Common Mistakes in Indoor Environmental Quality (IEQ)

26th September 2018

By: Ir. Ng Yong Kong
1. Indoor Environmental Quality (IEQ)

- More than just *Indoor Air Quality (IAQ)*
- HVAC system provides a comfortable environment for building occupants and contributes significantly to *Indoor Health Environment*

- Primary areas of concern in IEQ
  - Air Quality and Ventilation
  - Thermal Comfort: Design & Controllability of Systems
  - Lighting and Visual Perception
  - Acoustic and Noise Comfort
indoor environmental quality

- acoustics
- lighting
- thermal comfort
- indoor air quality
The Need to Improve Indoor Environmental Quality (IEQ)

- Occupants Care About IEQ
  - Thermal Comfort
  - Lighting Quality
  - Acoustic Quality
  - Indoor Air Quality (IAQ)

- Comfort Impacts Productivity of Occupants
The physical and chemical nature of indoor air, as delivered to the breathing zone of building occupants, which produces a complete state of mental, physical and social well-being of the occupants, and not merely the absence of disease or infirmity.

In commercial buildings, indoor air quality arise when there is insufficient quantity of ventilation air being provided for the amount of air contaminants present in the conditioned space.
Industry Code of Practice on Indoor Air Quality 2010
DOSH Malaysia* Ministry of Human Resources
Table 1: List of Indoor Air Contaminants and the Maximum Limits
### Acceptable Range for Specific Physical Parameters – 2010

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Acceptable range</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Air temperature</td>
<td>23.0 – 26.0 °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</td>
</tr>
</tbody>
</table>

### List of Indoor Air Contaminants and acceptable limits

<table>
<thead>
<tr>
<th>Indoor Air Contaminants</th>
<th>Eight-hours time-weighted average airborne concentration</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 dioxide</td>
<td>C1000</td>
</tr>
<tr>
<td>(b) Carbon monoxide</td>
<td>10</td>
</tr>
<tr>
<td>(c) Formaldehyde</td>
<td>0.1</td>
</tr>
<tr>
<td>(d) Ozone</td>
<td>0.05</td>
</tr>
<tr>
<td>(e) Respirable particulates</td>
<td>-</td>
</tr>
<tr>
<td>(f) 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>
</tbody>
</table>
Sick Building Syndrome

• commonly used for illness that occur among occupants as a result of poor IEQ in building.

• *Sick Building Syndrome (SBS)* is sometimes used to describe cases in which building occupants experience acute health and comfort effects that are apparently linked to the time they spend in building, but in which no specific illness or cause can be identified.
**Building-Related Illness (BRI)** is a term referring to illness brought on by exposure to the building air, where symptoms of diagnosable illness are identified and can be directly attributed to environmental agents in the air.
What is a Legionnaires’ Disease?

- Respiratory disease
- Bacteria – Legionella pneumophila
- Found in any aquatic environment, outbreaks have been traced to water systems including domestic water system (tanks, showers), Cooling towers, humidiers, evaporative condensers, whirlpool/spas, decorative fountains, fire sprinklers systems.
Cooling Towers

ASHRAE Guideline 12-2000
Minimizing the Risk of Legionellosis Associated with Building Water Systems

Code of Practice for the Control of Legionella Bacteria in Air-Conditioning Cooling Towers in Singapore-June 1994
Legionellosis: Risk Management for Building Water Systems

Approved by the ASHRAE Standards Committee on May 27, 2015; by the ASHRAE Board of Directors on June 4, 2015; and by the American National Standards Institute on June 26, 2015.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

© 2015 ASHRAE
ISSN 1041-2336
GENERAL STRATEGIES / APPROACH

1. When in doubt, follow the intent of each criteria and use common sense.

2. Proposed / implemented strategies must have impact and should be commiserate with a project’s size.
2) Indoor Environmental Quality  

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air Quality</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQ1 Minimum IAQ Performance</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>EQ2 Environmental Tobacco Control</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>EQ3 Carbon Dioxide Monitoring &amp; Control</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>EQ4 Indoor Air Pollutants</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>EQ5 Mould Prevention</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Thermal Comfort</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQ 6 Thermal Comfort Control</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>EQ 7 Air Change Effectiveness</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Lighting, Visual &amp; Acoustic Comfort</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EQ8 Daylighting</strong></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>EQ9 Daylight Glare Control</strong></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>EQ10 Electric Lighting Levels</strong></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>EQ11 High Frequency Ballasts</strong></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>EQ12 External Views</strong></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>EQ13 Internal Noise Levels</strong></td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Verification**

| **EQ14 IAQ Before & During Occupancy**  | 2 |
| **EQ15 Post Occupancy Comfort Survey**  | 2 |
Establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in building, thus contributing to the comfort and well-being of the occupants:

Meet the minimum requirements of ventilation rate in *ASHRAE 62.1-2007* or the local building code whichever is the more stringent.
Building code requirements

