A Case Study of Retro Commissioning in a Standard Commercial Office Building in Japan

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Abstract: This paper describes retro commissioning of a standard commercial office building in Japan. The owner's expectations for retro commissioning are realization of energy and cost savings, and controlling the increase in electric power demand, while continuing use of most existing equipment, and maintenance of high efficiency operation. First, the performance of the existing equipment was checked using the BEMS during retro commissioning program phase. Next, optimal selection of a system and heat source equipment was performed using the simulation in the design phase. Furthermore, the verification of the performance of the refrigeration machine installed was carried out as a Functional Performance Test. And the economic effect by a repair work was verified during the operation phase. The simple payback of the project was about six years.

1. INTORODUCTION

The Tozan building is a standard commercial use building in Japan which is 45 years old. Table A shows several key facts about this building. Retrofit of the HVAC systems was carried out in this building in 1989. In this retrofit, an ice thermal storage air-conditioning system was adopted for saving energy use and cost. Additional cooling capacity is needed with an increase of OA load in recent years after this retrofit. So, in 2000, the building owner considered adding air conditioning capacity, in order to cope with this increasing cooling load. And in order to be certain of realizing expected efficiency improvements, the building owner decided to carry out commissioning. The owner also made economic efficiency an important requirement during the process, satisfying the demand from the tenant who lives in this building. The commissioning process resulted in a successful addition of air condition plant capacity to the building from design through construction, and operation.

Tab. 1 Building description of the Tozan building

Building Name	Tozan building
Loacation	Nibombashi,TokyoMet.Japan
Type of building	Office building(to let)
No. of floors	9floors avove groud and 2floors under ground
Gross squre meters	9,368m^2
History	1960 Completion 1989 First Renwal Work 2000 Second Heat Source reninforcement
Retro-Commissioning	2000(on-going)

2. OUTLINE OF THE RETRO COMMISSIONING PROJECT

The owner wanted to ensure that this capacity addition would be successful. The owner also wanted to add value to this building while also raising the profit continuously, and the owner judged that commissioning was important for this success. There are three important aspects of this retro commissioning project. First, the owner’s requirements should be clearly laid out in the

commissioning plan for this repair work. The second is performing certainly the matter in which it should succeed in a commissioning process. The third is assembling the organization to carry out and effectively manage this commissioning project. These three matters are explained after this, respectively.

2.1 Owner's Project Requirements and Commissioning Plan

The Owner's Project Requirements (OPR) include seven items that include the opinion of the operations manager of this building as shown in Figure 1.. The Commissioning Authority (CA) represented the owner and operations manager to ensure that these requirements were implemented in the project and documented them. Note that a major requirement of commissioning on this capacity addition project was fusing or merging the installation and operation of the new equipment with the existing equipment.

2.2 Commissioning Process on This Project

The retro-commissioning process on this project is outlined in Figure 2. The items which must be checked and verified by commissioning in each project phase which results in a program step, design step, construction step, and operation step is arranged. The contents of this commissioning process were based on the guideline proposal about commissioning process of building services system shown in the Society of Heating, Air-Conditioning and Sanitary Engineers of Japan.

2.3 Commissioning Project Organization

This Retro-commissioning project Organization is shown in Figure 3. The owner considered selecting those who can become the position of CA out of a construction company. Of course, it becomes conditions that CA chosen from this construction company differs in a profit relation. As support for CA, owner selected the intellectuals of the energy services company (an electric power company) and the PhD et al about HVAC systems. This organization is because owner wanted to secure third person nature to CA to the last. Also in the technical information exchange between the construction construction sides and Cx Team which are performed in each stage of reinforcement construction, it was judged as effective organization.

