STREAM 1: SESSION 2 (Time 1500-1630):

ENERGY EFFICIENCY

BUILDING AUDIT:
ENERGY AUDIT EXISTING BUILDINGS

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For Architect Centre S/B.

Acknowledgement to ACSB Contributors:
Ir PS Soong
Ir Kok Yee Hin
Ir Kok Yen-Kwan
Chan Weng Loon
Architect centre
Services
Inspection teams
State of Building Audits in Malaysia
FACT:

• Urban Migration into cities; demand for buildings increase;
• Our Buildings consume 40% of world’s energy;
• Past 30 years increase of 30% in energy consumption;
• By 2020, 60% population will live in cities;
• Which represents 60% of energy consumption;
• 40% CO2 emission (outstripping Industry & Vehicle emissions).

Future:

• Energy efficient buildings, improved ecological footprint; while increasing quality of life;
• Innovative technology to bring energy efficient buildings;
• To design Energy positive buildings.
State of Building Inspection Audit in Malaysia

Increase awareness
More inquiries and interest
Limitation of money

Limitation to corporate institutional
Audit for New Buildings going for Green certification

Existing Buildings
More towards reducing energy consumption
Primary Concerns

“systematic energy audit of occupied buildings”

1. Reducing Energy Consumption*
2. Maintaining & Improving Human Comfort
3. Health & safety

- Energy audit seeks to prioritize the energy uses according to the greatest to least cost effective opportunities for energy savings.

- Home
- Commercial
- Institutional
### Architect Centre’s Inspection Reports

#### ASSESSMENT OF BUILDING CONDITION STATUS:
- STRUCTURAL Systems
- ARCHITECTURAL Systems
  - Roofing, Building Envelope
  - Landscape Features
- MECHANICAL Systems
- AIR CONDITIONING & MECHANICAL Systems
- ELECTRICAL Systems
- LIGHTING Systems
- PLUMBING Systems

#### CONCLUSION for BUILDING CONDITION STATUS
- determine fault and risk rating due to:
  - Defective Items
  - Design Flaws (Unfit for Purpose, unless intended)
  - Non-compliant to Building Codes / By-Laws
  - Incomplete Workmanship
  - Status of Lifespan or Lifecycle
  - Due to Abuse/Negligence
  - Lack of Maintenance
  - Inconclusive due to lack of access or evidence
  - No Action Necessary

#### RECOMMENDATION FOR:
- MAINTENANCE;
- REMEDIATION;
- REPLACEMENTS

IN ACCORDANCE TO CONCLUSIVE FINDINGS OF FAULT & RISK RATING – RECOMMENDATION TO RESTORE TO ORIGINAL OR IMPROVED CONDITION BY THESE ACTION(S):

- Review of Original Intended Uses & Purposes
- Re-Design & proposals to
  - New Utilization
  - New By-Laws
  - New MS Standards
- Corrective Action for Defective Items
- Review and Re-Design Existing Green Building Status & Carbon Footprint Optional
- Additional Investigation & Destructive testing(s) that may be required to determine building condition status

---

1. Architect Centre’s Inspection Reports
2. CONCLUSION for BUILDING CONDITION STATUS
3. RECOMMENDATION FOR:
   - MAINTENANCE;
   - REMEDIATION;
   - REPLACEMENTS

---

**ASSESSMENT OF BUILDING CONDITION STATUS:**

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- ARCHITECTURAL Systems
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**CONCLUSION for BUILDING CONDITION STATUS:**

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  - Status of Lifespan or Lifecycle
  - Due to Abuse/Negligence
  - Lack of Maintenance
  - Inconclusive due to lack of access or evidence
  - No Action Necessary

**RECOMMENDATION FOR:**

- MAINTENANCE;
- REMEDIATION;
- REPLACEMENTS

IN ACCORDANCE TO CONCLUSIVE FINDINGS OF FAULT & RISK RATING – RECOMMENDATION TO RESTORE TO ORIGINAL OR IMPROVED CONDITION BY THESE ACTION(S):

- Review of Original Intended Uses & Purposes
- Re-Design & proposals to
  - New Utilization
  - New By-Laws
  - New MS Standards
- Corrective Action for Defective Items
- Review and Re-Design Existing Green Building Status & Carbon Footprint Optional
- Additional Investigation & Destructive testing(s) that may be required to determine building condition status
Architect Centre’s Comprehensive Inspection
Home Energy Audit

1. Energy efficiency evaluated by a person (or team) using professional equipment (such as infrared cameras), suggest best ways to improve energy efficiency in heating and cooling the house.

