FUNCTION OF TEPCO'S FUTTSU LNG TERMINAL AND PLANS TO ENSURE ITS RELIABILITY (LNG TERMINAL PRODUCING ABOUT 10,000 MW)

FONCTIONS DU TERMINAL DE GAZ NATUREL LIQUEFIE (GNL) FUTTSU DE TEPCO ET LES PLANS DESTINES A ASSURER LA FIABILITE DES INSTALLATIONS (TERMINAL GNL D'UNE CAPACITE DE PRODUCTION D'ENVIRON 10.000 MW)

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ABSTRACT

The Futtsu Thermal Power Station, one of the most representative power stations using LNG run by Tokyo Electric, is currently undergoing expansion of facilities. When the facilities are completed, the station will become the world's largest thermal power station with a generating capacity of 5,040MW. The LNG terminal is also undergoing expansion work within the premises of the station. The LNG terminal, scheduled to handle 9 million tons of LNG a year, is expected to play an extremely important role in the future as the fuel supply terminal for approximately 10,000MW power generation, using gas pipelines and station gas pipelines which respectively feed gas at the pressures of 6.3MPa and 1.9MPa.

Accordingly, we are working on improving earthquake resistance, installing multiple power systems, and additionally constructing a berth, for the purpose of ensuring the reliability of LNG facilities to coincide with the additional construction of the LNG terminal. In addition, we put our efforts into improving the reliability and operability of gas supply to power generating facilities by taking advantage of the buffer effects of gas pipelines and sharing the gas supply lines.

In the area of operating control, we are proactively promoting labor saving through the adoption of a fully automated system which effectively uses CRT based operation in every detail. In the area of maintenance and disaster prevention, on the other hand, we adopted a system configuration which enables operation from a sub-control room set up together with a control equipment room in an outbuilding with improved earthquake resistance in case a disaster occurs in the central control room.

In the area of environmental protection, we have developed and adopted a low NOx-emission burner for power generating facilities, by fully taking advantage of LNG's environmental characteristics, and thus made it possible to additionally build power generating facilities while not allowing the increase of the environmental load.

This paper explains the positioning of the LNG terminal at the Futtsu Thermal Power Station, measures to ensure reliability, and our efforts in environmental measures.

RESUME

Les centrales thermiques situées dans la Futtsu Thermal Power Station sont actuellement en train d'être agrandies. Lorsque les travaux d'agrandissement des installations seront achevés cette centrale thermique sera la plus bgrande au monde avec une capacité de production d'électricité de l'ordre 5.040 MW. Le terminal GNL qui se trouve sur le même site est également en cours d'extension. Lorsque les travaux seront achevés, ce terminal traitant 9 millions de tonnes de gaz naturel liquéfié chaque année jouera un rôle clé comme le centre du système de fourniture en combustible destiné à la production d'électricité d'environ 10.000 MW au moyen de canalisations de 6.3 MPa et de canalisation de gaz sur le site de 1.9 MPa.

Nous sommes présentement en train d'améliorer la capacité de résistance aux tremblements de terre, de construire un système d'alimentation double et redondant et d'agrandir les installations d'amarrage et de mouillage en vue de garantir la fiabilité des installations GNL durant les travaux d'extension du terminal. En outre, nous utilisons les effets “line pack” des canalisations de gaz et partageons les lignes d'approvisionnement (en construisant le réseau de gazoducs pour les centrales thermiques) afin d'atteindre notre objectif final qui est de garantir la fiabilité et l'opérabilité de l'alimentation en gaz des centrales thermiques.

Dans le domaine du contrôle des opérations, nous prévoyons de réaliser proactivement des économies de main d'oeuvre en adoptant un système totalement automatisé avec une opération effective basée sur des moniteurs de contrôle à écran cathodique. Dans le domaine de la sécurité et de la prévention des désastres, nous avons adopté une configuration de système qui permet d'opérer le système à partir d'une salle de commande et de contrôle auxiliaire située dans un autre bâtiment qui a été renforcé contre les tremblements de terre, permettant ainsi de poursuivre les opérations même dans le cas où le centre de commande et de contrôle serait endommagé.