<table>
<thead>
<tr>
<th>Building type</th>
<th>Air Changes per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Building</td>
<td>0.14 cm³ per occupant</td>
</tr>
<tr>
<td>Commercial Premises</td>
<td>0.14 cm³ per occupant</td>
</tr>
<tr>
<td>Factory and Workshop</td>
<td>0.21 cm³ per occupant</td>
</tr>
<tr>
<td>School Classroom</td>
<td>0.14 cm³ per occupant</td>
</tr>
<tr>
<td>Projection Room</td>
<td>0.14 cm³ per occupant</td>
</tr>
<tr>
<td>Theatre and Auditorium</td>
<td>0.14 cm³ per occupant</td>
</tr>
<tr>
<td>Canteen</td>
<td>0.28 cm³ per occupant</td>
</tr>
<tr>
<td>Building of Public Resort</td>
<td>0.28 cm³ per occupant</td>
</tr>
<tr>
<td>Offices</td>
<td>0.14 cm³ per occupant</td>
</tr>
<tr>
<td>Conference Room</td>
<td>0.28 cm³ per occupant</td>
</tr>
<tr>
<td>Hospital wards</td>
<td>0.14 cm³ per occupant</td>
</tr>
<tr>
<td>Computer Room</td>
<td>0.14 cm³ per occupant</td>
</tr>
<tr>
<td>Hotel rooms</td>
<td>0.14 cm³ per occupant</td>
</tr>
</tbody>
</table>

(2) The minimum scale of fresh air ventilation in conjunction with the mechanical ventilation systems shall be as follows:

- Basement and garages: minimum of 6 air changes per hour
- Commercial premises (excluding factories and workshops): 0.25 cm³ per occupant
- Factory and Workshop (design shall be based on actual requirements): 0.56 cm³ per occupant
- Project rooms: 10 air changes per hour
- Theatre and Auditorium: 0.28 cm³ per occupant
- Kitchen: 20 air changes per hour

Note: All other areas shall meet with the minimum requirements of the ASHRAE STANDARD 62-73.
Ventilation is the key to Sustainable IAQ and ASHRAE Standard 62.1 is the most widely used Standard by most Local Authorities and HVAC Engineers in the world.

EQ1: Minimum IAQ Performance
ASHRAE Std 62.1-2016 – Ventilation For Acceptable Indoor Air Quality

1.) Ventilation Rate Procedure (VRP)
2.) Indoor Air Quality Procedure (IAQ)
3.) Natural Ventilation
Ventilation Rate Procedure

Outdoor Air Ventilation Rate for Breathing Zone

\[ V_{bz} = R_p P_d + R_b A_b \]

- **People Component**
  - Minimum cfm/Person \( R_p \) \( P_d \) \( \times \) Number of People

- **Building Component**
  - Minimum cfm/sq ft \( R_b \) \( A_b \) \( \times \) Building Area
DON’T JUST SAY:
Meet the minimum requirements of ventilation rate in ASHRAE Standard 62.1 or UBBL.
NRNC – EQ1 : Minimum IAQ Performance

MISTAKES
ii.) Some areas have no ventilation.
iii.) Only a few AHUs comply.
Using PAHU to supply fresh air to hotel guest rooms
Some submission used 20 cfm / person or higher. Is it acceptable?

Why some submission used higher ventilation rate?
1.) Used old ASHRAE Standard 62.1
2.) Satisfy LEED requirement.
3.) Latest development in Europe? CIBSE, REHVA
What are the consequences?
Some common mistakes in DA and CVA Submission

EQ1 – EE1 submitted in EQ1
“Mixed up Submission”
Naturally Ventilated Public Spaces

**Target:** All public and circulation spaces to be naturally ventilated to meet the minimum requirements of ventilation rate in the local building code.
## EQ1 MINIMUM IAQ PERFORMANCE | 3 POINTS

### INTENT
Establish minimum indoor air quality performance to enhance indoor air quality in building, thus contributing to the comfort and well-being of the occupants.

### DESCRIPTION
To ensure adequate fresh air supply to occupied spaces so as to maintain good air quality in building and to enhance indoor comfort through the provision of good natural ventilation design.

### DA : COMMON MISTAKE
Naturally Ventilated Public Spaces

**Target:** All public and circulation spaces to be naturally ventilated to meet the minimum requirements of ventilation rate in the local building code.
Naturally Ventilated Public Spaces

**Target:** All public and circulation spaces to be naturally ventilated to meet the minimum requirements of ventilation rate in the local building code.
Bylaw 39(1)

- Every room designed for residential, business or other purposes except hospitals & schools shall be provided with natural lighting and natural ventilation by means of one or more windows having total area not less than 10% of the floor area and shall have opening for uninterrupted air passage of 5%

Bylaw 39(2)

- Hospitals window area 15% and open able windows 10%

Bylaw 39(2)

- Schools window area 20% and open able windows 10%
INTENT
Establish minimum indoor air quality performance to enhance indoor air quality in building, thus contributing to the comfort and well-being of the occupants.

DESCRIPTION
To ensure adequate fresh air supply to occupied spaces so as to maintain good air quality in building and to enhance indoor comfort through the provision of good natural ventilation design.
UBBL 1984: By-Law 39

(1): Every room designed, adapted or used for residential, business or other purposes except hospitals and schools shall be provided with natural lighting and natural ventilation means of one or more windows having a total area of not less than 10% of the clear floor area of such room and shall have openings capable of allowing a free uninterrupted passage of air of not less than 5% of such floor area.
UBBL 1984
By-Law 39. Natural Lighting and Ventilation

Day Lighting Window > 10% Floor area
UBBL 1984
By-Law 39. Natural Lighting and Ventilation

Day Lighting Window > 20 ft²
Opening > 10 ft²

Room 1

Room 2
200 ft²
UBBL 1984
By-Law 40. Air-wells

Minimum size for air well:
(i) For buildings up to 2 storeys in height, 7 m²
(ii) For buildings up to 4 storeys in height, 9 m²
(iii) For buildings up to 6 storeys in height, 11 m²
(iv) For buildings up to 8 storeys in height, 13 m²
(v) For buildings more than 8 storeys in height, 15 m²
Example 1:

Example 2:
Minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to Environmental Tobacco Smoke (ETS):-

**Prohibit smoking in the building, AND**

**Locate any exterior designated smoking areas at least 10m away from entries, outdoor air intakes and operable windows**
NON-RESIDENTIAL NEW CONSTRUCTION (NRNC)
INDOOR ENVIRONMENTAL QUALITY (EQ)

EQ2 | ENVIRONMENTAL TOBACCO SMOKE (ETS) CONTROL | 1 POINT

**INTENT**
To minimize exposure of building occupants to Environmental Tobacco Smoke.

**DESCRIPTION**
Avoid health problems associated with tobacco smoke by preventing possible contamination in the building, thereby reducing health risks to occupants linked to “secondhand smoke”.