2. Thermal Performance – by recording various characteristics of the building envelope - walls, ceilings, floors, doors, windows, and skylights, checks for leakage rate or infiltration of air through the building envelope is of concern - affected by window construction, door seals.

3. M&E Systems - assess the efficiency, physical condition, and programming of M&E systems such as ventilation, air conditioning equipment, and thermostat.

4. Study of energy billing history.

5. Study of local climate criteria, thermostat settings, roof overhang, and solar orientation.

6. Written report
Energy* Audit – Commercial / Institutional Buildings

1. Adapted from *Performance Measurement Protocols “PMP” of Energy, Water and IEQ* by Ashrae Journal July 2012 (Bruce D.Hunn)
2. Preliminary Condition Visual Inspection
3. Establishing Objectives, Inspection Team, Schedule
4. Audit Criteria : Basic, Intermediate, Advanced
5. Data Collection, Measurements
6. Recommendations for “energy & water conservation and IEQ measures”
7. Written Report references made to UBBL, MS1525, DOSH (IAQ) 2010, GBI.
8. Costs estimates
<table>
<thead>
<tr>
<th>12 Months Ending</th>
<th>Site EUI (kBtu/ft²·yr)</th>
<th>Source EUI (kBtu/ft²·yr)</th>
<th>Site ECI ($/ft²·yr)</th>
<th>ENERGY STAR Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 2006</td>
<td>77.1</td>
<td>257.6</td>
<td>N/A</td>
<td>44</td>
</tr>
<tr>
<td>September 2010</td>
<td>40.7 (47% Savings)</td>
<td>136.1</td>
<td>1.30</td>
<td>93</td>
</tr>
</tbody>
</table>

**Table 2:** Annual whole-building energy use and cost for ASHRAE Headquarters Building (all electric), before and after renovation.
Performance Measurement Protocols “PMP” of Energy, Water and IEQ - NB and EB

1. Increasing demand for green certifications for NB & EB
2. Claims based on data and measurement collected using standardized performance audits accepted throughout the industry & reported against meaningful benchmarks.
3. Feedback to industry (manufacturers, designers) when measured performance does not match claims and design intent.
4. PMP forms basis for (MRR - Maintenance, Repair, Replacement policies and priorities)
5. Audit of Energy & Water use
6. Audit on Indoor Environmental Quality that includes:
   - Thermal comfort
   - Indoor air quality (IAQ)
   - Lighting, and
   - Acoustics
<table>
<thead>
<tr>
<th>Measure Categories</th>
<th>Levels of Performance Objectives (Cost vs. Accuracy/Instrumentation Level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Use</td>
<td>Basic (Indicative—Low Cost and Simple): Annual, Whole-Building Data</td>
</tr>
<tr>
<td>Water Use</td>
<td>Intermediate (Diagnostic—Medium Cost and Intermediate Technical Skill Level): Monthly, Major System Data</td>
</tr>
<tr>
<td>IEQ: Thermal Comfort</td>
<td>Advanced (Investigative—High Cost and Accuracy, Requiring Experts to Perform): Weekly/Daily/Hourly, System or Equipment Operational Data</td>
</tr>
<tr>
<td>IEQ: Indoor Air Quality</td>
<td></td>
</tr>
<tr>
<td>IEQ: Lighting/Daylighting Quality</td>
<td></td>
</tr>
<tr>
<td>IEQ: Acoustics</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Performance measurement protocols characteristics.
Audit Methodology

1. What, How and How Often (to measure)

2. Determine appropriate level of effort, detail or rigor fit for intended building typology.

3. For each measure category:
   • Objectives of the measurement.
   • Metrics to be used, including instrumentation and units of measure.
   • Performance evaluation and benchmarks.
Audit on Energy use - BASIC LEVEL

- **OBJECTIVES** for energy measurements:
  - Characterizing annual, whole building energy use and cost.
  - Establishing the energy performance ranking of the building relative to its peers.
  - Estimating the building's energy use savings potential.