Afin d'assurer la préservation de l'environnement, nous prévoyons d'exploiter de manière optimale les propriétés et caractéristiques environnementales du GNL au regard des centrales thermiques et de développer et d'adopter des brûleurs émettant peu de gaz nocifs NOx. Cci nous permettra de construire de nouvelles centrales thermiques sans avoir sur l'environnement un impact accru.

Ce document présente les fonctions du terminal de gaz naturel liquéfié (GNL) Futtsu de TEPCO , les mesures destinées à assurer la fiabilité des installations ainsi que les précautions prises à l'égard de l'environnement.

FUNCTION OF TEPCO'S FUTTSU LNG TERMINAL AND PLANS TO ENSURE ITS RELIABILITY (LNG TERMINAL PRODUCING ABOUT 10,000 MW)

1. INTRODUCTION

Tokyo Electric has 11 thermal power stations classified as demand site neighboring type thermal power stations set up along the Tokyo Bay where power demand is concentrated. Of these, nine are LNG-burning thermal power stations with a generating capacity of approximately 23,000 MW.

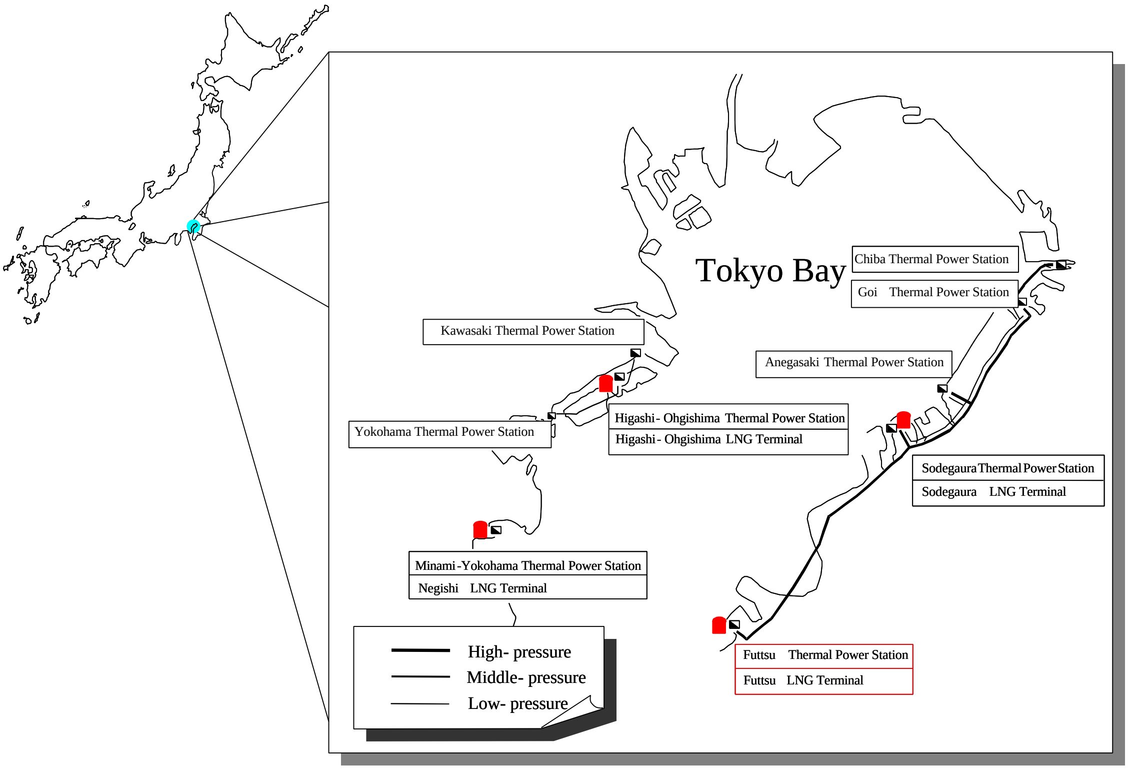


Fig. 1 Location of LNG Terminals and Thermal Power Station

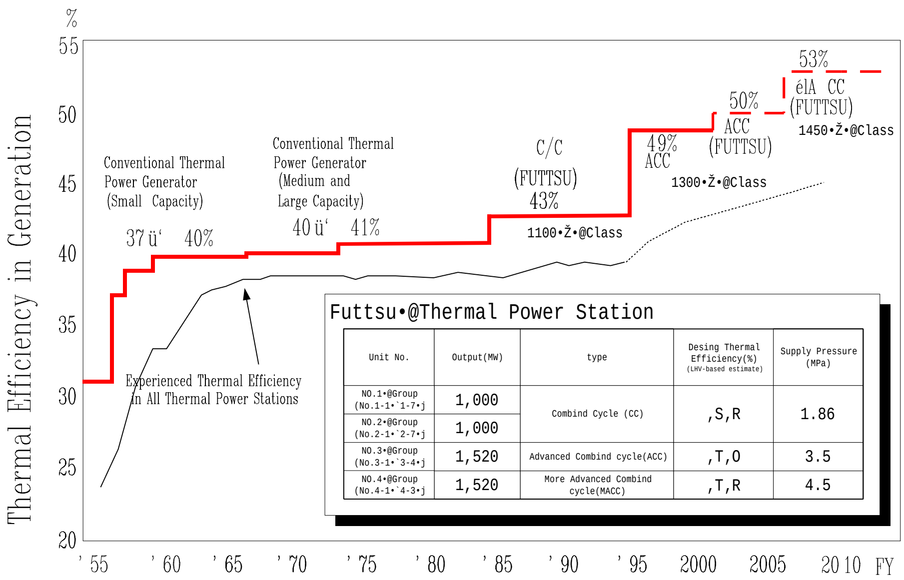
The addition of the thermal power generating facilities currently under construction will push the generating capacity up to approximately 26,000 MW in the near future.To these power stations, fuel gases are being supplied from four LNG terminals through gas pipelines.

The LNG terminal at the Futtsu Thermal Power Station, one of the most representative LNG terminals run by Tokyo Electric, is now in the process of achieving major transformation, including its thermal power generating functions located within the same premises. In this paper, we will introduce high-temperature, high-pressure technology in the field of thermal power generation and cryogenic technology in the field of LNG, both of which we have built up for many years, as well as our efforts in building state-of-the-art facilities which represent the culmination of our efforts to ensure reliability, to coincide with the preparation of the plan to construct the LNG terminal.

