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Investigation, Analysis and Solution of Higher Noise of Heat Pump Water Heater

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ABSTRACT

The paper made an investigation on noise problems of A.O Smith heat pump water heaters. One problem is that the noise and vibration performance of 1P compressor of wall hanging type water heater was unqualified. The sound pressure level of compressor sample was about 40dBA, and the clients hope to be controlled below 39dBA. Another problem is that the noise of HV-80 floor type water heater is large when used matching with the 1.5P compressor of our company. According to the test and analysis with Test.Lab software, it is found that the main noise came from fan and compressor. The solutions of noise reduction on fan and compressor were made and the consequences were recognized by clients and markets.

1. INTRODUCTION

There are two problems for A.O Smith water heater. One is unqualified performance on noise and vibration of 1P compressor of wall hanging type water heater. The sound pressure level of compressor sample was about 40dBA, and the clients hope that the sound pressure level can be controlled below 39dBA. So it is needed to make an investigation on noise of wall hanging type water heater and provide solutions. Another problem is that the noise of wall hanging type water heater is a little large when used matching with the 1.5P compressor of our company. The main noise came from fan. And there was also noise coming from compressor according to the noise test nearby the water heater shell. The investigation on noise of floor type water heater was commissioned by the clients. According to the analysis of noise mechanism, the large noise of wall hanging type water heater may be caused by follow reasons as Figure 1 (Wang, T. Y., 2001) (CHEN, G. and XIN, D. B., 2007).

2. INVESTIGATION AND ANALYSIS OF WAll HANGING TYPE WATER HEATER

According to the feedback from test director of A.O Smith, there are two problems need to be solved. One is that the products were too noisy. The clients hoped to control the sound pressure level of water heater below 39dBA. Another mission is improving the sound quality of water heater.

2.1 Noise Test and Analysis

Figure 2 shows the test results of noise under working condition of water temperature 39℃. As no permission to take a picture in the N&V laboratory of A.O Smith, the pictures of test site cannot be provided. According to the Figure 2, it can be found that the OA of water heater was 40.41dBA. There were two obvious peaks at 200Hz (31.42dBA) and 400Hz (34.48dBA). In order to find the effect of compressor and fan on noise, noise test and analysis were made when compressor and fan working respectively. For the apparatus was not calibrated, test results can just be used for contrast.

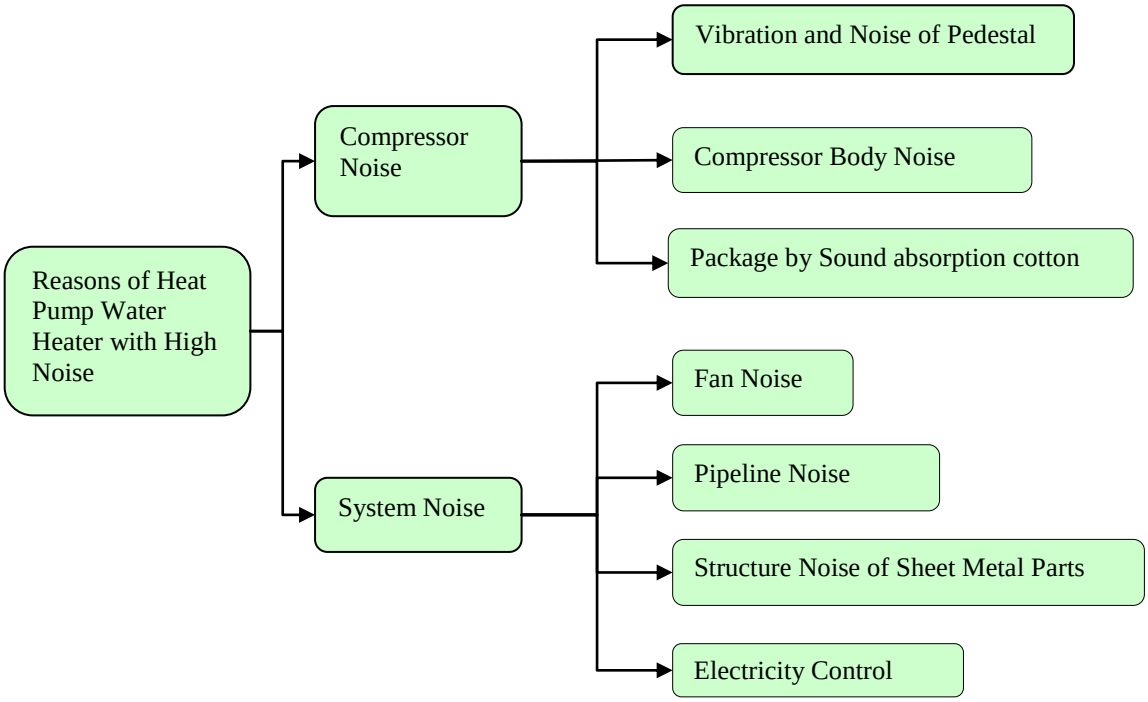

Figure 1: Sound sources analysis of heat pump water heater.

