**B&O HEADQUARTERS, STRUER, DENMARK**

<table>
<thead>
<tr>
<th>Building name: Bang &amp; Olufsen HQ</th>
<th>Year of completion: 1998</th>
<th>Type of building: Office</th>
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<tbody>
<tr>
<td><strong>Design Team:</strong></td>
<td></td>
<td></td>
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<tr>
<td>KHR Architects a/s, Teknikerbyen 7, DK-2830 Virum, Denmark</td>
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<tr>
<td>Birch &amp; Krogboe A/S, Teknikerbyen 34, DK-2830 Virum, Denmark</td>
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</tbody>
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**Site data**

<table>
<thead>
<tr>
<th>Design conditions winter</th>
<th>Design conditions summer</th>
<th>Average wind speed (m/s)</th>
<th>Prevailing wind direction</th>
<th>Terrain shielding</th>
<th>Dust pollution</th>
<th>Noise pollution</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Altitude (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T g/kg</td>
<td>T g/kg</td>
<td>4.9</td>
<td>W</td>
<td>open</td>
<td>no</td>
<td>no</td>
<td>56.42° N</td>
<td>8.58° E</td>
<td>12</td>
</tr>
<tr>
<td>-12°C</td>
<td>-</td>
<td>25°C</td>
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**Design philosophy for IAQ and Thermal Comfort and issues of concern for this building**

Bang & Olufsen required an office building of high quality with a minimum of technical installations, which should be simple and hidden. The office layout is based on an open plan principle. The north facade, which is shown in the above photo, is fully glazed with openings in the horizontal divisions serving as inlets for natural ventilation. The south facade has a moderate window area for daylighting and has user-controlled windows, which are automatically controlled at night to cool the building. Air is extracted through specially-designed cowls on top of the roof, which also has integrated fans to assist the flow when the natural driving forces are insufficient.
The building is specifically designed for natural ventilation. In the design stage for the ventilation the architects and engineers took into account both the thermally-generated pressures as well as the wind-induced pressures.

The indoor air quality during office hours in winter and summer is automatically controlled by CO₂ sensors.

Furthermore, the supply air is pre-heated to a certain level below room temperature to fulfil the requirements of displacement ventilation, which is the air distribution principle. Pre-heating the supply air will also reduce the risk of draught in cold periods, and will therefore lead to improved thermal comfort.

The occupants can increase the air change rate by opening the windows, which is done periodically, mainly in summer.

In summer the risk of overheating is reduced by use of night time ventilation.

**Principle of hybrid ventilation**

The ventilation principle is stack and wind driven natural ventilation with fan assistance.

The ventilation rates are based on a constant air flow principle to secure an acceptable indoor climate and thermal comfort during office hours.

Outdoor air is supplied and pre-heated through low-positioned ventilation windows at each office floor. The air is extracted through the top of two stairwells, which are openly connected to the offices. Fans to assist the natural driving forces are located at the top of the stairwells.

The design air change rate is 3 ach in summer and 1.5 ach in winter. These air change rates are obtained by natural driving forces and fan assistance based on a constant air flow principle.

Extraction fans are turned on during periods when the stack effect and wind are not strong enough for natural ventilation. Furthermore, the fans will support the neutral pressure level and secure the right direction of the air flow.

**Components used to solve main issues or problems**

*Ventilation devices for supply air:* A narrow band of automatically-controlled windows in the glazed north facade. The openings are positioned in the horizontal divisions. Ribbed heat pipes, with inlet temperature sensors, are used to pre-heat the supply air during the heating season. On the south facade, high-positioned daylight windows with actuators are used as supplementary inlet openings.

*Ventilation devices for extract air:* Two frequency-controlled axial fans at the top of the stairwells. The fans are controlled by air velocity sensors situated in the extracts. Low pressure drop dampers in extract cowls on top of roof. Baffles of sound-absorbent material at the top of the stairwells to reduce the noise level of the fans to a specified low level.

*The control system is based on a BEMS system:* The hybrid ventilation system is controlled by IAQ using CO₂ sensors and room temperature sensors. The ribbed heat pipes at the supply openings are controlled by inlet temperature sensors.
Control Strategies

The hybrid ventilation system is automatically controlled by CO$_2$ level, room temperature or occupancy. The hybrid ventilation system is active according to a certain time schedule or when the building is occupied, with three control modes:

- Constant mode based on time schedule or occupancy
- CO$_2$ mode based on time schedule and occupancy
- Night cooling with fan support based on room temperature

When outdoor temperatures are below 0°C the hybrid ventilation system turns off and occupants can use windows for short time venting.

Particular control strategy issues

The architecture of the control system is based on centralised components.

The position of the valve controlling the heat pipes is used to adjust the inlet openings at the north facade according to variations in wind pressure at different positions of the facade.

The ventilation system is overruled by rain or strong winds, which will shut down supply openings in the facades, fans and dampers in the extract.

Individual opening of daylight windows at the south facade is possible by user interaction.

The building management is carried out by internal staff.

Overall performance

The overall performance will be measured as part of a detailed monitoring programme in the Annex 35 project.