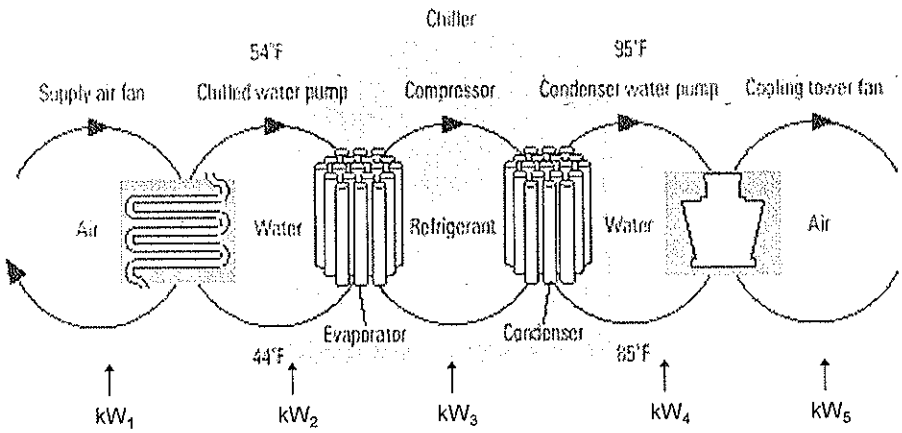
23/3/2016

Typical Issues in Chiller Plant Monitoring, Control, and Operation

Lee Eng Lock

The 5 Circle Diagram

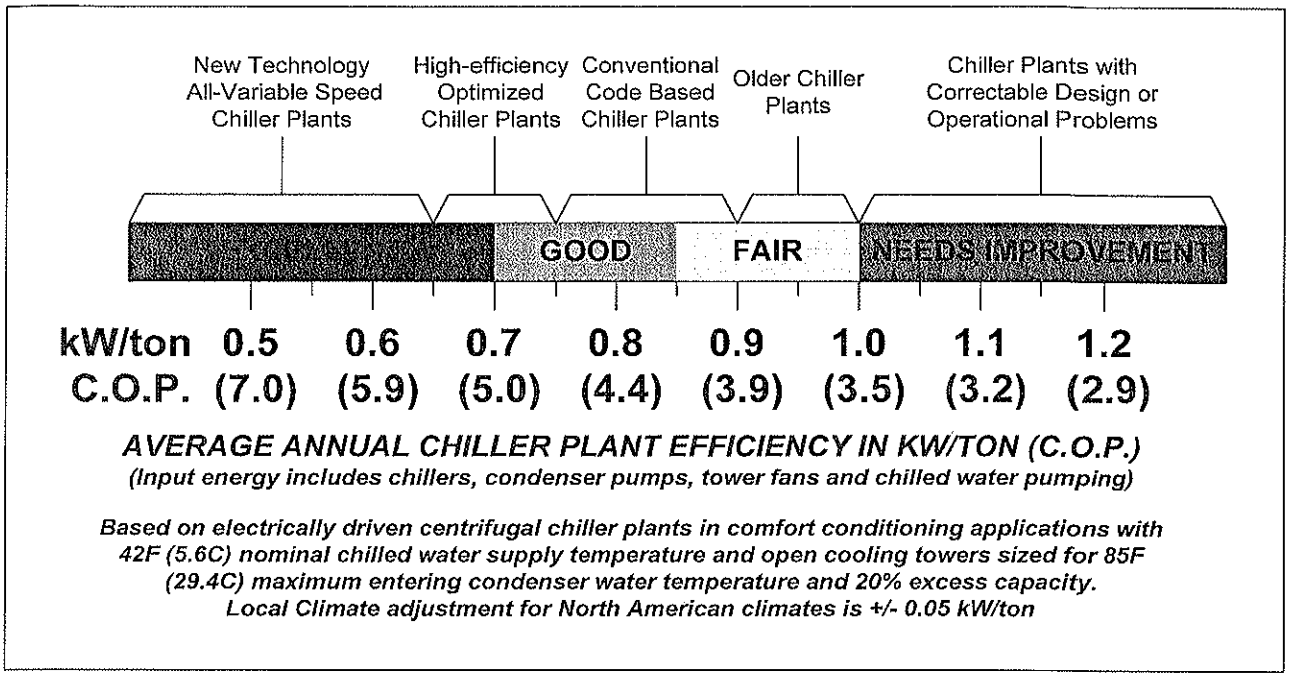
Total System HVAC Approach



Cooling System kW/Ton $= \dfrac{kW_1 + kW_2 + kW_2 + kW_4 + kW_5}{Ton}$

Parasitic Load to Chiller $= kW_1 + kW_2$ ≙10%

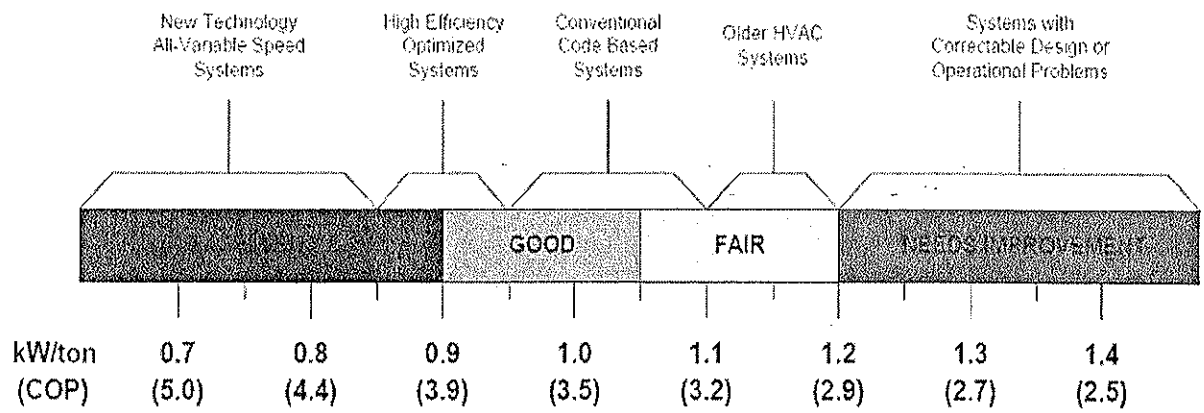
Ashrae--Chiller Plant Efficiency



AVERAGE ANNUAL CHILLER PLANT EFFICIENCY IN KW/TON (C.O.P.)
(Input energy includes chillers, condenser pumps, tower fans and chilled water pumping)

Based on electrically driven centrifugal chiller plants in comfort conditioning applications with 42F (5.6C) nominal chilled water supply temperature and open cooling towers sized for 85F (29.4C) maximum entering condenser water temperature and 20% excess capacity. Local Climate adjustment for North American climates is +/- 0.05 kW/ton

Air + Water Side System kW/Ton

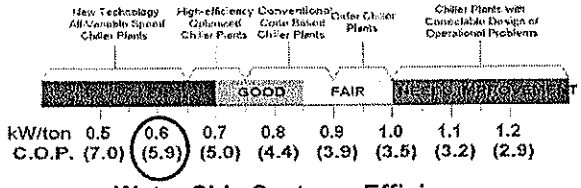


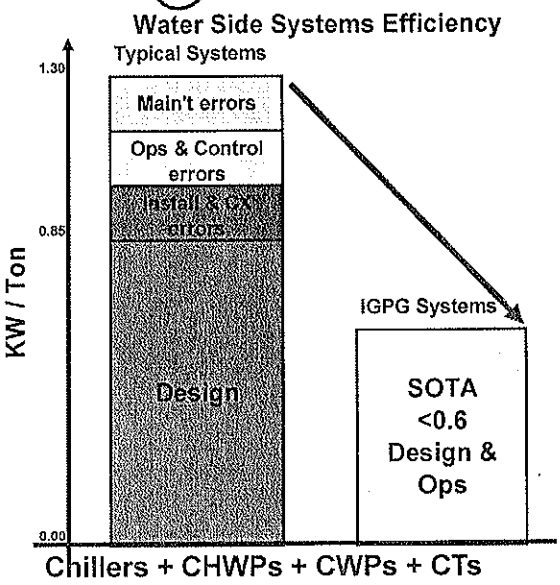
AVERAGE ANNUAL HVAC EFFICIENCY IN KW/TON
(Input energy includes all chillers, chilled water pumps, condenser water pumps, cooling tower fans, supply and return air-handler fans, and exhaust fans)

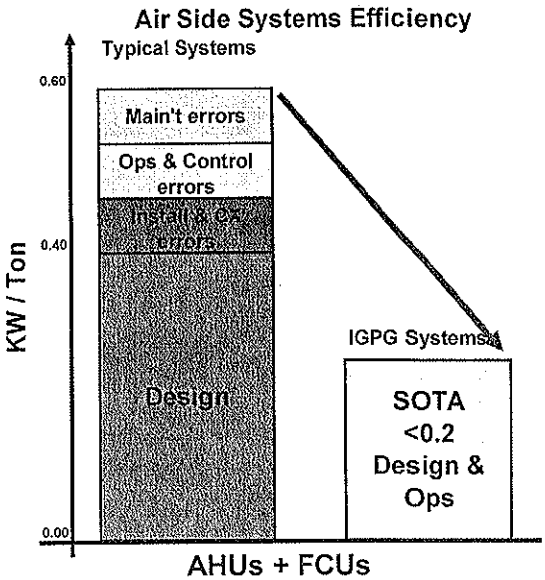
Based on electrically driven centrifugal chillers in comfort cooling applications with 42F nominal chilled water supply temperature and open cooling towers sized for 85F maximum entering condenser water temperature.

Figure 2: Total HVAC Energy Use Spectrum.

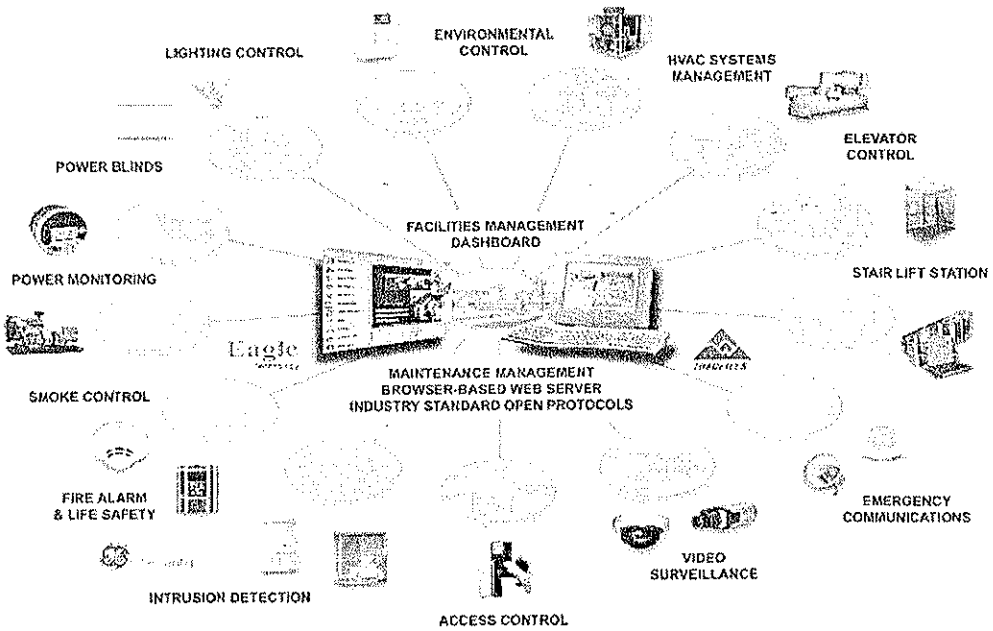
Typical vs State of the Art (SOTA)
air conditioning system average energy consumption