2. FEATURES OF THE FUTTSU THERMAL POWER STATION AND OVERVIEW OF THE LNG TERMINAL

2.1 Features of the Futtsu Thermal Power Station

The Futtsu Thermal Power Station, where we began commercial operation of Unit Group No. 1 in 1986 and Unit Group No. 2 two years later in 1988, became the first power station with 1100   class combined-cycle power generating facilities (Output: 1000 MW x 2 with thermal efficiency of 42%). Based on this track record in the operation of power generating facilities, we have added further alterations to increase the gas turbine temperature and developed a new heat-resisting alloy to build larger facilities, cooling technology to be applied to the moving and stationary blades, and high performance large gas turbines. All these efforts led to the construction currently underway of Unit Group No. 3, comprised of state-of-the-art 1300   class combined-cycled power generating facilities (output: 1520 MW with thermal efficiency of 50%), and Unit Group No. 4, comprised of 1450   class combined-cycle power generating facilities (output: 1520MW with thermal efficiency of 53%). When all the facilities now under construction are completed, the Futtsu Thermal Power Station will become the world's largest thermal power station with a 5,040 MW power generating capacity.



Unit No.	Output(MW)	type	Desing Thermal Efficiency(%) (LHV-based estimate)	Supply Pressure (MPa)
NO.1•@Group (No.1-1•`1-7•j	1,000	Combind Cycle (CC)	,S,R	1.86
NO.2•@Group (No.2-1•`2-7•j	1,000			
NO.3•@Group (No.3-1•`3-4•j	1,520	Advanced Combind cycle(ACC)	,T,O	3.5
NO.4•@Group (No.4-1•`4-3•j	1,520	More Advanced Combind cycle(MACC)	,T,R	4.5

Fig. 2 Changes in Thermal Efficiency

When building Unit Group Nos.3 and 4, we fully took advantage of the excellent environmental characteristics of LNG and thus succeeded in achieving the goal of not allowing an increase in the amount of NOx emissions.