**REQUIREMENTS**
Prohibit smoking in buildings, **AND**
Locate any exterior designated smoking areas at least 10m away from entries, outdoor air intakes and operable windows.

**APPROACH & IMPLEMENTATION**
Prohibition of smoking in air-conditioned public building is already mandatory under Malaysian Law. This credit can be achieved by strictly enforcing prohibition of smoking in the building, through supervision or signage. If designated smoking areas are provided outside the building, ensure that the tobacco smoke does not enter the building or the ventilation system.
NRNC – EQ2 : Environmental Smoke Control

MISTAKES

- Have one smoking area in a large space or building
- No Smoking Signage yet to be installed.
- Smoke circulate back.
Minimize exposure of building occupants, indoor surfaces, and ventilation air distribution systems to Environmental Tobacco Smoke (ETS).

Prohibit smoking in the building, by providing non-smoking signs at Lift Lobby area.

Exterior designated smoking area at least 10m away from entries, outdoor air intakes and openable windows.
Selecting CO₂ Criteria for Outdoor Air Monitoring

By Thomas M. Lawrence, Ph.D., P.E., Member ASHRAE

ASHRAE Journal ashrae.org
GREEN BUILDING INDEX DESIGN REFERENCE GUIDE & SUBMISSION FORMAT

NON-RESIDENTIAL NEW CONSTRUCTION (NRNC)
INDOOR ENVIRONMENTAL QUALITY (EQ)

| EQ3 | CARBON DIOXIDE MONITORING AND CONTROL | 1 POINT |

INTENT
To provide capacity for effective ventilation system monitoring and control to ensure the comfort and well-being of building occupants.

DESCRIPTION
Use carbon dioxide monitoring and control system to deliver the required outdoor air to the occupants to suit variation in occupancy.

REQUIREMENTS
Install carbon dioxide (CO₂) monitoring and control system with at least one (1) CO₂ sensor at main return air points on each floor to facilitate continuous monitoring and adjustment of outside air ventilation rates to each floor, and ensure independent control of ventilation rates to maintain CO₂ level < 1,000 ppm.

APPROACH & IMPLEMENTATION
Use of carbon dioxide monitoring system is a typical energy conservation measure to ensure different spaces receive adequate outdoor air for their current occupancy and the ventilation system can adjust the ventilation rate to meet changing requirements. This helps ensure occupants will receive adequate outdoor air at all times.
EQ 3: Carbon Dioxide Monitoring and Control

- EQ 3 – Install CO2 monitoring and control system with at least 1 CO2 sensor at all main return points on each floor to facilitate continuous monitoring and adjustment of OA rates to each floor and ensure independent control of ventilation rates to maintain CO2 level $\leq 1,000$ ppm.
TYPICAL AHU CONTROL SYSTEM

SCALE: N.T.S

LEGEND:

CO2  CARBON DIOXIDE SENSOR

MD   MOTORISED DAMPER
Mistakes in EQ 3

1.) No schematic drawings.

2.) Installed CO2 sensors in the supply duct.

3.) Installed too many CO2 sensors
   - hence more expensive

4.) Installed too few CO2 sensors

5.) CO2 sensors installed on top of the ceiling
Encourage use of non toxic products.

Reduce detrimental impact on occupant health from finishes that emit internal air pollutants:

- Use low VOC paint and coating throughout the building. Paints and Coatings to comply with requirements specified in international labelling schemes recognized by GBI, AND
- Use low VOC carpet or flooring throughout the building. Use low VOC adhesive and sealant or no adhesive or sealant used.
COMMON MISTAKES:

1.) DA Stage : NO CATALOGS SUBMITTED
   : Provide proof of GBI recognized Certifications for Low VOCs or No VOCs.

2.) CVA Stage : i.) No Photographic evidence provided.
   ii.) No Catalogues submitted to show what were used.
greenpagesmalaysia – an information resource directory for green building products and services.

The primary objective – providing info on sustainable building products and services to architects, engineers, developers and others.

A user-friendly, online interface will be consistently updated.
Sample Product Data Sheets

OFFICE FURNITURE – OPEN PLAN SYSTEM
ARTMATRIXX TECHNOLOGY SDN BHD

MAXIM-A (ECO), MAX-I (ECO), SIMPLEX (ECO), TREND-X (ECO), I-MODE (ECO), TRI-X PLUS (ECO)

WHY IS IT GREEN?
ARTMATRIXX is the first Malaysian company to have a range of workstation products carry the Environmental Choice Australia (ECA) eco-label verified and assessed by Good Environmental Choice Australia Ltd (GECA), an independent, non-profit organization. The workstation products are assessed with finding of leaving a lighter carbon footprint on the planet as the materials are non-toxic and sustainable.

Green labels / accreditation

Other labels

Contact details

PRODUCT FEATURES
- Product quality passed ANSI/IFMA X5.6 and warrant with 10 years quality.
- Under ARTMATRIXX product stewardship program, products of ARTMATRIXX can be returned through the selected distributor for recycling at the end of product life.