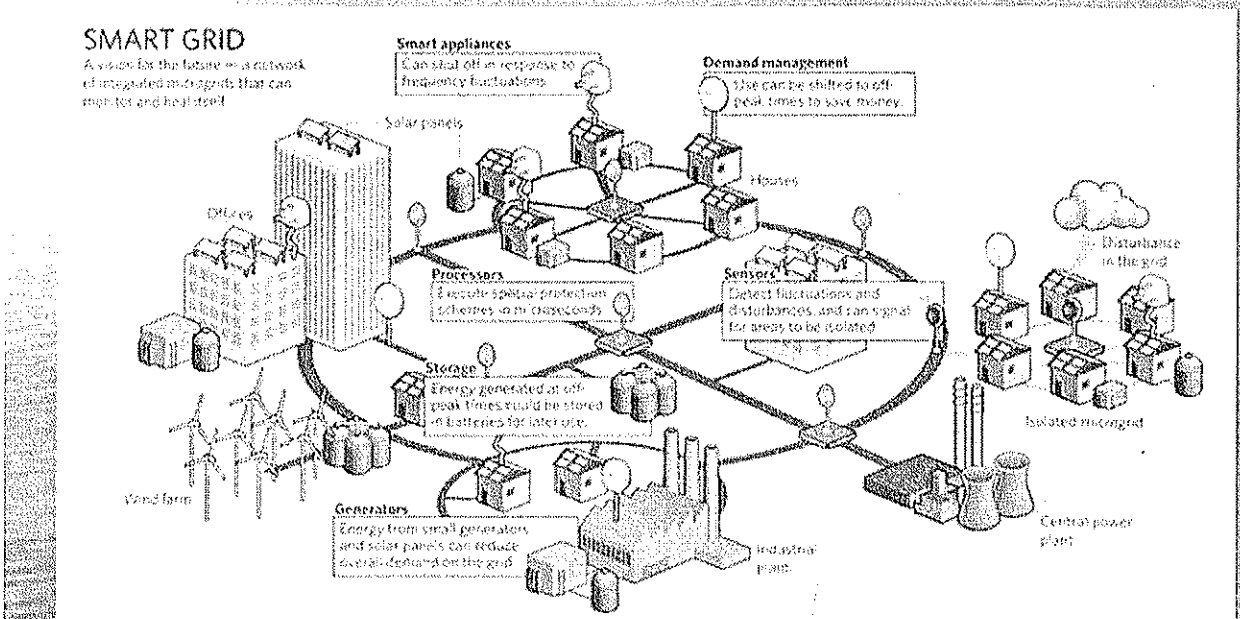


Typical functions of BAS



Control & monitor all systems in the building

Building Automation gets Griddy while colliding with the corporate Enterprise



Higher Level Integration

The Mediator – Enabling Convergence from the South to the North

North

Integrated Enterprise Application & Services, Web Services, XML-RPC, oBix

Open IT based protocols

Intelligent Middleware - "The Mediator" moving data up to the network using Internet Protocol – TCP/IP

Capability Gap

Proprietary and non proprietary Subsystems of a building such as HVAC, Lighting, Sensors, Security, Metering, etc.

Proprietary protocols

Variety of systems from a variety of manufacturers including Trane, Siemens, TAC, JCI Honeywell, Invensys, Carrier, PowerLogic, GE, Carrier, and more.

South

Source: Frost & Sullivan

USENERGYGROUP

Building Efficiency Through Information Management™

HOME | ABOUT US | PRODUCTS | TESTIMONIALS | SUPPORT | NEWS | BLOG | CONTACT US

USE Manager

Products Overview | USE Manager | USE Controller | USE Verifier | USE Mobile

USE Mobile is a web-based application designed for the iPhone that allows building managers and owners with a USE Controller EMS to access heating system information in real-time for their buildings.

USE Mobile gives the user the ability to:

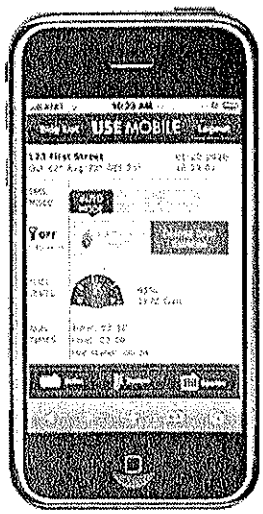
View Boiler Status – Current fuel valve and EMS status, oil tank level, and runtime for the day.

View System Status – Current aquastat, coil, domestic hot water, and stack temperatures, as well has highs and lows for the day and water loss.

View Space Temperatures – View individual unit temperatures in real-time to verify heat complaints.

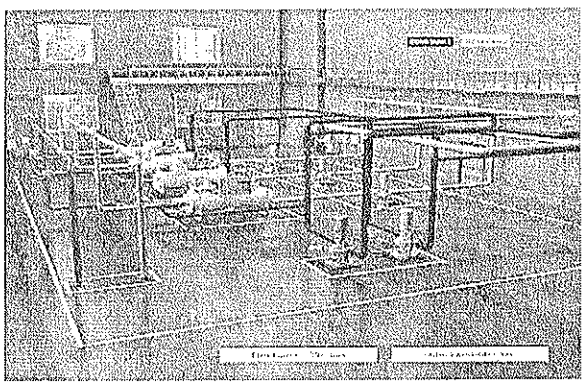
Remotely Bypass the EMS – Manually turn the heat on or off from your iPhone when needed.

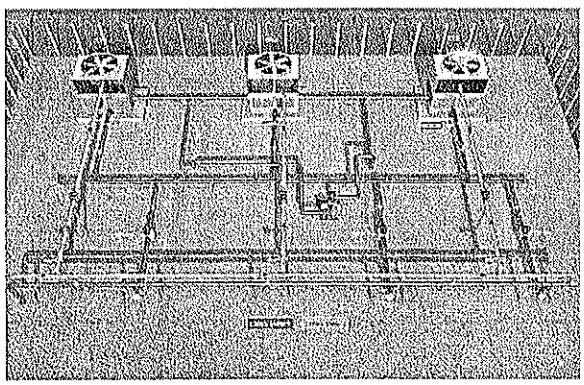
USE Mobile is available for free to all USE Manager customers. Simply visit www.use-manager.com from your iPhone and log in with the same username and password you use to access USE Manager. Save the application to your home screen for quick access later.

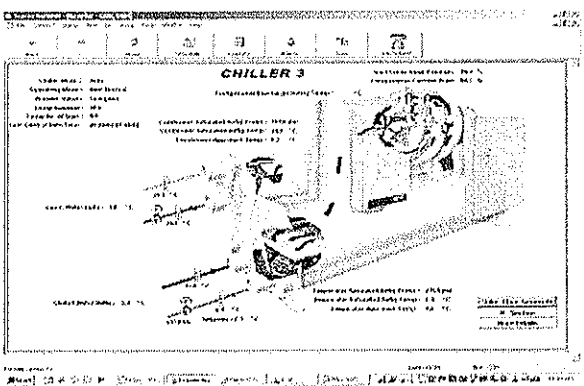


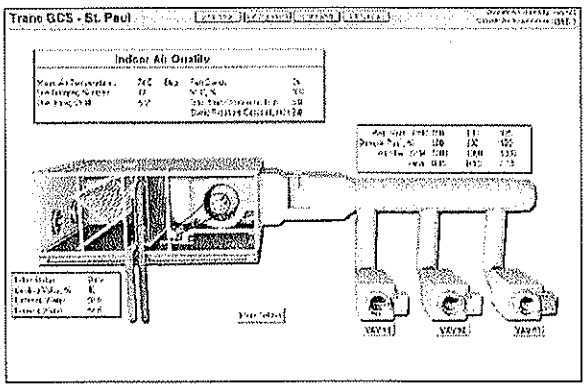
© 2009 US Energy Group, LLC

Workstation Graphics

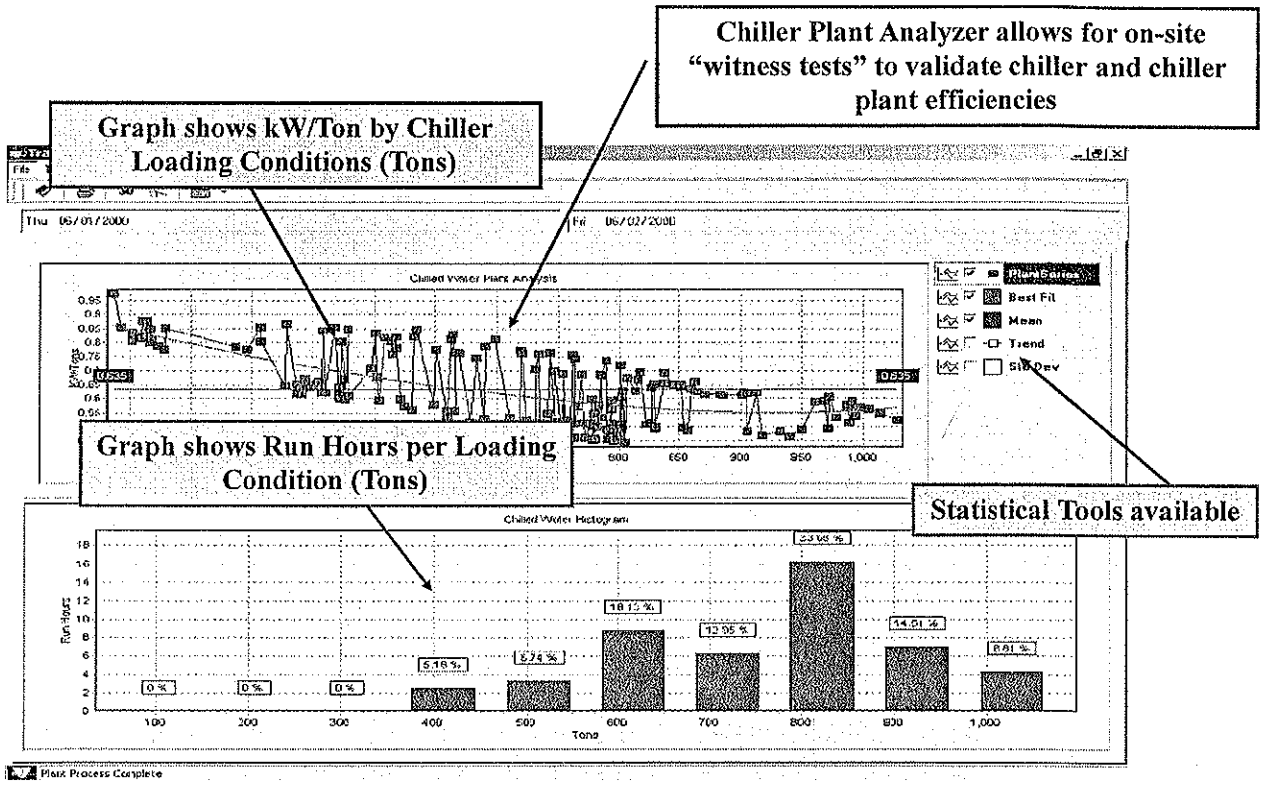








Energy Monitoring & Reports
Plant & Chiller Performance Analysis



Issues with existing BAS

- **NARRATIVE SUMMARY OF PROPOSED PROJECT**
- Contractor: Pacific Gas and Electric Co.
- Contractor's Project Manager: Steven L. Blanc
- Commission's Project Manger:
- Term of Project: 1 year
- **PURPOSE:**
- Based on our own and others research, we have determined that *the present state of building controls technology is inadequate to support the used of advanced control methods to save energy. The fragmented state of the industry and an incomplete understanding of the technical issues surrounding controls has led to mediocre design and under use of control systems presently in the building stock of California. A major area where we see potential for improvement on a wide scale involves data acquisition and monitoring.* This project will investigate the solutions to the data acquisition and monitoring challenges faced in using energy management systems for advanced control, performance monitoring, diagnostics and commissioning. The work falls into two phases: first, understanding the type and frequency of data needed to establish a viable database for the aforementioned services and second, investigating the type and accuracy of sensors actually needed for control system data acquisition. This work would support future phases investigating lower cost sensors for monitoring, measuring and data acquisition, and the needs for data acquisition facilities within the control systems themselves. The present request would cover the first tasks: understanding and documenting the type and frequency of data needed to establish a viable database for advanced control, performance monitoring, diagnostics and commissioning, then investigating the best combination of type and accuracy of sensors to support these services. This work is the necessary cornerstone to pursue fruitful research in this area and to give the controls industry further impetus to reach any significant energy efficiency gains.