The Unit Group Nos. 1 and 2, which have already been set up, adopted a diffusion-controlled combustion chamber to apply atomized vapor to LNG as a measure to prevent NOx emission.

The recently developed low NOx emission chamber, designed to produce an uniform fuel-air mixture of gasified LNG and compressed air prior to combustion, adopts a premix combustion system to reduce the peak temperature of flames which locally occur during combustion. With the planned introduction of this chamber not only to Unit Group Nos. 3

and 4, which are also to be built, but also to Unit Group Nos. 1 and 2, which are already set up, in a modified form, coupled with the installation of De-NOx facilities, we have made it possible to build power generating facilities without environmental deterioration.

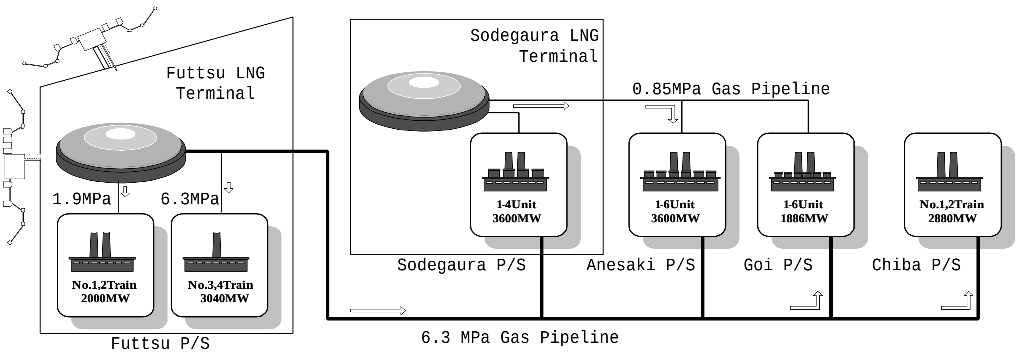


Fig. 3 Outline of the Gas Pipeline in Chiba Prefecture

In addition to all those mentioned above, the power generating facilities which demonstrate high power generating efficiency, which constitutes a feature of LNG-burning thermal power generation, will contribute to reducing the emission of CO_2, one of the causes of global warming.

2.2. Overview of Additional Construction of the Futtsu LNG Terminal

The Futtsu LNG Terminal, since it started operation in 1985, has received deliveries of 38 million tons of LNG in total over a period of about 15 years. The terminal currently handles approximately 5 million tons of LNG a year, an amount equivalent to that carried by about 90 vessels.

Fuel supply for power generation purposes from the terminal will expand not only to the Futtsu Thermal Power Station currently undergoing extension work but also to the Goi Thermal Power Station (with a 1886 MW power generating capacity) and Chiba Thermal Power Station (with a 2880 MW power generating capacity), both of which are connected by gas pipelines (which feed gas at the pressure of 6.3 MPa). This means that the Futtsu LNG Terminal will be supplying LNG to power generating facilities with a power generating capacity of approximately 10,000 MW.

To coincide with the construction of facilities currently underway, we are also building additional LNG facilities including a 79,000 DWT class berth, two underground LNG tanks (125,000 kL) and three vaporizers, and plan to further build two more underground LNG tanks (125,000 kL) in the future. When all these facilities are completed, the Futtsu LNG Terminal will be equipped with two berths (79,000 DWT class), with a total storage capacity of 1,260,000 kL (90,000 kL x 4 tanks and 125,000 kL x 8 tanks). As the world’s largest fuel supply terminal for power generation, the Futtsu LNG Terminal will be the most important terminal for Tokyo Electric accommodating up to 9 million tons of LNG delivery (equivalent to 17% of Tokyo Electric’s entire generating output if converted to electricity).

Fig. 4 Photo of Futtsu Power Station Premises

Principal features of additional LNG facilities to be built are as follows.

*Unloading facility: 79,000 DWT Dolphin LNG berth Unloading rate -- 12,000m3/h
Simultaneous unloading to the first and second berths is allowed.