PRODUCT COMPLIANCE
ISO 9001:2008 (Quality Management System)
ISO 14001:2004 (Environmental Management System)

PG RAINWATER HARVESTING SYSTEM
GRUNDFOS PUMPS SDN BHD

APPLICABLE GDI CREDITS

WHY IS IT GREEN?
The WAVE PG is an interconnect device that allows you to save precious drinking water by using your harvested rainwater for toilet and garden applications. Aweye! prompting the use of rainwater, the WAVE PG will automatically switch over to a mains water source when your rainwater tank runs low, or during electrical failure.

The pump itself is only active when the rainwater is being drawn from the tank. If it does not operate when the WAVE PG has switched to mains water. The pump controller automatically starts and stops the pump when a demand is sensed – for example, flushing a toilet or operating the garden tap.

PRODUCT FEATURES
- The WAVE PG features are as follow:
  - Easy to install
  - Does not require any regular maintenance
  - Inbuilt dual check valve for backflow prevention
  - Automatically switches to mains water in the event of a power or pump failure
  - 10m Rainwater tank sensor float switch
- The WAVE PG can be coupled with different types of Grundfos pumps to suit the various applications:
  - CM Horizontal Multistage Non-Self Priming pumps
  - S/S Self Priming pumps
  - 69/92G Submersible pumps

PRODUCT DATA SHEET

CONTACT DETAILS
GRUNDFOS PUMPS SDN BHD
7, Jalan Paquam U1/25, Glandana Industrial Park, 40150 Shah Alam, Selangor, Malaysia
Tel: +603 5569 3922
Fax: +603 5569 3073
Email: info@grundfos.com
Web: www.grundfos.com
<table>
<thead>
<tr>
<th>EQ2</th>
<th>VOLATILE ORGANIC COMPOUNDS MINIMISATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reduce the detrimental impact on occupant’s health from finishes that emit internal air pollutants.</td>
</tr>
<tr>
<td></td>
<td>1 point is awarded for any 2 of the following items, up to a maximum of 2 points:</td>
</tr>
<tr>
<td></td>
<td>1. Low VOC paint and coating to walls (at least 90% of walls) OR no paint or coating used.</td>
</tr>
<tr>
<td></td>
<td>2. Low VOC paint and coating to ceilings (at least 90% of ceilings) OR no paint or coating used.</td>
</tr>
<tr>
<td></td>
<td>3. Low VOC carpet or interior flooring (at least 90% of flooring) OR no carpet or interior flooring used.</td>
</tr>
<tr>
<td></td>
<td>4. Low VOC adhesive and sealant (at least 90% of overall usage) OR no adhesive or sealant used.</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EQ3</th>
<th>FORMALDEHYDE MINIMISATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reduce the exposure of occupants to formaldehyde and promote good indoor air quality in the living spaces.</td>
</tr>
<tr>
<td></td>
<td>Use products with no added formaldehyde OR use products which comply with the formaldehyde emission ratings recognised by GBI, if glue is used in the manufacturing process.</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
**RESIDENTIAL NEW CONSTRUCTION (RNC)**  
**RNC | INDOOR ENVIRONMENTAL QUALITY (EQ)**

<table>
<thead>
<tr>
<th>EQ4</th>
<th>DAYLIGHTING</th>
<th>3 POINTS</th>
</tr>
</thead>
</table>

**INTENT**
Encourage and recognize designs that provide good levels of daylighting for building occupants.

**DESCRIPTION**
Demonstrate that a nominated percentage of the habitable rooms as defined under Uniform Building By Law (UBBL) has a Daylight Factor of minimum 0.5% as measured at floor level;

**REQUIREMENTS**

<table>
<thead>
<tr>
<th>A) Landed</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>≥50% of habitable rooms, <strong>OR</strong></td>
<td>1</td>
</tr>
<tr>
<td>≥75% of habitable rooms, <strong>OR</strong></td>
<td>2</td>
</tr>
<tr>
<td>≥75% of all rooms.</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B) Low-rise <strong>OR</strong> High-rise</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>≥50% of habitable rooms, <strong>OR</strong></td>
<td>1</td>
</tr>
<tr>
<td>≥75% of habitable rooms.</td>
<td>2</td>
</tr>
<tr>
<td>All public and circulation spaces being naturally lit.</td>
<td>1</td>
</tr>
</tbody>
</table>
RESIDENTIAL NEW CONSTRUCTION (RNC)
RNC | INDOOR ENVIRONMENTAL QUALITY (EQ)

**EQ4**  DAYLIGHTING  **3 POINTS**

**Static Calculation**

**Daylighting Simulation**

Typical Section through External A/C Ledge @ Office/ Living (scale 1:50)

Daylighted Zone = window height x 1.5
= 2.15m x 1.5
= 3.225m
RESIDENTIAL NEW CONSTRUCTION (RNC)
RNC | INDOOR ENVIRONMENTAL QUALITY (EQ)