- **METRICS** to meet these objectives:
  - Cataloging basic building characteristics from building plans and specifications, as well as a walk-through audit.
  - Compiling annual, whole-building energy use and cost, by source. This includes 12 consecutive months of utility data; both total and net energy use, are reported.
  - Calculating annual energy use and cost indices (per unit of gross floor area) and normalized to occupancy.

- **BENCHMARK:**
  - Comparing the result to publication by Energy Commission, Green Building Energy Index, etc.
Audit of energy use - Intermediate & Advanced Level:

1. Objective intermediate level:
   - characterize energy end-use patterns
   - identify where performance improvement can be made.
   - Focus on monthly and weekly" energy data distinguishing between occupied and unoccupied periods.

2. Objectives advanced level:
   - track energy performance daily or hourly, for the whole building and through sub-metered data by system or end use,
   - identify additional performance improvements
   - verify improvements over time.
Audit of energy use - Intermediate & Advanced Level:

Metrics intermediate level:
- Focus on systems level (major end uses, i.e., cooling, lighting, plug/process loads).
- Sub-meters may be used to identify weekly, monthly and/or annual end use patterns.

Metrics advanced level:
- Based on daily or hourly data and include generation of advanced energy-use benchmark models using daily or hourly data, and more frequent performance comparisons against local, national or international norms.

Benchmarks: Self-reference benchmarks are used at the higher levels.
- As a supplement to end-use sub-metering, whole-building regression models can be used at the intermediate level to identify heating, cooling, and base load energy uses.
CONSUMPTION PATTERN (OFFICE)

Nightload  Start-up  Operation  Ramp-down
CONSUMPTION PATTERN (MALL)
Power data loggers used by ACSB in intermediate & advance level:
ACSB uses other advance means to diagnose energy efficiency of high performance building in indirect way as well:

**Day image**

**Night image**

**Duct insulation...some leakage**

Chilled slab thermal storage or radiant cooling: See chilled water pipes beyond concrete!
WATER LEAKS essentially produces “latent heat” to AC Systems; increases humidity and reduces IAQ.
Cracks & water leaks essentially produces “latent heat” to AC Systems; increases humidity and reduces IAQ.
Cracks & Leaks –
A Malaysian Phenomena
Drafty, leaking windows increases energy consumption, reduces IEQ – noise, humidity, heat, dust.
Audit on Water use – BASIC LEVEL

- **OBJECTIVES for water consumption measurements:**
  - Characterizing and rating whole-building water use and cost.
  - Aggregating total building/site water uses.
  - Identifying water-savings potentials.

- **METRICS to meet these objectives:**
  - The basic level water use is measured as the volume and cost of water metered by the utility, typically monthly, or otherwise metered on site.
  - Monthly and annual water use and cost indices, normalized by the building floor area and/or number of occupants.

- **BENCHMARKS**
  - The annual water use and cost are compared to appropriate benchmarks for peer buildings or self reference against past use.
  - Commonly used benchmarks are the Syabas indices by building type.
Audit on water use – Intermediate & Advanced Levels

1. Objective intermediate level
   ➢ separate the use and cost into the portion of water that enters the wastewater system and that which does not.

2. Objective advanced level
   ➢ measure separately as many water using components as possible.
Audit on water use – Intermediate & Advanced Levels

1. Metrics intermediate level
- include monthly and annual water use measurements using the main utility water meter and a landscape water meter.
- Periodic landscape water use is logged per unit of landscape area and is subtracted from the main water meter use to determine wastewater flow (approximate as some may be evaporated through cooling towers, swimming pools, or other such uses).

2. Metrics advanced level
- separate end uses are measured using meters for landscape, HVAC equipment, swimming pools and water features, kitchens and other process equipment, harvested rainwater and/or recycled gray water and the data are normalized per floor area, occupant, or item.
Audit on water use – Intermediate & Advanced Levels

Benchmarking at the higher levels is through self-reference against use prior to implementation of water saving strategies.

