety related systems - a unified approach The role of offshore fire and gas systems The protecting or upgrading of offshore installations using dry fix techniques Smoke and gas ingress detection for temporary refuges Clean agent fire suppression and life safety using inert gases Safety of personnel offshore - a union viewpoint Risk acceptance criteria - a comparison of practices under UK and Norwegian legislation Goal setting regulations applied to firewater systems Impact of process safety regulations on control systems Closing address
  - key themes: conference, risk assessment, North Sea,
- Offshore installation practice, J Crawford, 1987
  - Fixed and mobile offshore installations are essentially dealt with as marine installations, and all equipment essential to the safety of personnel and safe operation of the installation are to be constructed and installed in accordance with the classification/certification authority requirements. This book is intended for the instruction and guidance of those engaged in the design and installation of offshore units. Contents cover offshore gas and oil production installations… fire and basic principles of protective systems, fire detection, flammable gas detection, fire-extinguishing systems..
  - Key themes: design, recommendations, detection, extinguishing, building, construction,
- Dept. of Energy Offshore Report 1986 OTH 86 229 Review of the Dept. of Energy’s offshore fire research programme, F I Knight, 1986
  - key themes: Department of Energy,
- Offshore installations: guidance on fire fighting equipment, Department of Energy, 1980
  - This publication is intended to provide general guidance to owners of offshore installations, manufacturers of fire fighting equipment, marine surveyors and others in relation to the provisions of the Offshore Installations (Fire-Fighting Equipment) Regulations 1978 but it does not purport to be fully comprehensive.

    - Key themes: Department of Energy, equipment, firefighting

- Recent developments in evaluating and designing against offshore fire and explosion, G A Chamberlain, 1997

    - The current state of knowledge of the hazard loadings from fire and explosion is discussed along with the applicability of predictive models to safety engineering. After some introductory information a look is taken at event trees - overview of hazard consequences. Next releases and source terms are addressed. After this fire is considered followed by explosion

    - Key themes: risk assessment, m0odelling,

- The qualification of advanced composite pipe for use in fire water deluge systems on open type offshore oil platforms, R H Lea, M A Stubblefield, Pang Su-Seng, The American Society of Mechanical Engineers- ASME, 1996

    - Fire endurance testing was carried out according to modified ASTM 1173-95 guidelines on dry samples of FIBERBOND composite pipe (produced by Specialty Plastics Inc) with various compositions coatings coverings and thicknesses and with joints of the butt and strap type. The results are used to discuss its potential application in the deluge fire systems of offshore oil platforms.

    - Key themes: materials, research, composites,

- Performance of Materials Used on an Offshore Separator Affected by a Fire, G Berge, S Medonos, 2000

    - This paper presents a case study where an offshore separator that was designed in accordance with the API Recommended Practice was subjected to a dimensioning hydrocarbon jet fire. The Paper gives an overview of the temperature dependent thermal and mechanical properties available for the material of the separator and presents the simulated behaviour of the separator material during the fire. Although the separator was correctly designed to the API Recommended Practice it failed before the PSV opened. The Paper concludes that the API Recommended Practice currently in use may not lead to safety systems that are sufficiently robust to adequately protect pressurised equipment against hydrocarbon jet fires.

    - Key themes: experiment, testing, failure, materials,

- HSE Offshore Technology Information OTI 92 610 Thermal response of vessels and piepwrok exposed to fire, J N Davenport, S M Richardson, G Saville, HMSO, 1992

- The Development and Testing of the ProTek Offshore Fire and Blast Protection System, F Barnes, D F Ness, IMarE Conferences and Symposia, 1991

    - This paper describes the history of ProTek's involvement in providing materials and designed structures giving fire protection in the offshore industry. The use of composite materials their testing and quality assurance is explained in detail.

    - Key themes: materials, composites, ProTek

- Offshore Installations Protection Against Fire and Explosion, Department of Energy, 1989

    - This document reviews the need for fire and explosion protection on offshore installations. Current and principal regulations are discussed as are amendments proposed to these
    - key themes: Department of Energy, aftermath of Piper Alpha, review, amendments, overview,

