Exhaust gas cleaning systems: Guidelines for the management of consumables and waste products.
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Our industry is greatly in need of a set of guidelines to understand how to manage the consumables and waste from Exhaust Gas Cleaning Systems. Management of consumables and waste are not well understood by shipping industry and the challenges faced by onboard crew and shore staff are endless. The reason for this is that there has never been a comprehensive set of official guidelines published that highlights concerns and provides practical guidance on how to manage these two. This is a very good start and I encourage all shipowners and operators to produce their own specific onboard management procedures based around this piece of valuable work.

Yildiz Williams
Senior marine Consultant

Exhaust gas cleaning systems represent a new item of machinery to everybody onboard – and where those are of the closed loop type using caustic soda for wash-water condition control the introduction into the normal operating routine a potentially hazardous chemical. Consequently, we have developed these guidelines from practical experience with the objective of providing informed input for shipping companies to draw from when developing their own Safety Management System procedures covering these systems; the related supplies to the ship, the overall system operation and chemicals management onboard together with the subsequent disposal of the various related waste streams.

Andy Wright
Senior marine Consultant
1 Guideline development

1.1 Introduction

Exhaust gas cleaning systems (EGCS), sometimes referred to as SOx scrubbers, are increasingly fitted to ships as an approved alternative equivalent means of complying with the SOx control requirements as given by Regulation 14 of MARPOL Annex VI. Initially such systems were fitted to comply with the fuel oil 0.10% max sulphur content requirement within the Emission Control Areas (ECA) such as the Baltic and North Sea together with the EU ‘At berth’ requirements. This trend has accelerated following the 2016 confirmation of the 0.50% max sulphur content limit, which will apply from 1 January 2020 to all fuel oils used outside the ECAs.

While EGCS allow the continued use of conventional residual fuel oils, there are countervailing issues, with closed loop arrangements, in respect of the provision and management of the consumables – principally the potentially hazardous alkali used such as sodium hydroxide – and the waste products produced.

To assist shipowners / operators in developing a managed approach to those consumables and waste products, these Guidelines have been developed by Lloyd’s Register (LR).

1.2 Background

These guidelines have been developed by LR Marine Consultancy Services as an element in its assigned Activity 4 within a European Commission funded project entitled ‘Closing the Loop’. This project is intended to act as a knowledge-sharing activity in respect of EGCS to promote the wider use of such technology.

As part of that Activity 4, LR specialists sailed with EGCS equipped ships, as operated by Stena Line BV – another partner in the project – to observe their operation and management. Building on that experience and to address the project-assigned risk assessment element of Activity 4, LR undertook a HAZID workshop in conjunction with Stena. These Guidelines are an outcome of that work.
1.3 Definitions

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGCS</td>
<td>Exhaust gas cleaning system – accepted under MARPOL Annex VI as an equivalent means to achieving the SOx control requirements as given in Regulation 14 of that Annex</td>
</tr>
<tr>
<td>EGC unit</td>
<td>That part of the EGCS where the washwater is sprayed onto the exhaust gas for the purpose of reducing its SOx content</td>
</tr>
<tr>
<td>IMO EGCS guidelines</td>
<td>The requirements produced by the International Maritime Organization by which flag States approve and survey EGCS – currently Resolution MEPC.259(68)</td>
</tr>
<tr>
<td>MARPOL Annex VI</td>
<td>The air pollution control requirements, which includes SOx control, within the International Convention for the Prevention of Pollution from Ships</td>
</tr>
<tr>
<td>SDS</td>
<td>Safety data sheet</td>
</tr>
<tr>
<td>pH</td>
<td>A logarithmic scale used to specify the acidity or basicity of an aqueous solution with 7 as neutral, lower numbers indicating more acidity and higher numbers more basic. High numbers at either end of the scale indicate a product capable of causing acute harm to personnel</td>
</tr>
<tr>
<td>PPE</td>
<td>Personal protection equipment</td>
</tr>
<tr>
<td>SOx</td>
<td>Sulphur oxides – the product of combustion of fuel containing a sulphur fraction</td>
</tr>
</tbody>
</table>

1.4 Application

These guidelines have been developed as part of the overall European Commission project to assist shipowners / operators in developing their own onboard operating arrangements and procedures as regards the chemicals used and wastes resulting from the use of EGCS. As a generic template, these guidelines are intended to provide a starting point from which those individual ship / system arrangements and procedures would be developed and hence act to identify issues that will need to be addressed in the manner most appropriate to the particular ship, EGCS system and company operating practices. Furthermore, it is hoped that these guidelines will be duly informative to others who may have some connection with EGCS, such as port operators, chemical suppliers, waste contractors, equipment manufacturers, class and statutory surveyors, and inspectors.

Any EGCS on board a ship will need to be installed in accordance with the relevant Class requirements. Where the EGCS is to be used as an equivalent means of compliance under MARPOL Annex VI, the system will need to have been approved by, or on behalf of, the ship’s flag State, taking into account the IMO’s Guidelines: 2015 Guidelines for exhaust gas cleaning system – Resolution MEPC.259(68) – as may be amended. Those 2015 guidelines require, amongst other points, the provision of approved documentation covering a technical manual, an onboard monitoring manual and the SOx emission compliance plan together with an agreed format of the EGC record book (which may be written or electronic). These guidelines assume that the necessary Class and statutory approvals are in place and therefore do not address points related to those approvals.

It would be expected that any EGCS would be supplied with an operating manual from the equipment manufacturer. Although nothing in these Guidelines supersedes such instructions, it should be recognised that the equipment manufacturer may provide the manual solely from an equipment operation perspective rather than from an integrated chemical and waste management handling outlook, which these guidelines seek to promote.
1.5 Acknowledgements

LR would like to express deep gratitude to Stena Line BV ship and shore staff for their invaluable direct experience, assistance and hospitality during onboard and office visits. These guidelines could not have been developed without their open and practical input.
2 EGCS overview

2.1 General

Operators can use EGCS as an alternative way to comply with the SOx emissions limits.

There are two main types of EGCS:

- Wet EGCS that use water (seawater or freshwater) as the cleaning medium; or
- Dry EGCS that use a dry chemical as the cleaning medium.

Both wet and dry systems are established and mature, and have been used in industries such as electricity generation for many years. Wet cleaning, as generally used in marine applications, is a simple, robust and effective technique. There are two main types of wet cleaning:

- ‘Open loop’ systems, which use seawater to clean the exhaust gas. In these systems the seawater, as washwater, is passed only once through the EGC unit before being discharged to sea following any necessary treatment to meet the discharge criteria.
- ‘Closed loop’ systems, in which the washwater is continuously circulated from a process tank to the EGC unit and from there back to the process tank. To maintain washwater conditions, and to make up losses to the exhaust gas stream through evaporation, there are both make-ups (with freshwater or seawater depending on system and an alkali) and a bleed-off. This bleed-off, after treatment to meet the discharge criteria, is discharged to sea. However, as the flow rate of this bleed-off is relatively low (as compared to open loop systems), some arrangements include a holding tank to which the discharge water can be alternatively directed, so allowing a period of zero discharge to sea depending on tank capacity relative to the processed bleed-off flow rate. In those cases, the holding tank may thereafter be discharged ashore or, at a later time, to sea.
- In some instances, a ‘hybrid’ arrangement is adopted in which the system can operate in either open loop or closed loop modes as required. Alternatively, some systems may use an in-line arrangement with an open loop stage followed by a closed loop stage.

