COST OPTIMIZATION OF HEATING VENTILATION AIR CONDITIONING SYTEM (HVAC) BY USING BULIDING MANAGEMENT SYSTEM

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ABSTRACT

Heating, ventilation and air conditioning (HVAC) will account major portion of the money spent by any organization on the energy. The small adjustments in the HVAC systems will improve the building internal environment and can save energy utilized by the HVAC system, hence we can save money. Improvement of the energy efficiency will benefit in profitability of the organization. HVAC System is more frequently applied in industrial facilities as well as in living compounds and offices. Fully automatic control of these systems is impossible to avoid while going to save the energy cost. Basic parameter of air that needs to be monitored and regulated is temperature. The inside air temperature depends on the outside air temperature, mechanical Infrastructure and occupancy in the zone. For this reason it is necessary to produce a control technique capable of monitoring and controlling the temperature. By using the signals given by the sensing elements such as sensors, control system will perform full automatic control of HVAC system by comparing the current temperature with temperature defined in the Building Management system hence regulate the flow of chilled air into the zone by adjusting the Variable air volume throttle which acts as a gate to the chilled air into the specified zone. Hence we can maintain desired comfort level inside the building.
The zone control will allows user to maintain different temperature in different zone. Hence can save chilled water flow into the building, which will result in less load on chiller. Hence we can some amount of energy which consumed by the chiller, so we can reduce the cost which is spent on the energy.

Keywords: HVAC; BMS; Optimization; Time Control; Temperature Control; Zone Control:

INTRODUCTION

The population in world is growing very fast rate, with effect to that consumption of energy and resources also increasing. After the raw materials, energy is the second largest cost factor in the organization. In future this cost may be pushed up by increasing costs. Hence improvement in energy efficiency has two benefits: it benefits not only the environment and the climate, but also the profitability and competitiveness of company. The HVAC System in any commercial organization account more than 40% of total energy used by the organization building. The chillers represent the majority portion of HVAC energy costs [3]. So it is no wonder building owners, engineers and managers are looking to implement measures that can

save energy so that we can reduce the costs. By implementing an optimization process, the cooling cost can be reduced by 2 to 18 percent.

BUILDING MANAGEMENT SYSTEM (BMS)

A Building Management System is a type of control system [1] [2] which uses computers, installed in the organization building that controls and monitors the buildings mechanical and electrical equipments such as ventilation, lighting, power system, fire system and security systems. Building management system (BMS) are most commonly implemented in large project with the mechanical, HVAC and electrical system.

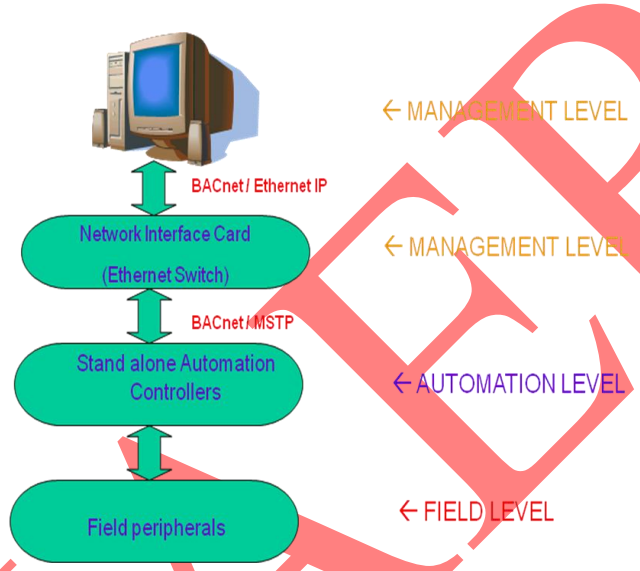

Figure 1. Building Management System Hierarchy.

A. *Function Performed by BMS*

- Central Supervisory and Control
- Air-Conditioning Control
- Electrical Distribution

B. *Benefits of BMS*

1. For Building Tenants/Occupants:

- Good control of internal comfort conditions.
- Increased staff productivity.
- Effective monitoring and targeting of energy consumption.
- Improved plant reliability and life.
- Effective response to HVAC related complaints.
- Save times and money during Maintenance.
- Possibility of individual room control.