1. Intermediate level the current rate of building water use and landscape water use are compared with past years usage.

2. Advanced level all the facility's water meters are used to estimate wastewater flows, calculated as the building water meter minus the sum of all sub-metered flows that do not end up in the waste stream.
Audit on Indoor Environmental Quality - Thermal comfort

All of the indoor environmental quality protocols begin with observations of the building, its environment and the occupants' responses to that environment. This is followed by recommended occupant surveys to determine occupant satisfaction with environmental conditions:

**Basic Level**

**OBJECTIVES for thermal comfort measurements include:**

- Thermal-comfort-related building characteristics, including complaint logs.
- Determine and rate occupant satisfaction against benchmarks of previous data and/or a database of previously measured performance of peer buildings.
- Identify thermal comfort problems using spot measurements of the thermal environment.
Audit on indoor environmental quality - Thermal comfort

All of the indoor environmental quality protocols begin with observations of the building, its environment and the occupants' responses to that environment. This is followed by recommended occupant surveys to determine occupant satisfaction with environmental conditions:

METRICS to meet these objectives:

➤ Evaluate complaint logs.
➤ Conduct occupant and operator surveys of satisfaction with overall thermal comfort and the impact on self-reported job performance. Most surveys use visual analog scales, representing a range from "very satisfied" to "very dissatisfied."

Paper-based occupant survey forms are shown overleaf.
➤ Spot measure temperature, relative humidity, mean radiant temperature and airspeed (optional) to determine causes of problems.

BENCHMARKS

➤ The thermal comfort survey results are compared to appropriate benchmarks for peer buildings and/or of identical or similar questions from past surveys.
Performance of New & Existing Buildings

Conventionally, occupancy survey is done for system performance by hard copy forms but scientific measurement is viable with advance of technologies.
Audit on indoor environmental quality - Thermal comfort

Intermediate & Advanced Level:

Objectives at the intermediate level are to optimize the operation of environmental control systems and minimize the effect of failures by continuously measuring the thermal environment.

Advanced level objectives are to characterize asymmetrical environments in temperature, air movement, and to characterize transient environments.

At the advance level, thermal comfort may be analyzed using models and criteria in standards, such as ASHRAE Standard 55.
Audit on indoor environmental quality - Thermal comfort

Intermediate & Advanced Level:
Measurements include air movement, temperature gradients, and radiant asymmetry are taken.

Benchmarking at the intermediate level provides for evaluating building performance through comparison to databases of peer buildings or to comfort criteria in standards such as ASHRAE Standard 55. Mean values from the occupant survey are recorded for thermal sensation, comfort, and acceptability.

At the advanced level, the ASHRAE database, Standard 55-2004, and published research projects provide the main benchmarks.
ASHRAE Standard 55 states that factors affecting comfort are:
1. Metabolic rate
2. Clothing insulation
3. Air temperature
4. Radiant temperature
5. Air speed
6. Humidity
**THERMAL COMFORT**

<table>
<thead>
<tr>
<th>EQ6</th>
<th><strong>THERMAL COMFORT: DESIGN &amp; CONTROLLABILITY OF SYSTEMS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Provide a high level of thermal comfort system control by individual occupants or by specific groups in multi-occupant spaces to promote the productivity, comfort and well-being of building occupants:</td>
</tr>
<tr>
<td></td>
<td>Design to ASHRAE 55 in conjunction with the relevant localised parameters as listed in MS1525:2007.</td>
</tr>
<tr>
<td></td>
<td>Provide individual comfort controls for ( \geq 50% ) of the building occupants to enable adjustments to suit individual task needs and preferences. <strong>AND</strong></td>
</tr>
<tr>
<td></td>
<td>Provide comfort system controls for all shared multi-occupant spaces to enable adjustments to suit group needs and preferences.</td>
</tr>
<tr>
<td></td>
<td>Conditions for thermal comfort include the primary factors of air temperature, radiant temperature, air speed and humidity. Comfort system control for this purpose is defined as the provision of control over at least one of these primary factors in the occupants’ local environment.</td>
</tr>
</tbody>
</table>

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**Architect Centre**

**ECO-B WORKSHOP 2013**
Example: Advanced but affordable instrument for assessment on actual condition & design intent – Indoor temperature & humidity condition
Temperature & Humidity – Data Logging

Temperature: 20 ± 1°C  Humidity: 60 ± 5%
Condition stabilized after adjustment and rectification to control valve & actuator. Monitoring of valve performance continues. Addition of return air duct shall be ideal.
Basic Level
OBJECTIVES for IAQ measurements:

- Observe condition of building and HVAC system from complaint logs and operational documentation. Determine occupant satisfaction with IAQ.

