# SUSTAINABLE DEVELOPMENT DESIGN OF AN ELECTRICAL SYSTEM A CASE STUDY OF ASIAFLEX PRODUCT SDN. BHD.

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ELECTRICAL & ELECTRONICS ENGINEERING
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JUNE 2010

**Sustainable Development (SD) Design of an Electrical System**

**A Case Study of Asiaflex Products Sdn Bhd**

by

LIEW WUI KEONG

Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Engineering (Hons)

(Electrical and Electronics Engineering)

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# CERTIFICATION OF APPROVAL

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Approved by,

(Ir. Perumal Nallagowden)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

June 2010

# CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

LIEW WUI KEONG

# ABSTRACT

Sustainable development (SD) is a simple way of ensuring a better quality of life for everyone, now and for generation to come. It refers to a perspective that considers all three aspects which are social, economic and the environmental. Designing an electrical system with sustainability refers to an approach that considers the use of renewable energy, energy efficiency, conservation and minimising usage of natural resources. Electrical system design is a vital part of engineering, extensive research works to incorporate sustainable development into the design of electrical system is carried out in this project. Asiaflex Products Sdn Bhd is taken as the case study for this project. Asiaflex is a flexible pipeline plant in Johor, Malaysia which is wholly owned by Technip Group. This report discusses about the eight major implementations that have been adopted in the Asiaflex project in order to achieve the goal of sustainable development. These SD implementations can be grouped into four main areas, namely supplementing consumption with renewable energy, use of high energy efficiency equipments, by design and also instilling SD awareness among employees. This report highlights the electrical system designs based on SD concept, equipments used and the comparisons between SD model and the conventional model. Comparisons are also done based on the energy consumptions, energy savings, costs and its return of investment. Justifications based on energy reduction and the effects towards environment, social and economic are the key part of this report.

# ABSTRACT

Sustainable development (SD) is a simple way of ensuring a better quality of life for everyone, now and for generation to come. It refers to a perspective that considers all three aspects which are social, economic and the environmental. Designing an electrical system with sustainability refers to an approach that considers the use of renewable energy, energy efficiency, conservation and minimising usage of natural resources. Electrical system design is a vital part of engineering, extensive research works to incorporate sustainable development into the design of electrical system is carried out in this project. Asiaflex Products Sdn Bhd is taken as the case study for this project. Asiaflex is a flexible pipeline plant in Johor, Malaysia which is wholly owned by Technip Group. This report discusses about the eight major implementations that have been adopted in the Asiaflex project in order to achieve the goal of sustainable development. These SD implementations can be grouped into four main areas, namely supplementing consumption with renewable energy, use of high energy efficiency equipments, by design and also instilling SD awareness among employees. This report highlights the electrical system designs based on SD concept, equipments used and the comparisons between SD model and the conventional model. Comparisons are also done based on the energy consumptions, energy savings, costs and its return of investment. Justifications based on energy reduction and the effects towards environment, social and economic are the key part of this report.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| A | Ampere |
| AC | Alternating Current |
| CAPEX | Capital Expenditure |
| CFL | Compact Fluorescent Light |
| CSI | Current Source Inverter |
| DC | Direct Current |
| EU | European Union |
| GTO | Gate Turn Off Thyristor |
| HSE | Health, Safety, Environment |
| HV | High Voltage |
| IGBT | Insulated Gate Bipolar Transistors |
| LED | Light Emitting Diode |
| LV | Low Voltage |
| OPEX | Operating Expenditure |
| O&G | Oil and Gas |
| PV | Photo voltaic |
| PWM | Pulse Width Modulation |
| SCR | Silicon-Controlled Rectifier |
| SD | Sustainable Development |
| THD | Total Harmonic Distortion |
| UPS | Uninterruptable Power Supply |
| V | Voltage |
| VSD | Variable Speed Drive |
| VSI | Voltage Source Inverter |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

Sustainable development was formulated in 1987, to meet the needs of present generations without compromising the capacity of future generations to satisfy their own [1]. Sustainable development encompasses three aspects, namely economic viability, care for the environment and responsible social concern [2]. In the economic dimension, the long term fundamental changes are taken into consideration and always try to come out with new idea to increase resource productivity. While in the environmental dimension, it is important to recognise the value of the environment assets and always be environmental caring. In the social dimension, pressing societal concerns such as exponential population growth, biodiversity loss, climate change, deteriorating of air and water quality, all are seen as threats to our life. If society is to advance without jeopardising the prospect for future generations, then we must take into consideration the environment and social consequences of our activities, as well as the economic benefits. These become among the most chanllenging issues to look into when we continue developing.

### *1.1.1 Plant Overview (Asiaflex Products Sdn Bhd)*

Technip as a global player in the oil and gas services adopted a proactive approach by creating a bench mark on Sustainable Development in their project. In early 2008, Technip Group has decided to further invest in another flexible pipeline plant in Malaysia- Asiaflex Products Sdn. Bhd. It is located in the Tanjung Langsat industrial complex, near Johor Bharu in Malaysia. Asiaflex Products manufactures flexible pipe for offshore O&G field. This manufacturing plant comprises of manufacturing workshop and warehouse, administration office, maintenance workshop, test building, packing building, TNB substation, Consumer substation, generator building and others as shown in the drawing in Attachment 1.0. With heavy emphasis on preservation of the earth, sustainable development issues raised, going green, recycle, reuse, reduce of natural resources, low carbon footprint, etc., the Electrical Department in Technip Kuala Lumpur decided to take the initiative to produce a proposal on Sustainable Development Designs. The proposals of SD designs comes with high CAPEX cost, hence it has to be tradeoff between project's budget cost and economical viability with consideration that the benefits are greater in value.

### 1.2 Problem Statement

Adopting sustainability development method into the design is one of the main challenges in this project. Energy and resources consumptions have to be reduce by providing a higher efficiency system. Energy conservation can be done by substituting fossil fuels with solar, wind or photo-voltaic in the generation of power on the plant. Besides that, reducing electricity losses in the distribution and transmission stages and designing a system that will optimize the usage of electricity are the main focuses of the SD designs.

Implementation of SD designs should take on a multi-discipline approach. Since SD will encompass the design of the project as a whole and involves various disciplines, a report on SD designs should be produced in which all disciplines contribute ideas and methods to implement such ideas.

The proposal of SD designs comes with high CAPEX cost for Technip, hence it has to be tradeoff between project's budget cost and economical viability with consideration that the benefits are far greater in value. Therefore project management has to be selective in implementations of SD programme or provide facilities for future accomplishment. Payback period, operational costs have to be calculated as well as the analysis in the electrical perspective has to be conducted to convince the management about the benefits of having the SD proposals implemented. The author is to produce a report to give feedbacks about SD implementations in Asiaflex Project for future project executions.

## 1.3 Objectives

Sustainable development should be elaborated on the three 'R's strategies in order to achieve its ultimate target which are social responsibility, economic viability and care for environment. The three 'R's are namely 'Reduce', 'Reuse' and 'Recycle'. The following areas have been identified in order to achieve the goal of sustainable development: [3]

a) Reduce

- By increasing energy efficiency and energy conservation.
- By increasing material and equipment efficiency.
- Impact on ecosystem.
- Waste.

b) Reuse

- Office waste
- Environmental/ nature's gift- rain.

c) Recycle

- Industrial waste

However, for this report emphasis will be put on the 'Reduce' aspect. To achieve the goals of sustainability development in electrical system design, write ups on how to reduce the losses and also energy/ power consumption by using renewable energy and also high efficiency equipments will be presented in this report. SD implementations in Asisflex Plant are grouped into four main areas, namely supplementing consumption with renewable energy, use of high energy efficiency equipments, by design and also instilling SD awareness among employees.

### 1.4 Scope of Study

The scope of the research works has been summarized as follows in order to achieve the objectives within the time frame and also budget allocated.

- Make comparison between SD designs electrical system and conventional designs electrical equipment. Identify benefits and advantages of SD design in terms of electrical perspectives. Give feedbacks about SD implementations in Asiaflex Project for Technip's future project executions.
- Study on the areas of SD implementations in an electrical system. These include energy efficiency and conservation, minimize losses in the distribution, use of high efficiency equipment, optimize energy usage, etc.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Brief Introduction of Asiaflex Project

Technip signed an agreement with Tanjung Langsat Port (1), for a 20 Ha land lease to set up a new flexible pipe manufacturing plant to be called Asiaflex Products. Located in Tanjung Langsat industrial complex, on the southern tip of Peninsular Malaysia in Johor State, this new plant will have direct access to a deep water quay-side.

Asiaflex Products will have a manufacturing capacity of 200 normalized km per annum of flexible pipes. It will allow Technip group to reach a total maximum production capacity of 1,060 normalized km per annum, including the current capacity of the two existing Technip plants which are Flexi France in Le Trait, France and Flexibras in Vitoria, Brazil [4].

Expected to be operational in 2010, Asiaflex Products' primary focus will be the emerging deep water oil & gas markets in the Asia-Pacific and Middle-East regions. The facility will have the capability of producing the complete range of Technip flexible pipes. The manufacturing site will be designed to allow future extension for umbilical production. The plant will provide employment for approximately 300 people.

## 2.2 Energy Efficiency and Conservation

The most common and widely used energy sources for conversion to electricity are fossil fuel, nuclear and hydro. The less common uses are solar, tidal, wind, photo-voltaic, geothermal, fuel cells and bio fuel [3]. Different sources of energy used will result in different negative implact to the environment. The less energy we consumed, the less damage to our environment. The following methods are the sustainable developement design methods that have been identified:

(1) Supplement the consumption of non-renewable energy with the use if renewable energy.

(2) Use of high efficiency equipment.

(3) Minimise losses in distribution.

(4) By design

(5) Off-peak energy usage.

(6) Carry-out energy audits.

(7) Educating the staff/ employees.

### *2.2.1 Use of Renewable Energy*

The use of photo voltaic (PV) system to produce electricity from the sun can be used to supplement or reduce the energy consumption from sources such as fossil fuels. A typical PV system for off-grid application (i.e. totally self sufficient and not connected to the utility supply) would consist of PV solar cells (or panels), charge controller, battery bank, inverter and distribution board [3]. The PV cells will convert sunlight to direct current (DC) electricity. The charge controller finds the most optimum volatge and current combination to maximise on the charging of the battery bank. The batterry bank stores electricity for later use. While the inverter inverts the DC electricity to 230V AC electricity for the use with common electrical appliances. The limittations for the implementation of PV system is the cost and efficiency.

### *2.2.3 Use of High Energy Efficiency Equipment*

Three of the main ideas that contribute to sustainable development in electrical system are optimizing usage, minimising losses and the use of renewable energy. Among these criterias, Asiaflex project focuses mainly on the first two ideas which are optimizing usage and minimising losses. This can be achieve by using high efficiency equipment and minimizing power distribution losses. The implementations that have been adopted in this project include using high power factor motors, high efficiency transformers, larger conductor size and good power supply quality. To minimise power losses at the consumers' end, the below measures can be incorporated into the design and selection of equipment:

- Use equipment with high efficiencies or with high energy star ratings.
- Use equipment with high power factors. Equipments with low power factor have to be fitted with power factor correction devices so that the losses in the power cable (due to higher current) can be minimised.
- Equipment with small motor which run long hours have to be the more efficient 3-phase type instead of the 1-phase type. Large motors are inherently of 3-phase design.
- Wherever possible always use equipement with power saving or power conservation mode.

### *2.2.4 Minimize Losses in the Distribution System*

The main losses in the cables and transformer are cause by conductor resistance and reactance. It is unavoidable for the losses to occur when the electrical power is transfer from the source to the load end. These losses can be minimized by using a high efficiency transformer and the load also can be minimized through conductors. Transformer should not be oversize and it should be loaded at least 70% of their rated capacities for optimum loss minimization [5]. Whereas, minimizing losses through conductors (cables, busbars) can be achieved by installing a larger size conductors since larger size conductors have lower impedances. The losses through the conductors should be less than 1.5%.

## 2.3 Power Generation

The capacity of electrical supply has to be capable of supplying continuously 125% of the peak load. The 25% spare capacity is required to cater for the possibility of future expansion plans [5]. Maintenance requirements, economic size, future load development pattern and the unit reliability determine the generator ratings and also the number of generator sets to be installed on a platform. Stand-by units or emergency generators have to be provided in the design to cater for generating sets failure and during maintenance period.

## 2.4 Energy Saving from High Effciency Distribution Transformers

Energy losses throughout the world's electrical distribution networks amount to a total of 1279 TWh. They vary from country to country between 3.7% and 26.7% of the electricity usage, which implies that there is a large potential for improvement. Distribution transformers are the second largest loss making component (after lines and cables) in electricity networks. The worldwide electricity savings potential of switching to high efficiency transformers is estimated to be at least 200 TWh [6].

Distribution transformers are used by utility companies to transform the electricity from a voltage level of 1 to 50 kV (the level at which the power is transported locally and supplied to many industrial consumers) to a voltage level ranging between 120 V and 1 kV (typically used by residential consumers and the industrial sector). Distribution transformers have higher energy effciency compared to other electrical equipment. Effciencies range between 90% and 99% [7].

### *2.4.1 Energy losses in distribution transformers*

A distribution transformer consists of an iron core, with a limb for each of the phases as shown in figure 1. Around each limb, there are two windings, one with a greater number of turns connected to the higher voltage side, and one with a lower number of turns connected to the low voltage [7].

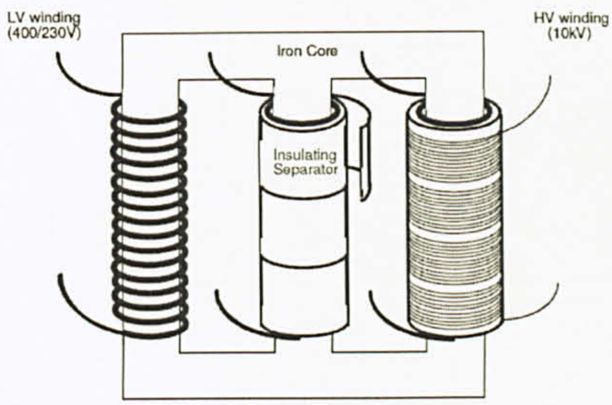


**Figure 1: Illustration of a Transformer**

There are 3 types of energy losses:

i. No-load losses/ core losses which is caused by hysteresis and eddy currents in the transformer core. It is a constant energy loss that is present from the moment the transformer is connected. In the average European distribution grid, no-load losses represent about 70% of the total loss [8].

ii. Load losses/ copper losses which is caused by resistive losses in the windings and by eddy currents in the windings.

iii. Cooling losses for some transformers that require fan cooling. This will lead to extra energy consumption. The larger the intrinsic losses of the unit, the greater the need for cooling and the higher the energy consumption by the fan. Cooling losses are relatively small compared to load and no-load losses [8].

*2.4.2 Minimizing Energy Losses in Transformer*

No-load losses can be reduced by improved design, assembling and selection of materials for the core. The no-load losses can be reduced by selecting a high performance steel for the core. Better steels for transformer cores have been developed over the years. Besides the selection of steel, the way in which the transformer cores are designed, cut, fabricated and assembled plays an important role in energy efficiency or energy saving. Increasing the size of the core reduces the density of the magnetic field and in this way improves the energy efficiency. The development of amorphous iron has also introduce a new evolution in reducing no-load losses more significantly.
Distribution transformers built with amorphous iron cores can have more than 70% lower no-load losses compared to the best conventional designs. It can also achieve up to 99.7% efficiency for 1000 kVA units. Because of the fexible structure of the core, the capacity of amorphous core transformers is currently limited to 10 MVA [9].