The discharge criteria are given in the IMO Guidelines. In addition, there may be national or local regulations that further control or ban discharge to sea as specified, usually in port or territorial waters.

More background information concerning EGCS arrangements is given in Appendix A.

2.2 EGCS involved in the development of these guidelines

As mentioned in the Introduction, these guidelines have been developed drawing from the actual experiences of EGCSs installed by Stena BV.

Those EGCS are of the closed loop type with one EGC unit to each of the uptakes from the four main engines. Two washwater circulating systems are installed, each serving two EGC units. In these systems, the basic washwater was seawater with sodium hydroxide (caustic soda – NaOH) in a 50% solution used as the alkali. Bleed-off treatment was by a flotation arrangement using both coagulant and flocculant chemicals to reduce the entrained exhaust gas material and with dosing of sodium hydroxide to control pH. To provide a relatively dry residue, the liquid outflow from the treatment unit was passed through a decanter. Discharge water was routed overboard while the semi-solid, but still pumpable, residue was collected in skips for discharge ashore.

These EGCS were installed on ro-ro ferry type ships, which have the benefit of being on fixed schedules and ports of call, only hours apart, together with the facility for deliveries and collections to be made by directly driving onto the ship's vehicle deck.

However, the following guidelines have been developed to apply to any EGCS on a generic basis. Hence, in the case of an open loop system, those aspects relating to the consumable chemicals will not generally apply, although
there may still be certain packaged chemicals used for discharge water testing or the calibration of discharge water monitors. Furthermore, an open loop system may or may not have a discharge water treatment element and hence the issue of residue to be discharged ashore. Closed loop systems may use alternative alkali materials such as magnesium oxide or sodium bi-carbonate, which are less hazardous than sodium hydroxide but may present other operational challenges. Bleed-off treatment may be by centrifuge or other dynamic means rather than chemical-assisted floatation.

In closed loop systems, the resulting residue may be of such a nature that it is handled as a fluid rather than a semi-plastic solid.

Also, in terms of ship type, most ships will not have the drive-on capability of a ro-ro ferry and therefore loading and discharge will more usually be achieved by lifting.
3 Ship operations

This section covers the consumables supplied to a ship and waste materials generated by the EGCS. In the case of the consumables, this covers their loading, storage and use. With regards to waste materials, this covers their holding onboard and subsequent discharge ashore. Common to both consumables and waste are the human factors, so this key aspect is considered first.

EGCS will represent a ‘new’ technology to crew onboard. In the case of closed loop systems with their corresponding chemical requirements, this also means potentially hazardous chemicals in the working environment, which cannot be considered in the same way as conventional engine room materials such as fuel oils or lubricants.

3.1 Human factors

It is important to recognise that there will be varying levels of involvement with the EGCS amongst those onboard, so the training and information provided should duly reflect that fact. Those involved are:

- Engineering Officers who will be directly working with the EGCS, its chemicals and wastes;
- Deck Officers who have responsibilities for the ship in general;
- Engine room crew who, while not having direct involvement, are in the same working areas; and
- Other crew, such as hotel staff, who, while having no involvement with the EGCS itself, would potentially be the first to be contacted by, for example, a passenger with an alkali contact burn.

3.1.1 Ship staff engagement

**EGSS is a new technology to virtually all at sea, so its introduction needs to be duly managed and provided for support equipment, manpower training and information.**

The loading and management of the chemicals used as consumables in closed loop EGCS involves additional work and care to avoid potentially hazardous situations. The ship’s staff involved need to be provided with suitable training and information. That training would include the handling, storage and use of those chemicals, the need for and the use of PPE together with first aid and response procedures in case of emergency.

Adjustment, maintenance and repair of the EGCS and its components can be a time-consuming task, so this additional work load needs to be allowed for by the shipowner/operator when considering manning requirements.

Turnover of ship’s staff involved with the EGCS needs to be taken into consideration when planning training and information dissemination. New or replacement personnel need, from the outset, the same level of training and other information that was provided to those initially assigned.

3.1.2 Provision of training and information

Each shipowner/operator needs to develop training programmes and plans that cover the specific issues of the EGCS installed as it applies to their ships, trading patterns, operating practices and personnel. These training programmes need to be regularly assessed for relevance of content, target group and the manner of delivery, then updated as required to address any identified shortcomings.

Given the potentially hazardous nature of some of the materials involved, particularly in the case of closed loop systems using sodium hydroxide as the alkali, the training needs to promote a high degree of engagement and achieve a high level of safety awareness in all aspects of the related operations. Training programmes should include various aspects, including operation, maintenance, repair, consumables, waste product, first aid, emergencies and drills. Training programmes need to be tailored for the different categories of ship staff and their respective levels of involvement with the EGCS, its consumables and its waste products. Every ship fitted with an EGCS will, of course, need to have procedures covering its operation, the consumables used
and the waste products generated. However, key to the training will be the reasoning and purpose behind those procedures so that they are effectively implemented in practice.

The safety information associated with the EGCS, its consumables and waste products needs to be effectively communicated to all, together with the company’s waste and compliance policies.

Ship’s staff receiving suitable first aid training need to fully understand why it is being provided and hence be prepared for any emergencies related to the consumables used for EGCS.

The ship’s safety management and permit to work systems must fully incorporate all aspects relating to the EGCS, including safe access to tank / confined space procedures, which consider the potential hazards posed by the in-service content of those tanks.

Scheduling of work should ensure that support / emergency back-up will be immediately available. Therefore ‘lone working’ on chemical systems or other EGCS aspects with hazard concerns should not be allowed.

Should an incident occur on board in relation to the EGCS, its consumables or waste products, it needs to be fully investigated by the company to ensure a repeat occurrence is avoided in the future, together with a commitment to any necessary resources. That outcome and the lessons learned should then be shared across the fleet and, as far as possible, with other users.

3.2 Consumables

All supplied chemicals and gases should be provided with a SDS. That, or copies of the data sheet, should be retained with the respective product while on board, noting that in the case of drummed or packaged chemicals, individual containers will be used. The SDS should be in the language of the crew and, if additional, an international language such as English. Procedures should be in place to ensure that all guidance given by the respective SDS is applied and that those chemicals with stated expiry dates are respected.

These consumables will typically cover:

- **Alkali** – in the case of the systems from which these guidelines were developed, this was sodium hydroxide 50% aqueous solution. Sodium hydroxide has a pH of 13 and is hazardous. It can cause severe skin burns, respiratory damage and eye injury. It is corrosive to aluminium, brass, bronze, tin, zinc (including galvanised coatings) and glass. The temperature when pumping must be above 20°C, as the viscosity rapidly rises below this temperature. However, it should not be above 50°C to prevent corrosion cracking of mild steel pipework, although stainless steel is resistant at higher temperatures.

- **Coagulant** – in the case of the systems from which these guidelines were developed, this was an acidic solution (pH < 3) of aqueous solution with poly-aluminium chloride. It is corrosive to metals, causes serious eye damage and must not be handled directly.