- Evaluate compliance with the Ventilation Rate Procedure in ASHRAE Standard 62.1
Audit on indoor environmental quality - Indoor air quality (IAQ)

METRICS to meet these objectives are as follows:

- Interviews of the facility manager or O&M contractor and evaluation of occupant complaints; the ACMV system should be inspected for potential problems.
- Occupant surveys to rate IAQ satisfaction levels against benchmark databases.
- Evaluation of compliance with the Ventilation Rate Procedure of Standard 62.1, including measurement of ventilation rates at the FA intake of each ACMV fan system

BENCHMARKS: The following evaluation criteria provide performance benchmarks:

- If local OA quality is unacceptable, additional filtering may be required.
- Resolve building and HVAC system problems to verify compliance with Standard 62.1
- Measure OA flows should meet the minimum specification in ASHRAE Standard 62.
IAQ – Indoor Air Quality
Intermediate & Advanced Level:
Objectives for intermediate level include determination of whether a strong local contaminant source is suspected, and that ventilation is in compliance with Standard 62.1

Objectives for advanced level, are to establish baseline measurements for pollutants and to identify potential contaminants of concern.
Audit on indoor environmental quality - Indoor air quality (IAQ)

IAQ metrics at the intermediate level include:

- Air quality data taken at the site should determine if JKKP are exceeded.
- Evaluate airflow pattern and/or duct leakage to identify interior pollutant sources.
- Measure OA rates at each OA intake.
- Measure CO2 levels in representative spaces to assess OA ventilation relative to occupancy, noting that in many circumstances CO2 is a poor metric of ventilation.

Advanced level metrics include:

To establish a baseline for detection of unexpected events, continuously measure CO2, fine particulates (PM2.5) and TVOCs (Total Volatile Organic Compounds)

Measure selected potential contaminants.

Benchmarking

At the intermediate level, if the local ambient OA quality is unacceptable, then Standard 62.1 requires that additional filtering at the OA intake be installed.

At the advanced level, the criteria in local guideline on particulates, TVOC, formaldehyde, VOCs, radon, and microbial concentrations, shall be verified on site.
Requirement of LEED on IAQ before occupancy:

**LEED 2009**

IEQ Credit 3.2: Construction Indoor Air Quality Management Plan—Before Occupancy

1 Point

For each sampling point where the maximum concentration limits are exceeded, conduct an additional flush-out with outside air and retest the noncompliant concentrations. Repeat until all requirements have been met. When retesting noncompliant building areas, take samples from the same locations as in the first test.

Demonstrate that the contaminant maximum concentration levels listed below are not exceeded:

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Maximum Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formaldehyde</td>
<td>27 parts per billion</td>
</tr>
<tr>
<td>Particulates (PM10)</td>
<td>50 micrograms per cubic meter</td>
</tr>
<tr>
<td>Total volatile organic compounds (TVOCs)</td>
<td>500 micrograms per cubic meter</td>
</tr>
<tr>
<td>4-Phenylcyclohexene (4-PCH)*</td>
<td>6.5 micrograms per cubic meter</td>
</tr>
<tr>
<td>Carbon monoxide (CO)</td>
<td>9 part per million and no greater than 2 parts per million above outdoor levels</td>
</tr>
</tbody>
</table>

* This test is only required if carpets and fabrics with styrene butadiene rubber (SBR) latex backing are installed as part of the base building systems.