Load losses are proportional to the square of the load current. They can be reduced by increasing the cross section of the windings, this reduces the current density and eventually the loss, although the construction cost will also increase. The energy consumption for cooling needs can be reduced by keeping the other types of energy losses low.

## 2.5 Lighting Design Calculations and Drawings

Lighting design can be performed using vendor software such as Chalmite. Chalmite is lighting design software developed by Chalmit Lighting. Lighting calculations are performed during design process to obtain information about lighting system performance. The required illumination levels (mean LUX) stated in the technical standard (e.g. PTS, DEP) have to be satisfied, lighting calculation software can help to determine these illumination levels [10]. A layout drawing shows the physical location and the civil provision to be made for installing all transformers, switchgears and other electrical power, lighting, earthing and auxiliary equipment located in a plant. The cable runs and support have to be shown. Space requirements for existing and future equipments have to be shown as well.

Plant lightings consist of normal, emergency and escape lightings. Emergency light fittings are located at strategic points in the plant such as control rooms, switch rooms, first aid rooms, main entrances, corridors inside buildings, and at escape routes on offshore platforms which include exit doorways, sleeping cabins, stairways and walkways, access to helideck, boat landing and survival craft stations and muster area.

Outdoor lighting is designed with photocell. Lighting for area with motor installation has to be alternated with at least power supply of two different phases to avoid stroboscopic effect. All light fittings are tagged for easy identification of the phases and circuit number they are connected to.

# CHAPTER 3

# METHODOLOGY

## 3.1 Procedure Identification

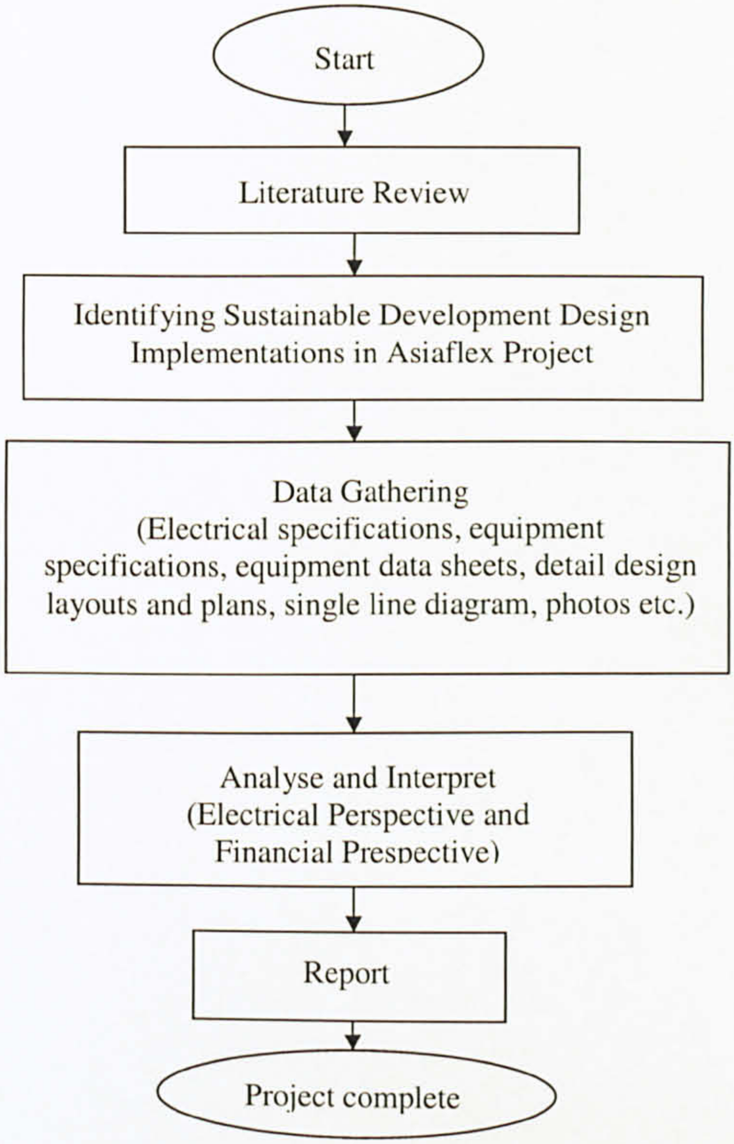


**Figure 2: Project Process Workflow**

### *3.1.1 Literature Research*

Literature research was done on the the proposed sustainable development implementations on eletrical system. The basic idea is to get an overview of the ideas of the project and also gain fundamental knowledge on the analysis work that will be done later on. Literature review is done by reading and reviewing on proposals, journals, past year final year projects, online research and also reference books.

# CHAPTER 4

# RESULTS AND DISCUSSIONS

## 4.1 Data Gathering & Analysis

The table below lists the main proposed ideas and the final outcome of SD implementations in Asiaflex project. Although many of the ideas adopted seems to be concentrating on conservation of energy (and operating cost), the actions and ideas will have long term implications and benefits to the community and especially Asiaflex plant employees themselves. Once the SD awareness are instilled in them, they will play a significant role in the success of the SD programme by participating, contributing and sharing their ideas on cost savings, environmental caring, HSE matters, etc. and making their working environment a very pleasant place to be.

**Table 1: SD Implementations for Asiaflex Project**

| Item | Proposed ideas | Implementation | |
|---|---|---|---|
| | | Adopted | Provision |
| (a) | Solar water heater system for shower/ changing room. | √ | |
| (b) | Use of high energy efficient lighting system, e.g. fluorescent light fittings with electronic ballasts, mirror reflectors, high output and long life lamps in order to reduce wastes going to the landfill. | √ | |
| (c) | Use of high efficiency equipment and minimise power distribution losses; e.g. high power factor motors; high efficiency transformers; larger conductor size and good power supply quality. | √ | |
| (d) | Variable speed drives system for air compressor motor control which could improve energy saving. | √ | |
| (e) | Monitoring of electrical energy consumption by installing meters at selected feeders for buildings and high energy users for in-house energy audit. | √ | |

| | | | |
|---|---|---|---|
| (f) | Lighting circuits in administration office to be grouped into zones, to install photocell controlled lights near windows and external area. | √ | |
| (g) | Building design to have low thermal mass and reduce solar heat gain, e.g. use of insulating bricks for outer walls, double-glazed windows, insulated roof with natural ventilation or wind driven ventilators., etc. | √ | |
| (h) | Instil awareness among employees by educating them the importance of SD. | √ | |
| (i) | Use dynamic UPS as a reliable power source to the extruder machine instead of a continuously running diesel generator. The dynamic UPS unit is essentially a diesel generator set on cold standby that has a heavy flywheel spinning at high speed. In the event of a power interruption, the flywheel provides enough momentum to keep the alternator running while the diesel engine starts and picks up the load. | | √ |
| (j) | Make provisions to allow future installation of photo-voltaic solar panels when their costs are more attractive. Presently, the electricity rates in this country are relatively low, therefore making installation of photo-voltaic solar panels not viable at the moment. | | √ |

| | | | |
|---|---|---|---|
| (k) | HVAC design to have multiple zones, digital scroll or inverter controlled (variable refrigerant volume) compressor units, use environmentally friendly refrigerants. | | (1) |
| (l) | Incorporate designs which allow some electricity usage to be shifted to off-peak hours, e.g. using oversized compressed air tank for charging at night for day use, charge batteries at night, etc., thus helping the plant to utilise cheaper off-peak electricity. | | (1) |
| (m) | Implement rain water harvesting system to supplement consumption of treated water from utility company, also to reduce rain water run-offs which can lead to flash floods. | | (1) |
| (n) | Reduce production of waste and unfriendly manufacturing process as one of the ways to manage wastes on site. | | (2) |

Note: (1) – Not implemented due to high CAPEX cost

(2) – Implementation by production management

## 4.2 Supplementing Consumption with Renewable Energy

### *4.2.1 Use of Solar Water Heaters*

Sunlight is abundant in Malaysia, and the use of solar water heaters should be given emphasis over other types of renewable energy sources due to their relatively low cost, no maintenance and environmentally friendly production. It does not use or produce toxic materials in the production of such equipment. Moreover, solar water heaters are readilly available from local manufacturers.

Solar water heating uses the thermal energy of the sun to heat water that is stored in a tank. On less sunny days, the system may need back up generation, usually provided by electricity or gas. Hot water from solar water heaters could be piped to the changing room building and shower rooms instead of using the conventional electric water heaters.

The solar heater systems used in Asiaflex Products are from Lexsun. The commonly available roof-top solar water heaters in Malaysia are the 30-gallons and 60-gallons capacities types. The capacity and quantity of the roof-top solar water heaters are selected based on the hot water consumption. As an option, electric water heating elements can be fitted to the storage tanks for the eventuality that the hot water available is not enough.

The commonly available solar water heaters cannot be considered "food-grade" type and the hot water from these units should preferably not be used for human consumption. However, places where such hot water can be used are including the shower, rinsing inside dish room, filling and topping-up of dishwasher, filling and topping-up of bain-marie (liquid filled food warmer), etc. Such hot water should preferably be piped to avoid such hot water wrongly used for human consumption [3].

#### *4.2.1.1 Components of a Solar Water Heating System*

The main components of a typical solar water heating system include:

- The solar collector
- The storage tank (cylinder)
- The circulation system
- Controller or timer.

The collector absorbs the sun's energy and the heat is transferred to the water in the storage tank by the circulation system. How efficiently this is carried out depends on the performance of each component and how well they are matched together as a system.

The size of the hot water tank in the system needs to be matched to the hot water usage and the size of solar collectors on the roof. If the tank is too small or too big there will be extra cost to boost the temperature of the water.

A properly insulated system (pipes and tank) is also very important. This helps to reduce the amount of heat loss while the hot water is being circulated

Timers, thermostats and controllers are other important components that contribute to the efficiency of the system. These will ensure that the backup heating is not heating water that would otherwise be heated by the solar heating system.

#### *4.2.1.2 Energy Reduction of Solar Water Heater*

Installing a domestic solar water heater system for the plant will reduce the load of electric water heater by almost 2500 kWh per year, preventing more than 4000 pounds of carbon dioxide from entering the atmosphere annually [11].

#### *4.2.1.3 Environmental Benefits of Using Solar Water Heater*

When solar energy is used to offset the amount of fossil fuels that are burned, contributions are being made to everyone's health and welfare. Operating a solar water heater instead of an electric water heater saves burning fossil fuels and reduces carbon dioxide emissions (greenhouse gas) and sulphur dioxide (contributes to acid rain) emissions.

#### *4.2.1.4 The Economics of a Solar Water Heater*

Solar water heating systems require a higher initial cost to purchase and install than conventional electric water heating systems. However, a solar water heater can save a lot of money in the long run.

The factors below determine how cost effective the solar water heater is:

- The amount of hot water consumed
- The water heating system's performance
- Geographic location and solar resource
- Available financing and incentives
- The cost of conventional fuels (natural gas, oil, and electricity)
- The cost of the fuel used for backup water heating system

On average, after installing a solar water heater, water heating bills should drop 50%–80% [11]. Also, because the sun is free, we are actually protected from future fuel shortages and price hikes.

*4.2.1.5 Return of Investment for Solar Water Heater*

**Table 2: Return of Investment for Solar Heater**

| Description | Electric Heater (A) | Solar Heater (B) |
|---|---|---|
| Total power (kW) | 24 | 36 |
| Storage capacity (gallon) | 4 x 33 | 12 x 60 |
| Operational Hours | 90 | 27 |
| kWH | 2160 | 972 |
| Rate / RM | 0.296 | 0.296 |
| Electricity Bill (RM) | 639.4 | 287.7 |
| Capital Investment (RM) | 41000 | 80000 |

$$\textbf{Return of Investment (months)} = \frac{\text{Capital Investment (B) - Capital Investment (A)}}{\text{Electricity Bill (A) - Electricity Bill (B)}}$$

$$= \frac{39000}{351.6}$$

$$= \mathbf{110.91\ months}$$

In Asiaflex Products plant, electric water heater systems need a capital investment of RM 41000, compared to RM 80000 for solar heaters. An additional cost of RM 39000 is required. With savings in electricity, solar water heaters pay for themselves within 111 months or nine to ten years. And solar water heaters last between 15 and 40 years, the same as conventional systems. So after that initial payback period is up, zero energy cost essentially means having free hot water for years to come.

### 4.3 Use of High Efficiency Equipments

#### *4.3.1 Use of High Efficiency Lighting System and Long Life Lamps*

The artificial lightings used for this project are mainly high bay lights, flood lights, fluorescent lights, down lights and exit ('KELUAR') sign lights. The lamps used high lumen output per watt type, such as high bay light (105 lumen/ watt), flood light (130 lumen/ watt) and fluorescent light (90 lumen/ watt). In the present design and for aesthetic reasons, compact fluorescent down lights and power LED type exit signs are used. A more environmentally friendly approach is to use electro-luminescense type exit sign light fittings which stores light in chemical coating and radiates light during power failure without the use of backup batteries which contain materials harmful to the environment. Also, light fittings using 4-feet 36W fluorescent lamps are energy efficient due to their higher light output and better coverage. And for even better energy efficiency are the high-bay and low-bay lights, e.g. sodium vapour, mercury vapour, metal halide, etc. It should be noted that high-bay and low-bay lights are only suitable for areas with high head rooms. Low-bay lights should be used in areas where the bottom of the luminaire is less than 20 feet above the floor. Whereas, high-bay lights should be used in areas where the bottom of the luminaire is more than 20 feet above the floor.

In addition, natural sunlight could be let into the work areas to reduce the artificial lighting in order to reduce electricity consumption and to create a more natural environment. For this, transparent/ transculent skylight is installed at the roof. Transparent skylight is made of polycorbonate and the advantages include it can protects the interior from ultra violet rays, it is available in various shapes and sizes, they can be made available in tinted shades and completely clear form. While transculent skylight is made of fiberglass and the advantages include it does not need any support, it is self standing, it is translucent, it protects the interior from ultra violet rays and it is available in various shapes, sizes and colors. However, care should be taken to minimise the transmission of heat into the work areas which would then need to be removed by the air-conditioning system, therefore negating the benefit of letting in natural sunlight.

Avoid using incandescent bulbs (including decorative halogen bulbs) which naturally consume more electricity and generate alot of heat. Some countries like Australia and the European Union are planning to ban the use of incandescent bulbs in the near future and replacing them with the Compact Fluorescent Lights (CFLs) [17]. The main advantages of CFLs include, higher light efficiency (output per watt of electricity) which is 3 to 4 times of incandescent bulbs and its longer lifetime (10 times longer than the incandescent bulb). The use of decorative halogen bulbs may be limited to illuminating showcases or pictures or where dimming effect is required.

For general lighting especially in the office work areas, light fittings incorporating 4-feet 36 W fluorescent lamps and mirror reflectors are used instead of downlights, uplights or any other designs. The 36W fluorescent lamps in combination with mirror reflectors provide high light output (per wattage) onto the working plane i.e. the working tables, and good light coverage and uniformity. The most energy efficient design for the office areas is to have lower illumination level for general lighting (less than 200 lux) and table lamps for each work area. For the 36W fluorescent light designs, electronic ballasts (typically have 2-Watt losses ) should be used instead of the conventional iron-core ballasts (typically have 6 to 8-Watt losses).

