CHEMICAL RISK MANAGEMENT

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Abstract

Chemicals are both transported in large quantities by sea and also used in the everyday operation of ships. This paper is an exploratory discussion of the extent of the risks involved in such transport, and use, and its implications for approaches to health and safety management on board vessels. It asks whether sufficient is known concerning the reality of chemical exposures and their control at sea, what the implications of this are, and whether further research is warranted to evaluate the effectiveness of risk management at sea. It presents some consideration of the broad strategies to manage and reduce chemical risks that have been the subject of previous work across a range of economic sectors. Based on recent literature and interviews with key informants representing interests in the supply, transport and use of chemicals in the maritime sector, the paper makes a preliminary attempt to establish what might be some of the issues for managing chemical risks to seafarers, while at the same time considering the extent of common ground between them and those addressed in land-based situations.

Introduction

During the 20th century the global production of chemicals increased from 1 million tonnes in 1930, to 400 million tonnes by the beginning of the 21st century. Much of this material requires transportation from producer to user. When raw materials such as the mineral ores and hydrocarbons involved in chemical production are included, the scale of global transportation of chemical substances and products is enormous. A substantial proportion of this transportation takes place at sea. In addition, on ships as in many other workplaces, chemical substances are used routinely in operational and maintenance work and may also be present in the shipboard environment as bi-products of other ship operations. In all these cases there is a degree of risk of harmful exposure. This presentation is an exploratory discussion of the extent of this risk and its implications for strategic approaches to health and safety management on board vessels. It asks whether sufficient is known concerning the reality of chemical exposures and their control at sea, what are the implications of this and whether

further research is warranted to evaluate the effectiveness of risk management and its supports at sea.

The paper begins with a review of recent literature on the toxic risks involved in working with chemical substances in maritime transport. It notes the presence of many 'known unknowns'. This, it suggests, is in common with the findings of land-based research on working with chemical substances and demonstrated need for a wider search for understandings of the nature and extent of chemical risks and how they can be most effectively addressed, embracing both land-based and maritime experience. At the same time it recognises that the maritime industry presents a unique working environment, which needs to be taken into account in discussing approaches to control risks of working with chemicals at sea.

This leads to some consideration of the broad strategies to manage and reduce chemical risks that have been the subject of previous work across a range of economic sectors. Based on recent literature and interviews with key informants representing interests in the supply, transport and use of chemicals in the maritime sector, the paper makes a preliminary attempt to establish what might be some of the issues for managing chemical risks to seafarers, while at the same time considering the extent of common ground between them and those addressed in land-based situations. It discusses factors that support or constrain sustainability and transferability of good practices. It identifies some challenges and asks what it would be useful to know in order to address them.

Chemicals and the nature of the risks they pose to seafarers

Accidents with hazardous chemicals at work may cause injury, acute ill-health or even death. The extent to which this is documented largely depends upon the coverage and accuracy of reporting systems for work-related incidents, which for a host of reasons are known to under-report such events. There are predictable variations by sector in the importance of chemicals as a cause of injury, and while they are not the main cause, they feature prominently across most sectors, especially associated with burns, being overcome by fumes, poisonings as well as commonly involved in major

incidents such as fires and explosions. Lack of standardisation of reporting systems in the shipping industry make quantitative assessment difficult but the qualitative details of incidents involving chemical substances suggest similar patterns, with accidental spillages, leaks, entry into confined spaces, fumes and handling chemical products in routine maintenance and cleaning, frequently occurring in shipboard incident reports.

However, such reporting only tells a small part of the story, because most of the consequences of working with chemical substances are chronic health effects, for many of which there is also a long latency between exposure and subsequent ill-health. In employment generally, by far the most prevalent health effects associated with exposure to chemical substances are diseases of the respiratory system and the skin, of which, asthma and chronic obstructive pulmonary disease (COPD) in the case of the respiratory system and contact dermatitis in the case of the skin, are the most common. Diseases of the central nervous system are linked to such exposures, as are allergies and reproductive, developmental and endocrine disorders. Cancer is also associated with exposure to chemicals at work.

In all cases, there are no reliable data concerning the full extent of occurrence. In Europe for example it has been estimated that nearly one third of all occupational diseases recognised annually in the EU are related to exposure to chemical substances. Occupational cancer is estimated to account for between 4 to 16 per cent of all cancer mortality and most occupational cancer is related to exposure to chemical substances of one sort or another. But it is also acknowledged that these are only partial measures and probably serious underestimations. Two major problems confound measurement of the extent of the health effects of working with chemicals. One occurs because neither the hazards of many chemical substances nor the extent of exposure to them are adequately researched, therefore understandings of risks to health and their quantification are based on limited data. The second occurs because the long latency between exposure and disease for many conditions associated with hazardous substances means it is often difficult to establish a causal relationship.