- **Floculant** – in the case of the systems from which these guidelines were developed, this was an acidic solution (pH 4) of a polyacrylamide – a polymeric material containing volatile hydrocarbons. As such it can cause skin irritation and serious eye irritation and must not be handled directly. It is harmful to aquatic life with long lasting effects.

- **Water test and calibration fluids** – composition, hazards and protection as per the accompanying SDS.

- **Exhaust gas analyser – span gases** - these will be at a gas mixture suitable for the ranges of the analysers, typically 10-20% CO2 and 50-100 ppm SO2 in a nitrogen base. Typically, at pressures up to 200 bars as supplied – pressure decreasing with use.

3.2.1 Loading consumables

The loading on board of the liquid chemical consumables may be divided into two groups: ‘bulk’ and ‘handlable’. In the case of bulk, this will be by road tanker delivery to ship or in the form of Intermediate Bulk Containers (IBC), otherwise termed pallet tanks, typically of around 1m³ capacity. Road tanker delivery would be direct to the ship’s storage tank(s), whereas the IBC would usually be loaded on board and then discharged to the ship’s tank. Handlable
would encompass those smaller packing arrangements from 10-25 litre drums to 50-500 ml packets and the smaller type of gas cylinders generally used (typically around 10-20 litres). The manner of delivery would usually depend on the quantities involved. For example: for the ships from which these Guidelines were developed:

<table>
<thead>
<tr>
<th>Manner of delivery</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road tanker</td>
<td>Alkali, sodium hydroxide 50% aqueous solution</td>
</tr>
<tr>
<td>IBC</td>
<td>Coagulant</td>
</tr>
<tr>
<td>Drums</td>
<td>Flocculant</td>
</tr>
<tr>
<td>Packets</td>
<td>Test and calibration chemicals</td>
</tr>
<tr>
<td>Pressure cylinders</td>
<td>Exhaust gas analyser span gas</td>
</tr>
</tbody>
</table>

However, as per the preceding section, it is important to recognise that, irrespective of the method of delivery, all of the materials being handled are potentially hazardous, so due precautions need to be generally applied. In the following sections, the hazards that a ship’s own arrangements and procedures would need to manage are highlighted:

### 3.2.1.1 Loading Station – as used for road tanker deliveries or the discharge of IBCs

Respective SDS and corrosive placards should be in place and clearly visible. These should be in the language of the crew and, if additional, an international language such as English. Each loading point should be clearly labelled as to the particular chemical to be handled.

An emergency shower and eyewash facility need to be located in close vicinity to the loading station. Adjacent, there needs to be a container with the necessary PPE and emergency equipment, including soak-up and spill control materials, as well as a separate container for the collection of any contaminated PPE or used containment / soak-up materials. These spill response and waste containers should be secured to prevent them being used for other purposes or general disposal.

The loading station should be located separate from other working areas and distinct from other loading / discharge flanges (i.e. fuel or lubricants). Also, as is reasonable, it should be located away from working walk routes. Other machinery or electrical controls or wiring should not be in the area to prevent damage from spills or vapours. A safe vicinity zone should be considered.

The loading station area should be well lit and ventilated.

There should be ready and safe access to the loading station for those involved in loading operations. However, consideration should be given as to whether closed, secured door access and caging of the loading station is also necessary – this may be particularly appropriate on ship types such as ro-ro ferries where the loading station is on the vehicle decks with public circulation in the immediate area. If caging in such situations is not considered appropriate, then particular precautions need to be considered to avoid contact by other ship staff and/or the public with the loading station and the associated fittings.

Raised coamings or a spill tray arrangement should be fitted around the loading station and the immediate working area. Where caging (as above) is installed, the containment should be within the caged area. These spill control arrangements should have their own dedicated overboard scupper, but during loading and subsequent wash-down operations it needs to be ensured that the scupper will not discharge on the quayside or onto other marine craft on the off-side. Condition of the paint and metalwork at discharge points should be monitored regularly for any deterioration.
3.2.1.2 Road tanker delivery

In an ideal situation, such as a ro-ro ferry, the delivery tanker can drive directly onto the vehicle deck and be parked adjacent to the loading station. However, for most other ship types the road tanker will be parked on the quayside and will have to pump up to the ship’s loading station. Consequently, the following section addresses delivery on those two scenarios.

Drive on

Preferably road tanker delivery operations should not be undertaken at a time when other drive on/off cargo operations are taking place – particularly those involving the public. Given the need for attendance and vigilance on the part of the ship’s staff during chemical delivery, other storing or operational discharges should not be undertaken at the same time unless there are sufficient personnel to cover each operation independently.

During delivery, a safety zone of reasonable distance should be coned off with clearly visible markings, lighting and placards as necessary.

Ship’s staff need to be present to assist the delivery person who may have no, or only limited, experience of delivery in a marine environment. The ship’s staff involved would probably include at least one of the Engineers with the Deck / Cargo Officers duly alerted. Communication arrangements (i.e. personal radio) between all parties would need to be in place and checked as working.

A check-sheet should be developed covering the procedures and specific points to which the ship’s staff need to pay attention during the delivery process. The check-sheet should divide into pre-delivery, delivery and post-delivery sections with the following action not started until the current operation is duly completed satisfactorily and checked-off. Existing fuel oil / lubricant delivery procedures could form the starting point of such procedures and check-sheet, particularly in respect of coordination between both delivery and ship personnel over emergency stop arrangements.

The ship’s staff attending the delivery should be suitably equipped with PPE, trained and be able to undertake various checks throughout the discharge process. This may include regular checks on hose for flow, any spillages and handling of filling connections. They should also be responsible for the completion of the check-sheet and fully aware of the significance and relevance of the points therein covered.

Given the nature of chemical to be loaded, it is to be ensured that both the quality (i.e. sodium hydroxide 50% aqueous solution, if that is the case) and the quantity are as required and can be fully accommodated within the tank(s) to be loaded. In respect of the latter, it is important to note that the ship’s staff know the available free capacity (m³) of the tank(s) to be loaded at that time (for example, that the density of sodium hydroxide 50% aqueous solution is 1.525 tonne/m³, so 20 m³ will represent close on 30 tonne) and that both they and the delivery person are both working on the same units (m³ or tonne).

A road tanker load of sodium hydroxide 50% aqueous solution will typically be carried at around 40°C, so this should be considered in terms of hazards, but also provide a ready means of checking flow.

As delivered on a drive-on basis, the transfer may simply be gravity fed, although pumping or pressure (by a truck-mounted pump or compressor) may be used to augment. Hence prior to any disconnection of the delivery hoses, they should be fully drained down (possibly by blowing through) and de-pressurised before any disconnection.

Procedures will need to include how the delivery process is to be shut down on completion. Those would need to include the closing-off of the ship’s delivery flange / connection and the comprehensive wash-down with water of the loading station area, its surrounding area and the vicinity of the delivery tanker’s discharge connection.
**Quayside deliveries**

In such operations, the delivering road tanker will be positioned on the quayside adjacent to the ship, so the procedures and practices applicable to road-delivered fuel or lubricant would provide a starting point for the development of the ship's procedures.