2. For Building Owner:

- Higher rental Value
- Remote control of building
- Increased level of comfort and time saving.

HVAC SYSTEMS

Heating, ventilation and air conditioning (HVAC) systems control the temperature [3], in buildings to a set of chosen conditions. Heating systems increase the temperature in inside the building to eliminate heat losses between the internal space and outside. Ventilation systems supply air into the building. Cooling is used to provide the required cooling level inside the building where heat gains have aroused from people, equipment or the sun. HVAC systems can be classified as either self-contained unit packages or as central systems. Self-contained package describes a single unit that converts a primary energy source into heating or cooling to the space to be conditioned.

With central systems, the primary conversion from energy takes place in a utility. Central systems is a combination of central supply and multiple end use subsystems. There are many variations of combined central supply and end use zone systems. The most frequently used combination is central hot and chilled water distributed to multiple fan systems. The fan systems use water-to-air heat exchangers to provide hot or cold air for the controlled spaces in the building. The end use subsystems are fan systems, they can be single or multiple zone type. The multiple end use zone systems uses VAV boxes.

OPTIMIZATION

Through the optimization program [8], we can identify energy drains and system inefficiencies — and can take corrective actions. System optimization is more than the tune-up process. It starts with a complete energy evaluation of your system. This is accomplished by metering how the each and every energy dollars are being spent. Then have to analyze strengths, weaknesses and opportunities for improvement. Then we can develop a plan of action to adjust and upgrade your system for maximum efficiency and minimized costs — total system optimization.

A. Optimization Methodology

1. Evaluation & Understand the Energy Use:

System optimization is more than the tune-up process. It starts with a complete energy evaluation of your system. This is accomplished by metering how the each and every energy dollars are being spent. The evaluation process covers three phase to determine what can be done to improve efficiency

- **Mechanical Infrastructure:** First look at the original chillers system design, the original facility requirements and create a benchmark of operations. Evaluate the condition of the equipment, how it's is all connected together and how well it as been maintained. Take measurement for power consumption and process variables, including temperatures, and pressure used.
- **The control system:** How is the chillers system being controlled and with what type of control system? Is the instrumentation sufficient and calibrated? Look at the control strategies used for sequencing the equipment and evaluated the temperatures and pressures used.

- **Operational Evaluation:** Look at the site-specification issues, such as site limitation or equipment issues forcing a workaround. Also review if operators have been trained and understand the impact of their actions.

2. Identify Your Opportunities:

Compile an energy checklist. Walk round your building and complete the checklist at different times of day (including after hours) to identify where energy savings can be made. Recommend an actions list for optimization.

3. Implementation:

Recommended actions typically include repair and changes to mechanical system, adjustments to the control strategy and operating changes. Implement your energy saving actions and measure against original consumption figures. This will assist future management decisions regarding your energy priorities.

4. Measurement and Verification:

Verify the proper operation of all the mechanical and components using testing instruments and existing building management system. Calculate the system's operating states; identify the failures causing inefficiency. It's best to collect data over a period of time to determine the best measures to implement.

B. Optimization Techniques

Energy efficiency is a growing concern for almost every industry, and the HVAC world is no exception. HVAC loads will vary at different times and in different parts of a building throughout the day. Well-set time controls should ensure that systems only operate when and where required. So here are some other techniques as follows,

1. Temperature control.
2. Time control.
3. Zone control.

In GVK International airport presently we are following temperature control technique. The temperature control is done manually.

1. Temperature Control: Temperature controls ensure systems provide the correct required temperatures [4]. If it is cold outside, building occupants will typically be wearing warmer clothing, so ensure temperatures are set accordingly. People will dress for warmer weather so does not freeze them with expensive overcooling.

- Set temperature controls to the correct temperature and then leave alone.
- Fit thermostats in the right place (away from draughts and heat sources – including direct sunlight) and set correctly.
- Consider fitting Thermostatic Radiator Valves (TRV) to radiators to provide more localized control.

Merits:

- Automatically adjusts between cooling cycles depends on temperature to maintain optimum comfort.
- Simple control techniques.

Demerits:

- In general these systems are limited to perimeter zone.
- This type control system needs a central control unit.
- Initial investment on thermostats is required.