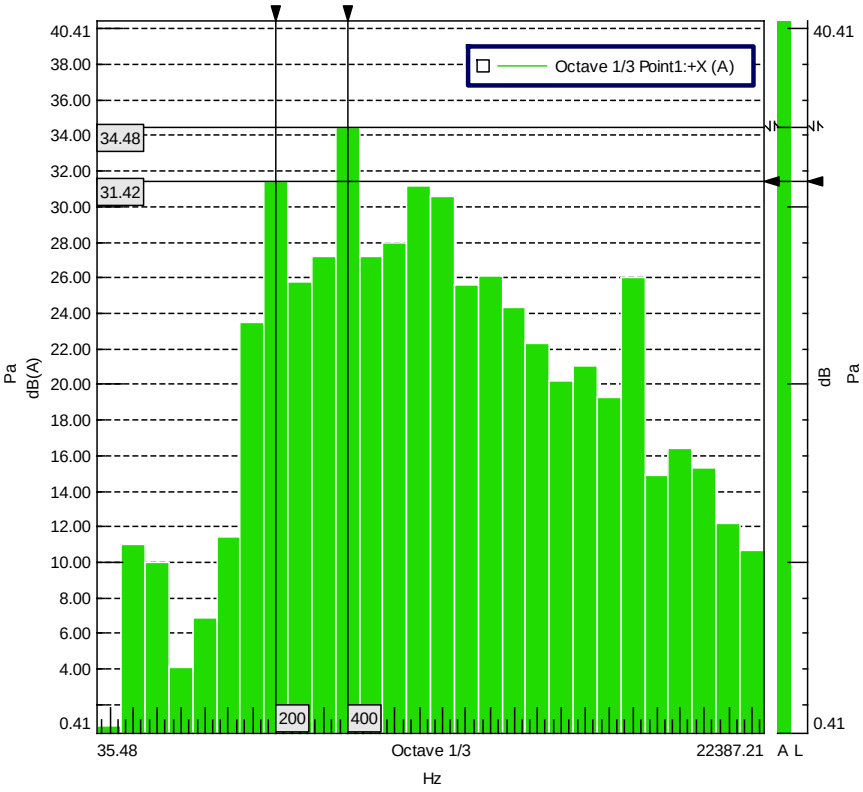

Figure 2: Noise test results of heat pump water heater on site.