This means of supply imposes a further constraint on the positioning of the ship's loading station since a key issue is to deliver using the minimum amount of hose length and the availability of ship's lifting arrangements to handle the supply hose during that process. The chemical ordering process would need to stress to the supplier what the anticipated overall length of delivery hose the road tanker would require, and that it would need to be suitable and capable of being held to deliver over a vertical height – a potentially unusual manner of operation for deliveries to land-based sites. Furthermore, the delivery tanker would need to have the ability, by either pumping or tank pressurisation, to deliver over that vertical height.

The arrangements and procedures, as given in the ‘Drive on’ section above, would be equally applicable in these quayside scenarios, but with the additional considerations of:

- Split work sites, and
- Lifting arrangements.

**Split work sites**

These result in potentially a need for duly trained and equipped ship's staff at both the loading station and at the delivery tanker with, as before, full and working communication arrangements between all parties.

**Lifting arrangements**

It should be expected that the ship will need to provide the lifting facilities, if only for the physical hauling up and return of the supply hose. Such arrangements also need to take the weight of the loaded hose during supply. Consequently, where ship's cranage is used, there is the need to ensure that it remains solely dedicated to that task for the entirety of the delivery process. Where simple rope hauling is used, ropes need to be duly secured off to avoid any trip hazard. Two further considerations apply in such instances:

Generally, particular care will need to be exercised at the end of delivery to ensure that the hose is fully depressurised and drained out before being lowered to the quayside and any disconnection occurs at the delivery tanker end.

In cold environments, there is the risk that the exposed length of delivery hose could cool the delivered product. In the case of aqueous solutions of sodium hydroxide, when the temperature drops below 20°C, the viscosity will sharply increase with a consequent risk of over pressurisation or an inability to supply.

**3.2.1.3 Delivery by IBC or similar**

This section covers the supply of chemicals in IBCs or other similar types of containment – for simplicity the term ‘IBC’ will only be used. The key issue on loading these is the discharge of those containers into the ships' storage systems. As an alternative, of course, the IBC itself may be used as the onboard storage container, so there is not the same one-off discharge issue on loading, yet effectively the same considerations would apply on changing from one IBC to another.

The IBC will typically be delivered on board either by a drive-on arrangement (i.e. ro-ros) or lift-on in most other instances. The onboard holding areas for both full and empty IBCs will need to be designated and away from general working areas or where cargo or other handling operations could result in contact.

If delivery on board is not to the exact location from which it is to be either discharged into the ship's tank or used, then procedures will need to be developed as to how those IBCs are to be moved by the ship's crew: whether by lifting or pallet truck or similar. Consideration should be given as to when such movements should not be undertaken.
– for example if the ship is rolling heavily.

The discharge location (or if use is directly from the IBC) as applicable to the loading station in 3.2.1.1 equally applies to that area.

Discharge should not take place if there is other work being undertaken close by. In the case of ro-ro type ships, the discharge should not take place when the public could be in the general vicinity – indeed with such ships it may be preferable to exclude such discharge being undertaken at least while that deck has vehicles loaded.

Discharge should only be undertaken by trained ship’s staff wearing the appropriate PPE and with spill and containment materials readily to hand together with a dedicated waste container for all used materials.

Where discharge is to be from the top connection, there will need to be a procedure for the wash-down of the pump suction line that has been immersed in the pumped chemical. Additionally, on completion of discharge, the general discharge area and the IBC itself should be washed down to ensure no residue material remains with the empty IBC, then promptly moved to the designated empty IBC storage area.

### 3.2.1.4 Drummed or packaged chemicals and gas cylinders

While these, due to their relatively low weight and small size, should not require any specialist lifting or carrying equipment, their handling on board should be undertaken separately from other storing operations. Of course, all the usual manual handling considerations still apply.

Persons supervising and handling should be wearing the appropriate PPE and trained as to what to look out for and what to do in case of any spillage, seepage or damage to containers / packaging. Leaked material would not only represent a possible chemical hazard but may also present a slip hazard due to the nature of the product. In case of leakage, the location will need to be ventilated and suitable PPE worn for it to be cleaned away into a suitably labelled spare container, and any residues removed by use of absorbent material followed by water washing off the affected area.

Procedures should be in place to ensure that these products are moved promptly from the point of receipt on board to their respective designated storage locations.

### 3.2.2 Onboard storage

In the case of sodium hydroxide 50% aqueous solution, a storage temperature between 20-50°C must be maintained. With this and any other chemical that requires to be heated above ambient temperatures, consideration should be given to the use of suitable electrical heating arrangements, so avoiding cross-contamination issues that would occur in the case of tank coil systems using a heated fluid. In the case of chemicals with maximum temperature limits, no heat sources must be in the vicinity and, for the same reasons as given above, immersed liquid cooling should not be used to avoid the contamination issues that would arise in the case of coil failure.

#### Tank storage

Storage for those chemicals received in bulk may be kept in integral tanks built into the ship’s structure or in free-standing tanks. Other chemicals supplied either drummed or packaged are to be retained in their supplied containers up to the point of use.
The delivery methods and storage arrangement will be a factor of the quantities involved. For example: for the ships from which these Guidelines were developed:

<table>
<thead>
<tr>
<th>Integral tank</th>
<th>Alkali, sodium hydroxide 50% aqueous solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free standing tank</td>
<td>Coagulant</td>
</tr>
</tbody>
</table>

For both integral and free-standing tanks, it is necessary to ensure that these are in locations where the tank walls will not be subject to impact or fluctuating loads as a result of cargo operations or other ship activities – for example, in areas where large engine components will need to be lifted or otherwise transported. If there is such a risk, such as a free-standing chemical tank on a ro-ro vehicle deck, then additional external protection barriers should be provided.

All integral tank fittings such as filling / suction connections, heaters and instrumentation should be arranged to have a suitable drip tray fitted. Free-standing tanks should be positioned within drip trays or with bunding. The condition of these trays or internal bunded areas should be regularly inspected and so the appearance of any leaked / seeped material immediately investigated and resolved.

Chemical storage tank vents should terminate in safe locations so as not to result in health and safety concerns or that the outflow from those vents could be entrained in the inflow to supply fans. The area around the vent heads should be enclosed by a save-all and regularly inspected for deterioration of metal or paintwork. Condensate from vent lines should be considered to have the same hazard as the chemical in the tank it serves and so be handled and routed accordingly.

**Drummed and packaged chemicals**

These chemicals, retained in their original packaging, should be duly stored in a designated chemicals storage locker together with their associated SDS in a manner that protects against ship movements. That locker should be dry, well lit, well ventilated and away from any heat or ignition sources. There should be controlled access to the locker by only trained and authorised ship’s staff.

There should be regular inspection and audit of the materials in that chemical locker to check the condition (any spills / leakages / seepages that need to be promptly dealt with), that SDS have been duly retained and that any expiry dates will be complied with. Those audits should be documented.

**Gas cylinders**

These should be stored in a marked designated safe area: well lit, well ventilated and away from temperature extremes. Given their shape, cylinders will need to be secured against movement and therefore a specific racking arrangement may provide the best solution for full, part used and empty cylinders. Gas cylinders in general, but particularly the valves, should be protected against heat and accidental impacts.

