Impact of natural gas usage on port operations

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Figure 1: LNG as a marine fuel has many benefits to ports.

Introduction

The potential benefits of the use of Liquefied Natural Gas (LNG) as a marine fuel are widely recognized. In summary, the use of this fuel would allow the elimination of emissions of sulphur compounds (SOX), reduction of emissions of nitrogen compounds (NOX) and particulates, and the reduction of greenhouse gas emissions (CO2). From a port operational aspect, this is positive as it embraces the mitigation of local air quality issues and assists with the reduction of the carbon footprint of the port.

A normal component of the services which are provided to port users is the provision of fuels to the ships in port. Some particular challenges arise for ports when considering the use of LNG as marine fuel. Large ports have a complex infrastructure in place to supply conventional fuels to the port users. These fuels range from Heavy Fuel Oils (HFO) derived from refinery residuals (RMG/RMK), through blends of residual and distillates - diesel oils (DMB), to pure distillate often referred to as marine gasoil or 'DMA'. There may be additional low-sulphur grades. All in all, potentially quite a large number of grades, however all are common in one respect - the specified minimum flash point is 60°C. In most cases, delivery is in bulk ex-barge, the exceptions being on some oil tanker berths where fuels may be supplied over the jetty and, at the other extreme, small deliveries, say less than 25 tonnes, may be by road tanker. The significance of the flash point is that, under delivery conditions, even for heated HFO, the bulk liquid temperature is less than 60°C and hence the risk of ignition from a minor spill or mishap is very low. One cannot say that the fuels are 'non-flammable', but to ignite the fuel spillage under these conditions requires either a high energy source, such as may result from a collision with another ship, or the spillage coming into direct contact with an open flame.

About LNG

LNG is a mixture of liquefied gases, primarily methane. It is stored in bulk at near atmospheric pressure as a boiling liquid with a temperature of about -160°C. The flash point of LNG is less than -170°C. The significance of this is that any spillage of LNG will produce a vapour cloud, some part of which will be in the flammable range. The flammable range of LNG vapour in air is usually taken as five to 15 percent by volume. The ignition energy to ignite an LNG vapour cloud is much less than that for vaporized diesel fuel.

Should a vapour cloud ignite, the burning characteristics of LNG vapour, especially from spills onto water, produces little smoke, in contrast to burning pools of diesel fuels. This results in Surface Emissive Power (SEP – ie. radiation from the flame) being some four to five times higher than for diesel pool fires.

When LNG is spilled onto water it rapidly vaporizes, forming a visible white cloud. Initially, the cloud is heavier than air, but as the vaporized LNG is warmed by contact with the air, it becomes lighter than air and disperses naturally. The visible cloud is actually water vapour frozen out of the air by the extremely cold vapour. Based on many research spill trials to date, it is generally accepted that, for spills onto water, the portion of cloud within the flammable range does not extend beyond the visible cloud limits. The evaporation process may leave ice/hydrates on the water, but no permanent residue is left on the surface.

Explosive transition

Another phenomena may occur when LNG is spilled onto water, that of Rapid Phase Transition (RPT). This is a rapid boiling phenomenon and, by 'rapid', it may aid understanding to say 'explosive'. RPTs look and sound like an explosion, but there is no combustion process, just very rapid transition of phase from liquid to vapour. The physics of the process are very complicated and not fully understood, but opinion is that, despite being startling, there is not enough energy release to threaten the integrity of steel structures, ie. ships hulls.

LNG has another characteristic which needs careful consideration. If conventional shipbuilding mild steels are suddenly cooled to -160°C, as in an LNG spill on to the deck, the steel becomes very brittle and will spontaneously fracture. The vapour from LNG spills is not toxic to humans but is mildly narcotic. However LNG coming into contact with human skin will instantly cause severe frost burns/tissue damage.

Lessons from the LNG industry

The established LNG industry is based on large-scale bulk movements of LNG over long distances. This may be contrasted with the characterization of a fuel delivery infrastructure which is around many movements on a much smaller scale over short distances. The existing industry has an enviable safety record. So much so, that some commentators describe LNG as being 'safe', almost as if it was somehow intrinsically safe. The previous paragraphs should dispel that perception. The safety record has been achieved by diligent attention of all involved.

The main target is, simply, to prevent releases occurring. This is underpinned by three main factors: good design and construction quality; effective operating and maintenance practices, uniformly applied; efficient training practices. The industry safety record has been achieved in full cognizance of the intrinsic hazards of LNG, not somehow in spite of those hazards.

LNG fuel supply infrastructure

In conventional ports there is typically a zoning arrangement. One zone is where hazardous cargo operations, such as crude oil, oil products, chemicals and liquefied gases are conducted; the remainder, eg. containerships, ferry operations dry cargo etc. are regarded as 'safe' cargos. This is a bit simplistic since, even in 'safe' zones, hazardous cargo, eg. in containers or trucks, may be handled.

There are several model concepts for LNG fuel supply. One can, for instance envisage a dedicated berth for supply of LNG bunkers, within the 'hazardous cargo' zone, if you like a 'gas station'. Such a facility may be part of an existing large-scale LNG import terminal or a stand-alone plant. After the ship has completed normal port operations, it visits the LNG bunker supply berth prior to sailing. A second model is the concept of 'containerized LNG', ie. delivery of LNG fuel to ships in International Maritime Dangerous Goods (IMDG) type containers. In this concept, ISO tank containers are filled at an LNG plant and delivered to the ship fully charged, used containers being returned to the LNG plant for refilling.

A third model is to replicate the existing fuel supply infrastructure with LNG bunker barges visiting the vessels on their normal jetties. Whilst the former models can work, they are more likely to find favour in smaller ports with low intensity operations. The latter model is the one we consider most likely to be favored, particularly in large, busy ports, because the first model raises issues around extending overall port time, increase in port movements, scheduling and traffic management issues at the bunker berth etc. The container concept may work well for lower levels of demand but becomes impractical when large quantities are needed. However, using this third model does significantly alter the 'zoning' concept of a port – a hazardous product is now being handled throughout the port area on a routine basis.

Emergency responders

The emergency responders are typically trained to deal with the hazards in the zone they are assigned to, those working in areas with oil and products will be trained to deal with large scale spills and potentially very large fires, whilst those assigned to other areas will have their training tailored to the specific requirements, for instance this may be around managing large numbers of passengers in an incident. This is not to make any value judgement, but to recognize that the needs are different.

Whilst existing bunker spills do represent a hazard, the emergency responders' role tends to be more focussed on containment of the spill and cleaning up. Spills of LNG represent a different order of magnitude of hazard.

Additionally, emergency responders will need to be aware that many vessels may now have significant inventories of LNG on board whilst alongside throughout the port. Clearly, the training of the emergency responders will need to be adapted to reflect the new situation presented by LNG fuelling of ships.

Concluding remarks

The LNG industry has a strong safety culture which has delivered a 'safe' industry. Whilst not all aspects from the large-scale LNG industry practice translate directly to the small-scale LNG bunker operation, it should be the aim of all those who have a part in establishing the LNG bunker infrastructure to achieve equivalency in safety to that shown to work in the large-scale industry. This is essential if the benefits from the use of LNG as marine fuel in reducing harmful environmental emissions are to be realised.

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ABOUT THE COMPANY

SIGTTO is a membership society whose mission is to promote safety by the sharing of knowledge and thus, the development of high standards and best practices throughout the international LNG and LPG shipping industry.

ENQUIRIES

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