2. Time Control: Time controls ensure systems only to operate in defined time band [5]. Check controls are appropriately set and displaying the correct time and date [6]. Adjust if necessary to ensure heating and cooling only operate when and where required. Optimum start & Optimum stop controls can be used to minimize the out of hour's operation of cooling plant.

- Set Time controls to the correct Time and date and then leave alone.
- Consider interlocked control of the HVAC system to prevent fans, heating and cooling operating when not required.
- Match ventilation flow rates to demand and control operating times using time controls.
- Consider weather compensation and optimum start – stop controls to adjust heating and cooling in line with the changeable Indian climate

Merits:

- Automatically adjusts between cooling cycles depends on time defined in controller.
- Simple control techniques.
- Less expensive compared to Temperature control.

Demerits:

- Fully depend on time defined in the controller.
- This type control system needs a central control unit.
- This type of systems will not deal with the room temperature.
- Should check controls are appropriately set and displaying the correct time and date.

3. Zone Control: HVAC zoning allows user to maintain comfort in every room or zone [7]. Zone controls ensure systems operate according to the temperature and time defined for a particular zone. The zones are considered according to the occupancy, temperature and timings. The zone control system allows a single HVAC unit to have separate temperature zones. Zoning is great way to decrease the monthly energy bills. Adding zoning to existing to the existing HVAC system can save up to 15% on monthly bill. With zoning we can shut off room that is not being occupied. This way we can save heat or AC on rooms that no one is in.

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- Consider interlocked control of the HVAC system to prevent fans, heating and cooling operating when not required.

- Match ventilation flow rates to demand and control operating times using temperature, humidity and CO2 sensors
- Consider weather compensation and optimum start – stop controls to adjust heating and cooling in line with the changeable Indian climate

Merits:

- A zone control system can prolong the HVAC system life.
- A zoning system increases the energy efficiency of air conditioning system.
- Saves Energy & Cost.
- Less stress on the equipment

Demerits:

- A zoned control system needs a central control unit.
- It requires individual thermostats in each zone.
- High initial cost.
- More Complicated compared to time and temperature control.

OPTIMIZATION OF HVAC

We have selected the zone control for implementation of optimization Technique [7]. HVAC zoning allows user to maintain comfort in every room or zone. Zone controls ensure systems operate according to the temperature and time defined for a particular zone. We considered zones according to the occupancy, temperature required. The zone control system allows a single HVAC unit to have separate temperature zones. Zoning is great way to decrease the monthly energy bills. Adding zoning to existing to the existing HVAC system can save up to 15% on monthly bill. With zoning we can shut off room that is not being occupied. This way we can save heat or AC on rooms that no one is in.

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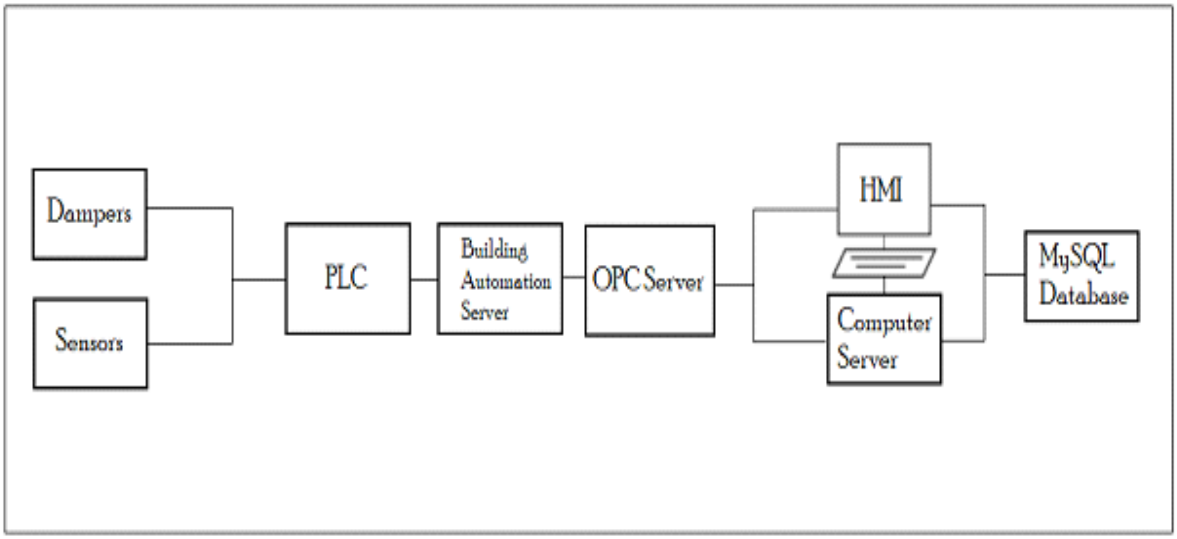