Latest NEA guidelines for energy audits in Singapore—June 2009

- Chilled water plant system performance

- System performance measurement error shall not exceed **±5%**. *This implies the use of high accuracy thermometry and calorimetry.*
- Detailed method statement explaining how the required degree of accuracy was achieved with the instruments and data acquisition hardware employed.
- Data required to establish system performance must be sampled and acquired simultaneously and continuously for a minimum of 1 week at one-minute intervals.
- Energy efficiency of major equipment compared against industrial benchmarks
- Measurement and verification (M&V) plan for monitoring and verifying energy savings for each of the recommendations
- CD-ROM containing the raw measurement data

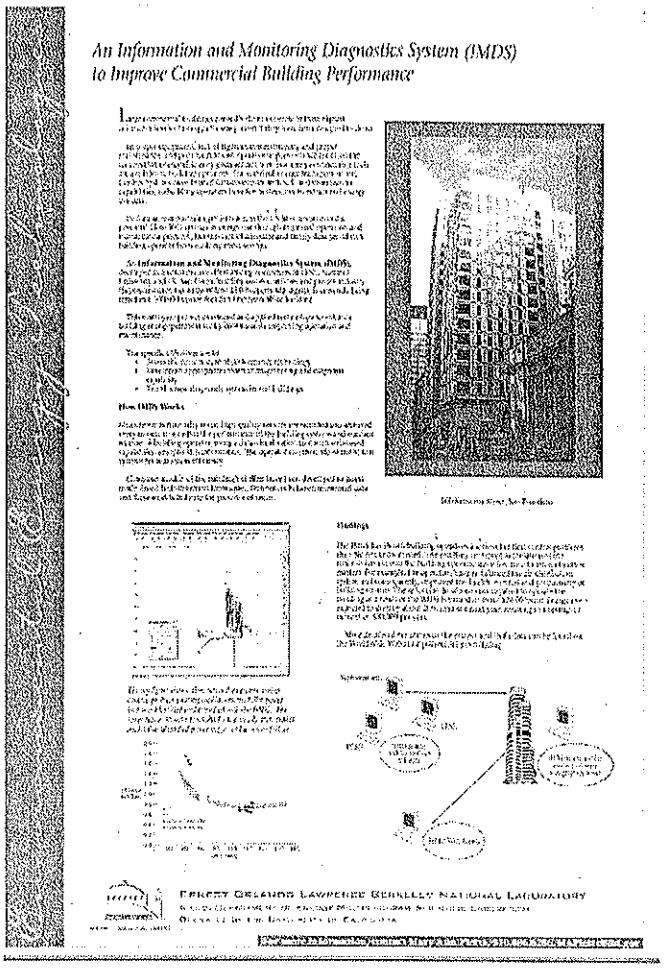
Making Energy Efficiency Accountable

Right now there is no off-the-shelf delivery process in place to develop truly effective energy efficiency improvements with long term performance assurance.

Thomas Hartman, P E
The Hartman Company
June 2007,
automatedbuildings.com

LBNL Research

- There has been work over decades to increase building efficiency
- The high accuracy and one minute monitoring and data analysis has been tested in california with favorable results

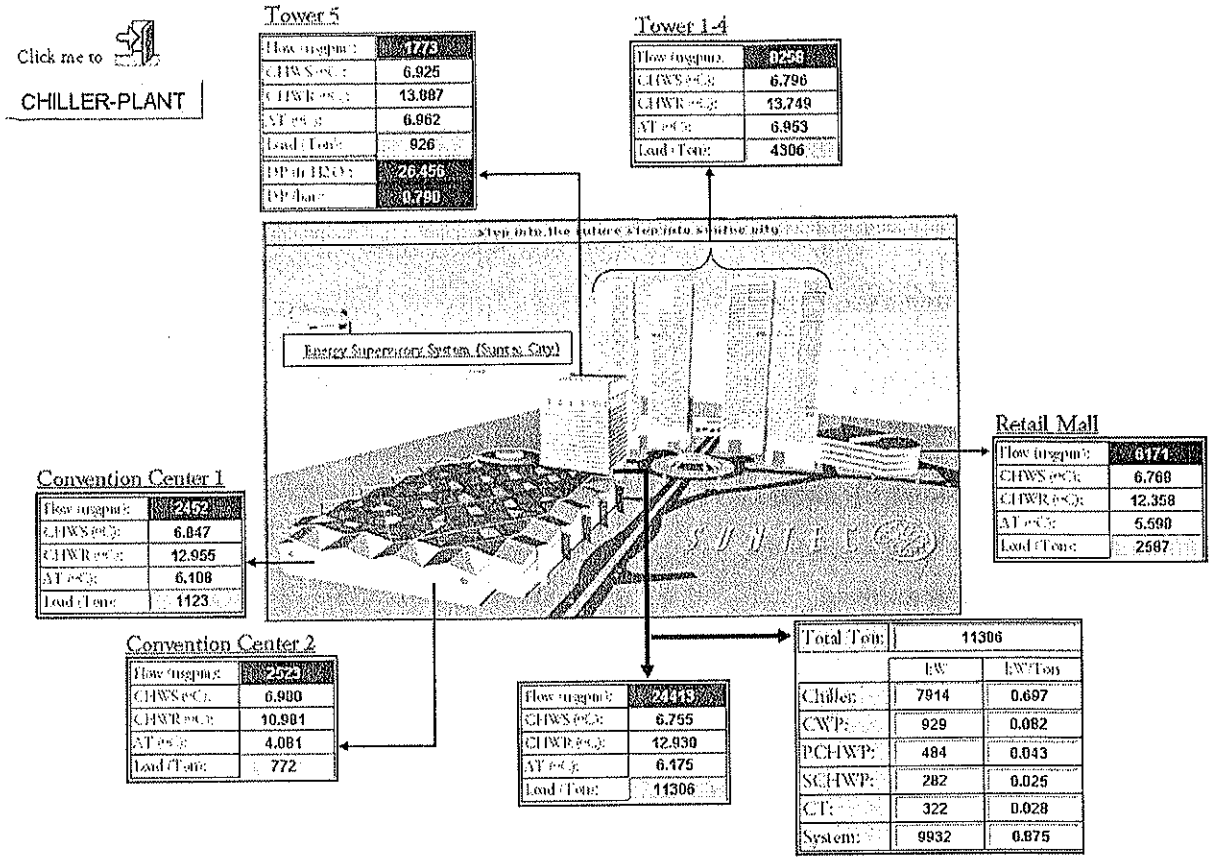




Adjustments Sub-committee members

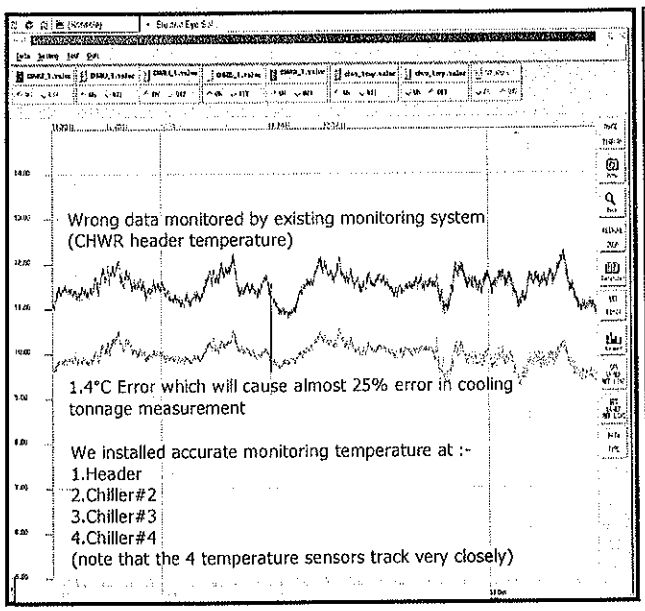
Joshi, Hemant (co-chair), Credit Rating Information Services of India Limited (CRISIL), India
Sathaye, Jayant (co-chair), Lawrence Berkeley National Laboratory
Vine, Edward (co-chair), Lawrence Berkeley National Laboratory

Abron, Lilian PEER Consultants
Berry-Lewis, Sylvia Honeywell
Bowie, Randall European Commission, Belgium
Cooley, Cris Sycomm
Cowan, John Cowan Quality Buildings, Canada
Datta Roy, G.C. DCM Shriram Consolidated Ltd., India
Jim Davis, Johnson Controls
Difiglio, Carmen International Energy Agency, France
Dutt, Gautam University of Buenos Aires, Argentina
Fisk, William, Lawrence Berkeley National Laboratory
Haberl, Jeff, Texas A&M University
Hansen, Shirley Kiona International
Halpern, Jim, Measuring & Monitoring Services Inc.
Johannes Heister, World Bank
Henner, Maury Enron Energy Services
Inclán, Ubaldo CONAE, Mexico
Kats, Greg Capital E
Kromer, Steve Enron Energy Services
Kumar, Satish Lawrence Berkeley National Laboratory
Lamberts, Roberto Universidade Federal de Santa Catarina, Brazil
Lashof, Dan, Natural Resources Defense Council
Lee Eng Lock, Singapore
LeFrate, Maurice U.S. Environmental Protection Agency
Lewis, Ian, Cumming Cockburn Limited, Canada
Martinot, Eric Global Environment Facility, United States
Martynova, Marina, National Pollution Abatement Facility, Russia
Meena, Hubert CEEST, Tanzania
Meier, Alan, Lawrence Berkeley National Laboratory
McBride, John, New Horizon Technologies
Milanez, Fernando, National Institute for Energetic Efficiency, Brazil
Moorcroft, David World Business Council for Sustainable Development, Switzerland
Poole, Alan National Institute for Energetic Efficiency, Brazil
Rapteun, Mykola, ARENA-ECO, Ukraine
Robledo, Carmenza, Swiss Federal Laboratories for Materials Testing and Research, Switzerland
Rose, Robert U.S. Environmental Protection Agency



In-accurate Sensors and Monitoring System

Example of in-accurate sensor reading in a Semiconductor Factory



Wrong data leading to wrong decision

Action:
Facility people sees high CHWR~12C,more than 100% Load of 2-chillers from BAS-display