Discharge lamps should use electronics ballasts instead of conventional ballasts. The comparison between 36W fluorescent light fittings fitted with conventional ballasts vs those fitted with electronic ballasts is shown in the table below.

**Table 3: Comparison between 36W fluorescent light fittings fitted with conventional ballasts vs those fitted with electronic ballasts**

| | **36W Fluorescent Light Fitting with Iron Core Ballast** | **36W Fluorescent Light Fitting with Electronic Ballast** |
|---|---|---|
| 1 | Power consumption: 44W (8W is lost as heat which the HVAC system need to remove) | Power consumption: 36W (just after starting); 32W (after warming up) |
| 2 | Lamp operates at system frequency of 50Hz which gives lower light output. 50Hz synchronises with the refresh rate of conventional CRT screens to give stroboscopic effect on the screens. This is both tiring and irritating to the user. Note: The refresh rate of newer CRT screens maybe adjusted to frequencies other than 50Hz (e.g. 60Hz, 75Hz) to avoid the stroboscopic effect. | Lamp operates at higher frequency (in kHz range) therefore higher light output and no stroboscopic effect on conventional CRT screens. |
| 3 | Typical power factor of ballast is 0.54. based on latest local authority requirement, a capacitor is to be fitted to raise the power factor (e.g. to 0.95). This arrangement may cause oscillation between an inductor (ballast) and a capacitor which can cause hormonics to be injected back into the building's electrical system. | The internal circuit of the electronic ballast inherently generates hormonics. It is therefore important to only use electronic ballasts with built in harmonic filters, of good quality and from well known manufacturers in order to avoid harmonics being injected back into rhe building's electrcal system. |
| 4 | Have more components (ballasts, starter & holder, fluorescent tube & holder) which may fail. Over some years, the ballasts may hum and starters fail to ignite the lamps causing lamps to flicker on/ off. | Less components to fail, consisting only of ballast and fluorescent tube (lamp) & lamp holder. If the ballast fail to ignite the lamp (probably due to lamp aging) after several attempts, the ballast will cut-off the circuit, therefore no flickering will occur. Lamps tend to last longer partly due to less striking in order to ignite the lamp.<br>Due to lesser maintenance required, light fitting with electronic ballast is especially suitable for installation in hard to reach places, e.g. high locations. |
| 5 | Usually takes a few seconds and several striking attempts before abe to start. This flickering when starting can be especially annoying to human eyes when inside a dark room because the iris tries to adjust to the flickering light. The effect of this flickering during | Instant starting without any flickering. |

| | | |
|---|---|---|
| | starting is less felt in an office work area where almost all the fluorescent lights are started (switched on) only once in the morning and then switched off in the evening. | |
| 6 | Very hardy and quite immune to poor quality power supply and lightning surge. | May be damaged by severe lightning surge, but their designs have improved and are more hardy than the models many years back. |
| 7 | Low cost. | Very expensive. |

#### *4.3.1.1 Use of High Output Fluorescent Lamps*

Conventional 36W fluorescent tubes typically give out 2500 lumens while the high output fluorescent tubes give out 3200 lumens [12]. The costs of conventional fluorescent tubes are about RM 5 per piece while the high output fluorescent tubes are about RM 10 per piece. By using high output fluorescent tubes, lesser light fittings are required which translate to lesser maintenance cost and lower electricity consumption. There is a newer type of fluorescent tube in the market, the TL5, which is slimmer (16 mm diameter) and more energy efficient. A smaller diameter lamps means that lesser material is used in manufacturing (less glass and phosphor and smaller metal end caps), which will reduces environmental impacts. However, the choices of light fitting designs using TL5 lamp is not as wide as the normal 26 mm 36W fluorescent tubes and they appear to work only with electronic ballasts.

#### *4.3.1.2 Use of Long Life Lamps*

Wherener possible, long life lamps should be used. Long life lamp guarantees a 3 to 4 times longer life cycle compared to conventional fluorescent lamp [17]. Using long life lamps will eliminate the need to frequently replace the lamps thus saving on maintenance costs (especially to replace hard to reach lamps), interruption to the factory/ office, etc. Not to mention saving the environment in terms of consuming less of earth's resources, less transportation and less polluting. Discharge lamps contain mercury vapour gas inside.

*4.3.1.3 Return of Investment for Fluorescent Light*

**Table 4: Return of Investment for Fluorescent Light**

| Description | Normal tube with normal magnetic ballast (A) | Extra long life + electronic ballast (B) |
|---|---|---|
| Power each tube(W) | 44 | 32 |
| Quantity | 2000 | 2000 |
| Total power (kW) | 88 | 64 |
| Operational Hours | 260 | 260 |
| kWH | 22880 | 16640 |
| Rate / RM | 0.296 | 0.296 |
| Electricity Bill (RM) | 6772.5 | 4925.4 |
| Tube replacement | 210000 | - |
| Capital Investment (RM) | 216772.48 | 320000 |
| Life span for tube (hours) | 10000 | 80000 |

**Return of Investment for electronic ballast (months) =**

$$\frac{\text{Capital Investment (B) - Capital Investment (A)}}{\text{Electricity Bill (B) - Electricity Bill (A)}}$$

$$= \frac{103227.52}{1847.0}$$

$$= \mathbf{55.89\ months}$$

Extra long life lamp with electronics ballast are used in Asiaflex plant. A total of 2000 lamps are used in the plant, where the power consumed by each tube is 32 W. Resulting in a total power of 64 kW. Extra long life lamp guarantees a 8 times longer life cycle compared to conventional fluorescent lamp. Hence,no tube replacement is required. The capital investment is RM 320000 when is 50% higher than the cost for conventional normal tube with normal ballast. As shown in the table above, the payback period is calculated to be 56 months.

*4.3.2 Use of High Power Factor/ High Efficiency Motor*

Energy saving, long life-time and efficiency of electrical drives in environmentally friendly structure can contribute to sustainable development. Motor consume more than 40% of total electricity in the EU and forecasts indicate that it has risen to 56% in 2010. The estimated motor electricity consumption in the EU by 2015 is 721 TWh in industry and 224 TWh in tertiary sector. Electric motor use 66% of electricity in a typical factory [1].

To reduce energy cost and cut down green house gasses, Asiaflex plant has been looking into utilizing high power factor and high efficiency motor system. High efficiency motors offer a number of potential benefits over standard models. These include lower electricity bills and reduced operating costs through lower failure rates and longer service life. Motor efficiency is the ratio of mechanical power output to the electrical power input. Energy-efficient motors use less energy to perform the same amount of work as standard motors. Motors operated in low power factors are inefficient and expensive. This may also results in utility supply companies having to increase generation and transmission capacity to handle the reactive power component caused by the inductive loads. Low power factor also reduces the distribution capacity of the electrical system by increasing current flow and causing voltage drops.

Motors consume the largest power in the Asiaflex plant. The utility loads such as compressor, air-conditioning and water pumps are rated 550 kW in total. The machine for production is 3760 kW. When high efficiency motors are used, with typically 2.4% more efficient than standard motors, there is saving of energy by 2.4% [3].

In the Asiaflex project, high power factor induction motors are used in the air compressors, air dryer and air receiver package. These high power factor motors are manufactured by SIEMENS and supplied by Kaeser Kompressoren Sdn Bhd. The electric motor data sheets are shown in Attachment 2.1and Attachment 2.2. This report will focus on two types of the low voltage induction motors used in the air compressor package which are the variable speed motor (model: CSDX 162 SFC) and fixed speed motor (model: BSD 72). Both of the motors are of efficiency class EFF1 which is the highest efficiency band. For the variable speed motor, efficiency at 100% rated power is 95.7. While the power factor at 100% is 0.89. Whereas, for the fixed speed motor, efficiency at 100%, rated power is 94.1. While the power factor at 100% is 0.88.

Design improvements and more accurate manufacturing tolerances are responsible for the increase in performance of energy efficient motors. Some of the design factors that can be found in the high efficiency motors are like lengthening of the core and using lower electrical-loss steel, thinner stator laminations and more copper in the windings to reduce electrical losses. Improved bearings and smaller, more aerodynamic cooling fans can also increase efficiency. Usually, high efficiency motors are 2 % to 8 % more efficient than the standard motors [13].

#### *4.3.2.1 Benefits of High Efficiency Motors*

Improving the efficiency of motors can save significant amounts of energy and reduce the operating costs. High efficiency motors cost more, but they can offer a return on investment within two years. Reducing operating costs through the purchase of higher efficiency motors can offer a substantial payback. In addition to energy savings, the better designs and improved construction of higher efficiency motors can lead to other benefits like longer insulation and bearing lives, lower heat output and less vibration, extended winding life, increased tolerance of overload conditions, higher tolerance for increased voltage rates or phase imbalance and also lower failure rates and extended manufacturer warranties.

### *4.3.3 Use of High Efficiency Transformers*

There are four 2000 kVA oil-immersed type distribution transformers (equipement tag: 1-TR 36-11, 2-TR 36-11, 1-TR 36-12, 1-TR 36-13) installed in the Asiaflex plant. The conventional transformer efficiency for this capacity is typically 97%. However, for the same capacity, a slightly higher efficiency transformer of 99% is used in Asiaflex project. This slightly higher efficiency translates into 8000 kVA x 2%= 160 kVA throughout the operation time. The 99% efficiency is the main criterion in the transformer selection to meet the sustainability development goal.

Transformers operate most efficiently when it is fully loaded, and the least efficiently when operate lightly loaded. Also, transformer losses increase with increase in kVA capacity. Therefore, transformers should not be too oversized. As a guide transformers should be loaded at least 70% of their rated capacities [3]. The transformer data sheet and the AM SGB test certificate are shown in Attachment 3.1 and Attachment 3.2. From the test certificate, the no load loss is 2450 W and the load loss is 4492 W. The efficiency for the transformer is 99.64%.

The efficiency of the transformer used in Asiaflex plant can be calculated as below:

$$\eta = \frac{(\text{Rating x Performance Factor x Load Factor})}{(\text{Rating x Performance Factor x Load Factor})+(\text{No Load Loss})+(\text{Load Loss x Load Factor}^2)}$$

$$= \frac{(2000\text{k x } 1 \text{ x } 0.5)}{(2000\text{k x } 1 \text{ x } 0.5)+(2450)+(4495 \text{ x } 0.5^2)}$$

$$= \frac{1\ 000\ 000}{1\ 003\ 573}$$

$$= 0.9964$$

$$= 99.64\%$$

**Table 5: Comparison between Conventional Transformer and High Efficiency Transformer**

| | Conventional Transformer | High Efficiency Transformer |
|---|---|---|
| Type | Oil-immersed type (sealed) | |
| Rating | 2000 kVA | |
| Efficiency | 97 – 98% | 99 % |
| No Load Losses | 21200 W | 2450 W |
| Load Losses | 30926 W | 4492 W |

These transformers normally work in continuous operation and have a long life span (25 to 30 years). As a result, a small effciency increase can add up to signifcant energy savings over the lifetime of the transformer. This savings also brings economic and environmental benefits that satisfy the SD goal. Taking the full life cycle cost into account, selecting high efficiency transformers is definitely an economically sound investment decision despite their higher purchase price (approximately RM 120, 000 per transformer). The payback periods for investing in high effciency transformers are often less than two years. A reduction of energy consumption is also an important advantage for the environment because of the reduction in greenhouse gas emissions.

Increasing the effciency of distribution transformers also results in a reduction of NOx (Nitrogen Oxides) and SOx (Sulfur Oxides) emissions [6].

#### *4.3.3.1 High Efficiency Transformer Designs*

The lowest loss transformer designs can generally be obtained with liquid filled transformers. Since oil and silicone are stronger dielectrics and coolants than air, liquid filled transformers can be designed with more compact winding and core configurations. Cast coil transformers also can be designed with relatively low losses comparable to those of liquid filled transformers. The conventional ventilated dry transformers are limited to improvements in design efficiency due to the fact that air is part of the insulation between the winding discs. The air space must be maintained to ensure good dielectric strength, and as a result the amount of core reduction and increase in conductor size is limited in a conventional dry transformer. A cast coil transformer uses the resin between the windings as part of the insulation system. Since the resin has a higher dielectric strength than air, the space between the windings can be designed smaller, the core can be made shorter, and more space is available for the winding conductor. As a result, cast coil transformers can be designed with lower losses, especially the no-load losses, than conventional ventilated dry transformers.

Lower loss designs can be obtained by a variety of methods. One method is to use a better grade of core steel that has lower losses but costs more than the lower grades of steel. The lowest loss core material is amorphous metal. This material is being used in wound core distribution and pad mounted transformers and provides an extremely low no load loss. This material has much lower losses than the lowest loss conventional core steel which is domain refined, Hi-B steel. The grades of core steel used in the standard efficiency designs have about double the losses of the domain refined, Hi-B steel. Using lower loss grades of core steel are justified only if the value of the loss reduction to the purchaser is greater than the additional cost of the better grade of core steel. Lower load loss can be obtained by reducing the current densities of the conductors, more finely subdividing the conductors to reduce eddy current losses, modifying the shape of the conductor to reduce skin effect, using structural materials that develop lower losses when penetrated by leakage flux, and using various shielding techniques to reduce the stray losses produced by leakage flux. [21]

### *4.3.4 Minimise Losses through Conductors*

The losses through the conductors (e.g. cables, busbars) are reduced by installing slightly larger size conductors since larger size conductors have lower impedance. The losses through these conductors in Asiaflex plant are ideally less than 1.5%. Figure below shows an extraction of the HV/ LV cables sizing summary for Asiaflex plant, full summary of the HV/ LV cables sizing is shown in Attachment 4.0.

| No. | FROM | TO | POWER (kW) | POWER FACTOR | EFFICIENCY | VOLTAGE (kV) | SHORT CIRCUIT RATING (kA) | SELECTED CABLE SIZE ($mm^2$) | CABLE TYPE | EST. CABLE LENGTH (m) | TABLE REF. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HV / LV CABLES/FEEDERS | | | | | | | | | | | |
| 1 | TNB SUB-STATION | 1-SW-3-1 BUSBAR A | 8500 | 0.85 | 0.95 | 11 | 24.05 | 2 x 3C x 240 | SWA | 160 | 1.01 |
| 2 | TNB SUB-STATION | 1-SW-3-1 BUSBAR B | 8500 | 0.85 | 0.95 | 11 | 24.05 | 2 x 3C x 240 | SWA | 160 | 1.02 |
| 3 | 1-SW-3-1 BUSBAR A | 1-TR-36-11 | 1700 | 0.85 | 0.95 | 11 | 24.56 | 1 x 3C x 185 | SWA | 30 | 1.03 |
| 4 | 1-SW-3-1 BUSBAR A | 1-TR-36-12 | 1700 | 0.85 | 0.95 | 11 | 24.53 | 1 x 3C x 185 | SWA | 32 | 1.04 |

**Figure 3: Extraction of the HV/ LV Cable Sizing Summary**

An example taken from the extraction above, the feeder conductor from TNB sub-station to 11kV switchgear 1-SW-3-1 Busbar A. The equipment rating is 8500kW, 10 000kVA with voltage rating 11.0kV. The power factor is rated as 0.85 and has an efficiency of 0.95. Estimated cable length is 160m, the installation method for this cable is underground. Proposed cable size is 3 core 240 $mm^2$ cable and 2 cables are running in parallel. An example of calculation in deciding the cable sizing is shown below:

## TNB SUB-STATION TO 11 KV SWITCHGEAR 1-SW-3-1 BUSBAR A

| | | |
|---|---|---|
| **FEEDER** | = | TNB SUB-STATION |
| EQUIPMENT RATING | = | 8,500 kW 10,000 kVA |
| VOLTAGE, Vn | = | 11.0 kV |
| POWER FACTOR (Cos $\Theta$), p.f. | = | 0.85 Sin $\Theta$ 0.53 |
| EFFICIENCY, eff | = | 0.95 |
| ESTIMATED LENGTH, L | = | 160 m |
| METHOD OF INSTALLATION | = | Underground |
| OVERALL CORRECTION FACTOR, C | = | 0.59 |
| PROPOSED CABLE SIZE (sq. mm) | = | 3C 240 $mm^2$ |
| NO. OF CABLE RUNNING IN PARALLEL, N | = | 2 |
| CABLE AMPACITY, $I_R$ | = | 538 A |
| CABLE RESISTANCE, R | = | 0.0984 Ω / km |
| CABLE REACTANCE, X | = | 0.0773 Ω / km |
| MAX VOLT DROP S/STATE, Vd Max | = | 3 % |
| MAX VOLT DROP MTR STARTING, Vdst Max | = | N/A % |
| P.F STARTING (Cos $\Theta_{ST}$) | = | N/A => Sin $\Theta_{ST}$ = N/A |
| STARTING CURRENT, $I_{ST}$ | = | N/A x $I_{FL}$ |
| PROSPECTIVE SHORT CIRCUIT CURRENT | = | 25 kA |
| MAX FUSE/CB TRIPPING TIME, t | = | 0.5 sec |
| CONSTANT FACTOR, k | = | 143 |
| BREAKER SIZE | = | 1250 |
| OVERLOAD FACTOR | = | 1.00 |

## CALCULATION

**STEP 1: AS PER SECTION 5.1 – OVERLOAD PROTECTION**

| | | |
|---|---|---|
| FULL LOAD CURRENT, IFL | = | $\frac{\text{EQUIPMENT RATING}}{\text{Sqrt(3) x Vn x p.f. x eff}}$ |
| | = | 552.49 A |
| PROPOSED CABLE SIZE | = | 3C 240 $mm^2$ |
| NO. OF CABLE PER PHASE, N | = | 2 |
| UNCORRECTED CABLE AMPACITY, IR | = | 1076.00 A |
| CORRECTED CABLE AMPACITY, (IZ = IR x C) | = | 631.24 A |
| IZ ≥ 1.00 x IFL @ FUSE/CB SETTING IS NOT KNOWN (1) | | |
| IZ ≥ IN @ FUSE/CB SETTING IS KNOWN (2) | | |
| ASSUMING (1), 1.00 x IFL | = | 552.49 A |
| **IZ ≥ 1.00 x IFL** | ➡ | OK |

**STEP 2: AS PER SECTION 5.2 - VOLTAGE DROP UNDER STEADY STATE**

CALCULATED VOLTAGE DROP AT STEADY STATE, Vdn = 0.09%

**Vdn < Vd Max ➡ OK**

**STEP 3: AS PER SECTION 5.4 - SHORT CIRCUIT THERMAL WITHSTAND CAPACITY (SHORT CIRCUIT PROTECTION)**

CABLE S/C RATING, ISC = 97.07 kA
LOAD END S/C FAULT CURRENT, ILF = 24.05 kA
**ISC > ILF ➡ OK**

**STEP 4: CHECK FOR Lmax. THIS IS TO CHECK MAX CABLE LENGTH IN ORDER TO LIMIT VOLTAGE DROP**

MAX. LENGTH, Lmax $= \dfrac{\text{Vn x Vd Max\% x 1000(km) x N}}{\text{Sqrt(3) x IFL x (RCos}\,\Theta + \text{XSin}\,\Theta\text{) x 100\%}}$

Lmax = 5546 m

**Lmax > L ➡ OK**

**<u>CONCLUSION:</u>**

**SINCE THE CALCULATION RESULTS ABOVE CAN MEET ALL THE CRITERIA,**

**HENCE, CABLE <u>2 x 3C x 240</u> sqmm IS ACCEPTABLE FOR THIS APPLICATION**

From the calculation above, the full load current is 552.49 A and the cable ampacity is 538 A. In step 1, we can see that the needed current is 552.49 A, the uncorrected cable ampacity for 3C 240 mm $^2$ cable is 1076.00 A. After multiplying this value with the correction factor which is 0.59, we get the corrected cable ampacity which is 631.24 A. This shows that by selecting this cable size, we are actually providing extra and thus selecting a larger size conductor. Due to the cable derating factor, a bigger sizing of a conductor also means that the losses are lower. The losses in the conductor can be calculated as well. Cable resistance is 0.0984 Ω/ km, while the estimated cable length is 160 m which means that resistance is 0.0157 Ω. Cable losses can be obtained by the $I^2R$ formula.

### *4.3.5 Improve the Power Supply Quality*

Power quality is the relative frequency and severity of deviations in the incoming power supplied to electrical equipment from the usual 50 Hz, sinusoidal waveform of voltage or current [14]. These deviations may affect the safe or reliable operation of equipment such as computers.

Poor power quality of electrical supply can contribute to additional losses and it affects the reliable operation of computer-based equiment. The supply authority guarantees that their power to the plant will be within limits and it is not possible for us to impose on them to further improve their power quality, it is however possible for us to ensure that the plant's electrical system and electrical equipment do not lower the power quality within the plant. In this respect, the plant's voltage and harmonics level are kept within acceptable limits, where there are no voltage dips/ sags, spikes, etc.

Voltage in the plant should be kept at a relatively constant level and within the tolerances of the equipment to ensure longetivity of electrical equipment and to ensure that they operate at their optimum efficiency.

#### *4.3.5.1 Harmonics Mitigation in the Electrical System*

The total harmonic distortion (THD) for this plant is kept below 5%. The sources of harmonics are the variable speed drive system (VSDS), switching power supply (e.g. in computers), overhead cranes and electronic ballast. The VSDS is equipped with harmonics filter so that the harmonics generated are not transmitted or injected into the distribution system. Both active and passive type harmonics filters are installed to achieve less than 5% of THD.

The purpose of harmonic mitigation equipment is to limit the effects of harmonics on the mains side of the connection within the electrical system to permit fuller utilization (increase energy efficiency) of the electrical system. This also stops the heating and voltage distortion that causes other equipment to fail.

The effect of harmonics include it create unwanted heat, causes loss of memory of computers, causes disturbance of electronic controllers, causes early rewinding of motors as it destroy winding insulations and it also causes error in electric meter readings.

*4.3.5.2 Power Factor Correction*

Under the power supply contract with the supply authority, the average power factor for the premise at the point of metering (at the boundary line) is kept above 0.85. A penalty will be imposed if the average power factor is less that 0.85. For this purpose, a capacitor bank with automatic power factor regulator is installed in the low voltage switchboard. Capacitor bank installed in the Asiaflex plant is the dry type, 100 kVAR (525 V), 50 Hz with circuit breaker. The date sheet is shown in Attachment 5.0.

However, to achieve high energy efficiency within the plant, all equipment should have higher rated power factors. Equipments with low power factor are fitted with power factor correction devices so that the losses in the power cable (due to higher current) can be minimised. For the process area, the power factor is above 0.85, while for non-process areas, the power factor is above 0.90. With higher power factors, the equipment's operating currents would be lower, thus causing less losses (which is proportional to current$^2$, $I^2$) along the cables. For most equipment, their power factor can easily be improved by installing correction capacitors at the equipment itself.

*4.3.5.3 The Benefits of Power Factor Correction and Power Harmonic Mitigation*

- Reduce electricity bill: Low power factor and power harmonics are resulting in increased power demand and reactive energy consumption. Both aspects are part of the electricity bill paid to the electricity utility that could be reduced by power factor correction and power harmonic mitigation.

- Reduce power losses: Power factor correction and power harmonic mitigation are reducing the power losses in the circuits by reducing the line currents needed for transmission of a given active power to the loads.

- Reduce cable size: The cable size is determined according to the current requirements. Reducing the line currents also means that the cable cross section can be reduced.

- Comply with power harmonic emission limits requested by utilities: In order to reduce the power losses in transmission and distribution networks, electricity utilities are fixing limits for harmonic distortion. The compliance to these limits is a requirement before connection of a new installation.

- Improve process quality: Process quality of machine operation can be optimized if voltage fluctuations and distortion are reduced by power factor correction. Disturbances of sensitive electrical equipment (e.g. computer system, sensors, etc.) can be avoided.

- Improve business performance: A lower cost of electrical equipment such as transformer, cables, switchgear, will result in a reduced Capex. Opex is reduced by reduction of power losses, reduction of subscribed power, and elimination of reactive energy penalties.

### *4.3.6 Use of Variable Speed Drives System*

The use of variable speed drive (VSD) in motor control could further improve energy saving. The motors of pumps, fans and air compressor represent an important item of energy consumption in the plant. These devices are characterized by a variable power consume according to the cube speed. (See graph below)

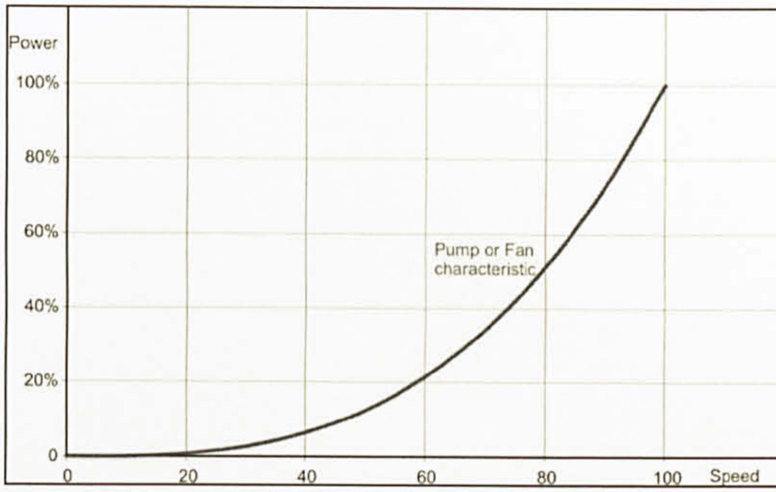


**Figure 4: Power vs Speed Curve for Pump**

Variable speed drives enable us to control the speed of engines thus offering substantial profits of energy. A pump needs only 20% of power to run at 60% of its speed [20]. Incorporating VSDS into applications such as fans, pumps, and air compressors can reduce energy use up to 50 % at partial loads by matching motor speed to the changing load and system requirements [20].

Equipment driven by electrical motor, such as pumps and fans, normally operate at a constant speed. Motor continues to operate at full speed and uses electrical energy at full load rate, even though it was performing less useful work. In this process, a great deal of energy is wasted. Operational capabilities of VSDs include lowering the peak energy use. Normally, when an AC motor starts, it draws an inrush of as much as 300 % of rated current while developing only 50 % of rated torque [15]. When a VSD starts a motor, it applies a very low frequency and very low voltage to the motor, gradually ramping up the frequency and voltage at a controlled rate. This allows the motor to develop 150 % torque while drawing only 50 % of rated current. The energy savings achieved by the variable speed drives can result in the investment to install drives being recovered in as little as a few months.

Savings on air-conditioning system could be achieved by inverter control air-conditioning system. The difference between inverter and non inverter control system is the inverter units can alter their speed in response to cooling demand. Some units have an initial over-speed period where they will run at a slightly higher capacity for a set time to pull down the temperature of a hot room. When they reach the set point temperature they can reduce capacity to maintain that level without cycling as much as a normal unit would [16]. This allows saving on power and electricity bills.

#### *4.3.6.1 Technologies of Variable Speed Drives System*

While all VSDS control the speed of an AC induction motor by varying the motor's supplied voltage and frequency of power, they all do not use the same designs in doing so. There are three major VSDS designs commonly used today: pulse width modulation (PWM), current source inverter (CSI), and voltage source inverter (VSI).

(1) PWM design

The PWM drive has become the most commonly used drive controller because it works well with motors ranging in size from about 1/2 hp to 500 hp. A significant reason for its popularity is that it's highly reliable, affordable and reflects the least amount of harmonics back into its power source. Most units are rated either 230V or 460V, 3-phase, and provide output frequencies from about 2 Hz to 400 Hz. Nearly 100 manufacturers market the PWM controller.

The AC line supply voltage is brought into the input section. Then, the AC voltage passes into a converter section that uses a diode bridge converter and large DC capacitors to create and maintain a stable, fixed DC bus voltage. The DC voltage passes into the inverter section usually furnished with insulated gate bipolar transistors (IGBTs), which regulate both voltage and frequency to the motor to produce a near sine wave like output.

The term "pulse width modulation" explains how each transition of the alternating voltage output is actually a series of short pulses of varying widths. By varying the width of the pulses in each half cycle, the average power produced has a sine-like output. The number of transitions from positive to negative per second determines the actual frequency to the motor.

Switching speeds of the IGBTs in a PWM drive can range from 2 KHz to 15 KHz. Today's newer PWM designs use power IGBTs, which operate at these higher frequencies. By having more pulses in every half cycle, the motor whine associated with VSD applications is reduced because the motor windings are now oscillating at a frequency beyond the spectrum of human hearing. Also, the current wave shape to the motor is smoothed out as current spikes are removed.

(2) CSI design

The incoming power source to the CSI design is converted to DC voltage in an SCR converter section, which regulates the incoming power and produces a variable DC bus voltage. This voltage is regulated by the firing of the SCRs as needed to maintain the proper volt/hertz ratio. SCRs are also used in the inverter section to produce the variable frequency output to the motor. CSI drives are inherently current regulating and require a large internal inductor to operate, as well as a motor load.

(3) VSI design

The VSI drive is very similar to a CSI drive in that it also uses an SCR converter section to regulate DC bus voltage. Its inverter section produces a six-step output, but it is not a current regulator like the CSI drive. This drive is considered a voltage regulator and uses transistors, SCRs or gate turn off thyristors (GTOs) to generate an adjustable frequency output to the motor.

#### *4.3.6.2 Benefits of using Variable Speed Drives System*

Apart from tremendous energy reduction offered which could improve energy saving. Other benefits of VSDs are less wear on equipment, lower maintenance costs, and a lower power factor. Putting together all these benefits, we can lower both the utility charge per kW hour (kWh) and the total kW hours (kWh) required.

Energy costs can drop by as much as 50 % when the connected loads are below rated capacity because at lower speed, the drive uses less power, rather than dissipating it as heat or other losses. Equipment wear will slow, resulting longer equipment life cycles, due to less stress on rotating parts, including bearings, sleeves, casing wear rings, couplings, and packing glands, as well as on electrical parts, such as windings and insulation [17]. Also, fewer vibration problems related to throttling will arise that will increase maintenance costs.

Another benefit of the AC variable speed drive is it will correct the power factor without using expensive capacitors on all induction motor circuits converted to VSD. Induction motors generally have low PF which is around 0.85. In addition to the energy savings from running at required speed, there are also savings associated with reducing the usage of reactive power.