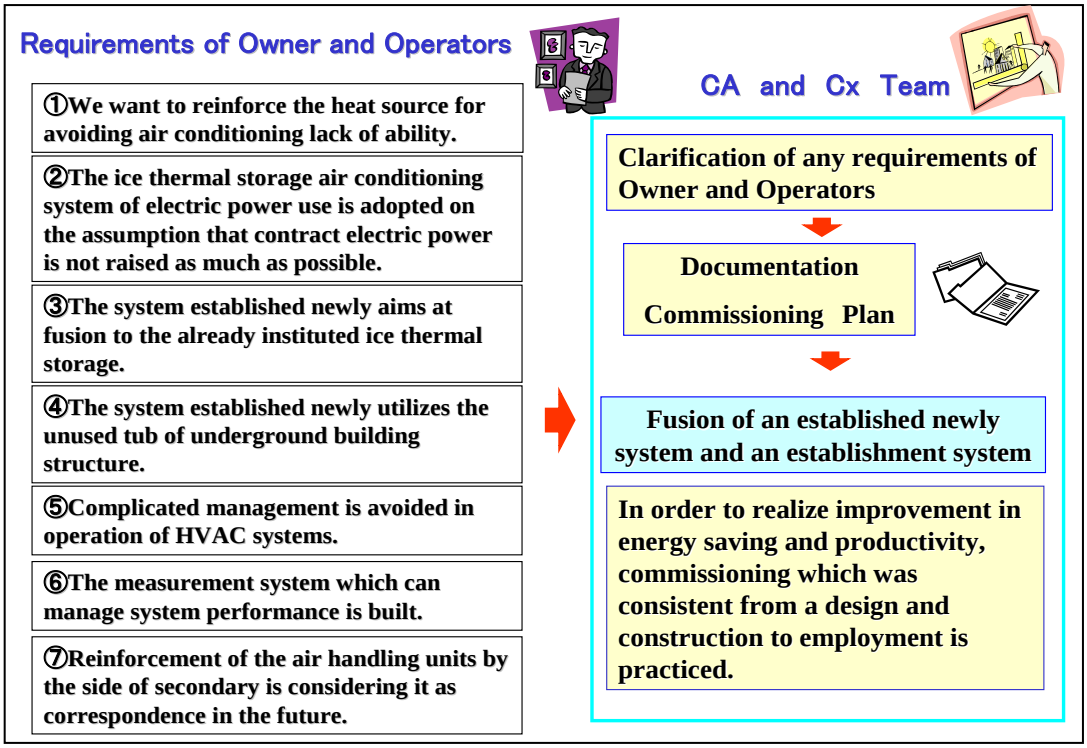


Fig. 1. OPR and commissioning plan

Program	・Owner describe project outline ・Owner makes draft document of OPR ・CA clarify acceptable performance and describe commissioning plan
Preliminary Design	・The optimal design by a simulation tools ・Planning of a measurement and verification plan ・The check of a Control-system
Working Design	・The check of HVAC sysytem ・The selected apparatus is recognized. ・The check of the installation position of a sensor
Construction	A difference of a drawing and construction is corrected with a check. ・Equipment duty check ・Wiring check
Acceptance	FPT ・TAB test results ・The individual components in the system ・The components with each other as a subsystem ・The subsystem with other subsystems in the building
Operation & Maintenance	・practice seasonal FTP (summer peak time, winter peak time, intermediate seasons both for heating mode and cooling mode) ・verify equipments yearly actual performance compared with manufacturers technical data ・The optimal adjustment work