Measurement taken over a period of minimum 4 hours.
GBI: Implementation in acquiring IAQ credit

<table>
<thead>
<tr>
<th>ITEM</th>
<th>AREA OF ASSESSMENT</th>
<th>DETAIL POINTS</th>
<th>MAX POINTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VERIFICATION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQ14</td>
<td>IAQ BEFORE &amp; DURING OCCUPANCY</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reduce indoor air quality problems resulting from the construction process in order to help sustain the comfort and well-being of building occupants. Develop and implement an Indoor Air Quality (IAQ) Management Plan for the Pre-Occupancy phase as follows:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1) Perform a building flush out by supplying outdoor air to provide not less than 10 airchanges/hour for at least 30 minutes operation before occupancy and continuous minimum 1 ACH during the initial 14 days occupancy of the completed building</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2) If low VOC materials and low formaldehyde composite wood are used, then building flush out can be performed by supplying outdoor air to provide not less than 10 airchanges/hour for at least 15 minutes operation or not less than 6 airchanges/hour for at least 30 minutes operation and continuous 1ACH during the initial 7 days occupancy of the completed building</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3) Within 12 months of occupancy, conduct IAQ testing to demonstrate maximum concentrations for pollutants are not exceeded according to the Indoor Air Quality Code of Malaysia.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>During Occupancy Stage:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Where a permanent air flushing system of at least 10 airchanges/hour operation is installed for use during occupancy stage</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Local Ventilation Code on Comfort and Safety

- Smoke exhaust
- Toilet exhaust
- Kitchen exhaust
- Car park exhaust, etc

Air contaminants
- Fresh air
- Microbial, etc

Table I: List of Indoor Air Contaminants and the Maximum Limits

<table>
<thead>
<tr>
<th>Indoor Air Contaminants</th>
<th>Eight-hour time-weighted average airborne concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ppm</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>C1000</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>10</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>0.1</td>
</tr>
<tr>
<td>Respirable particulates</td>
<td>3</td>
</tr>
<tr>
<td>Total volatile organic compounds</td>
<td></td>
</tr>
</tbody>
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## CONTENTS

### DEFINITIONS

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<td>1.2</td>
<td>Scope and application</td>
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</table>

<table>
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<td>Walkthrough inspection</td>
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<td>Initial findings</td>
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<td>2.4.3</td>
<td>Assessment of indoor air quality by indoor air quality assessor</td>
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<tr>
<td>2.5</td>
<td>Assessment report</td>
</tr>
</tbody>
</table>

<table>
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<th>3.0</th>
<th>CONTROL OF INDOOR AIR QUALITY</th>
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<td>Duty to control exposure</td>
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<td>3.2</td>
<td>Microbial contamination</td>
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<td>3.3</td>
<td>Inspection and maintenance of MVAC</td>
</tr>
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<td>3.4</td>
<td>Control for prescribed activities</td>
</tr>
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<td>3.5</td>
<td>Prevention and control for renovation work</td>
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<td>3.6</td>
<td>Pest control</td>
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<td>3.7</td>
<td>Housekeeping and cleaning</td>
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<td>Environmental Tobacco Smoke (ETS)</td>
</tr>
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<thead>
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<th>INFORMATION, INSTRUCTION AND TRAINING</th>
</tr>
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<tbody>
<tr>
<td>4.1</td>
<td>Information</td>
</tr>
<tr>
<td>4.2</td>
<td>Instruction</td>
</tr>
<tr>
<td>4.3</td>
<td>Training</td>
</tr>
</tbody>
</table>
Table 2: List of indoor air contaminants and the acceptable limits

<table>
<thead>
<tr>
<th>Indoor Air Contaminants</th>
<th>Acceptable limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ppm</td>
</tr>
<tr>
<td><strong>Chemical contaminants</strong></td>
<td></td>
</tr>
<tr>
<td>(a) Carbon monoxide</td>
<td>10</td>
</tr>
<tr>
<td>(b) Formaldehyde</td>
<td>0.1</td>
</tr>
<tr>
<td>(c) Ozone</td>
<td>0.05</td>
</tr>
<tr>
<td>(d) Respirable particulates</td>
<td>-</td>
</tr>
<tr>
<td>(e) Total volatile organic compounds (TVOC)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Biological contaminants</strong></td>
<td></td>
</tr>
<tr>
<td>(a) Total bacterial counts</td>
<td>-</td>
</tr>
<tr>
<td>(b) Total fungal counts</td>
<td>-</td>
</tr>
<tr>
<td><strong>Ventilation performance indicator</strong></td>
<td></td>
</tr>
<tr>
<td>(a) Carbon dioxide</td>
<td>≤1000</td>
</tr>
</tbody>
</table>
Table 1: Acceptable range for specific physical parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Acceptable range</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Air temperature</td>
<td>23 – 26 °C</td>
</tr>
<tr>
<td>(b) Relative humidity</td>
<td>40-70%</td>
</tr>
<tr>
<td>(c) Air movement</td>
<td>0.15 – 0.50 m/s</td>
</tr>
</tbody>
</table>
Measuring the Airborne Particles & Formaldehyde

Airborne particles measuring meter

Formaldehyde meter
Direct sensing instrument can be sufficient: It is real time in comparison to Air Sampling Kits.