## 4.4 By Design

### *4.4.1 Monitoring and Measurement System*

“Reduce” is one of the main objectives mentioned earlier in order to achieve sustainability development in an electrical system. The first thing to do if we want to optimize the consumption of a plant is to know, e.g. to measure and record in a database, all the consumptions for making analysis and having a clear vision on the consumptions in the building.

By having a good monitoring and measurement system, it is possible to:

- Assess real building energy performance.
- Identify and evaluate opportunities for energy savings.
- Evaluate energy saving investments and profitability.
- Identify drifts, abnormal consumptions and maintain the best energy performances.

In Asiaflex project, digital power meters are installed at selected feeders for buildings and high energy users for monitoring of the electrical energy consumption. Both incoming digital power meter (model: PM820) and outgoing digital power meter (model: PM710) are produced by Schneider. To facilitate in carrying out in-house energy audit, energy meters (e.g. kWh meters) are installed at the feeders to high energy users like air-compressors, extruder units, kitchen, central air-conditioning units, etc., as well as separately measure the electricity consumption of process and non-process areas.

Monthly consumption measurements are taken from these meters. Comparing the measurements with the previous months' consumption measurements, we can obtain a power consumption trend. Any improvements to the system/ process will show lower power consumption, while higher power consumption could means that something is wrong and needs immediate attention, e.g. an unnoticed leak in the compressed air line will show up in the air-compressor's monthly power consumption figure. From the LV system single line diagram shown in Attachment 6.0, we can see that power meters are installed at the feeders to high energy users like manufacturing cranes, profiling line, armour wire winding line, spiralling line, insulation line, drying line, etc..

*4.4.2 Lighting Circuits to be Grouped into Zones*

To reduce electricity wastage in an open office area, lighting circuits are zoned into 3 x 3 matrix per zone, or 3 x 4 matrix per zone, so that light fittings in unoccupied zones can be switched off. Each room is divided into a zone by itself and has its own dedicated lighting switch.

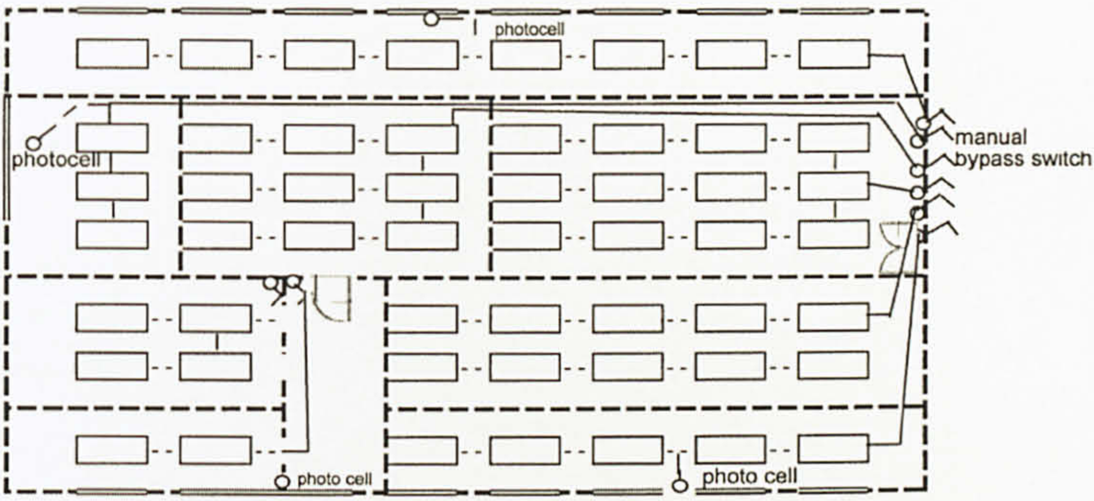


**Figure 5: Zoning and Control for Lighting System**

Light fittings near the windows are photo-cell controlled (with possibility to manually override) in order to utilise sunlight through the windows. Occupancy detectors are used to automatically switch on additional lights in low traffic areas, e.g. certain corridos, stair case, etc. When no human is present, only very minimum lighting is provided. The manucfacturing workshop and external lighting controls are photocell operated to minimise wastage of energy.

### *4.4.3 Building Design*

For a tropical climate, building should be designed with the aim to reduce solar heat gain as much as possible, and with low thermal mass.

#### *4.4.3.1 Doors and Windows*

As much as possible, there should be less doors and windows facing East or West. Windows that will have direct sunlight should be fitted with sunshades/ awnings on the building exteriors or use double-glaze glass, or shaded with trees. (Note: Tinted glass or normal glass with tinting film alone is not very effective as the heated glass will conduct heat into the rooms. The main entrance should be shaded and not face a concrete/ tiled driveway which can reflect sunlight into the entrance and heat from the heated driveway can find its way into the entrance.

#### *4.4.3.2 Roof*

Roof design to have long overhangs to provide extra shading to the walls and windows. Heat gain through the roof is to be minimised by ensuring that the roof design incorparates a passive, natural ventilation system. The design is best carried out by renowned local roof tiles manufacturers who have the experience, expertise and carry the necessary roofing accessories to accomplish such task. Such roofing solutions usually consist of a radiant barrier (woven aluminium sheet) beneath the roof tiles, a pest/ bird screen at the roof eaves to allow cool air into the space between the roof tiles and radiant barrier, and specially designed roof tiles installed on the high points to expel hot air. To further reduce the heat transmission to the attic space below, a layer of thermal insulation, e.g. 100 mm rock wool, could be installed below the radiant barrier. Light coloured, glossy roof tiles can be used to reflect the sun-rays from the roof thus reducing heat transmitted through the roof. Other benefits from using roof tiles with glossy finish are aesthetics, less chance of fungus growing on them, less porous and easier for rain water to run-off [18].

While water misting has been known to reduce surrounding temperature by absorbing the surrounding heat to evaporate the water mist, this method is not preferred as a means to cool the roof as compared to the above roof radiant barrier and insulation. If water misting were to be used for this purpose, a network of tubings and nozzles would need to be installed on the roof top and roof eaves, a water pump would need to be installed to pressurise the system (which uses electricity), not to mention the maintenance for the pump and nozzles, plus water loss from spraying that evaporates into the air. For buildings with high roof, e.g. factories and warehouses, wind driven ventilators can be used to remove hot air from below the roof.

#### *4.4.3.3 Walls*

The outer walls of a building should be made of thermally insulating materials, e.g. CSR bricks, or lined with insulating tiles, e.g. terracotta facade [19].

#### *4.4.3.4 Building Materials*

To reduce the impact to the environment when constructing this plant, as much as possible, use building materials which are recycled or are produced using environmentally friendly processes. Use locally produced building materials to reduce the use of fossil fuel needed to transport materials from overseas.

## 4.5 Intill Awareness among Employees

Employees of the plant should be educated about the meaning of SD design and its benefits. Large posters or pamphlets, etc. are to be pasted on walls throughout the plant to remind them on reduction of energy sources and wastes. Creating awareness among the employees is crucial to the success of the SD program. By organizing contests or rewards on the awareness of SD benefits, employees will be keen to contribute and share their ideas on cost saving and suggest other alternatives which may be used as an input for implementation. By having a SD designed plant, employees can be proud of being employed by the company that cares for the planet and they get to play a role in it.

# CHAPTER 5

# CONCLUSION AND RECOMMENDATIONS

## 5.1 Conclusion

As a conclusion, this report identifies sustainable development design on electrical system and the benefits of implementing sustainable development design in both the electrical prospect and financial prospect based on the case study of Asiaflex Project. This report discusses about the eight major implementations that have been adopted in the Asiaflex project in order to achieve the goal of sustainable development. These SD implementations can be grouped into four main areas, namely supplementing consumption with renewable energy, use of high energy efficiency equipments, by design and also instilling SD awareness among employees. The success of SD relies on social responsibility and also the willingness to make a small step forward at present to make a big difference in the future. SD involves high initial cost, hence it has to be trade off between the initial capital cost and economic viability. It is therefore, Technip has to be selective in implementation of SD implementation or providing facilities for future implementations.

## 5.2 Recommendations

We have seen major developments in various sectors leading to global warming, climate change and deterioration of our environment and ecosystem. Imagine what will happen in the next 20 or 30 years to the environment and future generation. Thus, we have to start fulfilling our social and environment responsibilities by implementing SD designs to our projects. Besides green building, we should have green plant or even green process to demonstrate our commitment to protect the environment. The idea of sustainable development should be introduced not only into the household and industrial facilities, but also it can be introduced into campus. For example, renewable energy sources (e.g. solar) can be used to reduce consumption on electricity. This can be implemented by using solar water heaters in the hostel building. Sunlight is abundant and free, therefore we should utilize it. Besides that, long life fluorescent lamps should be used instead of the conventional fluorescent tubes because the amount of fluorescent lamps used in a campus is so huge. By introducing high efficiency lightings and longer life time lightings, we can make a substantial savings on electricity and maintenance cost. Maintenance costs decrease over time, and fewer lamp exchanges ensure a better environment.

To reduce the consumption of treated water from the utility company, rain water system should be implemented for use where treated water is not required, e.g. toilet flushing, gardening use, water features (e.g. fountains, ponds, etc.) and outdoor washing purposes. Management also should provide education and instill awareness on staff and students on sustainable development technologies. This can be done through seminars, trainings, or even contests within the campus to encourage staff and students' participation and ideas.

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# APPENDICES

**Appendix A**: Site plan drawing

**Appendix B**: Data sheet for 3 phase squirrel cage motor (fixed speed)

**Appendix C**: Data sheet for 3 phase squirrel cage motor (variable speed)

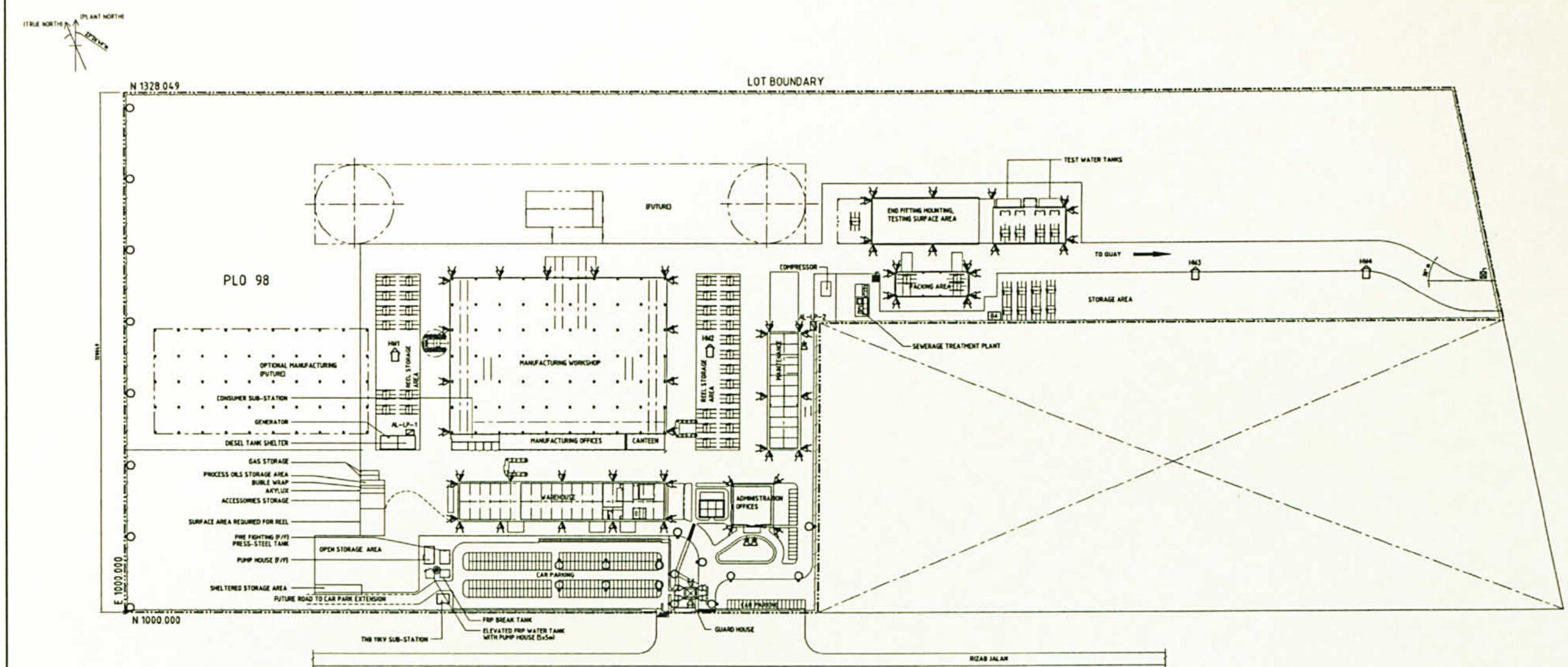
**Appendix D**: Transformer data sheet

**Appendix E**: Transformer test certificate

**Appendix F**: HV/ LV cable sizing summary

**Appendix G**: Data sheet for capacitor bank

**Appendix H**: Single line diagram for metering




SITE LAYOUT

| LEGEND | |
|---|---|
| SYMBOL | DESCRIPTION |
| | AREA LIGHTING & POWER PANEL<br>(DESIGN, SUPPLY & INSTALL BY ELECTRICAL CONTRACTOR) |
| B4 | POWER SOCKET CABINET (IP56) SELF SUPPORT TYPE<br>INCOMING BREAKER 100A TPN MCCB, 1 NO. ELR, 1 x 63A TPN MCCB,<br>1 x 32A TPN MCCB, 2 x 20A SPN MCB,<br>1 x 63A SOCKET OUTLET 415V 3ø 5PIN WEATHERPROOF TYPE<br>1 x 32A SOCKET OUTLET 415V 3ø 5PIN WEATHERPROOF TYPE<br>2 x 16A SOCKET OUTLET 240V 1ø 3PIN WEATHERPROOF TYPE<br>(DESIGN, SUPPLY & INSTALL BY ELECTRICAL CONTRACTOR) |
| | 40m HEIGHT HOT-DIPPED GALVANISED POLYGONAL HIGH MAST COLUMN, FLANGE MOUNTED TYPE c/w ANCHORAGE BOLTS & NUTS (GALVANISED), MOBILE HEAD FRAME (SUITABLE FOR UP TO MAXIMUM 16 x 1000W FLOODLIGHT)<br>DOUBLE DRUM WINCH SYSTEM, STAINLESS STEEL ROPE,<br>1 x 12CORE 2.5mm FLAT CABLE, LIGHTNING ROD, POWER TOOLS<br>(BASIC WIND SPEED 34m/s)<br>(SUPPLY & INSTALL BY ELECTRICAL CONTRACTOR)<br>- PLINTH (SUPPLY & INSTALL BY CIVIL CONTRACTOR))<br>- 1000W HPSV SYMMETRICAL FLOODLIGHT 1P66 c/w BALLAST AND LANTERN 6mm THICK TAMPERED GLASS COVER, ETC., TO FORM A COMPLETE SYSTEM :<br>a) HM1 - 10 NOS.<br>b) HM2 - 10 NOS.<br>c) HM3 - 6 NOS.<br>d) HM4 - 6 NOS.<br>(INSTALL BY ELECTRICAL CONTRACTOR) |
| | 8 NOS. 1000W HPSV SYMMETRICAL FLOODLIGHT 1P66 c/w BALLAST AND LANTERN 6mm THICK TAMPERED GLASS COVER, ETC., TO FORM A COMPLETE SYSTEM<br>(INSTALL BY ELECTRICAL CONTRACTOR) |
| | 150W HPSV STREET LANTERN c/w GEAR, LAMP MOUNTED ON 9m HIGH OCTAGONAL HOT-DIPPED GALVANISED POLE<br>(SUPPLY & INSTALL BY ELECTRICAL CONTRACTOR) |
| | 70W HPSV STREET LANTERN c/w GEAR, LAMP, 0.5m SINGLE ARM MOUNTED ON 6m HIGH OCTAGONAL HOT-DIPPED GALVANISED POLE<br>(SUPPLY & INSTALL BY ELECTRICAL CONTRACTOR) |

