Measuring and Monitoring the Efficiency of Central Chiller Plants

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All existing buildings with central air-conditioning systems and more than 10,000m² air-conditioned floor area, as well as new buildings with central air-conditioning systems, to:

a) Install instrumentation to monitor and report the Coefficient of Performance (COP) of their central air-conditioning plants; and

b) Achieve a COP of at least 4.7 (recommended COP of 5.4).
Central Chiller Plant Schematics

\[ \text{COP} = \frac{F_{ch} \times (T_{R1} - T_{S1})}{\sum kW} \times 4.19 \]
Temperature Sensor

Flow Sensor

Power Meter

BTU Meter
Issues Affecting Accurate Flow & Temperature Measurement

*Based on MOF GESP project*
Issues Affecting Accurate Temperature Measurement

- Errors introduced by sensor
- Errors introduced by transmitter, if used
- Errors introduced by wires (2-wire)
  - Poor shielding and earthing of wires
- Insufficient probe insertion depth
- Poor contact between sensor and thermo-well
  - Poor insulation

Notes:
- Contact grease
- Thermo-well
- Errors introduced by temperature sensor
Recommended Measurement Accuracy

For measuring the overall system energy efficiency of central chiller plant, the following measurement accuracies are recommended:

<table>
<thead>
<tr>
<th>Measurement System</th>
<th>Recommended Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (e.g. 4-wire PT100 - DIN 1/10 Class B, thermistor)</td>
<td>± 0.03°C</td>
</tr>
<tr>
<td>Flow (e.g. electromagnetic)</td>
<td>± 1%</td>
</tr>
<tr>
<td>Power</td>
<td>± 1%</td>
</tr>
</tbody>
</table>

| Data Acquisition System             | ± 1%                 |
| Long Term Drift                     | ± 1%                 |

Overall system efficiency measurement accuracy : +/- 5%
Parameters to be Measured

- Parameters to be Measured by BTU Meter / BMS
  - Chilled water supply temperature
  - Chilled water return temperature
  - Chilled water flow rate
  - Condenser water supply temperature
  - Condenser water return temperature
  - Condenser water flow rate
  - Electrical energy inputs to all chillers, pumps and cooling towers

- Heat Balance

\[
\text{Building Cooling Load} + \text{Compressor Work Input} = \text{Heat Rejection}
\]

\[
F_{ch} \times \Delta T_{ch} \times 1.191
\]

\((\text{Chilled water side})\)

\[
\text{Chiller kW / 3.517}
\]

\[
F_{c} \times \Delta T_{c} \times 1.191
\]

\((\text{Condenser side})\)
Measurement System Architecture (Without BMS)
Measurement System Architecture (With BMS)

Based on MOF GESP project

Temperature Sensors

BTU Meter

M-Bus hub with RJ11 connectors for easy distribution

AmbusNet

Standard 4 wire Cable for power transmission and data communication

Standard Telephone Cable RJ11

Expanible for Future system

*Based on MOF GESP project
## Example on Measurement Accuracy

<table>
<thead>
<tr>
<th>Measurement System</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power</strong></td>
<td></td>
</tr>
<tr>
<td>Power Consumption</td>
<td>± 0.5%</td>
</tr>
<tr>
<td><strong>Flow</strong></td>
<td></td>
</tr>
<tr>
<td>Chilled water flow rate</td>
<td>± 1%</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td></td>
</tr>
<tr>
<td>Chilled water supply temperature</td>
<td>± 0.03°C</td>
</tr>
<tr>
<td>Chilled water return temperature</td>
<td>± 0.03°C</td>
</tr>
<tr>
<td><strong>Data Acquisition System</strong></td>
<td></td>
</tr>
<tr>
<td>BTU meter</td>
<td>± 1%</td>
</tr>
</tbody>
</table>
Example on Measurement Accuracy

Measurement Accuracy

(A) Uncertainty for power measurement = ± 0.5%
(B) Uncertainty for flow measurement = ± 1%
(C) Uncertainty for temperature measurement = ± \( \frac{(0.03 + 0.03)}{(12.0 - 6.0)} \times 100\% \)
    = ± 1%
(D) Uncertainty for BTU meter = ± 1%
(E) Uncertainty for long term drift = ± 1%

Overall uncertainty = ± (0.5% + 1% + 1% + 1% + 1%)
    = ± 4.5%
Thank you