Comparison of China-ASHRAE HVAC Design Criteria in Coal-fired Power Plants

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Abstract: This paper investigates the requirements of Chinese and ASHRAE HVAC design manuals and codes for various types of buildings within the power plants. By analysing the characteristics of HVAC basic design criteria for different building areas, the summary of similarities and differences between these two design systems are found. This paper studies the applicability and adaptability of Chinese HVAC design system as an auxiliary design basis in foreign power plant project, aiming to provide the basis for the selection of HVAC design for foreign design of power plant projects.

1. Introduction

With the continuous deepening of Chinese power reform, the general trend of de-capacity in the coal-fired power industry and energy structure conversion become irresistible. In order to seek further development, more and more Chinese power design companies are seeking overseas power plant design projects. However, the current HVAC design of the Chinese power plant mainly follows Code DL/T 5035-2016[1] and Power Engineering Design Manual-HVAC[2]. However, in foreign projects, the HVAC design of most projects is required to meet ASHRAE handbook or standards[3-6], which is different to the Chinese design system.

Therefore, faced with great differences between Chinese and ASHRAE HVAC design system[7-11], this paper compares the similarities and differences of Chinese and ASHRAE HVAC design manuals and standards for different building areas in the power plant. The estimation is conducted to value the applicability of Chinese HVAC design system being a supportive basis to provide reference for the future HVAC design in foreign power plant, as well as the possibility to help Chinese designers adapt to the requirements of international market.

2. Method

On the basis of HVAC design, this paper compares six significant design parameters between China-ASHRAE handbook to analyze the similarities and differences. The chosen design parameters contain design outdoor parameters, indoor design temperature and humidity, room ventilation rate, pressurization and HVAC equipment redundancy. These are the most important design points influencing HVAC design scheme.

The comparison and analysis is carried out in mainly three parts including Air Conditioning,
Ventilation and Heating. The compared buildings areas include the main power block area, electrical and electric areas together with mechanical areas.

3. Result and Analysis

3.1 Comparison of design outdoor parameters

Table 1. Design outdoor parameters.

| Outdoor design parameter | Standard |
|-------------------------|----------|
| TW_H                    | Winter design outdoor temperature for heating | China |
| TW_A                    | Winter design outdoor temperature for A.C. heating | China |
| TW_V                    | Winter design outdoor temperature for ventilation | China |
| TS_V                    | Summer design outdoor temperature for ventilation | China |
| TS_A                    | Summer design outdoor temperature and humidity for A.C. | China |
| 0.4%/99.6%              | 0.4% unguaranteed rate | ASHRAE |
| 1%/99%                  | 1% unguaranteed rate | ASHRAE |

Table 1 indicates that in ASHRAE handbook [3-4], for different building areas of power plant, the corresponding design outdoor (Hereafter referred to as DO parameters) temperature guarantee rate is different. Thus the corresponding design outdoor temperature is different [12]. By this difference, the area can be roughly divided into two categories: air conditioning area and ventilation areas. Similarly, although there is no classification of guarantee rate for outdoor parameters in China, the design outdoor parameters are selected according to the HVAC design scheme (e.g. ventilation or air conditioning). Therefore, even though there are differences in the temperature values between China design manual and ASHRAE handbook, they have commonalities in the principle of DO temperature.

3.2 Comparison of air change rate requirement

The air change rate in the ASHRAE handbook is the estimated value in the absence of room heat dissipation. If the room heat dissipation is known, the ventilation rate should be calculated according to the ventilation equation. So the air change rate can be considered as the maximum estimated ventilation value. While the air change rate in China can be considered as the minimum ventilation volume that the room should meet at least. In Chinese codes or manuals, on the basis of satisfying air change rate, ventilation volumes should also meet other requirements, like exhausting room heat dissipation or air pollutants.

Therefore, there are great differences in the air change rate requirement between China and ASHRAE. As one is considered as maximum value while the other is minimum value, ASHRAE requirement can be several times larger than the Chinese one. It is suggested that the air change rate in ASHRAE Handbook should be carefully adopted during the design stage because it may lead to excess capacity of ventilation equipment.

3.3 Comparison of heating

The heating requirement of ASHRAE is higher than Chinese standards. For most building areas, the indoor design temperature in winter is 7°C (ASHRAE) compared to 5°C (China). It indicates a relatively larger heating capacity under ASHRAE guideline compared to Chinese ones under the same DO parameters.
3.4 Comparison of air conditioning

Table 2. Comparison of Design Criteria of Air Conditioned Areas.

