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Newsletter Summer 07
會員通訊

MESSAGE FROM THE PRESIDENT

As summer is approaching, besides planning for your summer getaways, I would like to draw your attention to the deadline for all of your construction workers to complete the construction registration mandated by the government before September 1, 2007.

Construction Workers Registration Ordinance (CWRO), enacted in July 2004 and came into effect on 29 December 2005, established the legal framework for the mandatory registration system for all construction workers. Thus, all construction workers are required to be registered under the CWRO according to their skill levels or as a general worker. Anyone fails to register will be prohibited from carrying out any construction works on site. Depending on the worker's qualifications of a designated trade as specified under Schedule 1 of the CWRO, the worker may seek registration as either a skilled, semi-skilled worker in that designated trade or as a general worker. Through the registration system, the skill levels of construction worker can be ensured and a quality culture in the construction industry will be fostered. From September 1, 2007, every construction worker is required to possess a construction registration card in order to gain access to construction site.

Raymond Synn
President

However, as of April 30, 2007, the registration figure for air-conditioning trade is still at an unbelievably low level and it will eventually lead to a serious situation whereby we may not have sufficient or even no registered skillful workers on site. Still, it is not too late to register now and I would like to take this opportunity to urge our members to promote this to every worker who has not yet registered.

Apart from the above, many "non-construction workers" are required to work on site still and it is indeed not practical or reasonable to ask everyone to register as construction worker in order to gain entrance eligibility. Thus, some certain guidelines from the government bodies are urgently required for exempting and/or clarifying the registration of the non-workers as follows:

1. Managerial staff of specialist contractor like PM, Engineers, etc.;
2. Site supervision staff such as supervisors, foremen, etc.;
3. Testing and commissioning staff including T&C manager, engineer, technician, and/or specialist engineers from overseas;
4. Supplier who is required to perform after sales service on site such as start up, training, etc.

I certainly look forward to seeing the relevant government bodies to consider the above issue and make the CWR into a great success.

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Contents

節省能源是現今熱門的話題。香港政府機電工程署轄下的能源效益事務處是於1995年開設，曾經出任能源效益事務處總工程師的林錦權先生，會為我們細說往事。

林錦權

流金歲月

林錦權先生，行內人稱「KK」，於1965年中學畢業後加入政府部門擔任文員工作。KK一面工作，一面於晚間在工專夜校進修，於1969年取得電機工程高級文憑後，轉到公務局在郭炳基先生（Mr. P. K. Kwok）的小組工作。在1972年，KK更被「香港政府訓練獎學金」挑選至蘇格蘭的Strathclyde University修讀空調課程。於1975年回港後升為助理工程師，KK在1980及1988年間分別在建築署被提升為工程師及高級工程師。更於1994 年被派到英國牛津的College of Petroleum Study修讀有關能源課程，在那時候可以説是一個很新的概念。於1995年轉到能源效益事務處工作，到1998年升為總工程師，直至2002年退休為止。

三個「百樂」

所謂有伯樂而後有千里馬，KK曾經遇到三位良師益友，對他一生的事業有着很大的影響。第一位是郭炳基先生，郭先生是KK的啟蒙老師，令KK從文職轉到工程界發展。第二位是李永祺先生，慧眼識英雄，挑選了KK到英國修讀空調及工程課程。第三位是Mr. Douglas Newton，他實用的空調設計知識，使KK在空調行業應用方面更上一層樓。

難忘的往事

70年代的商業大廈，很多是沒有空調供應。空調機組也只限於自己組裝的直接澎漲式機組。油壓式的控制雖然反應比較慢，但當時來説已經相當不錯。70年代尾至80年代初，因大廈外型已經漸趨多樣化，直接澎漲式機組會有平衡困難。冷水式機組就應運而生，而電動式的控制也流行起來，大埔政府合署的空調設計就是應用了這種概念。

到了1983至1984年，啟德機場改善工程第四期的時候，開始改用電子控制，但當時中央電腦還未發展十分完善，還停留在數據收集盤(Data Gathering Panel)的階段。直至到80年代末期和90年代初期，啟德機場改善工程第五期的時候，中央電腦才開始被應用於樓宇控制方面，但體積還是很龐大。現在科技日新月異，微型電腦已經非常普遍地應用在機電行業。

説到印象深刻的項目，就要數到東區醫院及喜靈洲監獄。東區醫院是全港第一個政府工程項目，選用直接分判商制度(Domestic Sub-Contractor) 。當時全港機電工程承辦商曾經發起杯葛行動，不進行投標，但最後政府引入外國機電工程承辦商才能順利推行。整個工程到最後都出現延誤，各方代表開會都有律師在場劍拔弩張，氣氛非常緊張。最後還是用軟硬兼施及彈性處理下，把整個項目在限期前完成。

喜靈洲監獄原是痲瘋病院，開發初期，大家都很害怕到工地做勘察工作，主要是對痲瘋病認識不足。而當時交通亦不太方便，很多設施在設計時都盡量不假外求，還要把這個低密度監獄的保養工作減至最少，可説是一項大挑戰。

説到最難的項目，當然要數啟德機場第四期的改善工程。當時機場每天也在運作，工作只能在晚上分段進行，一點也不能疏忽及大意。

KK於1995年轉到能源效益事務處工作，一直致力推動有效地使用能源及再生能源。其實當時香港人對能源效益不太注意，到2000年初，在政府的推動及教育下，才漸漸受到重視，能源效益事務處亦由最初的十多人，到2002年增至六十多人來滿足不同的人手需求。很多新穎的能源效益概念亦是由能源效益事務處一手推動，例如區域製冷、能源守則、再生能源、變頻及變速裝置和省電光管等等。他們還曾經到國內跟一些工廠直接交流，以加速產品的開發。

寄語行業

一個行業要成功，就要提高自身對政府及商界的影響力。行業必需要團結及有足夠資源去跟政府及政界人仕進行游説及反映意見。政府推行直屬分判商和設計及建造商制度是一個倒退現象，機電工程承辦商要有權參予及提供意見，機電工程的水平才能提高。不然，政府及用家往往只能得到最平最普通的設計，不能達到世界級水平，對推行節約能源是一個絆腳石。夢想與現實有時是有距離的，但只要行業齊心就能改變現況。

退休後的現況

KK沒有因退休而停下來，他現時在多間大學教授屋宇設備課程，為培育新一代盡一分力。在很多學會的活動中，我們也找到KK的踪影。閒時KK最喜愛旅行及品嚐當地美食，只要有山水秀麗的地方，也可能有機會踫上他。下次想不到去那裏旅行，不妨找KK提供一些意見。

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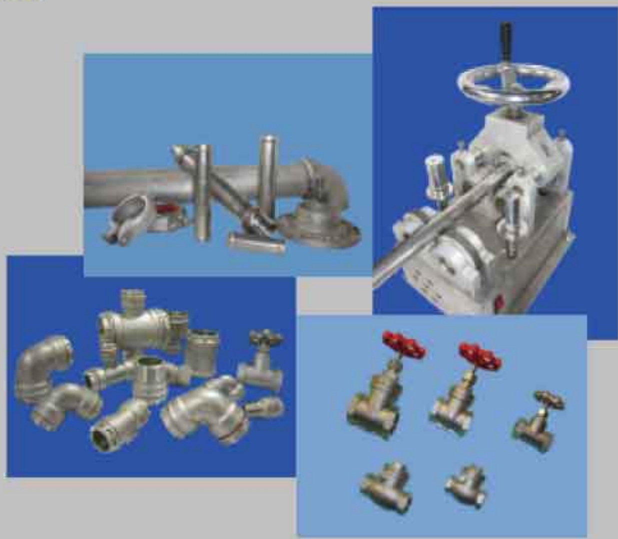

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Fire Rated Ductwork & Enclosure

Background

Buildings are usually sub-divided into compartments by walls and floors constructed to prevent the spread of fire to, or from, another part of the same building. The intention is to contain the fire in the compartment in which it begins, thereby stopping its spread from one compartment to another. The Building Regulations describe the design considerations that are required to be adhered to by Architects and Designers, and these include the fire rating and the maximum size of those compartments.

There are three methods of fire protection related to ductwork:

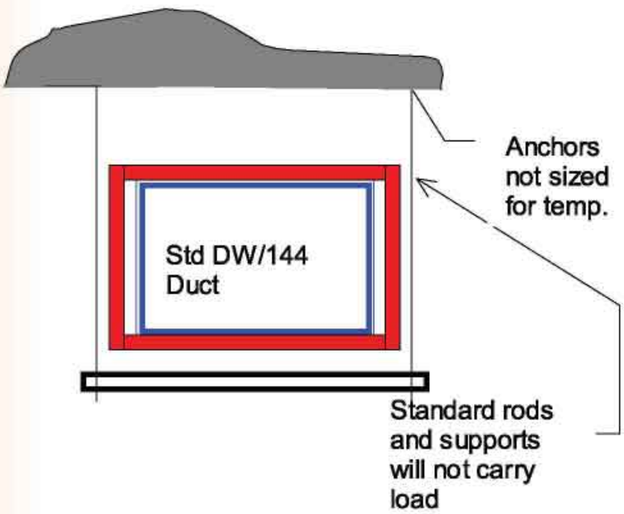
1. Use of Fire Dampers
2. Use of Builderswork Shafts
3. Use of Fire Rated Ductwork Systems

For the fire rated ductwork systems, board system have been used traditionally to use extra hangers and supports to make the ductwork becoming fire resistant. However, there are some problems arise from this board system, for example, wastage of material, limited headroom and extra labour cost are required.

Recently, some new alternative systems are developed to replace this traditional method such as the fire rated coating system and the enhanced ductwork system.

1. Board System

For the installation method, fire boards are cladded over the metal framework or used directly to construct it as the ductwork itself. The construction of duct is normally executed by the sub-contractor. Suppliers are usually only selling the boards. Moreover, more components would be used for this system, such as heavy fire rated boards, screws, staples and metal framework. The system should only be done on-site. Therefore, the quality control and source of responsibility of the system is very difficult during and after installation.



2. Enhanced Ductwork System

The principle of this system is to use thicker metal sheet and much bigger hanger and support in order to make the ductwork fire resistance. As the fire rating are 4 hour for Stability and Integrity only, high density insulation are needed to be cladded over the ductwork surface. For the construction standard of the ductwork, it should follow the manufacturer's standard.

3. Fire Rated Coating System

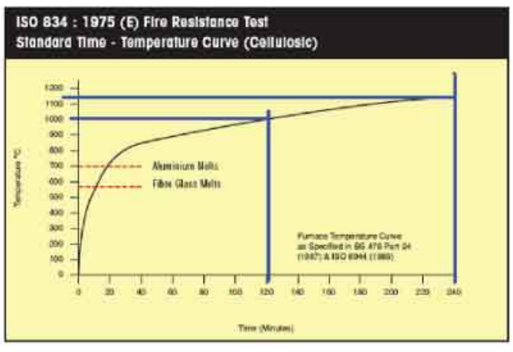
A thin layer of fire rated coating (with thickness below 1mm) is sprayed or brushed on the ductwork surface to make it fire resistance. It can be done in factory and sent to site ready to blot up. On-site application is also allowed. Ductwork is produced in sections and is assembled on site utilizing tested fireproof gaskets / sealants. The design and construction of duct are also very flexible. Any shape of ductwork such as rectangular, flat oval and circular ducts are also available.

Actually, it is the lightest fire rated duct system available. Colour of the system can be changed by painting or spraying any desired water based colour paint on the surface of this coating.

Testing Requirements

The complete fire rated duct system should been tested to BS 476 Part 24 (1987) and ISO 6944 (1985) (Method for determination of the fire resistance of ventilation ducts) up to a temperature of 1133 °C. The purpose of this test is to measure the ability of a ductwork system to resist the spread of fire from one fire compartment to another without the aid of fire dampers.

The following is the temperature of the furnace according to this testing standard.



Giving temperature rise as a function of time for all British Standard 476 Part 24 (1987) & ISO 6944 (1985) Fire Tests.

The fire rated ductwork shall be expressed in minutes of duration of heating until failure occurs, according to one or more of the following criteria.

1. Stability

Stability failure shall be deemed to have occurred when the duct specimen collapses inside or outside the area in which there is a fire in such a manner that the duct no longer fulfils its intended function.

2. Integrity

The presence and the formation of holes or other openings in the duct in the room adjacent to the fire (or through the fire stopping at the dividing wall) through which flames or hot gasses can pass, shall constitute integrity failure.

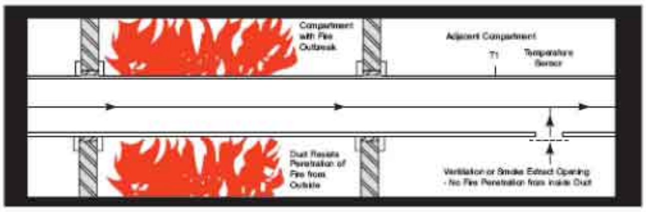
3. Insulation

Insulation failure shall be deemed to have occurred when the temperature rises above ambient temperature on the external face of the duct outside the area in which the fire is present, and exceeds either

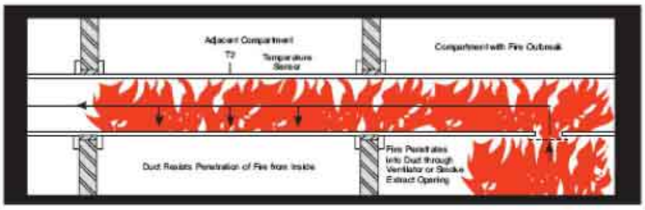
1. 140 °C as an average value, or
2. 180 °C as a maximum value.

The test differentiates between types of fire exposure as below.

i. Duct type A – Fire outside the duct



ii. Duct type B – Fire inside the duct



Application

There are four basic types of fire resistant ductwork that could be required or have special use under fire conditions. The following terms are used in identifying varying performance criteria for such ducts.

1. **Ventilation Fire Ductwork**
2. **Smoke Extract Fire Ductwork**
3. **Non Domestic Kitchen Extract Fire Ductwork**
4. **Pressurization Ductwork**

System Comparison

The following table is the comparison amongst three systems.

	Board System	Enhanced Ductwork System	Fire Rated Coating System
Working Principle	Calcium Silicate Board installed onto steel channel framework / Construct the board directly as the ductwork	Enhanced metal framework, stronger hanger and support	A thin layer of water-based compound coating on the surface metal framework
Thickness	25-80 mm	Greater than 1mm (For ductwork itself)	Under 1 mm
Weight	Heaviest	Heavier	Lightest
Wastage	High	Low	Low
Applicator	Board and ductwork have separated installer	Apply by authorized applicator	Apply by authorized applicator
Application	Only on-site is allowed, with plenty of elaborate boarding and fixing details	Both on-site and off-site installation are allowed, but specified ductwork construction and fixing details must be followed	Both on-site and off-site installation are allowed by simple spray on or brush the coating onto the ductwork surface
Air Leakage	High leakage and requires more costly method, such as corners angle bars to reduce leakage	No leakage since ducts are sealed and joints are fixed with gaskets	No leakage since ducts are sealed and joints are fixed with gaskets (Comply to DW/143)
Testing	BS, UL & ISO	BS & ISO	BS, UL & ISO
Fire Rating	Up to 4 hour	Up to 4 hour	Up to 4 hour
Duct Construction Standard	DW/144 or SMACNA	Manufacturer's Standard	DW/144 or SMACNA

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Conversion of Single-loop Chilled Water System to Variable Flow for Improved Energy and Control Performance

Cary Chan, Tony Lee and Jean Qin
Swire Properties Management Ltd.

ABSTRACT

Advances in chiller technology and building management system (BMS) present new energy conservation opportunities for the chilled water loop design and control. The use of variable primary flow in chilled water systems is increasing due to its potential in reducing energy consumption and initial cost when comparing with the more conventional chilled water systems, such as de-coupler and constant primary flow single-loop systems.

A detailed feasibility study is carried out on the conversion of an existing constant primary flow single-loop system to a variable primary flow system. The chilled water pumps of this project have been oversized in the initial design. Numerical models of pumps and chiller evaporating temperature are developed from the physical knowledge, in-situ tests and actual plant operating data. Prediction by modeling indicates significant pumping energy saving by the conversion together with an improvement in COP of the chillers as the result of the increase in chilled water return temperature.

The conversion involves the installing of variable speed drives (VSDs) and the adding control points for the chilled water pumps. The BMS is re-programmed for the new operation. A long-term measurement and verification (M&V) plan is set up at the outset. Test results show that around 50% pumping energy could be saved by the conversion. A higher average chilled water return temperature is also observed. This paper presents the retrofitting project with detailed energy calculation, in-situ M&V, the experience for the conversion and the discussion on the advantages & disadvantages of the system.

Keywords: building management system, variable primary flow, variable speed drive, measurement and verification

1. INTRODUCTION

There are more energy saving opportunities for the chilled water loop design and control as a result of the development of chiller technologies and building management systems (BMS). Advances in capacity controls, freeze protection, and flow detection have increased chiller operation stability. Manufacturers are providing more detailed variable primary flow application details including the recommended range of chilled water tube velocity.

The traditional primary/secondary chilled water systems are facing challenges due to the existence of low chilled water temperature differentials (ΔTs) in almost all big distributed chilled water systems (Kirsner, 1996). Kirsner even predicted the "demise" of primary-secondary systems. To improve the performance of primary/secondary systems, Fiorino (2002) listed 25 "best practices" to achieve high chilled water ΔTs ranging from component selection criteria to distribution system configuration. However, great efforts are needed to implement the "best practices". Avery (1998) recommended installing a check valve in the existing de-coupler bypass, which could achieve more energy efficient operation. For new construction, he (Avery, 2001) suggested using variable flow primary-only system. Years ago, Hartman (1996) discussed the design issues of variable chilled water flow through chillers. The studies concluded that the varying chilled water flow can save pumping energy. Redden (1996) investigated the impact of variable water flow on the chiller performance. The measured results showed higher evaporating temperatures when variable water flow was applied. Varying chilled water flow through an evaporator also decreased the compressor power consumption. Bahnfleth and Peyer (2003) compared the energy performance of different chilled water systems (primary/secondary, primary/secondary with check valve and variable flow primary-only). It was concluded that the reduction in annual pumping energy due to variable primary flow is generally between 25% and 50%. Relative to total plant energy, this is a reduction of 2% to 5%. Based on variable primary flow, Liu (2002) proposed a new variable flow system. The further advantage of this new system is that it has the same decoupling capacity of the primary/secondary systems to provide excessive water to buildings.

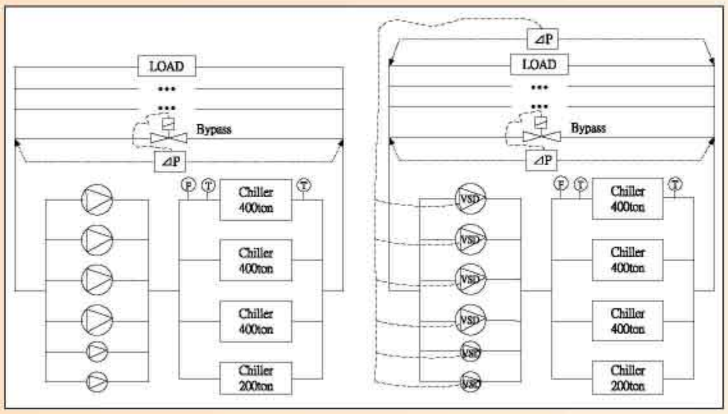
In Hong Kong, detailed site surveys on several local chiller plants in the past revealed that there existed a number of problems relating to plant design and operation, which has influenced the overall operating efficiency of the plants (Deng and Burnett, 1997). Deng and Burnett summarized problems generally found in local chiller plants, e.g. plant oversizing and poor instrumentation. To improve energy performance, a number of energy saving approaches were studied and some were applied in plants recently. The use of variable primary flow in chilled water systems is increasing due to its potential in reducing energy consumption and initial cost. Retrofitting constant primary flow plants to variable primary flow is also an energy saving means, especially for those with oversized pumps. Improvements on instrumentation could not only improve plant performance but also ensure the reliable control of advanced systems.

This paper presents a local conversion project of a plant from constant primary flow single-loop system to variable primary flow system. The energy and system performance comparison between the existing system and the proposed variable primary flow is conducted based on numerical models. The energy saving is verified by a long-term measurement and verification (M&V) plan, which is set up at the outset. This paper also shares the engineering experience for the conversion.

2. FEASIBILITY STUDY ON PLANT CONVERSION

2.1 Plant Configuration

The conversion of a central single-loop chilled water system serving a high-rise commercial building located at Hong Kong Island East to variable primary flow was studied after consulting the chiller manufacturer. The system consists of 4 chillers (3nos.x400ton + 1no.x200ton) and 6 pumps. The plant configuration is illustrated in Figure 1. Before the conversion, the chilled water was supplied by constant speed pumps and adjusted by the differential bypass to supply the required amount of water to the different floors. After the conversion, the pumps are installed with variable speed drives (VSDs). The VSDs are controlled by the differential pressure (ΔP) sensor at the farthest branch to meet the instantaneous demand of chilled water. As the allowable chilled water flow through chillers is 60-200% of the design flow, the differential bypass valve seldom needs to operate to ensure the minimum flow through chiller(s).



(a) Before (b) After

Figure 1 Plant configuration

The pumps were originally oversized. Before the conversion, the flow was adjusted by the globe valve at the pump outlet to 30% open. The installation of VSDs could release the globe valve to 100% open and therefore reduce the total head required by the pimps.

2.2 Modeling

To estimate the plant performance and annual energy saving, numerical models of pumps and chiller evaporating temperature are developed from physical knowledge, in-situ tests and plant operating data.

Pump. The performance of the variable speed pumps are determined by the system requirement of chilled water flow rate and the head to deliver the water flow rate to the terminals. The required head is modeled by the simplified system resistance and system flow rate relationship (Equation 1). The energy consumption of the pump is shown in Equation 2, where the efficiency of pump is from manufacturer's catalogues. The efficiency of motor and VSD are deduced from general characteristic curves of motor and VSD (Bernier and Bourret, 1999).

$$P_{pu} = R_{sys} \times V_{sys}^2 \quad (1)$$

$$W_{pu} = \frac{P_{pu} \times V_{pu}}{\eta_{Pu} \times \eta_m \times \eta_{VSD}} \quad (2)$$

Chiller evaporating temperature. The evaporator is modeled by the classical heat exchanger effectiveness based on semi-isothermal process (Bourdouxhe and Grodent, 1999). The heat transfer coefficient-area (AU_{ev}) is deduced from plant operating data.

$$NTU = \frac{AU_{ev}}{4.186 \times M} \quad (3)$$

$$\varepsilon = 1 - e^{\frac{1}{NTU}} \quad (4)$$

$$Q = 4.186 \times M \times (T_{rtn} - T_{sup}) \quad (5)$$

$$Q = \varepsilon \times 4.186 \times M \times (T_{rtn} - T_{ev}) \quad (6)$$

2.3 Energy and System Performance Comparison

By changing the pump speed, and hence the pump head-flow characteristics, the globe valves can be opened to reduce the network resistance. To study on the network characteristics, experiments on globe valve openness of chilled water pump No.2 were conducted. The measurements were taken after the flow meter was calibrated (Table 1). When the system resistance reduced from existing R_1 to fully open R_2 (Equation 7,8) with the consistent differential pressure (ΔP) of 70 kPa, pump head of (P_1-P_{req}) can be saved to deliver the same amount of water (V_1) under the same ΔP control (Equation 9,10). Further saving is expected to control the VSDs by relocating the ΔP control point from the main header to the farthest branch, which gives a better indication of the minimum pump head required.

$$\frac{P_1}{P_2} = \frac{\Delta P + R_1 \times V_1^2}{\Delta P + R_2 \times V_2^2} \quad (7)$$

$$R_2 = R_1 \times (\frac{V_1}{V_2})^2 \times \frac{P_2 - \Delta P}{P_1 - \Delta P} \quad (8)$$

$$P_{req} = \Delta P + R_2 \times V_1^2 \quad (9)$$

$$P_1 - P_{req} = (P_1 - \Delta P) \times [1 - \left(\frac{V_1}{V_2}\right)^2 \times \left(\frac{P_2 - \Delta P}{P_1 - \Delta P}\right)] \quad (10)$$

Table 1 Experiments on globe valve openness

Valve openness	Fully open[2] (12.5 turns)	8.5 turns	4.5 turns	Existing[1] (2 turns)	1.25 turns	0.75 turns
Flow rate (l/s)	**60.4**	60.5	60.1	**52.2**	43.6	28.7
Pump suction (kPa)	**850**	850	850	**850**	850	850
Pump discharge (kPa)	**1130**	1130	1130	**1150**	1160	1180

The existing plant operating data in Year 2005 was logged as the baseline for estimating the performance of the proposed variable flow system. The following data were captured for comparison with the new operating mode:

- chiller annual energy consumption

- pump monthly energy consumption
- hourly operating data:
  chilled water supply temperature / chilled water return temperature / chilled water flow rate through the main header / chilled water flow rate through the bypass line

Pumping energy under the new mode with variable flow is predicted under the condition of globe valves fully open, no bypass flow, ⊿P control point at the farthest branch and ⊿P set-point to be set at 50 kPa. To cater for the chilled water requirement of Year 2005 under the new mode, the pumping energy is estimated by the following steps:

1) estimate the required pump head for the flow rate
2) estimate monthly pumping energy using bin method with Year 2005 flow rate profile and the corresponding new pump head

Figure 2 demonstrates the monthly pumping energy of Year 2005 and the predicted pumping energy under the new mode. About 95,000kWh annual pumping energy saving is predicted.

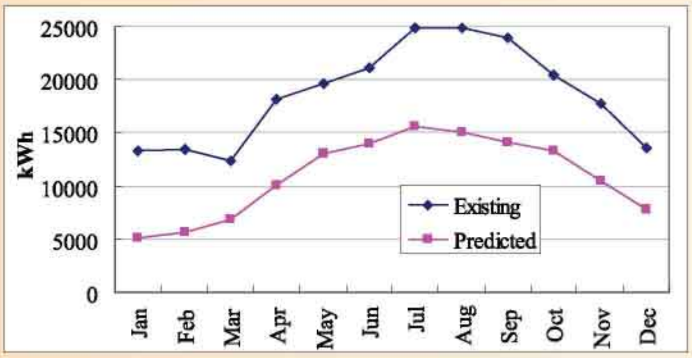


Figure 2 Pumping energy comparison

As the chilled water supply can better match with the chilled water demand, less chilled water will flow through the bypass and hence an average increase of about 0.5 °C in the chilled water return temperature was estimated due to less mixing of chilled water return from load side and chilled water supply from chillers. From the above mentioned chiller evaporating temperature model, a corresponding increase in average chiller evaporating temperature of about 0.1 °C is expected. Based on Wang, et al. (2000), it would result in about 0.2% reduction in chiller energy consumption. In this particular case, a further saving of 4,000 kWh per year is expected due to this rise in average chilled water entering temperature.

The above study shows that the plant conversion is feasible. The energy performance is further improved by 1) fully open the globe valves to reduce system resistance, 2) install the ⊿P sensor at the farthest branch to give the proper signal of the required pump head, and 3) reduce the by-pass flow to minimize the pumped flow.

3. PLANT CONVERSION

The conversion mainly includes the installation of six VSDs for the existing chilled water pumps, adding a remote differential pressure sensor and programming in BMS. The speed of the chilled water pumps is varied according to the set point of the differential pressure (⊿P) across the chilled water supply and return pipes on the roof of the building.

The total project cost is HK$225,000. Except the BMS work which are carried out by the BMS contractor, the VSD installation work was put out for tender and a HVAC contractor was selected for the work. To save cabling cost, the VSD control panels were located near the pumps so that the existing power cables could be used. The pumps were shut down for modification one by one so as to maintain daily chilled water supply. The existing star/delta starters were kept for standby purpose. Once the VSD had been installed, the globe valve at the pump discharge side could be fully opened.

Before testing and commissioning, maximum and minimum speed limits of the VSDs are determined based on the allowable range of evaporator flow rate from the manufacturer. The setting of flow switches for the chillers should be adjusted so that the chiller could operate at its minimum chilled water flow rate without tripping. The differential pressure set point for by-pass control valve was adjusted to maintain the minimum flow through the chillers when the system is operating at very low load. The VSDs should be set to restart automatically after power loss return for facilitating chiller plant automation. Finally, the performance testing on the installation including total harmonics distortion measurement was performed.

4. MEASUREMENT AND VERIFICATION

To quantify the savings by real measurements, a measurement and verification (M&V) plan is set up at the outset. The plan includes monitoring the plant performance before the change, real operating mode comparison during the conversion, and long-term monitoring on plant power consumption.

4.1 Monitoring on Plant Performance

Before the conversion, the plant performance was monitored by logging the chilled water flow rate through the main header and the bypass line, the chilled water supply and return temperature, and all terminal control valve openness. The following observations were noted which indicates a potential for energy saving:

- occurrences of bypass flow
- mostly 3-5 °C supply return temperature difference
- control valve openness was low

4.2 Operating Mode Comparison

With CHWP-1, 4 and 5 installed with VSDs, real operating mode comparison (Figure 1, before vs. after) was conducted from 8/5/2006 to 22/5/2006 as 2 nos. of normal duty chiller (400 ton) and 1 no. of night duty chiller (200 ton) were enough to cater for the cooling load pattern during the period. The comparison was carried out by changing the operating mode daily. 46% for CHWP-1&4 and 56% for CHWP-5 pumping energy saving (Table 2) was recorded. Also, an increase in average chilled water return temperature was observed.

Table 2 Pump operating power comparison

Period (8/5/2006–22/5/2006)	CHWP-1 VSD (22 kW)	CHWP-2 (22 kW)	CHWP-3 (22kW)	CHWP-4 VSD (22 kW)	CHWP-5 VSD (15 kW)	CHWP-6 (15 kW)
kWh consumed	**1026**	1725	2165	**993**	**574**	1449
Running hours	**87.7**	76.6	95	**77.4**	**93.5**	104.7
Average kW	**11.7**	22.5	22.8	**12.8**	**6.1**	13.8

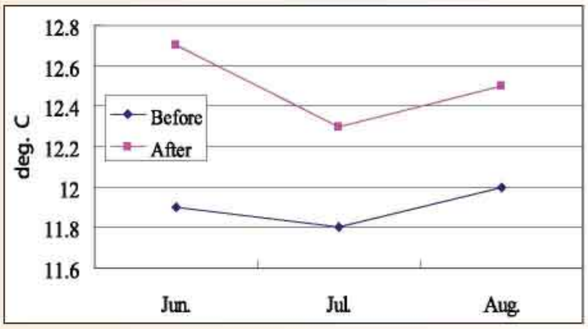


Figure 4
Measured chilled water return temperature

4.3 Long-term Monitoring on Plant Power Consumption

Continuously monitoring on system performance, the following operating data are recorded:

- pump operating Hz
- pump energy consumption
- chilled water flow rate
- chilled water return temperature
- chiller energy consumption

Based on the data of Jun., Jul. and Aug., around 50% pumping energy saving is measured (Figure 3) and an increase of chilled water return temperature is observed (Figure 4). The measurement results are in line with the model prediction.

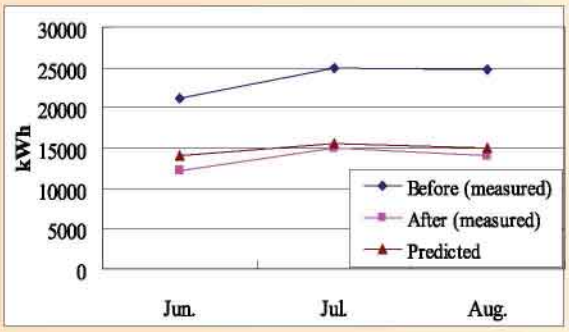


Figure 3
Measured and predicted pumping energy

5. CONCLUSION AND DISCUSSION

The application of variable primary flow with relocated ΔP control shows energy saving opportunities both on pumps and chillers. The measurement results of the plant conversion verified that about 100,000 kWh could be saved annually, which indicates that the payback period of the project is around 2 years. Thus traditional constant flow single-loop systems are recommended to upgrade to variable primary flow, especially for those with oversized chilled water pumps. Further saving could also be explored by differential pressure set-point reset, chilled water supply temperature set-point reset and manually adjusting the balancing valves at the terminals.

However, the conversion makes the bypass control more complex and reduces the reliability of the system since complex control systems are theoretically prone to failure. The traditional systems may be a better choice for buildings where fail-safe operation is essential. With the operation of VSDs, the power quality should be managed.

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NOMENCLATURE

- *AU:* *heat transfer coefficient-area (kW/°C)*
- *M:* *chilled water mass flow rate (kg/s)*
- *NTU:* *number of heat transfer units*
- *P:* *pump head (Pa)*
- *Q:* *cooling load (kW)*
- *R:* *resistance ($N*s^2/m^4$)*
- *T:* *temperature (°C)*
- *V:* *chilled water volume flow rate (m^3/s)*
- *W:* *pump power (kW)*

Greek symbols

- η: *efficiency*
- ε: *effectiveness of heat exchanger*

Subscripts and superscripts

- *ev:* *evaporating*
- *m:* *motor*
- *pu:* *pump*
- *req:* *required*
- *rtn:* *chilled water return*
- *VSD:* *variable speed drive*
- *sup:* *chilled water supply*
- *sys:* *system*

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* Science Park Building 4B, G/F	JRP
* Renovation Works for 48-49/F American Club at Exchange Square	Ferrier Chan & Partners
* Proposed Alteration and Addition Works For New Yoga Studio at 5/F & 9/F., Langham Place.	Kinetic
* Renovation Works for 26/F., Global Strategy Group Ltd. at Great Eagle Centre, Wan Chai.	Kinetic
* Skyplaza North Office Tower, Hong Kong International Airport.	Airport Authority
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ACRA ACTIVITIES 2007

ACRA GOLF DAY ACTIVITY

The ACRA Annual Golf Competition was held on Nov 15 at The Jockey Club Kau Sai Chou Golf Course. Six participants won the competition and prizes were presented by ATAL Engineering Ltd. Mr. Victor Law.

NOVEMBER 15, 2006

THE 45TH ANNIVERSARY ANNUAL DINNER

ACRA celebrated the 45th Anniversary Dinner at J W Marriott Hotel on Nov 27. It is our honor to invite Dr. Sarah Liao, Secretary for the Environment, Transport and Works to deliver the opening speech for our annual dinner.

NOVEMBER 27, 2006

SKILLS UPGRADING SCHEME CHARITY WALK 2007

It was the first Charity Walk organized by Education & Manpower Bureau and Skills Upgrading Scheme for M & E industry in Hong Kong. The activity was held at Shatin Central Park on 3 Feb with more than 50 of our members and their relatives participated in this event. A $3,500 was raised and donated to "The Community Chest of Hong Kong" on behalf of ACRA.

FEBRUARY 3, 2007

TECHNICAL VISIT ON MESAN COOLING TOWER FACTORY

ACRA organized a two-days technical visit to Mesan Cooling Tower Factory in Dongguan on Feb 9 - 10. Mesan kindly introduced to us an overview of cooling tower manufacturing process. It was a valuable opportunity for our members to learn more about the practices of their quality control and assurance. To thank for their warm reception, Mr. Conson Yu represented ACRA to present a souvenir to Mesan.

FEBRUARY 9-10, 2007

MARCH 12, 2007

ACRA SPRING DINNER 2007

ACRA Spring Dinner was held at World Trade Centre Club on Mar 12 and Mr. Kelvin Tam joined our event as the guest speaker of "Taiji and Health" Talk and took photo with most of our Council Members after the dinner.

VISIT TO CHINA REFRIGERATION EXHIBITION 2007

The 18th International Exhibition for "Refrigeration, Air-conditioning, Heating and Ventilation, Frozen Food Processing, Packaging and Storage" was carried out at Pazhou on April 4-6. Our Council Member (from left to right) K.L. Chan, Victor Law, K. Y. Ip and Kenny Wong were invited to represent ACRA to attend the Welcome Dinner Reception.

APRIL 4-6, 2007

APRIL 4, 2007

JOINT VISIT TO CHINA REFRIGERATION EXHIBITION 2007

A one-day joint visit to "18th International Exhibition for China Refrigeration 2007" was jointly organized by ACRA and ASHRAE successfully. More than 30 members from the 2 organizations had been taken part in this visit of which a long waiting list has been found this time. It was encouraging to see the overwhelming response from ACRA members for this event.

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Brisky Limited	穿梭科技有限公司	2511 3161	Supply & Install Window / Split Type & Packaged VRV Systems
Bun Kee (International) Ltd.	彬記(國際)有限公司	2748 9319	Wholesale
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Clear Air Services	堅毅服務	2425 5033	Environmental Protection Services , Indoor Air Quality , Duct Cleaning System
Clydeman Engineering Ltd.	佳電工程有限公司	2332 3591	E & M Contracting
Crowntin Limited	冠殿有限公司	2416 8066	Contracting / Supplier / Building Automation
Dah Chong Hong (Engineering) Ltd.	大昌貿易行工程有限公司	2768 3388	HVAC Installation , E & M Packaged Installation
Dah Fung Service	大豐空調服務	2836 0301	Contracting
Delta Pyramax Co., Ltd	佳澤科技有限公司	2511 2118	Trading
Dura Duct International Ltd.	都得國際有限公司	2605 6606	Supply and Installation of Ductworks and Accessories
Eaxon (H.K.) Co., Ltd.	香港恩案機電科技有限公司	3590 4656	Supply of HVAC equipment
Enviro-Tech Engineering Co., Ltd.	鷹達工程有限公司	2827 0688	Trading
Euro Airconditioning Ltd.	歐諾空調有限公司	2323 0809	Supplier (Authorized Dealer of AC Products – Daikin, Toyo , Valmatic , Honeywell-MNG)
Extensive Trading Co., Ltd.	精基貿易有限公司	2889 1681	Trading – Mechanical Equipment , Building Materials , Environmental Products
Fook Loong (HK) Ltd.	福隆 (香港) 有限公司	23937773	Most Complete Line in INSULATION Industry Supplier
Fungs E & M Engineering Co., Ltd.	馮氏機電工程有限公司	2682 7200	E & M Contracting
GTECH Services (Hong Kong) Ltd.	英國通用工程(香港)有限公司	2123 0888	Contracting
GELEC (HK) Ltd.	香港通用電器有限公司	2919 8383	Supplier
Gether-Force Air-Conditioning Engineering Co., Ltd.	群力冷氣工程有限公司	2890 2622	Contracting
Getwick Engineers Limited.	佳域工程有限公司	2893 3600	Contracting
Golden Phoenix Engineering Services Ltd.	金鳳凰工程服務有限公司	2117 9211	Contracting
Goodway Electrical Engineering Ltd.	佳濤電業有限公司	2405 0888	Authorized Distributors
Goodways International Ltd.	協進國際有限公司	2575 8770	Manufacturer's Representative
Gotop Engineering (HK) Ltd.	高陞工程(香港)有限公司	2459 3038	Electrical & Mechanical ; MVAC Engineering
Hang Shun Engineering Co.	鄧氏恒信工程有限公司	2428 8640	Aluminum Cladding for Air-Conditioning
Harvest Peak International Ltd.	禾峰國際有限公司	2730 3272	Supply ' Shangfeng blowe & fan for ventilation
Honest Air Conditioning Ltd.	明發冷氣有限公司	2396 8108	Contracting & Supplier
H.W.International Air-Conditioning Ltd.	豪華國際空調有限公司	2796 8888	Manufacture of Air-Conditioning Equipment
IES (Hong Kong) Limited	恒豐工程(香港)有限公司	2992 0830	Supply & Install Central Hot Water Plant and Seawater Plant , Supply of Equipment
IMS International Limited	雋程國際有限公司	2881 8011	Manufacturer of " IMASU " ventilation product
Kinden Corporation		2368 6136	Building Services – E & M Works
Kings View Airconditioning Engineering Co. Ltd.	景匯空調工程修有限公司	2796 2417	HVAC Contracting & Maintenance
Landis & Gyr Ltd.	蘭吉爾有限公司	2960 7800	Supply of Cold Meter , Chilled Water Energy Meter
Lee Tack Engineering Co., Ltd.	李德工程有限公司	2305 3111	Registered Ventilation Contractor
Link The Best Company Ltd.	必發(香港)有限公司	2568 4092	Supply Pre-insulated Pipe Air Filter , Butterfly Valve , Electrostatis Precipitator , UV Sterilizer & Other Building Material
McQuay Air-Conditioning Ltd.	麥克維爾空調有限公司	2893 6261	Split type A/C , Chilled Water Fan Coil Unit , Water Cooled Package & Split Type Water Source , Heat Pump Chiller Supplier
Mesan Fiberglass Engineering (Int'l) Ltd.	明生玻璃纖維工程(國際)有限公司	2787 5717	Manufacturer of 'MESAN' water cooling tower ; Distributor of Air-Conditioning Equipment
Midea Electric (HK) Ltd.	美的電器(香港)有限公司	2669 4888	Supplier & Manufacturer of 'MD' Product
Nap Acoustics (Far East) Ltd.	NAP 聲學工程(遠東)有限公司	2866 2886	Design, Supply, Installation of Acoustic Treatment and Vibration Control Products
No. 1 Engineering & Material Supply Ltd.	第一工程及物料供應有限公司	2334 3871	Contracting Supplier
Oxprime (International) Ltd.	鑫輝(國際)有限公司	2590 8088	Pump , Cooling Tower , VAV Box, Vibration Isolators , Dura Duct , Liquid-Solids Separation Systems , Fibreglass Supplier
Peterson Engineering Ltd.	必德信工程有限公司	2365 0372	Contracting
Practical Engineering (HK) Co.,Ltd.	百利高工程(香港)有限公司	2402 2772	Contracting / Supplier
Raising Engineering Ltd.	威信工程有限公司	2395 6081	Authorized Distributor of Toshiba & Carrier product Registered Contractor
Richmax Air-Conditioning Co., Ltd.	萬聯空調有限公司	2698 3423	Distributor of HVAC product
Royalson Asia Ltd.	和信亞洲有限公司	2385 5121	Trading of "SINRO" Cooling Tower , Fan Coil , AHU & Control
Sanby Trading Co., Ltd.	聖備貿易有限公司	2573 4219	Specializing in trading Construction Insulation Material , such as Phenolic Foam , Fibreglass
Shun Hing Ref. A/C Engineering Ltd.	順興雪櫃冷氣工程有限公司	2387 2882	Design , Supply & Installation of Air-Conditioning
Sing Kin Ltd.	陞建有限公司	2333 1518	Contracting
Southa Engineering Limited	南龍工程有限公司	2963 7241	Air-Conditioning & Refrigeration Installation
Super Mark (H.K.) Engineering Co., Ltd.	鎬達(香港)工程有限公司	2595 1122	Supplier / Distributor for Electrostatic Precipitator
Thermtech Building Products	泛達建築材料有限公司	2756 3837	Contracting / Supplier for Weatherproof / Fire Resistant Materials to E & M Services
Tom's Equipment Co., Ltd.	義隆設備有限公司	2757 5539	Insulation Material Supplier
Union Manor Ltd.	聯明有限公司	2797 2168	Contracting
Viewco Building Services & Eng. Co., Ltd.	偉保工程有限公司	2543 0610	Contracting
Vital Engineering Co., Ltd.	威圖工程有限公司	2571 5382	Contracting
Wai Luen Air Conditioning Ltd.	偉聯空調設備有限公司	2890 9321	Contracting
Welcome Oncho Denki Ltd.	偉基溫調電機有限公司	2806 8316	Trading of HVAC Equipments
Wo Kee Hong Ltd.	和記電業有限公司	2522 3128	Supplier of Electric Appliances (Brand Name : Mitsubishi Daiya , LG , GREE , TCL & Body sonic, etc)
Wolter Asia Ltd.	華德亞洲有限公司	2456 0198	Supply & Manufacturing of full range of Ventilation Fans
Wysermann Co., Ltd.	威士文有限公司	2614 2213	Trading & Manufacturing Air Conditioning Accessories
Yordland Engineering Ltd.	日島工程有限公司	2362 2186	Design , Supply & Installation and Maintenance of HVAC, Electrical and Fire Services System