- Advanced numerical computation of fire mitigation by water systems in offshore environments by Kameleon FireEx, Trond Evanger, Bard Grimsmo, Nils I Lilleheie et al., 2002
    - KFX (Kameleon FireEx) is a user-friendly 3D transient numerical computation code for practical fire and gas dispersion simulation in the oil and gas industry… including the dynamic structural response of structures exposed to fires. A Lagrangian two-phase spray model for handling fire suppression and mitigation by water system is implemented. Based on fundamental physical and numerical modelling of droplet interaction with the flame structures modelled by the EDC a practical tool for analysis of fire mitigation by water is developed. The model is discussed and practical examples from offshore installations are shown.
    - Key themes: modelling, simulation, water system
- Sea water fire water and produced water offshore piping systems- is GPR a safe and cost-effective option for the UK sector, M J Bellamy, IMarE Conferences and Symposia, 1992
    - The Norwegian offshore industry is prepared to use glass reinforced plastic (GRP) for seawater and fire water piping systems. GPR has been used on Norwegian platforms for some water piping systems since 1988 and from 1992 the Norwegian Petroleum Directorate (NPD) will allow the use of a GRP fire water piping system on the Amoco Valhall platform with the prerequisite that the material passes certain fire tests. Paper reviews material selection for piping systems on platforms including copper-nickel alloys stainless steels titanium and aluminium and GRP materials. Fire test results of GRP are also given.
    - Key themes: water pipes, materials, tests,
- Offshore fire dampers- development and use, P J Lucas, 1992
    - This paper traces the development of the offshore fire and gas dampers from the mid 1970s to the present day and relates the current regulations to general practice in operation testing and installation. There is still no internationally agreed fire test specification nor is there a requirement for seismic or blast testing. Topics covered include testing of external blast loadings performance under severe vibration, the need to maintain adequate air inside the TSR, insulation requirements, operation and control and reliability and maintenance.
    - Key themes: history, regulations, practice,

Searching the LR Publication Articles on Excel:

Searching “fire” brings up 22 cells:

- “The Hidden Menace”, from 100A1, December 1976-

    - British Admiralty charts p. 15-21 includes photos of HMS Fox, passing through the Frigg Field, HMS Hydra, crew lowering equipment in to sea, and more equipment lowered in to sea from HMS Hecla, a small launch used in very shallow waters, the Antilles on fire after hitting a reef and the Igara after she struck an uncharted rock off China.
    - key themes: a case study of the Antilles

- "New Rules will protect big yachts", from 1001 Issue 4, 1993
    - LR introduces the first Classification Rules to bring fire safety requirements for large yachts into line with the SOLAS convention for passenger ships.
    - key themes: yachts, SOLAS, policy, law, passenger

- "Success hangs by a very thick thread", 100A1, September 1975
    - The work of Smit International in salvaging ships, towing oil rigs etc. p. 2-8 includes a photo of an underwater oil storage tank being towed, Smit Rotterdam, the rig Endeavour being towed from USA to North Sea, the Diane on fire with a number of tugs fire fighting and on standby, Taklift 1, British Lantern being refloated with the help of a large number of tugs, Zwarte Zee and the Metula (which is also on the front cover)
    - key themes: case study: the Diane.

- "Classification without Tears", in 100A1 January 1981
    - 'Fire-damaged Urquiola is reborn at Bazan's El Ferrol yard
    - key themes: case study, the Urquiola

- "Luisa M.S.", LR News Letter February 1951, p.4
    - Fire and explosion along to quay at Venice. Mr Cesari, Engineer Surveyor at Trieste, with the assistance of the Chief Officer, and later the Port Fire Authorities, directed operations whereby the vessel was brought to a safe place before the final explosion occurred.....
    - key themes: case study: Luisa M.S.
    - This source has been digitised it is on the dropbox

- "Around the world- Nigeria", Annual Report, 1984
    - LR's marine work has largely centred on the repairs carried out on the Lagos State Ferry Services vessels Baba Kekere and Itafaji, both of which were seriously damaged by an external fire.
    - Key themes: case study, repairs, Nigeria

Searching 'fire' into Lloyd Register's website:

- The 2014 Guidelines for Fire Loading and Protection (also available to me on Dropbox thanks to Louise):

    - These Guidance notes provide different risk based methodologies to establish dimensioning fire loads ranging from a simplified approach to more detailed probabilistic approaches. The methodologies are applicable to any offshore unit where fire hazards are identified as a possible outcome from any type of accidental releases including LNG releases. As well as other types of fires including electrical cable insulation fires, diesel fires and methanol fires. They also describe the types of fire likely to occur on an installation, and how design conditions and safety factors affect the characteristics of those fires
    - key themes: guidelines, design, structures, types of fire, materials, ventilation
- Start-up deploys wireless sensors across ship's cargo hold to predict fire, Mar 2020
    - shipping vehicles is a big cause of fires. Wallenius Wilhelmsen would use MonoLets' knowledge and expertise of wireless technologies to prove the effectiveness of using a mesh network of BLE (Bluetooth Low Energy) sensors in detecting pre-fire conditions and communicating results, when deployed across the cargo hold of a ship…. Wallenius Wilhelmsen wanted to understand the minimum number of sensors required to provide adequate coverage across the entire cargo area. This would determine the cost of deploying MonoLets' solution post-trial…. According to Allianz's Safety and Shipping Review 2019, 174 fire incidents were reported the previous year, with an incident occurring every 60 days on average. Through their Risk Barometer, Allianz predict that fire and explosion will be the biggest safety threat for the Marine & Shipping sector in 2020. Maritime insurers are welcoming new fire-fighting methods, capable of quickly detecting and extinguishing fires and reducing these incidents. The technology demonstrated in this pilot could form part of a wider solution, to identify pre-fire conditions
    - Key themes: costs, technology, detection, effectiveness, trial
- Reduce the Potential Explosion and Fire Risks from Hydrocarbon Leaks, 2016:
    - "today, we launched our first phase of our latest JIP aimed at resolving a long-term industry issue that could save the industry billions of dollars in costly downtime, possible injury claims and damage to the environment. "Ignition of hydrocarbon leaks in gas turbines is a critical issue for oil and gas operators," says Ingar Fossan from our Consulting business. "Findings from this JIP will lead to safer design of new installations, reduction in risk of future incidents on existing infrastructure, leading to tangible cost reduction." Onshore and offshore installations contain dedicated turbine and power generation facilities that produce energy to run the installation's various processes. The turbine enclosures and generator rooms are high risk areas because of the combination of very high temperatures, moving parts, fuel and lubricants. Flammable gas included in the intake air of a gas turbine is a widely-known and potential source of ignition. However, the residual risk is still not adequately understood. More detailed understanding of the potential ignition mechanism is required to find the best possible way to design the ignition control parameters for gas turbine equipment. It is based on the main conclusion from the MISOF report (Modelling of Ignition Sources on Offshore oil and gas Facilities) that we issued on behalf of the Norwegian Oil and Gas Association
    - key themes: modelling, fuels, gas, oil, designs