*Storage tan: Underground membrane storage tank
Inside diameter – 69m Depth -- 35 m
Simultaneous loading and unloading are allowed. Unloading to all the storage tanks from the first and second berths is allowed.
Mixed LNG storage to allow all the projects to be unloaded into the same storage tank is carried out during operation.

*ORV: 180 t/h; Open rack vaporizer; Supplies gas at the pressure of 6.3 MPa when connected with gas pipelines.

*BOG processors: The BOG compressor increases pressure and supplies fuel gas for existing combined cycle. The gas compressor further increases pressure and supplies gas to gas pipelines.

*Decompression facilities:
Reduces the pressure of the gas supplied by gas pipelines for gas application to Unit Group No. 3 6.3->3.5 MPa. Also reduces the pressure of the gas supplied by gas pipelines for gas application to Unit Group No. 4 6.3->4.5 MPa

3. MEASURES TO BUILD LNG FACILITIES

3.1. Facility Construction and Cost Reduction

3.1.1 Implementation of Optimum Premise Layout

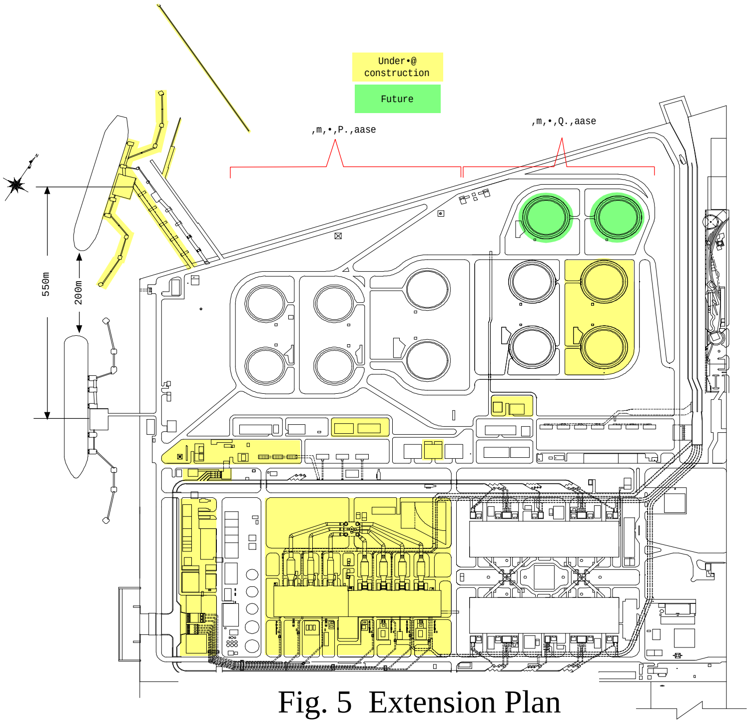


Fig. 5 Extension Plan

The unloading facilities were placed approximately 500 m away from the first berth so that the waterway for the first berth should be used and that breakwaters and bunker berths already set up should effectively be used for the purpose of reducing cost.

To take into consideration the dual aspects of gas supply functions (meaning that the gas needs to be supplied both within and outside the premises), the station facilities were arranged in a functionally decentralized layout. More specifically, storage tanks No.1 to No. 6 and vaporizers were laid out to form Base No. 1, which is primarily designed for power generation at the Futtsu Thermal Power Station and storage tanks No. 7 to No. 12 which include storage tanks currently under construction and vaporizers were laid out to form Base No. 2, which is designed for gas supply through gas pipelines. Under normal operating conditions, these bases will be operated as an integrated system. However, they were designed to function individually under abnormal facility conditions.

As shown in Fig. 5, we clearly demarcated the storage tank yard, vaporizer yard and electric room yard, when laying out facilities. Special considerations entered the layout of storage tanks in order to ensure safety against gas leakage as well as ensure maintainability and operability. More specifically, the storage tanks were laid out away from all the facilities as well as the boundary with the sea, by a distance equivalent to the diameter of the storage tank.

