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Military and Defence Engineering Services

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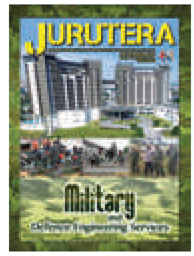

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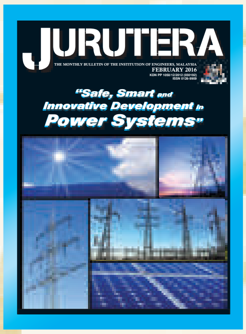

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Art of Military Engineering

Is civil engineering back full circle with military engineering? Throughout history, civilisations are replete with battlefields and wars. Wise men of the day utilised their knowledge of the forces of nature and those with better insight of such knowledge made huge impacts, even to this day, especially in building of civilisations. Countries with better weaponry and arms fared better and triumphed.

Military engineering is the use of the art and practice of designing and building military works and maintaining lines of military transport and communication. Military engineers are also responsible for the logistics behind military tactics.

First, civil engineering branched out from military engineering. Then came other branches of engineering such as chemical, mechanical and biological. The latter incorporated more life sciences into engineering.

Civil engineers study the need for roads, airfields, buildings and other facilities. They conduct surveys of construction areas and design construction projects as well as help select contractors to build facilities. They also check construction progress to make sure it is done according to the plans.

Civil engineers plan and direct facility maintenance and modernisation and plan temporary facilities for use in emergencies. They also keep master plans for military bases up to date. They undertake each initiative by conceiving, planning and completing on time, within budget and according to specifications,

So are civil engineers back in the groove with military engineers. Why not? A crop of competent civil-military engineers can be developed, based on specific needs of the military and to meet future challenges. The Institution of Engineers, Malaysia (IEM) can be tasked to look into such a possibility. ■

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Defence Engineering Services in the ARMED FORCES


Wisma Perwira ATM (Photo courtesy of BPKP)

> **BPKP is the mirror image of JKR. BPKP is JKR of the Armed Forces of Malaysia.**"
>
> *Brig. Gen. Dato' Pahlawan Abu Sufian bin Hj. Ahmad*

The Director-General of *Bahagian Perkhidmatan Kejuruteraan Pertahanan* (BPKP) of Angkatan Tentera Malaysia, Brig. Gen. Dato' Pahlawan Abu Sufian bin Hj. Ahmad, talks about its roles in modern military engineering.

The fledgling Malayan Armed Forces of yesteryear has grown into the Malaysian Armed Forces (Angkatan Tentera Malaysia, ATM) today.

The Armed Forces also includes various military engineering set-ups today as befitting their roles during peacetime, war and natural disasters.

As a crucial part of the Armed Forces, *Bahagian Perkhidmatan Kejuruteraan Pertahanan* (BPKP, Department of Defence Engineering Services) provides ATM with the necessary defence engineering support services.

BRIG. GEN. DATO' PAHLAWAN ABU SUFIAN BIN HJ. AHMAD
MA (UKM) MM (UNSW) mpat psc
Director-General
Department of Defence Engineering Services (BPKP)
Malaysian Armed Forces Headquarters

Brig. Gen. Dato' Abu Sufian, BPKP's director-general since 2015, was commissioned as an officer in Royal Engineers Corps in 1977. He holds master degrees in Strategic Defence from Universiti Kebangsaan Malaysia (UKM) and Master in Management from The New South Wales, Australia. He has attended courses for senior officers at Defence College of Armed Forces. Throughout his 40 years of services in the Armed Forces, he has hold various positions including Director, Department of Geospatial Defence (2013), Defence Attaché at Malaysian Embassy in Turkey (2007-2012) and United Nation's Military Observer at Bosnia Herzegovina (1996-1997).

"BPKP is the mirror image of JKR (Jabatan Kerja Raya, the Public Works Department/PWD). BPKP is the JKR of our Armed Forces," said Brig. Gen. Dato' Pahlawan Hj. Abu Sufian bin Hj. Ahmad, Director-General of BPKP, during an interview at Wisma Perwira ATM in Kuala Lumpur.

He added that work, such as carrying out military engineering in remote areas and building roads to develop the economy of those areas, is similar to what JKR is doing. These include development of infrastructures, buildings and facilities. Furthermore, BPKP is the custodian of assets belonging to the Malaysian Armed Forces.

According to Brig. Gen. Dato' Abu Sufian, the predecessor of BPKP was set up in 1960 and operated as part of the Logistics Division of the Armed Forces, responsible for its housing and accommodation. In 1972, it became the Construction And Housing Section. In 1979, it was under the Directorate of Accommodation & Works. Then, in 2010, under a restructuring programme, it became known as BPKP, which currently has close to 400 staff consisting of officers (engineers and other professionals), other ranks and civilians.

BPKP is an implementation agency of the Armed Forces. Its roles include managing infrastructure and development of Armed Forces projects such as army camps, buildings, quarters and the maintenance of buildings and infrastructures as well as property and asset management.

The four branches of BPKP are: Planning and development, technical (architecture, C&S, M&E, QS, land survey), project management and facility and asset management.

Essentially, its functions and responsibilities include the following: Matters relating to planning and concept development, finance and project administration and management, matters related to design and technical development, implementing all development, modification and upgrading project works coordinating the Planning and Project Brief for Armed Forces development projects implemented by JKR/PWD and other implementation agencies as well as maintenance of buildings, infrastructures and facilities constructed by BPKP and JKR/PWD.

BPKP staff members are also trained soldiers. Brig. Gen. Dato' Abu Sufian said they play different roles during peacetime and war. During natural disasters, it offers support roles to Armed Forces teams as in search and rescue missions, life saving missions, recovery of bodies of victims and so forth. One example in recent years was the 2014 flood relief mission in the eastern states of Kelantan, Terengganu and Pahang where it was involved in rebuilding temporary structures like houses and tents. It was also involved in providing water treatment and clean water systems as well as electric/ power installation.

In essence, BPKP has evolved from a unit that initially looked after small projects to looking after and maintaining big projects which are sensitive in nature or of strategic value.

It has also progressed to building military camps. All these are no small feats. One of its developments is the military camp in Gemas, Negri Sembilan, which is now a growing township with good infrastructure and facilities such as schools and a mosque. The military camp, with land area of 18,000 acres and a population of about 20,000 people including families, is the largest in Southeast Asia.

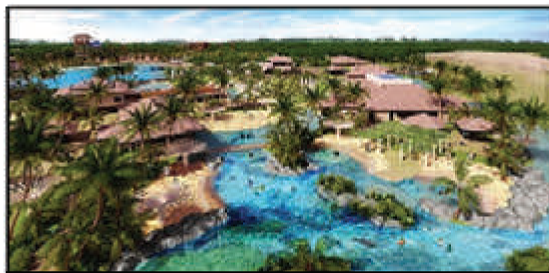
With its comprehensive team of professionals, ranging from planners and project managers to surveyors, architects and engineers, BPKP today maintains all the facilities and infrastructures belonging to the Armed Forces.

In Gemas, it developed facilities and amenities. Now, what used to be just a railway station located at the end point, is a developing township.

We also integrated the systems for the facilities and we prepared the weaponries. In some camps, there are specialised military facilities. Developments by BPKP are ongoing," said Brig. Gen. Dato' Abu Sufian, adding


STP Tank – Klang, Selangor


PTP Port – Tg. Pelepas, Johor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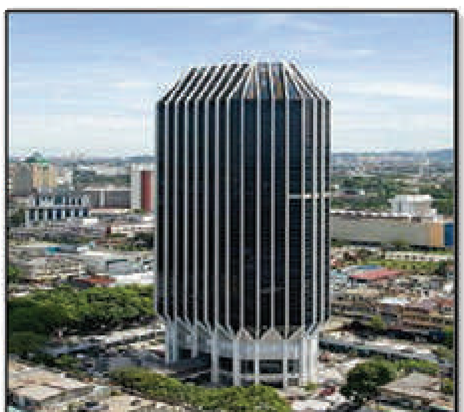
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that like JKR/PWD, BPKP also engages consultants and contractors.

Military engineering involves the designing and building of military works as well as building and maintaining lines of military transport and communications. Military engineering is among the oldest of engineering skills and is the precursor of civil engineering.

Modern military engineering is divided into three main tasks.

1. The first task is combat engineering or tactical engineering support on the battlefield.
2. The second is strategic support by performing works and services in communication zones such as constructing airfields and depots, improving ports as well as road and rail communications and the storing and distribution of food.
3. The third task is ancillary support such as distributing maps and disposal of unexploded warheads.

Brig. Gen. Dato' Abu Sufian further explained the role of BPKP in modern military engineering during peacetime, war and when natural disasters strike, such as severe floods, earthquakes and landslides.

In peacetime, Malaysian army engineers continue to train and prepare for war, engaging in war logistics and preparedness.

They also assist civilian authorities in the handling of key ports and transport modes. In addition, they participate in national development programmes such as building roads to improve the socio-economic status of residents in the areas.

For instance, in Sarawak, the Engineering Corp of the Armed Forces has constructed more than 1,200km of rural roads. The project also includes upgrading timber roads into rural roads and building new roads and connecting them to existing roads.

"Not being at war doesn't mean BPKP engineers don't do anything. Furthermore, they can build good roads at cheaper cost," noted Brig. Gen. Dato' Abu Sufian.

In a wartime scenario, their tasks will include building roads and other transport infrastructures such as bridges, building, repairing and maintaining airstrips and landing zones, clearing obstacles, minefields and booby traps as well as building camps and providing shelter and water supply.

They will assist the Army to lift, move and build shelters to ensure that soldiers are able to survive. Combat engineers are the forefront people in designing and building shelters in addition to doing detailed planning and constructing information.

RELIEF EFFORTS

When disasters strike, they are able to provide rapid, coordinated and appropriate responses to ensure that any crisis is mitigated by effective delivery of relief and aid.

The Military has the manpower, equipment, training and organisation necessary to gather the relief effort. These are areas where the Armed Forces can offer expertise in transport, logistics and deploy immediate help.

The Army is fully effective for the counter-disaster role as it is capable of sustained operations in all kinds of weather, day or night. Its well-established management system makes it ideal for efficient disaster relief operations.

Many of its activities parallel those in public emergency services. It can assist victims with invaluable support in engineering, communications, transport, emergency medical services, field sanitation, water supply and so on.

The Armed Forces assisted during the tsunami and earthquake relief operations in the country many years ago, collaborating with civilian bodies and using its helicopters for search-and-rescue operations.

Another example was the unprecedentedly heavy rainfall in December, 2014, which resulted in devastating floods and caused deaths as well as the displacement of more than 230,000 people in Kelantan, Pahang and Terengganu. The rising flood waters and subsequent landslides blocked major roads, limiting access to evacuation centres and impeding the delivery of food, drinking water and other emergency relief supplies.

File pictures: Army engineers in action

The government coordinated relief efforts by the Armed Forces, Police, Malaysian Red Crescent Society and several NGOs to provide relief assistance to victims holed up in evacuation centres. USAID's Office of US Foreign Disaster Assistance also responded to the disaster.

TRAINING PROGRAMMES

Career progression, such as postings, promotions and sending personnel to courses, is conducted by the Chief Engineer. BPKP encourages skills enhancement and allows its personnel the time to learn and acquire knowledge. It also has programmes to promote junior engineers to be members of The Institution of Engineers, Malaysia (IEM).

"Our task in peacetime is to train for war. In wartime, all of us take up guns and fight. The department would be abolished during such a time," said Brig. Gen. Dato' Abu Sufian.

"In peacetime, we all undergo courses and seminars to increase our knowledge or boost technical advancement. Our own engineering school in Kluang, Johor, trains officers and sends them for courses."

Universiti Pertahanan Nasional Malaysia (National Defence University of Malaysia) in the Sungai Besi Camp, Kuala Lumpur, offers both military and academic programmes, ranging from defence engineering to medicine. Although it prepares students for the armed forces, its graduates have a chance to be employed as engineers with BPKP as well as to join any field as professionals competent in the private sector or government.

Brig. Gen. Dato' Abu Sufian noted that BPKP's tasks comprise planning, technical planning, execution of plans and maintenance. It is capable of handling the whole process of facilities management, from initial planning and maintenance of buildings to, if the need arises, demolition.

BPKP's technical planning wing has staff members from all the necessary disciplines too, from quantity surveyors to architects although, for some projects, it does engage external consultants and contractors to design and build.

The technical planning wing is involved in buildings and projects. Once a project is finalised and contracted out, the implementation wing will carry it out from A to Z. Then, the completed project will be handed over to the end-user and BPKP will maintain it.

This whole process, pertaining to military facilities for the Army, Navy and Air Force, is carried out by BPKP.

In the course of duty, it sometimes works in places inaccessible to others, for instance, remote, security-risk areas like Lahad Datu. The Eastern Sabah Security Command (ESSCOM) is a Malaysian security area covering 1,400km of the east coast of Sabah.

CHALLENGES

On another matter, Brig. Gen. Dato' Abu Sufian said BPKP does encounter challenges and issues such as the maintenance of military camps built by the British in the 1950s and 1960s. Apart from financial constraints, these camps are also located in remote areas in Sarawak.

In addition, BPKP also has to apply to the local authorities in these areas for approval before maintenance work can be carried out.

"It is BPKP's vision and hope that we would be endorsed. We are also a technical body in the government, at least in military installations but even now, we have to comply with JKR/PWD rules and regulations. We hope that, for security reasons, BPKP can, some day, be endorsed," said Brig. Gen. Dato' Abu Sufian.

"Currently, we are strengthening our structure for review by the relevant bodies for endorsement. We already have our own Armed Forces code of practices."

There are also issues of water supply and electricity, such as special licences given to BPKP combat engineers as contractors to carry out work.

He said the Armed Forces play a vital role in nation building and, for the good of the nation, the National Blue Ocean Strategy is intended to enhance its strategic cooperation with other stakeholders.

While the Armed Forces build homes for Armed Forces veterans and BPKP engineers develop the infrastructure, there are still various Acts that exclude the armed forces. For instance, the Department of Occupational Safety and Health (DOSH) and its Jabatan Keselamatan & Kesihatan Pekerjaan (JKKP), and the Uniform Building By-laws (UBBLs), exclude military installations.

"Our lifts comply with DOSH requirements but JKKP does not check our lifts even though these are used by our family members who are civilians. We hope to have an opportunity to discuss this with them," said Brig. Gen. Dato' Abu Sufian.

On BPKP's roles and those of JKR/PWD and Jabatan Pengairan dan Saliran or Department of Irrigation and Drainage (JPS/DID), Brig. Gen. Dato' Abu Sufian said JKR/PWD and JPS/DID are the two technical agencies currently recognised by the government. BPKP is overlooked even though it is the body that carries out inspection of projects and certifies them fit for occupancy on behalf of the Armed Forces for JKR/PWD projects.

BPKP has to closely work with JKR Cawangan Keselamatan (Security Division) for planning and implementing national security infrastructural projects.

"There have been cases of infrastructures built by JKR/PWD and other implementation agencies which are not suitable and which do not fulfill the doctrine of military organisation of various units, giving rise to military operational problems," said Brig. Gen. Dato' Abu Sufian.

"The problem is mainly due to lack of interaction and involvement of military users and implementation agencies. This is why BPKP's role is important to close this gap, since it needs to advise JKR/PWD of military functions and requirements when planning and constructing. It should be involved from the early part of the project until completion."

The government has entrusted BPKP to embark on projects under NBOS (National Blue Ocean Strategies)

1. Pusat Pemulihan Kemasyarakatan (Community Rehabilitation Centre) - Construction of Low-Security Prison facilities in Military Camps such as at Pengkalan Chepa, Kluang, Gemas, Kuching, Kota Belud.
2. Construction of Military-Community Transformation Centres (MCTC) at the Lumut Naval Base, Labuan Airforce Base, Kem Desa Pahlawan (Kelantan), Kem Penrinson (Kuching).

RECENT BPKP PROJECTS

Armed Forces Married Quarters (MQ), 3rd Border Regiment, Pengkalan Hulu, Perak.
From Nov 2014 to Nov 2016. Cost: RM67.3 mil.