EQ4  DAYLIGHTING  3 POINTS

Sample Submission

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Floor Area (sq.m.)</th>
<th>Window Area (sq.m.)</th>
<th>Window/ Floor Ratio</th>
<th>Estimated Daylight Factor (DF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1C (10th-25th floor)</td>
<td>Office/ Living Bedroom</td>
<td>36.98</td>
<td>11.94</td>
<td>0.32</td>
<td>3.23%</td>
</tr>
<tr>
<td></td>
<td>Bath</td>
<td>4.84</td>
<td>0.72</td>
<td>0.15</td>
<td>1.49%</td>
</tr>
<tr>
<td>Type 1A (10th-25th floor)</td>
<td>Office/ Living Bedroom</td>
<td>36.7</td>
<td>12.98</td>
<td>0.35</td>
<td>3.54%</td>
</tr>
<tr>
<td></td>
<td>Bath</td>
<td>5.12</td>
<td>0.72</td>
<td>0.14</td>
<td>1.41%</td>
</tr>
<tr>
<td>Type 1B (10th-25th floor)</td>
<td>Office/ Living Bedroom</td>
<td>37.05</td>
<td>15.59</td>
<td>0.42</td>
<td>4.21%</td>
</tr>
<tr>
<td></td>
<td>Bath</td>
<td>4.77</td>
<td>0.72</td>
<td>0.15</td>
<td>1.51%</td>
</tr>
</tbody>
</table>

Typical Floor Daylight Factor (%) =

Total Daylighted Area / Total Habitable Room
= 457.64 / 727.6
= 0.629
= 62.9%

Legend
- | Daylighted Zone
- | Habitable Room
Mistake DA/CVA:

1.) Not achieving the percentage required

2.) Percentage calculated not using the habitable rooms.
Prevention of mould growth problems.

| EQ5 Mould Prevention | 1 |

Design system/s which reduce the risk of mould growth and its associated detrimental impact on occupant health:-

Where it is demonstrated that the mechanical air-conditioned ventilation system will maintain a positive indoor air pressure relative to the exterior and can actively control indoor air humidity to be no more than 70% RH without the use of active control that will consume additional energy.
Construction Practices

- Temporarily seal HVAC ductwork after installation to keep out dust & water
- Keeping materials (insulation, etc.) dry; if they get wet dry immediately
During Construction

EQ5 – No change.
Dust inside the AHU
Prevention of Mould Growth Problems.

**MISTAKES :**

NONE OR NOT YET
GUIDELINES ON THE PREVENTION OF MOULD GROWTH IN BUILDINGS

PUBLIC WORKS DEPARTMENT (JKR) OF MALAYSIA

Special thanks to the following individual who helped to produce this document:

1. Ir. Ng Yong Kong
   - Managing Director, NYK Engineering & Trading Sdn Bhd.
   - President (2001-03), Malaysia Air Conditioning & Refrigeration, Association (MACRA), B.E. (Hons.) U.M., MBA (HULL), AFPM, MIEM, P.Eng

2. Ir. Chen Thiam Leong
   - Managing Director, Primetech Engineers Sdn Bhd
   - President (2007-08), American Society of Heating, Refrigerating and Air Conditioning Engineers Malaysia Chapter (MASHRAE)
   - BSc (Mech Eng) Univ Of Leeds, UK, IEM, FASHRAE, MIFireE, PEng, CEng

3. Ir. Ong Ching Loon
   - CEO, Cofreth (M) Sdn Bhd.
   - Vice President, Malaysia Association of Energy Service Companies (MAESCO)
   - B.Sc (Hons), MBA (Bath), MIEM, PEng, M.ASHRAE, MCIAbr

JABATAN KERJA RAYA MALAYSIA
2009
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:

Design to ASHRAE Standard 55 in conjunction with the relevant localised parameters as listed in MS 1525

Encourage provision of close comfort control.
Indoor Environmental Quality – Thermal Comfort (EQ6)
Design to ASHRAE 55-2013: Thermal Environmental Conditions for Human Occupancy in conjunction relevant localised parameters as listed in MS 1525:2007

Specifies Conditions likely to be thermally acceptable to at least 80% of the adult occupants in a space

6 Primary factors that must be addressed when defining conditions for thermal comfort are:

1.) Metabolic rate
2.) Clothing insulation
3.) Air temperature
4.) Radiant temperature
5.) Air speed
6.) Humidity
Can individual thermal controls be met with the provision of task fans? The definition of thermal comfort control means being able to control the temperature, air speed, humidity or radiant temperature. Using task fan is a mean of controlling the air speed which should be compliant to fulfilling the objective of this requirement.

**YES, if the nett effect of the air speed temperature, humidity, etc. is within the comfort range as recommended in ASHRAE 55 with relevant localized parameters as listed in MS1525.**
EQ 6 : Thermal Controllability

DA/CVA Submission Mistake:
1.) No Control.
2.) Controls installed wrongly
3.) Get the wrong person to sign.
# Non-Residential New Construction (NRNC)
## Indoor Environmental Quality (EQ)

### EQ6
**Thermal Comfort: Design & Controllability of Systems**

### Intent
To provide a thermal environment that is comfortable and supports the productivity and well-being of building occupants.

### Required Submission for Completion & Verification Assessment (CVA)

3. Summary report on the individual types of control and the controls for multi-occupant spaces that are provided to achieve the credit compliance.
4. Photographic evidence of each typical type of sensor and control installed.
5. Describe any deviations or additions to the DA submission.