There is no reason to suppose that the pattern of chemically related ill-health or the problems in documenting its extent in seafaring are likely to be any different from those found elsewhere. Seafarers are potentially exposed to a range of hazardous

chemicals in their routine work and, as already noted, in addition, a substantial proportion of global chemical production is transported by sea, from producers to users, including many substances that are known to be hazardous to health. Seafarers regularly employed in such transport may be particularly at risk as a result of exposures during loading and unloading operations, as well as in routine maintenance and as a result of leakage. There is some evidence of this in the mortality data for seafarers generally (Bloor *et al* 2000) and for particular seafaring occupations. For example elevated cancer incidence has been demonstrated amongst merchant seamen (Greenberg, 1991), in Danish engine room crew (Brandt *et al* 1994); for mates on Norwegian tankers (Moen *et al* 1994) as well as for Danish seafarers employed on tankers generally (Kaerlev *et al* 2005). For Finnish seafarers, it has been noted that occupational exposure of both deck and engine room crews on tankers add to their risk of various forms of cancer (Pukkala and Saarni, 1996; Saarni et *al* 2002). Elevated risks of lung and bladder cancer have also been found amongst Icelandic seamen (Rafnsson and Gunnarstoditter, 1995). As well as historical exposure to asbestos in engine rooms, exposure to polycyclic aromatic hydrocarbons (PAH) and to benzene are commonly reported in studies of seafarers. Exposures to carcinogenic agents in tanker operations and in engine rooms has been noted (for example, Verma *et al* 2001, Nilsson *et al* 2004, Moen et al 1995a and 1995b) and in relation to the inspection of commercial tank barges (Davenport *et al* 2000). Other than carcinogens, chemical substances such as organic solvents for example, have been associated with neurotoxic effects amongst seafarers (Riise and Moen 1990; Nilsson *et al* 1997). There is also some limited evidence that subgroups of seafarers with a higher risk of hospitalisation as a consequence of lifestyle related conditions also have increased risk of hospitalisation due to injury and poisonings, the latter caused by chemical substances (Hansen *et al* 2005).

However, overall, the extent to which the health effects of working with chemicals at sea are reported and analysed in the international scientific literature on the subject, is comparatively limited in comparison with studies on the effects of occupational exposures in land-based industry. There are good reasons for this. Problems of monitoring such ill-health are particularly challenging in seafaring, where many individuals are employed on short-tem contracts across a range of employers and agencies, and where the large part of the labour supply is from countries in which

disease reporting systems are poorly developed.[1] As Thebaud-Mony (2007) has shown in relation to the incidence of work-related cancers amongst contract workers in the nuclear and chemical industries in France, such employment arrangements are major factors promoting the low visibility of ill-health in routine reporting systems even in Western countries with robust reporting systems. Combined with poor public health data reporting systems in most major maritime labour supply countries, this means that complete information on the long term health consequences of seafarers' exposures to chemicals is unlikely to be available. As a result, there are no reliable data on the proportion of the morbidity and mortality that can be attributed to work involving the transportation of chemical substances by sea.

Nor is exposure to chemical substances that occurs during sea transportation systematically documented. While some ships are fitted with automatic devices that are designed to warn workers about toxic chemical contamination and are equipped with hand-held simple detection devices for checking for contamination in confined spaces, such devices cannot be used to monitor workers' exposure during work. Some chemical tanker companies also require more frequent than average routine medical examinations for seafarers employed on their tankers, however, here again, such medical monitoring is unlikely to detect effects of more than a very limited number of the range of hazardous substances to which seafarers may be exposed in their work. Moreover, such examples represent exceptional cases in which the dangers of the chemical substances involved are to a large extent known and precautionary measures are implemented. In many other cases, arguably the majority, the hazards and the exposures concerned as well as their consequences for seafarers are simply unknown.

In land-based workplaces there is also little systematic information on exposures. Exposure data-bases exist in some industries in a few countries — for example, the DOK-MEGA database in Germany — but they are exceptional. In the UK, the Health and Safety Executive (HSE) has maintained measurements of exposure to hazardous substances on the National Exposure Database since 1986. But research carried out by the Institute of Occupational Medicine (Cherrie, *et al* 1999) noted that its coverage is only partial and that it has proved difficult to persuade industry and others to

[1] All the epidemiological studies cited, are concerned with Western European or North American subjects, reflecting the relative availability of data from such sources.

contribute towards this database. In Europe more widely, self-assessment based surveys conducted for example by the European Foundation for the Improvement of Living and Working Conditions found that 22 per cent of respondents throughout the EU considered themselves to be exposed to dangerous substances for at least a quarter of their working time, while 16 percent thought they handled dangerous substances daily (European Foundation 2001). It has been estimated that some 22-24 million workers in EU countries are exposed to occupational carcinogens (Kauppinen et al 2000). National surveys support this thesis, for example, analysis of the French 2003 SUMER survey indicated that 14 per cent of the French workforce were exposed to one or more of 28 carcinogenic substances at their place of work (DARES 2005). No such information on the exposure of seafarers has ever been gathered systematically. But snapshot small scale surveys suggest substantial exposures, for example Jensen *et al* (2005) indicate that 55 per cent of a sample of over 6000 seafarers thought themselves to be exposed to chemicals with the highest exposures experienced, not surprisingly, on tankers.

