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ECO-FRIENDLY LNG SRV: COMPLETION OF THE REGAS TRIAL

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ABSTRACT

This paper describes the Samsung's eco-friendly LNG SRV (Shuttle and Regasification Vessel) which is equipped with steam heated regasification system using Water/Glycol as intermediate medium. Unlike conventional LNG carriers, which transport liquefied natural gas from the production sites to consumption sites, the LNG-SRV of Samsung gasifies LNG at the marine sites, and directly supplies it to the ground locations through pipelines. A conventional regas process, which results in the discharge of 20,000㎥of frozen seawater per day, can disrupt an ocean ecosystem. But Samsung's LNG-SRV discharges no seawater, reduces harmful gas emissions by 92% with its electricity powered engine, and prevents water pollution through the recirculation of cooling water.

The SRV's regas system comprises one suction drum and three regasification skids. Each skid has a capacity of 250 MMSCFD and all skids or selected skids are operated simultaneously. Before the delivery, The LNG SRV had successfully completed the partial regas operation test with actual LNG during the sea and gas trials. The SRV's first actual regas operation and commissioning was conducted at Neptune deepwater port outside Boston March, 2010. And the Regas Trials (incl. performance test) had been completed satisfactorily in accordance with requirements of the Contract and the Specifications.

The SRV was a good opportunity to confirm the Samsung green technology and the experience from SRV design, construction and operation could be a foundation stone for the future offshore plant market.

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1. INTRODUCTION

The LNG SRV (Shuttle and Regasification Vessel) is leading model of the conventional LNG carrier during the voyage, and at the same time it is used for an offshore regas terminal when connected to a submerged buoy.

The LNG SRV built for the Neptune deepwater port which is located at 10 miles off the coast of Massachusetts. It supplies LNG to meet New England's growing demand for natural gas. A conventional regasication process, which uses the seawater for heating of the gas, which can disrupt an ocean ecosystem, hence according the US coastguard policy the seawater is not allowed in the region. So to meet their policy and reduce environmental effect, the Samsung is designed and constructed the LNG SRV.

2. REGASIFICATION SYSTEM

The LNG SRV is equipped with steam heated regasification system using Water/Glycol as intermediate medium. The system comprises three Regasification skids and one suction drum. Each Regas skid has a capacity of about 250 MMSCFD (abt. 7 million m3 per day), and discharge pressure is about 10 Mpa which depends on shore pipe line pressure.

The LNG feed pumps feed LNG to a common suction drum. The suction drum is used as a buffer for feeding each skid with LNG. On the skids, LNG is pressurized in multi stage centrifugal pump(s) to approx 12 – 16 MPa. The LNG is then heated to approximately 10°C in a Shell & Tube heat exchanger. LNG is evaporated/ heated in the tubes, and fresh water/glycol mix is heating the tubing at the shell side.

Fresh water/ glycol mix is circulated with a circulation pump at a constant flow. Fresh water/glycol mix enters the LNG heat exchanger at about 90°C and leaves at about 30°C, at nominal LNG flow. The mix is then heated in a condensed steam heater and a steam heater before it is returned to the LNG heat exchanger. The fresh water/glycol mix condensed steam heater and steam heater are printed circuit heat exchangers (PCHE).

The steam that is used to heat the fresh water/glycol mix is at 2.3 MPa (basis) of saturated steam from regas boiler. In the fresh water/glycol mix steam heat exchanger, steam is condensed and sub-cooled to 100°C or lower temperature and it returned to the condensate tank at atmospheric pressure.

There are two main control loops on each Regasification skid. LNG flowrate is controlled by a flow control valve located between the LNG Booster pumps and S&T heat exchanger. And steam supply is controlled by a regulation valve on inlet to PCHE that gets feed-back from NG temperature out of skid.

3. SEAWATER CLOSED COOLING SYSTEM

The LNG SRV contains electrical/mechanical equipment for propulsion and electric generation. As normal vessel, the fresh water is used for cool the engine and electrical equipment. The fresh water gets heated up after passing all equipments, and then water pass through heat exchanger. For cooling heated fresh water in Heat exchanger, the sea water used as coolant in heat exchanger. This sea water gets heated up after circulating in Heat exchanger. Then, in usual the heated sea water is discharged into sea, but, here, instead of discharging into sea the sea water sends to water ballast tank.

