Subject: Introduction on Exhaust Gas Cleaning System (EGCS)

IMO Requirement:

Refer to IMO/ MARPOL/ Annex VI/ Reg. 14, Sulphur Oxides (SO_x) and Particulate Matter,

- The Sulphur content of any fuel oil used on board ships shall not exceed the 0.50% m/m on and after 1 January 2020.
- While ships are operating within an Emission Control Area, the Sulphur content of fuel oil used on board ships shall not exceed the 0.10% m/m on and after 1 January 2015.

Regulation 4 allows, with the approval of the Administration, the use of an alternative compliance method at least as effective in terms of emission reductions as that required by the Annex, including the standards set forth in regulation 14.

Approval Procedure:

Ship designers, owners and operators have a number of different routes to achieve SOx regulatory compliance:

- Use low-sulfur marine fuels in existing machinery
- Install new machinery (or convert existing machinery where possible) designed to operate on a low sulfur
- alternative fuel, such as liquefied natural gas (LNG)
- Install an Exhaust Gas Cleaning System (EGCS) as an after treatment device

Similar to a NO_x emission reduction system, an exhaust gas cleaning (EGC) unit may be approved subject to:

- A periodic parameter and emission checks, or
- A continuous emission monitoring system

Provision of two basic Schemes for compliance to be used for EGCS approval, Scheme A or Scheme B, at the choice of the equipment manufacturer.

- **Scheme A** based on initial emission performance unit certification together with a continuous check of operating parameters and daily exhaust emission monitoring
- **Scheme B** based on continuous exhaust emission monitoring together with a daily check of operating Parameters

- **Scheme A** requires an EGCS to be certified by the manufacturer to meet the requirements of MARPOL Annex VI 14.1/14.4. Under Scheme A, the manufacturer is to test the unit with fuel containing the maximum Sulphur content specified by the operating parameters. The manufacturer is also required to test maximum and minimum exhaust gas flow rates at all points in the system. When the unit is verified by the manufacturer, a SOx Emissions Compliance Certificate (SECC) can then be sought. The purpose of Scheme A is to forego continuous exhaust gas emission monitoring via electronic data collection of system operational parameters. However, a record book must be kept for the purpose of logging daily spot checks, maintenance and service.

  Options under Scheme A of guideline MEPC.259 (68) provide for:

  - Unit approval;
  - Serially manufactured units; and
  - Production range approval.

- **Scheme B** does not require initial approval of the EGCS from the manufacturer and does not require an SECC. The purpose of this scheme is to demonstrate compliance through continuous electronic monitoring. Daily spot checks are also required to verify performance.

Scheme A and Scheme B compliance (©IMO)

Document	Scheme A Parameter check	Scheme B Continuous monitoring
SECP: SOx emissions compliance plan	Yes	Yes
SECC: SOx emissions compliance certificate	Yes	---
ETM-A: EGCS technical manual for Scheme A	Yes	---
ETM-B: EGCS technical manual for Scheme B	---	Yes
OMM: On-board monitoring manual	Yes	Yes
EGCS record book	Yes	Yes
Electronic monitoring system and data collection	---	Yes

Compliance should be demonstrated on the basis of the SO_2(ppm)/CO_2 (% v/v) ratio values.

Fuel oil Sulphur limits recorded in regulations 14.1 and 14.4 and corresponding emissions values

Fuel oil Sulphur content (% m/m)	Ratio emission SO2(ppm)/CO2(% v/v)
0.50	21.7
0.10	4.3

- **The SOx Emissions Compliance Plan (SECP):**
  SECP should list all combustion units fitted with an EGCS. For Scheme A, the plan should demonstrate compliance without continuous monitoring of the exhaust gas emissions. For Scheme B, the plan should outline how continuous exhaust gas monitoring meets compliance.

- **The On-board Monitoring Manual (OMM):**
  OMM should detail service, maintenance and calibration requirements for all sensors and analyzers. The manual should also indicate the positions from which emissions and wash water measurements are taken and other information relevant to the functionality of the monitoring system.