All this suggests that the current level of knowledge of the full extent of the health effects of transporting and working with chemical substances at sea, does not provide a reliable basis on which to implement or evaluate control strategies. Although seafaring may represent a cause for concern in this respect, it is clear that it is not unique. In recent years there has been a growing recognition of the extent of 'known unknowns' in relation to workplace chemical exposures and their effects across a wide range of work situations and a variety of sectors. This prompts the question of what is to be done to minimise exposure and manage risks.

The development of current occupational chemical risk management strategies

Conventional approaches towards health and safety at work involve imposing regulatory duties on those that create risks, requiring them to take reasonable steps to protect those that may be exposed to them. This is also true as far as the risks of using and working with chemical substances are concerned. In addition, in the case of chemicals there are a host of further requirements imposing duties on manufacturers and suppliers of chemical products to provide information on their hazards and how

they may be transported, used and disposed safely and without risks to health or the environment. This makes for a complex regulatory framework for managing the risks of hazardous substances. Nowhere is this more evident than in the shipping industry, where sections of international regulations, codes and conventions such as MARPOL, SOLAS, STCW and so on, as well as a host of national measures and industry requirements, provide for an exceedingly complex regulatory framework addressed to the supply, transport, use and disposal of chemical products at sea, providing general standards and detailed requirements specific to particular trade sectors and ships.

Despite this complexity there are some relatively simple conceptualisations about risk management that can be distilled from both land-based and maritime requirements. To appreciate their significance requires first understanding a little of their background.

The 1970s and 1980s were decades when the modern approach to regulating the management of health and safety took hold.[2] Regulatory approaches to achieving systematic risk management were increasingly advocated, both in relation to health and safety generally and for specific hazards such as chemical exposures. While it could be argued that the maritime industry was somewhat slow to follow suit, with its adoption of the ISM Code in the 1990s, it too implemented a more systematic approach to general safety management on board ships. On land, requirements began to emerge at EU and national levels in which good occupational hygiene practices were emphasised in the regulation of systematic chemical risk management. Where safer substances or processes could not be introduced, concepts of controlling exposure at source were advocated, standards were required against which exposures could be monitored and the risks to workers controlled. Today as result, although there are some differences of detail, most countries in the EU have broadly similar regulatory requirements for general chemical risk management, derived from, or harmonised by, EU provisions. They are outlined in Table1. In addition there are special requirements that apply to sites and substances that are deemed to be especially hazardous.

[2] Regulating health and safety management (process regulation), as opposed to setting prescriptive regulatory standards with which duty holders are required to comply (prescriptive regulation) was a feature of national legislation such as the Health and Safety at Work Act (HSW) Act in the UK, the various Work Environment Acts of Scandinavian countries and the Netherlands, all of which date from this period. They influenced the content of the EU framework Directive 89/391, which extended such process-based regulation to all member states from the early 1990s onwards. They also influenced similar developments in Australia, Canada and New Zealand.

Table 1: Requirements on chemical risk management

Substitution, obligatory for some substances in some countries but also in most countries there is an obligation on duty holders to consider whether there may be safer products available
Risk assessment — this requires appropriate suppliers' information, i.e. on labels and in material safety data sheets (SDS), but also the capacity to understand it and to consider the tasks for which chemical products are required. It also requires inventories of substances used. More technically, it requires exposure assessment.
Information and training for workers about risks to health and safety and risk prevention/control measures, often interpreted as written working instructions
Implementing control measures according to the established hierarchy of good practice for control
Health surveillance where necessary

Similar requirements can be found amongst the regulatory details that cover the shipping industry, applying generally to chemical risk management in the industry as well as more specific requirements on ship design, substance and plant safety that apply to situations such as chemical and oil tanker transport, and are analogous to those on land addressed to hazardous installations and very toxic chemicals.

Despite the plethora of regulatory and other measures aimed at the control of the risks to health of working with chemicals, as the preceding section suggests, both on land and at sea there is reason to be concerned that reduction or control of these risks to acceptable levels remains to be achieved. On land such concern is not new — indeed the measures outlined above were a response to earlier worries in this respect. In the past decade however attention has shifted from the systematisation of process regulation of chemical risk, to the practicability of the achievement of control in workplaces in which resources to operationalise such ends are limited.

It became increasingly apparent, for example, that the effective implementation of systematic approaches to chemical risks management was dependent on several preconditions. They included, not least, good quality information concerning the hazards of substances, clear criteria on which exposure standards could be set, good systems for communicating this information to duty holders, sufficient technical capacity to monitor, evaluate and control risks and monitor workers' health in workplace scenarios, sufficient grasp of what was required and how it should be

achieved by duty-holders, as well as adequate inspection and control. Yet the reality was that information on the hazards of the vast majority of substances used in European workplaces was far from complete, exposure standards were set for comparatively few substances and the criteria used subject to variation and debate. The quality of communication on hazard information to duty holders as well as that between duty-holders and their employees was poor. Technical capacity was limited to large enterprises or external services and there was growing evidence that a substantial proportion of duty–holders neither understood what was required of them, nor possessed the capacity to deliver the systematic approaches framed by regulation (Walters and Grodzki 2006).