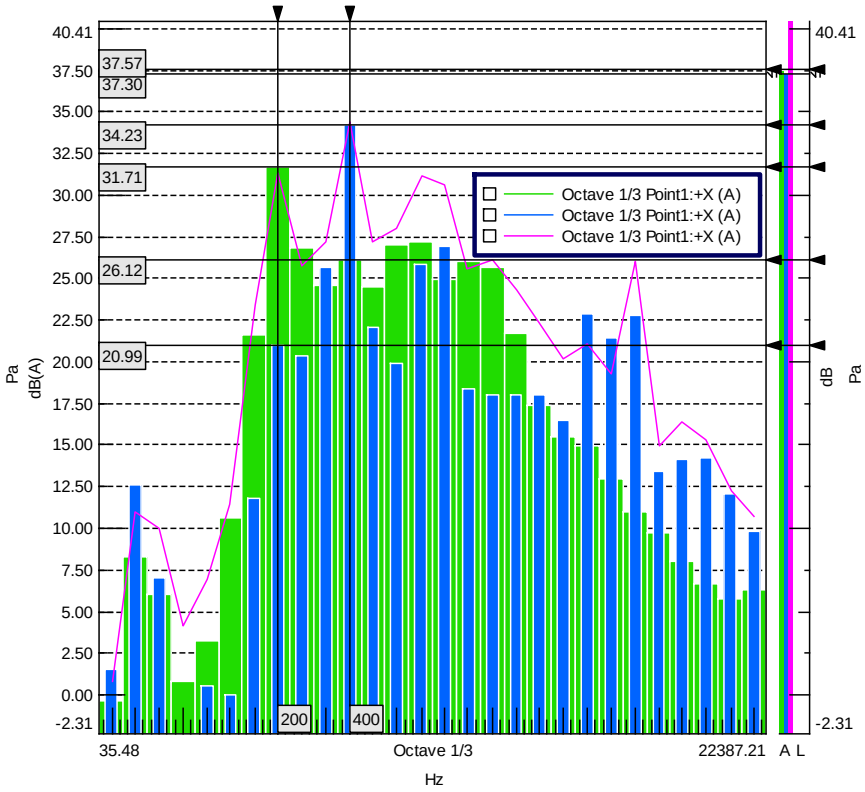

Figure 3: Noise test results of heat pump water heater when compressor and fan stopped respectively.

Under working condition of water temperature 39℃, noise tests were made when compressor and fan were stopped respectively. The test results are showed in Figure 3. The green bar is result when compressor was stopped, the blue bar is result when fan was stopped, and the purple line is result when water heater was running normally. When water heater was running normally, the OA was 40.41dBA. When only compressor was stopped, the OA was 37.57dBA and the peak at 400Hz declined from 34.23dBA to 26.12dBA. When only fan was stopped, the OA was 37.30dBA and peak at 200Hz declined from 31.71dBA to 20.99dBA. Obviously, the peak at 200Hz is caused by fan or its parts related, and the peak at 400Hz is caused by compressor or its parts related (Zhu, X. Y., 2009). In order to reduce the compressor noise, compressor was packed by double layers sound absorption cotton (Mao, D. X., 2010). For the apparatus was not calibrated, test OA results can just be used for contrast.

2.2 Noise Reduction Solution

The noise test results of compressor packed with double layers sound absorption cotton are showed in Figure 4 (the green is the result before package and the blue is the result after package). When water heater was running normally, the peak at 400Hz declined from 34.47dBA to 32.63dBA, and SPL declined by more than 3dB above 5kHz. For the peak at 200Hz increased about 2dB, the OA only declined by 0.66dB, which cause the reduction effect to be not obvious. According to the test results and analysis above, the peak at 400Hz is related to compressor. For further confirmation, location test of sound source was made around compressor by method of nearby noise frequency scan (Wang, Z. M., 2009). It was found that the peak at 400Hz was mainly caused by ducts of fan, and the noise at 400Hz was not remarkable around compressor. Considering test results, improved solution that attaching sound absorption cotton on the inside of fan duct cover of water heater was made. For the apparatus was not calibrated, test OA results can just be used for contrast.

The test results of compressor packed with double layers sound absorption cotton and inside of fan duct cover attached with sound absorption cotton are showed in Figure 5 (the green is the result before package and the blue is the result after package). When water heater was running normally, the peak at 400Hz declined from 34.45dBA to 31.04dBA, by about 3.4dB. The OA declined from 40.41dBA to 39.63dBA, by about 0.78dB. Noise reduction effect was prominent at 400Hz, but not well above 3150Hz. For the apparatus was not calibrated, test results can just be used for contrast.

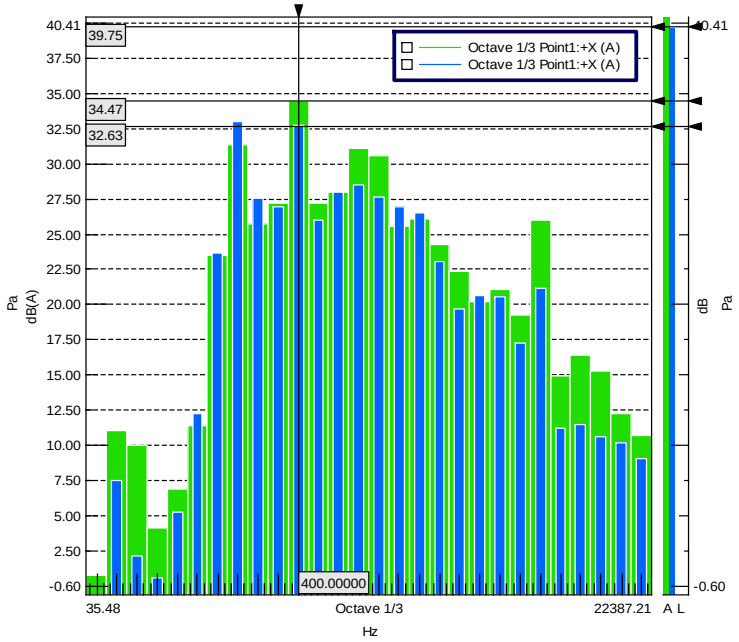

Figure 4: Noise test results of compressor packed with double layers sound absorption cotton.