### 3.3 Chemical service systems and in-use

It is important to recognise that the use of EGCS, particularly closed loop systems with their corresponding washwater control and bleed-off treatment systems, introduce into routine engine room practice chemicals that otherwise would be treated as MARPOL Annex II or III cargo products and all that such categorisation involves. However, as with the use of gas fuels in engine rooms, given the required initial design and installation arrangements and provided that due care and attention is applied to the appropriate safety procedures, it has been demonstrated in practice that those chemicals do not represent a hazard. Hence it is the issue of ‘due care’ that this section seeks to highlight.

This context is not only taken to be the usual day-to-day operation of the EGCS, but also inspection, maintenance and servicing.

At all locations where work will be undertaken on the system, such as dosing pumps and bleed-off treatment units,
and at strategic locations around the system, eyewash and emergency showers need to be available to speedily counteract any chemical contact by personnel.

### 3.3.1 Bulk chemical use

This covers those chemicals stored on board in tanks, either integral or free-standing. As such, these will have associated piping systems together with pumping arrangements.

All chemical piping should be clearly marked with a dedicated colour tape to differentiate it from other piping systems and to highlight the need for immediate resolving action should any leakage / seepage be observed. To that end, splash tape may be applied to all flanges and connections.

Chemical piping runs as installed should be reviewed from the perspective of possible contact or impact damage and, where that is identified, additional protection applied. Another in-service aspect is pipe movement or vibration, which would need to be resolved but without adding further clamping or restraining loads on the piping. In this, it should be noted that chemical piping will generally be quite small in diameter and therefore, despite the heavy gauge used, could be more susceptible to damage.

Ideally flanges and connections to chemical piping runs should not be above the usual walkways within the engine room or over susceptible equipment or wiring. However, where this is found to be the case, additional drip protection could be appropriate.

Chemical piping systems handling sodium hydroxide 50% aqueous solution need to be maintained at above 20°C to remain pumpable as the viscosity dramatically increases at lower temperatures. Where there is the chance that engine room temperatures will fall below that temperature at any point in the operating profile, heating tape and lagging would need to be maintained and verified as being in good condition. In particular, avoid piping runs that could be unduly cooled by engine room ventilation fans. It should, however, be noted that this is a readily reversible process, so should temperatures fall below that 20°C, pumping viscosity is restored on reheating. Other chemical handling temperatures, either maximums or minimums, would need to be identified from the respective product SDS and duly managed.

In the case of closed loop EGCS, alkali dosing will be provided to both the recirculating washwater system and the bleed-off treatment unit. The necessary pumps should be enclosed in a locked cabinet with integral spill tray, float operated alarms and shut-downs in case of leakage. It should be possible, by the use of suitable viewing panels and lighting, to be able to undertake routine checks on the condition of the pumps and associated valves / controls without the need of opening the cabinet doors.

Bleed-off treatment equipment may well have both piped and local dosing of process chemicals, so should be arranged either with a closed drip tray or bunding together with float-operated alarms and shut-down. Operation and control should only be by duly authorised and trained ship’s staff in accordance with the manufacturer’s instructions; any modifications or temporary fixes must not compromise safety as the chemicals used may cover both extremes of the pH scale and therefore must be maintained thoroughly segregated.

### 3.3.2 Drummed and packaged chemical use

These chemicals should only be withdrawn from the designated storage locker as required and then only by authorised and trained ship’s staff. In the case of drummed products, the usual handling and lifting safeguards should apply. Should any spillage occur, the affected area should be immediately sealed off and recovery undertaken by ship’s staff provided with suitable PPE and designated collecting receptacles.

Process water testing and calibration of discharge water monitors should be undertaken following the given procedures using only the chemicals in the manner so specified.
3.3.3 Gas cylinders for exhaust gas analyser span checks

In those systems that have in-built span check procedures, it will be necessary to periodically change-over the span gas cylinders. That routine change-over should be undertaken only by authorised and trained ship's staff in accordance with the given instructions. In changing over where that is a purely manual process, it would need to be ensured that the cylinder valve is first closed and all pressure relieved to a safe location before commencing to remove the regulator. On bringing the new gas cylinder into use, it should be verified that the regulator is securely attached and that there is no gas leakage.

3.3.4 EGCS System inspections

The operating EGCS procedures should, in terms of periodic inspections, go beyond just checking the basic functioning of the system in order to encompass the condition of the associated chemical systems with the findings duly recorded. Hence where any seepage or leakage occurs, it is readily identified as ‘new’ and promptly dealt with – not simply allowed to accumulate. Consequently, where there are repeated problems with the same issue, it will be evident that there is the need for a more fundamental resolution to the problem, which may involve other parties such as the equipment manufacturer.

Storage tanks, the EGC unit and system tanks (i.e. process, buffer, holding tanks) should be periodically inspected for condition both externally and internally for signs of deterioration. This would be particularly important in the case of tanks with chemical resistant lining and where (as in, for example, the cases of the EGC unit and process tanks) the washwater flow may have a scouring action or there is a risk of accumulations of sediments. Such internal inspections need to be integrated into the ship’s work-safe procedures, taking fully into account the nature of the material normally contained in that space or tank.

3.3.5 Maintenance and servicing

Where components (pumps, flow controllers, etc.) or piping used for chemicals are to be opened up for maintenance and servicing, there is the particular issue of how that system is made safe in the first instance and the further need to ensure that any opened up or removed part is safe to work on.

There are no specific issues in this regard for water (seawater / freshwater) handling systems and even for fuel and lubricant systems, and while the handling of those fluids requires care, it is quite within the ship's staffs’ experience. However, when dealing with products such as sodium hydroxide 50% aqueous solution (pH > 14) or some of the bleed-off treatment chemicals (pH < 3), extreme care needs to be exercised in how the system is to be opened up in the first instance. Consequently, the system should have been designed from the outset to facilitate this, while the ship’s pre-prepared procedures on how this is undertaken includes the containment and subsequent management of any drained-out fluids.

In undertaking any maintenance or servicing, it’s essential to be aware of the possibility that components, even when the associated system has been drained down, may still retain pockets of the handled chemical, which could be released on movement. Even when that is not the case, there will still be surface residues. So the ship’s procedures will need to ensure that such components are first rendered safe to work on. This may involve removal to the workshop in a suitable chemical-resistant container and thorough water washdown before undertaking any work or sending off the ship. Where that maintenance or servicing requires the drain-down of EGCS process or buffer tanks, the ship’s procedures should ensure that the discharge is either to another system tank or, if to be discharged overboard, that the discharge criteria as given in the IMO EGCS Guidelines are complied with.

In addition to the record-keeping requirements as given by the IMO EGCS Guidelines, there should be a documented system for recording inspections, findings, remedial actions and other actions relevant to the EGCS.