As for the layout of vaporizers, the open rack vaporizers and vaporizers for existing pipelines were laid out in a way so as to take sea water from different sides; to improve the reliability of sea water properties, the open rack vaporizers take sea water from where power generating facilities which belong to a different system than the vaporizers for the existing pipeline take water.

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3.1.2 Adoption of New Construction Techniques

We adopted several new construction techniques and technologies in order to reduce the construction period, ensure safety and bring down cost.

Fig.6 Unit construction method adopted for the pipe rack

* Second berth:

Adoption of a new unit construction method. We adopted a unit construction method for the pipe bridge, unloading pipe frame and loading arm platform.

*Storage tank:

Adoption of a large block technique for the roof of the underground storage tank.

The roof panels of the underground storage tanks are generally welded after the roof frame is constructed at the bottom of the storage tank and jacked up. Recent years have seen growing application of the air raising technique, which involves the construction of a roof from factory-manufactured large roof blocks at the bottom of the storage tank and raising it using pneumatic force (Storage tanks No. 7 and No. 8 located at the Futtsu Thermal Power Station). This time, we plan to introduce, for the first time in the world, the direct roof installation technique using large roof blocks, which involves the installation of large roof blocks directly over the storage tank. This technique is expected to improve operation safety as it reduces the amount of work at high altitude and the construction period.

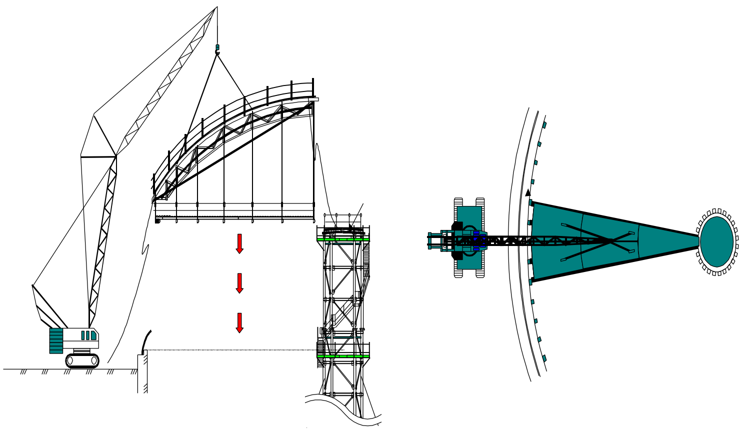

Fig. 7 Direct Installation Technique for the Storage Tank Roof

* Vaporizers: Adoption of high performance heat exchanger tubes
The adoption of the new high performance tube reduced the installation space to half of what is required by the ORV of the same capacity for gas supply, making it possible to also install vaporizers in small areas. Prior to the adoption of the tube, we conducted a year-long test to check how marine organisms adhered to the tube.

* BOG processing: Adoption of the booster gas compressor
The increases in storage tank capacity and unloading frequency give rise to a problem with BOG processing. BOG has conventionally been processed by Unit Group Nos. 1 and 2. However, on the understanding that supplying BOG mixed gas to thermal power stations through pipelines is more economically advantageous from the perspective of efficiency and that doing so increases the number of locations where BOG is processed, we adopted a booster gas compressor which increases BOG from 1.9 MPa up to 6.3 MPa. We also adopted the technology to use cryogenic heat of LNG, which we are planning to introduce in the poster session, for the purpose of cooling gas for the booster gas compressor.

3.2 Measures to Improve Reliability

3.2.1 Improvement of Earthquake Performance

Japan, located in the Pacific Rim Volcanic Zone, is often hit by earthquakes. The most severe earthquake that hit Japan in recent years was the South Hyogo Prefecture Earthquake (magnitude 7.2), which occurred in Hyogo Prefecture in 1995. This inland earthquake was of the same nature as that which hit California. We accordingly examined resistance against severe inland earthquake motion of similar magnitude. We then designed and built facilities which demonstrated a level of elasticity based on our findings.