| Building Area                        | Design Outdoor Dry-bulb | Indoor Temperature °C | Relative humidity % | Room Ventilation Rate, ach* | Pressurization | Redundancy |
|--------------------------------------|-------------------------|-----------------------|---------------------|----------------------------|----------------|------------|
| Controls rooms and control equipment| 0.4%/99.6%              | 24±1 22±1             | 30 to 65            | ASHRAE Std.62.1            | P              | 100%       |
| Offices                              | 1%/99%                  | 26 21                 | 30 to 65            | ASHRAE Std.62.1            | P              | None       |
| Laboratories                         | 1%/99%                  | 26 21                 | 30 to 65            | ASHRAE Std.62.1            | P              | None       |
| Locker rooms and toilets             | 1%/99%                  | 26 21                 | None                | ASHRAE Std.62.1            | NE             | None       |
| Shop (air-conditioned)               | 1%/99%                  | 26 18                 | None                | ASHRAE Std.62.1            | None           | None       |

DL/T 5035-2016& Power Engineering Design Manual-HVAC(1,2)

| Building Area                        | Design Outdoor Dry-bulb | Indoor Temperature °C | Relative humidity % | Room Ventilation Rate, ach* | Pressurization | Redundancy |
|--------------------------------------|-------------------------|-----------------------|---------------------|----------------------------|----------------|------------|
| Controls rooms in Power Block area   | TSₐ & TW₂/ₐ/TWH         | 24-28                 | 18-22               | 40-65                       | Fresh air ratio 10%/30m³/h·p | 5-10Pa      | 100%       |
| Electronic instrument rooms in Power Block area | TSₐ & TW₂/ₐ/TWH | 26±1 20±1             | 50±10               | Fresh air ratio 5%/30m³/h·p | 5-10Pa         | 100%       |
| Electrical rooms: relay room, etc. in Power Block area | TSₐ & TW₂/ₐ/TWH | 24-28 18-22           | 40-65               | Fresh air ratio 5%/30m³/h·p | 5-10Pa         | Multi-     |
| Local control room                   | TSₐ & TW₂/ₐ/TWH        | 26 18                 | None                | 30m³/h·p⁴                  | None           | None       |
| Offices, Meeting                     | TSₐ & TW₂/ₐ/TWH        | 26 18                 | None                | 30m³/h·p⁴                  | None           | None       |
| Locker<sup>a</sup>                   | TSₐ & TW₂/ₐ/TWH        | None                  | 25                  | None                       | 2-3            | None       |
| Toilets<sup>b</sup>                  | TSₐ & TW₂/ₐ/TWH        | None                  | 14                  | None                       | 5-10           | NE         |

<sup>a</sup>From design code for heating ventilation and air conditioning of civil buildings GB 50736-2012.
<sup>b</sup>From design code for heating ventilation and air conditioning of industrial buildings GB 50019-2015.
<sup>c</sup>Mult is the abbreviation of Multiplicity. P is the abbreviation of Positive. NE is the abbreviation of Negative.

Table 2 shows the comparison of air conditioning area between China-ASHRAE HVAC design criteria. For areas needing air conditioning, the requirements of ASHRAE are stricter. For example, air conditioning is required in the toilet area by ASHRAE, while it is common practice to provide ventilation only in China. The main difference is about control rooms. In ASHRAE handbook and standards, regardless of the room location, control rooms containing electronic equipment are commonly required with accuratetemperatureand humidity control, together with redundancy of 100%. Compared to that, Chinese national manual or standard is more reasonable. The air-conditioned control room with precisetemperature and humidity control is limited to the control block area, together with lower temperature requirement. For control rooms outside the CCB area. There is no requirement of precise temperature and humidity control. It only needs to guarantee 26°C in summer and 18°C in winter, with no redundancy requirement.

3.5 Comparison of ventilation

3.5.1 Steam Turbine/Generation Areas

Table 3. Comparison of Design Criteria of Steam Turbine/Generation Areas.

| Building Area        | Design Outdoor Dry-bulb | Indoor Temperature °C | Relative humidity % | Room Ventilation Rate, ach* | Pressurization | Redundancy |
|----------------------|-------------------------|-----------------------|---------------------|----------------------------|----------------|------------|
| Steam Turbine Area   |                         |                       |                     |                            |                |            |
| Suboperating area    | 0.4%/99.6%              | DO +6                 | 7                   | None                       | 30             | None       |
| Above operating floor| 0.4%/99.6%              | DO +6                 | 7                   | None                       | 10             | None       |
| Steam generation area| 0.4%/99.6%              | DO +6                 | 7                   | None                       | 30             | None       |

ASHRAE HANDBOOK HVAC-APLICATIONS& ASHRAE Std.62.1[3,5]
Table 3 shows the comparison of the Steam Turbine/Generation area between China-ASHRAE HVAC design criteria. In the steam turbine building and boiler area, both ASHRAE and China adopt ventilation, both with stipulating different design requirements of different areas. However, there are differences in the area division principle. For example, ASHRAE is based on different floors, while for Chinese, is based on different functional area. Moreover, In ASHRAE, the temperature difference is 6°C, which is obviously stricter than Chinese code. Consequently, for a particular steam turbine building or boiler area, the total ventilation volume required by ASHRAE is significantly larger than Chinese codes or manuals.