Numerous studies across the range of northern European countries demonstrated that owners/managers especially in small enterprises did not understand suppliers' information or use it appropriately, they frequently did not understand the application exposure assessment/control, nor were they willing or able to employ expertise to do so (see for example Research International 1997). At the same time, many studies pointed to the inadequacies of information, both with regard to labelling and SDS – considerably more so in the case of the latter — identifying severe limitations in the quality of information and of its accessibility for small enterprises. (See for example, Samways 1988, Geyer et al 1999 and more recently CLEEN, 2004). It was also becoming evident that regulatory inspectorates lacked the capacity to check compliance adequately across the range of duty-holders subject to the regulation and it was, in short, a situation in which there was mounting evidence of regulatory failure.

It would seem to be important to ask to what extent this land-based experience is repeated at sea. Unlike the situation on land, there has been little independent evaluation of the effectiveness of arrangements to manage chemical risks to seafarers. However, there are several points of comparison. For example there would appear to be some degree of parallel between land-based experiences in the chemical and oil industries, and that on board chemical and oil tankers, where industry experience, regulatory scrutiny and the presence of large and well resourced companies, combine to influence good practice in controlling chemical risks both in terms of the safety technology of plant/ship design, and in the systematic management of operations to

ensure delivery of best occupational hygiene and safety practices. As well as requirements on design and operation in relation to the carriage of hazardous cargo, in the oil and chemical tanker sectors of shipping there are especially pronounced requirements on the training of seafarers that are also in place.

Turning to the other sectors of the shipping industry, practices in the carriage of hazardous substances are considerably more varied, most probably reflecting the diversity of ships, companies and clients involved. This is therefore a further parallel with land-based situations in which it is well established that outside of large companies, the chemicals industry and high-risk hazardous installations, there is similar variety of practice in terms of chemical risk management across a wide range of workplaces and sectors. What is also known to be the case on land however is that it is in these situations that previous regulatory strategies to control chemical risks failed because they did not address the conditions of risk communication and control commonly experienced in these workplaces.

Tackling the challenge

Acknowledgement of this failure led to recent strategies to improve chemical risk management by addressing them towards the limitations of risk communication (Russell *et al* 1998, Topping 2001. For example in the UK, the production of *COSHH Essentials*, the recasting of requirements on exposure limits, and the recent reorientation of the COSHH Regulations have all occurred within a policy debate at national level in which the weaknesses referred to above have been aired. Similar debates have taken place more recently in Germany, explicitly addressing the need to make the legal framework for regulating chemical risk management 'more small enterprise friendly' and have influenced Hazardous Substances Ordinance 2005. Within the recently re-established Committee on Hazardous Substances, (*Ausschuss für Gefahrstoffe – AGS*) for example, there is a working group to develop proposals to improve the accessibility of support tools directed at SMEs. In Sweden, the *KemiGuiden* (Chemical Guide) is a complete tool that allows employers to identify regulatory requirements on chemical risk management and implement appropriate responses. It was developed with support and financing from trade unions' and

employers' organisations and is delivered with their active institutional support as well as that of the Work Environment Authority.

Other countries have adopted comparable approaches, embedding them in wider strategic initiatives to engage employers and their workers. For example, in the Netherlands the *VASt* programme, requires employers to engage with preparation of sectoral level action plans for chemical risk management that identify specific improvement activities in high-risk sectors. Alongside another major Dutch strategy that promotes the adoption of covenants (*Arboconvenanten*) between employers and trade unions at sectoral level, setting achievable targets for improvement of health and safety issues, this provides a framework for institutional support in which tools for chemical risk management can be deployed.

In Austria, the AUVASafe system (*AUVAsicher)* provided by the AUVA (the major insurance organisation for occupational risks) is a free preventive support service for smaller worksites. Employers can call upon the services of health and safety expertise from prevention centres run by the AUVA. Chemical risk management is not the only part of its programme, but it is nevertheless a central one (Friedl 2000; Pfoser and Peer 2004).

Such approaches are increasingly international. At the level of the European Union, for example, the rhetoric behind the recently introduced Regulation on Registration, Evaluation and Authorisation of Chemicals (REACH) places considerable emphasis on risk communication in the supply chain and its requirements are intended to promote two way exchange between suppliers and users concerning exposure scenarios at the workplace.

None of this seems to be taking place at sea where there has been no parallel acknowledgement of limitations in the application and operation of requirements for safety in the transport and use of chemicals, as was the case on land. Of course it is possible that this is because, unlike in the majority of land-based scenarios, requirements for managing chemical risks on board ships work effectively. If so, it would seem important to know what are the supports for effectiveness in this respect on board ships and the extent to which lessons learned here can be transferred to land-

based situations. Alternatively, it may be that similar failings to those perceived to occur on land are in fact commonplace in chemical risk management on board ships, but neither they nor their consequences have been properly investigated or documented. If this were the case, again it would seem important to learn more about the reasons for such failings in order to better understand ways in which they may be overcome.

A focus for further study?

A great deal is already known about the technology of preventing harmful exposures to chemical substances. Yet, if the indications of the evidence of exposure and its consequences referred to previously are to be believed, harmful exposure to chemical risks continues to be a commonplace experience at work and a cause of substantial work-related mortality and morbidity. Furthermore, although we cannot document it in detail, it seems likely that such exposure will be no less an issue in the shipping industry than it is in other sectors of the economy.