| LEGEND | |
|---|---|
| SYMBOL | DESCRIPTION |
| | 1 X 1000W HPSV FLOOD LIGHT COMPLETE WITH TEMPERED GLASS COVER WEATHER PROOF IP56<br>(INSTALL BY BUILDING CONTRACTOR) |
| | 1 X 400W HPSV FLOOD LIGHT COMPLETE WITH TEMPERED GLASS COVER WEATHER PROOF IP56<br>(INSTALL BY BUILDING CONTRACTOR) |
| | 1 X 150W HPSV FLOOD LIGHT COMPLETE WITH TEMPERED GLASS COVER WEATHER PROOF IP56<br>(INSTALL BY BUILDING CONTRACTOR) |
| | 16A WEATHERPROOF IP56 SWITCH SOCKET OUTLET c/w PLUG FOR SUCTION PUMP c/w SELF SUPPORT MOUNTING<br>(SUPPLY & INSTALL BY ELECTRICAL CONTRACTOR) |
| | 30A TPN IP56 ISOLATOR c/w SELF SUPPORT MOUTING |
| | 60A TPN IP56 ISOLATOR c/w SELF SUPPORT MOUTING |
| | |
| | |
| | |

| | |
|---|---|
| DRAWING NO. | DESCRIPTION |
| REFERENCE DRAWINGS | |

| REV | DATE | DESCRIPTION | DRN | CHK | APP |
|---|---|---|---|---|---|
| B | [illegible] | ISSUED FOR IFB | [illegible] | CHD | [illegible] |
| A | [illegible] | ISSUED FOR IEC | [illegible] | CHD | [illegible] |
| REVISIONS | | | | | |

CONSULTING ENGINEER: Technip — TECHNIP CONSULTANT (M) SDN. BHD.

PROJECT: CADANGAN MEMBINA KILANG PEMBUATAN "FLEXIBLE PIPE" UNTUK TETUAN ASIAFLEX PRODUCTS (M) SDN. BHD. DI ATAS LOT PLO 98 TANJUNG LANGSAT, JOHOR.

DRAWING TITLE: SITE LAYOUT — AREA, FENCE & STREET LIGHTING LAYOUT

| Scale | | Drawing Number | REV |
|---|---|---|---|
| [illegible] | A1 | 5003-000-DW-1632-001 | B |

**Datenblatt für Drehstrom-Käfigläufermotoren**
*Data sheet for three-phase Squirrel-Cage-Motors*

SIEMENS

| | |
|---|---|
| Kunden-Auftrags-Nr./Client-Order-No.: | Item-Nr./Item-No.: 7.6701.0 |
| Siemens-Auftrags-Nr./Order-No.: | Komm.-Nr./Consignment-No.: |
| Angebots-Nr./Offer-No.: | Anlage/Project: |

## Bestell-Daten/ *Ordering Data*

| | |
|---|---|
| **Motortyp** *Motortyp* | **1LG6 207-2AA96 - Z** |
| **Kurzangaben** *Order Codes* | A11 +K31 +K40 +K83 +Y53 +Y55 +Y82 |

## Elektrische Daten/*Electrical Data*

| | | | |
|---|---|---|---|
| **Bemessungsspannung** *Rated motor voltage* | 400VD/690VY±10% | | 460VD±10% |
| **Frequenz** *Frequency* | 50 Hz | | 60 Hz |
| **Bemessungsleistung** *Rated motor power* | 37 kW (SF 1,17) | | 37,5 kW (SF 1,17) |
| **Bemessungsdrehzahl** *Rated motor speed* | 2960 $min^{-1}$ | | 3565 $min^{-1}$ |
| **Bemessungsmoment** *Rated motor torque* | 119 Nm | | 100 Nm |
| **Bemessungsstrom** *Rated motor current* | 64 A | 37 A | 58 A |
| **Anzugs-/ Bemessungsstrom** *Starting-/ Rated motor current* | 850 % | | 970 % |
| **Kipp-/ Bemessungsmoment** *Breakdown/ Rated motor torque* | 360 % | | 400 % |
| **Anzugs-/Bemessungsmoment** *Starting-/ Rated motor torque* | 280 % | | 320 % |
| **Wirkungsgrad bei** *Efficiency at* **100 % Pn, 75% Pn, 50 % Pn** *100 %, 75 % and 50 % rated power* | 94,1/94,1/93,6 % | | 93,0/93,0/91,5 % |
| **Wirkungsgradklasse** *Efficiency class* | EFF1 | | EPACT |

| | | | |
|---|---|---|---|
| **Leistungsfaktor bei** *Power factor at* **100 % Pn, 75 % Pn, 50% Pn** *100 % Pn, 75% Pn, 50% Pn* | 0,88 | 0,85 | 0,78 |

## Allgemeine Daten/*General Data*

| | | |
|---|---|---|
| **Baugröße** *Frame size* | 200 L | |
| **Bauform** *Type of construction* | IM B 35 | A 400 |
| **Gewicht in kg , Bauform IM B3 ohne Opt.** *Weight in kg, Type of construction IM B3 without Opt.* | 255 kg | |
| **Gehäusematerial** *Frame material* | Grauguss / cast iron | |
| **Schutzart** *Degree of protection* | IP 55 | |
| **Kühlart, TEFC** *Method of cooling, TEFC* | IC 411 | |
| **Vibrationsklasse** *Vibration class* | N (Standard) | |
| **Isolation** *Insulation* | F, ausgenutzt nach B / F, utilized B | |
| **Betriebsart** *Duty type* | S1 | |
| **Drehrichtung** *Direction of rotation* | bidirektional / bidirectional | |

## Klemmenkasten/ *Terminal box*

| | | |
|---|---|---|
| **Klemmenkastenmaterial** *Material of terminal box* | Aluminium / aluminium alloy | |
| **Typ** *Typ* | GK 430 | |
| **Gewinde Kontaktschraube** *Terminal screw thread* | M 6 | |
| **Max. Leiterquerschnitt** *Max. cable diameter* | 25 mm² | |
| **Kabeldurchmesser von ... bis ...** *Cable diameter from ... to ...* | 27 mm | 35 mm |
| **Kabeleinführung** *Cable entry* | 2xM40x1,5 + 2xM16x1,5 von rechts | |
| **Kabelverschraubung** *Cable gland* | Verschlussstopfen / plugs | |

## Mechanische Daten/*Mechanical Data*

| | | |
|---|---|---|
| **Schalldruckpegel (LpfA)** *Noise* | 71 dB(A) | 75 dB(A) |
| **Trägheitsmoment** *Moment of inertia* | 0,18 $kgm^2$ | |
| **Lager AS** *Bearing AS* | 6212 C3 | |
| **Lager BS** *Bearing BS* | 6212 C3 | |
| **Art der Lagerung** *Locating bearing* | Festlager BS (Standard) / fixed bearing NDE | |
| **Kondenswasserlöcher** *Drain Holes* | Nein / no | |
| **Nachschmiereinrichtung** *Regreasing device* | Ja / yes | |
| **Schmiermittel** *Type of lubrication* | ESSO UNIREX N3 | |
| **Fettgebrauchsdauer:** *Relubrication interval at:* | 2000 h | |
| **Fettmenge Nachschmierung:** *Quantity of grease for relubrication* | 10 g | |
| **Äußere Erdungsklemme** *External earthing* | Nein / no | |
| **Anstrich** *Paintwork* | RAL7016 Anthrazitgrau | |

## Explosionsschutz/ *Explosion protection*

| | |
|---|---|
| **Zündschutzart** *Type of protection* | ohne (Standard) / without(standard) |

## Sonderausführungen/ *Special configurations*

A11 - 3 Kaltleiter für Abschaltung
A11 - 3 PTC thermistors for tripping
K31 - Zusätzliches Leistungsschild, lose
K31 - extra rating plate, loose
K40 - Nachschmiereinrichtung
K40 - regreasing device
K83 - Klemmenkasten um 90° gedreht, Einführung von AS
K83 - terminal box rotated 90° entry from drive end
Y53 - Normalanstrich RAL 7016
Y53 - standard paintwork in other colors RAL 7016
Y55 - Anormales zyl. Wellenende nach Kaesermaßzeichnung
Y55 - shaft end special design based on Kaeser dimension drawing
Y82 - Zusatzschild mit Kundenangaben
Y82 - extra rating plate

## Umgebungsbedingungen/ *Site conditions*

| | |
|---|---|
| **Umgebungstemperatur** *Ambient temperature* | -20°C - +45°C |
| **Höhe über Meeresspiegel** *Altitude above sea level* | 1000 m |
| **Normen und Vorschriften** *Standards and specifications* | IEC, DIN, ISO, VDE, EN |

**Technische Änderungen vorbehalten. Differenzen zwischen berechneten und Leistungsschilddaten möglich**
*Technical and ordering data are subject to change. There may be descrepancies between calculaded and rating plate values.*

**Bemerkungen/*Remarks:***

Lüfter 200mm und Lüfterhaube von BG225
SF 1,17 bei Netzbetrieb, SF 1,15 bei FU-Betrieb, Max Übertemp. 97 K

**22.12.2008 Br.**

50_60_DL01 1 2

**Datenblatt für Drehstrom-Käfigläufermotoren**
*Data sheet for three-phase Squirrel-Cage-Motors*

SIEMENS

| | |
|---|---|
| Kunden-Auftrags-Nr./Client-Order-No.: | Item-Nr./Item-No.: 7.6776.00100 |
| Siemens-Auftrags-Nr./Order-No.: | Komm.-Nr./Consignment-No.: |
| Angebots-Nr./Offer-No.: | Anlage/Project: |

## Bestell-Daten/ *Ordering Data*

| | |
|---|---|
| **Motortyp** *Motortyp* | 1LG6283-2AB96-Z |
| **Kurzangaben** *Order Codes* | 7.6776.00100 |

## Elektrische Daten/*Electrical Data*

| | | |
|---|---|---|
| **Bemessungsspannung** *Rated motor voltage* | 400/690 VD/Y | 460 VD |
| **Frequenz** *Frequency* | 50 Hz | 60 Hz |
| **Bemessungsleistung** *Rated motor power* | 90 kW (SF 1,20) | 125 HP (SF 1,27) |
| **Bemessungsdrehzahl** *Rated motor speed* | 2980 $min^{-1}$ | 3582 RPM |
| **Bemessungsmoment** *Rated motor torque* | 288 Nm | 240 Nm |
| **Bemessungsstrom** *Rated motor current* | 152 A/ 88 A | 138 A |
| **Anzugs-/ Bemessungsstrom** *Starting-/ Rated motor current* | 955 % | 107 % |
| **Kipp-/ Bemessungsmoment** *Breakdown/ Rated motor torque* | 377 % | 411 % |
| **Anzugs-/Bemessungsmoment** *Starting-/ Rated motor torque* | 312 % | 361 % |

| | | | |
|---|---|---|---|
| **Wirkungsgrad bei** *Efficiency at* **100 % Pn, 75% Pn, 50 % Pn** *100 %, 75 % and 50 % rated power* | 95,7 | 95,7 | 95,0 |
| **Wirkungsgradklasse** *Efficiency class* | EFF1 / EPACT | | |
| **Leistungsfaktor bei** *Power factor at* **100 % Pn, 75 % Pn, 50% Pn** *100 % Pn, 75% Pn, 50% Pn* | 0,89 | 0,87 | 0,81 |

## Mechanische Daten/*Mechanical Data*

| | | |
|---|---|---|
| **Schalldruckpegel (LpfA) 50 Hz/60Hz** *Noise 50Hz/60 Hz* | 73 | 78 |
| **Trägheitsmoment** *Moment of inertia* | 1,1 $kgm^2$ | |
| **Lager AS** *Bearing AS* | 6217 C4 | |
| **Lager BS** *Bearing BS* | 6217 C4 | |
| **Art der Lagerung** *Locating bearing* | Festlager BS (Standard) / fixed bearing NDE | |
| **Kondenswasserlöcher** *Drain Holes* | -/- | |
| **Nachschmiereinrichtung** *Regreasing device* | ja/yes | |
| **Schmiermittel** *Type of lubrication* | Esso Unirex N3 | |
| **Fettgebrauchsdauer: 40°C/25°C** *Relubrication interval at 40°C/ 25°C* | 2000 h | 2000 h |
| **Fettmenge Nachschmierung :40°C/25°C** *Quantity of grease for relubrication* | 15 g | 15 g |
| **Äußere Erdungsklemme** *External earthing* | -/- | |
| **Anstrich** *Paintwork* | RAL7016 Anthrzitgrau | |

## Umgebungsbedingungen/ *Site conditions*

| | |
|---|---|
| **Umgebungstemperatur** *Ambient temperature* | -20°C - +45°C |
| **Höhe über Meeresspiegel** *Altitude above sea level* | 1000 m |
| **Normen und Vorschriften** *Standards and specifications* | IEC, DIN, ISO, VDE, EN |

## Allgemeine Daten/*General Data*

| | |
|---|---|
| **Baugröße** *Frame size* | 280M |
| **Bauform** *Type of construction* | IM B35, A400 |
| **Gewicht in kg** , Bauform IM B3 ohne Opt. *Weight in kg, Type of construction IM B3 without Opt.* | 615 kg |
| **Gehäusematerial** *Frame material* | Grauguß / cast-iron |
| **Schutzart** *Degree of protection* | IP 55 |
| **Kühlart, TEFC** *Method of cooling, TEFC* | IC 411 |
| **Vibrationsklasse** *Vibration class* | N ( Standard) |
| **Isolation** *Insulation* | F, ausgenutzt nach B / F, utilized B |
| **Betriebsart** *Duty type* | S1 |
| **Drehrichtung** *Direction of rotation* | bidirektional / bidirectional |

## Klemmenkasten/ *Terminal box*

| | | |
|---|---|---|
| **Klemmenkastenmaterial** *Material of terminal box* | Grauguß / cast-iron | |
| **Typ** *Typ* | GT520 | |
| **Gewinde Kontaktschraube** *Terminal screw thread* | M10 | |
| **Max. Leiterquerschnitt** *Max. cable diameter* | 120 $mm^2$ | |
| **Kabeldurchmesser von ... bis ...** *Cable diameter from ... to ...* | 34 mm | 42 mm |
| **Kabeleinführung** *Cable entry* | 2xM63x1,5 + 2xM20x1,5 | |
| **Kabelverschraubung** *Cable gland* | | |

## Explosionsschutz/ *Explosion protection*

| | |
|---|---|
| **Zündschutzart** *Type of protection* | ohne (Standard) / without(standard) |