3.3.6 Open loop systems

While open loop EGCS systems do not usually have any process chemical requirements, there will still be the chemicals used for water tests and discharge water monitor calibration. Hence the respective comments given above covering drummed or packaged chemicals (as applicable) would be equally relevant.
However, the ship’s procedures need to address a further point regarding 'chemical' matters that’s particular to open loop systems: the generation of a potentially low pH washwater as a result of the action in the EGC unit through to the point where its pH is raised by onboard dilution or it is discharged overboard. While normally that low pH washwater will be retained in the drop line from the EGC unit, there is the risk of leakage. Ship’s staff should therefore be aware of the potentially acidic nature of any such leakage and hence training and the ship’s procedures should duly address that point.

3.4 EGCS waste products and materials landed ashore

In a simple open loop arrangement, there would essentially be no waste to be held on board other than used packaging from any chemicals used for water or discharge water monitor calibration.

In terms of the fluids involved, this may be discharged overboard provided that the given discharge water criteria have been met, although where there is some filter or other treatment arrangement installed, there will be some residue generated on board. In accordance with the IMO Guidelines, any EGCS generated residue, irrespective of its composition, cannot be disposed of via the ship’s incinerator or overboard.

In contrast with closed loop systems, there will be an inevitable generation of residue, which will need to be stored on board until it can be landed ashore. Also, to be handled will be emptied IBCs, drums used to supply chemicals to the ship, used spill control materials, and chemical contaminated PPE material. Furthermore, if the ship is operating on a ‘zero discharge to sea basis’, there will be the treated bleed-off, which may be discharged ashore rather than subsequently to sea.

Where the EGC unit or process tanks (or other system tanks) have been opened up, there may be accumulated sediment / residue, which would need to be landed along with the EGCS bleed-off treatment generated residue. Potentially, there could also be process chemicals to be landed ashore, such as drummed products, that have gone beyond their expiry dates. Any chemicals drained down from systems that are opened up for maintenance may also need to be disposed of rather than returned into storage.

Empty IBCs, drums and packaging in which EGCS chemicals were supplied will also need to be landed ashore together with any used spill containment materials and chemical-contaminated PPE.

Discharged gas cylinders would also be returned ashore, provided they are depressurised. There are no specific considerations to be addressed under this heading since such cylinders have an inherent value and they should be landed to a representative of the gas supplying company.

A further stream of EGCS material to be landed ashore would be closed loop EGCS discharge water, which has been retained in a holding tank. This would be discharge water that has met the discharge criteria given by the IMO EGCS Guidelines but which, due to company policy or possibly local restrictions, is not discharged overboard as generated. While there are no particular hazards associated with such discharge water, it would need to be landed in accordance with local regulations and requirements as applicable, so the ship’s procedures should ensure that these are complied with.

3.4.1 EGCS residue

This is the material removed by the bleed-off treatment system and will be composed of exhaust gas solids and washwater salts together with a trapped water fraction. It may be in a condition ranging anywhere from a full fluid to a semi-plastic but still pumpable material (using some type of positive displacement pump) through to an essentially solid material.
In the case of a fluid, it should be retained separate from other oily wastes and landed ashore as such. In the case of the ships from which these guidelines were developed, the standard bleed-off treatment system was followed by a decanter stage, which resulted in a considerable reduction in water content. Consistency of the residue was controlled by decanter speed to achieve a pumpable but not too fluid semi-plastic substance. By way of example, composition of randomly drawn residue samples in those instances is given below:

<table>
<thead>
<tr>
<th></th>
<th>Ship A</th>
<th>Ship B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Insolubles</td>
<td>29%</td>
<td>17%</td>
</tr>
<tr>
<td>Ash</td>
<td>12%</td>
<td>11%</td>
</tr>
<tr>
<td>Carbon</td>
<td>45%</td>
<td>20%</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>4%</td>
<td>3%</td>
</tr>
</tbody>
</table>

From the study material available, EGCS residue is not in itself a material hazardous to personnel. It does however represent a potential environmental hazard and therefore must be disposed ashore in a controlled manner.

In general, the onboard procedures covering the handling of residue should cover these points:

- Ship's staff handling or dealing with the EGCS residue or associated spillages should be duly trained and equipped with the appropriate PPE.
- Residue should be stored in suitable robust skips capable of closure with well-fitting lids that can be secured shut as required.
- Skips filled, being filled or awaiting use should be located away from other working areas. If these are in areas where the public will be present (i.e. ro-ro vehicle decks), they should be caged or screened to prevent contact.
- Access to skip holding area to allow for delivery and removal of skips by lifting, fork-lift or other transport means to be used.
- All skips should be restrained by suitable ties or chains to prevent moving while the ship is at sea.
- The skips should be appropriately marked as to contents.
- The skips should be marked with fill-line to avoid any overfilling.
- Any tools used to level out the residue should have a dedicated storage point away from easy reach of unauthorised onboard staff and, if relevant, the public.
- The skips and their surrounding area should be kept clean. Any residues or spillages should be cleaned by authorised personnel immediately and not allowed to accumulate.
- When switching between skips, due care needs be taken to avoid any spillages.
- Skip handling – both onboard and when being landed ashore – should be scheduled outside ‘cargo’ operations. If unavoidable, the allocated ship’s staff should be assigned only to one task or the other.
- Skips should only be landed to receivers duly authorised by the State in which they operate. Landing should be documented, and the receipts retained on board.

### 3.4.2 Empty IBC and other EGCS related garbage

In this context EGCS related garbage includes emptied chemical drums, packaging, contents of spill response waste containers, chemical-contaminated PPE and any chemicals to be landed ashore. These materials should be considered as hazardous as the respective chemicals as loaded, so overall the same procedures and precautions should be applied.
Empty chemical containers and EGCS garbage should be retained in a secured dedicated area with access only by those duly authorised and trained wearing appropriate PPE. That secured area should be enclosed by a raised coaming or other bunding to ensure that any spilled or leaking material does not spread outside that area, and such spills and leaks are promptly cleaned away.

Empty chemical containers and EGCS garbage should be secured / packed so they are not affected by ship movement.

Adjacent to this holding area there should be an eyewash facility and emergency shower together with a spill response container and used material waste container.

Empty IBCs should be returned to a representative of the supplying company for further use.

Ship’s procedures need to ensure that disposal ashore of EGCS garbage is in accordance with local, regional, national and / or international regulations and is only undertaken by duly authorised local contractors. All such garbage landed ashore should be documented and receipted.

EGCS related waste handling – both on board and when being landed ashore – should be scheduled outside ‘cargo’ operations. If unavoidable, the allocated ship’s staff should be assigned only to one task.

### 3.5 Support and non-routine / exceptional events

The above sections on ship operation have essentially covered those aspects related to the day-to-day operation of an installed EGCS and the associated supply and disposal activities. However, it is important that the ship’s procedures extend to also cover aspects related to activities such as:

- Functioning and checking PPE and response equipment
- Ship safety committee engagement
- Response drills
- Emergencies
- Outside personnel
- Shipyard time

#### 3.5.1 Functioning and checking PPE and response equipment

The availability and use of the appropriate PPE is central to the safe operation of EGCSs that use potentially hazardous chemicals. Should an incident occur, the necessary remedial measures must be applied within seconds, hence the need for such facilities as eyewash and emergency showers at all points where such incidents could occur. Having occurred, the incident must be prevented from spreading, so the need for spill containment and recovery arrangements are equally important. The ship’s procedures need to ensure that these requirements will be met at a time or place where an incident occurs.

