Data Centre Cooling Strategies

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Abstract

Strategies for upgrading cooling systems for two existing data centres have been explored. The systems are located in a challenging noise environment. The ability of the systems to withstand conventional noise control treatment was explored. For one system, a conventional noise control solution has been adopted. For the second system a more unusual solution is being considered using only outdoor air. The project is ongoing.

1. INTRODUCTION

Two data centres A and B are located in a high-rise office building. Both data centres are cooled using DX indoor process coolers and air-cooled condensers. Air is circulated under the raised computer floor, drawn up through the enclosed computer racks, and drawn back in through the top of the process coolers. Refrigerant is piped from the indoor process coolers to external condensers located on a raised outdoor platform.

Noise complaints from the operation of the outdoor condensers have been received. The daytime noise limit is L_{10} 65 dBA, the night-time noise limit is L_{10} 60 dBA.

The site is surrounded on two sides by adjacent high rise buildings that are within metres of the site boundary. There is an open concrete car park which extends underneath the data centre building. Noise from the condensers is reflected around the concrete carpark and radiates into the vertical gap between the buildings on two sides. In noise control terms the site is challenging.

2. DATA CENTRE A

A noise measurement made in 2009 gave a result of L_{10} 70 dBA, made only metres from the data centre A condensers. Noise control work was implemented by others, however subsequent measurement results in the range of L_{10} 63-65 dBA indicate compliance with the night-time noise limit has not been achieved.

Because of the reflective nature of the site, noise levels do not vary much around the building. We have measured noise levels of L_{10} 61-62 dBA at level 8 of the building - the condensers are located at level 1.

The previous noise control treatment implemented consisted of a “shroud” constructed over the top of the condensers, with internally lined discharge ducts. The underside of the the condensers was left untreated, however intake airflow is obstructed to a degree by other building structure.

Further noise control work would require restricting the airflow around the condensers, especially on the intake side. The ability of the condensers to cope with a further restricted airflow, and the effect of this on the cooling capacity, needed to be explored.

We established that the existing condensers were operating at reduced capacity due to the reduced air flow rate. The addition of the “shroud” on the discharge side, and the already slightly obstructed intake path, meant in reality the condensers would be at full capacity or more, especially in summer months. We concluded that there was no opportunity to reduce the fan speed of the existing condensers to reduce noise.

The condensers could have been enclosed in a ventilated plant room, but space constraints and cooling considerations made this impractical.

Raising the condensers to install additional intake treatment below was also considered. Additional attenuators would need to be very large in order to keep air velocity and pressure drop low. Given site and cost constraints this was not considered to be practical.

The existing condensers were using R22 refrigerant which is being phased out, resulting in a further loss of efficiency.

After due consideration it was decided that the best solution would be to replace the existing condensers with newer quieter models with greater cooling capacity. Because of the excess cooling capacity of the new proposed condensers, fan speed can be reduced to 400-500 rpm. The newer condensers are physically larger but will still fit on the same outdoor platform, with a relatively minor extension.

Overall the replacement condensers have a sound power rating approximately 15 dB less than the existing condensers.

3. DATA CENTRE B

Data centre B is in the same building. Again, cooling is by DX indoor process coolers, but in this instance the external condensers are built into the building façade. Our measurements indicate that noise from these "façade condensers" may be reflecting around the site and contributing to overall measured noise levels.

Analysis again showed the cooling system was operating at or near maximum thermal capacity. The "facade" condenser arrangement added another complication in terms of recycling of warm air between condensers, which is difficult to quantify but more than likely is reducing efficiency.

One option would be similar to the solution adopted for data centre A, i.e. install new "low noise" condensers in an outdoor location. A large new raised condenser platform would be needed.

4. ALTERNATIVE COOLING OPTION

Another option would be to scrap the the existing DX cooling systems and replace it with outdoor air cooling systems

There has been a rapid advancement of outdoor air cooling during recent years, mainly due to the innovation of end users of server equipment such as Google, Facebook & Yahoo driving down cooling energy costs. In most cases advancements in technology precede the end users, in this instance however technology and standards have been updated to keep up with the end users.

A good example of this is the ASHRAE standards for data centre temperatures which have been revised repeatedly to keep up with the end users.

The latest ASHRAE standards for the inlet temperatures to server equipment are shown in the referenced white paper by Microsoft/Intel (1)

As a result of the increased temperature drive by end users, the maximum air temperature into server equipment has been steadily increased by server manufacturers e.g. Dell – refer (2).

Most server manufacturers (CISCO, Dell, HP, IBM etc), now rate their servers at at least 35 °C air into the servers. This means that keeping modern computer rooms cooled to low temperatures may not be necessary.

There have been several innovative designs by end users to cope with the higher temperatures, such as re-designing servers with power and data cabling in the cold isle.

The term PUE (power usage effectiveness = total data centre power divided by power consumed by servers) is used to define the efficiency of data centres.

Large data centre owners such as Google and Facebook now have data centres that are PUE < 1.1 as compared to DX cooled centres which would be around PUE = 1.5 +.

5. CONSIDERATIONS

The following preliminary design considerations must be taken into account for outdoor air cooling systems for data centres;

The age and thermal capacity of the equipment must be established. Newer equipment with a higher temperature rating is required.

The room must be able to be configured into an alternating "hot aisles" and "cold aisles" layout. Outside "cold" air is drawn through the server racks to the "hot aisle" side, where it is exhausted from the building.

Fans, filters & ducting are required to supply and exhaust the air. There must be sufficient space inside the room for the fans and associated ductwork or silencers.

Benefits

In adopting an outside air solution, cooling systems are replaced with fans (with back-up as needed). The systems are simpler and overall electricity savings can be significant.

We have estimated that if outdoor air systems were implemented for the data centres, costs savings could be of the order of $100,000+ per year due to reduced electricity costs. Payback of the cost of converting to "outside" air would take 1-2 years, thereafter the cost savings would be significant and on-going.

Outside air cooling also increases space and reduces the need for expensive maintenance contracts.

Disadvantages

Studies have shown that there is a slight decrease of performance, increase of server power consumption (mainly due to the increased server cooling fans speed) and increase of noise levels (due to the higher server fan speed). There can also be a slight increase of equipment failure rate, although in New Zealand conditions this is expected to be minimal.

The hot isle in the room will be warmer than traditional "cooled" computer rooms (say 40°+ in summer in the hot isle in New Zealand conditions), and therefore less comfortable.

The noise levels in the room will increase – we measured around 80 dB(A) in the existing data centres, which is already fairly noisy.

Workers inside such data centres should be lightly dressed (in shorts and T shirts!), and wearing ear muffs, as the server fan noise levels will be high depending on the outside air temperatures.

6. CONCLUSION

This study raises a number of interesting points;

Advances in technology are rapid and can trickle-down and effect many aspects of what we do. Keeping up with the technology industry "best practice" is an on-going exercise.

End users can drive innovation and force revision of standards and industry "norms".

Finally, as always, the best noise control is no noise control. Eliminating condensers or chillers entirely is the ultimate "noise control at source". On "difficult" sites it certainly makes the acoustic consultant's job easier, and can also save money.

7. REFERENCES & ACKNOWLEDGEMENTS

[1] http://www.intel.com/content/www/us/en/data-center/data-center-management/data-center-server-cooling-power-management-paper.html

[2] http://content.dell.com/us/en/corp/d/press-releases/2011-07-28-fresh-air-initiative ¶