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Date</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Submitting Professional</th>
<th>Name</th>
<th>Designation</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ir. xxxxx</td>
<td>Director</td>
<td>xxxxx</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Client</th>
<th>Name</th>
<th>Designation</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>xxxxx</td>
<td>General Manager</td>
<td>xxxxx</td>
<td></td>
</tr>
</tbody>
</table>

--

*NOTE: Attach all submittals with this cover page*
Provide effective delivery of clean air through reduced mixing with indoor pollutants in order to promote a healthy indoor environment. Demonstrate that the Air Change Effectiveness (ACE) meets the following criteria for at least 90% of the NLA:

The ventilation systems are designed to achieve an ACE of ≥0.95 when measured in accordance with ASHRAE 129: Measuring air change effectiveness where ACE is to be measured in the breathing zone (nominally 1.0 m from finished floor level)
EQ 7 : Air Change Effectiveness

MISTAKES IN DA/CVA Submission :
Nil as the issue will be addressed during the DA Submission.
REFERENCE GUIDE

REQUIREMENTS
Demonstrate that the Air Change Effectiveness (ACE) meets the following criteria for at least 90% of the NLA:
The ventilation system is designed to achieve an ACE ≥ 0.95 when measured in accordance with ASHRAE 129 -1997.
Measure air change effectiveness, where ACE is to be measured within the breathing zone (nominally 1.0 m from finished floor level).

APPROACH & IMPLEMENTATION
Compliance may be met either through measurement of the completed building in accordance to ASHRAE 129 or equivalent or using CFD simulations.
Air flow adjusted to suit individual needs.

Pollutants & spent air rise naturally with warm air.
Dedicated Workstation Ventilation
<table>
<thead>
<tr>
<th>Lighting, Visual &amp; Acoustic Comfort</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EQ8 Daylighting</strong></td>
</tr>
<tr>
<td><strong>EQ9 Daylight Glare Control</strong></td>
</tr>
<tr>
<td><strong>EQ10 Electric Lighting Levels</strong></td>
</tr>
<tr>
<td><strong>EQ11 High Frequency Ballasts</strong></td>
</tr>
<tr>
<td><strong>EQ12 External Views</strong></td>
</tr>
<tr>
<td><strong>EQ13 Internal Noise Levels</strong></td>
</tr>
</tbody>
</table>

**Verification**

| EQ14 IAQ Before & During Occupancy      | 2 |
| EQ15 Post Occupancy Comfort Survey      | 2 |
Reduce discomfort of glare from natural light. Where blinds or screens are fitted on all glazing and atrium as a base building, incorporate provisions to meet the following criteria;

a) Eliminate glare from all direct sun penetration and keep horizontal workspace lux level below 2000;

b) Eliminate glare from diffuse sky radiation for occupant workspace at viewing angles of 15° to 60° from the horizontal at eye level (typically 1.2m from floor level)

c) Control with an automatic monitoring system (for atrium and windows with incident direct sun light only - not applicable for fixed blinds/screens); AND

d) Equip with a manual override function accessible by occupants (not applicable for fixed blinds/screens)
When your strategy includes internal blinds…

use only horizontal blinds (not vertical)
Mistake in Daylight Glare Control–Installed Vertical Blinds
Use Horizontal Blinds

Automated Shading Device (Blackout Blind)

Manual Roller Shading Device (Opaque Blind)
Discourage over provision of artificial lighting.

**Baseline building office lighting not to be over designed:**

*Demonstrate that office lighting design maintains a luminance level of no more than specified in MS1525 for 90% of NLA as measured at the working plane (800mm above the floor level).*
1. Submit narrative (summary) page, describing how the lighting design meets this criteria compliance;

2. Submit typical lighting layout floor plans complete with manually calculated or simulated lux levels meeting MS 1525.
REQUIRED SUBMISSION FOR CVA

1. Submit narrative (summary) page, describing as-installed lighting systems meeting this criteria compliance.
2. Submit As-Built drawings showing lighting layout plans.
3. Submit photometric measurements of all typical floors to demonstrate compliance with this criteria.
4. Furnish photos of typical floor lighting installation.
5. Describe any deviation or addition to the DA submission.
Common Mistakes

1. DA STAGE:
   i.) Failed to submit design layout plans showing lux level compliance
   ii.) Submitting simulated design layout plans with lux level exceeding MS 1525

2. CVA STAGE:
   i.) Submitting measurement results of lux level exceeding MS 1525
Encourage high IEQ fixtures.

<table>
<thead>
<tr>
<th>Increase workplace amenity by avoiding low frequency flicker that may be associated with fluorescent lighting:-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install high frequency ballasts in fluorescent luminaires over a minimum of 90% of NLA. 1</td>
</tr>
</tbody>
</table>
DA:

Catalogues not submitted

CVA:

Few High Frequency Ballast installed in the Building.
**EQ12 External Views**

Encourage external views as part of IEQ.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce eyestrain for building occupants by allowing long distance views and provision of visual connection to the outdoor.</td>
<td></td>
</tr>
<tr>
<td>Demonstrate that ≥ 60% of the NLA has a direct line of sight through vision glazing at a height of 1.2m from floor level.</td>
<td>1</td>
</tr>
<tr>
<td>Demonstrate that ≥ 75% of the NLA has a direct line of sight through vision glazing at a height of 1.2m from floor level.</td>
<td>2</td>
</tr>
</tbody>
</table>
EQ5  EXTERNAL VIEWS

Office Cubicle
Glass Meeting Room with Operable Blinds
Sample Submission

<table>
<thead>
<tr>
<th></th>
<th>External View (window) sq.m</th>
<th>External View (atrium) sq.m</th>
<th>Total External View sq.m</th>
<th>NLA sq.m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Level</td>
<td>1243.3</td>
<td>694.8</td>
<td>1938.1</td>
<td>1940.6</td>
</tr>
<tr>
<td>Level 1</td>
<td>1043.8</td>
<td>749.3</td>
<td>1793.1</td>
<td>2697.7</td>
</tr>
<tr>
<td>Level 2</td>
<td>1283.1</td>
<td>899.5</td>
<td>2182.6</td>
<td>2848.5</td>
</tr>
<tr>
<td>Total</td>
<td>5913.8</td>
<td>7486.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total percentage of area with direct line of sight through vision glazing

\[
\text{Total Area w/ External View} = \frac{\text{Total NLA}}{7486.8} = \frac{5913.8}{7486.8} = 78.99\% 
\]