Infrastructure Development Project for Royal Military College, Kem Sungai Besi, Kuala Lumpur.
From December 2010 to December 2012.
Cost: RM75 mil.

Construction of 12-Storey Armed Forces Quarters, Kem Kementah, Kuala Lumpur.
From June 2010 to May 2011. Cost: RM24.6 mil.

Construction of Armed Forces Officer's Mess (Wisma Perwira ATM), Ministry of Defence, Kuala Lumpur.
From August 2008 to March 2012.
Cost: RM102.7 mil.

Construction of Armed Forces Married Quarters, Kem Slim, Cameron Highlands.
From August 2014 to February 2017.
Cost: RM10.9 mil.

Construction of Army College, Kem Segenting, Port Dickson
From June 2008 to June 2011. Cost: RM175.3 mil.

Construction & Rehabilitation (CARE) of 22nd RAMD, Kem Sri Kinabatangan, Sandakan
From August 2013 to July 2015.
Cost: RM51.5 mil.

(Photo copyright : BPKP)

PROFESSIONAL DEVELOPMENT

On professional development, Brig. Gen. Dato' Abu Sufian said BPKP encourages all its personnel to further their studies. In fact, it can also have some form of collaboration with IEM for IEM professionals to lecture at its engineering school in Kluang on ethics and other specific topics as part of the professional development of its engineers and to update their knowledge to enable them to become IEM members.

There are also seminars and collaborations with other agencies. A recent bilateral exercise with Australian engineers in Johor Baru emphasised on the hands-on building of a house for Armed Forces veterans.

"We work together with the Chief Engineer of the Army to produce military personnel who are competent, versatile and can multitask," said Brig. Gen. Dato' Abu Sufian.

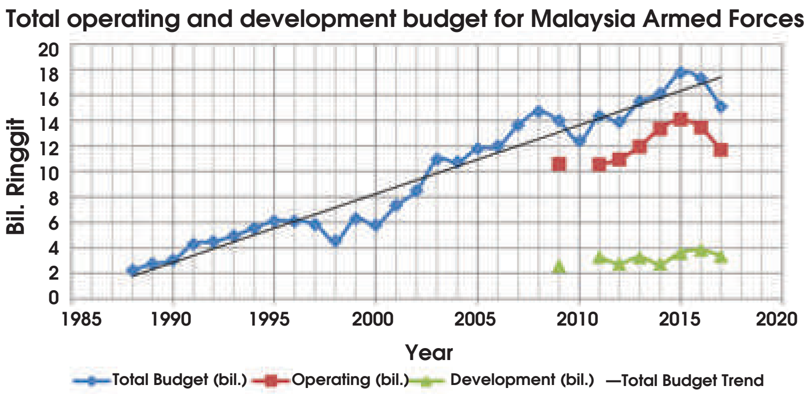
"Our vision is to have our own system to produce military proficient people. We want to attract young engineers to join military engineering as a profession with BPKP. We also have opportunities for professional engineering technicians or PETs." ■

Developing Indigenous Rocket Technology to Solve Known Problems Arising from Expired Missiles and Rockets: UTM Experiences

Ir. Wan Khairuddin Wan Ali

Ir. Wan Khairuddin Wan Ali, *B.Eng (Tasmania), M.Sc Ph.D. (Avionics) (Cranfiled University, UK) is currently a Professor and head of Aeronautical Laboratory, Universiti Teknologi Malaysia. He has more than 25 years of engineering experience as an academic and researcher in rocket propulsion, avionics and aircraft instrumentation. He hold 5 patents and has published over 100 technical papers and proceeding articles.*

Rockets (including missiles) have been in service in the Malaysian Armed Forces since the 1970s (Keling, 2009; 2011) and are purchased with funds from annual defence budgets which have been increasing over the years as shown in Graph 1.



Graph 1: Malaysian Defence Budget (1998-2017).

INTRODUCTION

From the early 1990s, modernisation of the Armed Forces saw the purchase of military hardware that included short- and medium-range rockets (Keling 2009). With this exercise, it was inevitable that the Armed Forces would face several major problems which required long-term solutions. These problems are:

1. Shortage of land to build storage facilities for new rockets as well as maintaining the old, in-service rockets,
2. Lack of storage facilities or methods for the disposal of expired and out-of-service rockets,
3. Lack of maintenance capability for old and new rockets; depending totally on foreign expertise will mean an increase in non-performance budget spending,
4. The increasing cost of new rockets will put a strain on the annual defence budget.

The most logical solution would be for Malaysia to acquire and develop its own rocket technology. But based on the world history of rocket development, this was not technology that could be bought easily.

However, with our own technology, we can build indigenous rockets and develop our own expertise in this field. It will also solve most of the problems such as re-servicing old rockets, thus easing the need for new storage facilities and reducing the need to purchase new rockets. Malaysia can also be more selective in the purchase of advanced new rockets.

SCARCITY OF USEFUL TECHNICAL DATA

Rocket technology developed rapidly after World War II. A tremendous amount of reference literature on rocket technology was published but the critical technical information or data in this area appeared to be scarce worldwide. Such critical technical information or knowledge was largely kept classified by the individual countries.

From the history of successful rocket technology development in countries such as USA, Russia, Brazil, India, China and Israel, and drawing similarities between them, one would notice that they all started with a solid propellant development programme, followed by the launching of short-range rockets (Gruntman, 2004; Conca, 1992; Flank, 1993; Hunley, 2008).

Unfortunately details of the technical data were not available and most likely had been categorised as classified materials. In USA, only selective technical reports containing such data were unclassified after several years of development (Reshotko, 1953).

UNIVERSITI TEKNOLOGI MALAYSIA ROCKET PROGRAMME

The rocket research programme in UTM started in 1989 through individual interest for civilian application. Before that, rocket research in Malaysia was almost non-existent, apart from a few small research projects conducted by Pusat Sains dan Teknologi Pertahananan (PSTP, which was later upgraded to Science & Technology Research Institute for Defence or STRIDE) and the Malaysian Air Force. Their research was basically done using existing solid rocket propellant from expired rockets and the results were never made public.

In the first 3 years, the objective was mainly to establish the correct method of research, finding the right type of rocket motor to be developed and building the right resources. In 1992, experimental research and testing were conducted on composite ammonium perchloride solid propellant. The research areas at that time were split into 3 focus areas:

1. Propellant technology development.
2. Motor and nozzle technology development.
3. Instrumentation and test equipment technology development.

Before the first government research grant was awarded 10 years later, i.e. in 1999, the research activities were sustained through personal funding. This allowed the team to produce a prototype propellant that had enough potential to convince the grant provider to finance the project.

From 1999, with better financial funding and human resource support from UTM and related government agencies, the research areas expanded to include aerodynamic research. This was partly due to the setting up of wind tunnel facilities.

1. PLANNING FOR DEVELOPMENT

In the 1980s, the government did not have any clear science and technology policy on rocket propulsion. Through individual interest, a research project was initiated in 1989 to develop small rocket motors for civilian applications. There were two objectives:

a) to develop and localise rocket technology in Malaysia and
b) to attract attention from the relevant government agencies in the hope of getting some policies made and financial support along the way.

After 10 years, the first government research grant was awarded in 1999. The first decade of the development process was very defining. Due to lack of funds and policy backing from the government, the researchers themselves had to decide on the type of rocket propulsion to be developed. Lack of manpower and funds as well as hands-on experience forced the researchers to consider only the solid propellant rocket motor.

The philosophical development concept employed at that time was to establish a strong foundation and know-how in key areas such as propellant, nozzle and combustion chamber design, instrumentation, testing facilities and safety procedures.

2. PIONEERING THE DEVELOPMENT

The first experimental solid propellant was studied by (Kandiah Padmanathan, 1992) under the author's guidance and supervision, using Ammonium Perchlorates (AP) as oxidizer, Aluminum (Al) powder as fuel and Polyvinylchloride (PVC) powder as binder. Later, carbon (C) powder was added to investigate its influence on the burning rate. Table 3.1 shows chemical compositions of the propellant studied. With this result, the project moved forward to using propellant composition No. 9 as rocket motor propellant grain in the ballistic test. Thrust measurement was done with a rudimentary ballistic test rig consisting of a common weighing machine (Figure 3.1).

Table 3.1: Composition of propellants used by Padmanathan (1992).

PROPELLANT NO.	FORMULATION (%)					CURING TEMPERATURE (°C)	CURING TIME (HRs)	BURNING RATES (cm/s)
	AP	PVC	SA	Al	C			
1	80.0	20.0	-	-	-	170	1.5	Very slow
2	62.0	20.0	18.0	-	-	170	1.5	0.195
7	75.0	10.0	10.0	2.5	2.5	190	1.75	0.714
8	80.0	8.0	10.0	2	-	190	1.75	1.000
9	80.0	8.0	8.0	4.0	-	190	1.75	1.163
9a	80.0	8.0	8.0	4.0	-	190	1.75	1.155
9b	80.0	8.0	8.0	4.0	-	190	1.75	1.149
9c	80.0	8.0	8.0	4.0	-	190	1.75	1.150

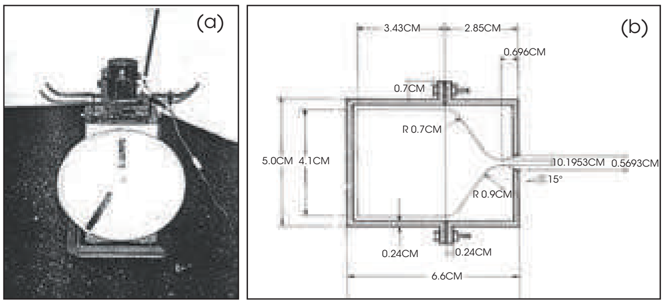


Figure 3.1: (a) Rudimentary test rig in Kandiah Padmanathan's experiment, (b) and cross-sectional view of rocket motor.

The thrust measurement system available at UTM in 1992 was too simple and the result was not satisfactory. In order to capture accurate and reliable results, a test rig consisting of an electronic data acquisition (DAQ) system integrated with a load cell, was designed by Liew (1994). The test rig and the firing of the rocket are shown in figure 3.2.

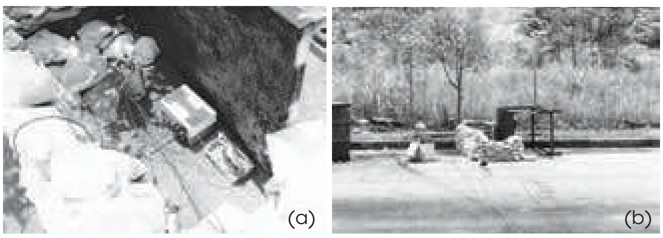


Figure 3.2: (a) The actual DAQ ready for firing, (b) the firing of rocket motor.

Mu (1994) and Wong (1996) continued Padmanathan's work by changing the curing time to 4 hours and lowering the curing temperature to 175˚C. The method produced propellant grains with an average density of 992.3 kg/m^3. A set of mild steel rocket motors was designed (Figure 3.3).

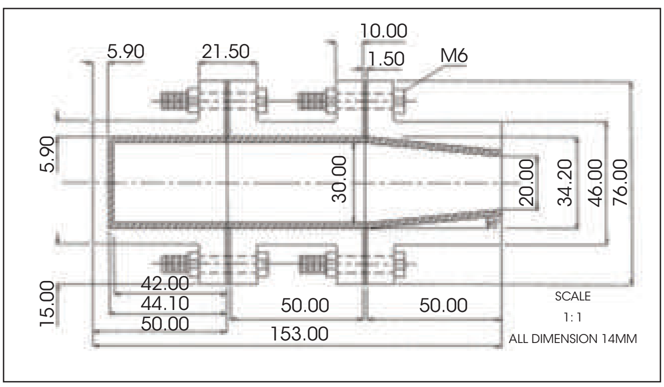


Figure 3.3: Design of nozzle 1 in Mu's report.

Some encouraging observations were recorded by Mu (1994) during the experiments. A constant flame of white smoke (Figure 3.4) was observed at the end of the nozzle during each firing process, followed by an aggressive burning behaviour at the end of the burning process.

From these pioneering researches, the methods of testing were studied and further improved, together with better propellant design, rocket motor design and facilities. These improvements were developments in their own right.

Figure 3.4: Firing test in the Mu's experiment.

CURRENT STATUS OF PROPELLANT TECHNOLOGY DEVELOPMENT

A primary chemical reaction occurs inside the combustion chamber, usually a short distance from the burning surface. These combustion products have to be analysed together with the chemical reaction that occurs in the nozzle and along the flow path. The complex analysis of the combustion process and subsequently, the gas flow characteristic from chamber to nozzle exit, though not impossible, is very difficult to do for any new solid propellant mixture or chemical composition.

In order to keep the analysis simple, while concentrating on the mechanical aspect of the production, well-known chemical compounds such as $NHNO_4$, KNO_2, S, Al etc were used. With their readily available thermo-chemistry data, using these chemicals helps the development to progress more rapidly, as the researchers could concentrate on mechanical production and testing techniques.

1. PROPELLANT PRODUCTION TECHNIQUE

The methods of fabricating solid propellants usually involve many complex, specialised chemical and physical processes (Sutton and Biblarz, 2001). At UTM, the manufacturing of solid propellant follows the flow chart as shown in figure 4.1.

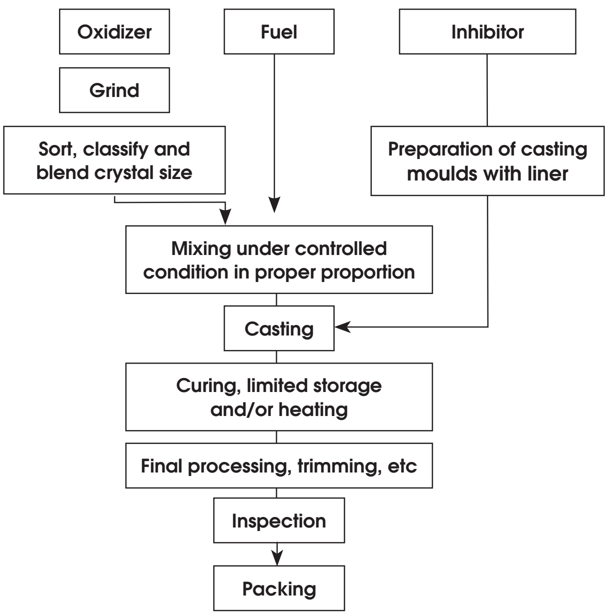


Figure 4.1: Propellant manufacturing flow chart.

2. PROPELLANT COMPOSITION

Lack of knowledge and experience in propellant chemistry were some of the reasons why earlier researchers adopted the trial and error method. In the beginning, they had to refer to chemical compositions based on books, journals, papers etc. They soon realised that most of the compositions listed were incomplete. A lot of the elements were purposely left out, so it was difficult and almost impossible to copy or reverse engineer the exact propellant composition. To add to that, some elements were not available here and had to be imported from friendly countries.

Unfortunately since the attack on the New York World Trade Centre on 9 Nov, 2001, some of these countries ceased to regard Malaysia as a "friendly country". Researchers were embargoed where several chemical elements were concerned. As a result they had to use chemical elements available locally. Table 4.1 show the latest propellant composition developed at UTM.

Table 4.1 Chemical composition studied by Aziz (2011).

Formulation	AP (%)	Al (%)	O/F ratio	Average burn rates at 1 atm pressure
P73	73	12	2.70	1.680
P68	68	17	2.13	1.580
P66	66	19	1.94	1.565
P64	64	21	1.78	1.590
P63	63	22	1.70	1.560
P60	60	25	1.50	1.527

CURRENT STATUS OF TESTING FACILITIES

Testing facilities are the key in bringing together a diversity of researchers to look for solutions to the many problems they faced. Early researchers had to resort to a dangerous and primitive testing procedure as there was no existing testing facility, and rocket motors were tested in the open near the research buildings. Explosions (Figure 5.1) were common and researchers were protected only by simple concrete walls.

Figure 5.1: A rocket motor exploding during a test.

There were frequent complaints from faculty members about safety and unscheduled loud noises as well as the foul smell from the combustion. So researchers had to reconsider the testing sites. At first, they went inside oil palm plantations in the UTM backyard and set up makeshift static thrust testbeds. But it was still in the open and subjected to environmental changes. For protection, the researchers had oil palms which created a sort of shield (Figure 5.2).

Figure 5.2: Testing the rocket motor shielded by oil palms.

Figure 5.3: Early thrust measurement method.

The equipment used was very simple and accuracy was low. Figure 5.3 shows the simple balance used to measure the thrust.

Because of the weaknesses and inadequacy of proper testing facilities, the researchers had to find new ways to conduct their work. They took a look at the numerous tests that had to be conducted on rockets before these could be launched or used and concluded that the motor was the key component that needed to be tested the most.

Before a rocket motor could be operational, it had to be subjected to various tests. Some of these tests were mentioned by Sutton and Biblarz (2001). All together, the tests could be grouped into 6 parts:

1. Manufacturing inspection and fabrication tests (Figure 5.4)

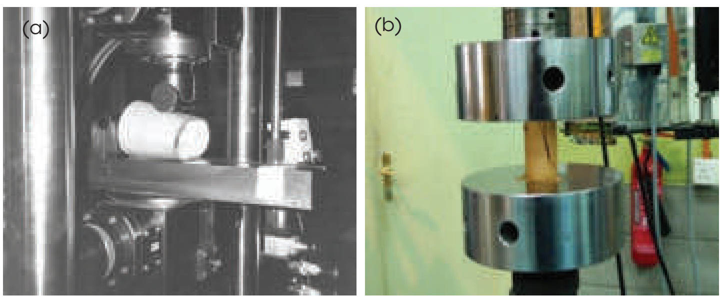


Figure 5.4: (a) Testing the strength of rocket motor casing, (b) Testing the strength of ceramic material for nozzle development.

2. Component test (Figure 5.5)

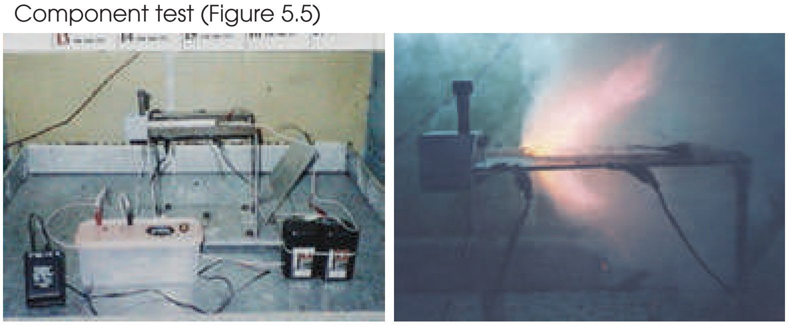


Figure 5.5: Testing the igniter system.

3. Propellant burning characteristic tests to measure the time of burning rate and determining the empirical formula of burning rate, $r = a\,p^n$
4. Static thrust test
5. Dynamic test
6. The Flight test.

1. PROPELLANT BURNING CHARACTERISTIC TEST FACILITIES

There are three methods for measuring the burning rate: Strand burner (Crawford Bomb), small-scale ballistic evaluation motor (BEM) and full-scale motor. All measuring techniques and devices will introduce a degree of errors and accurate prediction is possible by establishing a correlation between full-scale motor, subscale test motor and strand burner test (Aziz, A, 2011). Figure 5.6 shows the burning of the propellant strands in the open.

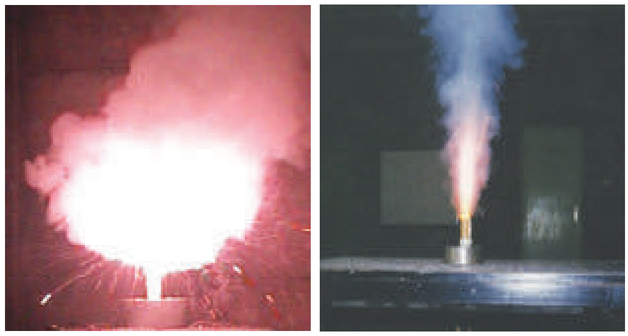


Figure 5.6: The propellant strand being tested in the open and in the laboratory.

Open burning of the propellant strand proved to be inefficient and resulted in a lot complaints from other faculty members about the smell of toxic combustion products. There was also the possibility of the laboratory building catching fire. This led to the construction of a wooden combustion chamber (Figure 5.7) and later, a proper Crawford bomb that could withstand 500 psig pressure (Figure 5.8). The latest Crawford Bomb was fitted with a new electronic timer and strand holding mechanism which improved the testing procedure and the result accuracy.

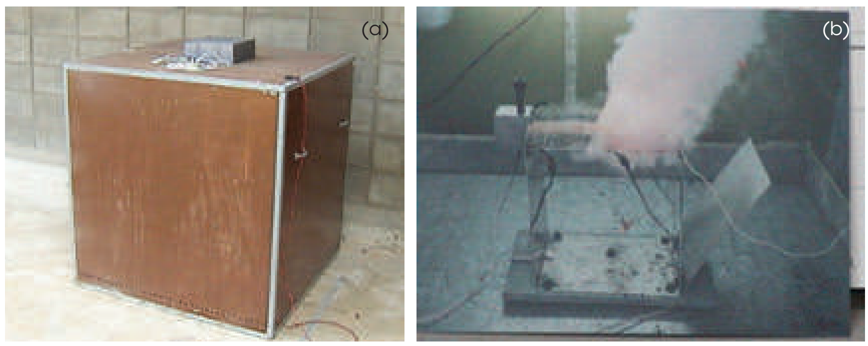


Figure 5.7: Wooden combustion chamber – (a) the exterior view (b) the propellant strands being tested.

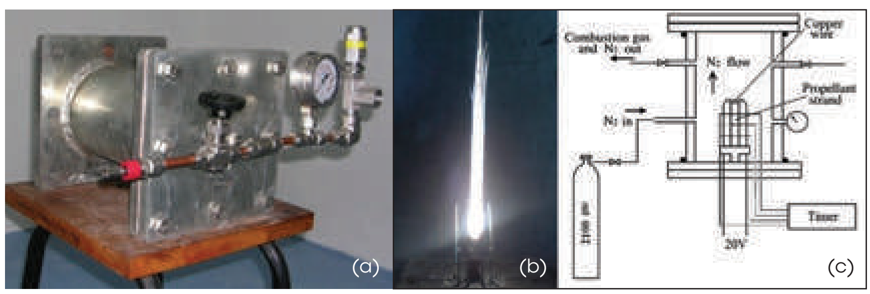


Figure 5.8: (a) Latest Crawford Bomb, (b) The burning of propellant grain on the strand holder, (c) Schematic diagram of the Crawford Bomb.

2. STATIC THRUST TEST FACILITIES

The characterisation of a new propellant was also carried out using a ballistic evaluation motor (BEM). The risks in BEM testing were accidental explosions and uncontrolled fires as well as the possibility of the burning propellant shooting out from the combustion chamber (Figure 5.9).

All these risks had to be handled with strict safety procedures and, over the years, the researchers developed their own safety code and for the past 24 years, held a 100% safety record, without any injury or loss of lives. However, in term of testing, it was not efficient, so the project group had to consider the need for a dedicated propulsion laboratory where safe testing could be conducted more efficiently.

Figure 5.9: Incident where solid propellant shot out from combustion chamber, uncontrolled fire and the explosion of BEM.

2.1. THE PROPULSION LABORATORY DEVELOPMENT

The specifications for the propulsion laboratory were set by the researchers according to their requirements as follows:

1. One-stop centre for propellant characterisation and BEM testing.
2. Safe and conducive indoor testing facility.
3. To avoid attracting undesired attention to the test centre/ facility and the testing activities.
4. A conducive environment for propellant and rocket motor preparation.
5. Easy access to the facility.

Taking all these into consideration, a propulsion laboratory (Figure 5.10) was designed and built.

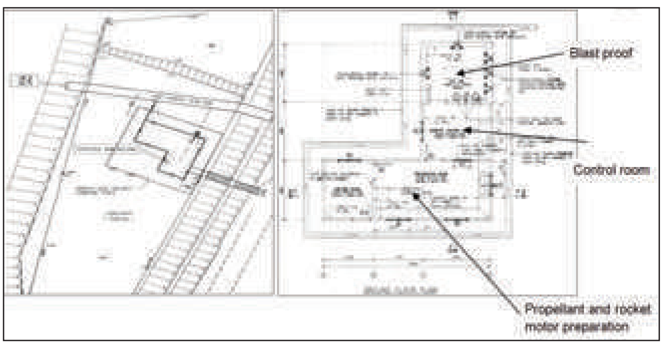


Figure 5.10: The location of the propulsion laboratory and layout.

3. DYNAMIC TEST FACILITIES

To simulate the effect of trailing wake pressure on motor exit pressure during the low level flight of a rocket, a 60m rail was designed and built. This comprised angle bars supported with 33 concrete columns. Figure 5.11 shows a rocket motor being readied for firing on a rail test.

Figure 5.11: A rocket motor readied for firing on a rail test.

Figure 5.12: Rockets launched at UTM football field.

4. FLIGHT TEST

In the early stages of development, rockets were built for short range and lower altitude flights. Therefore a suitable test site was found in the UTM football field. Figure 5.12 shows two flight tests conducted on the football field.

However, in 2001, a near-miss accident happened. On that fateful day, a rocket was launched at the UTM football field but because of corrosion inside the nozzle, it vectored in a dangerous direction toward the busy road. Immediately after that incident, a safety review on flight procedure was conducted and the findings gathered were:

1. UTM was not the best and safest location for flight testing.
2. Other safe areas had to be found for future tests.
3. Safety procedures for flight testing had to be formed.

From 2001, no fewer than 14 rocket launches have been carried out at a new site but for security reasons, this location cannot be disclosed in this publication. Figure 5.13 shows 3 different classes of rockets launched at a coastal launching area.

Figure 5.13: (a) Layang class rocket launched in 2001, (b) Petir class rocket launched in 2007, (c) Tedung Kilat class rocket launched in 2010.

CONCLUSION

Since 1989, UTM has worked to localise the rocket motor technology in Malaysia. Lots of experiences had been gained from this exercise and a number of useful facilities had been established. Today, UTM is in a better position to further develop the technology and to decimate the knowledge to the rest of the country.

In design, the researchers have developed a strong foundation in terms of rocket motor design and rocket propellant fabrication methodologies. Some of the significant findings have also been reported in several other publications and will be a valuable reference for other research institutions involved with rocket technologies. ■

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IEM DIARY OF EVENTS

Title: 2-Day Course on Fundamentals of Successful of Project Management

14-15 Dec 2016

Organised by : Project Management Technical Division
Time : 9.00 a.m. – 5.00 p.m.
CPD/PDP : 14

Title: 1-Day Course on "Vertical Transportation Systems"

14 Dec 2016

Organised by : Mechanical Engineering Technical Division
Time : 9.00 a.m. – 5.30 p.m.
CPD/PDP : 7

Title: Technical Visit to CELP, Universiti Putra Malaysia, Serdang (Rescheduled from 13th December 2016, Tuesday)

14 Dec 2016

Organised by : Electrical Engineering Technical Division
Time : 9.00 a.m. – 1.00 p.m.
CPD/PDP : 3.5

Title: Evening Talk on Engineering Case Study in Slope Stabilization Works

14 Dec 2016

Organised by : IEM Women Engineer Section
Time : 5.30 p.m. – 7.30 p.m.
CPD/PDP : 2

Title: Talk on "Automotive Aerodynamics and Hydrodynamics"

14 Dec 2016

Organised by : Mechanical Engineering Technical Division
Time : 5.30 p.m. – 7.30 p.m.
CPD/PDP : 2

Title: 2-Day Course on Project Planning & Control Using Primavera P6 Client Fundamentals

15 Dec 2016

Organised by : Project Management Technical Division
Time : 8.30 a.m. – 5.00 p.m.
CPD/PDP : 13

Title: Talk on "Rationalisation of Sewerage System in Malaysia" - (Rescheduled from 12th November 2016, Saturday)

17 Dec 2016

Organised by : Water Resources Technical Division
Time : 9.00 a.m. – 1.00 p.m.
CPD/PDP : 2

Kindly note that the scheduled events below are subject to change. Please visit the IEM website at www.myiem.org.my for more information on the upcoming events.

Recent Developments and Applications of Computational Fluid Dynamics

Ong Kian Chuan

Ong Kian Chuan, *B.Eng (Mechanical) (University of Nottingham) is currently a postgraduate research student at the University of Nottingham with research interest is on computational fluid dynamics (CFD). He looks into new numerical solution algorithms for fluid flow with multidisciplinary applications as well as turbulence modelling, and aims to tackle these challenges by the terms efficiency, robustness, and accuracy.*

Professor Andy Chan

Professor Andy Chan, *PhD (Univ. of Hong Kong), currently is the Dean of the Faculty of Engineering, University of Nottingham Malaysia Campus (UNMC) and the director of the Asia Aerospace City Research and Technology Centre (AAC) which focus on research on aerospace manufacturing technologies. Prior to joining UNMC, he was a scientist in the National Center for Atmospheric Research (NCAR), USA.*

Computational Fluid Dynamics (CFD) is the application of the numerical method to solve fluid flow problems. With the development of accurate and robust numerical algorithms, CFD has now matured to where it used as a key tool for a broad range of applications such as aerospace, automotive and various engineering design process.

As CFD becomes increasingly routine, it is even more prudent that attention is focused on developing a method with robustness, accuracy and generality and which must be able to compute stable and accurate solutions under various flow conditions. In addition, as the regime of application is extended, e.g. to distinct fluid flow regimes as a function of Mach number or to different sets of conservation laws, robustness and accuracy should be maintained (1). The Mach number represents the ratio of the local flows speed and the local speed of sound.

In many applications, Mach number varies throughout the flow, for instance, a re-entering space shuttle (Figure 1), where low-Mach viscous boundary layers are embedded in a hypersonic flow, and transonic flow over a RAE2822 airfoil (Figure 2), where a supersonic region with shockwave is presented within a subsonic/transonic flow.

For such an application, Mach-uniform algorithm is important which is a unified numerical formulation for fluid flow computations at all speeds, i.e. arbitrary Mach number regimes.

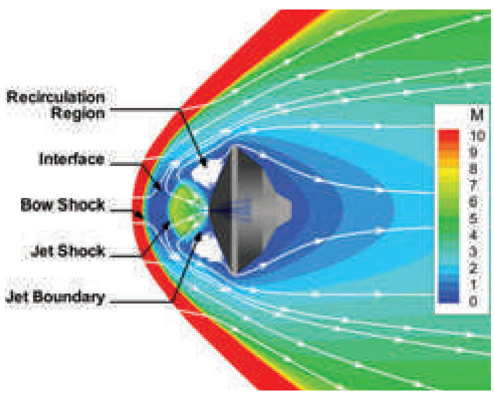

Figure 1: Re-entering space shuttle.

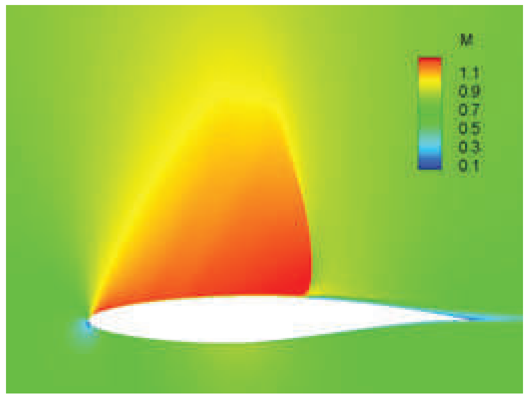

Figure 2: Transonic flow over a RAE2822 airfoil.

Historically, most of the existing techniques are developed specifically for either compressible fluid flow or incompressible fluid flow regimes. These are beset by substantial barriers when one applies a scheme of one regime to a problem of another regime. Continual efforts have been carried out to develop Mach-uniform methods by bridging the gap between the two distinct methods, namely density-based algorithm and pressure-based algorithm, to enhance them to compute fluid flows at arbitrary Mach number regimes.

The density-based algorithms were initially developed for high-Mach number applications. The conservation of mass acts as an equation for density whereas pressure is computed from the energy equation and equation of state. They are very effective for high-Mach number fluid flow, but stability and robustness significantly deteriorate when solving low-Mach number fluid flow.

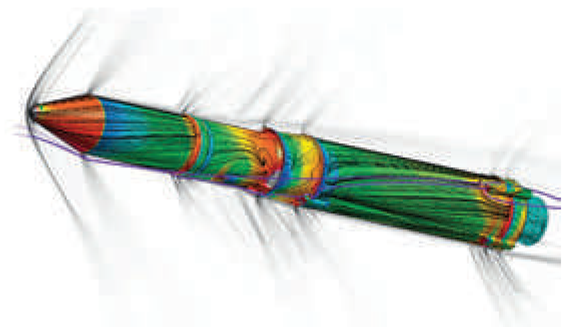

Figure 3: Computation of flow stream-line around a rocket.

Conventionally, they are applied to low-Mach number regime through preconditioning (2). In the more recent decades, all-speeds versions of Advection Upstream Splitting Method (AUSM) have been proposed (1). The all-speeds AUSM and the variant AUSM-family schemes are simple, accurate, robust and possess superior shock-capturing properties (3). These methods do not involve sophisticated differentiations, such as Jacobian matrix, in the evaluation of numerical fluxes and so, are readily extendible to a general equation of state, to thermal non-equilibrium flows or to turbulence model equations (4). Hence, all-speeds AUSM-family schemes are very promising for the computation of fluid flows at arbitrary Mach number regimes. Figure 3 shows an example of the application of AUSM-family schemes in the computation of flow topology around a rocket.

Contrary to density-based algorithms, pressure-based algorithms were originally proposed to solve incompressible fluid flow. The first pressure-based algorithm proposed for all-speeds fluid flow was based on a semi-implicit formulation that extended from Marker-And-Cell (MAC) method to Implicit-Continuous-Fluid-Eulerian (ICE) method for solving transient fluid flow problems at all-speeds (5).

Subsequently, some all-speed pressure-based algorithms have been developed. The feasibility of pressure-based algorithm is based on the fact that pressure variation remains finite, spanning arbitrary Mach number regimes.

All-speeds pressure-based algorithms generally suffer from numerical instability in the computation of compressible flow due to the hyperbolic nature of governing equations and the lack of the shock-capturing capability (6).

Recently, the pressure-based algorithm was combined with AUSM-family schemes for fluid flows computations at arbitrary Mach numbers. The AUSM-family schemes fit perfectly into the pressure-based algorithm due to the separate treatment of convective and acoustic part (pressure) (7). The advantages of the hybrid combination are that the shock-capturing properties at high-Mach number regime are greatly improved, and ad hoc modifications are not needed at low-Mach number regimes (8). This algorithm is successfully extended to solve the magnetohydrodynamics at all-speeds (9), as shown in Figure 4, and it is readily applied to various application of fluid flows at arbitrary Mach number regimes, with complex flow topologies such as shock wave/ boundary layer interactions. ■

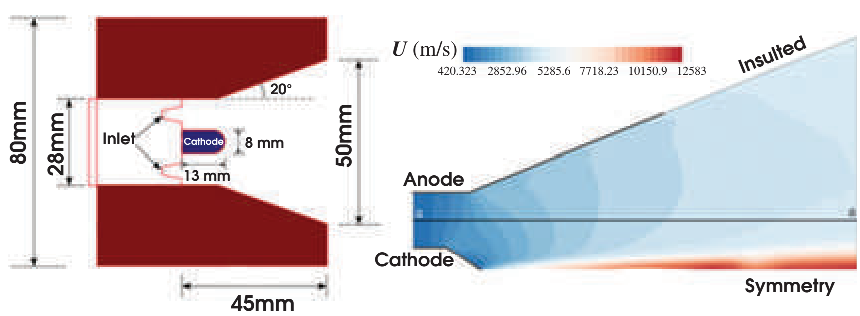

Figure 4: Magnetoplasmadynamic (MPD) thruster.


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IEM DIARY OF EVENTS

Title: 26th Annual General Meeting of the Oil, Gas and Mining Technical Division, IEM

17 Dec 2016

Organised by : Oil, Gas and Mining Engineering Technical Division
Time : 11.00 a.m. – 1.00 p.m.
CPD/PDP : 2

Title: Understanding ISO 9001:2015 for Business Improvement

19 Dec 2016

Organised by : Project Management Technical Division
Time : 9.00 a.m. – 5.00 p.m.
CPD/PDP : 6

Title: 2-Day Course on "Boiler Design & Efficiency"

20-21 Dec 2016

Organised by : Mechanical Engineering Technical Division
Time : 9.00 a.m. – 5.30 p.m.
CPD/PDP : 14

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Title: Talk on "Overview of Hong Kong Recent Infrastructure Development"

19 Dec 2016

Organised by : Consulting Engineering Special Interest Group
Time : 5.30 p.m. – 7.30 p.m.
CPD/PDP : 2

Title: 2-day Course on Introduction to Malaysian Civil Engineering Standard Method of Measurement

20-21 Dec 2016

Organised by : Sub Committee on Engineering Contracts of Standing Committee on Professional Practice
Time : 9.00 a.m. – 5.00 p.m.
CPD/PDP : 15

CONGRATULATIONS

IEM would like to congratulate Y.Bhg. Datuk Ir. Prof. Dr Wan Ramli Wan Daud, Ir. Prof. Dr Mohd Ali Hashim, Ir. Prof. Dr Sharifah Rafidah Datu Wan Alwi, Ir. Prof. Dr Siti Kartom Kamarudin and Ir. Prof. Dr Zahira Yaakob being the recipients of the Malaysia's Rising Star Awards 2016 from Y.B. Datuk Seri Idris Jusoh on 1 September 2016.

Multi-Storey Office Building: Mechanical Design Considerations

by Lum Wai Leong

***Editor's Note:** This article which has been edited for clarity, is based on Professional Interview (PI) essay question by the author. It describes design considerations of mechanical engineering services for a 20-storey office building with a NLA measuring 60 ft by 150 ft per floor and 3 basement carpark floors. It also describe the detail design of chilled water system for the building.*

Before any design consideration is made, an engineer must first sit down with the client to find out more about the expectations for the building. The engineer will make enquiries about the type of office building, requirement for GBI (Green Building Index) or any other green certifications, requirements for MSC (Multimedia Super Corridor) status, exclusivity of the building etc. The client's expectation must be fully understood to ensure the design consideration is made in the right direction.

It is crucial to understanding the client's expectations and the requirements of the office building as engineering designs vary greatly and the selected design approach should best suit the use of the building.

If the building is to be constructed and marketed as a Grade A office building, the air-conditioning within the office spaces will be designed based on a centralised AHU system. This will eliminate the risk of chilled water pipes leaking in work areas and causing disturbance to the occupants or damaging office spaces.

If the building is designed as small offices for sale, the air-conditioning system should be individual fan coil units as these will better facilitate individual operations and temperature control in the individual office spaces. In addition, there will be a clear separation of equipment and maintenance ownership of the air-conditioning system for the individual small offices.

The engineer will also look at the architecture layout and space usage. This is done to identify the relevant building codes and to ensure that mandatory requirements by the authorities are complied with. For instance, the fire sprinkler requirement based on MS1910 for office buildings is the OH I Hazard Group. But if part of the office building space is used as a car park, the classification of fire hazard is increased to OH III Hazard Group. The capacities of the fire sprinkler pumps, storage tanks and requirements of sprinkler heads will be increased to cater to the higher hazard group. This thorough building examination exercise is performed to ensure full compliance with all the building codes and requirements by the authorities.

Once the type of office building and the requirements are fully understood, the engineer will begin design considerations for each of the mechanical services. This will be elaborated in greater detail based on the following categories: Hydraulics, Fire Protection and Air Conditioning & Mechanical Ventilation services.

HYDRAULICS (COLD WATER & SANITARY PLUMBING)

When designing cold water services, the height of the building must be considered first. Typically, an office building will have 4.2m floor-to-floor height per typical office floor. So a 20-storey building will be 84m high. With this height and considering the limited pressure from the incoming cold water supply, the cold water pumping system to deliver to the water storage tanks on the building roof will be designed.

To avoid taking up high value NLA, the Reinforced Concrete (R.C.) cold water suction tank will be located in any of the basement levels except the lowest level. This is to prevent cold water in the tank from coming into contact with flood water from unintended flooding or water seeping from the lowest basement floor due to ground hydrostatic pressure. As the building height is more than the maximum 70m limit of vertical cold water stage, a cold water break tank will be provided at an intermediate level to comply with SPAN Uniform Technical Guidelines. Therefore, cold water suction pumps will deliver water to the break tank at an intermediate level and transfer pumps will then deliver water vertically to the storage tanks on the roof.

The few office floors at the top will have insufficient domestic water supply pressure due to close vertical proximity to the water storage tank at the roof. Most sanitary fittings will require a 1.0bar water supply pressure for the fittings to operate with satisfactory discharge pressure.

Flush valves will need higher water pressure and, coupled with the additional pressure required to overcome the pressure losses in the distribution pipes, the top 5 office floors will be supplied from the roof water storage tank, assisted by pneumatic pumps complete with VSD drives and pressure vessels. The levels below the top 5 floors will have sufficient hydrostatic pressure and the water supply to the office floors below is by gravity feed.

To avoid having the next occupant wait for the cistern to be refilled from immediate previous use, WCs and urinals with flush valves will be used.

FIRE PROTECTION

Building height is a major consideration when it comes to the design for fire protection services. This is because fire extinguishing and rescue will be very difficult should a fire break out at a high level.

Because of the building height, a 2-stage sprinkler piping system will be provided. Each sprinkler stage is no more than 45m high from the lowest sprinkler head to the highest sprinkler head. Considering the large capacity of the sprinkler tank, it will be located at the basement, directly below ground level. Due to the basement levels being used as car parks, the automatic sprinkler piping system and tank are designed for OH III Fire Hazard Group.

As a building of this height cannot be covered by fire hydrants at ground level, it is required to provide a wet riser system. Buildings with heights over 30.15m, must have a wet riser system. The wet riser system comprises a wet riser tank in the basement, a wet riser break tank at an intermediate level and landing valves on every floor. The wet riser break tank is provided because the 84m building height has exceeded the maximum height limit of wet riser vertical stage of 70.15m as defined in MS1489.

Based on the 10th schedule of Uniform Building By-Laws (UBBL), a hose reel system is also required for the office building. It is proposed that the hose reel tank be located on the roof together with the hose reel pumps.

AIR CONDITIONING & MECHANICAL VENTILATION SERVICES

Past experience indicates that the heat load for office spaces generally ranges between 50 and 60 Btuh/ft². An office building with GBI certification and having low-E double glazing windows with relatively good shading coefficient (SC), will have about 50 Btuh/ft² heat load whereas a regular office building with normal insulated glass and is not airtight, will have 60 BtuH/ft² heat load. For discussions on this 20-storey office building, we will use a 55 BtuH/ft² heat load with supply airflow requirement of 1.8cfm/ft².

When determining the selection of AHU or FCU units, the layout of the office floor has to be studied first. Generally, AHUs complete with VAV boxes for open office space and FCU units for small offices, will be used. This is due to the occupational pattern of the office space. For open offices, most people tend to be working in the office at the same time, so air-conditioning will be required for the entire office space and AHU is ideal in this case.

As for small offices, individual owners in the different industry sectors will have irregular office hour patterns, so FCU providing flexible air-conditioning operation, will be more suitable. Assuming that the 20-storey building has an open office layout, one AHU for the open office area and an FCU unit for the office lobby will be used.

The water-cooled chilled water system for the building will comprise of a chiller plant room in the basement level, AHU and FCU on every office floor and a cooling tower on the roof. The water-cooled system is selected for its superior efficiency over the air-cooled system.

The AHU for every office floor is sized according to the total heat load of the office area. For a 60ft by 150ft NLA office space at 55 Btuh/ft² and 1.8cfm/ft² air flow requirement, the AHU per office floor is sized at 495,000 BtuH (41.25 Rton) cooling capacity at 16,200 cfm air flow.

The chiller plant room must be able to provide cooling for all the 20 floors. Hence, the summation of a 20-storey heat load is the capacity of the chiller which is 825 Rton. In reality, the diversity factor must be taken into account in the sizing of the chiller plant room, so as to reflect the absenteeism of occupants over the 20 floors. For the purpose of this case study, the total capacity of 815 Rton and configuring the chillers based on 2 duty and 1 standby, with each chiller sized at 415 Rton, will be maintained. This will enable the chiller plant to operate at full load even if one of the chillers is down for maintenance or due to wear and tear.

The chilled water system designed for this office building will be based on a variable primary flow system. This system is selected due to better energy efficiency by being able to ramp down the chillers and pumps and the recent advancement in chiller technology with the chillers being able to cope better with the varying flow rates. In addition, my configuration of similar capacity chillers of 415 Rton each also permits the operation of the variable primary flow system. If the chillers are of different capacities, the chillers sequencing will be made more difficult and a primary-secondary system will be a more viable option.

The challenge of the variable primary flow system lies in the chiller sequencing. The starting of the second chiller will constantly cause the first to trip as it will not be able to cope with the abrupt decrease in chilled water flow. Similarly, the 2 chillers should also unload slowly during the scheduled shutdown of AHUs after office hours. The sudden decrease in chilled water flow rate will trip the system, so it is advisable to not shut down the AHUs simultaneously.

As most buildings run air-conditioning at partial load most of the time, the chilled water pumps are equipped with VSDs to allow the pumps to run at part-load to match the office building part-load profile.

This is contrary to the conventional constant flow chilled water system where pumps must run at full load even when the building is operating on a part-load profile. Having pumps with VSDs enables energy savings by ramping down pumps when an extra chilled water flow rate is not required.

Finally, the design for the cooling tower is based on the ratio of 1 cooling tower: 1 chiller. The cooling tower is designed on this basis for simplicity in controlling the start/stop of the chiller system. This will also leave one cooling tower on standby and to be used when necessary. ■

SAFE TEA TIME

The Safe Path

by Ir. Shum Keng Yan

Ir. Shum Keng Yan *is a chemical engineer and a certified accident prevention and safety practitioner. He advises on EHS in the chemical, fast moving consumer goods, heavy metal manufacturing and building services industries across Asia Pacific and beyond. He regularly delivers talks at conferences, forums and universities.*

Now that you have a Safety Professional, does that mean the job will be done? The order of the day seems to be putting a person on the job and hoping the person stays or starting over and hiring someone new. In a small operation or low EHS risk operation, this may be short-term feasibility. But what about a more complex industry or organisation?

One way to create a learning organisation is to have a proper career path and this applies even to the Safety Professional. Let us take a quick look a simple career path model.

A simplified model in a large organisation will have, basically, a Management Stream and a Technical Stream. Both streams can share the same job grade within the same band. The titles can be adjusted. The Management Stream is quite traditional while the Technical Stream caters to those who are more technically inclined. They complement each other in managing risk.

	Coordinators	Engineers	Managers	Director	Vice President
Management Stream	Entry Level	General Practitioner	Heads a Unit	Heads a Geographical Area	Strategic - Organisational
Technical Stream	Entry Level	Subject Matter Specialist	Heads a Subject Matter	Heads a Technical Unit	Strategic - Risk Control

At entry level, we can start with a Safety Coordinator. This role is useful for developing future professionals. Fresh graduates or those studying to become Safety and Health Officers are suitable candidates.

Next will be the move to Safety Engineer. At this level, the expectation should, at least, be a Safety and Health Officer registered with DOSH. On the higher band, we will have Senior Safety Engineers.

The move to Safety Manager will require core competencies. We shall look at competencies later on. The Safety Manager basically leads the unit and should have leadership and coaching abilities.

In a large organisation, the role can move up a few more notches. Often, a person will leave an organisation if his/her desired path is not attainable due to lack of vacancy or organisational structure. This should not be the reason why we should not put a career path in place. Have you cleared a path?

Send your comments to: pub@iem.org.my. ■

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References: MC Hee & Associates, AC Haimi Jurutera Perunding, Vasco Scaffold Sdn Bhd, Perunding ZNA (Asia) Sdn Bhd, SNA Consult Sdn Bhd,Universiti Putra Malaysia, Syarikat Sesco Berhad, Kimlun Sdn Bhd, Getmy Solution Sdn Bhd, Segi University, Universiti Tunku Abdul Rahman, Universiti Teknologi Malaysia, Cébéiller Sdn Bhd, Housing Inc Sdn Bhd

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SULTANAH AMINAH HOSPITAL FIRE: THE NEED TO ENHANCE FIRE AND SAFETY REQUIREMENTS

The Institution of Engineers, Malaysia (IEM) expresses regret over the fire that broke out in the ICU ward of the Sultanah Aminah Hospital (HSA), Johor on 25 October, 2016, which resulted in the loss of six lives. According to news reports, the fire and rescue department responded promptly and prevented the spread of the fire.

A working fire alarm system is important, because it will alert occupants and visitors to a fire incident; the public should then proceed to the nearest fire staircase and leave the building. For public buildings such as hospitals and other government buildings, IEM recommends that a qualified professional engineer be commissioned to inspect the fire and life safety systems to ensure that these are operational, well maintained and complies with safety requirements.

High risk areas in hospitals should be fitted with hazard detection systems. In addition to the smoke detection system, there should also be oxygen detectors as these are important in areas where more oxygen is present or used. An enriched oxygen atmosphere can make the ordinary combustible more easily ignitable and when a fire happens, it helps the fire grow faster and spread quicker.

All buildings occupied by large numbers of people, should have a public address (PA) or voice communication system. This would enable the building management, security or fire officer to inform occupants of an emergency situation and give instructions on what they should do. The older building by-laws do not prescribe such PA system requirements. The latest amendment of the Uniform Building By-Laws (of which Selangor and Terengganu have gazetted) however, mandates that a PA system is required for buildings such as hospitals.

Often, patients may not be mobile due to their condition or illness. During a fire, the usual advice is to not use the lift. IEM urges lawmakers to improve building regulations and ensure that high-rise hospitals are equipped with occupant evacuation lifts. Such lifts should be fire-rated and designed so that they can be used for bed or stretchers to evacuate patients.

The Uniform Building By-Laws stipulates the required number and width of fire staircases and escape corridors. However, there have been cases where, upon reaching ground level, evacuees cannot exit the building quickly due to obstacles such as open drains, road curbing, planter boxes and uneven roads. It is the responsibility of building owners to make sure that there are no obstructions to impede the egress of a physically-challenged or impaired person.

Hospitals use various types of electrical equipment and instruments. The wiring in an older electrical system may not have the required safety features. One important safety feature that should be properly checked is the earth-fault protection. This device protects against electrical shock as well as prevent electrical faults from igniting a fire.

IEM reiterates the importance of systematic and regular maintenance and inspection of all building facilities, equipment and safety devices. It is of paramount importance that all building facilities and safety requirements are inspected and maintained at regular scheduled intervals, that equipment and devices are calibrated and that the safety system and procedures are in compliance with requirements and best practices.

IEM believes that a maintenance audit on all public buildings should be carried out on a periodic basis, to ensure the functionality of all the facilities. This is especially crucial if buildings are old and dilapidated.

IEM expresses its heartfelt sympathies to the family members of the victims. We are willing and ready to provide the technical expertise and independent advice to authorities in reviewing the guidelines required to prevent similar accidents from recurring. ■

Ir. Tan Yean Chin
President, The Institution of Engineers, Malaysia
26 October 2016

AFEO Energy Tour 2016, Malaysia

ELECTRICAL ENGINEERING TECHNICAL DIVISION

reported by
Dr Kwan Ban Hoe,
Sub-Committee,
Electrical Engineering
Technical Division.

Group photo at IEM building.

IEM's Electrical Engineering Technical Division (EETD), in collaboration with ASEAN Federation of Engineering Organisations (AFEO), organised the AFEO Energy Tour 2016 in Malaysia on 21- 23 September, 2016.

There were 15 representatives from Brunei, Cambodia, Indonesia, Myanmar, The Philippines, Thailand, Timor Leste and Vietnam. The event was sponsored by International Copper Association Southeast Asia (ICA) and Dexon Electrical Engineering Sdn. Bhd.

Delegates were welcomed in the morning of the first day at IEM Building with an address presented by Ir. Ellias Saidin, ASEAN Engineer Register (AER) Head Commissioner. It was followed by a briefing on the tour itinerary by EETD Chairman Ir. Yau Chau Fong.

Then Ir. Francis Xavier Jacob, AFEO Energy Chairman, presented "Overview of Malaysia's Energy Efficiency (EE) Initiatives" and Dato' Ir. Dr Ali Askar Sher Mohamad, IEM, presented "Overview of Malaysia's Renewable Energy (RE) Initiatives".

There was also the launch of the ASEAN Engineering Inspectorate (AEI) guidebook, titled A Guide to Inspection and Testing of Low Voltage Electrical Installations of Buildings, officiated by Ir. Ellias Saidin, Ir. Yau Chau Fong and Mr. Bek Chee Jin from ICA. The guidebook, funded by ICA, is aimed at promoting harmonisation of electrical inspection standards and practices in ASEAN. Subsequently, the ASEAN Service Providers' Confederation (ASPC) was launched by Ir. Choo Kok Beng, ASPC President.

Delegates from Cambodia, Indonesia and Thailand also presented their topics on "Renewable Energy Development in Cambodia", "35 GW Projects & Indonesia Integrated LNG/Gas Infrastructure Projects" and "Energy Technology for Environment" respectively.

In the afternoon, there was a visit to The Energy Commission Diamond Building, winner of the multiple energy building award, in Putrajaya. The overview of Energy Commission was presented by Ir. Abdul Rahim Bin Ibrahim, Director of Energy Management Development and Service Quality Department.

After that, Encik Zulkiflee Umar, Head of Demand Side Management Unit, gave a presentation titled "Energy Commission Diamond Building - A Showcase of Energy Efficient & Sustainable Building". The Diamond Building is designed to reduce energy consumption through the installation of photovoltaic panels, a tilting facade, use of radiant cooling slabs, rainwater harvesting and optimise daylight utilisation with reflective panels. Most of these features were highlighted during the building tour.

In the evening, there was a free and easy tour of Putrajaya, arranged by the Federal Administrative Centre of Malaysia, followed by an evening cruise of the scenic Putrajaya Lake, which included a delicious dinner aboard the boat.

On Day Two, delegates visited Bus Rapid Transit (BRT) – Sunway Line in the morning. The elevated BRT system is a project by Prasarana Malaysia Berhad and Sunway Berhad under the Public-Private Partnership initiative, with the aim to solve traffic congestion in Bandar Sunway and Subang Jaya.

The system has 5.4km dedicated bus lanes with 7 stations between Setia Jaya and USJ7. The stations are serviced by 12 eco-friendly, battery-run electric buses which can accommodate 60 passengers each.

After the presentation on BRT operations by Encik Shamsul Rizal Mohd Yusof, Chief Operating Officer of BRT Sunway Line, a tour of the BRT control room and BRT depot was arranged. To end the visit, the delegates took a round-trip BRT ride from SunU-Monash Station.

The delegates then stopped for lunch at Sunway Pyramid Shopping Mall before going to Malaysia Transformer Manufacturing Sdn. Bhd. (MTM) Factory in Ulu Klang. MTM, a wholly owned subsidiary of Tenaga Nasional Berhad (TNB), has positioned itself as a One Stop Solution Provider for the local electrical transformer market. Its General Manager (Sales & Marketing), Encik Azhar bin Alias, presented the MTM Business Overview, whereas the technical content of power transformers was presented by Encik Zahrullai Abu Bakar, the General Manager (Engineering). Then there was a guided factory tour to see the transformer manufacturing process, which included paper lapping of copper wire, winding, coil drying and pressing, core cutting and building.

In the evening, the ASEAN delegates went on a sightseeing tour of Kuala Lumpur City Centre before dinner at Songket Restaurant. The dinner was also attended by IEM members and representatives from Energy Institute of Malaysia, The Electrical and Electronics Association of Malaysia (TEEAM), Terasaki Electric Malaysia Sdn. Bhd. (sponsor of the dinner) and other industrial participants.

On the morning of the third day, the delegates visited Seri Ulu Langat Palm Oil Mill Sdn. Bhd. (SULPOM) 7 MW Biomass Cogeneration Power Plant in Dengkil, Selangor. After the introduction and safety briefing session, the Biomass Power Plant Conceptual presentation was delivered by Mr. Yap Hai San, Director of SULPOM Group. The biomass and biogas power plants utilise wastes from palm oil mill to generate electricity for export to the power grid. Plant Manager Encik Yahaya and Assistant Plant Manager Mr. Yap Leong Chee took the delegates on a tour of the biomass power plant before lunch, which was hosted by Tenaga SULPOM Sdn. Bhd.

In the afternoon, delegates visited Malaysia's first floating solar system at the Sungai Labu Water Treatment Plant (WTP) in Sepang, Selangor. The safety briefing was given through a short video presentation, after which Plant Manager Encik Khairul Nidzham Zainal Abidin presented an overview of Sungai Labu Water Supply Scheme and WTP operations.

Sungai Labu WTP is a dedicated WTP for Kuala Lumpur International Airport (KLIA). Later, a presentation titled "Pilot Grid-Connected Floating Photovoltaic System" was delivered by Encik Mohd Razwan Rusli from TNB Research Sdn. Bhd. This project has a total solar capacity of 108 kWp. After the presentation, a visit was made to the project site at Sungai Labu Off River Storage.

On the behalf of the organisers, Mr. Low Pek Jun, Committee Member of AFEO Energy Tour 2016, closed the event, followed by EETD committee members singing the Malay folk song, Rasa Sayang. The delegates were also given the opportunity to provide feedback on the event. ■

Technical Visit to Silterra Malaysia Sdn. Bhd.

ELECTRONIC ENGINEERING TECHNICAL DIVISION

reported by Dr Huzein Fahmi bin Hawari,
Committee Member, Electronic Engineering Technical Division.

IEM participants checking out the state of the art foundry facility system.

On 15 August, 2016, the Electronic Engineering Technical Division (eETD) arranged a technical visit to Silterra Malaysia Sdn. Bhd. in Kulim Hi-Tech Park, for 24 participants comprising IEM members from Kuala Lumpur, Kedah and Penang.

It started at 2 p.m. with an overview presentation on Silterra operations by its deputy director, Dr Mohd Azizi bin Chik, who was part of Silterra FAB start-up team.

THE BACKGROUND

Silterra is a project of strategic national interest which promotes front-end semiconductor manufacturing and is a catalyst for high technology investments in Malaysia.

Started in November 1995 as Wafer Technology Malaysia Sdn. Bhd., it was renamed Silterra Malaysia Sdn. Bhd. in December 1999. It has served many top-tier global fabless design and product companies, covering the consumer electronics, communications & computing and mobile device market segments.

It offers CMOS design and a broad range of fabrication processes for Integrated Circuits (IC) in Advanced Logic, Mixed Signal & Radio Frequency and High Voltage applications. Silterra provides complete design solutions for the creating of leading-edge products, optimised for its high-yielding manufacturing processes, through strategic partnerships with industry-leading Intellectual Property (IP) design library providers, Design Services and Electronic Design Automation (EDA) suppliers. Silterra also offers comprehensive in-house Failure Analysis (FA) services to high-tech companies and universities, performing detailed construction and failure analysis of nano-scale structures.

TALK ON SEMICONDUCTOR FABRICATION IN SILTERRA

Dr Mohd Azizi bin Chik started the talk by sharing the semiconductor growth in Malaysia. "The future for semiconductor fabrication is healthy with the recent expansion of Infineon Kulim and the OSRAM plant will be established in Kulim Hi-Tech Park in 2017," he said.

It is interesting to note that wafer fabrication is a very complex process of 300-900 steps and more than 35% re-entrance to the same equipment at 10-18 times. To ensure

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semiconductor manufacturing operation, selection of products to be processed and processing time have to be scrutinised.

Silterra's Industrial Engineering has also been working on manufacturing operation simulation modelling which can be used for continuous improvement strategy and manufacturing optimisation options.

Finally, Dr Azizi shared information about Silterra products and technology and how they end up in the final market. He also gave information on the company's current expansion activities before concluding the presentation.

During the Q&A session, IEM participants were interested to find out more about the nano-scale technology and devices fabricated at Silterra.

The technical visit ended with a tour of Silterra's facilities.

INTRODUCTION TO IEM TALK AND MEMBERSHIP DRIVE

In conjunction with Engineering Week, eETD also conducted a parallel session titled Introduction to IEM, and a membership drive for some 80 Silterra engineers. It was conducted by Ir. Bernard Lim Kee Weng. ■

Silterra engineers attending the IEM talk conducted by Ir. Bernard Lim.

IEM DIARY OF EVENTS

Title: 2-Day Intensive Course on Design, Protection, Sizing, Installation and, Inspection and Testing of Low Voltage Electrical Installations (Wiring) of Healthcare Facilities to MS IEC (IEC) 60364 – 7 – 710 & MS 2366, and HTM 06 – 01 Part A & B

22-23 Dec 2016

Organised by : Electrical Engineering Technical Division
Time : 9.00 a.m. – 5.30 p.m.
CPD/PDP : 11

Title: 1-Day Course on Leadership Coaching for Engineers

11 Jan 2017

Organised by : IEM Women Engineer Section
Time : 8.30 a.m. – 5.00 p.m.
CPD/PDP : 7

Kindly note that the scheduled events below are subject to change. Please visit the IEM website at www.myiem.org.my for more information on the upcoming events.

Technical Visit to Modipalm Engineering Sdn. Bhd.

AGRICULTURAL AND FOOD ENGINEERING TECHNICAL DIVISION

reported by
Ir. Hor Kok Luen,
Secretary/Treasurer, Agricultural and Food Engineering Technical Division.

Group photograph with the management team of Modipalm Engineering Sdn. Bhd.

The Agricultural and Food Technical Division (AFTD) organised a visit to Modipalm Engineering Sdn. Bhd. (Modipalm) in Kawasan Perusahaan Telok Panglima Garang, Selangor, in July 2016, for 31 IEM members as well as non-members.

On arrival the group was received by Modipalm marketing manager Mr. Lim Zee Ping. Modipalm, formerly known as CBIP, has a 30-year history. From fabricating spare parts and servicing of palm oil mills, CBIP has grown to be one of the largest palm oil mill contractors in the world that is capable of producing 12 mills a year from 10 ton/hour to 120 ton/hour processing capacity. Currently it has 150 employees.

The management team has an average 30 years of hands-on experience in design, fabrication, retrofitting, maintaining and servicing various types of machinery and system in palm oil mills. They specialise in certain technologies with respect to pre-treatment of biogas formation, biomass handling, waste water treatment and composting.

MODIPALM CS

Of particular note is Modipalm's Continuous Sterilisation (CS) system; it is a joint patent holder with MPOB since 1999. The Modipalm CS system was created to improve the older generation of batch horizontal sterilisers under the following key points:

1. Automated continuous process that significantly reduces the total manpower required.
2. Safety concerns when sterilisation is carried out under atmospheric pressure instead of pressurised conditions. This is crucial as most accidents in the palm oil industry happen in the sterilisation station.
3. Producing oil of superior quality.
4. Using smaller carbon footprint and a simple foundation design.
5. Less maintenance issues as overall, the CS design involves fewer moving parts.

Modipalm's success can be attributed to its philosophy with regards to the manufacturing process. It is about the standardisation of product with optimal performance and mass production. With mass production, the chances of error will be less and cost can be optimised.

Each department in Modipalm is tasked with specific job functions and can do a high volume of product assembling with a minimum number of workers. ■

2016 Meeting of the International Network of Women Engineers and Scientists – Asia Pacific Nation Networks (INWES APNN)

WOMEN ENGINEERS SECTION

reported by
Ir. Assoc. Professor
Dr Leong Wai Yie,
Chairman,
Women Engineers Section.

This year, the annual Meeting of The International Network of Women Engineers & Scientists – Asia Pacific Nation Networks (INWES-APNN) 2016 was held in Wellington, New Zealand, on 17 August. The meeting, hosted by the Institution of Professional Engineers New Zealand, was represented by all Chair Ladies of Women Engineers and Scientists from the Asia-Pacific region.

The occasion was graced by Kong-Joo Lee (President of INWES), Elena Trout (President of IPENZ), Susan Freeman-Greene (Chief Executive of IPENZ) and Tracey Ayre (Organising Chair).

The Chair Ladies presented their country's reports and shared valuable information on issues relating to national policies facing woman scientists and engineers. They also discussed ways to connect women engineers, locally and internationally. They hoped to establish strong networking, encourage women engineers to participate in engineering activities and make contributions to society as well as enable a platform for self-development and continuous learning.

Ir. Assoc. Professor Dr Leong Wai Yie, Chairman of IEM Women Engineers Section, presented the IEM WE yearly activities and initiatives which included reports of technical seminars, charity events and corporate connections organised.

The networking meeting would definitely play a key role in guiding INWES regional networks (Africa, Europe and other regions) to reach another milestone. At the meeting, the committee expressed its intention to bid for the APNN meeting in 2018 and the International Conference of Women Engineers and Scientists (ICWES) in 2020.

Assoc. Prof. Leong, also Chair Lady of INWES APNN Working Group of Gender Equality and Governmental Act, presented the joint strategies and initiatives for gender equality by Japan, South Korea, Malaysia and other ASEAN countries.

The Chair Ladies of Asia Pacific Nation Network.

Tomoko Numazawa from Japan presenting the country report.

It was also noted that the KWSE/APNN Young Women Scientists Camp & Smart Sister Workshop would be held in October 2016.

INWES is a global organisation network of women in Science, Technology, Engineering and Mathematics (STEM) with members from over 60 countries. While the field of engineering appears male-dominated, the landscape is rapidly changing and there is now growing support for the training of more women engineers in Asia. The Chair Ladies of INWES-APN will continue their work to highlight the contribution of women in Engineering and Science. We will meet again in Yokohama (Japan) in 2017. ■

COLLECTION OF MALAYSIAN STANDARDS IN THE LIBRARY

The IEM Library has several collections of the latest Malaysian Standards (MS) which can be viewed by IEM members as and when necessary. You may also log in to the IEM library portal to find out whether the required Standards are available.

Members can also give suggestions to purchase the standards for the library collection and beneficial to all.

Please contact library at 03-79684012 or email to **jamaliah@iem.org.my** or **ida@iem.org.my** for more information

The Committee hopes that the library will provide better services for you and the future generation.

Thank you.
Library Sub Committee 2016/2017

Technical Visit to Samsung SDI Energy (M) Bhd – A Green Energy Solution Provider

Reported by Ir. Dr Oh Seong Por,
IEM Negeri Sembilan Branch

The participants at SDIEM.

The Institution of Engineers, Malaysia, Negri Sembilan branch (IEMNS) organised a technical visit to Samsung SDI Energy (Malaysia) Plant or SDIEM, at Tuanku Jaafar Industrial Zone, Sg Gadut, Negri Sembilan on 24 May, 2016.

The delegation of 11 participants from an engineering consultant firm, the corporate sector, universities and IEMNS office, spent half a day touring SDIEM, the sole manufacturing plant in Malaysia producing rechargeable lithium ion battery or LIB, which is currently used in handphones, laptops, cordless power tools and e-bike industries.

The participants arrived at SDIEM at 9.30 a.m. and was welcomed by the Manufacturing Director cum Deputy Managing Director, Ir. Dr Oh Seong Por. Participants were briefed on factory establishment, product portfolio, production capacity and total workforce. Ir. Dr Oh also took the opportunity to explain the working principle of charging and discharging a lithium ion battery.

Then the participants visited the production lines to see the manufacturing of cylindrical and prismatic model LIBs. They also witnessed the world's fastest speed 310 ppm (310 parts per minute) cylindrical production line and the complex process of preparing the electrode, the key component of the battery. After the tour, participants were served lunch at the VIP lounge in the company cafeteria. The visit ended with a photograph session and the presenting of a certificate and souvenir.

BASIC MANUFACTURING PROCESS OF LI-ION BATTERY

The upstream process is the mixing of slurry chemical to make cathode and anode electrodes. For the cathode, lithium cobalt oxide is used and for the anode, graphite C6 is the core component. Cathode and anode slurry are mixed separately in giant mixers, called combi and planetary despa tanks respectively.

When completed, the slurry is coated on thin foil with a thickness ranging from 8 to 30 microns. Coating is performed inside a coater machine. Lithium cobalt oxide slurry is coated on aluminum foil to make the cathode electrode while carbon C6 slurry is coated on copper foil to form the anode electrode.

The electrode is then pressed, using hydraulic rolls, to the required thickness of 90-45 microns. The thin electrode is then slit to the desired width which actually determines the length of the final product battery. The final electrode preparation process is when the slit electrode is dried inside a vacuum chamber.

A pair of cathode and anode electrodes is needed to make a battery. However, there must not be any direct contact of cathode and anode, to prevent short circuit which can lead to overheating, fire or, in extreme cases, explosion. To ensure this, a thin film of polyethylene separator is positioned between the cathode and anode electrodes. All three materials are inter-wound in a winding process to form either rolling jelly roll for cylindrical models or folding jelly roll to make a prismatic battery. Next, the jelly roll is inserted into a can, followed by the injection of electrolyte lithium salt. Finally the can is sealed, either by crimping (pressing for cylindrical battery) or laser welded (ball pressed for prismatic model).

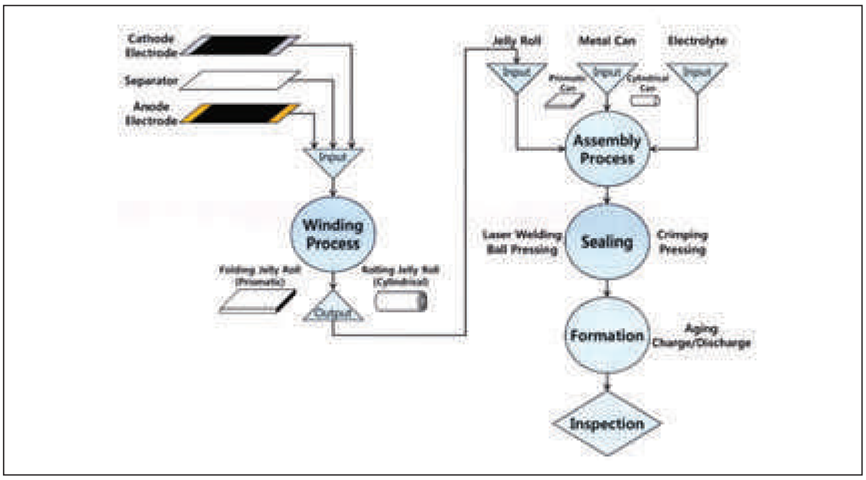
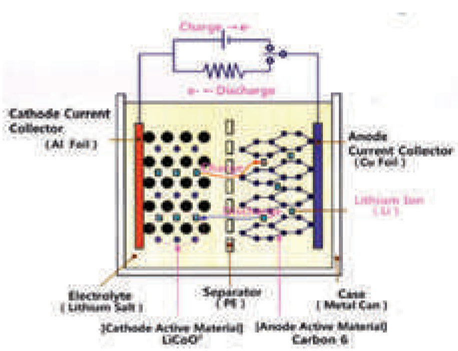


Figure 1: Process flow of LIB.

The next process is called "formation" where batteries are placed in an enclosed storage for 72 hours to allow for complete absorption of the electrolyte into the jelly roll. After this, batteries are charged and discharged with specific voltages. This is meant to activate chemical components of electrodes before they are subjected to various inspection gates in which good cells are packed for customers. Figure 1 illustrates the major process flow of manufacturing LIB.

WORKING PRINCIPLE OF LI-ION BATTERY.

The movement of lithium ion through electrolytes between cathode and anode and vice versa creates a potential difference which induces electrons to flow through a conducting wire that connects the cathode and anode (Figure 2).



MAJOR COMPONENT AND FUNCTION:

Cathode electrode – lithium cobalt oxide.

Anode electrode – carbon 6 that acts as Li-ion collector.

Electrolyte – lithium salt which provides medium for Li-ion to flow.

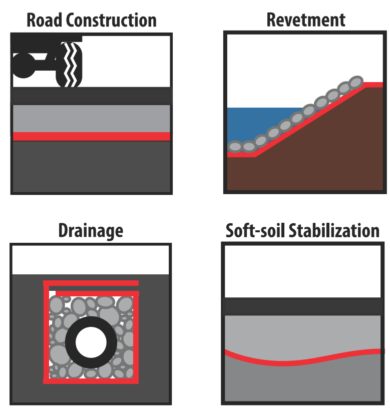
Separator – polyethylene film that prevents direct contact between cathode and anode.

Figure 2: Charge / Discharge Principle.

When electric energy is supplied by an external power source (charger), electrons move from cathode to anode via a conducting wire while Li-ion losing electrons flow through electrolyte from cathode to anode where they are stored between layers of carbon C6. This is called charging state where electric energy is converted to chemical energy and stored in the battery.

In the reverse state, when the circuit is closed, potential difference induced in the charged battery will cause electrons to flow back from anode to cathode through the conducting wire to power the electrical device. Inside the battery, Li-ion losing electrons will flow through the electrolyte from anode to cathode. This is known as discharging state, when chemical energy is transformed to electric energy to power the electrical device.

Therefore by charging and discharging, a Li-ion battery can be used repeatedly as a green energy provider. ■



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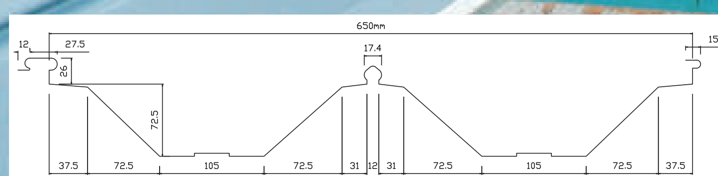

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Ir. Chin Mee Poon
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Ir. Chin Mee Poon *is a retired civil engineer who derives a great deal of joy and satisfaction from travelling to different parts of the globe, capturing fascinating insights of the places and people he encounters and sharing his experiences with others through his photographs and writing.*

With my head lamp lighting the way, I scrambled up the jagged slope of black lava rock, panting heavily. It was 2.30 in the morning and the air was cold but crisp and bearable. I was with my youngest brother, his wife and his two daughters, deep in the process of conquering Mount Fuji, Japan's iconic and highest mountain which was admitted to UNESCO's list of World Heritage Sites in 2013, not so much for its natural beauty as for its cultural value.

We had flown to Tokyo two days earlier, travelled by express bus from Shinjuku Station to Kawaguchiko in 1½ hours and stayed the night there. The following morning, we arrived at Station 5 (2,305m above sea level) after a slow, hour-long bus ride. We could see many other climbers had already gathered there.

After an early lunch, we started our climb at 12.30 p.m. It was an exceptionally beautiful, sunny day. Both Mt. Fuji and the Fuji Five Lake area at its foot were clearly visible.

Mt. Fuji, 3,776m asl, is a dormant volcano which last erupted in 1707. Those contemplating a hike up this mountain can choose from 4 routes but the most popular is Yoshida Trail. Each route is divided into 10 stations with the first at the foot and station 10 on the summit.

The official Mt. Fuji climbing season for 2016 was from 1 July to 10 September. You can still go up the mountain outside of the official climbing season, but most facilities along the routes will be closed and weather conditions will be unpredictable and less conducive for climbing.

We chose to begin our climb on Merdeka Day as we felt the crowd would be thinner towards the end of the climbing season. It turned out to be a very lucky decision.

In Kawaguchiko, shortly before our departure for Station 5, we met a Taiwanese girl just down from Mt. Fuji. She told us she did not reach the summit because it was closed due to the typhoon. So you can imagine how blessed and jubilant we felt when we were making our way slowly but steadily towards Station 8, with the afternoon sun shining in warm encouragement and we had a full view of Fujisan as our guiding beacon. The zigzag trail is quite well maintained and distinct, so a guide is utterly unnecessary and no one would go astray.

It took me 40 mins to reach Station 6 (2,390m) and another hour to reach Station 7 (2,700m). The slope was becoming steeper and parts of the trail were very rocky. An hour and 35 mins later, I reached Taishikan, the half-way refuge at Station 8 (3,100m).

Dinner was served at 5.15 p.m. and by 6 p.m., we went to bed. But I could hardly get any sleep as the guy next to me in the dormitory made some irritating nasal and throat noise every so often through the night.

When we got up at 2 a.m., I had no appetite for food. It was clear that I was suffering from mild altitude sickness. Unlike the previous afternoon, I was feeling very lethargic. Every step became a drudgery.

Instead of reaching the summit to catch the sunrise, I was still at Station 8.5 (3,450m) when the sun rose above the horizon at 5.10 a.m. Pushing on hard, I walked past the wooden torii (traditional gateway) at Station 9 (3,600m) 40 mins later and finally, after another gruelling 45 mins, a pair of stone lions and a wooden torii welcomed me to the summit.

The highest point on the summit, Kengamine Peak (3,776m), was still 1.4km away and it took us greater effort to reach this at the crater rim. But in the end, all five of us made it. Hooray! ■

Editor's Note: *We welcome contributions from all members on travel stories.*

Tarikh: 14 November 2016

Kepada Semua Ahli,

SENARAI CALON-CALON YANG LAYAK MENDUDUKI TEMUDUGA PROFESIONAL TAHUN 2016

Berikut adalah senarai calon yang layak untuk menduduki Temuduga Profesional bagi tahun 2016.

Mengikut Undang-Undang Kecil IEM, Seksyen 3.8, nama-nama seperti tersenarai berikut diterbitkan sebagai calon-calon yang layak untuk menjadi Ahli Institusi, dengan syarat bahawa mereka lulus Temuduga Profesional tahun 2016.

Sekiranya terdapat Ahli Korporat yang mempunyai bantahan terhadap mana-mana calon yang didapati tidak sesuai untuk menduduki Temuduga Profesional, surat bantahan boleh dikemukakan kepada Setiausaha Kehormat, IEM. Surat bantahan hendaklah dikemukakan sebulan dari tarikh penerbitan dikeluarkan.

Ir. Yam Teong Sian
Setiausaha Kehormat, IEM,

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Pengumuman yang ke-98

SENARAI PENDERMA KEPADA WISMA DANA BANGUNAN IEM

Institusi mengucapkan terima kasih kepada semua yang telah memberikan sumbangan kepada tabung Bangunan Wisma IEM. Ahli-ahli IEM dan pembaca yang ingin memberikan sumbangan boleh berbuat demikian dengan memuat turun borang di laman web IEM http://www.iem.org.my atau menghubungi secretariat di +603-7968 4001/5518 untuk maklumat lanjut. Senarai penyumbang untuk bulan Oktober 2016 adalah seperti jadual di sebelah:

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3	17103	ENGRCHEAH SONG HOCK
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9	05585	ONG ANG KOOI
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80468	SOH BOON PING	B.E.HONS.(UTP) (MECHANICAL, 2014)
80749	SYED MOHD ILYAS SYED MOHD NASSIR	B.E.HONS.(UNITEN) (MECHANICAL, 2015)
80751	TAN CHOR HUM	B.SC.(SOUTHERN ILLINOIS)(MECHANICAL, 2003)
80568	TAN HUAT HUI, JOSHUA	B.E.HONS.(MMU) (MECHANICAL, 2013)
80700	TENGKU MAHAINEE BINTI TENGKU MAHMOOD	B.E.HONS.(MONASH) (MECHANICAL, 2008)
80557	VICENTE L MORAN JR	B.SC.(MANITOBA) (MECHANICAL, 2006)
80177	VIGINES A/L GENGATHARAN	B.E.HONS.(UNITEN) (MECHANICAL, 2012)
80450	WAN AB RAHIM BIN WAN ENDUT	B.E.HONS.(UPM) (MECHANICAL, 2007)
80460	WONG NING	B.E.HONS.(UTP) (PETROLEUM, 2012)
79407	WONG WEI YUEN, LEONARD	B.E.HONS.(UMS) (MECHANICAL, 2013)

KEJURUTERAAN MEKATRONIK

80548	KHAIRULBADRI BIN AHMAD	B.E.HONS.(NOTTINGHAM) (MECHATRONICS, 2011) M.SC.(SHEFFIELD) (CONTROL SYSTEMS, 2014)
80588	MAHATHIR BIN ABDUL RAHMAN	B.E.HONS.(IIUM) (MECHATRONICS, 2008)

KEJURUTERAAN PEMBUATAN

80448	DR. ADNAN BIN IBRAHIM	B.E.HONS. (PORTSMOUTH) (MANUFACTURING SYSTEMS, 2000) M.SC.(STRATHCLYDE) (INTEGRATED PRODUCT DEVELOPMENT, 2002) P.HD.(UKM)(RENEWABLE ENERGY, 2012)
79575	DR. NORHASHIMAH BINTI MOHD SHAFFIAR	B.E.HONS.(IIUM) (MANUFACTURING, 2002) M.E.(UTM)(MECHANICAL-ADV. MANUFACTURING TECH., 2006) P.HD.(UTM) (MECHANICAL, 2013)
79559	MOHD SYAFIQ BIN ABDUL MANAN	B.E.HONS.(USM) (MANUFACTURING WITH MANAGEMENT, 2009)
80195	PAI YUN SUEN	B.E.HONS.(MALAYA)(CAD & MANUFACTURING, 2013)
80214	RAVICHANDRA KUNUGALI RANGAPPA	B.E.(KUVEMPU) (AUTOMOBILE, 1998) M.E.(MALAYA) (THERMOPHORETIC DEPOSITION, 2009)
79580	TAY LEE WEH	B.E.HONS.(MALAYA)(CAD & MANUFACTURE, 2008)
80747	WONG KOK HOE	B.E.HONS.(MALAYA)(CAD & MANUFACTURE, 2010)

KEJURUTERAAN PETROLEUM

80519	ABDUL AFIF BIN OSMAN	B.E.HONS.(UTP) (PETROLEUM, 2013)
80539	ABDUL AFIQ BIN NGAH	B.E.HONS.(UTP) (PETROLEUM, 2013)
80518	ABDUL HAKIM BIN ALIAS	B.E.HONS.(UTP) (PETROLEUM, 2012)
80540	ADNAN BIN HANAPAI	B.E.HONS.(UTP) (PETROLEUM, 2013)
80517	AFZAN BINTI ABDUL SATAR	B.E.HONS.(UTM) (PETROLEUM, 2012)
80541	AHMAD FAIZ BIN OMAR	B.E.HONS.(UTP) (PETROLEUM, 2011)
80516	AHMAD FARIS HAFIZI BIN AHMAD PAUZI	B.E.HONS.(UTP) (PETROLEUM, 2013)
80514	AHMAD LUTTPHI BIN ISMAIL	B.SC.(COLORADO OF MINES)(PETROLEUM, 2013)
80513	AMEERA FATIN BINTI ABDULL HADI	B.SC.(KANSAS) (PETROLEUM, 2013)
80512	AMIERUL BIN AMRAN	B.E.HONS.(UTM) (PETROLEUM, 2012)
80511	AMMAR THAQIF BIN ABDUL RAHAMAN	B.E.HONS.(UTP) (PETROLEUM, 2014)
80542	ANDREW DEVASAHAYAM A/L THANARAJU	B.E.HONS.(UTP) (PETROLEUM, 2013)
80510	ANIS NADIAH BINTI M.SUKREY	B.E.HONS.(UTP) (PETROLEUM, 2012)
80526	ARUNAN A/L ISVARAN	B.E.HONS.(UTP) (PETROLEUM, 2013)
80507	DELWISTIEL ANAK JAMEL	B.E.HONS.(UTP) (PETROLEUM, 2013)
80506	ESKANDAR BIN MOHD SUKRI	B.E.HONS.(UTP) (PETROLEUM, 2013)
80505	FADZRIL SYAFIQ BIN JAMALDIN	B.E.HONS.(UTM) (PETROLEUM, 2011)
0	FARADIANA BINTI MOHD RAZIF	B.E.HONS.(UTP) (PETROLEUM, 2011)
80503	FARIS IMADI BIN ABU BAKAR	B.E.HONS.(UTP) (PETROLEUM, 2014)
80537	HAZIM KAMARUL ZAMAN	B.SC.(TULSA) (PETROLEUM, 2013)
80502	KANAGASWARRAN A/L CITALINGAM MUDLIAR	B.E.HONS.(UTP) (PETROLEUM, 2012)
80501	KAYATHIRI A/P CHANDRAN	B.E.HONS.(UTP) (PETROLEUM, 2013)
80500	KOONG XIN YI	B.E.HONS.(UTP) (PETROLEUM, 2013)
80498	LAI YEN HUA	B.E.HONS.(UTP) (PETROLEUM, 2013)
80520	LEE MING HWA	B.E.HONS.(UNSW) (PETROLEUM, 2009)
80497	LIEW SIN YOONG, WILLIAM	B.E.HONS.(UTP) (PETROLEUM, 2012)
80496	LIM WIN SHEN	B.E.HONS.(UTP) (PETROLEUM, 2013)
80494	LOW JUN LEON	B.E.HONS.(UTP) (PETROLEUM, 2013)
80493	LYE YAN CHING	B.E.HONS.(UTP) (PETROLEUM, 2013)
80492	MA SHIAN EE	B.E.HONS.(UTP) (PETROLEUM, 2013)
80490	MOHAMAD FARID BIN ALI	B.E.HONS.(UTP) (PETROLEUM, 2014)
80489	MOHAMAD FIKREE BIN OTHMAN	B.E.HONS.(UTP) (PETROLEUM, 2013)
80488	MOHAMAD HAZWAN BIN YUSOFF @ MOHD YUSOFF	B.E.HONS.(UTP) (PETROLEUM, 2013)
80486	MOHAMMAD SYAHMI BIN MOHD ZURHAN	B.E.HONS.(UTP) (PETROLEUM, 2014)
80485	MOHD ASHRAF BIN NOR AZROL	B.E.HONS.(UTP) (PETROLEUM, 2013)
80484	MOHD FAKHRULHADI BIN A. RAZAK	B.E.HONS.(UTM) (PETROLEUM, 2011)
80535	MOHD HILMI BIN ABU BAKAR	B.SC.(TULSA) (PETROLEUM, 2013)
80483	MOHD MAJDAN BIN MOHD ZARAWI	B.E.HONS.(UTP) (PETROLEUM, 2012)
80482	MOHD REDHA BIN CHE MAT	B.E.HONS.(UTM) (PETROLEUM, 2010)
80481	MOHD RIDZUAN BIN HAMID	B.E.HONS.(UTP) (PETROLEUM, 2013)
80479	MOHD ZHAFRAN BIN ABD RAHMAN	B.E.HONS.(UTM) (PETROLEUM, 2011)
80480	MUHAMAD FIRDAUS BIN ZAINI	B.E.HONS.(UTP) (PETROLEUM, 2013)
80478	MUHAMMAD AIZAT HAIDI BIN HOD	B.SC.(ALBERTA) (PETROLEUM, 2013)
80477	MUHAMMAD FAIZAL BIN GHAZALI	B.E.HONS.(UTP) (PETROLEUM, 2012)
80456	MUHAMMAD FARID AFIQ BIN ZOLKIFLI	B.E.HONS.(UTP) (PETROLEUM, 2014)
80534	MUHAMMAD HAIDIR NIZAM BIN BAHARUDDIN	B.E.HONS.(UTP) (PETROLEUM, 2013)
80455	MUHAMMAD HANAFI BIN MOHD KHALID	B.E.HONS.(UTP) (PETROLEUM, 2014)
80476	MUHAMMAD HARIS BIN HAMZAH	B.E.HONS.(UTP) (PETROLEUM, 2012)
80533	MUHAMMAD IZHAM KAMIL BIN ISHAK	B.E.HONS.(UTP) (PETROLEUM, 2013)
80532	MUHAMMAD NAZRIN BIN SOHAILI	B.E.HONS.(UTP) (PETROLEUM, 2013)
80473	MUHAMMAD QAYYUM BIN AHMAD ANI	B.E.HONS.(UTP) (PETROLEUM, 2012)
80472	MUHAMMAD RAIMI BIN JOHARI	B.E.HONS.(UTP) (PETROLEUM, 2012)
80454	MUHAMMAD SADIQ SHAFIQ BIN SAM	B.SC.(COLORADO OF MINES)(PETROLEUM, 2013)
80531	MUHAMMAD SYAMIM BIN HUSSAIN	B.E.HONS.(UTP) (PETROLEUM, 2013)
80471	MUHAMMAD SYAZWAN BIN SAARI	B.E.HONS.(UTP) (PETROLEUM, 2012)
80530	MUHAMMAD ZAHIN BIN ABD RAZAK	B.E.HONS.(UTP) (PETROLEUM, 2013)
80529	NOOR HIDAYAH BINTI ABDUL RASHID	B.E.HONS.(UTP) (PETROLEUM, 2013)
80463	NUR EMMI ANIESHYA BINTI SALEH	B.E.HONS.(UTP) (PETROLEUM, 2012)
80453	NUR FADZLIANA BINTI AZMI	B.E.HONS.(UTP) (PETROLEUM, 2012)
80457	NUR ZULAIKAR BINTI MD JUSOH	B.E.HONS.(UTP) (PETROLEUM, 2014)
80528	NURFUZAINI BINTI ABD KARIM	B.E.HONS.(UTP) (PETROLEUM, 2013)
80527	NURUL NADIA EZZATTY BINTI ABU BAKAR	B.E.HONS.(UTP) (PETROLEUM, 2013)

80458	ONG SHEAU HUN	B.E.HONS.(UTP) (PETROLEUM, 2012)
80464	RAHIMAH BINTI ABD HALIM	B.E.HONS.(UTP) (PETROLEUM, 2012)
80465	RAIHANA BINTI RADZLAN	B.E.HONS.(UTP) (PETROLEUM, 2013)
80525	RAIS BIN HALID	B.E.HONS.(UTP) (PETROLEUM, 2013)
80461	RAJA MUHAMMAD HAFIZI BIN RAJA ISMAIL	B.E.HONS.(UTP) (PETROLEUM, 2014)
80459	SAIFOL ANUAR BIN MAT ISA	B.E.HONS.(UTM) (PETROLEUM, 2011)
80467	SATHISHKUMAR A/L ARUMUGAM	B.E.HONS.(UTP) (PETROLEUM, 2013)
80524	SATTIYARAJU A/L SELLAPAN	B.E.HONS.(UTP) (PETROLEUM, 2013)
80523	SITI SHAHARA BINTI ZAKARIA	B.E.HONS.(UTP) (PETROLEUM, 2013)
80522	SIVANESAN A/L SANTHASWDI	B.E.HONS.(UTP) (PETROLEUM, 2013)
80470	TANG CHUIN CHERNG	B.E.HONS.(UTP) (PETROLEUM, 2013)
80469	WONG VUN NYAP, DARREN	B.E.HONS.(UTP) (PETROLEUM, 2012)
80521	ZULHILMI BIN MOHD ISMAIL	B.SC.(PENNSYLVANIA) (PETROLEUM & NATURAL GAS, 2011)

KEJURUTERAAN POLIMER

80556	AHMAD FAIZAL BIN MOHD RAMLY	B.E.HONS.(USM) (POLYMER, 2008) M.SC.(USM)(POLYMER, 2011)

KEJURUTERAAN SISTEM MEKANIKAL

80753	MOHD ZARIR BIN ISMAIL	B.E.(TAKUSHOKU) (MECHANICAL SYSTEM, 2011) M.E.(TAKUSHOKU) (MECHANICAL SYSTEM, 2013)

KEJURUTERAAN SUMBER MINERAL

80697	IMRAN BIN MOHAMAD DAUD	B.E.HONS.(USM)(MINERAL RESOURCES, 1998)
80193	MAHZAN BIN HAMDAN	B.E.HONS.(USM)(MINERAL RESOURCES, 2009)

PERMOHONAN MENJADI AHLI 'COMPANION'

KEJURUTERAAN AEROANGKASA

No. Ahli	Nama	Kelayakan
78472	DR. MOHD RASHDAN BIN SAAD	M.E.HONS. (MANCHESTER) (AEROSPACE, 2009) PHD.(MANCHESTER) (AEROSPACE, 2013)
79341	LOW HOCK SOON	B.E.HONS.(USM) (AEROSPACE, 2012)

KEJURUTERAAN ALAM SEKITAR

No. Ahli	Nama	Kelayakan
79007	TAN LEY BINN	B.E.HONS.(UNIMAP) (ENVIRONMENTAL, 2012)

KEJURUTERAAN AWAM

No. Ahli	Nama	Kelayakan
79350	ABDUL HALIM BIN ABDUL HAMID	B.E.HONS.(MALAYA) (CIVIL, 1985)
78870	ABDUL HAYYI BIN AWANG	B.E.HONS.(UTHM)(CIVIL, 2008)
78470	AGILARAJAN A/L SELVARAJAH	B.E.HONS.(UTHM)(CIVIL, 2011)
78413	AHMAD FAUZAN BIN AHMAD FIKRI	B.E.HONS.(UITM)(CIVIL, 2014)
78873	ARIF SYAHIR BIN AHMAD NASARUDDIN	B.E.HONS.(UITM) (CIVIL, 2012) M.SC.(EAST LONDON) (CIVIL, 2014)
78862	ATIQAH BT AZMI	B.E.HONS.(UNITEN) (CIVIL, 2013)
78464	CHAI SHIONG YEN	B.E.HONS.(MALAYA) (CIVIL, 2011)
79548	CHANG KAI LIANG	B.E.HONS.(UTAR)(CIVIL, 2015)
79547	CHEAM KOK SENG	B.E.HONS.(UTAR)(CIVIL, 2015)
78863	CHIN YU LIN	B.E.HONS.(UTM)(CIVIL, 2014)
78456	CHRISTOPHER CHERIAN GEORGE	B.E.HONS.(MALAYA) (CIVIL, 2012)
79262	DR. CHOW MING FAI	B.E.HONS.(UTM) (CIVIL, 2007) PHD.(UTM)(CIVIL, 2012)
78454	DR. ZAINORIZUAN BIN MOHD JAINI	B.E.HONS.(KUITTHO) (CIVIL, 2006) M.SC.(SWANSEA)(COMP. MODELLING & FINITE ELEMENTS IN ENRG. MECHANICS,2009) P.HD.(SWANSEA)(CIVIL, 2013)
79338	ERLINDA MASI	B.E.HONS.(UMS)(CIVIL, 2007)
78859	FAIZAL AZFAR BIN ZULKEFLI	B.E.HONS.(UTP)(CIVIL, 2011)
79035	G. MARAHATHANANGGAI A/P GOVINDAN	B.E.HONS.(UNITEN) (CIVIL, 2007)
79311	HENG RENYI	B.E.HONS.(UMP)(CIVIL, 2014)
78462	JILL JACKSON	B.E.HONS.(UITM)(CIVIL, 2012)
79315	KEW KA WAING	B.E.HONS.(USM)(CIVIL, 2009)
78891	KHOR OOI CHONG	B.E.HONS.(UTM)(CIVIL, 2007)
78461	LAW PUANG RONG, KELVIN	B.E.HONS.(SWINBURNE) (CIVIL, 2011)
79538	LEE JUN LIM	B.E.HONS.(UTAR)(CIVIL, 2015)
79536	LEE KUAN MENG	B.E.HONS.(UTAR)(CIVIL, 2015)
79533	LIAN CHAU YUAN	B.E.HONS.(UTAR)(CIVIL, 2015)
79541	LIM YONG KEN, GEBER	B.E.HONS.(UTAR)(CIVIL, 2015)
78894	LING ZHONG YIE, JOSHUA	B.E.HONS.(UTP)(CIVIL, 2010)
79530	LONG JLA HAO	B.E.HONS.(UTAR)(CIVIL, 2015)
79354	MAURICE MICHEAL JOMININ	B.E.HONS.(UMS)(CIVIL, 2009)
79344	MOHAMMAD RADZEE BIN AHMAD	B.E.HONS.(UTP)(CIVIL, 2007)
78425	MOHD ADLI BIN SANI	B.E.HONS.(UTM)(CIVIL, 2010)
78465	MOHD FAHKERY BIN HASSAN	B.E.HONS.(UITM)(CIVIL, 2012)
79334	MOHD HAFIZ BIN MOHD SABRI	B.E.HONS.(UITM)(CIVIL, 2012)
79011	MOHD HAMDAN BIN HASSAN	B.E.HONS.(UNITEN) (CIVIL, 2009)
78888	MOHD NORHALISHAFIQ BIN AZHAR	B.E.HONS.(UITM)(CIVIL, 2013)
78073	NG SHENG YEONG	B.E.(TASMANIA)(CIVIL, 2008)
79524	NG WUI KUEN	B.E.HONS.(UTAR)(CIVIL, 2015)
79523	NG YOONG LIM	B.E.HONS.(UTAR)(CIVIL, 2015)
78881	NGU SIAW LING	B.E.HONS.(UTM)(CIVIL, 2010)
79335	NOOR EZNIRA BINTI RHAZALI	B.E.HONS.(UITM)(CIVIL, 2011)
78490	NOR AISYAH BINTI ABDUL RAHIM	B.E.HONS.(UTM)(CIVIL, 2013)
78890	NOR AZIAH BINTI ISHAK	B.E.HONS.(UTM)(CIVIL, 2011)
79336	NOR FARHANA BINTI ISMAIL	B.E.HONS.(UITM) (CIVIL, 2009) M.SC.(UITM)(CIVIL-STRUCTURE, 2011)
78877	NORAZMI BIN LOP	B.E.HONS.(UITM) (CIVIL,2011)
79347	NU'MAN BIN HILMY MUJAHID	B.E.HONS.(UTP)(CIVIL, 2011)
79317	NUR SYAHEERA BINTI OTHMAN	B.E.HONS.(UTHM)(CIVIL, 2010)
78876	NURULHIDAYAH BINTI ZAINUDDIN	B.E.HONS.(MALAYA) (CIVIL, 2014)
79521	OOI ZHENG HUAN	B.E.HONS.(UTAR)(CIVIL, 2015)
78449	RAHMAN BIN ABDULLAH@TOR WENG SONG	B.SC.(NEWCASLE UPON TYNE)(CIVIL, 1984)
79298	RAWI BIN ISA	B.E.HONS.(UPNM)(CIVIL, 2013)
78412	SALLEHUDDIN SHAH BIN AYOP	B.E.HONS.(UTM)(CIVIL, 2000)
78896	SHAHRUL NIZA BIN MOKHATAR	B.E.HONS.(KUITTHO) (CIVIL, 2006) P.HD. (KYUSHU)(CIVIL & STRUCTURAL, 2013)
79337	SHOBAN A/L GUNASEKARAN	B.E.HONS.(UNITEN) (CIVIL, 2013)
78874	SITI HAWA BINTI HAJI MEAN	B.E.HONS.(UITM)(CIVIL, 2013)
79517	SO KAH KHEONG	B.E.HONS.(UTAR)(CIVIL, 2015)
78883	SYAZIE NORDZAIMA BINTI ALI MOHAMAD	B.E.HONS.(UNIMAS) (CIVIL, 2010) M.E.(UNIMAS)(CIIVL, 2011)
79514	TAN JUN YUEN	B.E.HONS.(UTAR)(CIVIL, 2015)
79513	TAN KHAI CHUAN	B.E.HONS.(UTAR)(CIVIL, 2015)
79304	TAN MIAO GIN	B.E.HONS.(UNIMAP) (CIVIL, 2014)
79512	TAN SOO CHEE	B.E.HONS.(UTAR)(CIVIL, 2015)
78864	TAN WEE KEONG	B.E.HONS.(UNITEN) (CIVIL, 2014)
79331	TANGGARAJ A/L CHANDARAGUNALA	B.E.HONS.(IUKL)(CIVIL, 2014)
79515	TEH IT SEEN, STEPHEN	B.E.HONS.(UTAR)(CIVIL, 2015)
79543	TIU SHAN KHAI, ERVIN	B.E.HONS.(UTAR)(CIVIL, 2015)
79260	TUEE HUI WEN	B.E.HONS.(LEEDS) (CIVIL & STRUCTURAL, 2012) M.SC.(LEEDS) (STRUCTURAL, 2013)
79333	VICKNEISAN A/L KATHERASON	B.E.HONS.(IUKL)(CIVIL, 2013)
79255	WAN MOHAMED KHAIRIL BIN WAN ISA	B.E.HONS.(UITM)(CIVIL, 2011)
79295	WONG CHOONG KIET	B.E.HONS.(IUKL)(CIVIL, 2014)
79303	WONG MEI YEE	B.E.HONS.(UTM)(CIVIL, 2000)
78872	WONG SEN SEN	M.E.HONS. (BIRMINGHAM)(CIVIL, 2007)
78884	WONG SHER MEIN	M.E.HONS.(SHEFFIELD) (CIVIL & STRUCTURAL, 2014)
79509	WONG TZE YUNG	B.E.HONS.(UTAR)(CIVIL, 2015)
78478	YEW CHOO YANG	B.E.HONS.(UMS)(CIVIL, 2012)

KEJURUTERAAN BAHAN

No. Ahli	Nama	Kelayakan
79294	DR. CHANG BOON PENG	B.E.HONS.(USM) (MATERIALS, 2009) P.HD. (USM)(COMPOSITE, 2014)
79312	DR. TUAN ZAHARINIE BINTI TUAN ZAHARI	B.E.HONS.(MALAYA) (MATERIALS, 2006) M.E.SC.(MALAYA)(ENRG. MATERIALS, 2009) P.HD.(MALAYA)(2014)

KEJURUTERAAN BIOPERUBATAN

No. Ahli	Nama	Kelayakan
78451	CHOY YEE WA	B.E.HONS.(UTAR)(BIO-MEDICAL, 2013)
79257	DR. LIEW YIH MIIN	B.E.HONS.(MALAYA) (BIO-MEDICAL, 2005) P.HD.(WESTERN AUSTRALIA)(2013)
79348	GAYATHRI A/P THANABALAN	B.E.HONS.(MALAYA) (BIOMEDICAL, 2006)

KEJURUTERAAN ELEKTRIKAL

No. Ahli	Nama	Kelayakan
79057	ABU BAKAR HAFIS BIN KAHAR	B.E.(RYUKYUS) (ELECTRICAL & ELECTRONIC, 2010)
78892	AHMAD ARIF B. AZLI	B.E.HONS.(UPNM) (ELECTRICAL & ELECTRONICS, 2012)
79097	AHMAD FAIZAL BIN AHMAD DIN	B.E.(UMP)(ELECTRICAL-POWER SYSTEMS, 2012)
79015	AHMAD FATIHY BIN MOHD SUBBRI	B.E.HONS.(ADELAIDE) (ELECTRICAL & ELECTRONICS, 2006)
79082	AHMAD KHAIRUL HAFFIZ BIN ISMAIL	B.E.HONS.(APU) (ELECTRICAL & ELECTRONIC, 2013)
79089	AHMAD NAZRIN BIN MOHD ROMI	B.E.HONS.(CURTIN) (ELECTRICAL, 2007)
79084	AHMAD SYAZWAN BIN AZNAN	B.E.HONS.(UCSI) (ELECTRICAL & ELECTRONICS, 2014)
79076	AMIRULLAH BIN ZAINUDIN	B.E.HONS.(UNITEN) (ELECTRICAL & ELECTRONIC, 2009)
79090	ANA MARDHIAH BINTI JOHARI	B.E.HONS.(UNITEN) (ELECTRICAL POWER, 2013)
79094	BRACEWELL ANAK MIGA	B.E.HONS.(UTEM) (ELECTRICAL-INDUSTRIAL POWER, 2008) M.E.(UNITEN) (ELECTRICAL, 2012)
79293	CHONG FOOK MING	B.E.HONS.(UCSI) (ELECTRICAL & ELECTRONIC, 2012)

78417	CHONG RUEY SHENG	B.E.HONS. (NOTTINGHAM TRENT) (ELECTRICAL & ELECTRONIC, 1999)
79037	CHOW HIN MUN	B.E.HONS.(UTEM) (ELECTRICAL-INDUSTRIAL POWER, 2014)
79073	DE-APLI'ANTO PARAN LAING	B.E.HONS.(UTM) (ELECTRICAL, 2003) M.E.(UTM)(ELECTRICAL-POWER, 2005) P.HD. (CARDIFF)(2014)
79028	DR. MUHAMMAD SAUFI BIN KAMARUDIN	B.E.HONS.(UTM) (ELECTRICAL, 2007)
79101	EZWAN FARIT BIN AHMAD	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79091	FARIS MARWAN BIN ABDUL RAHMAN	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79070	FATIN FATEHAH ABD WAHAB	B.E.HONS.(UITM) (ELECTRICAL, 2015)
78452	GOH CHING CHOK	B.E.HONS.(UTP) (ELECTRICAL & ELECTRONICS, 2007)
78424	HAZRIZAM BIN AB.RAHIM	B.E.HONS.(UNITEN) (ELECTRICAL POWER, 2006)
79017	IMRAN BIN SUTAN CHAIRUL	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79098	IZZATASWAD BIN IBRAHIM	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79067	KHAIRUL ANWAR BIN JOPRI	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79100	KHARISMI BIN BURHANUDIN	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79021	KOK SIEN EE	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79537	LEE KING LOON	B.E.HONS.(UTAR) (ELECTRICAL & ELECTRONIC, 2015)
78075	LING YANG MING	B.E.HONS.(WALES) (ELECTRICAL & ELECTRONICAS, 2003) M.SC.(UMIST) (ELECTRICAL POWER, 2004)
79005	LIU SU HUNG	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79343	LO CHIN KIM	B.E.HONS.(UTAR) (ELECTRICAL & ELECTRONIC, 2009) M.E.SC.(UTAR)(2012)
79063	MOHAMAD ARIFF NUR HAKIM BIN MOHAMAD ZAHIR	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79325	MOHAMAD HAFIZ BIN MUSTAPHA	B.E.HONS.(UTM) (ELECTRICAL & ELECTRONIC, 2009)
79085	MOHAMAD HAFIZUL HARIZ BIN MAHAZIR	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79077	MOHAMAD SHAIR BIN MOHAMED ISA	B.E.HONS.(UITM) (ELECTRICAL, 2015)
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79062	MOHAMMAD NOOR IZHAR MAT SALLEH	B.E.HONS.(UITM) (ELECTRICAL, 2015)
78414	MOHD AISAR BIN ABDULLAH@DOLLAH	B.E.HONS.(UTHM) (ELECTRICAL, 2009)
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78420	MOHD FADHILLULLAH BIN ABDULLAH	B.E.HONS.(UITM) (ELECTRICAL, 2012)
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79329	MOHD FU'AD BIN SUKAR	B.E.HONS.(UITM) (ELECTRICAL, 2007)
78475	MOHD HAFIZ @ HERY HAMZAH	B.E.HONS.(UNIMAP) (ELECTRICAL SYSTEM, 2009)
78885	MOHD HAZIQ BIN MOHD NOOR	B.E.HONS.(UNITEN) (ELECTRICAL & ELECTRONICS, 2010)
79060	MOHD HEFNEY BIN MOHD SAIBON	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79078	MOHD KHAIRI BIN MOKHTAR	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79072	MOHD KHAIRIL BIN RUMLI	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79345	MOHD KHAIRUNAZ BIN MAT DESA	M.E.HONS. (LOUGHBOROUGH) (ELECTRICAL & ELECTRONIC, 2008)
78423	MOHD NAZIRUL MUBIN BIN ABD RAHMAN	B.E.HONS. (CANTERBURY) (ELECTRICAL & ELECTRONICS, 2014)
79256	MOHD SAFWAN BIN RAMLI	B.E.HONS.(UMS) (ELECTRICAL & ELECTRONIC, 2013)
78483	MOHD YUSRI BIN SARDAR ALI	B.E.HONS.(UNIMAP) (ELECTRICAL SYSTEM, 2012)
78480	MOHD ZUNNUR BIN ANWAR	B.E.HONS.(UITM) (ELECTRICAL, 2012)
79080	MUHAMAD SAFWAN BIN ABDULLAH	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79012	MUHAMMAD FAREZSHAFIQ BIN MOHD YEEN	B.E.HONS.(UITM) (ELECTRICAL, 2015)
79083	MUHAMMAD IZZAT BIN ISHAK	B.E.HONS.(UITM) (ELECTRICAL, 2015)
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78077	MURALI A/L HARIPALAN	B.E.HONS.(MMU) (ELECTRONIC-TELECOMMUNICATION, 2007)
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79099	NATASHA BINTI MUKHTAR	B.E.HONS.(UITM) (ELECTRICAL, 2015)
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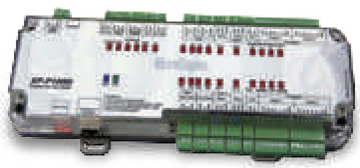

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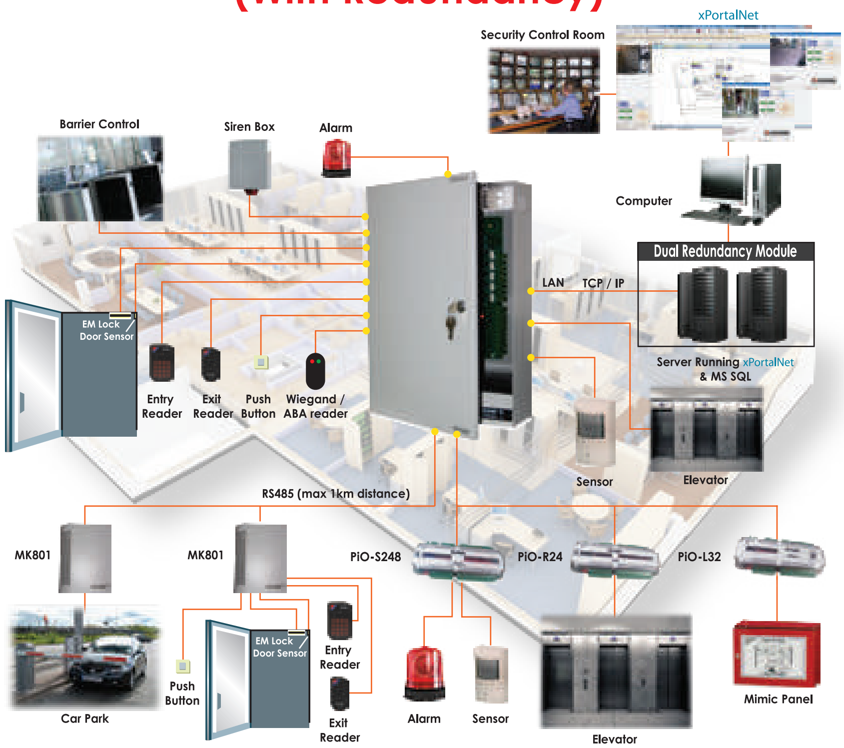

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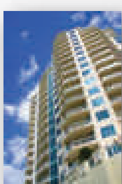

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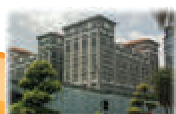

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