- Aker BP: Using Data intelligently to cut Planned Maintenance in Half, 2019
    - Aker BP is a well-established exploration and production company, with activities on the Norwegian Continental Shelf (NCS). Measured in production, our client is one of Europe's largest independent oil companies. As an energy leader, the company was keen to see how it could make the most of its real-time equipment data to safely reduce maintenance workloads and spending. Aker BP asked us to run a pilot project, with the Skarv floating production, storage and offloading (FPSO) unit it operated as the test asset. The pilot focused on two core maintenance areas: the FPSO's centrifugal pumps and fire and gas detectors, covering a total maintenance history of 60 months. The objective was to quickly demonstrate the business benefits of our recommended approach, combining our data and engineering expertise with our AllAssets Maintenance Optimisation software solution. To optimise the maintenance of the FPSO's fire and gas detectors, we reviewed data from the client's computerised maintenance management system, alongside supporting documentation. This covered over 1,700 in-service devices of various types, representing a 60-month operational period. We set a target minimum reliability of 99.3% for all fire and gas detector types, except 99.9% for smoke detectors (in accordance with the client's safety requirement specification). Reduced the annual maintenance hours/cost for fire and gas detectors by more than 50%, by optimising test intervals and reducing inspection activities.
    - key themes: technology, data, efficiency, detectors, costs, trial, experiment
- LR and UK P&I Club launch three new pocket checklist mobile apps, 2015
    - LR and the UK P&I Club have released three new pocket checklist mobile apps to help owners and operators comply with international convention requirements and reduce the risk of port state controls detentions. The Marine Fire Safety pocket checklist app includes a list of where deficiencies are most commonly found and certificates and documents that must be carried on board. The apps enable ships' crews and their managers to easily view necessary legislative and regulatory requirements, save multiple checklists, check off completed activities, add essential notes/ images and send completed checklists via email. Robert Brindle, LR's Lead Specialist on Port State Control, commented: "the seafarers of today were calling out for a paperless solution that was portable and interactive. These apps allow us to update users when new legislation comes into force, helping to ensure they're in compliance with the latest regulations."
    - key themes: technology, modernisation, workers, training, education, international requirements, law, policy, efficiency
- Safe Haven for Maritime Maisie after 100-day ordeal, 2014:
    - The ship has since been held at sea by tugs with the Japanese and South Korean governments unwilling to give it refuge due to the hazardous nature of its cargo and the severe damage to the hull, despite the risk of a wider environmental disaster if it breaks up and sinks. LR's response provided a breadth of service that has set a new standard, even supporting the client with media activity- virtually unprecedented for a classification society during such an incident. LR's global press release described our expert assessment of the ship's condition at a time when it was far from certain a safe port would be provided. this release made the front page of Lloyd's List, the

leading maritime website, positioning Lloyd's Register as a technical leader and showing that LR could not only act in a technical capacity but also provide influential public commentary to further support a client's goals. This isn't the end of Lloyd's Register's involvement in the story of Maritime Maisie. Now that she has arrived in port, LR will be involved in overseeing the safe unloading of the cargo, cleaning of the ship and a full assessment of the vessel to see if she can be salvaged. Further assistance for the safe movement to a repair or recycling facility will also be required.

    - key themes: modernisation, new role for LR, publicity, environmental damage, case study

- Modelling risk for safer environment,
    - "we can ensure safer operations across your assets by predicting accident effects on the environment and people… we use consequence modelling to predict accidents effects and the impact on people, the environment and property."
    - key themes: consultancy, risk assessment, Computation Fluid Dynamics Software,
- Inspection of water mist nozzles, 2016
    - "Since the introduction of MSC.1/Circ.`1516- Maintenance and inspection of fire protection and appliances there has been quite some debate with respect to the application of this on board yachts…
    - key themes: relationship of classification society guidelines and the IMO, International convention, yachts
    - This might be an interesting document to compare to earlier documents that might show something of the relationship between the advice given by LR and classification societies and the conventions laid down by the IMO