Liquefied Natural Gas (LNG) receiving, storage and regasification facilities in the Marsaxlokk Bay: first technical report about the QRA procedure and safety requirements

References:

a) OHSA ACT (CAP. 424): Control of Major Accident Hazard Regulations, 2003 and amendment, 2005 (L.N. 37 of 2003, L.N. 6 of 2005);
b) MEPA: Supplementary Planning Policy Guidance. Major Accident Hazards and Hazardous Substances, November 2004;
d) Health & Safety Executive (HSE): LNG source term models for hazard analysis. A review of the state-of-the-art and an approach to model assessment, 2010 (Research Report RR789);
e) SGS Tecnos SA: Project for a new LNG regasification facility to be located in the Marsaxlokk Bay, QRA PRELIMINARY REPORT (Report No. 02-901-188098-12141):
   * revision 0.1 (11 July 2013);
   * revision 1.2 (19 November 2013);
   * revision 2 (4 December 2013);
g) site inspection and meeting with the Competent Authorities (OHSA, MEPA and CPD), the Operator and his consultants held on 13 and 14 November 2013.

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0 – Introduction

Enemalta Corporation operates the existing **Delimara Power Station**, presently fuelled by HFO and Diesel, at Delimara in the Marsaxlokk Bay.

In June 2013, the Company started the **Environmental Impact Assessment (EIA) procedure** and submitted to the MEPA - Malta Environmental & Planning Authority the Project Description Statement (PDS) of “**Delimara Gas and Power - Combined Cycle Gas Turbine and Liquefied Natural Gas Receiving, Storage and Regasification Facilities**”, which includes

- a **natural gas-fired power unit (200 MWe)**, to be located in the existing power station site;
- the **LNG receiving, storage and regasification facility** to be located in the Marsaxlokk Bay.

As required by the Competent Authorities, the LNG plant safety risks are analyzed in a **Quantitative Risk Assessment (QRA) procedure**, since both the **existing Delimara Power Station** and the **new LNG plant** are singularly “upper tier” establishments under COMAH - Control of Major Accident Hazards Regulations that implement the latest version of the Seveso Directive (Directive 2003/105/EC, which amended Directive 96/82/EC).

On behalf of the Maltese COMAH Competent Authority (CA) a **preliminary technical report** was issued in September 2013 describing:

- some remarks to the QRA preliminary report (revision 0.1 of 11 July 2013);
- a preliminary list of the technical measures required in the facility design to reduce the risks.

In October 2013 Enemalta Corporation announced that the **ElectroGas Malta Consortium** is the preferred bidder shortlisted in the competitive process for the building and running of the LNG facilities and the new power plant: the QRA preliminary report has been revised according to the technical proposal of the Operator and the additional prescription required by OHSA.
Therefore, this updated technical report includes some remarks to the last versions of the QRA report (revision 2 of 4 December 2013) and the list of the technical measures required to reduce the safety risks and protect the environment, as arisen from the QRA report, the site inspection and the meeting with the Competent Authorities, the Operator and its consultants held on 13 and 14 November 2013. Note anyway that since the project development is at its initial stage, further prescriptions could be issued in the near future.
II – Project description

II.1 - LNG plant layout

The QRA PRELIMINARY REPORT, revision 0.1 of 11 July 2013, issued before the end of the competitive process for the gas supply agreement, compares three final realistic layout options, based on state-of-the-art plants across Europe, namely:

- option A: the whole regasification plant onshore, to be built on reclaimed land close to the ENEMALTA fuel oil tank farm, currently an artificial hill;
- option B: floating LNG storage unit (FSU) moored in the southern part of the harbour and regasification plant onshore, to be built in the same location than option A, but without any clearing of the hill;
- option C: floating storage and regasification unit (FSRU), moored in the southern part of the harbour.

The ElectroGas Malta Consortium, the winning bidder for the building of the LNG plant and the new gas power station, proposes a LNG plant layout according to Option B of the preliminary QRA, that is to say the FSU - Floating Storage Unit moored in the harbour and the regasification unit placed onshore to the south of the artificial hill:
The Consortium is made up by Germany’s Siemens, Azerbaijan’s SOCAR, UK-based Gasol and Maltese investor group GEM Holdings.

Presently no information has been provided about the technical reasons of the choice of this layout by the Operator ElectroGas Malta and which was the importance of this issue in the criteria adopted by Enemalta Corporation for the result of the competition. Anyway the proposal layout is one of the preferred choice in order to minimize the individual risk to the population as well as the damage to the Delimara Power Station in case of flash-fire, as stated in the conclusion of the QRA PRELIMINARY REPORT, revision 0.1 of 11 July 2013 (page 71).