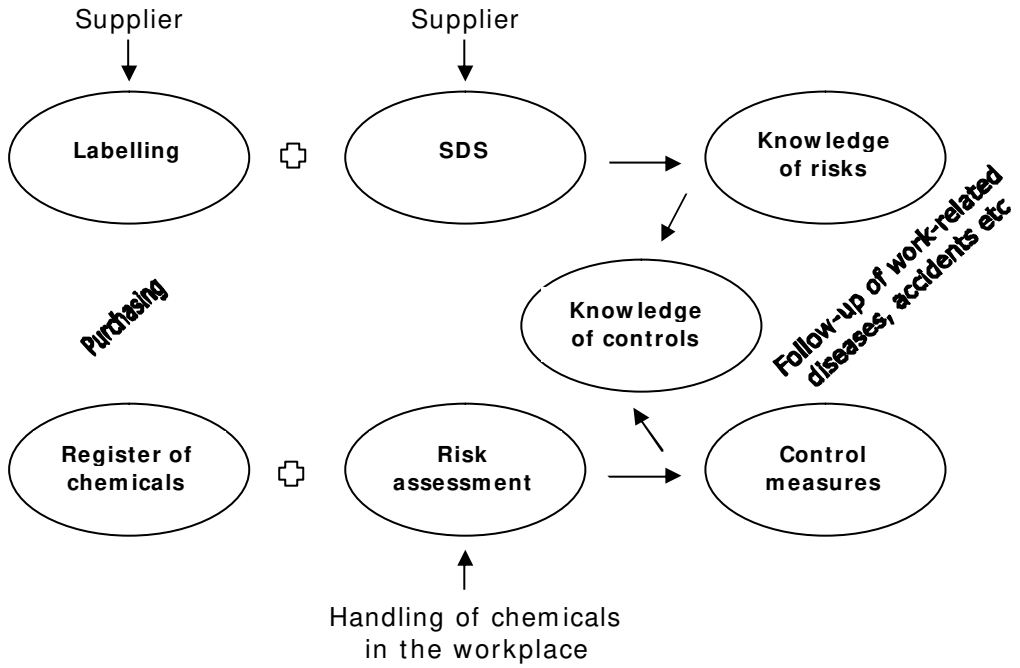
While it is relatively straightforward to show that the technical means exist to prevent harmful exposures, to use chemical substances safely and to monitor workers' exposure and health, as preceding sections illustrate, it is equally easy to demonstrate that they are seldom applied across all the situations in which chemicals are used and it is far from simple to find practicable and economically feasible solutions to this problem.

From a social science research perspective, an interesting set of questions arise concerning the socio-economic factors that act as supports or barriers to desired improvement in chemical risk management of which the following are some examples.

Communicating risk: Figure 1 illustrates the flow of information from supplier to user in chemical risk communication and how it drives the operation of risk management at the workplace. Many of the known weaknesses in present practice take place at points in this diagram. For example, as we have seen, land-based study suggests that

the content of SDSs are frequently inadequate. Preliminary interviews in the present study suggest that there are similar concerns about chemicals both in use and carried as cargo on ships. Further study of the extent and nature of such inadequacy would seem to be warranted since good suppliers' information is both fundamental to downstream safe use of chemical products as well as being one of the cornerstones of regulatory strategies. This does not only concern requirements on the generic design of SDS but also monitoring the extent to which they are observed in practice.

Figure 1: **Aspects of chemical risk management**



(after Walters 2007)

Several other aspects of the role of suppliers are important. In land-based studies, they are shown often to be the major source of specialist and trusted advice on chemical safety, especially for many users in smaller establishments who do not have the resources or knowledge to use alternative sources of advice. It is largely based upon this understanding that modern European regulation such as REACH advocates a greater role for the chemical supply chain and for risk communication between suppliers and users. In shipping the role of economic relations between shipping companies and their clients in the transport of goods can sometimes be major factors that influence the management of safety on board ships, including that of chemical safety. Equally, some of the chemical products used on board ships are often sourced

from relatively few suppliers for whom shipping companies are a major source of business. In these situations the supply chain may be an important influence on safety and the leverage for improvements that may be possible in such relationships. Yet, it is equally clear that there is much variation in the quality of help available from suppliers and that supply chains are not simple relationships (Walters 2007; James *et al* 2007). Their role in improving chemical risk management at sea would therefore benefit from further detailed study to identify both their supporting and constraining features.

Purchasing and registering: Figure 1 also shows the importance of purchasing strategies in chemical risk management. Here too there are several aspects of land-based experience that may be worthy of further study. Fundamental to the control of chemicals hazardous to health is the notion of the substitution of dangerous products with those less dangerous. As researchers have pointed out, such substitution extends beyond substances and can also include plant or processes (Ahrens *et al* 2006). Substitution certainly occurs in the purchase of chemical substances in shipping, but its extent of significance is not clear and a better understanding of these matters and their effects would be useful.