Legend

- Apertures
- Walls
- External View (window)
- External View (courtyard)
- No External View
- View Direction

scale 1:400
Internal Atrium View
<table>
<thead>
<tr>
<th>EQ5</th>
<th>EXTERNAL VIEWS</th>
<th>1 POINT</th>
</tr>
</thead>
</table>

Internal Courtyard View

Image: www.floodslicer.com.au
MISTAKES:
Not meeting the percentage – trying hard.
**EQ13 Internal Noise Levels**

Control excessive internal noise level to assure good IEQ. **MISTAKE: NOT MEETING THE CRITERIA.**

| Maintain internal noise levels at an appropriate level. Demonstrate that 90% of the NLA do not exceed the following ambient internal noise levels:-  
| **Within the entire baseline building** general office, space noise from the building services does not exceed 40dBAeq.  
| **OR**  
| **Within the baseline building office space,** the sound level does not exceed 45dBAeq for open plan and not exceed 40dBAeq for closed offices | 1 |
EQ6  SOUND INSULATION  1 POINT

Sample Submission

Legend
- 175mm thk RC shear wall with skim coat finish (STC = 57)
- 175mm thk Light weight block with skim coat finishes on both sides (STC = 46)
- Window Opening (STC = 31/window)
- Floor (STC = 55)
- Entrance Door - Solid Timber Door (38mm fire-rated) (STC = 27/door)
- Inter-dwelling shared wall between units
# EQ6 | SOUND INSULATION

1 POINT

## Sample Submission

<table>
<thead>
<tr>
<th>Sketch</th>
<th>Brief Description</th>
<th>STC</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Sketch" /></td>
<td>1. 12x8x16, 3-cell lightweight concrete masonry units (43 lbs./block). 2. Paint both sides with 3 coats of latex block filler.</td>
<td>50</td>
</tr>
<tr>
<td><img src="image2.png" alt="Sketch" /></td>
<td>1. 12x8x16, 3-cell lightweight concrete masonry units (43 lbs./block). 2. Paint one side only with 3 coats of latex block filler.</td>
<td>51</td>
</tr>
<tr>
<td><img src="image3.png" alt="Sketch" /></td>
<td>1. 6&quot; cast concrete wall (71 psf).</td>
<td>57</td>
</tr>
<tr>
<td><img src="image4.png" alt="Sketch" /></td>
<td>1. 6&quot; cast concrete wall. 2. &quot;Z&quot; furring channels. 3. ½&quot; gypsum board.</td>
<td>59</td>
</tr>
<tr>
<td><img src="image5.png" alt="Sketch" /></td>
<td>1. 6&quot; cast concrete wall. 2. &quot;Z&quot; furring channels. 3. 1½&quot;, 18-pcf rockwool. 4. ⅛&quot; gypsum board.</td>
<td>62</td>
</tr>
<tr>
<td><img src="image6.png" alt="Sketch" /></td>
<td>1. 6&quot; cast concrete wall. 2. 2x2&quot; wood furring. 3. 1½&quot;, 4-pcf rockwool. 4. ⅛&quot; gypsum board.</td>
<td>63</td>
</tr>
</tbody>
</table>

**Additional DA Material**

### Sound Insulation

**STC Report Source** - Door

**Centrus SOHO 1 @ CBD Perdana 3**

---

**Source:** U.S. Department of Housing and Urban Development
<table>
<thead>
<tr>
<th>Lighting, Visual &amp; Acoustic Comfort</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EQ8 Daylighting</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>EQ9 Daylight Glare Control</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>EQ10 Electric Lighting Levels</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>EQ11 High Frequency Ballasts</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>EQ12 External Views</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>EQ13 Internal Noise Levels</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Verification</strong></td>
<td></td>
</tr>
<tr>
<td><strong>EQ14 IAQ Before &amp; During Occupancy</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>EQ15 Post Occupancy Comfort Survey</strong></td>
<td>2</td>
</tr>
</tbody>
</table>
Ensure achievement of high sustainable IAQ.

*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:*
During Occupancy Stage:
Where a permanent air flushing system of at least 10 airchanges/hour operation is installed for use during occupancy stage
During Occupancy Stage:
Where a permanent air flushing system of at least 10 airchanges/hour operation is installed for use during occupancy stage

MISTAKE:
FLUSHING NOT PROPERLY DONE & DOCUMENTED
During Occupancy Stage:
Where a permanent air flushing system of at least 10 airchanges/hour operation is installed for use during occupancy stage

MISTAKE:
FLUSHING NOT PROPERLY DONE & DOCUMENTED
EQ14 Flushing options 1: Example

Perform a building flush out by supplying outdoor air to provide not less than 10 air changes /hour for at least 30 minutes operation before occupancy and continuous minimum 1 ACH during the initial 14 days occupancy of the completed building.

The approximate floor area of the office is around 3,600 sq. ft. (335 m²), and the floor ceiling height is 10 ft (3000mm) maximum. Ventilation rate of one air change (ACH) is = 3600 x 10 /60 = 600 cfm.

Primary flushing with 10 ACH for 30min, the volume of air required for flushing is:

= 600 cfm x 10 x 30min = 180,000 cu.ft.

If smoke spill system is available, it will be 10 ACH. If this is not available and temporary fan of 3,000 cfm is used, then the flushing time shall be:

= 180,000 cu.ft / 3,000 cfm = 60 min (1 hour)

If flushing with >10ACH ventilation, time cannot be shorten, must be minimum 30 min.