It needs to be regularly verified that the required PPE, to the standard necessary for the chemicals in question, is available, distributed as appropriate and that it is all in good order. Any found deficiencies should be immediately rectified.

In checking eyewash fluids, it must be ensured that these are within date range and available at all designated positions. Any used, damaged, or time-expired packs should be immediately replaced.

Emergency showers need to be checked that they actually work and immediately deliver the essential mitigating action instantly on activation. This covers not only the valve action itself, but also that the full flow water will be delivered as required – that the piping to the shower head is not air-locked or partly (even fully) choked with system debris.
Where eyewash fluids or the showers are used, there is an instant need for a wider response – where an individual may be working alone it is unrealistic to expect that person, in having had a chemical contact that has necessitated the use or the eyewash and/or shower, to be able to do anything other than activate an easy-to-use ‘alert’ button. As an alternative, eyewash holders and shower valves may be alarmed so that, if used, there is an immediate and automatic alert to a manned position. Consequently, whatever ‘alert’ arrangement is applied, it should be part of the regular checking process.

3.5.2 Ship safety committee

Each individual involved in the operation of an EGCS and the handling of the associated chemicals should be required to immediately raise any concerns they identify within the ship’s management structure for resolution. On that basis the ship’s safety committee should be in a position to have an overview of issues raised and their subsequent timely resolution.

3.5.3 Response drills

Aspects related to the EGCS and its associated chemicals should be considered for inclusion in the ship’s emergency drills rota.

Such drills could include chemical contamination of an individual, a chemical spill on loading or a chemical leakage for the service system. Ship’s staff should be encouraged to develop other scenarios as may be appropriate to the particular system and chemicals used.

3.5.4 Emergencies

It should be planned what would be required should an emergency situation such as fire, flooding or heavy listing occur. The plan should include what is to be done, by whom and when.

Fire safety plans should make clear to any user what potentially hazardous chemicals are on board and where those are stored, so they are immediately advised and can thereby react accordingly.

3.5.5 Outside personnel

While the information and training aspects covered in Section 3.1 cover the ship’s staff, it has to be recognised that there may be others on board who are outside that scope. Particularly in the case of ro-ro type ships where there is the inevitable presence of the public as passengers in a working ‘cargo’ area (vehicle decks), they should, as above, be generally shielded and screened from any EGCS related activities so that they are totally out of contact with any potential hazard. However, for others who may be on board for a variety of reasons, they could be in one way or another more involved / in contact with the ship’s operations and therefore cannot be so readily excluded. These may include:

- Shoreside workers involved in cargo operations,
- Contractors or service personnel working on board, particularly in the engine room areas, and
- Statutory or Class surveyors, port State or other inspectors.

Depending on the nature of the work being carried out by those persons, they may or may not be under the direct supervision or in attendance of ship’s staff. Consequently, there should be established arrangements (including information briefings, notes, etc) appropriate to their particular activities and working locations. The arrangements should inform them of the presence of chemicals and other potentially hazardous materials within the working areas, for which due attention is required, and the action to be taken if there are concerns or incidents.

3.5.6 Shipyard time

Prior to any dockings that will involve shipyard personnel being present on board, the ship’s current status as regards
EGCS chemicals and other related potentially hazardous materials should be established and the shipyard informed. Where those chemicals or other materials are to be retained on board, the shipyard should be supplied with all necessary information that allows them to duly alert and protect their personnel, who will be working on the ship against what is, to date, a relatively unusual set of additional issues.

During dockings where the ship staff are also on board, they should remain watchful as to the activities of shipyard personnel regarding any potentially hazardous situation that is, or has, developed and know how to react accordingly.

The shipyard should be advised whether heating arrangements for temperature sensitive chemicals such as sodium hydroxide are to be retained in use and be required to ensure that this remains in-service.

As ever after a docking, the ship's staff will themselves need to ensure that all systems, arrangements and settings are as required – this would therefore need to extend to encompass the EGCS related aspects.

### 3.6 On-going development and evolution of EGCS related procedures

An EGCS after installation may be subject to subsequent modifications, either by the manufacturer or the user. Therefore, there needs to be an updating process that includes not only the relevant drawings and documentation, but also the related procedures and how they are to be developed to cover the changes resulting from any such modifications.

EGCS, being a relatively new development at sea, is an area that lacks a depth of existing experience or established practice. Shipowners / operators should keep their related training and information programmes both updated and responsive to feedback received from any ship's staff involved with EGCS operation and other users.

In particular, the ship's staff's own experience of applying the initial sets of procedures should be noted. Feedback from such experience from across the fleet or other users should also be considered when taking the related procedures forward. Consequently shipowners / operators of EGCS equipped ships should seek to establish platforms by which such experience can be shared.

Any incidents that should occur should be analysed for the lessons to be learned with systems, arrangements, equipment, training and procedures adapted accordingly.
4 Port operations

In most cases, the introduction of EGCS and the resulting chemical and waste handling requirements will be as new to port operators and their staff as they have been to the marine side. Port involvement could range from simply providing access arrangements to berthed ships for the delivery of chemicals and consumables, the collection of waste products and materials, providing intermediate storage / holding facilities, and the associated transport arrangements between the ship and those facilities.

Furthermore, whereas some ports will be serving EGCS equipped ships on a fixed or regular basis, in other instances those EGCS equipped ships may be ‘one-off’ visits.

Therefore, just as shipowners / operators have decided whether or not to take the EGCS route to SOx emissions compliance, it is equally up to ports, other than providing access, to decide the extent to which they would want to provide additional EGCS related services.

Port operations have, of course, to comply with applicable local rules and requirement and this may affect the extent of the services provided.

In general, the comments given in the human factors and port interface related elements in Ship Operations in Section 3 will also be applicable to port operators and should therefore be referred to.

4.1 Access only

Access only could cover the delivery of chemicals or other consumables (such as pressurised gas cylinders) and / or the collection of EGCS residue and / or related garbage. In either case, at least initially, port operators should allow for the fact that delivery / collection drivers may not be familiar with port practices, and so would require an additional level of control / direction as to standard and emergency procedures.

In the case of deliveries / collections made on a ‘drive-on’ basis – such as to a ro-ro ferry vehicle deck – the service is simply that of providing that access. As given in the relevant Ship Operations section, the port operator should be aware that the event will most likely be scheduled outside ‘cargo’ operations and allow for this accordingly.

Where deliveries are to be made quayside, the usual arrangements for that access would apply. However, in the case of chemical deliveries – either in bulk, IBCs or drums / packets – or the landing of EGCS related garbage, the necessary precautions would need to be in place to deal promptly and effectively to any spills or other such incidents. Hence port staff in attendance should be duly trained and equipped with the necessary PPE. Adjacent to this handling area should be an eyewash facility and emergency shower together with a spill response container and used material waste container. During such transfers, the area in question should be clearly cordoned off from other activities and warning placards displayed.

4.2 Access together with intermediate holding of chemicals, other consumables or waste products, EGCS related garbage

Where the port operator is also to provide intermediate holding facilities, in addition to the points covered in Section 4.1 above, there will need to be consideration of those storage facilities and the transport arrangements between the ship and that facility.