3.2.2 Power Supply Reliability

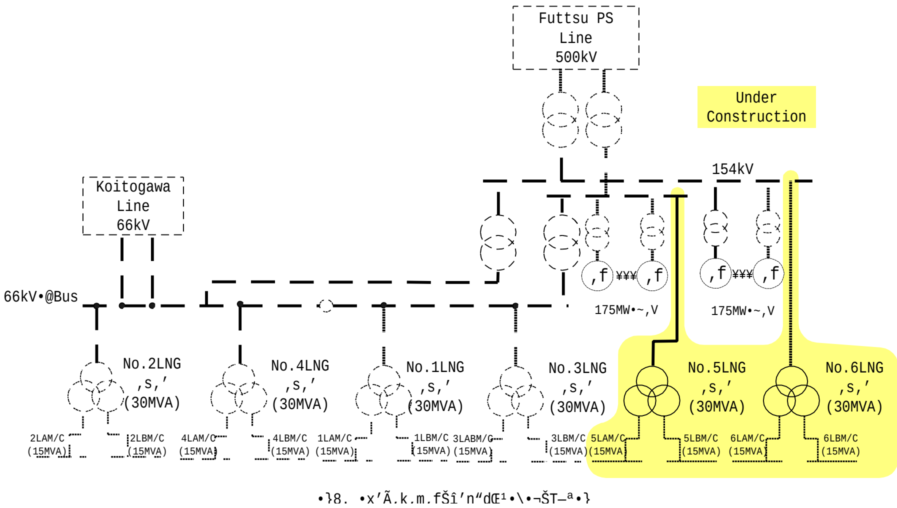

Fig.8 Sketch of Power Supply Configuration at the Futtsu LNG Terminal

The power supply reliability may be interpreted as the reliability of the terminal. The power supplies currently used at the Futtsu LNG Terminal receive power from two systems, 500 kV and 175 kV power transmission systems, in order to ensure system redundancy. However, in the event of incidents such as lightning which affect multiple

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power transmission lines, it may be difficult to receive power from even one of these systems.

In anticipation of a situation like that mentioned above, we newly set up a system to directly receive power from a bus connected to a generator by taking advantage of the fact that power generation facilities are located nearby. This will make it possible to receive power for power supplies used within the station premises through independent operation of power generation facilities within the premises even in case power generating facilities are isolated from systems by incidents such as lightning which affect multiple transmission systems. The installation of this additional system has further improved power supply reliability.

3.2.3 Unloading Facilities

Since the unloading linefrom the second berth runs approximately 1.3 km, inevitably making the return gas line long, this gave rise to concern that it would take time to cool the same line which returns to vessels. Internal pressure of the group of storage tanks newly constructed is kept at 120 hPa during operation in order to place restrictions on BOG, while that of the existing group of storage tanks is kept at 60 hPa.