Of course purchasing decisions also take account of a variety of other factors. For example, there is some evidence to suggest that in land-based scenarios as well as maritime ones, some organisational strategies have quite explicitly taken into account environmental issues in the purchase of chemicals and with beneficial effects (Gorton 2001). It would seem to be important to explore how widespread this practice is in shipping companies and how far it is possible to create links between the purchase of substances for use on board ships and already present environment policies in many shipping companies.

A consequence of purchasing that is often a legal requirement is the creation of an inventory of substances used at the workplace. Some firms use this requirement as an opportunity to keep purchasing policies under review to ensure only necessary substances are acquired and in necessary amounts. An example of a similar approach used at sea is found on Wallenius Lines (Gorton 2001). Again, it would be useful to

know how widespread such approaches are and what are their effects in relation to the use of chemicals across the industry as whole.

Risk assessment and control: Reasons for a register of chemicals, and good quality suppliers' information are in a large part to enable adequate assessment of the risks involved in the handling and storage of substances at the workplace. Risk assessment on board ships is required not only by specialised rules and regulations on chemical safety but also more generally as part of the shipboard safety management systems called for under the ISM Code. Elsewhere, risk assessment has been fundamental to regulatory strategies on chemical risk management at the workplace for several decades, and has been seen as an important stage in the development of appropriate control strategies in the professional practice of occupational hygiene for a lot longer. Despite this history, it is a process that is much misunderstood, and often inappropriately and incompletely applied. Research on the practice of managing chemical risks suggests that employers in workplaces other than those that are large and well resourced are poorly equipped to undertake risk assessment and even when they are supplied with appropriate information there remain major problems with their understanding and capacity to carry out the task adequately (Walters 2007). Since the primary purpose of assessing risks is to ensure that adequate and appropriate measures are taken to control them, it follows that failure to discharge this task properly will lead to further problems in implementing appropriate controls.

It was the acknowledgement of this failure that has led the development of the latest national strategies, to improve chemical risk management in land-based industries, some examples of which were outlined previously, and in which generic control solutions and greater engagement with support infrastructures and suppliers are advocated. Properly conducted study of the effectiveness of these approaches has been shown to be limited. However, some indications of supports and constraints to these approaches are evident.

It seems clear for example that simplified and generic control solutions are not a complete answer. Their application requires engagement and support from actors in the economic infrastructures of the sectors and trades in which they are applied. These may include trade unions and employers organisations, trade bodies such as economic

chambers, insurance organisations, inspectorates and occupational health and safety services as well as the suppliers of substances and equipment themselves, and client companies and other intermediaries that are in positions of leverage (Walters 2006 and 2007). The exact nature of such constellations of influence is shown to vary according to firm size, economic position, country, and sector. What is possible by way of support for chemical risk management is very different in, for example, the German printing industry, where there is active, insurance-based, technical support for health and safety, well established co-operation between small firm users of chemicals, the insurance organisation, the trade bodies, the suppliers of chemicals and the regional health and safety inspectorates and say, the British construction industry where many substances are in unsupervised use on a daily basis by non-union employees of small subcontractors with no direct link to suppliers, often at temporary building sites for short periods and with no more than the remotest of connections with the health and safety management arrangements of principal contractors on such sites (Walters 2007).

In contrast to the situation on land, the extent of the success or failure of traditional approaches to risk assessment and control of chemical substances has not really been tested in the shipping industry. Based on the available literature and the preliminary findings from interviews in the present study however, the picture that emerges suggests at least some commonality with land-based experience. For example, most of the work that has been done on exposures to hazardous substances at sea has been undertaken in the chemical and oil tanker trade, paralleling the similar situation in the chemical and oil industries on land. It is in these sectors that the most developed strategies for managing chemical risks exist and again this is the case on land. However, the extent of the research evaluating the effectiveness of these strategies at sea is limited in comparison with that in the same sectors on land. Importantly, there appears to be no documentation of the range and extent of demonstrable good practice on chemical risk management in these trades or of the extent to which such practice might be transferable to other parts of the shipping industry, or of the likely barriers or supports for such transfer. Nor does there appear to be any sign of an emerging research literature paralleling that on land that considers the role of leverage in the economic and social relations of the supply of chemical products, or, in the case of their transportation, of these relations between suppliers, shippers, ship- operators and

users. Yet anecdotal accounts suggest that such relations provide opportunities for leverage in the supply chain and in the relations between shipping companies and their clients that may be important influences on practice.

If all of this could be explored further in the tanker trade, it certainly would warrant investigation in other sectors of shipping where the transport and use of chemicals are commonplace but where the situations and contexts of control are considerably more varied. Here too anecdotal accounts in interviews for the present study suggest that supply chain leverage could be an important support for the introduction of more accessible approaches to risk assessment and control and for sustainable good practice in their operation. Such activities as the storage and use of paints, engine room materials and substances used in general cleaning and maintenance are to some extent comparable with those in land-based activities where the role of suppliers in improving and sustaining good practice have been described further. For example in the motor vehicle trade in Germany large manufacturers are able to influence the management of chemical products both in relation to their contracted dealers and repairers, as well as in some cases, the suppliers of components and there are many other examples in the same vein in other trades (Walters 2007).