Whatever instrument, need to know limits of instrument and appreciate timing of measurement.
Basic Level

OBJECTIVES for lighting quality measurements include:

- Determination of occupants' satisfaction with the lighting and rating performance against previously measured buildings.
- Identification of problems and how they might be corrected.
- Spot measurements of basic photometric parameters.

METRICS to meet these objectives are as follows:

- Surveys using the occupancy survey form for Lighting
- The lighting checklist in as in MS1525
- Spot measurements of illuminance at representative work surfaces.
Intermediate & Advanced Level:

Objective:
At intermediate level, it is to provide a more detailed evaluation of potential issues.
At advanced level it is to gather high-resolution data (detailed illuminance and luminance data and measurement of discomfort glare) for lighting-critical situations.

Metrics:
At the intermediate level include data to capture individual, average, and uniformity of illuminance. A grid of measurement points, at desk height, is used to cover the surface under consideration. Also included are luminance measurements to determine the brightness of various points in the room. Discomfort glare is may need ot be measured if occupants’ complaint is strong.
At the advanced level, an array of illumination data logger may be deployed on floors to determine the luminance distribution pattern and luminance ratios, and/or to assess glare.

Benchmarks:
For the intermediate & advance level it includes comparing average illuminance, maximum-to-minimum uniformity ratio, and average-to-minimum uniformity ratio to recommendations of the Illuminating Standards.
Advanced instrument for lighting assessment

Electric & daylight profile can be traced by deploying many light meter & data loggers on the floor over a duration.
Basic Level

OBJECTIVES for evaluation of acoustic annoyance:
- Use of an occupant survey to identify acoustical problems.
- Evaluation of background noise by measuring the A-weighted sound pressure level.

METRICS to meet these objectives are as follows:
- Occupant acoustic satisfaction survey to identify conditions that may produce annoying sounds.
- Spot measurement of A-weighted equivalent sound pressure levels in representative spaces. Measurements should be made with an integrating sound level meter and an omni-directional condenser microphone under full ACMV system operation and other operating conditions.

BENCHMARKS
- The results of the sound level pressure measurements are benchmarked by space type against the noise criteria in JKKP standard or any international standards for specific working environment.
Intermediate & Advanced Level:

Objectives:
For intermediate level, it includes the assessment of acoustic annoyance.
For advanced level it is to ensure that high levels of speech communication and privacy and sound isolation have been met for rooms with special acoustic needs.

Metrics:
Intermediate level metrics include more rigorous measurements of background noise in octave bands. Instrumentation should meet Type 1 sound level meter specifications defined in ANSI standards. Where room use requires good speech communication, reverberation time measurements use the impulsive excitation method.

Instrumentation at the advanced level to provide for speech privacy should meet ANSI standards specifications and use parallel octave band filters. Finally, sound isolation or acoustic privacy sound transmission loss should be measured in accordance with ASTM standards.

Benchmark:
For the intermediate level benchmarks measurements are compared to the noise criteria of respective working space.

For advanced level measurement, it should confirm a speech privacy rating (PI), depending on confidentiality and privacy needs. For speech communication, a speech intelligibility rating (STI) is determined.
Advanced instrument for assessment

A sample of noise spectrum taken from the floor below chiller plant room has the typical profile as below:
Architects & Engineers are invited to participate with Building Inspection @ Architect Centre.

Register to get Accredited.

THANK YOU!
WORKSHOP:

DEMONSTRATION OF MEASUREMENTS INSTRUMENTATION by:

Ir KOK YEE HIN
Ir KOK YEN-KWAN
TJ
Infra - Red Thermography

Details of demonstration
(to be advised)