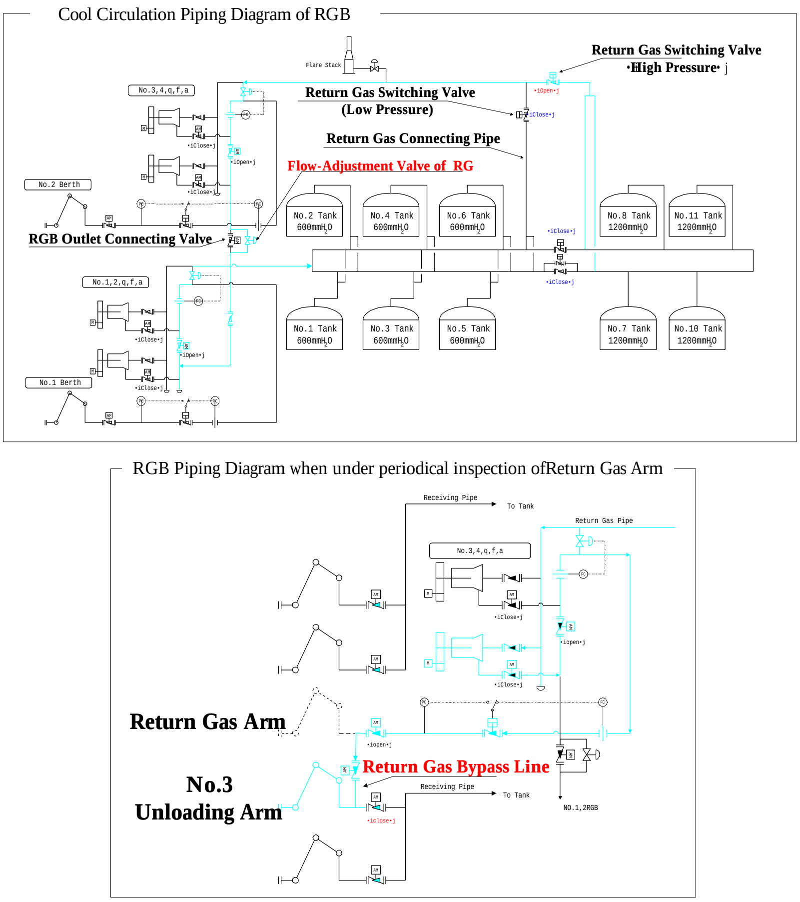

Fig. 9 RG System

We developed an automatic RG line cooling system by taking advantage of the difference in internal pressure between two groups of storage tanks. This system allows shifts of low temperature BOG of approximately 5,000m3N/h between groups of storage tanks. This line can also be applied to backup RGB operation between berths.

The second berth was designed to allow high-frequency unloading at the rate of one container vessel every two days. The first and second berths were designed to collectively allow the unloading of a maximum 9 million tons a year. We also reviewed the loading arm specifications and unitized oil pressure pipes so that a series of operations ranging from maintenance to post-inspection installation would be completed within three days. At the same time, to improve earthquake resistance, we adopted the 1/2 double ball valve of the emergency release coupler (ERC) with the 1/4 double ball valve and improved the strength of each part. As for the RGB loading arm, which may impose restrictions on unloading when it undergoes maintenance, we connected the RGB line and liquid line pipes to use the liquid line as a substitution for RG.

3.2.4 Utilization of Line Pack Gas

Gas supply reliability means, in other words, the reliability of power generating facilities. We have taken all possible measures, to ensure reliability. For example, by preparing a facility configuration in a way to ensure excess surplus capacity for gas supply facilities such as vaporizers and examining how ideally we will be able to perform operational management of standby equipment. This resulted from the fact that the quantity of line pack of the gas pipeline and the amount of gas used by power stations did not match. What improved this situation was the connection between the gas supply line and the gas pipeline which connects Futtsu and Chiba.

This pipeline is operated at the pressure of 6.3 MPa. The line pack gas has allowed the power generating facilities connected to the pipeline and power generating facilities to be set up to be operated for a certain period of time even if gas supply comes to a halt when a problem occurs in the terminal. This has also helped to improve efficiency through the reduction of the number of backup vaporizers and the reduction of the standby facility.

3.2.5 Improvement in Operation Reliability

Effective and accurate operation of these facilities is required with a small number of staff. When extension work is completed, more than 10,000 detectors will be set up at the Futtsu LNG facilities.

Fig.10 Central Control Room and Sub-control Room

A large amount of data to be collected will be processed by digitally controlled devices arranged in decentralized, hierarchical order, and man-machine communication system using graphics will provide accurate information to the operators. We also set up a large screen, electric alarm panels and large digital display panels to allow all the operators to share the same information. These systems are fully automated, together with an accurate voice notification device, to carry out a range of operations from unloading to gas supply including emergency action. As such, manual operation is not usually required. With the adoption of CRT based operation, however, operators are also allowed to perform manual operation while monitoring information provided in graphic form.

We also adopted a system configuration that enables operation from a sub-control room set up together with a control equipment room in an outbuilding with improved earthquake resistance in case a disaster such as a fire occurs in the central operation room.

4. AFTERWORD

We explained the positioning of the Futtsu LNG facilities and measures to ensure reliability. LNG is expected to enjoy continuous widespread application as a fuel for power generation as it demonstrates excellent environmental characteristics. The Futtsu LNG Terminal we introduced in this paper is scheduled to be completed in July, 2002. These facilities are currently under construction based on the principles of safety maintenance as well as systematic design and construction management, and when completed, will demonstrate their functions as a terminal under the supervised maintenance management system and operation management system. We are confident that these facilities will be then incorporated, for the first time, into the LNG chain run by Tokyo Electric.

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