The hot sea water has stored in ballast tank up to their volume. After filling up water ballast tank by hot sea water, the cycle has closed and the stored ballast water is used as coolant in heat exchanger. The number of ballast tank are eight, the first ballast tank's seawater supplies to engine cooling system and discharged into same tank. This seawater is circulated between engine cooling system and ballast tank. Simultaneously, other ballast tank's seawater is cooled by heat exchanged with outside seawater. Through ballast tank's wall, the heat in the ballast's tank is transferred to outside seawater. Tank's seawater temperature will be decreased. When the first ballast tank's seawater temperature reaches to 32℃, using ballast tank is changed to the other tank.

By this closed cooling system, which is patented by SHI, No seawater discharge operation can be carried out at the field during regas operation.

4. SCR SYSTEM

There is no seawater discharge in the LNG SRV, but exhaust gas is generated by regas boiler and Dual fuel engine. Although LNG is clean fuel compared to others, Nitrogen oxides in the exhaust gas will cause acid rain and lung diseases. To reduce nitrogen oxide emission, The LNG SRV is equipped with SCR (Selective Catalytic Reduction) system on the regas boiler, DF engine.

Using the system, nitrogen oxides are transformed into harmless nitrogen and water by reaction with a reducing agent such as a urea in the presence of a suitable catalyst. A gaseous reducing agent is added to a stream of exhaust gas and is absorbed onto a catalyst.

5. REGAS TRIAL AT NEPTUNE DEEPWATER PORT

Before the delivery, The LNG SRV had test with actual LNG during the sea and gas trial at yard. During the trial, the LNG feed pump operation, the regas boiler burning, and other ship systems have been verified.

In continuation of the gas trial, Regas function test has been carried out. The LNG feed pump feed LNG to suction drum. Using the LNG, Suction drum, HP booster pump pot, and Regas system pipeline was cool down. After cooldown of regas system, HP booster pump running test has been carried out one by one under recycle mode for limited time. During the HP booster pump running test, small amount of LNG sent out into the LNG vaporizer. Regasified NG by the LNG vaporizer returns to the suction drum, and it is used by control of suction drum pressure. In the yard test, there is no connection of STL which is regasified high pressure NG discharge equipment via buoy to subsea pipeline. So LNG regasification Capacity test can not be carried out in the yard, only limited amount of LNG could be regasified. Nevertheless, it was successful challenge to confirm lots of regas system function before the actual Regas Trial.

The LNG SRV's first actual regas operation and commissioning was conducted at Neptune deepwater port outside Boston March, 2010. SHI participated in the regas trial to support the owner and Hamworthy which is designer of regas plant for successful operation.

The Regas trial consists of the each skid operation and skid combination operation. But the three skids full capacity operation was not carried out due to the limited access to subsea pipeline capacity. Not only regas plant capacity but also gas consumption at receiving side is very important factor for the regas capacity test. And due to the moisture in the subsea pipeline, the discharge natural gas temperature was controlled at +35°C which is higher than design value (10°C) to prevent formation of methane hydrate. The LNG SRV is steam heated regas system so that gas temperature can be easily controlled.

In spite of these limitations, the Regas Trials (incl. performance test) had been completed satisfactorily in accordance with requirements of the Contract and the Specifications. The regas load test was conducted on each skid. The maximum gas delivery rate was 250 MMSCFD and the gas temperature was controlled at +35°C. The Trial result is showed on table 1 and figure.

Also no discharge seawater operation had been carried out in the Regas Trial. The LNG SRV adopted the indirect steam heating system which is using Water/Glycol as intermediate medium.

There is no seawater intake for the regas operation including seawater discharge. And the LNG SRV equipped with seawater closed cooling system which operation result is showed on the figure. When the ballast tank's seawater temperature reaches to about 23°C, using ballast tank is changed to the other tank. The ballast tank changing temperature is depending on the operator's discretion or regases field's policy. Temperature increasing rate of ballast tank water is different due to the each ballast tank's water volume. Refer to the figure 7, 8(a mimic of ballast tank system, cooling water temperature)

6. CONCLUSION

The LNG SRV refers to the LNG ship that has regasification facilities on board. Unlike existing offshore regasification vessel, LNG SRV is a new eco-friendly concept regas vessel that can supply NG with no discharge seawater. In addition, closed cooling system, i.e. it is no intake/discharge seawater, therefore, no risk of marine life being sucked into the engine cooling system and no discharge of used cooling water. Although exhaust gas which is made by regas boiler can cause air pollution, it is handled by SCR system to reduce harmful gas emissions. To correspond with the tightening ocean / environment regulation, these systems was designed and built.