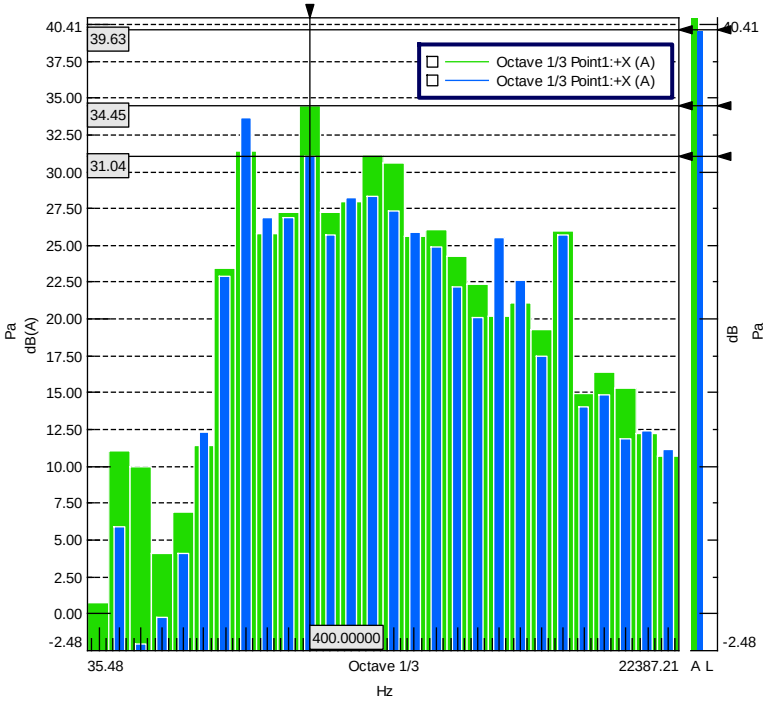

Figure 5: Noise test results of compressor packed with double layers sound absorption cotton and inside of fan duct cover attached with sound absorption cotton.

3. INVESTIGATION AND ANALYSIS OF FLOOR TYPE WATER HEATER

3.1 Noise Test and Analysis of Type HV-80 Water Heater

According to the feedback of clients, the noise of type HV-80 water heater compressor was large. The main noise came from fan when running. Besides fan noise, there was also noise coming from compressor according to the noise tested nearby the water heater shell. But compressor noise was not remarkable at some distance away from water heater.

Client's test engineer had made noise test with their own apparatus. Measurement points were 1m away from water heater. The test results were 50.9dBA in front of water heater, 49.3dBA in the side close to compressor, 58.9dBA in the side close to fan and 54.9dBA in behind of water heater. The noise close to fan was higher than noise close to compressor about 10dB. According to the test data, fan noise was the main sound source of water heater.

In order to make a further study on noise of water heater, the spectrum analyzer was used to make a detailed spectrum analysis (Chen, K. A., 2010). Make a contrast between the test result of water heater running normally and that when compressor stopped (only fan working). It was found that the spectrum of water heater working normally was coincident with spectrum when only fan working. The peaks of two spectra appeared at 160Hz. The detailed results are showed in Figure 6.

3.2 Noise test and analysis of Type HV-50 Water Heater

The noise test of type HV-50 water heater was made by SHEC directly after communication with clients. According to the test results, it was found that the correlation of spectra was bad between water heater working normally and only compressor working (see Figure 7). And the correlation of spectra was good between water heater working normally and only fan working. The peaks appeared at 160Hz and 200Hz (see Figure 8).

According to the test results and analysis above, it is found that the fan noise is the main sound source of water heater. In order to improve the sound quality of water heater, it is better to decline the rotating speed of fan or change the structure design of fan.