Fig. 2.Commissioning process on this project

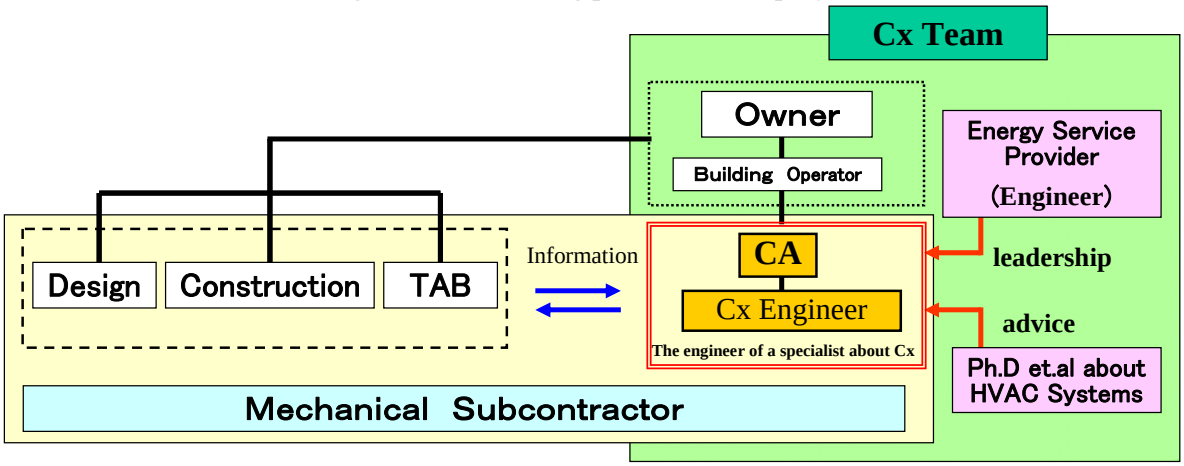
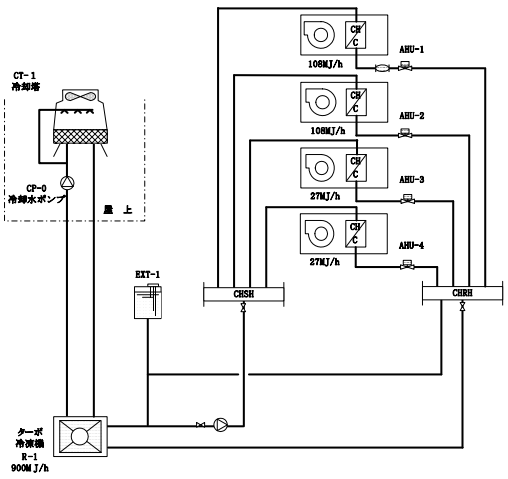
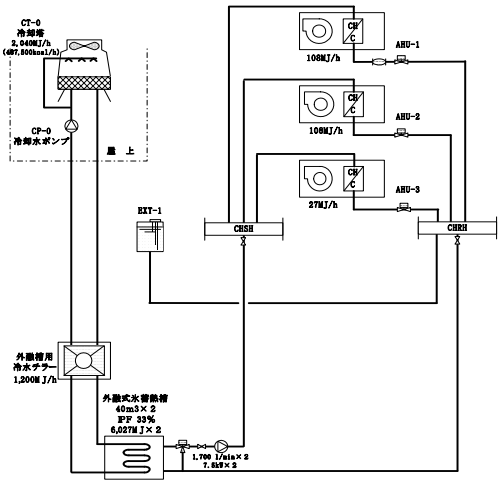


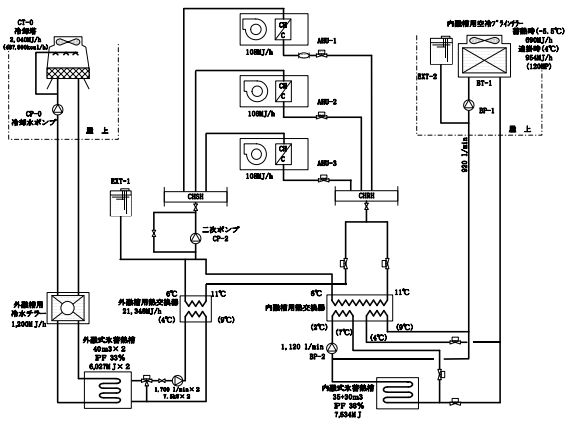
Fig.3.Commissioning project organization



(a) History of the change about HVAC



(b) External melting type ice thermal storage system



(c) Internal melting type ice thermal storage system

Fig.4.The history of this building

2.4The History Of This Building

This building was completed in 1960.systems from completion to the present are shown in Figure 4.The heat source was the simplenon-thermal storage system of aturbo refrigerator at the time of completion. Although enforcementhas been certainly carried out aboutthe control of maintenance of equipment, as for equipment apparatus including a refrigerator, updating time surely comes. Therefore,the necessity for the updating construction accompanying superannuation of equipment occurred.

Then, the first repair work of HVACsystems was carried out in 1989. Inthis repair work, owner took intoconsideration the employment formof prospective cooling and heatingload and tenant's use in a building.Furthermore, it endeavoredpracticing the optimal repair worksincluding enery consumption orefficiency. So, it opted for adoptionof an ice thermal storage air-conditioning system in this repair work.Then, reinforcement of the furtherair conditioning cooling demandis needed with the rise of anoccupancy rate and the increase inOA load. However, not only anexpense side but the point of efficiencydesired a positive reinforcementplan, employing the first repairwork efficiently, in order to have metthe demand. Owner's demand matterin this reinforcement plan leads t oenforcement of commissioning.The optimal system which wasdetermined by enforcement ofcommissioning and which is reinforcedwas adoption of an ice thermal storage

air- conditioning system too. Theconclusion which fully satisfies ademand of owner has been obtainedalso in the present building employment.The details of the reinforcement construction are asbeing shownin the lower part of Figure 4.

3. CARRIED-OUT CONTENTS IN RETRO-COMMISSIONING PROJECT

The object of Retro-commissioning is reinforcement construction of the heat source for air conditioning in 2000. The contents carried out by this Retro-commissioning are shown.

1) It is examination of the practical use method about the unused tub of underground structure.

2) Cooling load was examined from three simulation results to the design of a suitable ice thermal storage air-conditioning system.

3) The selection of the optimal refrigeration machine capacity.

4) The check of the accuracy of a flow meter and FPT of a heat exchanger.

5) Decision of the operating method for realizing high efficiency performance of total HVAC system.

6) Verification of the running performance by the data after completion of reinforcement construction.

Each carried-out contents are explained.

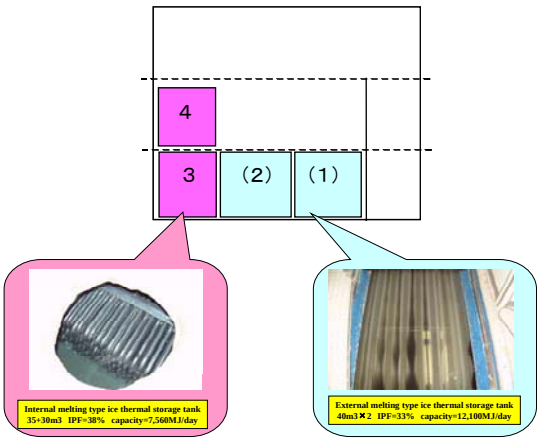


Fig.5 The arrangement plan of a thermal storage

3.1 How Is An Unused Tub Utilized?

The arrangement plan of a thermal storage tank is shown in Figure 5. The unused tub of 3 and 4 was converted into the ice thermalstorage tank. The biggest subject of this plan is aiming at cooperation with the ice thermal storage tank which already exists

in 1989. Inorder to secure stable thermal storage operationand want to storage many quantity of heat in small capacity, so this internal melting type ice thermal storage system was adopted. The system of the lower part of Figure 4 was constructed from examination which ice making and heat dissipation make balance.

3.2 Practical Use Of The Simulation In The Optimal Design

For the purpose of selection of the optimal ice thermal storage system and refrigeration machine capacity, the simulation of the present cooling load was carried out by three techniques (tools). First, the cooling load was calculated with the simulation tool used as the usual design technique. This tool is the calculation method based on the design criteria and point of Government Ministry of Land, Infrastructure and Transport of Japan. This tool can calculate the cooling load of a four representation time (9:00, 12:00, 14:00 and 16:00) maximum load day during year (Figure 6 [A]). Presumption of this result to refrigeration machine capacity is possible. However, presentation about a Japanese addition cooling load required in order to design a thermal storage system is not carried out. Then, another simulation tool performed calculation for the cooling load according to time again. This is assumed based on the design technique of a common thermal storage system. According to the calculation, the amount of a cooling load obtained the result of 31,200 MJ/day (Figure 6 [B]). These two calculation can obtain the result depended on the model which standardized the characteristic which a peculiar building has. In this building, the data of the past which can grasp the thermal characteristic of a building existed. The compensation based on the data was performed and calculation for the second time was carried out using the development tool of our company which can calculate the load according to annual time. According to the calculation an hour, the amount of a cooling load obtained the result of 29,700 MJ/day and the maximum load increased about 6%.The more realistic cooling load was able to be assumed by this 3rd calculation.

3.3 The Detailed Performance Test In The Manufacturer

It carried out by commissionig work that the detailed performance test of the manufacturer for selection of the optimal refrigeration machine capacity.

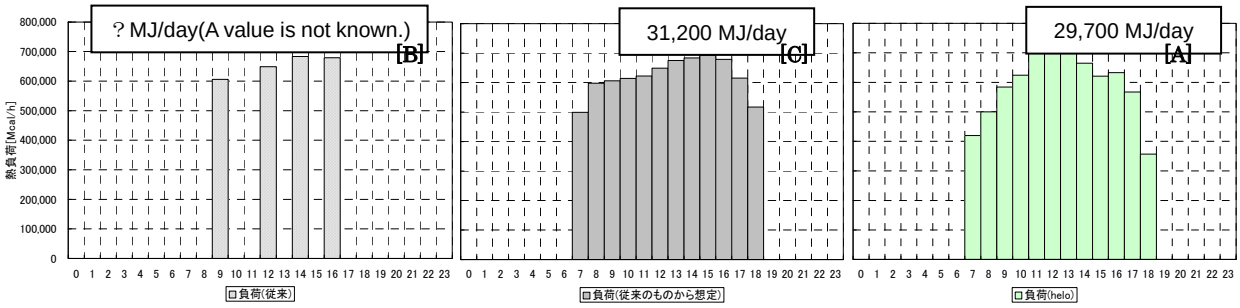


Fig 6. The result of having enforced the three simulation techniques tank at design step

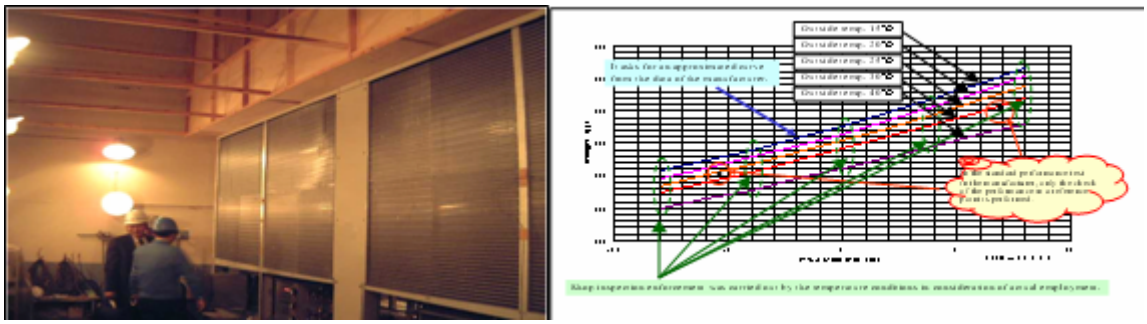


Fig.7 The detailed performance test of the manufacturer

In the standard performance test of the manufacturer, only the check of the performance in a reference

point is performed. It lets it pass annually and operation on a standard is not continued. A refrigeration machine does not operate in the reference point during year. It is very important to check a difference of conditions and the machine performance of low load operation from that. The result is indicated to be the situation of the shop inspection to Figure 7. Reflecting this result, apparatus smaller than the selection at the time of a design will actually be recognized.3.4 The Check Of The Accuracy Of A Flow Meter And Fpt Of A Heat Exchanger

It is necessary to check having secured the engine performance designed in operation with the constructed actual HVAC system. For that purpose, acquisition of exact data serves as conditions. Therefore, this Retro commissioning project which utilized construction of a measurement system and its data was practiced. In this reinforcement construction, BEMS which can evaluate the detailed data collection of a HVAC system and running performance was built (Figure 8). This BEMS is collecting the measurement items of about 500 points and holds the function of the graphic screen of many in which exact grasp of operational status is possible. This BEMS is optimizing everyday operation management. This BEMS supported Retro-Commissioning, too.

The contents carried out in FPT of Retro-Commissioning are explained.

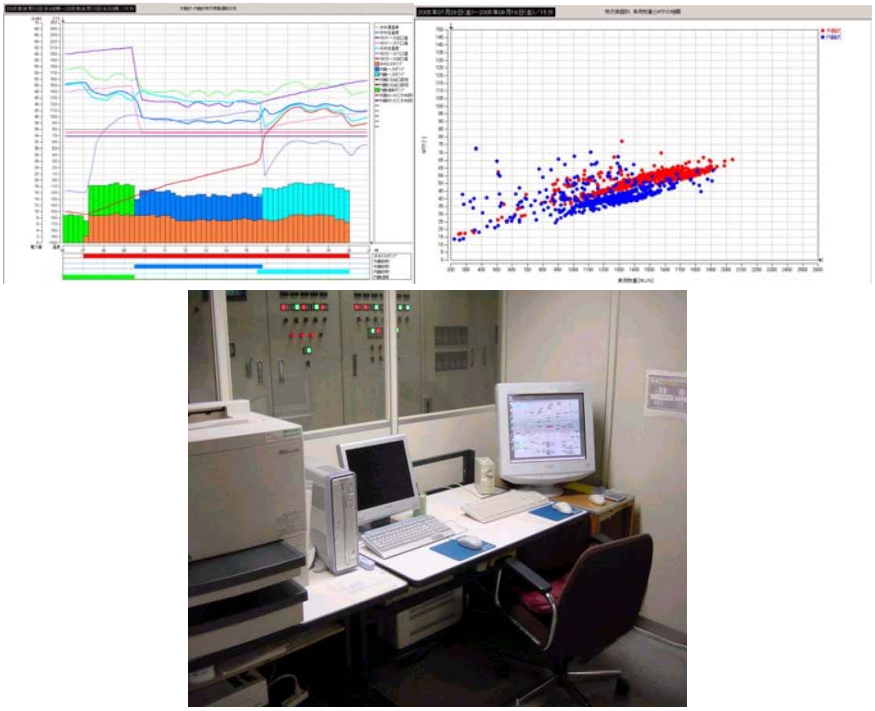


Fig.8. BEMS established newly and sample of graphic screen

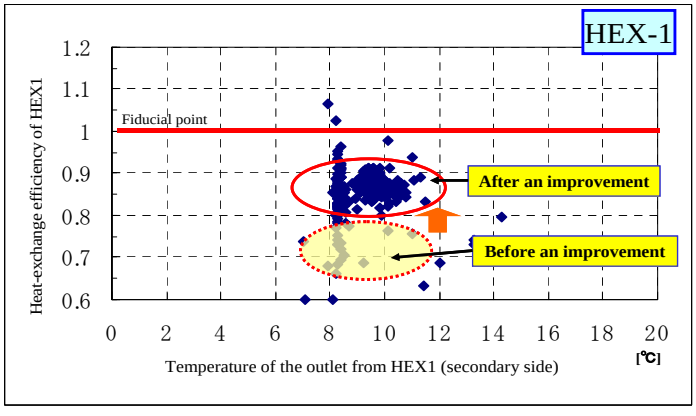


Fig 9. Change of the heat-exchange efficiency of HEX1 before and behind proofreading of a flow meter

3.5 FPT Of Heat Exchanger (HEX-1)

As a result of carrying out FPT which checks the performance of a heat exchanger, the situation where the efficiency of a heat exchanger about HEX-1 was falling was checked (Figure 9). Then, this cause was investigated using BEMS.Consequently, the accuracy of the flow meter which is measuring the performance of a heat exchanger was judged to be the cause. Then, the flow meter was removed and the check experiment of accuracy was conducted. This experiment used the accuracyverification experimental device of a flowmeter. The outline of this experimental device is shown in Figure 10. In measurement,about 20% of error had produced the flow meter as a result of this accuracy check experiment. And after adjusting this error and installing the flow meter again, the performance of a heat exchangerwas checked. As a result, the efficiency of a heat exchanger was mostly recovered to the value as a design. In response to this result, it succeeded in the accuracy check of all flow meter currently installed in all
buildings after that.

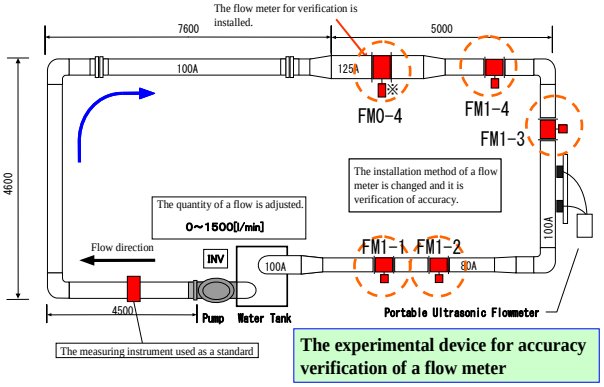


Fig. 10. The experimental device for accuracy verification of a flow meter

3.6 Running Performance Of Refrigeration Machine

Verification of the refrigeration machine performance at the time of real operation iscontinued as On-Going Commissioning.Here, the performance at the time of real operation is verified as contrasted with the performance characteristic checked in inspection of the manufacturer carried out in the construction stage. The verification result in August, 2002 is shown in Figure 11.This is an operation track record for the 1st year after reinforcement construction completion. The capability measured by the performance characteristic currently checked in inspection of the manufacturer is plotted. The plot which has outlet temperature in the range of 0 to –5 degrees is the capacity at the time of thermal storage operation, and the plotof 0 degrees or more is the capacity at the timeof non-thermal storage operation. Operation as a design value is realized under outside temperature and temperature of the outlet from refrigeration machine.

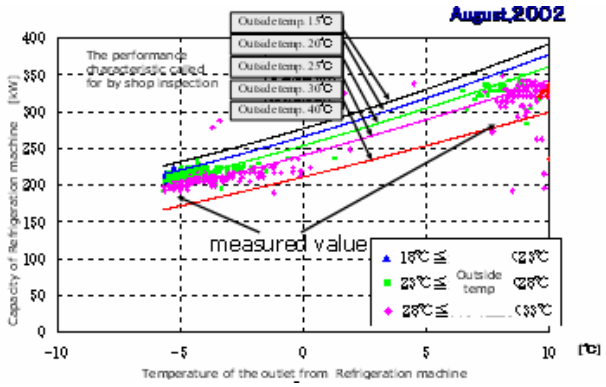


Fig. 11. The verification result of refrigeration machine capabilitytank

4.RESULT OF RETRO-COMMISSIONING PROJECT

Optimal heat source reinforcement construction for air conditioning was realized by execution of this Retro-Commissioning. And the plan of owner's Retro-Commissioning project was successful and the OPR was realized certainly. It was one of the OPR of Retro-commissioning plan that the ice thermal storage air conditioning system of electric power use is adopted on the assumption that contract electric power is not raised as much as possible. The result is shown in Figure 12. This is the trend of contract electric power from 1989 to 2005. There is no big increase in contract electric power after completion of reinforcement construction, and it succeeds in operation. Of course, dealing with increase of a cooling load and an improvement of air-conditioning environment are also made. It can check that OPR is realized and Owner is very much satisfied of this result.

The examination about cost effectiveness is shown in Figure 13. Transition for ten years after the reinforcement construction in 2000 is shown. A blue

line is the result of making the trial calculation of the initial investment and the operating cost at the time of constructing a non-thermal storage system and a red line is the result of making the trial calculation of the initial investment and the operating cost of this reinforcement construction. As for this reinforcement construction, initial investment serves as high cost compared with the non-thermal storage system. However, an operating cost serves as low cost compared with a non-thermal storage system. Therefore, an examination about years of deprecition became 5.6 years and owner brought a satisfactory result.

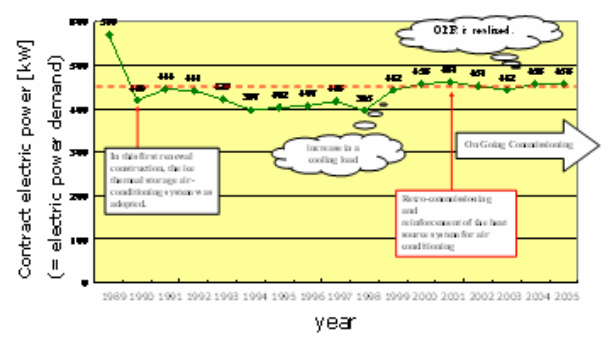


Fig. 12. The Trend of contract electric power

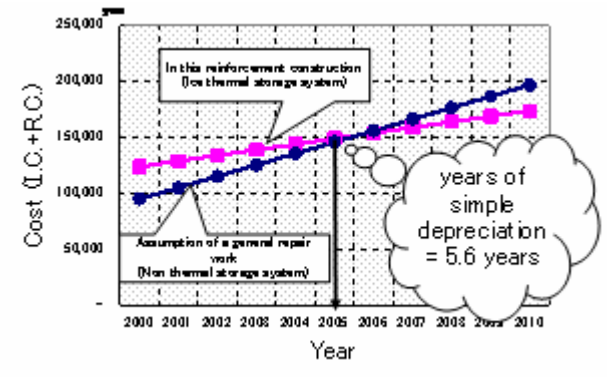


Fig. 13. Examination about years of

5.CONCLUSIONS

This report presents the contents of enforcement of Retro-Commissioning carried out at the standard Commercial Office Building. It was the time the importance of commissioning process began to be recognized in Japan those days. The owner of this building practiced promptly. The result stored a wonderful success as mentioned above. High efficient operation is maintained in On-Going commissioning by continuation still now. However, it became a subject about examination and the convenience effect of commissioning work expense.

REFERENCES

[1] Norimi Inomata, et al : Commissioning for Building HVAC System in Tozan Building (part 1 and part 2), Proceedings of SHASE Academic Meeting , Septe 2002.