Conclusions: Learning from experience

Working with chemical substances is a widespread feature of modern life at sea as well as on land. Some chemical substances are hazardous and exposure to them at work may cause serious ill-health and may even prove fatal. The problem is a significant one but its dimensions are not known, especially not in seafaring, where both exposure and its consequences are difficult to monitor. Nevertheless, sufficient is understood of the means to prevent harm in working with chemical substances to suggest that applying a precautionary principle would be good management practice. Unfortunately, research shows that regulatory approaches to achieving such good practice across anything like the full range of workplaces in which chemicals are used in land-based situations has until now met with only limited success. There are several reasons underlying this limited achievement but research further suggests that important amongst them is the failure of risk communication and support for the

implementation of chemical risk management in enterprises that lack the resources to gain specialist knowledge in this field. The absence of similar study of the situation at sea means that it is unclear to what extent approaches have been successful here, but it would appear that there is sufficient similarity with many land-based situations to warrant caution in assuming such success.

In land-based situations, acknowledgement of regulatory failure in chemical risk management has meant that the orientation of current research and policy has increasingly focused on discovering ways of supporting and sustaining the effectiveness of interventions by exploring the socio-economic contexts in which they occur. It is suggested that there would be something to be gained from the exploration of these contexts in shipping too.

At the same time on land, a general crisis in the resourcing of regulatory inspectorates combined with neo-liberal economic policies has promoted a desire for more self-regulatory approaches towards health and safety management generally on the part of industry. As a result there has been a growing interest in the role of economic drivers, in leverage in the relations of supply, and in the role of actors in social and economic infrastructures that support business relations in achieving improved and largely self-regulatory approaches to health and safety management. These approaches are already the norm in shipping, where in a globalised industry self-regulation has been a well-developed feature for a considerable time. It is therefore quite possible that by investigating the role of economic drivers in determining best practice in chemical risk management at sea, by documenting what works and why it works in these situations, significant lessons may be learned that could have a wider application in other economic sectors.

While it is important to understand and utilise the possibilities for support and leverage to improve chemical risk management in the shipping industry, it also needs to be acknowledged that there are likely to be some limits to the extent to which economic relations can be utilised to drive self-regulated approaches, since there are always those companies that fail to see the commercial advantages of improved quality and are unresponsive to economic pressures to achieve it, opting instead to compete for business by cutting costs. Here again there would seem to be some room

for further study, this time concerning 'best fit' in the relationship between economic drivers and international regulation and its enforcement in achieving improved working practices on board ships.

Particularly interesting at the macro-level for example, would be some consideration of what might be the extent of the possible increased supply chain focus of international regulatory intervention, and to what extent it might be possible to explore linkage between improving workplace health and safety in the use and transport of chemicals at sea, with that of measures aimed at environmental and consumer protection. Such has been the character of the new European approach to chemical regulation typified by REACH. Here, a refocusing of the chemical suppliers' duty of care has occurred so that it is industry rather than the state that is responsible for ensuring the safety of chemical products, and the extent of this responsibility extends beyond use at work to embrace consumer and environmental protection also. In so doing, the role of risk communication in the supply chain has become a prominent issue for regulatory attention.

It is far too early to see what the effect of these measures will be, but for our purposes, it is important to note the already existing parallels in some of the requirements of MARPOL, in the voluntary practices of larger oil and chemical suppliers, shippers and shipping companies and to suggest that their effects could be the subject of fruitful future inquiry.

References

Ahrens, A., Braun, A., von Gleich, A., Heitman, K. and Lissner, L. (2006) *Hazardous Chemicals in Products and Processes: Substitution as an Innovative Process,* Physica-Verlag, Heidlberg.

Bloor, M. Thomas, M. and Lane, T. (2000) Health risks in the global shipping industry: an overview, *Health, Risk and Society*, 2 (3): 329-340.

Brandt, L.P.A., Kirk, N.U., Jeneva, O.C. and Hansen, H.L (1994) Mortality among Danish merchant seamae 1970-1985, *American Journal of Industrial Medicine*, 25:867-876.

Chemical Legislation European Enforcement Network (CLEEN) 2004 ECLIPS *European Classification and Labelling Inspections of Preparations, including Safety Data Sheets*, FINAL REPORT. http://www.cleeneu.net/projects/ECLIPS_Final_report.pdf

Cherrie J, McIntosh C, Ritchie P, Sewell C (1999), *Voluntary reporting by UK industry of occupational exposure data on chemicals – a feasibility study*, Institute of Occupationa1 Medicine, CRR 227/1999 HSE Books, Sudbury.

DARES (2005) Les expositions aux produits carcinogens, *Premiere Syntheses Informations,* No 28.1.

Davenport, A. C. Glynn, T.J and Rhambarose, H. (2000) Coast Guard exposure to gasoline, MTBE and benzene vapours during inspection of tank barges, *American Industrial Hygiene Association Journal*, 61(6): 865-72.

European Foundation for the Improvement of Living and Working Conditions (2001) *Third European Working Conditions Survey* , Luxembourg: Office for Official Publications of the European Community.