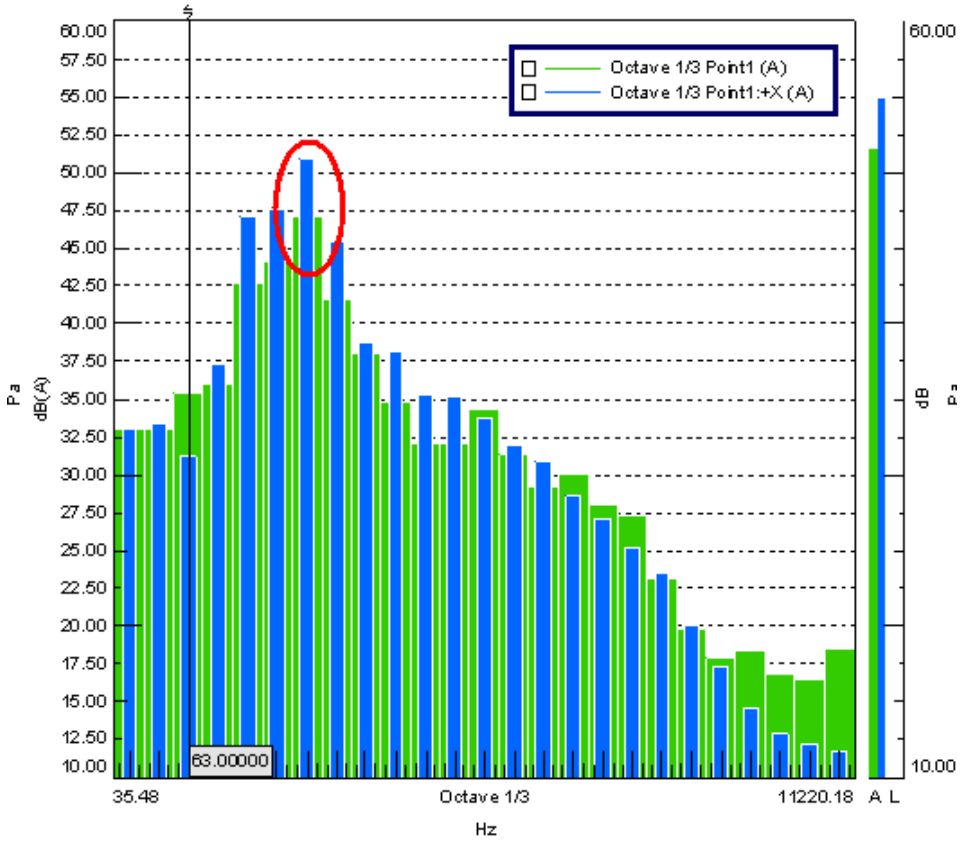

Figure 6: Noise test results of type HV-80 water heater running normally and when compressor stopped.

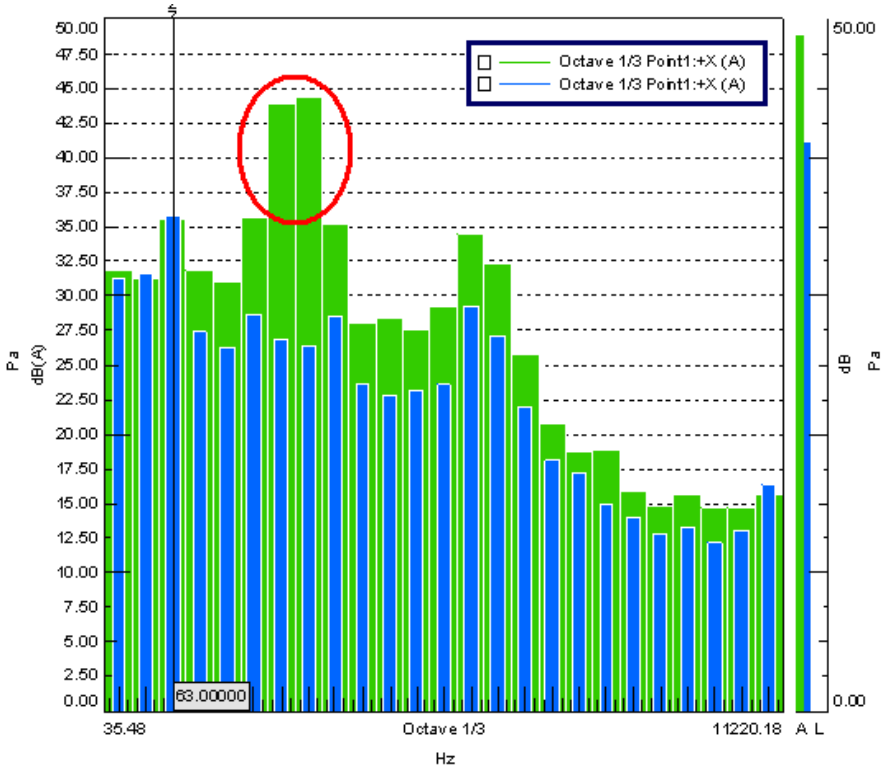

Figure 7: Noise test results of type HV-50 water heater running normally and when only compressor working.