II.2 - Other LNG plant main features

The preliminary project of the Operator ElectroGas includes:

- a liquid storage capacity of 125,000 m$^3$ in the Floating Storage Unit (with respect to the original maximum expected capacity of 180,000 m$^3$). About $6 \div 8$ LNG shipments a year (up to a maximum capacity of 140,000 m$^3$) are required to ensure the gas feed to the power units;
- the ship to ship (FSU) LNG unloading by 250 mm diameter flexible hoses (No. 4 for liquid phase and No. 1 for vapour phase), fitted with emergency release couplings (ERC). The overall unloading rate will be 6,000 m$^3$/h;
- the ship (FSU) to shore LNG unloading by a 12” diameter unloading arm having a rate of 145 m$^3$/h;
- a 6” pipeline for LNG from the unloading arm to the regasification unit;
- a regasification unit having a maximum pressure of 47.5 barg and a nominal pressure of 43 barg;
- a 6” pipeline for natural gas from the regasification unit to the turbine, with a maximum flow delivered by the compressor of 5,700 Nm$^3$/h.
III – Delimara Power Station: present and future arrangements

III.1 - Present arrangement

The Power Station was first commissioned in 1992 and present activities are:

- the heavy fuel oil (HFO) and diesel storages in the following aboveground vertical tanks:

Table 1 - Delimara Power Station Storage Inventories

<table>
<thead>
<tr>
<th>Tank No. [1]</th>
<th>Combustible</th>
<th>Capacity (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Oil Tank 1</td>
<td>Heavy fuel oil</td>
<td>25,000</td>
</tr>
<tr>
<td>Fuel Oil Tank 2</td>
<td>Heavy fuel oil</td>
<td>25,000</td>
</tr>
<tr>
<td>Fuel Oil Tank 3 [2]</td>
<td>Heavy fuel oil</td>
<td>5,000</td>
</tr>
<tr>
<td>Diesel Tank 0</td>
<td>(Raw) Diesel</td>
<td>8,000</td>
</tr>
<tr>
<td>Diesel Tank 1</td>
<td>(Raw) Diesel</td>
<td>8,000</td>
</tr>
<tr>
<td>Diesel Tank 2</td>
<td>(Raw) Diesel</td>
<td>8,000</td>
</tr>
<tr>
<td>Diesel Tank 3</td>
<td>(Treated) Diesel</td>
<td>8,000</td>
</tr>
</tbody>
</table>

Notes:
[1] all tanks are made of steel and fixed roof type;

- the unloading of ships at an adjacent quay, equipped with a loading arm for diesel and flexible pipes for HFO. Typically the shipments are 2 HFO shipments per month, each amounting 10,000 tonnes; 1 diesel shipment per month of about 7,000 tonnes;

- the unloading of road tankers with diesel at an unloading point fitted with 2 transfer pumps;

- installed capacity of about 450 MWe of power generation by
  * HFO fired steam generators and turbines,
  * diesel open cycle and combined cycle gas turbines.

The establishment is an Upper Tier site under COMAH because the storage of diesel is more than 25,000 tonnes (L.N. 6/2005 – Schedule 1, part 2).
The Operator Enemalta issued the last version of the Safety Report in February, 2005.
The revised version, required at least every 5 years according to the regulation 9 of L.N. 37/2003 and its amendment L.N. 6/2005, has not been issued yet.

**III.2 - Future arrangement**
The project will change the site arrangement as follows:

1. the installation of a **new LNG Plant** having a FSU - Floating Storage Unit in the harbour and the regasification unit onshore. This will be independently owned, constructed and operated. The **LNG plant itself is an Upper Tier site under COMAH** because the storage of liquid natural gas is more than 200 tonnes (L.N. 6/2005 – Schedule 1, part 2), since 125,000 m$^3$ equals to 73,000 tonnes (liq. density: 0.422 t/m$^3$);

2. the changes in the power generation units, namely:
   - the decommissioning of the oldest unit "Delimara 1 - ST";
   - the conversion of the current 149 MWe Plant "Delimara 3" to operate on natural gas (the work required is not included in the agreement with the Operator ElectroGas Malta);
   - the installation of the new CCGT power plant, built and operated by ElectroGas Malta. The recovered heat from the CCGT is used in the re-gasification of LNG.