Fact:
Wrong reading on CHWR
Wrong calculation on tonnage

Action
Turn on 3rd chiller and observe 100%load displayed on micro-panel of all chillers

Fact :
Display on micro panel
100% electrical ≠100% cooling load Chiller2(520RT)
100%electrical load but only 50% cooling part load and operating around 1.35kW/RT

Waste of 400kW power ~
3,456,000kWh
$320,000 electrical bill per year

Typical BAS Sensor Specs

Technical Specifications

TE-6300 Series Temperature Sensors (Part 1 of 2)

Sensor Reference Resistance	1k ohm Nickel	1k ohms at 70°F (21°C)
	1k ohm Nickel Averaging	
	1k ohm Platinum	1k ohms at 32°F (0°C)
	100 ohm Platinum Averaging	100 ohms at 32°F (0°C)
	1k ohm Platinum Averaging	1k ohms at 32°F (0°C)
	2.2k ohm Thermistor	2,252 ohms at 77°F (25°C)
	10k ohm Thermistor	10.0k ohms at 77°F (25°C)
Sensor Accuracy	1k ohm Nickel	±0.34F° at 70°F (±0.19C° at 21°C)
	1k ohm Nickel Averaging	±3.4F° at 70°F (±1.9C° at 21°C)
	1k ohm Platinum	±0.73F° at 70°F (±0.41C° at 21°C), DIN Class B
	100 ohm Platinum Averaging	±1.0F°at 70°F (± 0.58C° at 21°C)
	1k ohm Platinum Averaging	
	2.2k ohm Thermistor	±0.36F° (±0.2C°) in the range: 32 to 158°F (0 to 70°C)
	10k ohm Thermistor	±0.9F° (±0.5C°) in the range: 32 to 158°F (0 to 70°C)

Yamatake Industrial Grade Sensor

Pipe Temperature Sensor

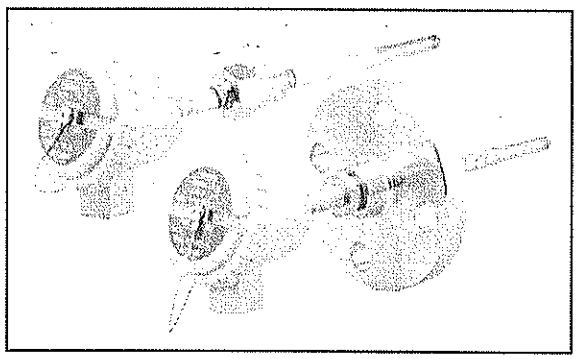
Model TY783

General

Model TY783 is a pipe-mount (insertion type) temperature sensor. Its Pt100 resistance (equivalent to JIS* C1604 Class A) output is used for temperature reading, control, and recording of the media of a pipe, tank, or heat exchanger.

Model TY783 is also applicable to temperature sensing of a duct or chamber.

* JIS: Japanese Industrial Standards



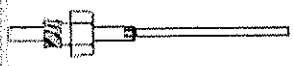
Specifications

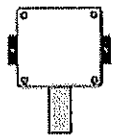
Item	Specification
Sensing range	-50 °C to 200 °C
Applicable measuring fluid	Different depending on the materials of thermowell. Refer to "Corrosiveness of the Sensor Thermowell" section.
Sensing accuracy	± (0.15 + 0.002|t|) °C t: temperature measured
Time constant	Models TY7830A to TY7830F, TY7830J, TY7830K, TY7831A to TY7831F, TY7831J, TY7831K (weld thermowell): Approx. 50 s (in agitated water) Models TY7830G, TY7830H, TY7830M, TY7830N, TY7831G, TY7831H, TY7831M, TY7831N, TY7832G, TY7832H, TY7832M, TY7832N (hollow thermowell): 20 s (in agitated water)

AHRI 550

ATAL

Data Recording Solutions 2003-2004





Temp. (Pt1000)	TEP-109	TEP-110
Application	Water	Room
Range	-50 to 150°C	-30 to 80°C
Output signal	Pt1000 / 3850ppm	Pt1000 / 3850ppm
Accuracy	±(0,15 + 0,002 x t)°C	±(0,15 + 0,002 x t)°C
Protection class		IP65
Response time t63	<20sec.	< 8sec.
Probe dimensions	L=10, Ø=6, ¼" BSP	L=50, Ø=18

What is the cost of such errors?

Assume average lifetime of 15 years.

Assume 30c/kwh average over 15 years.

Assume average 1,000 TR x 8000 hrs pa.

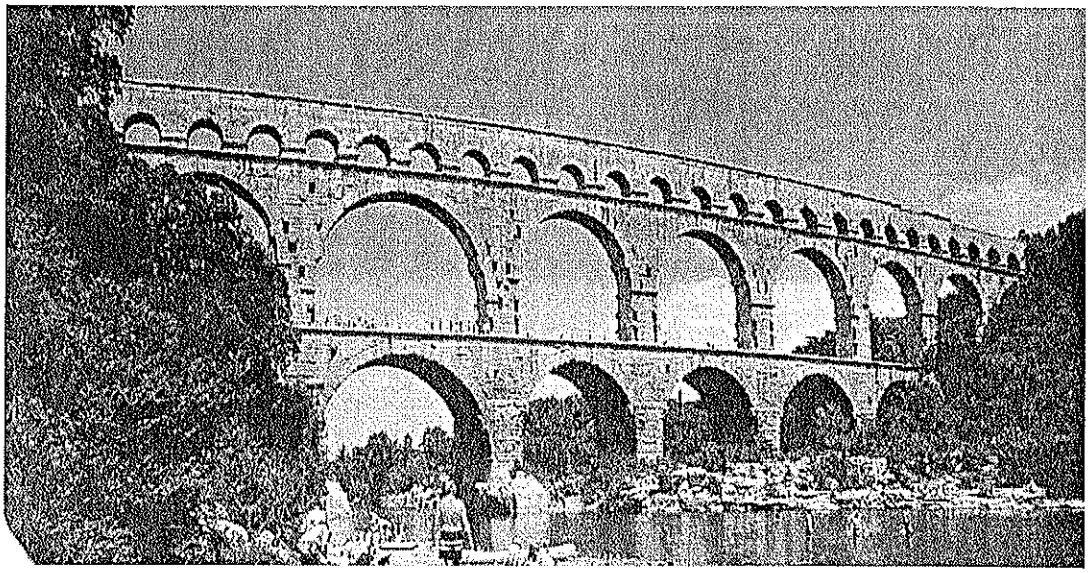
Assume loss of 0.2 kW/Tr average.

This gives 0.20 x 1,000 x 8000 x 30c
= S$ 0.48 m pa
= S$7.2m in 15 years.

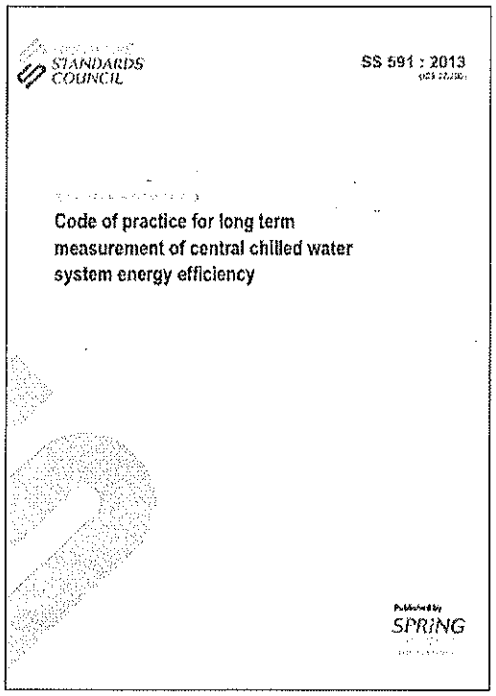
Education of the HVAC industry is very worthwhile.

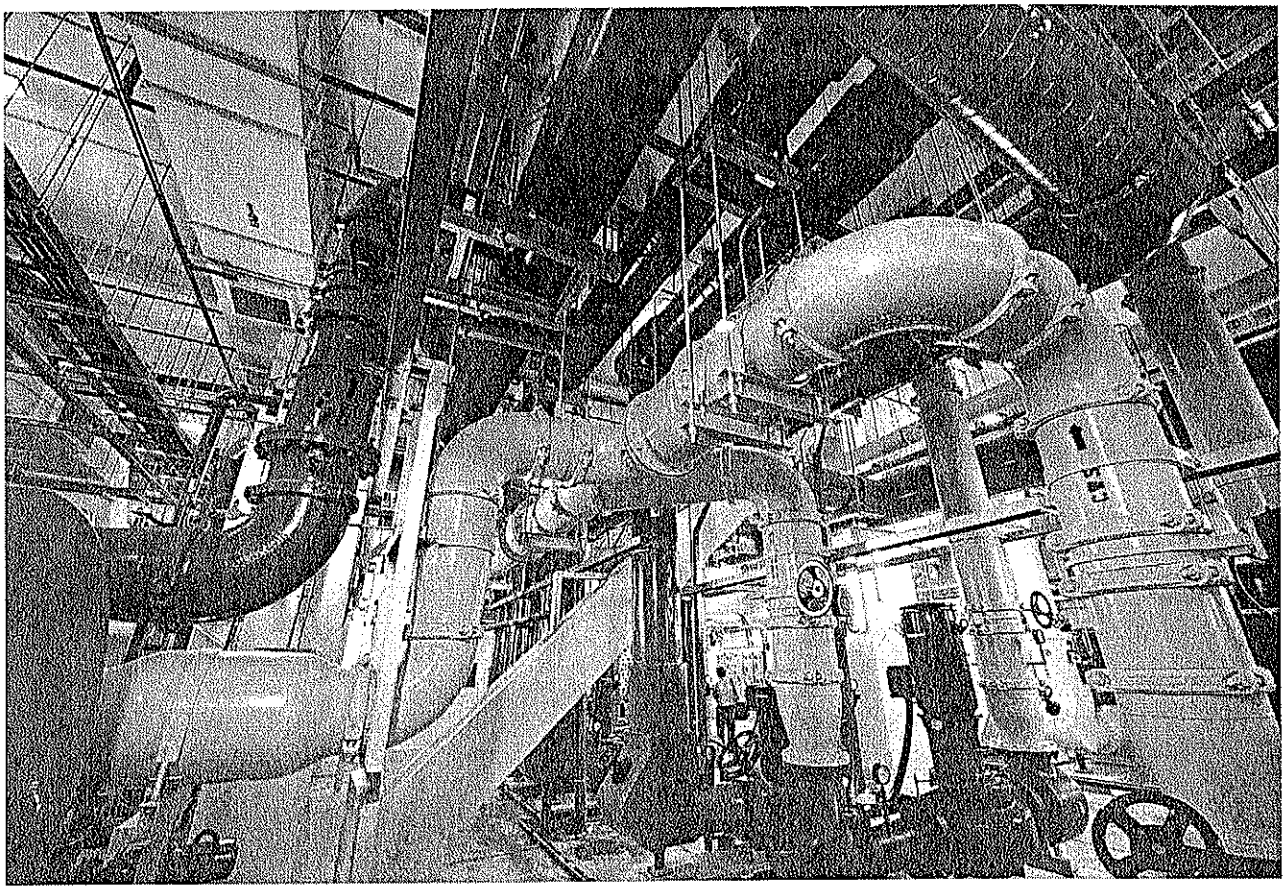
Roman bridge engineers…

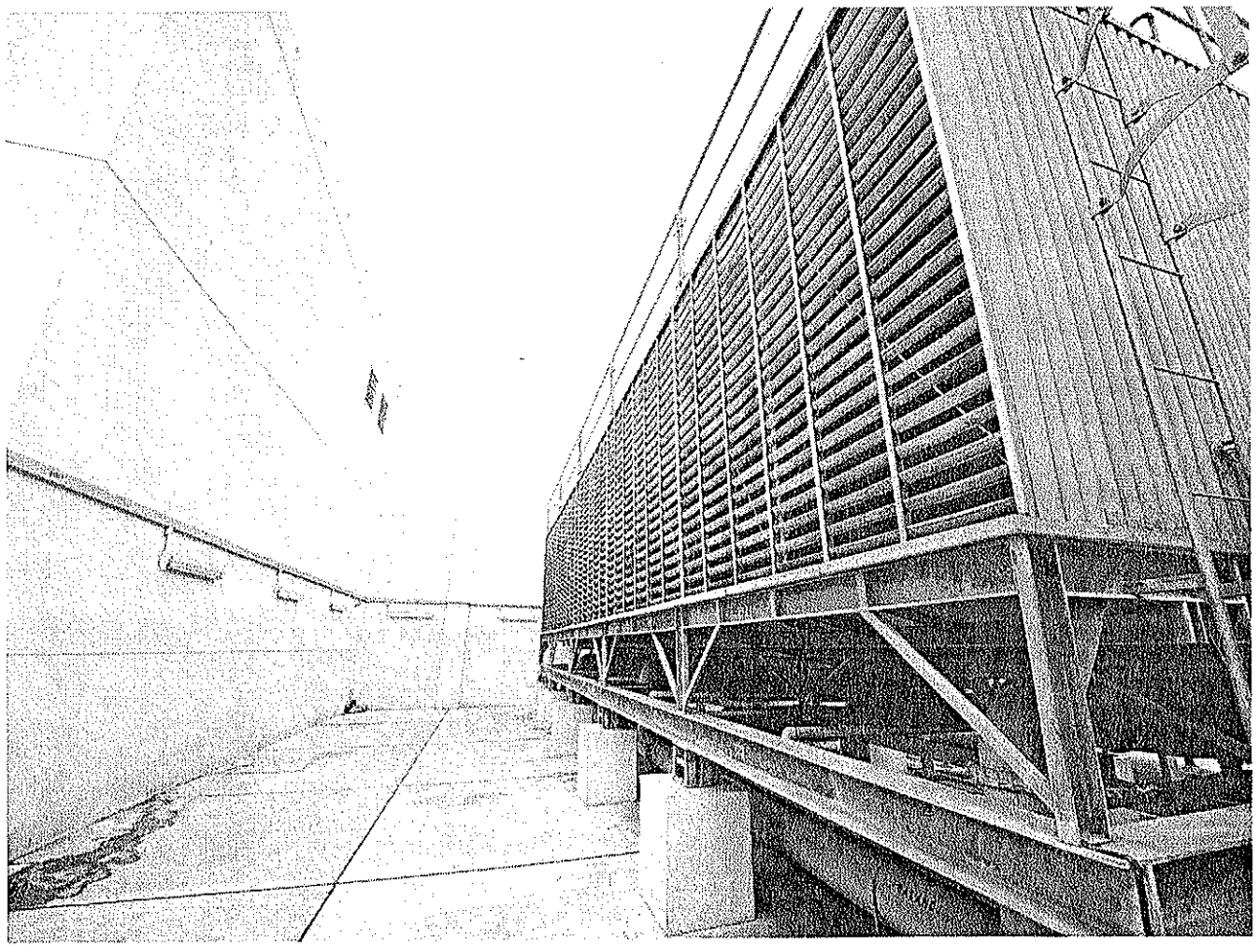
- had to stand under the bridge as the first legion marched across.

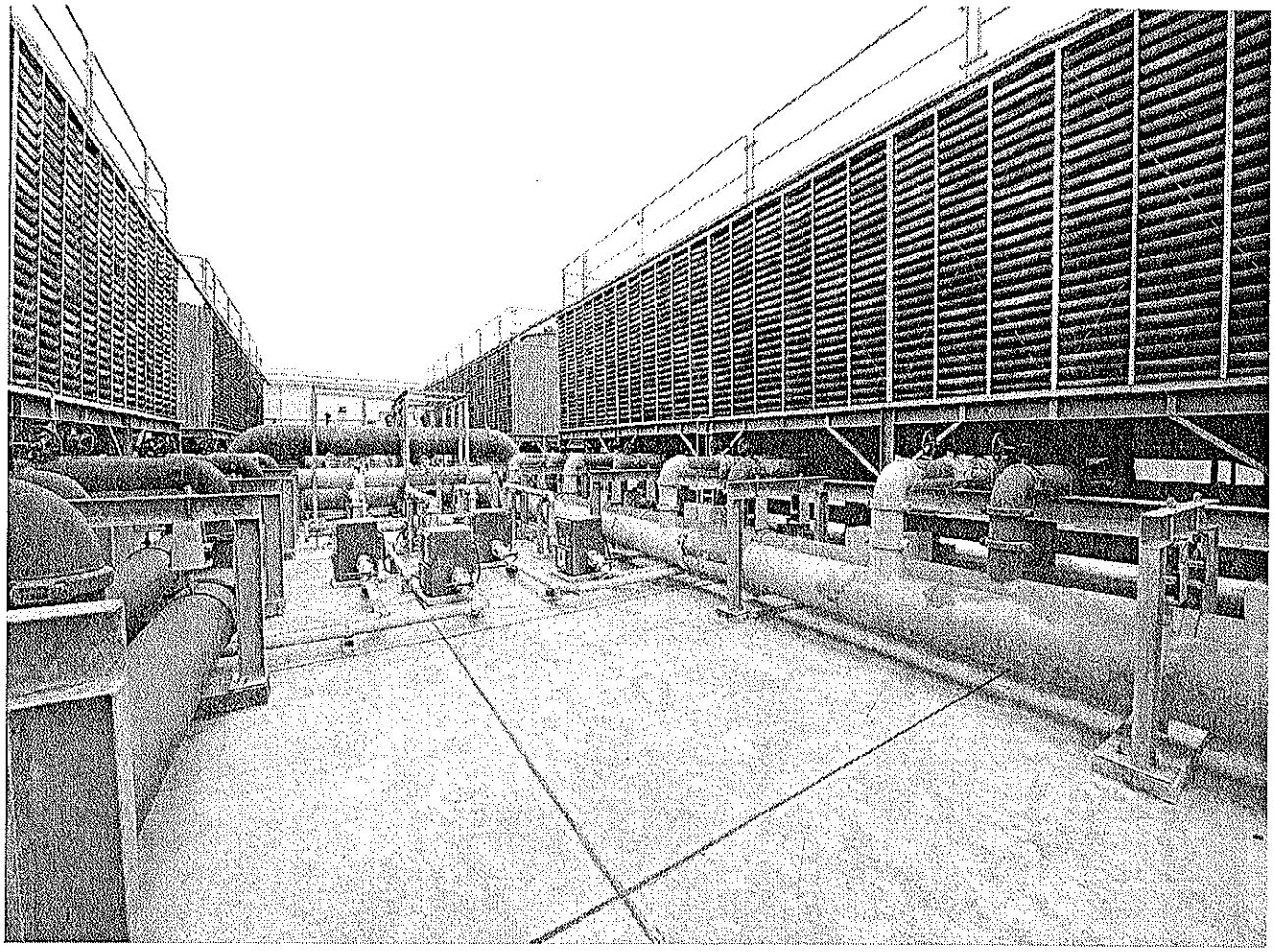


Recommended standard for chiller plant long term measurement of chiller plant energy efficiency

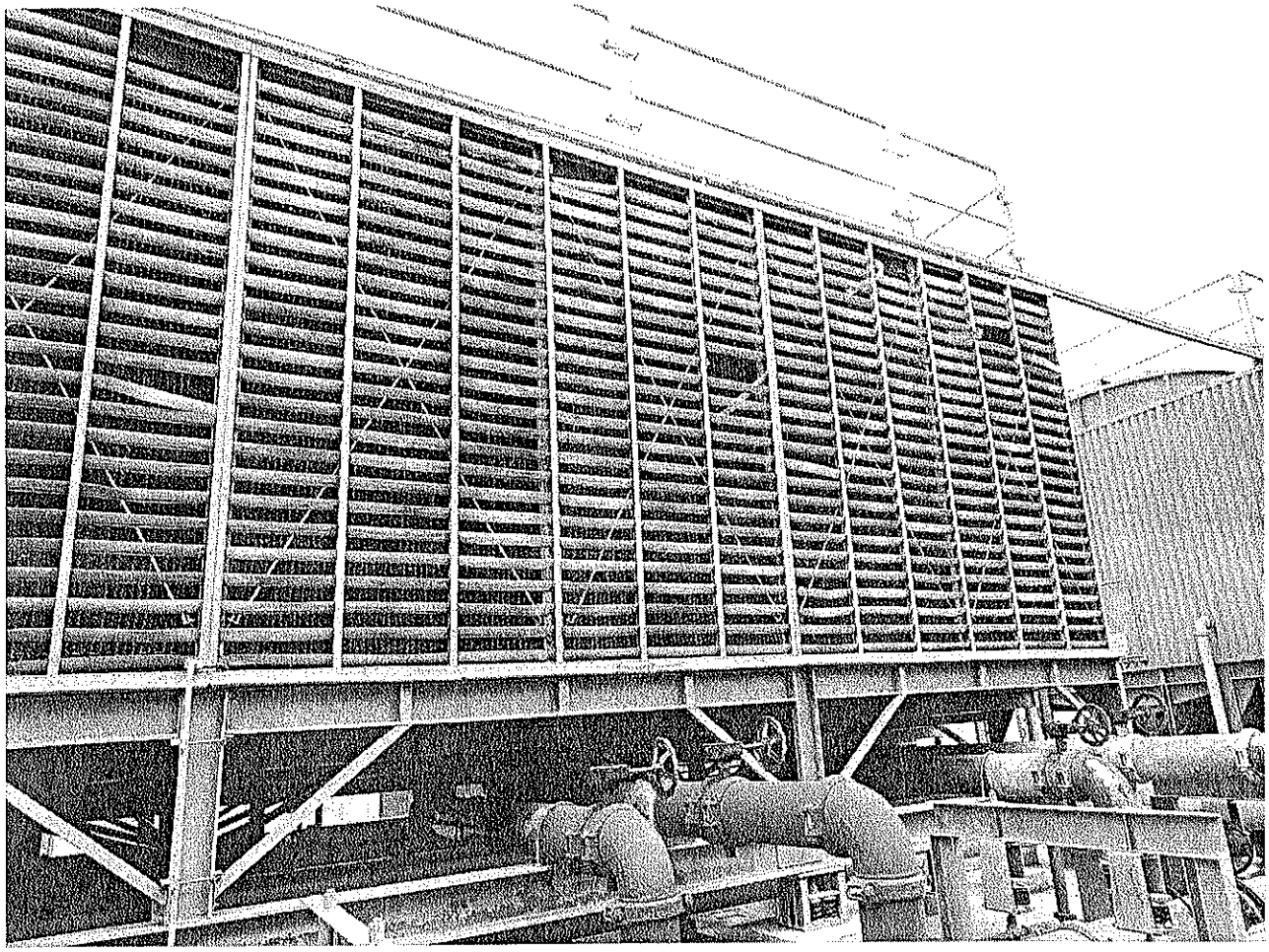


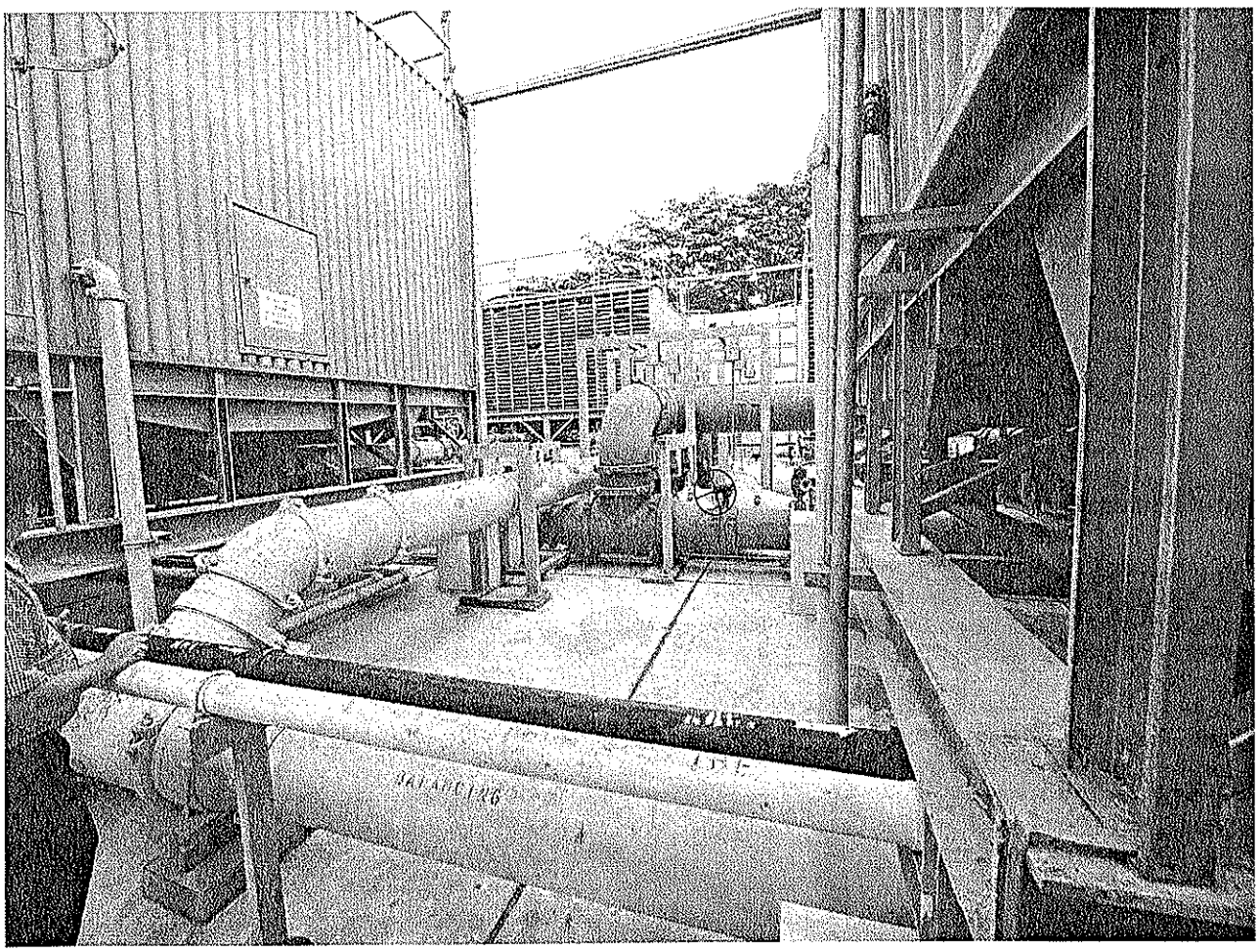


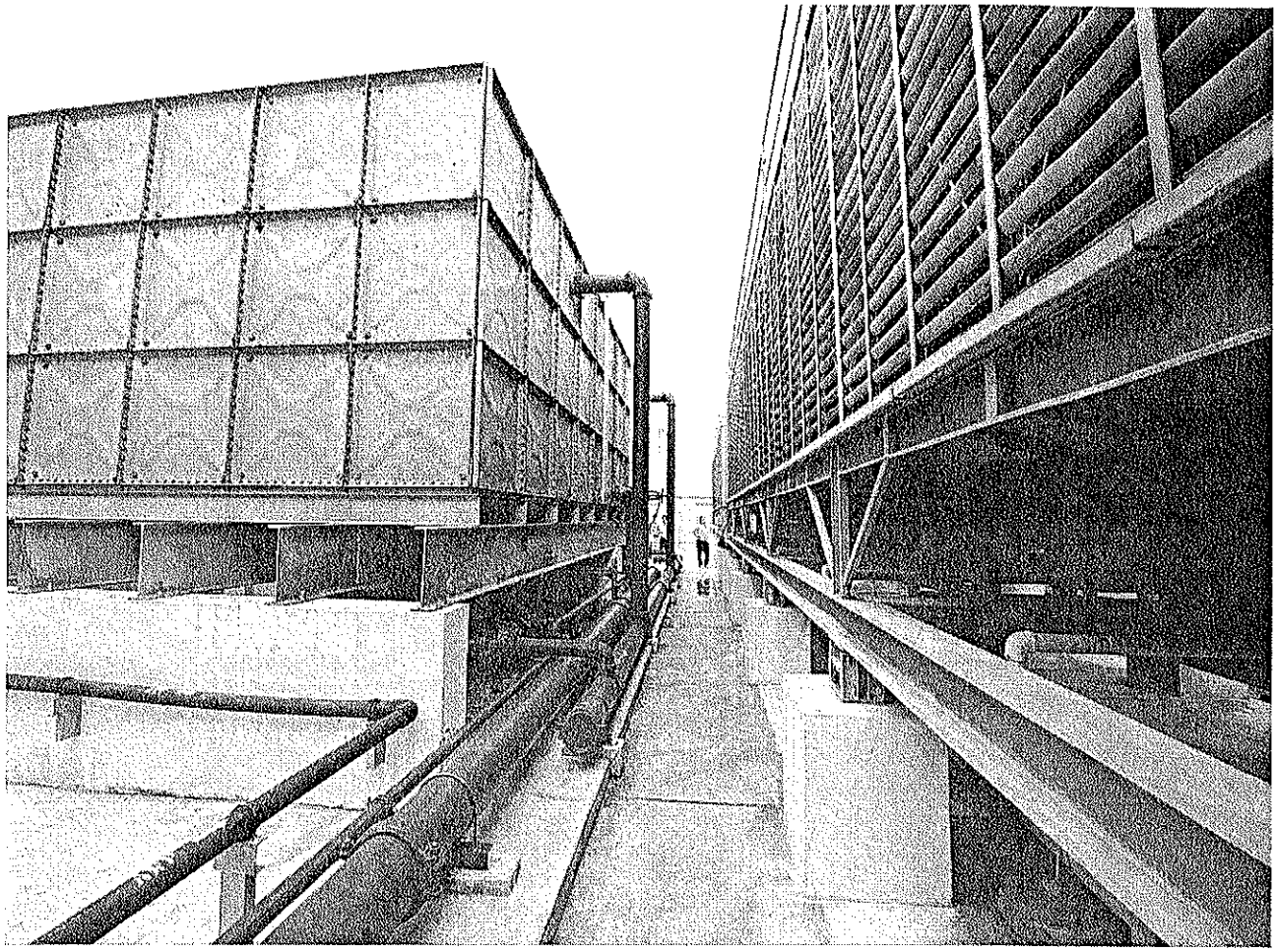


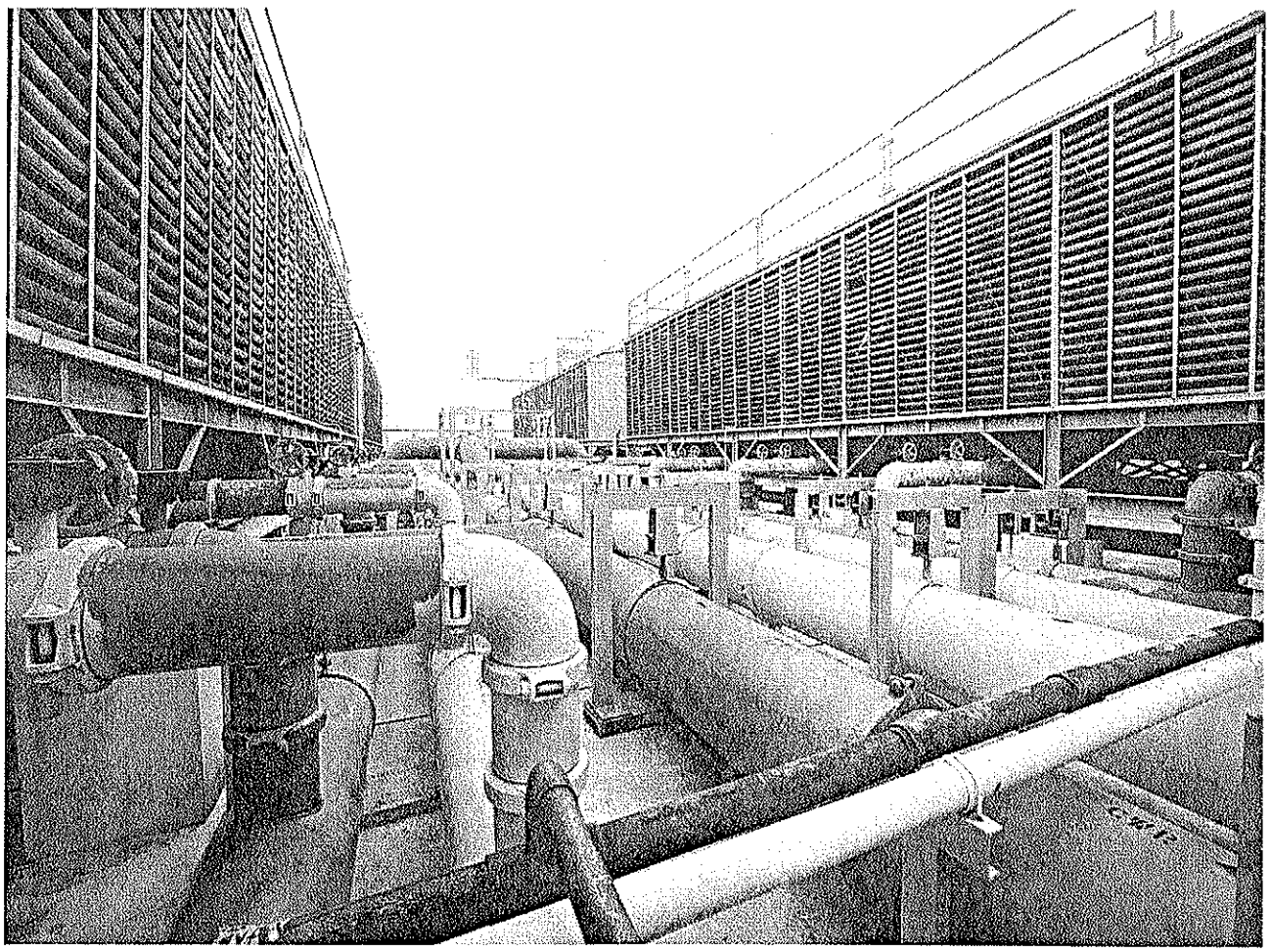



A
AMPERES

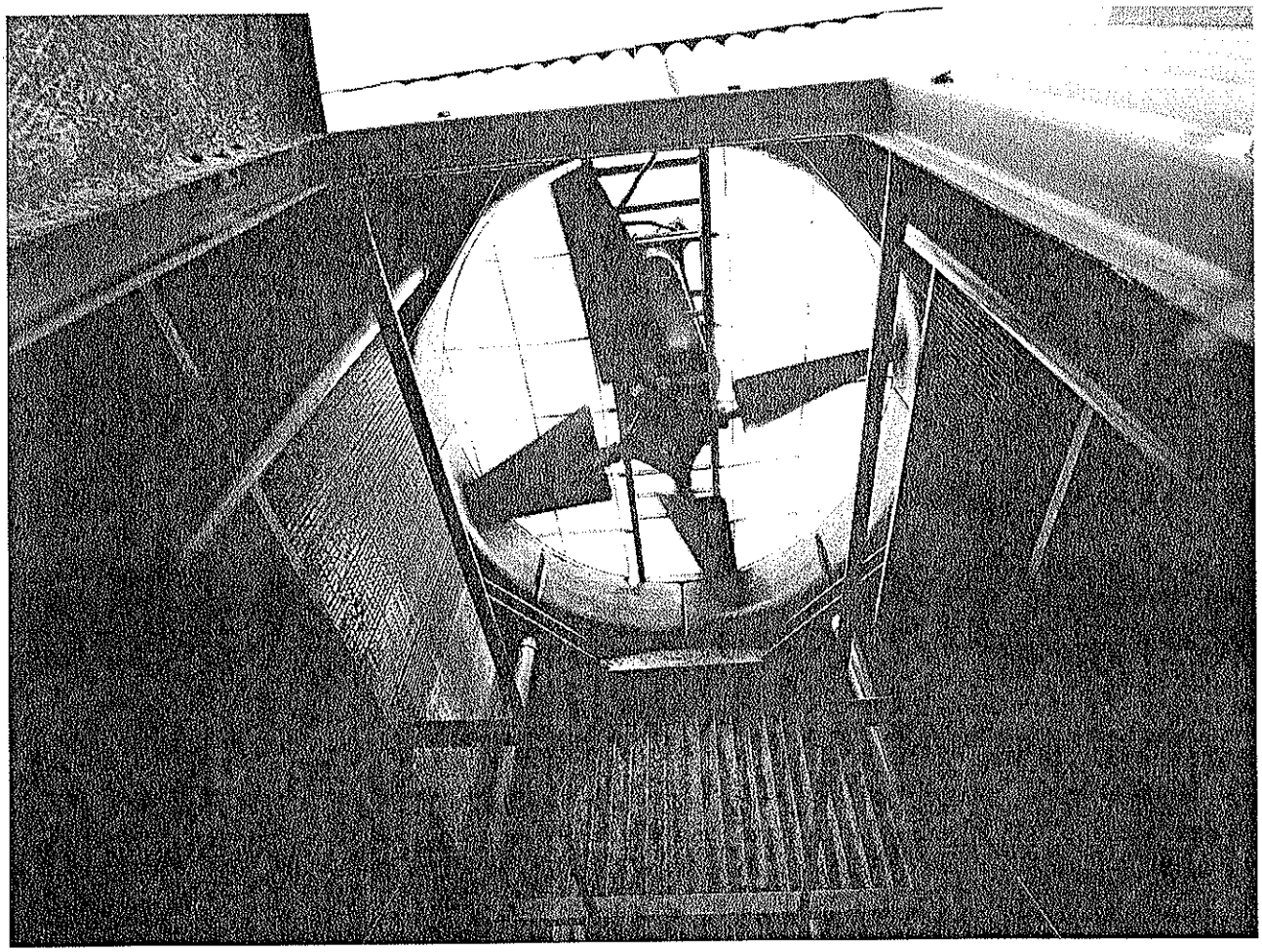




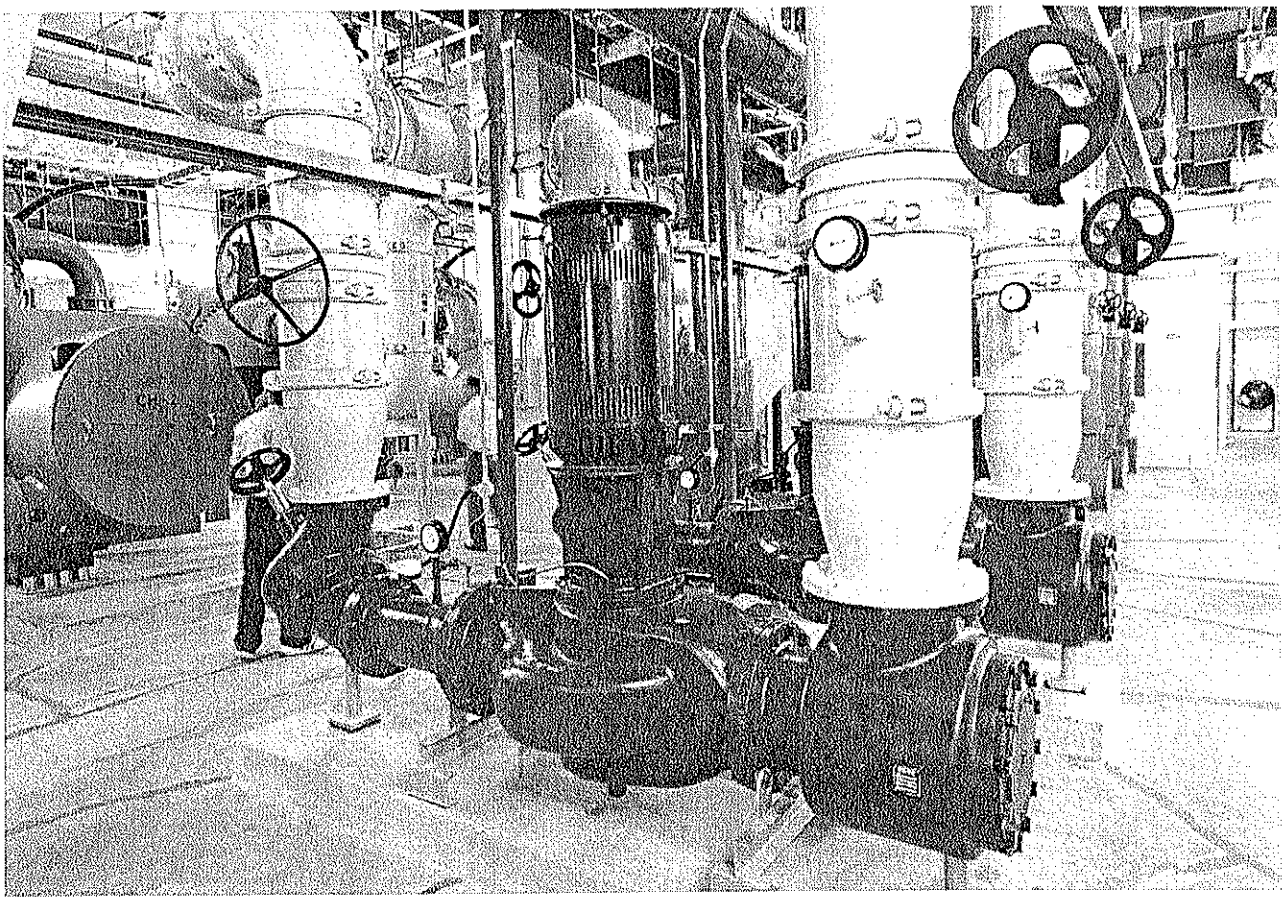


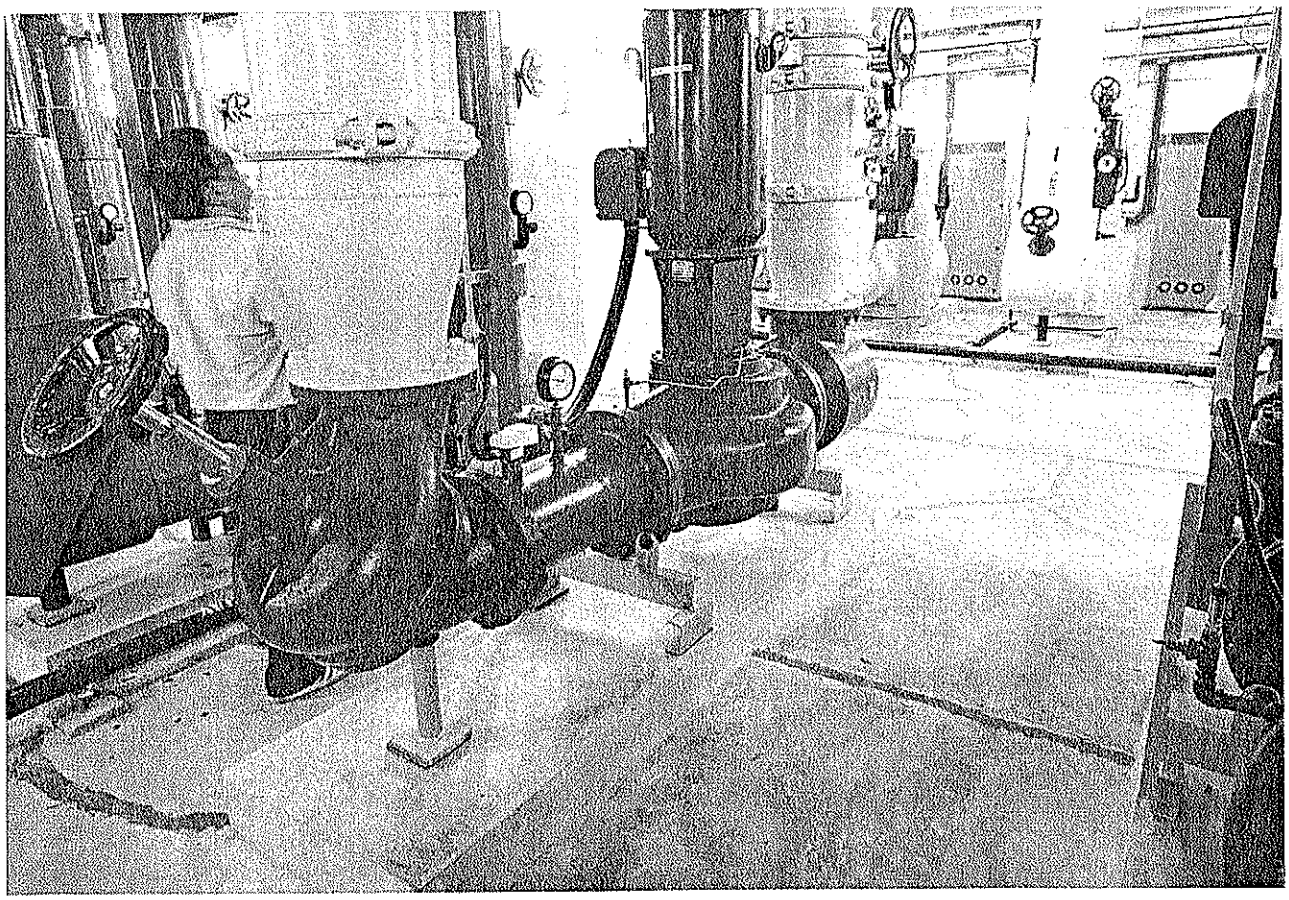


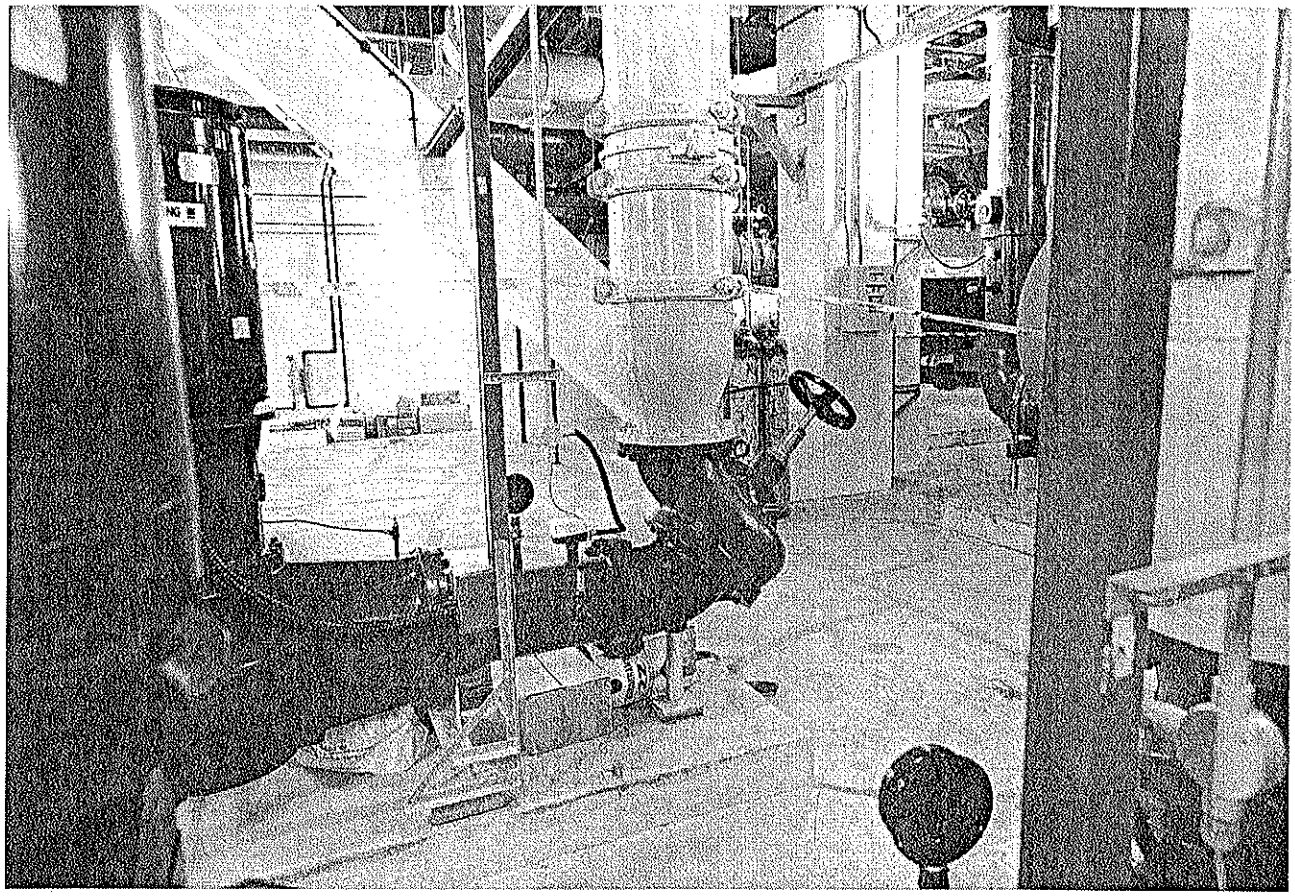

DO NOT ENTER
WHEN

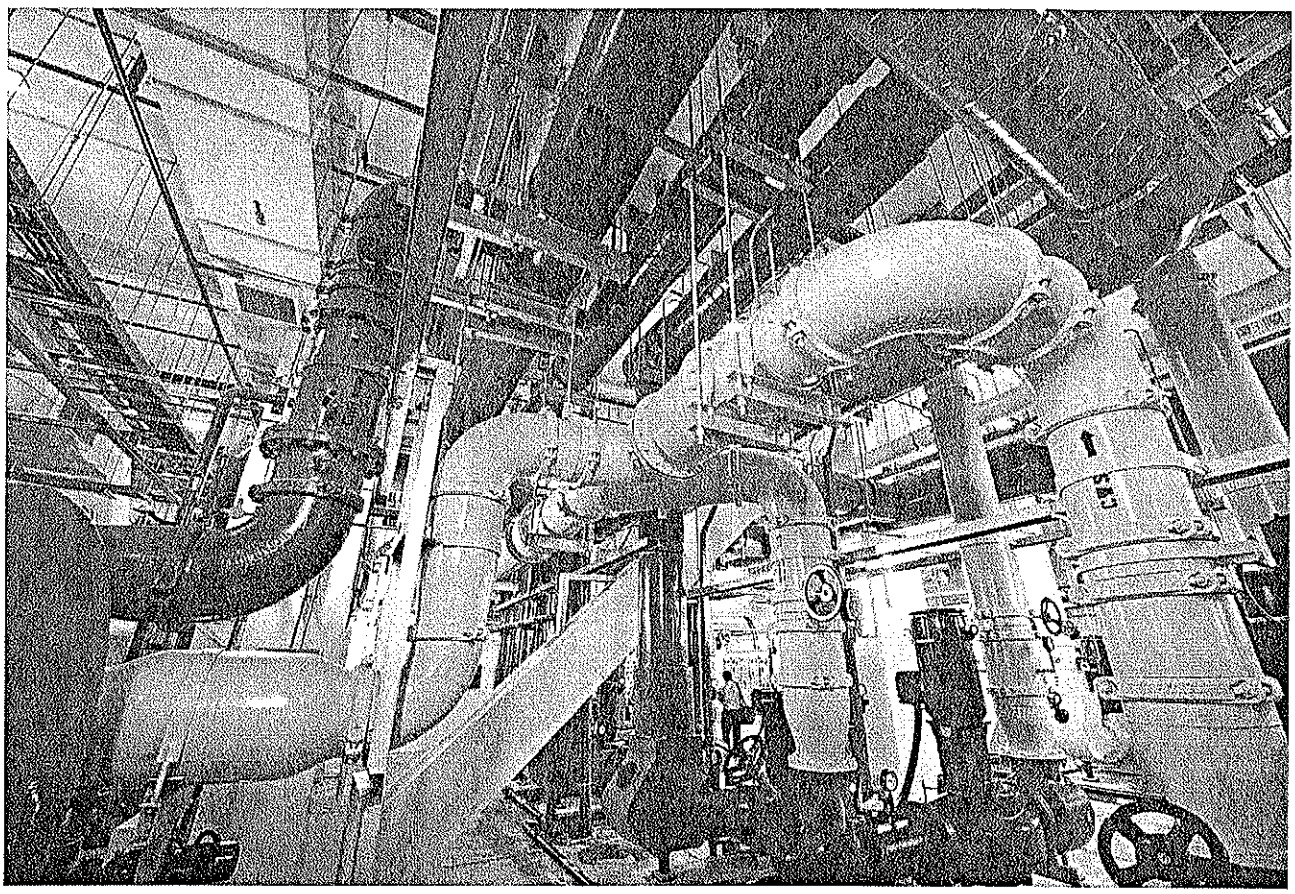


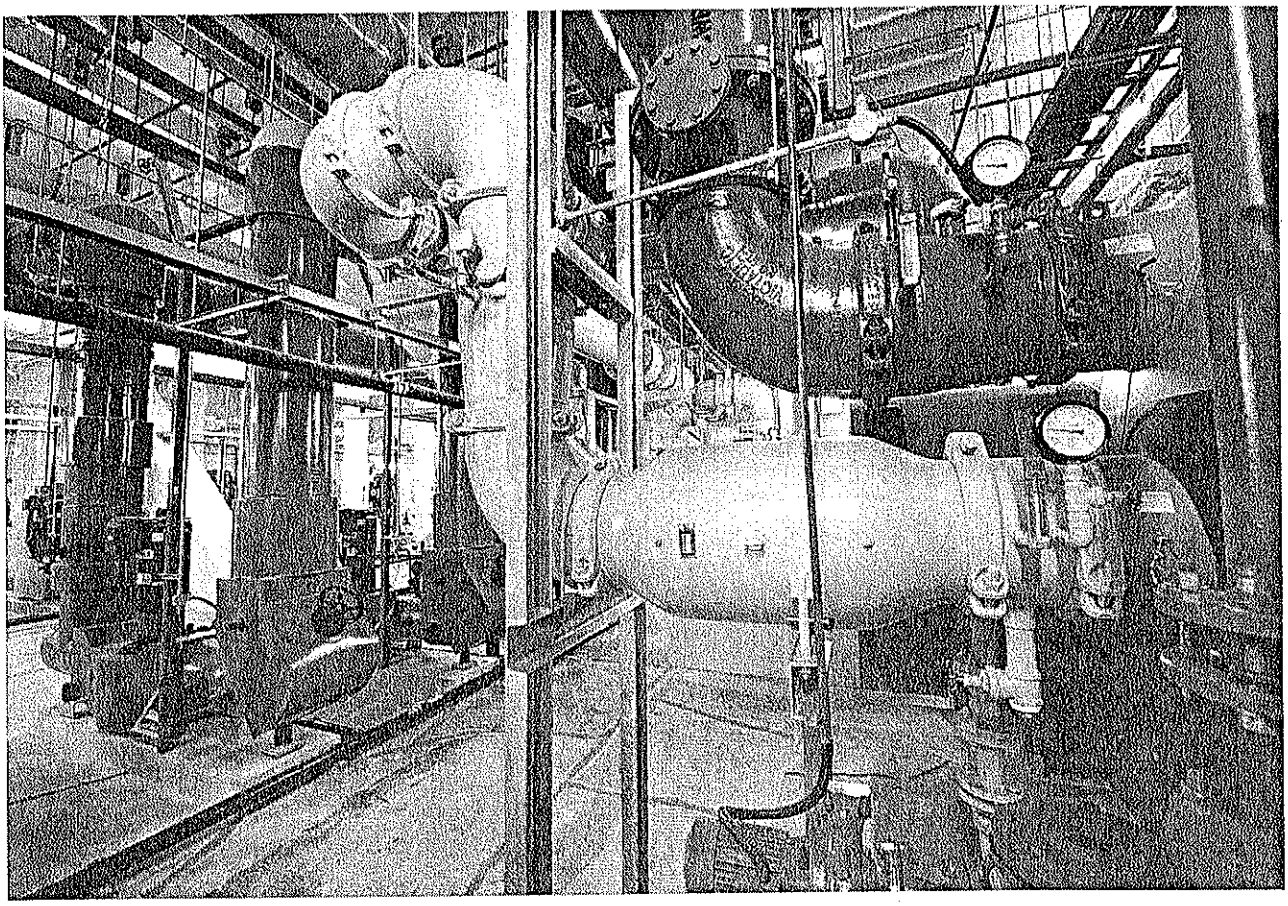
CHWS
CHRS











Thank you for your attention.

Questions?

Proprietary Information of Steven Kang 2011