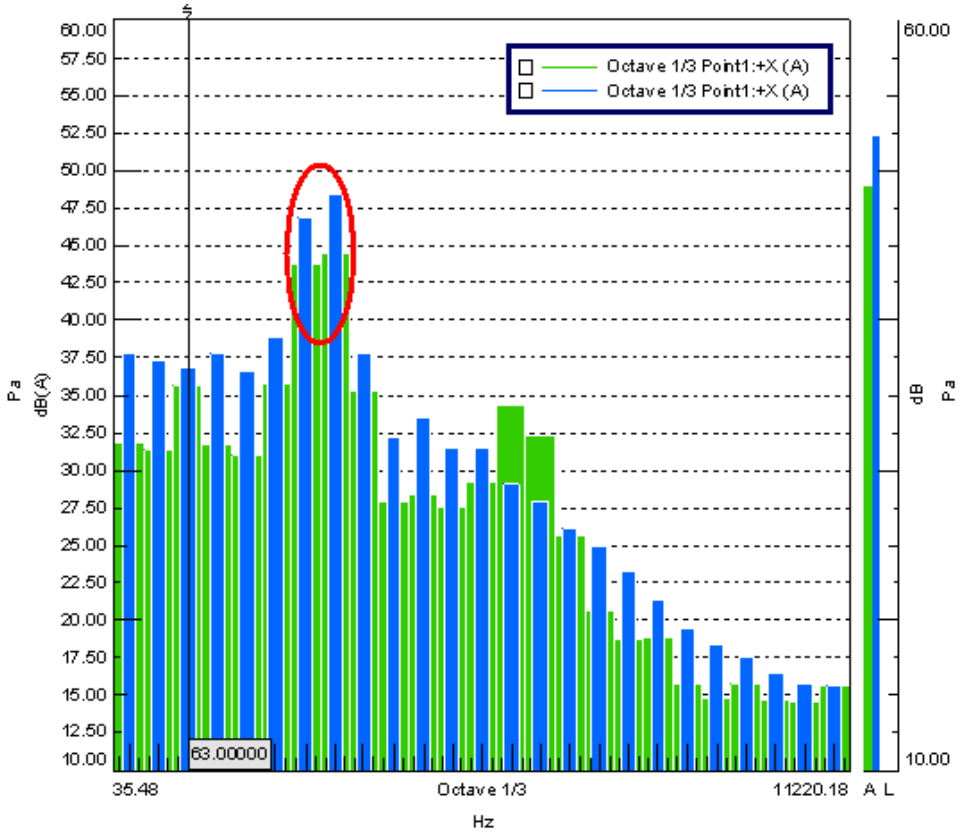

Figure 8: Noise test results of type HV-50 water heater running normally and when only fan working.

4. CONCLUSIONS

Noise reduction solutions and effects of wall hanging type water heater are showed in Table 1.

Table 1: Noise reduction solutions and effects

Design	Improvement effect
Packing compressor with single layer sound absorption cotton	OA was 39.4dBA tested by Smith, declined by 1dB. There were remarkable peaks at 200Hz and 400Hz.
Packing compressor with double layers sound absorption cotton	OA was 38.8dBA tested by Smith, declined by 1.6dB. The result satisfied the need of clients that the noise was below 39 dBA.
Packing compressor with double layers sound absorption cotton and attaching sound absorption cotton on the inside of fan duct cover	OA was 38.6dBA tested by Smith, declined by 1.8dB. The result satisfied the need of clients that the noise was below 39 dBA.

Noise reduction solutions of floor type water heater are showed in Table 2.

Table 2: Noise reduction solutions

Problems	Investigation	Solution
① The noise of water heater is large. ② When water heater was running, the main noise came from fan. Besides fan noise, there was also noise coming from compressor according to the noise tested nearby the water heater shell. But compressor noise was not remarkable at some distance away from water heater.	① Noise measurement points were 1m away from water heater. The test results were 49.3dBA in the side close to compressor and 58.9dBA in the side close to fan. The noise close to fan was higher than noise close to compressor about 10dB. ② The spectrum of water heater working normally was coincident with spectrum when compressor was stopped. The peaks of two spectra appeared at 160Hz.	According to the investigation result, the main noise source is fan. In order to improve the sound quality of water heater, it was suggested to decline the rotating speed of fan or change the structure design of fan. The proposals were recognized by clients.

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