The LNG SRV was a good opportunity to confirm the Samsung green technology and the experience from LNG SRV design, construction and operation could be a foundation stone for the future offshore plant market.

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LIST TABLES

SKID NO.	Date	NG TEMP	NG PRESSURE	FLOWRATE
		(deg.C)	(MPa)	(MMSCFD)
SKID 1	2010.03.24	35.00	8.63	249.50
SKID 2	2010.03.24	35.06	8.23	249.82
SKID 3	2010.03.17	34.94	8.94	250.06

Table 1. Results of the Regas performance test.

LIST OF FIGURES

Figure 1. The LNG SRV and The Regas Skid

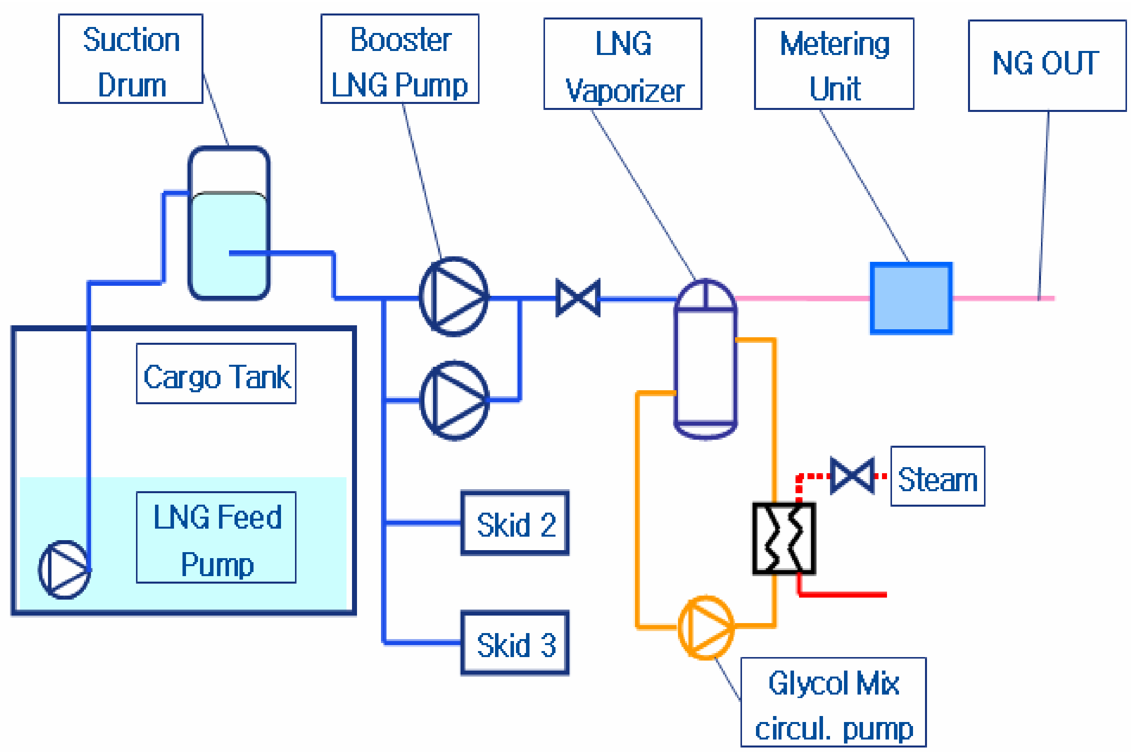