## Sonderausführungen/ *Special configurations*

A11 - 3 Kaltleiter für Abschaltung
A11 - 3 PTC thermistors for tripping
K10 - Klemmenkasten seitlich links (Blick auf AS)
K10 - side-mounted terminal box, left (viewed to DE)
K31 - Zusätzliches Leistungsschild, lose
K31 - extra rating plate, loose
K31 - Leistungsschild nach NEMA mit Kaeser-Teile-Nr.: 7.6776.00100
K31 - rating plate to NEMA with Kaeser-part-no.: 7.6776.00100
K85 - Klemmenkasten um 180° gedreht
K85 - terminal box rotated 180°
L27 - Isolierter Lagereinsatz
L27 - Insulated bearing cartridge
Y53 - Normalanstrich RAL 7016
Y53 – normal painting RAL 7016
Y55 - Anormales zyl. Wellenende
Y55 - shaft end special design
Y80 – Kaeserspezifischer Leistungsschild
Y80 – Kaeserspecific rating plate

**Technische Änderungen vorbehalten. Differenzen zwischen berechneten und Leistungsschilddaten möglich**
*Technical and ordering data are subject to change. There may be descrepancies between calculaded and rating plate values.*

Bemerkungen/*Remarks:*

**13.02.2007 St**

50_60_DL01 1.2

| REV | DATE | STATUS | WRITTEN | CHECKED | APPROVED |
|---|---|---|---|---|---|
| 0 | 22-Oct-08 | ISSUED FOR PURCHASE | CHOI Y Y | WONG C O | SOH C L |
| A | 12-May-08 | ISSUED FOR REVIEW | CHOI Y Y | WONG C O | SOH C L |

**Technip** DATA SHEET DISTRIBUTION TRANSFORMER

| PROJECT : ASIAFLEX PROJECT | PROJECT N°. | UNIT | DOCT. CODE | SERIAL N° | REV | SHEET |
|---|---|---|---|---|---|---|
| | 5003 | 000 | SP 1641 | 001 | 0 | 1 of 2 |

TO BE COMPLETED BY PURCHASER

| | | |
|---|---|---|
| 1 | General specification: 5003-000-JSS-1641-001 | Standards, codes: IEC 60076 |
| 2 | Equipment Tag: 1-TR-36-11,12,13 & 2-TR-36-11 | Quantity: 4 nos |
| 3 | | |
| 4 | **ENVIRONMENTAL CONDITIONS** | |
| 5 | Installation (indoor/outdoor) / Ambient Type | OUTDOOR \| 34 °C |
| 6 | Ambient Design Temperature | Max: 40 °C \| Min: 16 °C |
| 7 | Altitude (if > 1000m)/Relative Humidity | a.s.l.: <1000 m \| 100 % |
| 8 | Protection degree (IP) | IP55 |
| 9 | | |
| 10 | **GENERAL REQUIREMENTS** | |
| 11 | Type | Oil immersed type: Breathing □ \| Sealed ■ |
| 12 | | Dry type: Impregnated □ \| Cast resin □ |
| 13 | Kind of transformer | With separate windings ■ \| Autotransformer □ |
| 14 | Mode of operation (individual / parallel) | INDIVIDUAL (PARALLEL FOR SHORT TIME) |
| 15 | Frequency / Phases | 50 Hz \| No: 3 |
| 16 | Primary system apparent short circuit power rating | max. 500 MVA |
| 17 | Maximum short circuit duration | 3 s |
| 18 | System earthing | SOLIDLY EARTHED @ SECONDARY STAR POINT |
| 19 | Off Circuit Tap Changer | 2.5 % per step \| N° steps: 5 \| Total range: ± 5 % |
| 20 | On Load Tap Changer (with voltage regulator) | ± % per step \| N° steps: \| Total range: ± % |
| 21 | Winding Connection and Vector Group | DELTA-STAR CONNECTION, Dyn11 |
| 22 | Insulation class | CLASS A |
| 23 | Winding material (copper/aluminium) | Copper |
| 24 | Oil / Winding Temperature Rise | Oil: 60 °C \| Winding: 65 °C |
| 25 | Oil type | PCB FREE - SILICON OIL |
| 26 | | |
| 27 | **TRANSFORMER SPECIFICATION DATA** | |
| 28 | Cooling type (ONAN, ONAF,...) | KNAN |
| 29 | Rated Power Natural Cooling (ONAN) | 2000 KVA kVA |
| 30 | Rated Power Forced Cooling (ONAF) | NA kVA |
| 31 | Primary Connections | Bus Duct □ \| Cable ■ \| (NOTE 1) mm² |
| 32 | Secondary Connections | Bus Duct □ \| Cable ■ \| (NOTE 1) mm² |
| 33 | Cable Type | Primary THREE CORE XLPE/SWA/PVC CU |
| 34 | | Secondary SINGLE CORE XLPE/AWA/PVC CU |
| 35 | CT on primary (number per phase / ratio / class) | |
| 36 | Primary plug in terminals | yes □ No ■ |
| 37 | Secondary plug in terminals | yes □ No ■ |
| 38 | Secondary : neutral brought out | yes ■ No □ |
| 39 | Neutral connection: cable type / section | (NOTE 1) \| (NOTE 1) mm² |
| 40 | CT on neutral (ratio / class) | 3000/5 A/A \| 5P10 |
| 41 | Auxiliary Connections | |
| 42 | Terminal boxes provided with cable glands | Primary yes □ No ■ |
| 43 | | Secondary yes □ No ■ |
| 44 | Cable gland plate - removable type | Non-magnetic gland plate for single core cable |
| 45 | Tank cover | Bolted □ \| Welded ■ \| Bell □ |
| 46 | Transformer mounting | Skid ■ \| Rollers □ \| Bidirectionnal roller □ |
| 47 | Accessories | |
| 48 | DGPT2 relay | yes ■ No □ |
| 49 | Buchholz relay with 2 contacts (alarm / trip) | yes □ No ■ |
| 50 | air breather and dryer | yes □ No ■ |
| 51 | conservator oil drain plug | yes □ No ■ |
| 52 | Pressure/vacuum gauge with needle valve | yes ■ No □ |
| 53 | Thermostat with 2 contacts (alarm/trip) | yes ■ No □ |
| 54 | Dial thermometer | yes ■ No □ |
| 55 | Liquid level gauge | yes □ No ■ |
| 56 | Pressure relief valve with operating signal contact | yes ■ No □ |
| 57 | Oil level gauge with alarm contact | yes ■ No □ |
| 58 | Surge arrester | yes □ No ■ |
| 59 | Lifting rings | yes ■ No □ |
| 60 | Safety valve | yes □ No ■ |
| 61 | filling valve | yes ■ No □ |
| 62 | tank oil drain valve / oil sampling valve | yes ■ No □ |
| 63 | oil filler plug | yes ■ No □ |
| 64 | 2 filterpress connections | yes □ No ■ |
| 65 | Insulation for tank earth protection (including CT) | yes ■ No □ |
| 66 | 2 grounding clamps | yes ■ No □ |
| 67 | lugs and hooks | yes ■ No □ |
| 68 | Painting (Mfr standard,... / color). | RAL 7033 |
| 69 | Noise Level with / without cooling | 55 db(A) at 1 m \| db(A) at m |
| 70 | | |
| 71 | Notes: | |
| 72 | | |
| 73 | | |
| 74 | | |

SILICONE OIL FILLED TRANSFORMER

# TEST - CERTIFICATE

Tag no.: 1-TR-36-11

TECHNIP GEOPRODUCTION (M) SDN BHD

| | |
|---|---|
| Type : | DOTE 2000/10 |
| Year of manufacture : | 2009 |
| Order No. : | 1020858 |
| Serial No.: | 716064 |
| Standard : | IEC 60076 |
| Vector group : | Dyn11 |

**Rated Power [kVA] :** 2000 **Frequency [CPS]:** 50 **Duty cycle:** S1

*Rated Voltage in [V] (HV / LV) :*
11000 +/-2 * 2.5 % / 420

*Rated Current in [A] (HV / LV) :*
105 / 2749

| | |
|---|---|
| *Insul.-Cl :* | A |
| *Cooling :* | KNAN |
| *Sh.circ.cur. [kA] max:* | 1.65 |
| *Sh. circ.dur. [s] max:* | 2 |
| *Oil Weight [kg]:* | 1500 |
| *Total Weight [kg]:* | 6000 |

**Guaranteed Data**

| | |
|---|---|
| $P_o$ in [W] : | 2300 |
| $P_L$ (75 °C) in [W] : | 19500 |
| $e_z$ (75 °C) in % : | 6.25 |
| $I_o$ in % : | n.a. |

Tolerances :
Po<15%; PL<15%; Po+PL<10%; ez <+/-10%

## MEASUREMENT OF NO-LOAD LOSSES AT TAP 3 ; FEED AT: LV

*Freq.[Hz]:* 50

| *Phase* | *Read [V]* | *Average [V]* | *Read [A]* | *Average [A]* | *Read [W]* | *Total [W]* | *Io in %* |
|---|---|---|---|---|---|---|---|
| a - b | 421.08 | 420.17 | 9.43 | 8.57 | 742 | **2450** | 0.31 |
| b - c | 421.13 | | 7.07 | | 557 | | |
| c - a | 418.29 | | 9.21 | | 1151 | | |

## MEASUREMENT OF LOAD LOSSES AT TAP 3 ; FEED AT: HV LOAD AT: LV

| *Phase* | *Read [V]* | *Average [V]* | *Read [A]* | *Average [A]* | *Read [W]* | *Total [W]* |
|---|---|---|---|---|---|---|
| A - B | 353.18 | 349.00 | 52.04 | 52.58 | 1798 | 4492 |
| B - C | 347.71 | | 53.19 | | 1338 | |
| C - A | 346.11 | | 52.51 | | 1356 | |

Tamb.[°C]: 31 *Losses in [W] at 75 °C* *Rated Imped. Voltage in % at 75 °C* *Frequency:*

| *Losses [W] at $I_r$ [obj.]* | Pz | $I^2R$ | $P_L$ | ez | er | ex | 50 CPS |
|---|---|---|---|---|---|---|---|
| 17904 | 2014 | 18125 | **20139** | **6.35** | 1.01 | 6.27 | |

## MEASUREMENT OF RESISTANCE

Tamb.[°C]: 31

| **Connect./Tap-No.** | **A - B** | **B - C** | **C - A** | **Average [Ohm]** |
|---|---|---|---|---|
| 11kV/3 | 0.444851 | 0.444180 | 0.446742 | 0.445258 |

| **Connect./Tap-No.** | **a - b** | **b - c** | **c - a** | **Average [Ohm]** |
|---|---|---|---|---|
| 420V/- | 0.0007167 | 0.0007175 | 0.0007351 | 0.0007231 |

## MEASUREMENT OF VOLTAGE-RATIO AND VECTOR GROUP

*Connection* *Ratio Deviation in % at tap:*

| *Primary to Secondary* | | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| A - B -> | a - n | 0.05 | 0.00 | 0.15 | 0.08 | 0.02 |
| B - C -> | b - n | 0.05 | 0.00 | 0.15 | 0.08 | 0.02 |
| C - A -> | c - n | 0.05 | 0.00 | 0.15 | 0.08 | 0.02 |
| Rated Ratio: | | 47.63 | 46.50 | 45.36 | 44.23 | 43.10 |

## DIELECTRIC TEST AT TAP 1

| *Separate Source Test* | | [kV] | [CPS] | Dur. |
|---|---|---|---|---|
| HV | : | 28 | 50 | 1min |
| LV | : | 3 | 50 | 1min |
| *Ind. Overvolt. Test* | : | 0.84 | 125 | 48s |

## ADDITIONAL TEST

| | | MOhm |
|---|---|---|
| *Insulation Resistance:* | HV -> LV ; ( T-E ) | 6150 |
| at 2.5 kV D.C | LV -> HV-E; ( T-E ) | 1730 |
| (1kΩ/V) | HV -> LV-E; ( T-E ) | 7200 |

RH [%]: 48

## REMARKS:

Oil type : **Silicone oil**

Insul.Value of Oil (VDE 0370 / 71): 62.5 kV / 2.5 mm

AM SGB Sdn. Bhd. TS PASSED

| Test Date : | Tested by : | Verified by : | |
|---|---|---|---|
| 22.10.2009 | | | **AM SGB SDN. BHD.** |

| No. | FROM | TO | POWER (kW) | POWER FACTOR | EFFICIENCY | VOLTAGE (kV) | SHORT CIRCUIT RATING (kA) | SELECTED CABLE SIZE ($mm^2$) | CABLE TYPE | EST. CABLE LENGTH (m) | TABLE REF. | Total Est. cable length | Est. cable length 1 x 1C 120 sq.mm PVC earth cable | Est. cable length 1 x 1C 25 sq.mm PVC earth cable |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **HV / LV CABLES/FEEDERS** | | | | | | | | | | | | | | |
| 1 | TNB SUB-STATION | 1-SW-3-1 BUSBAR A | 8500 | 0.85 | 0.95 | 11 | 24.05 | 2 x 3C x 240 | SWA | 160 | 1.01 | 320.00 | | |
| 2 | TNB SUB-STATION | 1-SW-3-1 BUSBAR B | 8500 | 0.85 | 0.95 | 11 | 24.05 | 2 x 3C x 240 | SWA | 160 | 1.02 | 320.00 | | |
| 3 | 1-SW-3-1 BUSBAR A | 1-TR-36-11 | 1700 | 0.85 | 0.95 | 11 | 24.56 | 1 x 3C x 185 | SWA | 30 | 1.03 | 30.00 | | |
| 4 | 1-SW-3-1 BUSBAR A | 1-TR-36-12 | 1700 | 0.85 | 0.95 | 11 | 24.53 | 1 x 3C x 185 | SWA | 32 | 1.04 | 32.00 | | |
| 5 | 1-SW-3-1 BUSBAR B | 1-TR-36-13 | 1700 | 0.85 | 0.95 | 11 | 24.49 | 1 x 3C x 185 | SWA | 35 | 1.05 | 35.00 | | |
| 6 | 2-SW-3-1 | 2-TR-36-11 | 1700 | 0.85 | 0.95 | 11 | 24.64 | 1 x 3C x 185 | SWA | 25 | 1.06 | 25.00 | | |
| 7 | 1-SW-3-1 BUSBAR B | 2-SW-3-1 | 4675 | 0.85 | 0.95 | 11 | 20.89 | 1 x 3C x 240 | SWA | 400 | 1.07 | 400.00 | | |
| 8 | 1-TR-36-11 | 1-SW-6-1 BUSBAR A | 1700 | 0.85 | 1.00 | 0.4 | 45.09 | 4 x 1C x 630 | AWA + E | 21 | 1.08 | 294.00 | 21.00 | |
| 9 | 1-TR-36-12 | 1-SW-6-1 BUSBAR B | 1700 | 0.85 | 1.00 | 0.4 | 45.95 | 4 x 1C x 630 | AWA + E | 17 | 1.09 | 238.00 | 17.00 | |
| 10 | 1-TR-36-13 | 1-SW-6-1 BUSBAR C | 1700 | 0.85 | 1.00 | 0.4 | 45.95 | 4 x 1C x 630 | AWA + E | 17 | 1.10 | 238.00 | 17.00 | |
| 11 | 2-TR-36-11 | 2-SW-6-1 | 1700 | 0.85 | 1.00 | 0.4 | 45.95 | 4 x 1C x 630 | AWA + E | 17 | 1.11 | 238.00 | 17.00 | |
| 12 | 1-SW-6-1 BUSBAR A | D-CP-DU-6-2 | 1000 | 0.85 | 0.95 | 0.4 | 35.35 | 3 x 1C X 630 | AWA + E | 60 | 1.12 | 720.00 | 60.00 | |
| 13 | 1-SW-6-1 BUSBAR B | 1-ESW-6-1 | 1000 | 0.85 | 0.95 | 0.4 | 42.64 | 3 x 1C X 630 | AWA + E | 60 | 1.13 | 720.00 | 60.00 | |
| 14 | 1-ESW-6-2 | D-CP-DU-6-2 | 1000 | 0.85 | 0.95 | 0.4 | 35.35 | 3 x 1C X 630 | AWA + E | 60 | 1.14 | 720.00 | 60.00 | |
| 15 | 1-ESW-6-1 | D-CP-DG--1 | 1000 | 0.85 | 0.95 | 0.4 | 35.35 | 3 x 1C X 630 | AWA + E | 25 | 1.15 | 275.00 | 25.00 | |
| 16 | 1-ESW-6-1 | M1-EPDB-1 | 85 | 0.85 | 0.95 | 0.4 | 25.70 | 1 x 4C x 95 | PVC | 17 | 1.16 | 17.00 | | |
| 17 | 1-ESW-6-1 | M1-PP-G203-2 | 254 | 0.85 | 0.95 | 0.4 | 16.52 | 2 x 4C x 150 | PVC | 107 | 1.17 | 214.00 | | |
| 18 | 1-ESW-6-1 | CHILLER PUMP CONTROL | 150 | 0.85 | 0.95 | 0.4 | 7.82 | 1 x 4C x 185 | PVC | 170 | 1.18 | 170.00 | | |
| 19 | 1-ESW-6-1 | CHILLER 1 | 117 | 0.85 | 0.95 | 1.0 | 20.60 | 1 x 4C x 185 | PVC | 45 | 1.18 | 45.00 | | |
| 20 | 1-ESW-6-1 | CHILLER 2 | 117 | 0.85 | 0.95 | 1.0 | 19.58 | 1 x 4C x 185 | PVC | 49 | 1.18 | 49.00 | | |