Toilet exhaust of the floor = 617 cfm ~ 600 cfm (1 air change)

Secondary flushing can be done with toilet exhaust system for next 14 days. Volume of air required for flushing = 617 cfm x 24 hr x 60 x 14 = 12,438,720 cu. ft.

Flushing with <1ACH is not acceptable, temporary fans have to be added.

Flushing time with ventilation >1 ACH shall be 14 days, no reduction.
EQ14 Flushing options 2: Example

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 air changes/hour for at least 15 minutes operation or not less than 6 air changes/hour for at least 30 minutes operation and continuous 1 ACH during the initial 7 days occupancy of the completed building.

The approximate floor area of the office is around 3,600 sq. ft. (335 m²), and the floor ceiling height is 10 ft (3000mm) maximum. Ventilation rate of one air change (ACH) is:

\[ 3600 \times 10 \div 60 = 600 \text{ cfm} \]

Primary flushing with 10 ACH for 15min, the volume of air required for flushing is:

\[ 600 \text{ cfm} \times 10 \times 15 \text{ min} = 90,000 \text{ cu.ft.} \]

If smoke spill system is available, it will be 10 ACH. If this is not available and temporary fan of 3,000 cfm is used, then the flushing time shall be:

\[ 90,000 \text{ cu.ft} / 3,000 \text{ cfm} = 30 \text{ min} \]

If flushing with >10 ACH ventilation, time cannot be shorten, must be minimum 15 min.

Toilet exhaust of the floor = 617 cfm ~ 600 cfm (1 air change)

Secondary flushing can be done with toilet exhaust system for next 7 days. Volume of air required for flushing:

\[ 617 \text{ cfm} \times 24 \text{ hr} \times 60 \times 7 = 6,219,360 \text{ cu. ft.} \]

Flushing with <1 ACH is not acceptable, temporary fans have to be added.

Flushing time with ventilation >1 ACH shall be 7 days, no reduction. Fresh air supply actually at 1,650 CMH (970 cfm) = toilet exhaust + exfiltration.
EQ14 Flushing to achieve IAQ before and during occupancy

Comment:

• Air circulation must be adequate, no stagnant air or “dead corner” in air circulation path. Additional stand fans may have to be added for circulation.

• Make-up air must be sufficient and ideally mixed well with indoor air without direct bypass to extraction point.

• Care not to bring in moist air when outdoor humidity is high. Occupants’ comfort level has to be closely monitored for days.

• Care in using life safety equipment for flushing. Smoke spill system can have very high static pressure or velocity that can result in property damage or personnel injury.

• Airflow must be verified by instruments and report on airflow or velocity reading must be taken and documented.

• Sampling readings on air quality parameter, though not required, are recommended to be taken for effective monitoring during flushing. Data logging on temperature & humidity is recommended.
Though not necessary, IAQ readings can be taken to track the trend:

Indoor air quality has been checked while flushing with the following state-of-art equipment: Graywolf IQ-604 air sensing solution and Riken Keiki formaldehyde detector.
EQ15 Post Occupancy Comfort Survey

Ensure occupants truly benefit from the design intents.

| Provide for the assessment of comfort of the building occupants:– |
| Conduct a post-occupancy comfort survey of building occupants within 12 months after occupancy/building completion. This survey should collect anonymous responses about thermal comfort, visual comfort and acoustic comfort in a building. It should include an assessment of overall satisfaction with thermal, visual and acoustic performance and identification of thermal-related, visual-related and acoustic-related problems. |

AND
thermal comfort

- metabolic rate
- air speed
- humidity
- mean radiant temperature
- clothing insulation
- air temperature
<table>
<thead>
<tr>
<th>Comfort Category</th>
<th>A - Thermal Comfort</th>
<th>B - Acoustics</th>
<th>C - Indoor Air Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NS</td>
<td>S</td>
<td>NS</td>
</tr>
<tr>
<td>1 Total</td>
<td>9</td>
<td>54</td>
<td>20</td>
</tr>
<tr>
<td>2 Poll</td>
<td></td>
<td></td>
<td>63</td>
</tr>
<tr>
<td>3 Percentage</td>
<td>14%</td>
<td>86%</td>
<td>32%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Comfort Category</th>
<th>D - Lighting Levels</th>
<th>E - Cleanliness</th>
<th>F - Others</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NS</td>
<td>S</td>
<td>NS</td>
</tr>
<tr>
<td>1 Total</td>
<td>19</td>
<td>44</td>
<td>3</td>
</tr>
<tr>
<td>2 Poll</td>
<td></td>
<td></td>
<td>63</td>
</tr>
<tr>
<td>3 Percentage</td>
<td>30%</td>
<td>70%</td>
<td>5%</td>
</tr>
<tr>
<td>EQ7</td>
<td>POST OCCUPANCY EVALUATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Provide for the assessment of quality and comfort of the building occupants.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Commit to implement a post-occupancy comfort survey of building occupants within 12 months after issuance of Certificate of Completion and Compliance (CCC). This survey should collect anonymous responses about air quality, thermal comfort, daylighting comfort, visual comfort and acoustic comfort in a building. This should include measurement of overall thermal, daylight and acoustic performance and identification of thermal-related, visual-related and acoustic-related problems.</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**MISTAKE:**

**DA : Usually None**

**CVA :** 1.) Asking questions not related to IEQ. 2.) No Corrective Actions taken.
Thank You

By: Ir. Ng Yong Kong, email: nyk@nyk.com.my
Tel: +6012 201 9319