Figure 2. Simple diagram of W/G steam heated Regasification

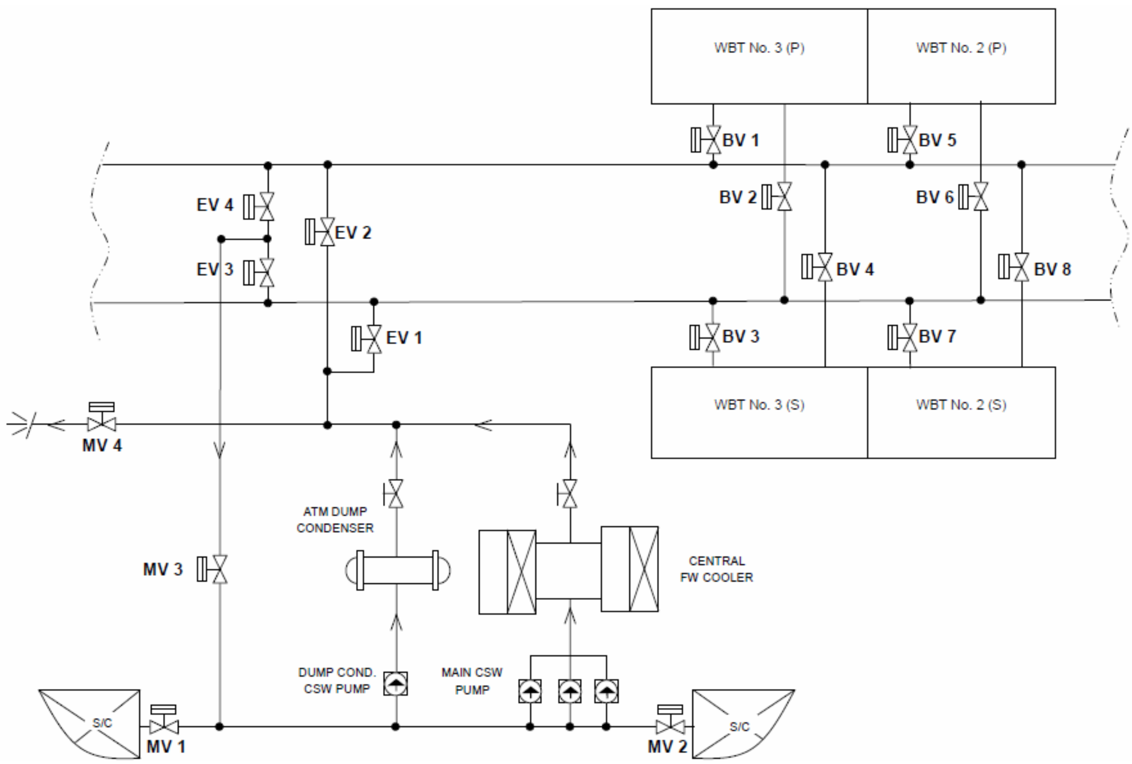

Figure 3. Schematic diagram of SW closed cooling system

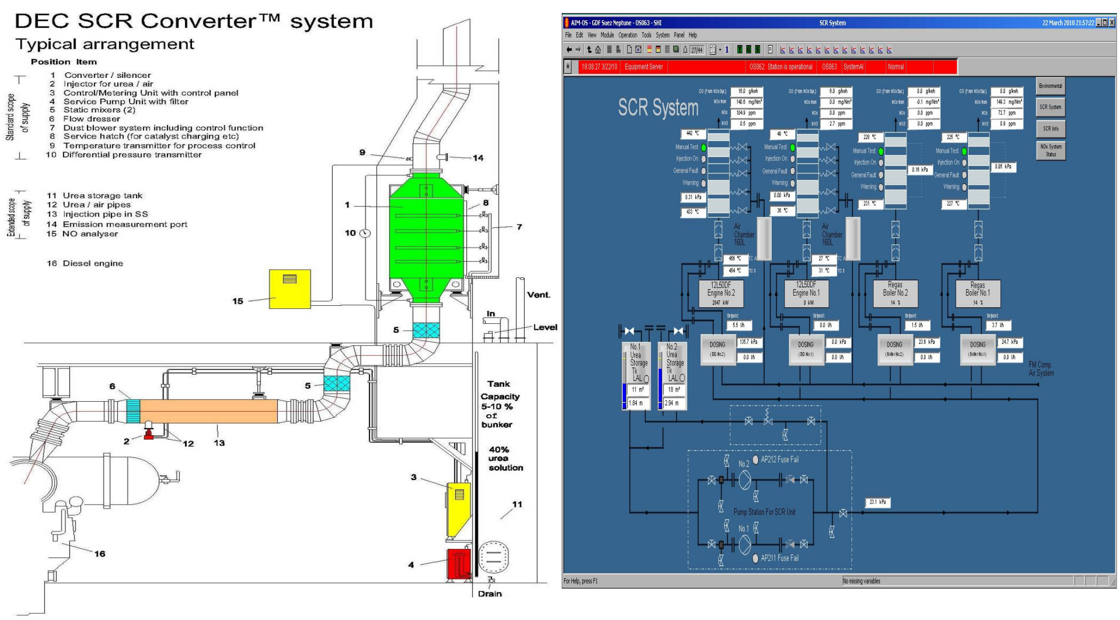

Figure 4. SCR (Selective Catalytic Reduction) system

Figure 5. The LNG SRV at Neptune deep water port with STL connection