The existing and future arrangements are summarizes in the following chart:

**Table 2 – Electric power generation units**

<table>
<thead>
<tr>
<th>Power station block</th>
<th>Units</th>
<th>Year completed</th>
<th>Gross supply capacity (MWe)</th>
<th>Fuel feed</th>
<th>Running timee (hr/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delimara 1 - ST</td>
<td>2 Conventional Steam Units (60 MW each)</td>
<td>1992</td>
<td>120</td>
<td>HFO</td>
<td>shut down in 2015</td>
</tr>
<tr>
<td>Delimara 2A - GT</td>
<td>2 Open Cycle Gas Turbines (37 MW each)</td>
<td>1994</td>
<td>74</td>
<td>Diesel</td>
<td>Diesel</td>
</tr>
<tr>
<td>Delimara 2B</td>
<td>1 Combined-Cycle Plant</td>
<td>1999</td>
<td>110</td>
<td>Diesel</td>
<td>Diesel</td>
</tr>
<tr>
<td>Delimara 3</td>
<td>8 internal combustion engines (Wartsila 18V46), 4 stroke medium speed diesel engines, operating in combined cycle mode, with eight heat recovery boilers and one steam turbine</td>
<td>2012</td>
<td>149</td>
<td>HFO</td>
<td>Methane</td>
</tr>
<tr>
<td>ElectroGas Malta</td>
<td>new Combined Cycle Gas Turbine power plant</td>
<td>2015</td>
<td>180-220</td>
<td>-</td>
<td>Methane</td>
</tr>
</tbody>
</table>
IV – Remarks to the QRA report (revision 2, issued on 4 December 2013)

A Quantitative Risk Assessment (QRA) analyses the risks of accidents involving with dangerous substances, resulting in lethal victims, injuries and/or material damage to surroundings. The calculated risks are expressed in terms of:

- **Individual Risk (IR):** it is the chance per year that a person on a specific location, who is continually and unprotected present at that spot, is victim of an accident with dangerous substances. The "Iso Risk Contours" on a map present locations were the IR has identical values. It can also be presented in a so-called "FX curve", which presents the fraction lethal versus distance, for one specific wind-direction;

- **Societal Risk (or Group Risk):** it is the chance per year that a group of a specific size becomes lethal victim of an accident with dangerous substances. It is presented in a "FN curve", showing the frequency (chance) on a logarithmic Y axis versus the number of victims on a logarithmic X-axis. To calculate Societal Risks, population distribution information is required.

The QRA preliminary report (revision 2) provides individual and societal risks both for the "consultant layout" (proposal B of the previous QRA Preliminary Report, revision 0.1 of July 2013) and the preliminary layout and design proposal by the Operator ElectroGas Malta ("ElectroGas layout"). It is noted that:

- the remarks made to the previous revision 0.1 of the QRA Report were included in the revision 2;

- the way of performing the QRA is correct;

- the input data and the models used (Effects and Risk Curves by TNO) are suitable;

- the top events seem to be assessed in a correct way in term of frequency and consequences. The annex E (Calculation outputs) is not included in the document (calculation outputs are presented in a separate file in the electronic version only) so it is not possible to check the results;

- domino effect for the thermal radiation (page 59) has been studied where the thermal flux can exceed 37.5 kW/m². This is not a conservative approach, because the thermal radiation of 12.5 kW/m² is enough to cause a damage to process equipment, seals, gaskets and melting or softening of plastic equipment (as
described also in BS 5980:1990). Then the domino effect result has to be reviewed according to the threshold value of 12.5 kW/m².

- both individual and societal risks calculations seem correct and risk for population is within the acceptable range set by HSA of Ireland¹ and HSE of UK² both for the consultant and the Operator layouts.

Note anyway that at this preliminary layout and design stage, for the ElecroGas proposal the individual risk contour is interesting a wider area (figure #8) than the layout consultants and the societal risks gives the same number of fatalities corresponding to a higher frequency (page 80/88 of the QRA preliminary report, revision 2).

Regarding the respect of the Maltese legislation³ (page 80/88) in land use planning, it is imperative that:

- all the highest safety & environmental standards to both the new LNG facility and the new Combined Cycle Gas Turbine (the EIA procedure includes both of them) are applied,
- the COMAH and EIA procedures are carried out together with the aim of optimize the design both for safety and environmental items, because:
  - Delimara Peninsula is designated as National Park and it is an environmentally sensitive area,
  - a flammable gas cloud ignition can have a domino effect on the existing Delimara Power Station (figure # 11) and a spill of Diesel or HFO from fuel storage tanks or pipes can cause a severe contamination to the marine environment.