| | | | | | |
|---|---|---|---|---|---|
| 0 | 22-Oct-08 | ISSUED FOR PURCHASE | CHOI Y Y | WONG C O | SOH C L |
| A | 12-May-08 | ISSUED FOR REVIEW | CHOI Y Y | WONG C O | SOH C L |
| REV | DATE | STATUS | WRITTEN | CHECKED | APPROVED |

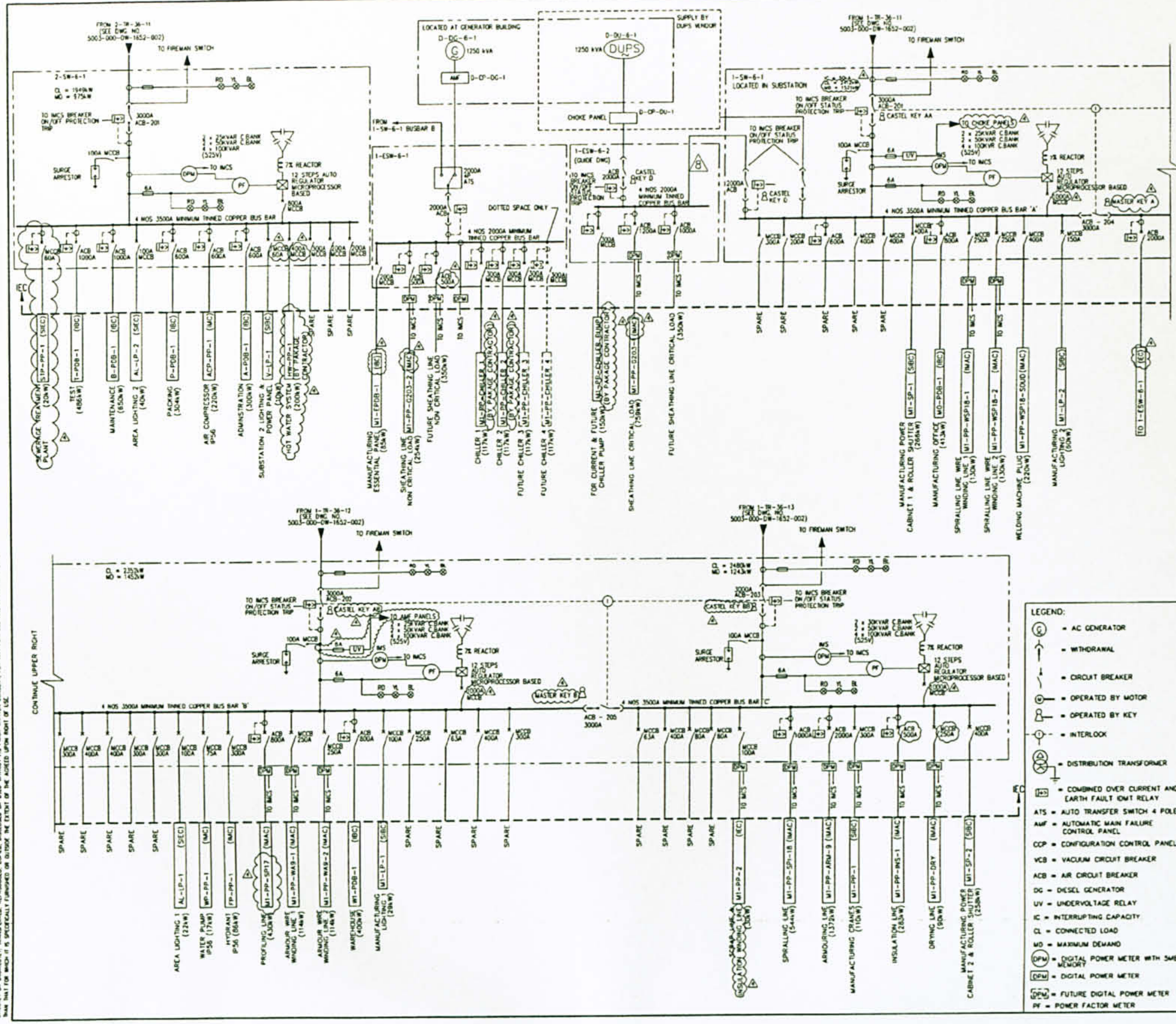
Technip

# DATA SHEET CAPACITOR BANKS

| PROJECT : ASIAFLEX PROJECT | PROJECT N°. | UNIT | DOCT. CODE | SERIAL N° | REV | SHEET |
|---|---|---|---|---|---|---|
| | 5003 | 000 | SP 1656 | 001 | 0 | 1/2 |

TO BE COMPLETED BY PURCHASER

| | | | |
|---|---|---|---|
| 1 | ITEM: | QUANTITY: TBA | MR: 5003-000-MR-1654-001 |
| 2 | General specification: 5003-100-JSS-1654-001 | Standards, codes: IEC | |
| 3 | Manufacturer: | Model: | |
| 4 | | | |
| 5 | **ENVIRONMENTAL CONDITIONS** | | |
| 6 | Installation (indoor/outdoor) / Ambient Type | Indoor | Tropical / Saliferous |
| 7 | Ambient Design Temperature | 40 | ℃ |
| 8 | Altitude/Relative Humidity | a.s.l.: <1000 m | 100 % |
| 9 | | | |
| 10 | **GENERAL REQUIREMENTS** | | |
| 11 | Type (open rack/ in cabinet) | Attached to 400 V Switchgear | Metal-enclose type |
| 12 | Connection (front, rear) | | |
| 13 | Cable Entry | By bus duct ☐ | By cable above ☐ / By cable below ■ |
| 14 | Max N° of cables & section | | |
| 15 | Protection Degree | Notes: (1) | |
| 16 | | | |
| 17 | Network Voltage/Frequency/Phases | 400 +/-10% V / 50+/-5% Hz | N°: 3 Phases |
| 18 | 3 phases fault level at the place of connection | max. 500 | MVA |
| 19 | Network neutral system | | |
| 20 | Rated voltage / Insulation Voltage | 525 V | |
| 21 | Rated power of capacitor bank | Notes: (1) | |
| 22 | Permitted over-voltage | Notes: (1) | % |
| 23 | Permitted over-current toward harmonics | Notes: (1) | % |
| 24 | | | |
| 25 | Lighting of cubicles | yes ■ No ☐ | |
| 26 | Cubicle heating / automatic with thermostat | yes ■ No ☐ | yes ■ No ☐ |
| 27 | Painting (Mfr standard,... / color) | Manufacturer standard / TBA | |
| 28 | | | |
| 29 | | | |
| 30 | **GENERAL CHARACTERISTICS** | | |
| 31 | Isolating device (disconnector, switch, CB) | yes ■ No ☐ | Air Circuit Breaker |
| 32 | Switching device / type (SF6, vacuum, air) | Switch ☐ Contactor ■ | Air |
| 33 | Capacitor internal fuse protection | With ■ Without ☐ | |
| 34 | MV fuses / type | yes ☐ No ☐ | VTA |
| 35 | Earthing switch | yes ☐ No ☐ | |
| 36 | Control relay / Type | Fixed ☐ Withdrawable ■ | |
| 37 | Capacitor type | Single phase ☐ Three phase ■ | |
| 38 | Capacitor connection | Delta ■ Single star ☐ | Double star ☐ |
| 39 | Number of capacitor elements | | |
| 40 | | | |
| 41 | | | |
| 42 | | | |
| 43 | | | |
| 44 | **AUXILIARY VOLTAGES** | | |
| 45 | Type | Internal ☐ External ☐ | |
| 46 | Control system Power Supply | 110 V | ■ AC ☐ DC |
| 47 | Auxiliary Relays Power Supply | 110 V | ■ AC ☐ DC |
| 48 | Cubicle space heater / lighting Power Supply | 240 V | ■ AC ☐ DC |
| 49 | | | |
| 50 | | | |
| 51 | **OPERATING REQUIREMENTS** | | |
| 52 | Compensation type | Fixed ☐ Switched steps ■ | |
| 53 | Control | Automatic ■ Manual ☐ | |
| 54 | Quantity of steps | N° 12 | |
| 55 | Interlocking by key / electrical | yes ☐ No ☐ | yes ☐ No ☐ |
| 56 | Remote control | yes ☐ No ■ | |
| 57 | Signalisation: | | |
| 58 | Type / Lamp, LED's | Mechanical ☐ Electrical ■ | |
| 59 | | | |
| 60 | | | |




LEGEND:

- (G) = AC GENERATOR
- = WITHDRAWAL
- = CIRCUIT BREAKER
- = OPERATED BY MOTOR
- = OPERATED BY KEY
- = INTERLOCK
- = DISTRIBUTION TRANSFORMER
- = COMBINED OVER CURRENT AND EARTH FAULT IDMT RELAY
- ATS = AUTO TRANSFER SWITCH 4 POLE
- AMF = AUTOMATIC MAIN FAILURE CONTROL PANEL
- CCP = CONFIGURATION CONTROL PANEL
- VCB = VACUUM CIRCUIT BREAKER
- ACB = AIR CIRCUIT BREAKER
- DG = DIESEL GENERATOR
- UV = UNDERVOLTAGE RELAY
- IC = INTERRUPTING CAPACITY
- CL = CONNECTED LOAD
- MD = MAXIMUM DEMAND
- DPM = DIGITAL POWER METER WITH 5MB MEMORY
- DPM = DIGITAL POWER METER
- FDPM = FUTURE DIGITAL POWER METER
- PF = POWER FACTOR METER

LOCAL AUTHORITY

OWNER'S SIGNATURE

CONSULTANT'S SIGNATURE

NOTES

1. SIBC - DESIGN, SUPPLY, DELIVERY, INSTALLATION, TESING AND COMMISSIONING INCLUSIVE OF ALL SUPPORT, MOUNTING ACCESSORIES BY BUILDING CONTRACTOR
2. SIEC - DESIGN, SUPPLY, DELIVERY, INSTALLATTION, TESING AND COMMISSIONING INCLUSIVE OF ALL SUPPORT, MOUNTING ACCESSORIES BY ELECTRICAL CONTRACTOR
3. IMAC - INSTALLATION, TESING AND COMMISSIONING INCLUSIVE OF ALL SUPPORT MOUNTING ACCESSORIES BY MACHINE CONTRACTOR.
4. IBC - INSTALLATION, TESING AND COMMISSIONING INCLUSIVE OF ALL SUPPORT MOUNTING ACCESSORIES BY BUILDING CONTRACTOR. CLIENT SUPPLY ONLY THE SUB-SWITCHBOARDS.
5. IEC - INSTALLATION, TESING AND COMMISSIONING INCLUSIVE OF ALL SUPPORT MOUNTING ACCESSORIES BY ELECTRICAL CONTRACTOR.
6. IMC - INSTALLATION, TESING AND COMMISSIONING INCLUSIVE OF ALL SUPPORT MOUNTING ACCESSORIES BY MECHANICAL CONTRACTOR.
7. THE GENERATOR VENDOR SHALL INCLUDE THE DESIGN OF THE SYSTEM TO THE REQUIREMENT AS STATED IN THE BIDDING DOCUMENT.
8. BUSBAR CONNECTION BY SWITCHBOARD MANUFACTURER, THE PANEL ARE ADJACENT TO EACH OTHER.

| DRAWING NO | DESCRIPTION |
|---|---|
| | |

REFERENCE DRAWINGS

| REV | DATE | DESCRIPTION | DRN | CHK | APP |
|---|---|---|---|---|---|
| 4 | 22-APR-09 | REVISED AS MARKED | ZH | CHOI | CL SON |
| 3 | 03-MAC-09 | REVISED AS MARKED | HFZ | CHOI | CL SON |
| 2 | 09-DEC-08 | RE-ISSUED FOR DETAIL DESIGN/CONSTRUCTION | HFZ | CHOI | CL SON |
| 1 | 14-OCT-08 | RE-ISSUED FOR DETAIL DESIGN/CONSTRUCTION | HFZ | CHOI | CL SON |
| 0 | 26-SEP-08 | ISSUED FOR DETAIL DESIGN/CONSTRUCTION | HFZ | CHOI | CL SON |
| A | 15-AUG-08 | ISSUED FOR APPROVAL | ADEE | CHOI | CL SON |

REVISIONS

CONSULTING ENGINEER

Technip

TECHNIP CONSULTANT (M) SDN. BHD.
(338999-T)
2nd FLOOR, WISMA TECHNIP
241 JALAN TUN RAZAK
50400 KUALA LUMPUR, MALAYSIA

PROJECT

CADANGAN MEMBINA KILANG PEMBUATAN "FLEXIBLE PIPE" UNTUK TETUAN ASIAFLEX PRODUCTS (M) SDN. BHD. DI ATAS PLO 98 TANJUNG LANGSAT, JOHOR.

DRAWING TITLE

# SINGLE LINE DIAGRAM FOR LV SYSTEM

| Scale | | Drawing Number | REV. |
|---|---|---|---|
| NONE | A1 | 5003-000-DW-1652-006 | 4 |

FILENAME: 5003-000-DW-1652-006 REV A.DWG