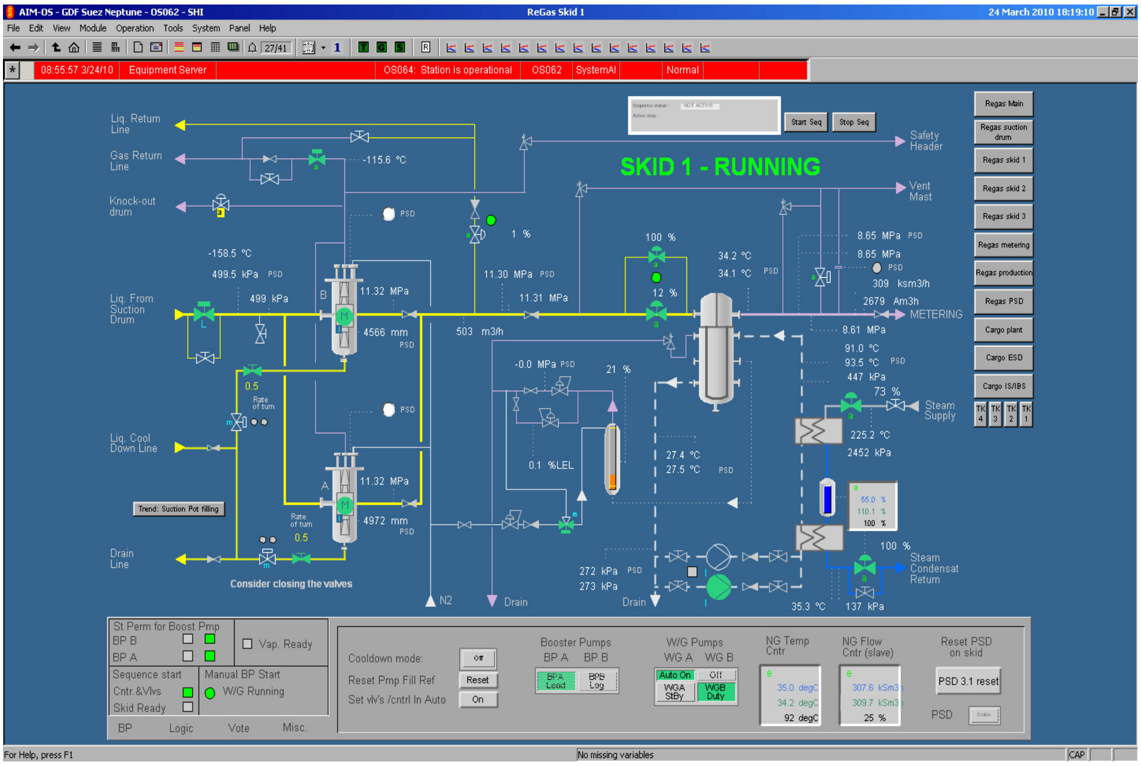

Figure 6. Mimic of Regas skid 1 operated at max capacity

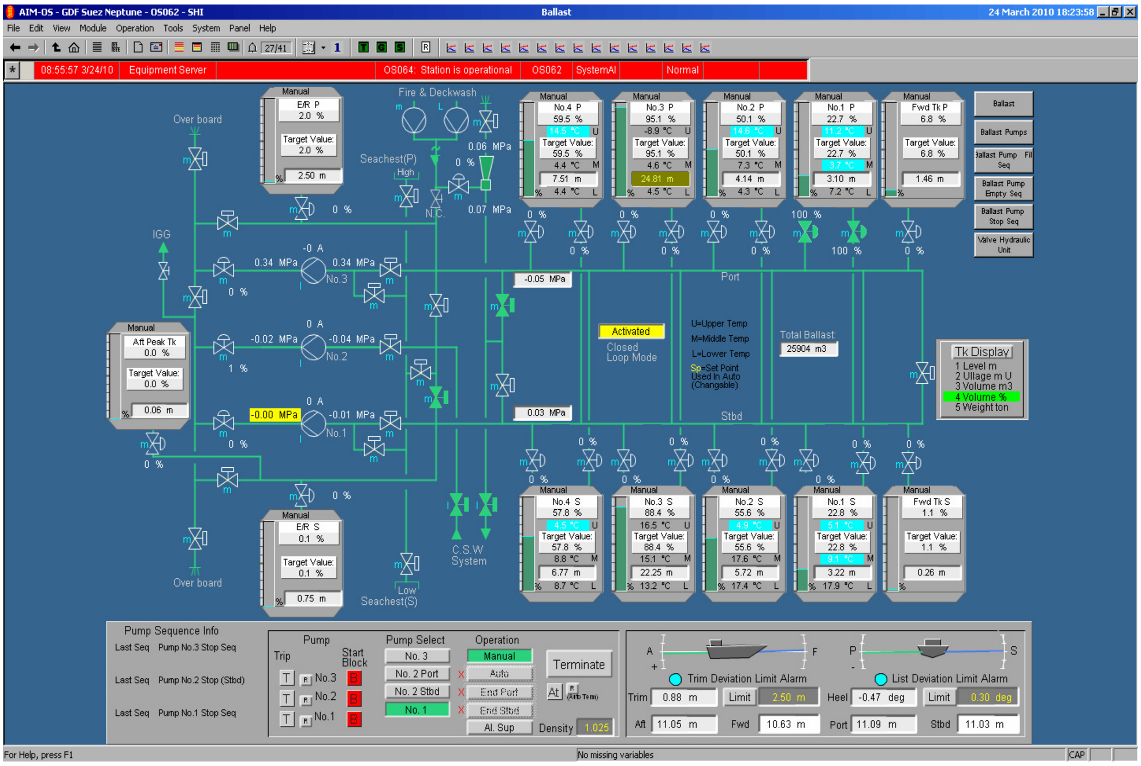

Figure 7. Mimic of ballast system

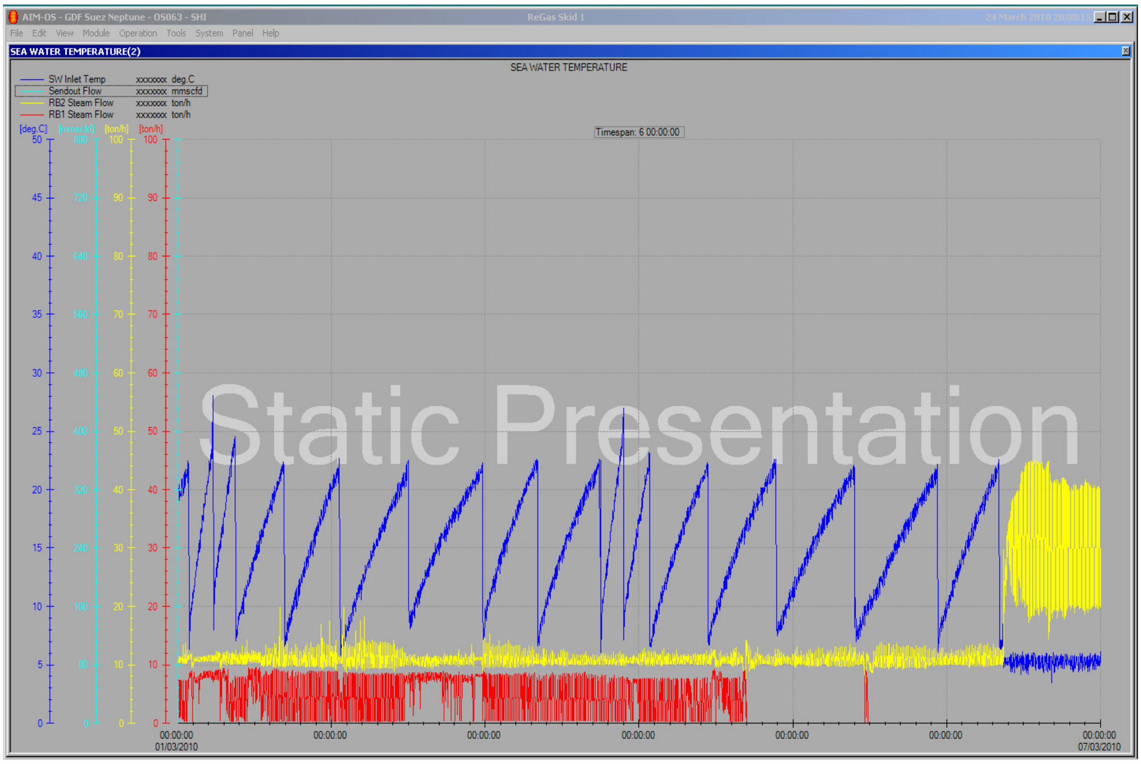

Figure 8. Seawater cooling water temperature trend