- **EGCS Technical Manual (ETM):**
  Each EGCS must be accompanied by an **EGCS Technical Manual (ETM)** appropriate to the scheme it is certified for (ETM-A/ETM-B). Except where noted, the following outlines the required information to be included in the ETM-A and ETM-B:
  - Maximum and minimum exhaust gas flow rates.
  - Parameters of the combustion unit(s) the EGCS is designed to.
  - Maximum and minimum wash water flow rate, inlet pressures and alkalinity.
  - Exhaust gas inlet temperature ranges and maximum/minimum outlet temperature.
  - Required salinity level necessary to provide adequate neutralization. 6. Requirements and restriction applicable to EGCS.
  - Maintenance, service and adjustment requirements (ETM-A only).
  - Corrective measures for exceeding maximum allowable emission ratio.
  - Verification procedure for surveys (ETM-A only).
  - Variation of wash water characteristics throughout the operating range.
  - Design requirements of wash water system.
  - SOx Emissions Compliance Certificate (SECC) (ETM-A only).

- **ETM-A & ETM-B:**
  The ETM-A & ETM-B should be approved by the Administration. The ETM-A & ETM-B should be retained on board the ship onto which the EGC unit is fitted and should be available for surveys as required. Amendments to the ETM-A & ETM-B which reflect EGC unit changes that affect performance with respect to emissions to air and/or water should be approved by the Administration. Where additions, deletions or amendments to the ETM-A & ETM-B are separate to the ETM-A & ETM-B as initially approved, they should be retained with the ETM-A & ETM-B and should be considered as part of it.

- **Survey and certification of the EGCS:**

  Approval, survey and certification of the EGCS are to be carried out in accordance with the provision of the applicable IMO Resolution. Schemes A and B either require classification society approval which encompasses a full design assessment, validation or type testing, and a manufacturing assessment. Emissions testing for SOx should meet the requirements of chapter 5 of the 2008 NOx Technical Code.

  Each EGC unit meeting the requirements of above should be issued with a **SECC (SOx emissions compliance certificate)** by the Administration or RO.

  The EGC unit should be subject to survey on installation and at initial, annual/intermediate and renewals surveys by the Administration.
  Following the installation survey as above, section 2.6 of the Supplement to the ship's International Air Pollution Certificate should be duly completed.

  For each EGC unit, the ETM-A should contain a verification procedure for use at surveys as required. This procedure should not require specialized equipment or an in-depth knowledge of the system.
  The verification procedure should be submitted by the EGC system manufacturer and approved by the Administration.

  The EGC unit should include means to automatically record when the system is in use.

- **EGC Record Book:**

  An **EGC Record Book** should be maintained by the ship owner recording maintenance and service of the unit including like-for-like replacement. The form of this record should be submitted by the EGC system manufacturer and approved by the Administration. This EGC Record Book should be available at surveys as required and may be read in conjunction with engine-room log-books and other data as necessary to confirm the correction operation of the EGC unit. Alternatively, this information should be recorded in the vessel's planned maintenance record system as approved by the Administration.

  The 2015 guidelines also specify the following for water sampling:

  - Discharge measurements are to be taken after wash water is dosed, but before any dilution to determine pH, PAH, turbidity and nitrites + nitrates.
  - Inlet water is to be measured at the sea chest where seawater is at ambient temperature.
  - Discharge water should have a pH of no less than 6.5, measured at the ship's overboard discharge. When the ship is maneuvering or in transit, a maximum difference between the inlet and outlet of 2 pH units is allowed, measured at the ship's inlet and overboard discharge.
  - The allowable concentration of PAH (a by-product of incomplete combustion).
  - Wash water turbidity increase limits above the inlet water turbidity (turbidity is a measure of how much material suspended in water decreases the passage of light through the water).
  - The discharge levels of nitrites + nitrates (a measure of how much Nox has been removed from the exhaust gas).

EGCS SYSTEM CONCEPTS

EGCS can be categorized as wet or dry systems, in four different configurations:

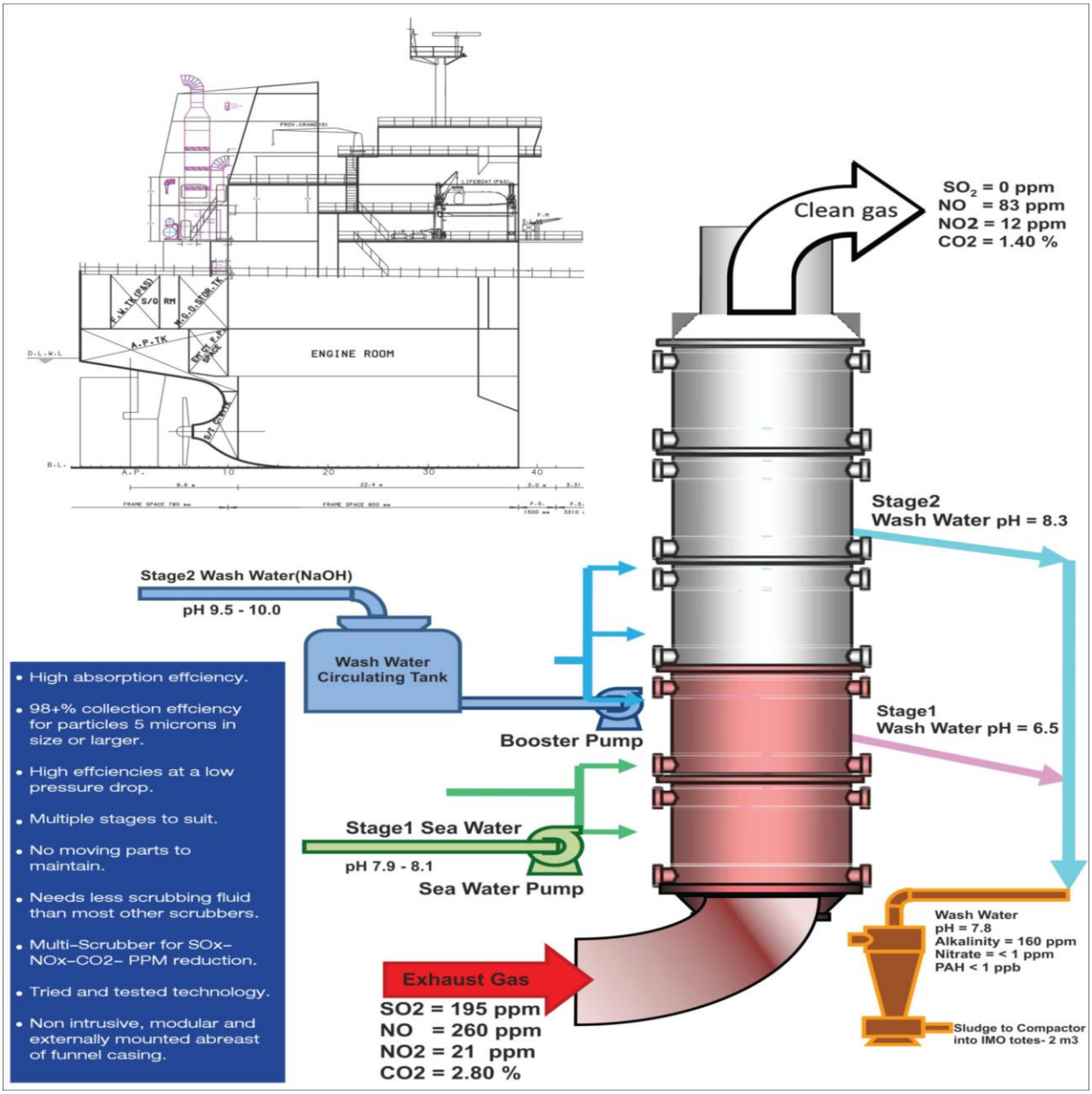
- Wet
  - ❖ Open loop
  - ❖ Closed loop
  - ❖ Hybrid (open loop when at sea, closed loop when in port or as required)
- Dry
  - ❖ Dry system

For open, closed or hybrid systems the seawater, or treated seawater/freshwater, is sprayed into the exhaust gas scrubber unit of the EGCS, which is a component of the system that acts to remove Sox. To increase the absorption of Sox, the exhaust gas scrubber unit typically uses the counter flow of exhaust gas and water, water pressure and baffles to induce turbulence. As the water flashes to steam, energy is removed from the exhaust gas. This lowers the temperature and allows unburnt hydrocarbons to condense out of the exhaust gas. The wash water is then filtered and/or treated, and either discharged overboard or recirculated.

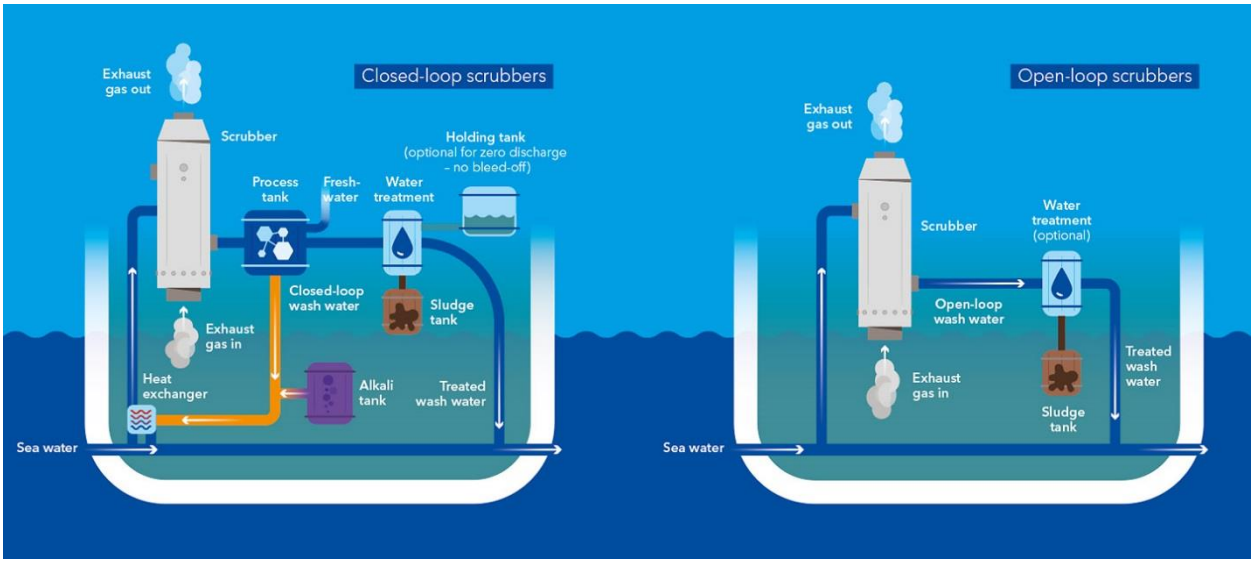
It is important to note that system configuration, effectiveness and operation varies between manufacturers and depends heavily on the gap between the design parameters and the actual operating parameters (Sulphur content in the fuel, seawater alkalinity, etc.). The choice of appropriate design parameters is a key point for the efficiency and effectiveness of the chosen system.

There are four different types of exhaust gas cleaning system available:

1. Open loop (seawater scrubber units) use untreated seawater (i.e. the natural alkalinity of the seawater) to neutralize the Sulphur from exhaust gases.
2. Closed loop (freshwater scrubber units) are not dependent on the type of water the vessel is operating in, because when the exhaust gases are added to freshwater in a closed loop system they are neutralized with caustic soda or magnesium oxide.
3. Hybrid scrubber units – allows the use of either open loop or closed loop.
4. Dry scrubber units do not use any liquids in the process as exhaust gases are cleaned with calcium hydroxide, commonly known as caustic lime.

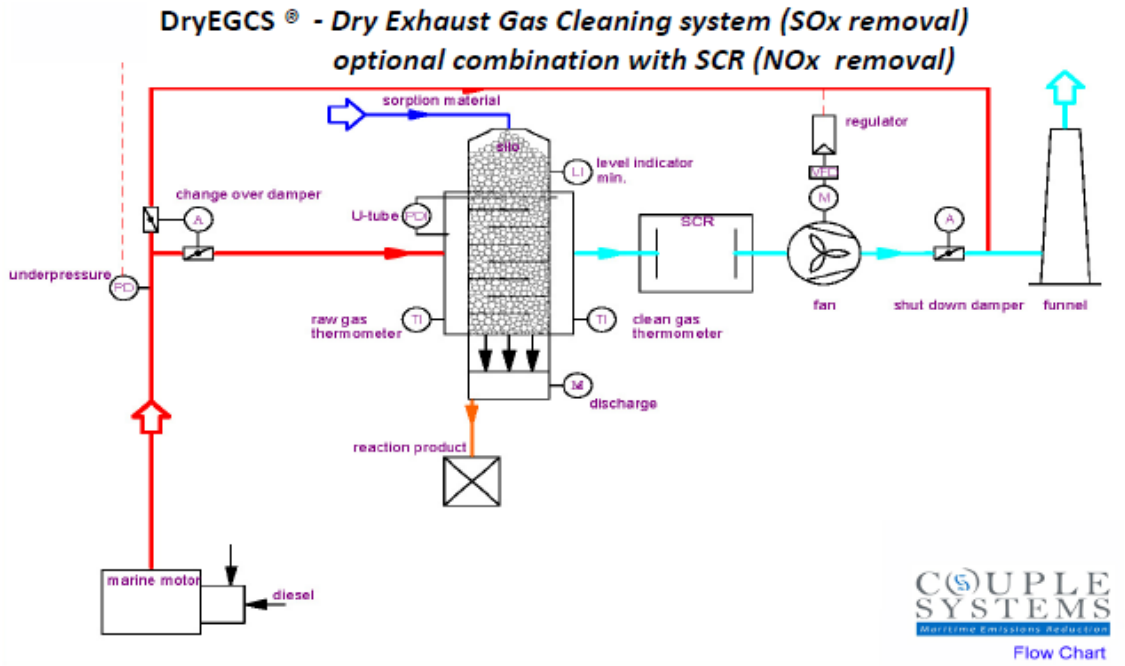


THE EGCS – Hybrid System



Closed-loop scrubber **open loop Scrubber**

Due to wash water discharge limitations set by the IMO and various regional and U.S. Federal regulations, the pH of the wash water discharge must be measured prior to overboard discharge. Monitoring of turbidity and PAH are also mandatory.



Most exhaust gas scrubber units are custom sized to suit the application aboard a vessel based on the following criteria:

- Expected exhaust gas flow rate and temperature.
- Operational conditions of the vessel.
- Machinery or operational constraints.

When selecting an exhaust gas scrubber unit, the following items should be considered:

- Location and trade of vessel.
- Sulphur content of the fuel to be used.
- The alkalinity of the water that the vessel will be operating in.

Some exhaust gas scrubber units are in-line units that may replace the engine silencer(s). These units are similar to the silencer in weight and size. Some scrubber units are capable of performing the job of the silencer whether or not the exhaust gas scrubber unit is in operation. Other exhaust gas scrubber units are not in-line units and require multiple passes or stages to effectively remove the SOx from the exhaust gas. These systems typically do not replace the silencer and have greater space requirements compared to in-line units. Some exhaust gas scrubber units are also available as multi-inlet solutions capable of handling exhaust gas from several pieces of combustion equipment at once. The capabilities of multi-inlet units vary by manufacturer and are ultimately limited by back pressure. There are also safety and other regulatory code issues to consider for dual-fuel (methane gas) combustion systems.

Considerations

- **Materials and corrosion**

  Most wet exhaust gas scrubber units involve caustic reactions at high temperatures (typically where the exhaust gas temperature is in excess of 250°C) which accelerate the corrosion process. The lower portion of exhaust gas scrubber units are often made of a high-grade nickel alloy or duplex stainless steel, chosen for their resistance to high temperatures and corrosion. The upper portion of the exhaust gas scrubber unit is typically made from a lower grade of stainless steel, because the increased condensation in the exhaust gas means it does not get as hot.

  Hastelloy or AL6XN are examples of materials used in exhaust gas scrubber unit construction because of their increased oxidation, corrosion and high temperature resistance. However, such materials tend to cost more than lower grade materials of similar composition.

  For ambient seawater supply systems, rubber-lined, galvanized, nickel-copper or Glass Reinforced Epoxy/Glass Reinforced Plastic (GRE/GRP) piping can be used. Any piping, pumps and separators that will come in contact with wash water should use materials appropriate to the pH, temperature and content of the wash water. Tanks containing wash water, sludge or caustic dosing chemical can be constructed from approved plastics, GRP or stainless steel. Pumps should be equipped with seals of the proper material to withstand the corrosive environment of the wash water.

- **Bypasses and back pressure**

  One issue associated with exhaust gas scrubber units, especially the wet type, is the exhaust back pressure. As back pressure increases, the engine must create more power to overcome it. As a result, back pressure can cause an increase in NOx production, an increase in exhaust gas temperature and an increase in fuel consumption. Back pressure can be reduced by careful design of the exhaust gas scrubber unit with regard to nozzle design, baffle design, multiple stages, and flow rates of exhaust gas and water. Exhaust fans may also be used to mitigate back pressure, although careful consideration must be given to the effects of an exhaust fan failure. The engine manufacturer should be consulted for this data. Furthermore, the presence of an exhaust gas economizer may create additional back pressure on the system, though a majority of EGCS manufacturers claim that their systems can operate in line with an economizer. An exhaust gas bypass will typically not be required for scrubber units that are capable of running dry (no wash water flowing).

- **Compatibility**

  Before the installation of a SOx EGCS, consideration should be made in the evaluation of NOx technology and its compatibility with the selected SOx EGCS. NOx systems will have to be suitable for operating with high levels of SOx and other substances produced by burning high Sulphur fuels at high operating temperatures. Operating NOx technology satisfactorily with a SOx EGCS will depend on the manufacturer's operating parameters of both systems. Manufacturers and Class Societies should be consulted for further assistance in the proper selection of a suitable and compatible EGCS.

- **Electrical loads**

  In a wet EGCS, the biggest electrical load is the feed pump and/or circulation pump. The capacity required for these pumps can be similar to the ship's seawater cooling pumps. Other loads to consider include:

  - ❖ Exhaust fans.
  - ❖ Separators.
  - ❖ Dosing units.
  - ❖ Control processes.
  - ❖ Sensors and monitoring equipment.

  An open loop system in some circumstances could require marginally more power than a closed loop system. A closed loop system is capable of removing the required amount of Sulphur with a lesser flow rate of water through the scrubber unit, because it is dosed with reactants that are more effective than seawater per unit mass.

- **Installation**

  Installation time for an EGCS depends on the manufacturer and type of system being installed. The main considerations are size, complexity of the system and the components involved. Depending on manufacturer, the EGCS may or may not be in-line. An in-line unit should be installed directly in-line with the silencer and exhaust gas economizer.

  Units that are not in-line require multiple passes and often have separate bypass ducts which tend to take up more space than an in-line unit. Open loop systems have fewer components and require less tank space than a closed loop or hybrid system and installation can be expected to be less complicated and time consuming. Closed loop, hybrid systems and dry systems take up more space, require several tanks for storage, dosing units, separators, multiple pumps and more complex control units.

  Depending on the complexity of the system and amount of preparatory work done beforehand, scrubber installation at wet berth can take several weeks.

- **Safety and crew training**

  IMO has identified the following as potential safety hazards associated with EGCS:

  - ❖ Handling and proximity of exhaust gases.
  - ❖ Storage and use of pressurized containers of pure and calibration gases.
  - ❖ Position of permanent access platforms and sampling locations.
  - ❖ Hazards associated with the handling of caustic materials.

  Crews should be adequately trained to handle hazardous reactants or chemicals used (or chemicals that are created as a result of the process) and be trained to deal with possible medical emergencies. The required Personal Protective Equipment (PPE) is dictated in the associated Safety Data Sheet (SDS) of the hazardous chemicals that will be handled. Health, safety and environmental risk assessments associated with EGCS should be performed to identify hazards and to facilitate the reduction of uncertainties associated with costs, liabilities, or losses.

- **Cost**

  The biggest operating cost associated with an EGCS is the additional power requirements of the system, which is highly dependent on the cost of fuel. Other operating costs to consider include the EGCS and associated equipment maintenance; increased fuel costs due to increased back pressure and power consumption; manning (additional to or additional percent of an operating engineer); bulk reactant procurement, storage and consumption; waste management and disposal; and crew training.

  The capital expenditure element of purchasing an EGCS is dependent on the size of the system, type of system, whether the system is single-inlet or multi-inlet, and the type of reactant used. Open loop systems are typically less costly than closed loop systems, which are similar in price to hybrid systems.

For any questions about this Technical Information, please contact:

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