Storage facilities need to be suitable for the materials to be handled. Typically, this will require a well-ventilated area with weather protection not subject to standing or surface water flows and with the materials not exposed to sunlight or temperature extremes. The respective areas need to be clearly and separately delineated and materials duly segregated with access restricted to duly authorised and trained personnel. Appropriate signs should be displayed. PPE, eyewash and emergency shower facilities, as appropriate to the materials being held, need to be available. Port operators should ensure that the relevant SDS is clearly available and retained with each product during both storage and on delivery to the ship.
Internal port transport arrangements will need to take into account the nature of the materials being handled and therefore should only be undertaken by duly trained and equipped personnel.
APPENDIX A: EGCS background

A.1 Open loop EGCS

In an open loop EGCS, seawater is supplied to the EGC unit or chamber and subsequently discharged as washwater to the sea. A simple open loop EGCS is shown in Figure 1.

Figure 1 – an open loop EGCS arrangement

In an open loop system, SOx is removed from the exhaust gas in a series of conventional chemical reactions within the EGC unit or chamber; these vary according to the technology used.

The resulting sulphate charged, single pass, washwater is discharged to sea provided it meets the criteria given in the IMO EGCS Guidelines – to which end some form of washwater treatment may be fitted together with subsequent dilution for pH control. The relatively high washwater flow rates of open loop systems result in higher power loads as compared to closed loop systems, but do not normally need alkaline additives and are comparatively simple to operate and maintain.
A.2 Closed loop EGCS

In a closed loop EGCS, the washwater is recirculated. Washwater condition is maintained by bleeding-off a limited proportion of the flow with a balancing make-up of water and alkali. A closed loop arrangement is shown in Figure 2.

![Figure 2 – a closed loop EGCS arrangement](image)

In a closed loop arrangement, the washwater is circulated through a cooler, to remove the heat acquired from previous contact with the exhaust gas, to the EGC chamber or unit where it contacts as a fine spray with the exhaust gas and thereafter drains back to the process tank.

SOX is removed from the exhaust by the action of the washwater. Dissolved SOX forms sulphuric and sulphurous acids; a series of chemical conversions results in these acids being converted to sulphite and bisulphite, generating excess hydrogen ions and acidity. This acidity is neutralised by alkaline carbonates and bicarbonates in the seawater – a process known as pH buffering. Many marine systems use sodium hydroxide for pH buffering.

The washwater is subject to bleed-off in order to control the concentration of sodium sulphate. If sodium sulphate is left uncontrolled, crystals will form and lead to a progressive degradation of effectiveness.

The rate of make-up to the system not only depends on the bleed-off rate, but also on losses to the exhaust through evaporation and the bleed-off. The rate of evaporation is influenced by exhaust and washwater temperatures, which in turn are governed by factors such as engine load and the temperature of the seawater supply to the system coolers. As a counter flow, some of the water vapour incorporated within the exhaust may be captured into the washwater.

The bleed-off is subject to treatment to reduce the entrained exhaust gas material and to regulate the pH to the extent necessary to meet the discharge criteria given by the IMO EGCS Guidelines, after which it can be discharged to sea.

Given the relatively low bleed-off rates, a period of zero-discharge to sea is instead possible by the incorporation of a holding tank into the system. The contents of that holding tank are then either discharged ashore or, when outside the zero-discharge area, to sea. As such this could allow an EGCS to continue to operate in areas where the port / coastal state prohibits such discharges to sea.
Closed loop systems require more tankage than open loop systems. A process or buffer tank is required in the cleaning water circulation system. A holding tank is required for zero discharge mode (size dependent on ship requirements). Loading facilities, storage tanks and dosing equipment are required for sodium hydroxide or other alkali used.

The alkalinity and pH buffering of sodium hydroxide reduces water flow compared to open loop systems and removes sensitivity to seawater carbonate and bicarbonate levels. Control of pH by dosing with sodium hydroxide enables the washwater circulation rate, and therefore power consumption, to be about half that of open loop systems. Closed loop systems can also be operated when the ship is operating in those waters where the alkalinity would be too low for open loop operation.
### APPENDIX B: Example of road tanker delivery check sheet

#### ALKALI BUNKER CHECK LIST (50% NaOH)

**LOCATION:**

**PREPARATION BUNKERING**

1. SAFETY SHEETS READ AND RISK REALISED.
2. APPROPRIATE PPE WORN BY BUNKER STATION CREW - (EYE, FACE, BODY, FEET AND HANDS).
3. CHEMICAL SHOWER TESTED AT LOCATION.
4. SPRAY HOSE CONNECTED AND TESTED AT LOCATION.
5. BRIDGE INFORMED - NO VESSELS TO BE ALONGSIDE OR OVERBOARD ACTIVITY IN VICINITY OF ALKALI STORAGE TANK VENT AT
6. ENGINE CREW TO BE INFORMED - NO PERSONS NEARBY THE ALKALI BUNKER LINE STBD SIDE OF MAIN ENGINE ROOM, PUMP ROOM OR STABILISER ROOM.
7. ACCESS RESTRICTED TO ALKALI BUNKER STATION
8. DELIVERY NOTE CHECKED FOR CORRECT CHEMICAL CLASS AND QUANTITY.
9. CHECK ALKALI TANK (61 M³) HAS SUFFICIENT FREE CAPACITY (SG= APP. 1.52!!) - SEE ITEM 24.
10. RADIO CHECK.
11. BUNKERHOSE CONNECTED. TIME:
12. BUNKER VALVE OPEN. CHECK TANK VALVE IN STABILISER ROOM IS OPEN.
13. 2 MEN AT BUNKER STATION FOR DURATION OF OPERATION - ONE MAY BE THE TANKER DRIVER

**DURING BUNKERING**

14. CHECK FOR LEAKAGE CONSTANTLY AT BUNKER STATION.

**FINISHED BUNKERING**

15. ENSURE THAT TANKER DRIVER BLOWS PIPEWORK THROUGH WITH AIR.
16. BUNKER VALVE CLOSED. LEAVE TANK VALVE OPEN TO DRAIN BUNKER LINE.
17. BUNKER HOSE DISCONNECTED. TIME:
18. LEVEL / CONTENT CHECK ALKALI TANK 61 M³ (SG= APP. 1.52!!) - SEE ITEM 25.
19. CLEAN AND DRY ALKALI BUNKER AREA INCLUDING DRIIP TRAY, DISPOSE OF CLEANING WASTE TO DEDICATED CONTAINER.
20. PUT LOCAL WATER HOSE AWAY AND ISOLATE WATER TO EMERS. SHOWER.
21. CLEAN AND STORE ALL PPE IN LOCKER "SCRUBBER PPE" ENGINE WORKSHOP.
22. REMOVE ACCESS RESTRICTION TO BUNKER AREA.
23. FILE THIS SHEET AND DELIVERY NOTE IN SCRUBBER LOG FOLDER IN ECR.

24. TANK READING BEFORE: M³
25. TANK READING AFTER: M³
26. BUNKERED AMOUNT: M³

27. TIME BUNKERING STARTED:
28. TIME BUNKERING STOPPED:
29. DATE:
30. SIGNATURE: