Continuous Energy Commissioning Program in Hospitality Sector

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Agenda

- Challenges and Opportunities
- Continuous Energy Commissioning Program
- Key Factors in Continuous Energy Commissioning Program

Challenges and Opportunities

Hospitality Sector

- 24 Hours operation.
- Upkeep the equipment and service standards all the time.
- Service maintenance and operation changed over the time.
- Staff turnover and new replacement need time to familiar with the operation.
- Equipment and fixtures high usage and changeover.
- Limited time for the repair and maintenance.

Challenges and Opportunities

Most regular maintenance program is based on routine service.

Energy Profile not the same over the months or years.

There is a need for the change and adopt new operation with this dynamic profile.

For example: weather condition and occupancy

Macau Monthly Cooling Degree Day (CDD)

	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14
CDD total	32	40	91	217	334	412	448	420	409	341	210	32

	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15
CDD total	37	54	120	219	362	421	423	432	386	327	249	71

2015 Total CDD = 2986
2016 Total CDD = 3101

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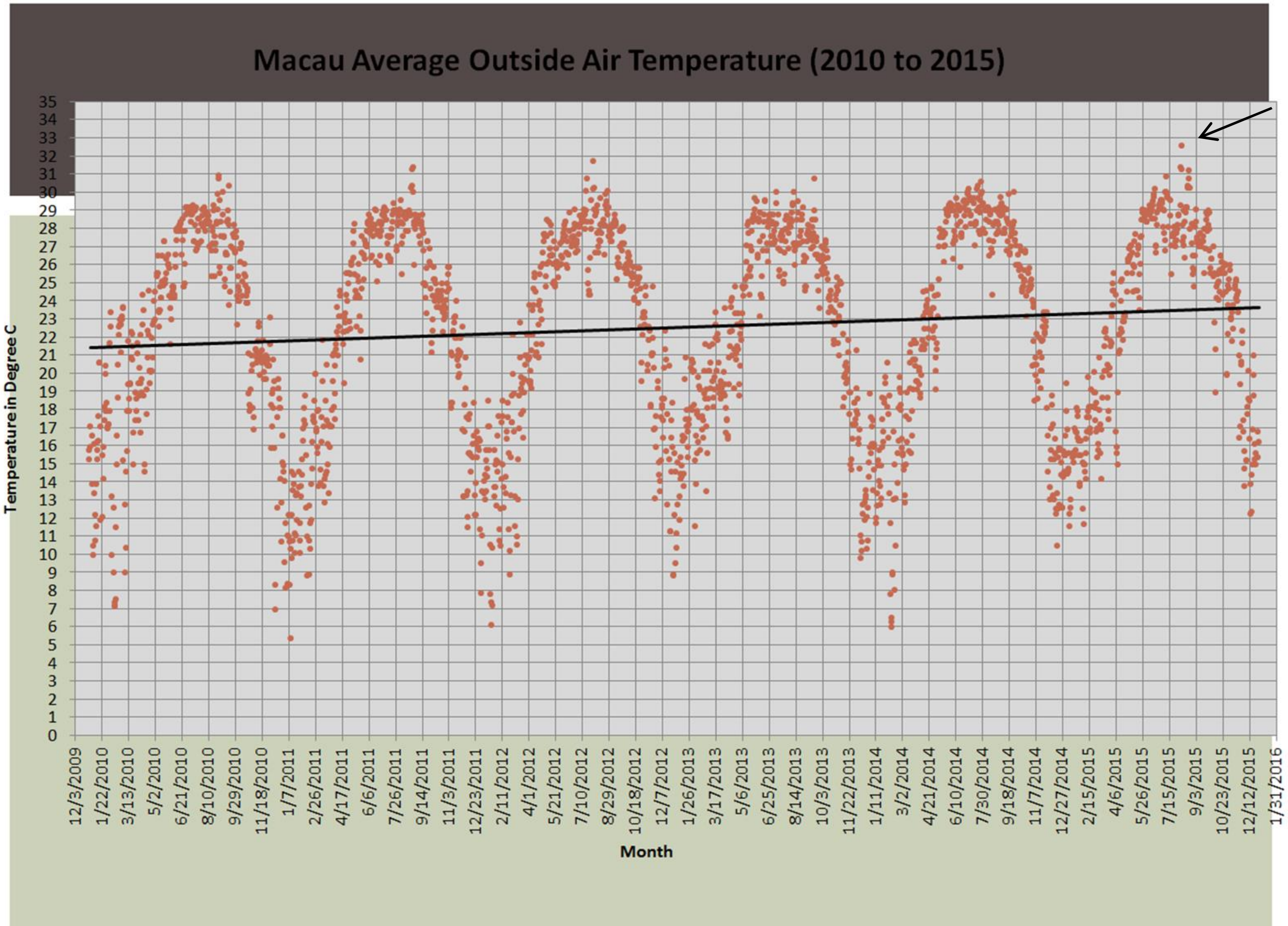
Challenges and Opportunities



Maximum temp was higher compare to past years.

Average temp increased about 3 Deg C. from 2010 to 2015.

Challenges and Opportunities

Equipment and System Deterioration Issue

- End of product lifespan that led to efficiency drop.
  - For example:
  - Lighting level drop.
  - Air filter static pressure increased.
- Monitoring device change of accuracy.
  - For example:
  - Increased error of sensor reading.
  - Sensing element degradation.
  - No calibration.
- Frequent of breakdown.
  - For example:
  - Variable Speed Drive breakdown and the AHU fan switched from variable to constant speed mode.
  - Occupancy sensor malfunction led to the room lighting turned off all the time.

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Continuous Energy Commissioning (CEC) Program

The continuous process of saving energy and improving building performance through optimization of building system and energy management system during the building operation stage.

- Correct the possible error and maintain the energy performance and efficiency to prevent further energy loss.
- Continuous monitoring of the conditions and performance to upkeep the standards.
- Identify, solve or avoid the failure of equipment in a short period of time.
- Improved facility and operations knowledge of facility operations personnel.
- Reduced maintenance costs and usually 10% to 15% annual cost avoidance.
- CEC process is more on labor intense to maintain the process and a low cost initiatives with short simple payback (usually less than 1 year)

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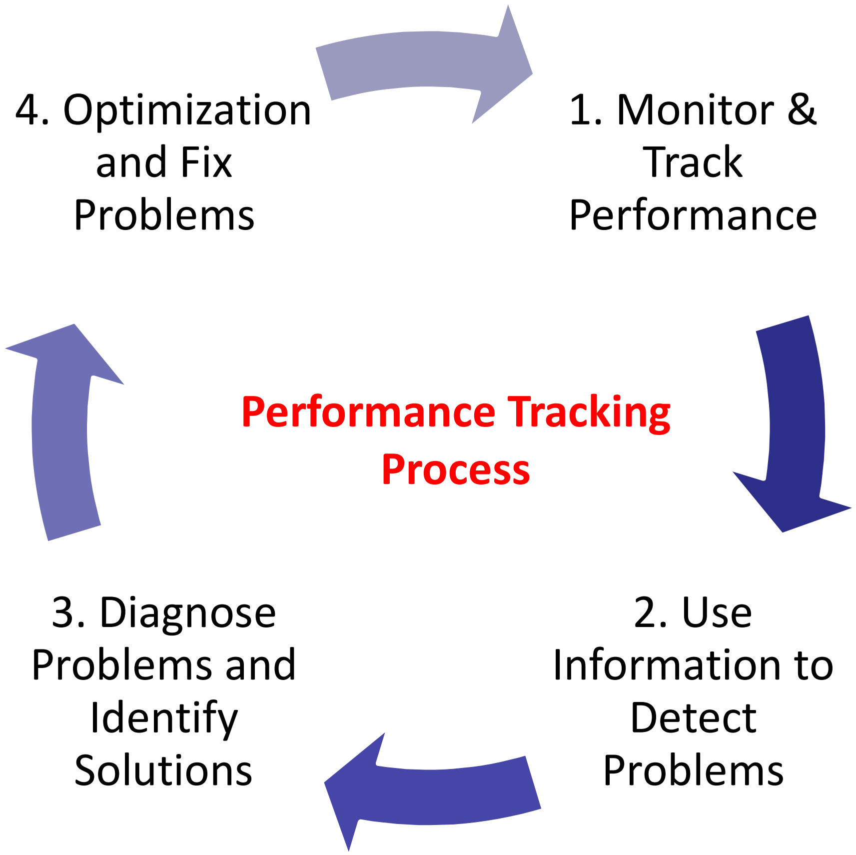
CEC Process

Major Tasks in CEC: Performance Tracking Process

1. Monitor and Track
2. Detect
3. Diagnose
4. Optimize



Key Factors in CEC Program

1. Monitor and Track Performance is a critical stage in CEC process.

2. No accurate performance data always leads to failure analysis and decision making.

<u>Four key factors in this stage</u>

Measurement Uncertainty

Condition of Equipment

Schedule and Control

Integration Issues and Performance

Measurement Uncertainty

- Measurement Uncertainty is a quantitative indication of the quality and reliability of the measurement results.
- It is a key point in judging the fitness for purpose of a measurement result.
- There are always error and uncertainty exist in the measurement or sampling process.
  - For example, 10 Deg C +/- 1 Deg C.

Measurement Uncertainty

Uncertainty Sources:

- **Calibration** – ie. Manufacturers' specifications or field calibration
- **Data Acquisition** – ie. Sensors, data logger, signal conditioning.
- **Data Reduction** – ie. Processing raw data, computational round off errors, missing trend logs.
- **Methods** – ie. Random sampling, averaging points, medium and material properties

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Measurement Uncertainty

Example of Chiller Plant Measurement

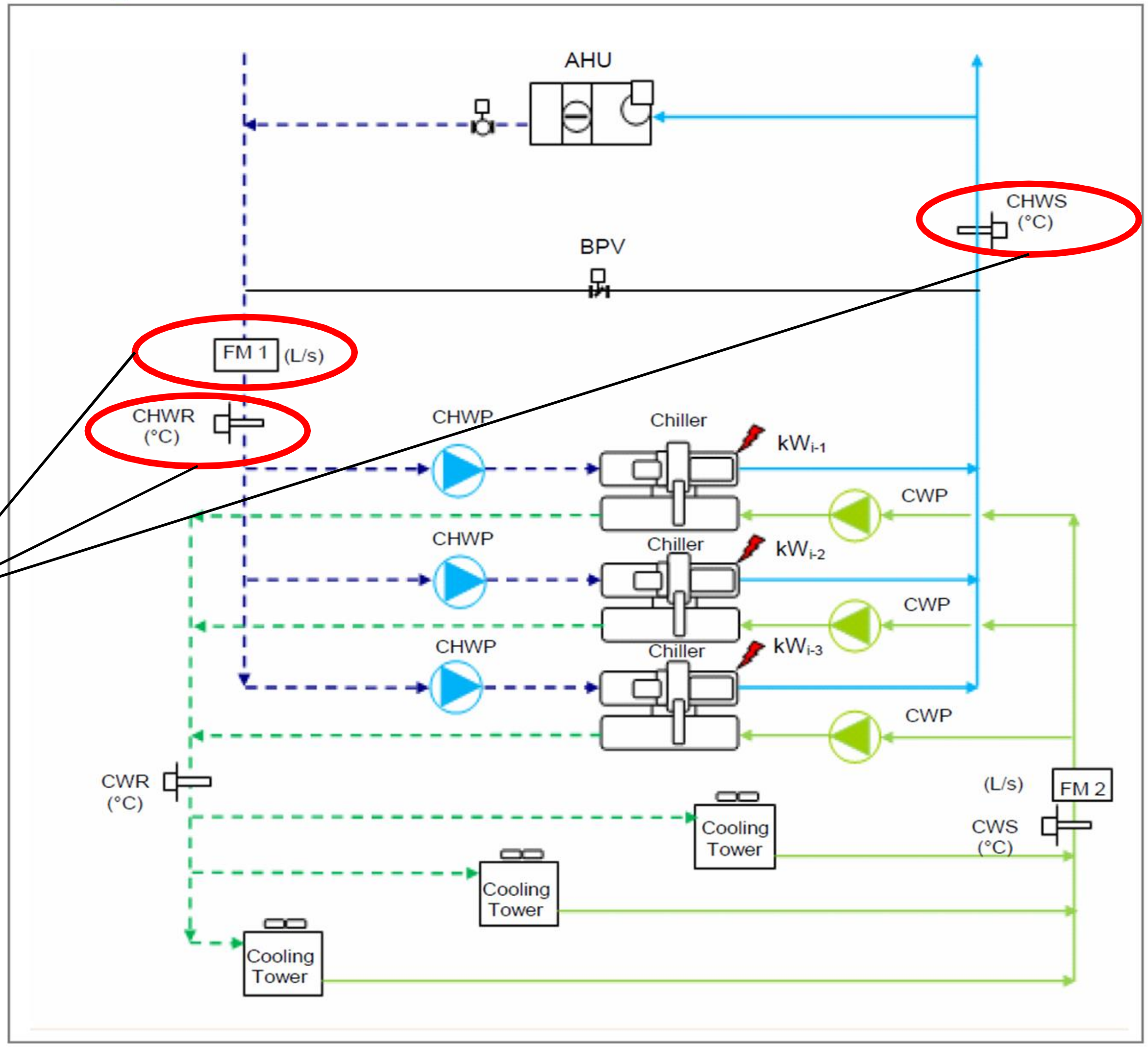
Chiller Plant Main Power

⇩

Chiller Plant Efficiency (COP or kW/RT)

⇧

Cooling Load



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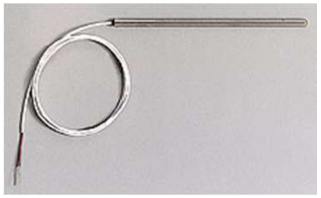
Measurement Uncertainty

Example for the sensor and meter error

- Water Temperature Sensor
  - Case 1 = +/- 0.5 Degree C error
  - Case 2 = +/- 1.0 Degree C error



- Power Meter = 1% error

- Flow Meter = 1% error

Measurement Uncertainty

Case 1

Measurement Error Analysis		
Chilled Water Header Measurement		
Description	Measurement Error (% of reading)	
Temperature Sensor (Delta T)	3.85%	
Flow Sensor	1.00%	
Power Meter	1.00%	
Total Uncertainty	**4.10%**	
Uncertainty should be within 5% according to the ASHRAE Standard		
Temperature Measurement Error		
Description	Temperature in Deg. C.	Formulas
Sensor Accurancy@0 Deg. C.	0.5	CHWS Temperature
Sensor Accurancy@0 Deg. C.	0.5	CHWR Temperature
Design Delta T	6.50	
Measurement Error for Delta T	3.8462%	(CHWST x CHWRT)/Delta T

Measurement Uncertainty

Case 2

Measurement Error Analysis		
Chilled Water Measurement		
Description	Measurement Error (% of reading)	
Temperature Sensor (Delta T)	15.38%	
Flow Sensor	1.00%	
Power Meter	1.00%	
Total Uncertainty	**15.45%**	
Uncertainty should be within 5% according to the ASHARE Standard		
Temperature Measurement Error		
Description	Temperature in Deg. C.	Formulas
Sensor Accurancy@0 Deg. C.	1	CHWS Temperature
Sensor Accurancy@0 Deg. C.	1	CHWR Temperature
Design Delta T	6.50	
Measurement Error for Delta T	15.3846%	(CHWST x CHWRT)/Delta T

Measurement Uncertainty

Case 1

- Total Measurement Error – 4.10%
- 5,000 RT x (0.65 kW/RT) = 3,250 kW (perfectly no error)
- 5,000 RT x (0.65 kW/RT * (1 + 4.1%)) = 3,383 kW
- 133 kW difference by 0.5 Degree error (+/- 4.10%)
- Convert back to Cooling Load (RT) = 205 RT

Case 2

- Total Measurement Error – 15.45%
- 5,000 RT x (0.65 kW/RT) = 3,250 kW (perfectly no error)
- 5,000 RT x (0.65 kW/RT * (1+15.45%)) = 3,752 kW
- 502 kW difference by 1.0 Degree error (+/- 15.45%)
- Convert back to Cooling Load (RT) = 772 RT

****Potential Loss from Error 0.5 Deg C. to 1.0 Deg C.****

(502 kW – 133 kW) x 24 hours x 365 days x $1.22 per kWh = $3,954,382

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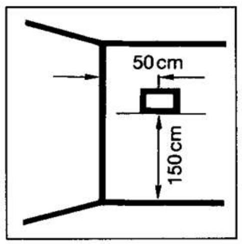
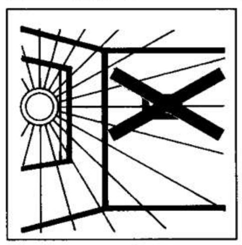
Measurement Uncertainty

Location for sensors can affect the measurement uncertainty level.

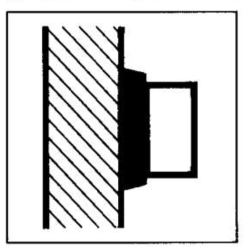
Install sensors at a height of 1.5 m in occupied spaces, and at least 50 cm from the adjacent wall.



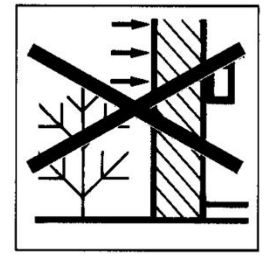
The sensor must not be exposed to direct solar radiation.



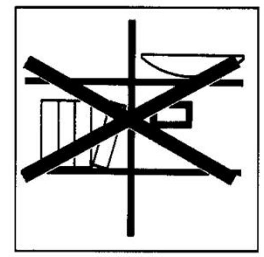
Always use a thermally insulated backing when fitting to solid walls (steel, concrete etc).



Avoid external walls.



Avoid recesses and alcoves.



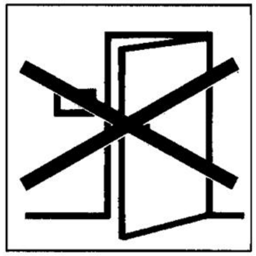
Do not install near lamps or above radiators.

Avoid chimney walls.

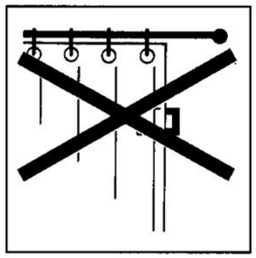
Source: Building Controls Group

Measurement Uncertainty

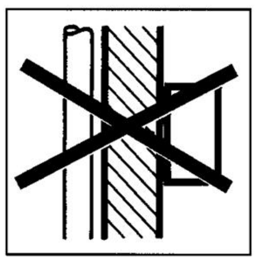
Do not install directly adjacent to doors.



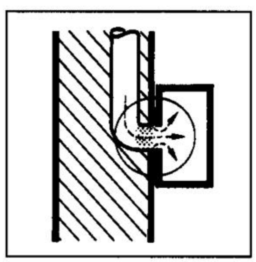
Do not install behind curtains.



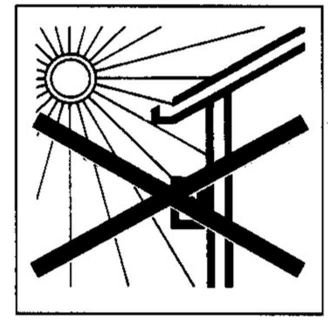
Do not fit to walls concealing hot-water pipes.



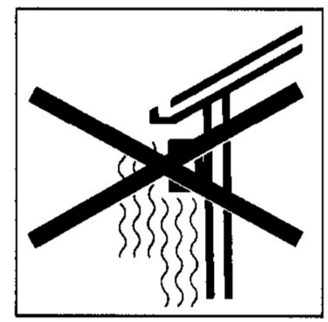
Seal plastic and metal conduits, and cavity walls, to prevent draughts.



Do not expose to direct solar radiation.



Do not install on facades affected by significant rising heat (e.g. metal), or facades which will be heated by solar radiation.

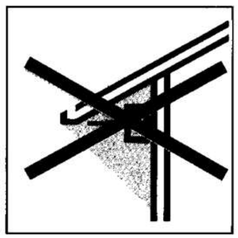


Source: Building Controls Group

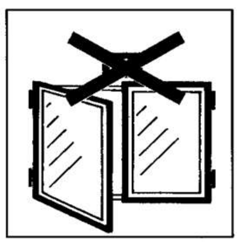
Measurement Uncertainty

Avoid chimney walls.

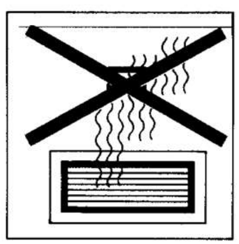
Do not install under eaves.



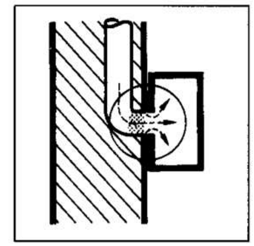
Do not install above windows.



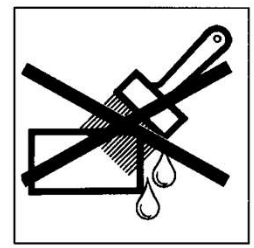
Do not install above ventilation shafts.



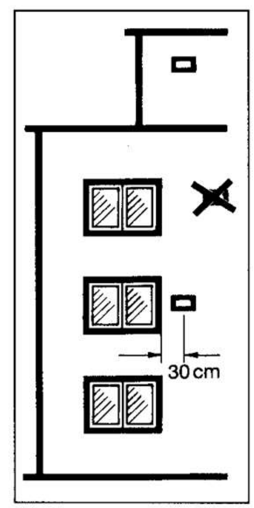
Seal plastic sleeves and metal conduits to prevent draughts.



Do not paint the sensor.

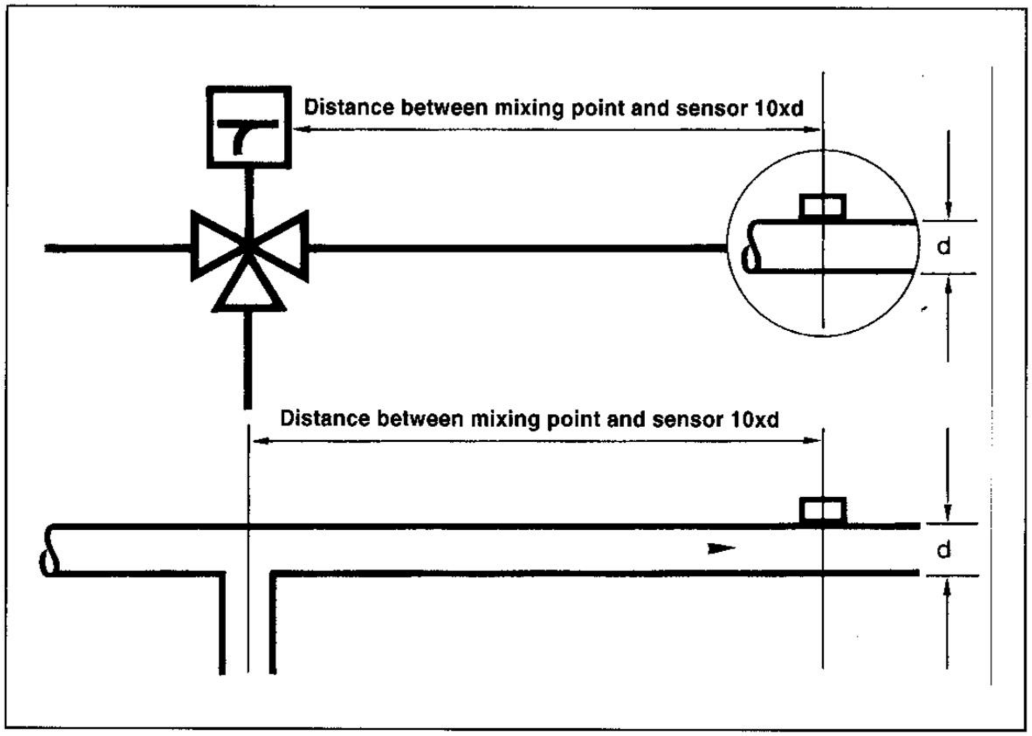


Ensure accessibility
(for inspection / verification).



Source: Building Controls Group

Measurement Uncertainty



When mixing water at different temperatures, always maintain an adequate distance between the mixing point and the sensor (to take account of stratification).

Source: Building Controls Group

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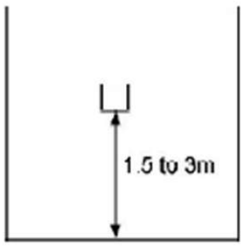
Measurement Uncertainty

Indoor Air quality Sensors

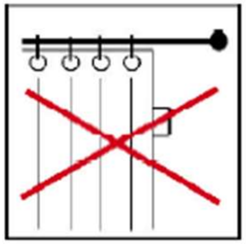
Room mounted sensors

The location of the sensor should be representative of the indoor air quality, e.g. on an open wall 1.5 to 3 m above the floor



The sensor should not be mounted in niches or bookshelves,

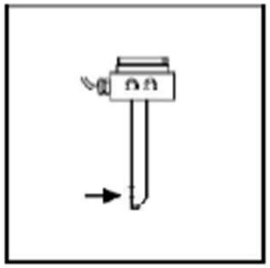
.... not behind curtains,



.... or in locations where people are continuously present (within one or two meters such as speakers desks, working places, etc.

Duct mounted sensors

Locate the sensors in the extract air duct as close as possible to the room air outlets.
The sensor should be installed in a vertical position.
Care should be taken to ensure the correct orientation of the duct probe with respect to the air flow.

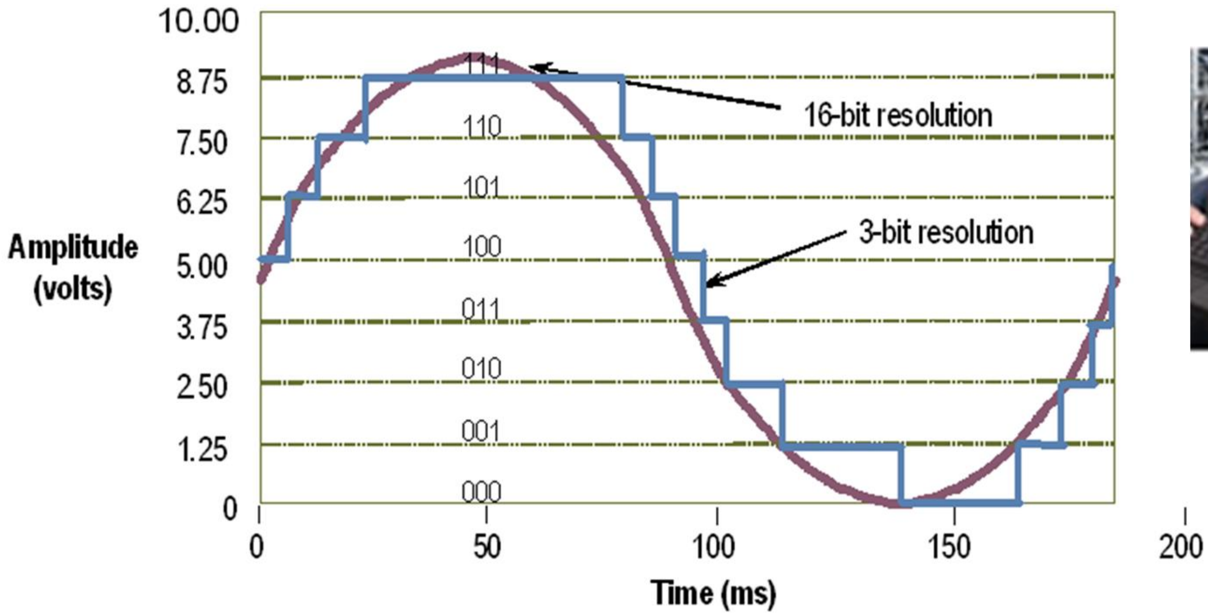


The probe should not be installed in a vertical position with the head at the bottom.

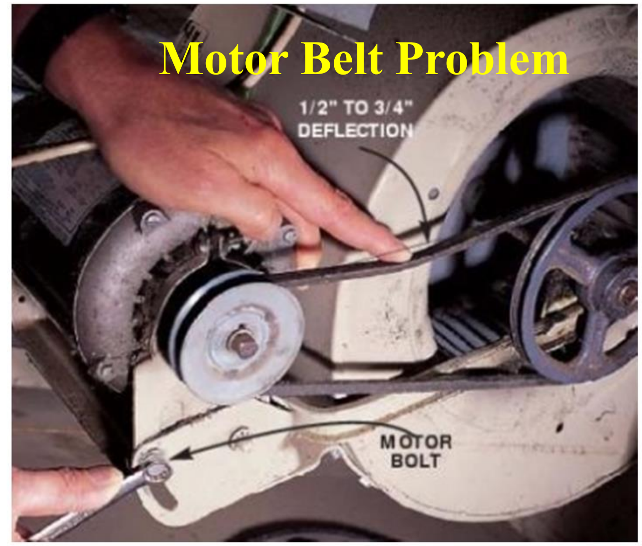
Source: Building Controls Group

Measurement Uncertainty

- Importance of selecting a higher resolution for the BMS Controller or Data Logger from Analog to Digital Conversion (AC to DC resolution)
- For example, 12 bits ADC = 2^12 = 4,096 / 16 bits ADC = 2^16 = 65,536
- Resolution limits the precision of a measurement.
- Higher the resolution (number of bits), the more precise the measurement.



Condition of Equipment



- Physical condition – each equipment configuration and condition are different than others.
- Taking inspection and sampling with “typical unit or equipment” can lead to wrong data collection in the performance tracking and monitoring stage.
- Sensor technology supplier will not be guaranteed 100% measurement error free.
- As-built drawings is not always 100% matching system configuration on site.

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Condition of Equipment

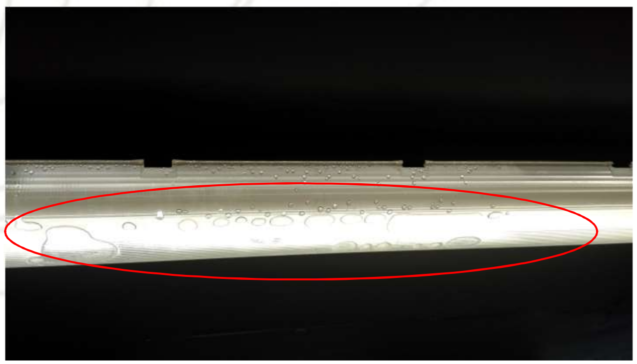
Software or System monitoring of equipment is limited with basic parameters.

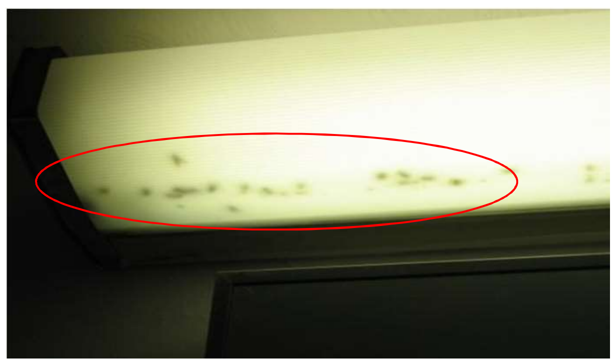
Operating log sheet is documented with key parameters to tell the true performance of equipment.

For example, check the operating pressure, temperature and oil level for the chiller condition.


Log 1 | Log 2
PRV
S.T.D(ΔT)
deg C
12828
100
88
340
12828
701
23.11.2014
624 kPa
23.6
28.3
4.7
0.2
270
190
80
11.6
6.0
5.6
0.8
1360
1290
70
147
262
dBA
drops/min

Condition of Equipment





"External Factors" to affect the performance of equipment.

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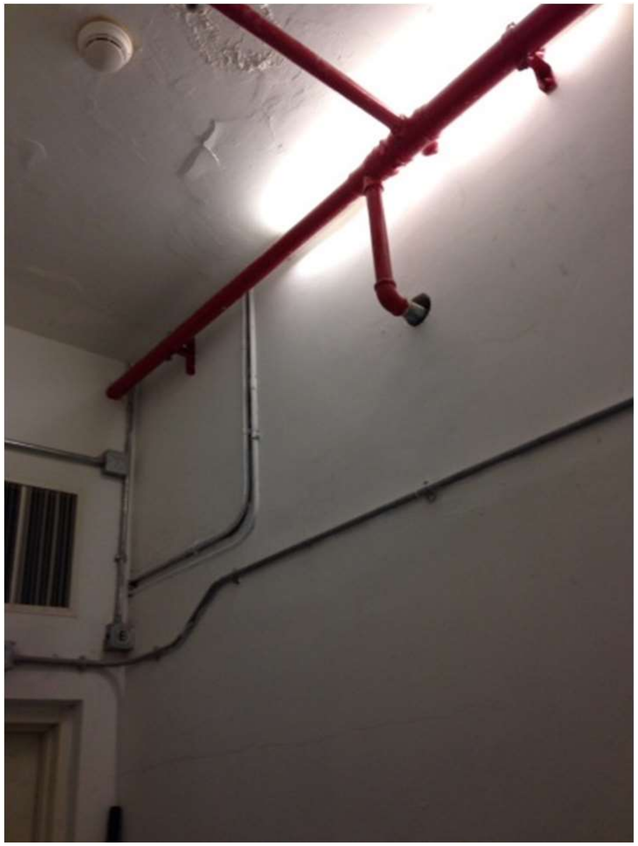
Condition of Equipment



Current Condition of Equipment

Schedule and Control

- Operating schedule is the key of the energy consumption by equipment (kW x Running Hours = kWh).

- Scheduling problem is quite common issue found in the CEC process.

- Smart scheduling can save money by allowing reduction of energy output during the demand time in the operation.

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Schedule and Control

Modeling equipment schedule techniques in CEC process

- **Task Model** – each task has its priority and task profile for the power consumption. It can be defined into different classes.

- **Backtracking-Based Scheduling** – identify the complexity and potential issues that may incur the additional energy usage in the operational schedule.

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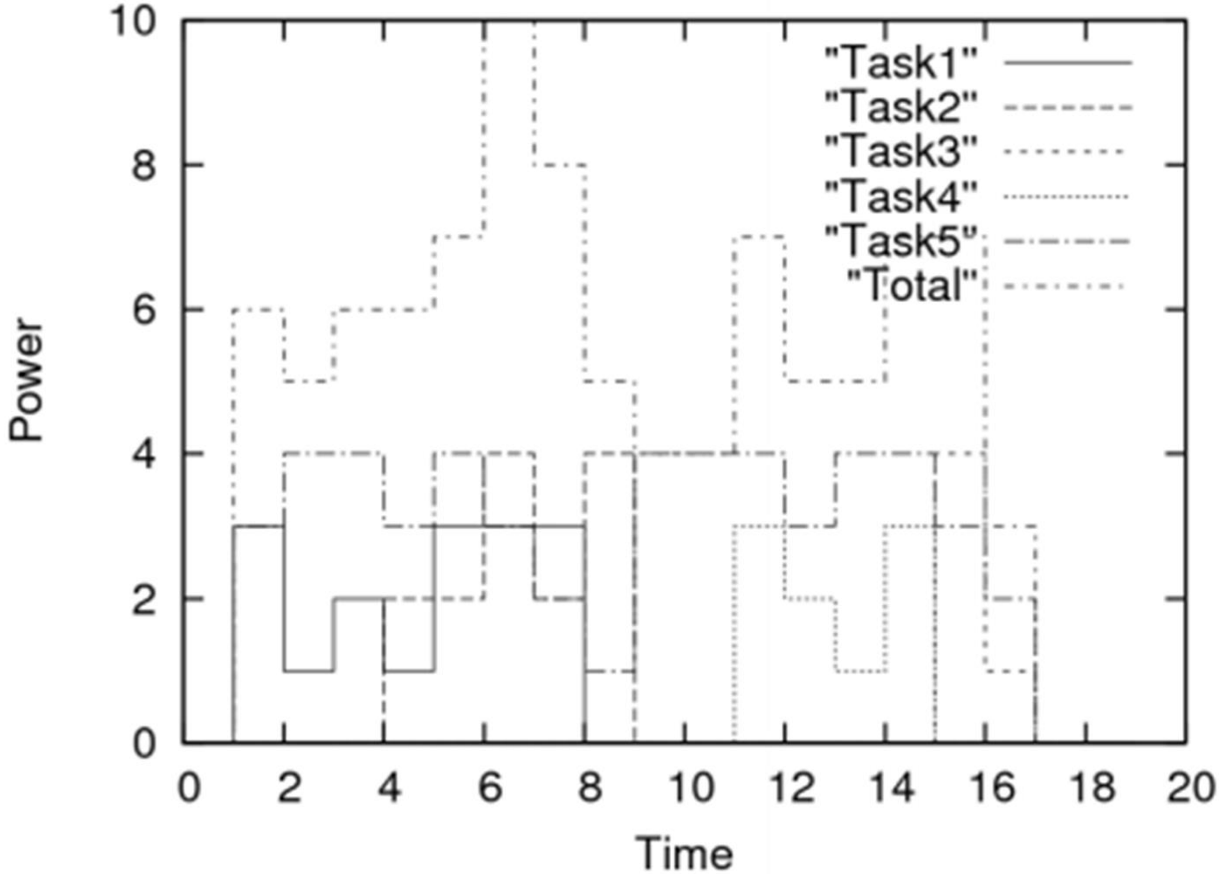
Schedule and Control

Task Model

- Class 1 task – start immediately after the task gets ready and cannot be ceased to the end. (F&B Outlet A/C to start before the guest comes to the outlet)
- Class 2 task – don't have to start as soon as they get ready but their operations are not preemptive (dish washer or laundry machine can start anytime as long as the task can be completed within a specific time)
- Class 3 task – can also start after their activation time as class 2 task but they are preemptive (Electric charging)

Schedule and Control



Task Profile and Schedule

Schedule and Control

Backtracking-Based Scheduling

- Tracking the control sequence to match the schedule
- Potential unexpected activities (Example: occasional dinner functions or business events)
- End user behavior (different customers or occupancy in peak or non-peak session)

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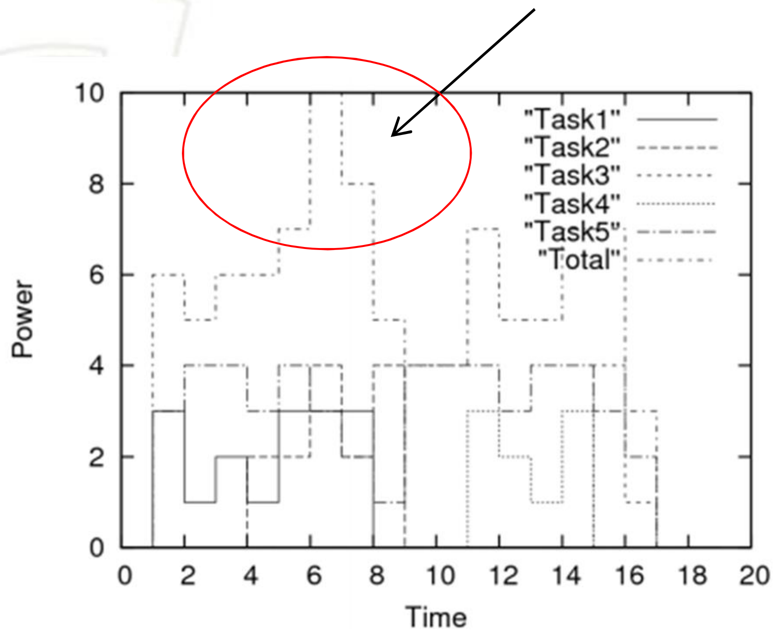
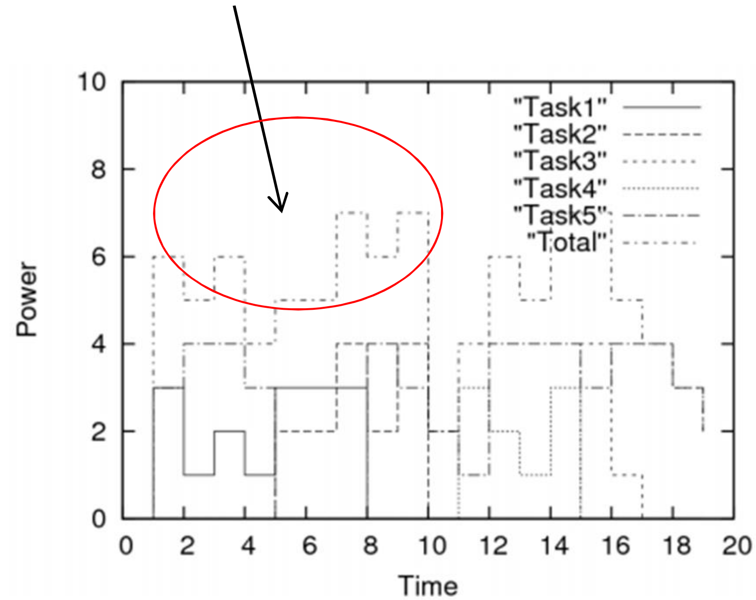
Schedule and Control

Backtracking Tasks to find opportunity





Power Reduction by an Optimal Schedule

Schedule and Control

Equipment Performance and Efficiency depending on how well the control of equipment

Common Problems as below

1. VSDs that do not modulate
2. Faulty Control Valves
3. Unimplemented reset schedules
4. Controls out of calibration
5. Static pressure higher than required
6. Night setbacks not implemented
7. Equipment operating more than necessary or inefficiently
8. ECM never programmed
9. Improper sequences of operation/simultaneous heating and cooling
10. Improper outside air damper settings and controls

Schedule and Control

Key review of the extended functional testing in CEC:

- **Unacceptable cycle length during the change of weather condition.** Setpoint temperature is fixed but the ambient outside conditions are changing (Low/strong wind, heavy rain or low cloud base level).

- **Cool-Down or Warm-Up process.** The space condition is not brought up to temperature by the time of occupancy, resulting in occupant discomfort. To solve this problem, scheduled operation is often changed to start much earlier. If the earlier start persists in the long term, energy is wasted.

- **Rapid equipment cycling.** Rapid cycling of equipment creates the demand spike that can overcome in utility charges to exceed the costs associated with staging the start up of the systems over a longer timer interval such as electrical heaters, walk-in cold room compressor.

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Integration Issue and Performance

Conserve Energy is important to maintain the operational cost optimized but occupant comfort, health and safety activities always came in “First Priority”. Optimize Energy and occupant comfort must review together.

Implementing Energy Conservation Measures is not just simply saving the energy. There are always an impact to other building performance.

Optimizing the **Total Building Performance** is the ultimate goal.

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Integration Issue and Performance

- **Total Building Performance** – Set of coordinated strategies aimed at assessing the quality performance of a building in Air Quality, Thermal Comfort, Visual Comfort, Acoustical, Structural, Spatial and Building Integrity.
- Continuous Energy Commissioning **is not just looking at the energy performance** but also looking into other building performance.
- Minimize the energy usage and maximize different building performance by using integrated optimization and smart responses.
- Balance the Building Performances so it will not complicate other performances.

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Integration Issue and Performance

	PHYSIOLOGY	PSYCHOLOGY	SOCIOLOGY	ECONOMY
Spatial	Ergonomic Handicapped access Functional services	Habitability Aesthetics quality External view	Way-finding Provision of common space Ease of interaction	Space conservation Function optimization Health & injury costs
Thermal	No cold hand/ feet No drowsiness No heat stroke	Perceivable comfort Moderately cool Ability to control	Flexibility to adjust attires Commonality of thermal preference	Energy conservation Performance benefits
Indoor Air Quality	Fresh air intakes No respiratory illness No skin rashes	Perceivable freshness No foul smell Presence of nature (plants, flowers)	Behavior leading to untolerable air ETS	Energy conservation Health-related costs
Visual	No glare Proper illumination Clear way-finding	Color-emotion effect Spaciousness Liveliness	Territorial sense Well-lit common space	Energy conservation Performance benefits
Acoustic	No intolerable noise Speech/ music quality No hearing damage	Quietness, soothing Active, excite Liveliness	Ease of communication SRS performance for meeting areas	Performance benefits
Building Integrity	Fire safety Weather-tightness Structural strength & stability	Personal image Sense of safety Maintainability	Organization status Demonstration of quality	Material conservation Maintenance costs

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Integration Issue and Performance

Sample Performance Failures* From Visual Performance Decisions

Decisions made for:	Leading to failures in:
Visual Performance	**Thermal Performance**
increased floor-to-ceiling height	increased thermal stratification and conditioning needs
reflective glass to reduce glare	reduced potential for solar heating during underheated periods
increased use of glass for daylighting	excessive gains during overheated periods
increased number of light fixtures	excessive heat gain from lights, especially with poor lumens/watt
Visual Performance	**Acoustical Performance**
fluorescent lighting	buzzing, depending on quality, maintenance and age
sea of evenly spaced fixtures for flexibility	increased potential for sound reflection
venetian blinds for light control instead of fabric curtains	increased sound reflectivity
Visual Performance	**Spatial Performance**
ambient lighting only in circulation areas	loss of full spatial flexibility
open plan offices to maximize daylight penetration and artificial light distribution	loss of privacy and hierarchy
central light management systems	loss of individual control, poor energy performance
undifferentiated task-ambient lighting	loss of wayfinding, workplace definition
Visual Performance	**Air Quality**
artificial lighting alone for control and efficiency	without sunlight, potential psychological dissatisfaction; dying plants; germ and mold build-up
use of fluorescent light fixtures	poor spectral distribution; possible radiant and particulate pollution
Visual Performance	**Building Integrity**
reflective film retrofit to reduce glare	fissure cracks, visual degradation
poor selection of light diffusers/lenses on fixtures	dust buildup, yellowing, increased maintenance
highly reflective, light-colored furnishings for light distribution	marring, discoloring, staining; high maintenance
daylighting	fading, discoloring, brittleness, cracking

*Examples drawn from five years of occupied office building evaluations in U.S., Canada, and England.

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THE END