Further prescriptions could be issued in the near future about this report.

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V – Environmental and safety requirements

The following requirements are aimed to reduce the safety risks and to protect the environmentally sensitive area of Delimara Peninsula:

1. Compliance with COMAH legislation: although the new LNG plant and CCGT power unit will be independently owned and operated, they will be placed in the same Delimara Power Station site. Therefore the Safety Report of Delimara Power Station site will include both all the present Delimara Power Station facilities (power plants and storages) and the future LNG plant (receiving, storage and regasification facilities) and Combined Cycle Gas Turbine.

2. Risk assessment: a HazOp study is required for the identification of all the top events both for existing and future plants. This procedure for LNG plant and Combined Cycle Gas Turbine will be carried out when the detail designs are issued. Moreover a specific and detailed study is required for the ship to ship (FSU) unloading of LNG by flexible hoses (and the other equipment comprising the lifting cranes, as proposed by the Operator ElectroGas Malta) instead of marine unloading arm.

3. Integrated risk assessment procedure for the Marsaxlokk and Birzebugga areas, from the Delimara Power Station site (including new LNG facilities and CCGT unit) to the LPG storage and distribution installation operated by Gasco Malta Ltd. An integrated approach in managing risk in this area is required due to the simultaneous presence of hazardous industrial plants (upper tier installation under COMAH), production activities, transport by road and sea of dangerous goods and residential areas. This approach has been already applied in many industrial sites, e.g. in the port area of Ravenna (Project ARIPAR - Analisi dei Rischi Industriali e Portuali dell’Area di Ravenna, started in 1987), which has similarities with the industrial and transport concerns of the Marsaxlokk and Birzebugga areas. The procedure requires:
   - the analysis of the existing and future arrangements in terms of transport (by road and sea), storage and handling of hazardous substances / dangerous goods;
- the analysis of the risk sources;
- the area characterization in terms of population distribution, land use and sensitive targets;
- the "Quantitative Area Risk Analysis" with the calculated risks expressed in terms of individual and societal risks;
- the proposals for mitigation and prevention measures.

The study will give important information in terms of land use planning, emergency planning and transport management.

The study will be promoted and supervised by the Public Authorities and financed by the Operators whose establishments are placed in the area.

It should be issued before the starting of the LNG facilities since its results can give important information about the mitigation and prevention measures to prescribe.

4. Replacement of the fuel unloading area, presently on the dolphin in the Marsaxlokk bay, for the feed to the onshore facilities (Has Saptan underground installation operated by Enemalta Corporation), as already required at page 66 of the QRA Preliminary report, revision 2: the unloading area on the dolphin has to be removed in order to reduce the possibility of a ship collision or spillage from other tankers affecting the LNG carrier. The ships directed to the dolphin can moor to the same jetty presently used for the Delimara Power Station fuels. Within June 2014 the Operator Enemalta Corporation is required to submit to the Competent Authorities a specific design for the decommissioning of the dolphin unloading area.

5. Seismic risk: the design of all the plant facilities has to take into account the value of an expected PGA (peak ground acceleration) of 0.2 g, which arises from the maximum expected value found in technical literature\(^4\) increased by a safety factor to ensure the new facility to withstand the maximum credible earthquake.

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\(^4\) "Malta: Seismic history of the Maltese islands and considerations on seismic risk" by Pauline Galea, Physics Department, University of Malta, Msida (ANNALS OF GEOPHYSICS, VOL. 50, N. 6, December 2007), page 736: “A seismic hazard study commissioned before the construction of a new power station on Malta gives an expected PGA of 0.12 g for a 475-year return period (Mouchel and Partners, 1990)”
6. Application of the BAT (Best available technologies) to reduce the safety risks: all the available technologies for limiting the extension of a pool in case of LNG spillage and diluting the flammable cloud have to be included in the final design of the Operator ElectronGas Malta (e.g. some technologies are listed at page 65 of the QRA preliminary report, revision 2 of 4 December 2013, as the hydro-shield system around the area of the spillage).

7. Application of the BAT (Best available technologies) to prevent the environmental pollution: the new CCGT power plant has to respect the threshold limit of 20 mg/Nm$^3$ with O$_2$ level of 15%, achieved by low NOx premix burners and/or SCR (Selective Catalytic Reduction) abatement technology (see the European Commission BRef - Reference Document on Best Available Techniques for Large Combustion Plants, July 2006, Executive Summary - page viii).

Since the project development is at its initial stage, further requirements could be issued in the near future.