Friedl, W. 2000 Occupational safety and health protection in small and medium-sized enterprises in Austria, FORUM News (Bulletin of the European FORUM of Insurance against accidents at work and occupational diseases) No16. Vienna: AUVA, p13-15. DL: www.europeanforum.org/pdf/forumnews_nr16_ed.PDF [14.10.2004]

Geyer, A, Kittel, G, Vollebregt, L, Westra, J and Wriedt, H. (1999) *Assessment of the Usefulness of Material Safety Data Sheets (SDS) for SMEs.* Final project report. Linz: PPM.

Greenberg, M. (1991) Cancer mortality in merchant seamen, *Annals of the New York Academy of Science*, 643: 321-32.

Gorton, S. (2001) Chemicals used on board. What can be done*? Scandinavian Shipping Gazette*, 6 32-33.
Hansen, H.L., Tuchsen, F. and Hannerz, H. (2005) Hospitalisations among seafarers on merchant ships, *Occupational and Environmental Medicine*, 62:145-150

James, P., Johnstone, R., Quinlan, M. and Walters. DR (2007) 'Regulating supply chains to improve health and safety'*, Industrial Law Journal*, (in press).

Jensen ,O.C., Srensen, J.F. Canals, M. L. Hu, Y.P Nikolic, N. and Bloor, M. (2005) Subjective assessments of safety, exposure to chemicals and use of personal protection equipment in seafaring, Occupational Medicine (6) : 454-58.

Kauppinen, T. et al (2000) Occupational exposure to carcinogens in the European Union, *Occupational and Environmental Medicine*, Vol. 57, pages 10-18

Kaerlev, L., J Hansen, J., Hansen, H.L. and Nielsen, P.S. (2005)
Cancer incidence among Danish seafarers: a population based cohort study
Occup. Environ. Med., 62(11): 761 - 765.

Moen, B. E., Riise, T and Helseth, A. Mortality among seamen with special reference to work on tankers, (1994*) International Journal of Epidemiology*, 23(4): 737-41.

Moen, B.E., Hollund, B.E, Bernsein M., *et al,* (1995 a) Annals of Occupational Hygiene, 39:347-61.

Moen, B.E., Hollund, B.E, Bernsein M., *et al,* (1995 b) Occupational exposure of deck crews to carcinogenic agents on crude oil tankers, American Journal of Industrial medicine, 27: 555-64.

Nilsson, R., Nordliner, R, Hogstdt, B., Karlsson, A and Jarvholm, B. (1997) Symptoms, lung and liver function, blood counts and genotoxic effects in coastal tanker crews, *International Archives of Occupational and Environmental Health*, 69: 392-298.

Nilsson, R., Nordlinder, R., Moen, B.E., Ovreba, S., Bleie, K., Skorve, A.H., Hollund, B.E. and Tagesson, C. (2004) Increased urinary excretion of 8-hydroxydexyguanosine in engine room personnel exposed to polycyclic hydrocarbons, *Occupational and Environmental Medicine,* 61: 692-696.

Pfoser, W., Peer, H. 2004 Beratungsschwerpunkte - Betreuung AUVAsicher: AUVA intern ASQS-Sondernummer, S.12-14. DL: www.auva.at/mediaDB/75242.PDF [13.1.2005]

Pukkala, E. and Saarni, H. (1996) Cancer incidence among Finnish seafarers, *Cancer Causes Control*, 7: 231-39.

Rafnsson, V. and Gunnarstoditter, H. (1995) Cancer incidence among seamen in Iceland, *American Journal of Industrial Medicine*, 27:187-93.

Research International (1997), "*Industry's perception and use of occupational exposure limits",* HSE CRR no.144, HSE Books, Sudbury.

Riise, T. and Moen, B.E. (1990) A nested case-control study of disability pension among seamen, with special reference to neuropsychiatric disorders and exposures to solvents, *Neuroepidemiology* 1990 (9): 88-94.

Russell R, Maidment S, Brooke I. and Topping M (1998), "Introduction to a UK scheme to help small firms control health risks from chemicals*", Annals of Occupational Hygiene*, vol. 42 No 6 pp.367-376.

Saarni, H, Pentii, J. and Pukkala, E (2002) Cancer at sea a case control study among male Finnish seafarers, *Occupational and Environmental Medicine*, 59: 613-619

Samways M (1988), "Functionally illiterate worker also has right-to-understand", *Occupational Health and Safety*; 57(1): 49-50, 52–53.

Thebaud-Mony, A (2007) *Travailleur peut nuire gravement a votre sante*, La Decouverte, Paris

Topping , M. (2001) Occupational exposure limits for chemicals, *Occupational and Environmental Medicine* Vol. 58:138-144.

Verma, D. K., Johnson, D.M., Shaw, ML and des Tombe, K. (2001) Benzene and total hydrocarbons exposures in downstream petroleum industries, American Industrial Hygiene Association journal, 62(2):176-94.

Walters, D.R. (2007) *Within Reach? Managing chemical risks at work*, Baywood, Amytyville, New York. (in press)

Walters, D. R. and Grodzki, K (2006) *Beyond Limits? Dealing with Chemical Risks at Work in Europe*, Elsevier, Oxford.

Walters, D.R (2006) 'The efficacy of strategies for chemical risk management in small enterprises in Europe: evidence for success?' *Policy and Practice in Health and Safety*, 4.1: 81-116.