3.5.2 Electrical equipment, mechanical and water treatment areas

Table 4. Comparison of Design Criteria of Other Areas.

| Building Area | Design/Indoor Temperature | Relative humidity (%) | Room Ventilation Rate, ach* | Pressurization | Redundancy |
|---------------|---------------------------|-----------------------|-----------------------------|----------------|-----------|
| Electrical Equipment | | | | | |
| Enclosed transformer | 0.4%/99.6% | DO+6 | 7 | None | 60 | P | 100% |
| Critical equipment | 0.4%/99.6% | DO+6 | 7 | None | 30 | P | 100% |
| Miscellaneous electrical | 0.4%/99.6% | DO+6 | 7 | None | 20 | None | Multi- |
| Mechanical Equipment | | | | | |
| Pumps, large power | 0.4%/99.6% | DO+6 | 7 | None | 30 | None | Multi- |
| Valve station, miscellaneous | 0.4%/99.6% | DO+6 | 7 | None | 15 | None | None |
| Elevator machine rooms | 0.4%/99.6% | 32 | 7 | None | None | P | None |
| Diesel generator area | 0.4%/99.6% | DO+6 | 7 | None | 30 | None | None |

DL/T 5035-2016& Power Engineering Design Manual-HVAC[1,2]

| Building Area | Design/Indoor Temperature | Relative humidity (%) | Room Ventilation Rate, ach* | Pressurization | Redundancy |
|---------------|---------------------------|-----------------------|-----------------------------|----------------|-----------|
| Electrical Equipment | | | | | |
| Enclosed transformer(oil/dry) Equipment areas | TSv | 45/40 | None | None | None | P | None |
| Critical Distribution/MCC/Switchgear (in Critical Area) | TSv/TWb | 35 | 5 | None | None | P | 2*50% |
| Miscellaneous Distribution/ MCC/Switchgear | TSv/TWb | 40 | 5 | None | None | P | 2*50% |
| Miscellaneous Electrical | Varies | Varies | Varies | None | Varies | Varies | Varies |
| Mechanical Equipment | | | | | |
| Water Pumps, large power (circulating water pump) | TSv/TWb | 40 | 5 | None | 15 | None | Multi- |
| Valve station, miscellaneous pump | TSv/TWb | None | 5 | None | None | None | None |
| Elevator machine rooms | TSv/TWb | 35 | 5 | None | 10 | None | None |
| Diesel generator area | TSv | 40 | 5 | None | normal 10/ operation | None | None |

*positive pressure only for oil-immersed type or dry type within dusty ambient environment
*positive pressure for rooms within dusty ambient environment
2*50% redundancy for air conditioning equipment, no redundancy requirement for ventilation equipment
depending on the storage of acid and alkali
Table 4 shows the comparison of other areas between China-ASHRAE HVAC design criteria. The division of electrical rooms in China is more detailed than ASHRAE. The electrical rooms with different functions have different HVAC design principles. Some rooms need air-conditioning, while others only need ventilation. In the Chinese design system, for critical distribution rooms, if $T_{\text{SA}}$ in summer is more than 30°C, air conditioning should be adopted. While for ASHRAE, air conditioning is not required regardless of the design outdoor temperature. In Chinese design, mechanical exhaust or supply is according to the cleanliness of the outdoor environment. While for ASHRAE design, regardless of the cleanliness of outdoor air, mechanical supply system and room positive pressure is required. For redundancy, these two design systems are completely different too.

For building areas like mechanical area, where adopt ventilation other than air conditioning, the design principle of ASHRAE is to meet indoor/outdoor temperature difference between 6 °C regardless of the outdoor ambient temperature. While for Chinese manual or standard, no matter what HVAC scheme (ventilation or air conditioning) is adopted, the design principle is to make indoor temperature no more than a pointed upper limit, etc., 35°C or 40°C. At this time, different cities may adopt different design schemes depending on the city’s outdoor temperature.

4. Conclusion and Discussion
This research indicates that even though ASHRAE Handbook is not as detailed as the Chinese design manual on the classification of power plant building areas, they have commonalities in design principles. Moreover, many ASHRAE design requirements are stricter than the Chinese ones, especially in heating and air conditioning design principles. In terms of ventilation design principles, ASHRAE is more applicable than the China manuals or standards, especially for hot areas with high outdoor temperatures in summer. For such areas, ventilation can be adopted according to ASHRAE, while air conditioning must be adopted according to Chinese codes. It implies cost increment by Chinese codes under the above circumstances. However, for areas with cool summer, Chinese principles will help to provide a large temperature difference compared to ASHRAE. These may lead to a decrease in ventilation volume compared to ASHRAE.

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