Figure 2. Control System.

The control system [1][2] consists of a programmable logic controller (PLC), a building automation server (BAS), an OPC (Object Linking and Embedding [OLE] for Process Control) server, a human machine interface (HMI), and a database server . The PLC collects data [8], including temperature and humidity sensor signals and damper position signals, and controls the damper position, chiller and supply fan. The inputs are collected from two input/output data acquisition modules. The BAS, also referred to as the network automation engine (NAE), is a web-enabled network controller that communicates using information technology (IT) and Internet languages. The BAS acts as a bridge between the PLC and user interface/database and allows a fine level of control. All high level programming is written in the BAS. Programs in the BAS can be manipulated or viewed by a user logged into the server. The BAS is connected to the OPC server, which acts as a gateway to an HMI and a computer server. The OPC server is a software application that acts as an application programming interface or protocol converter. It translates the data into an industry standard format. The test data and control variables are stored using a database server.

HVAC control system, from the simplest room thermostat to the most complicated computerized control, has four basic elements: sensor, controller, controlled device and source of energy.

1) Sensor measures actual value of controlled variable such as temperature and provides information to the controller.
2) Controller receives input from sensor, processes the input and then produces output signal for controlled device.
3) Controlled device acts to modify controlled variable as directed by controller.
4) Source of electrical energy is needed to power the control system.

Figure-3 and 4 illustrates a basic control loop for room heating. Here the thermostat assembly contains both the sensor and the controller. The purpose of this control loop is to maintain the controlled variable (room air temperature) to some desired value, called a set point.

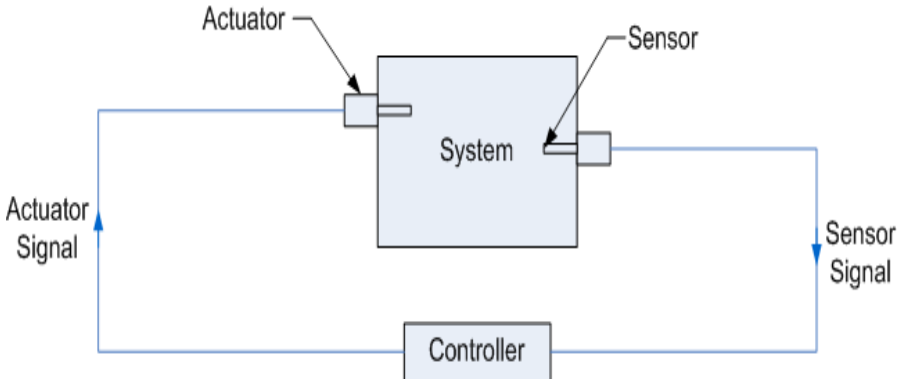

Figure 3. Basic Control Loop.

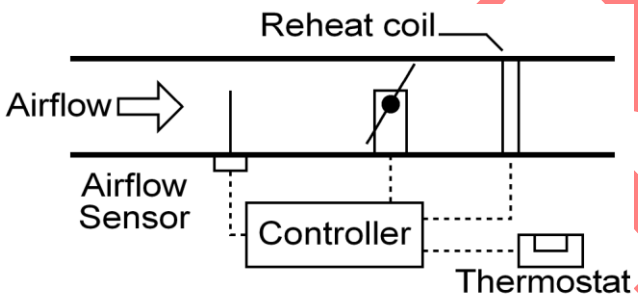

Figure 4. Basic Control Loop.

Many HVAC systems are configured as "single-supply" or single-path, multiple- zone, reticulating ventilation systems.

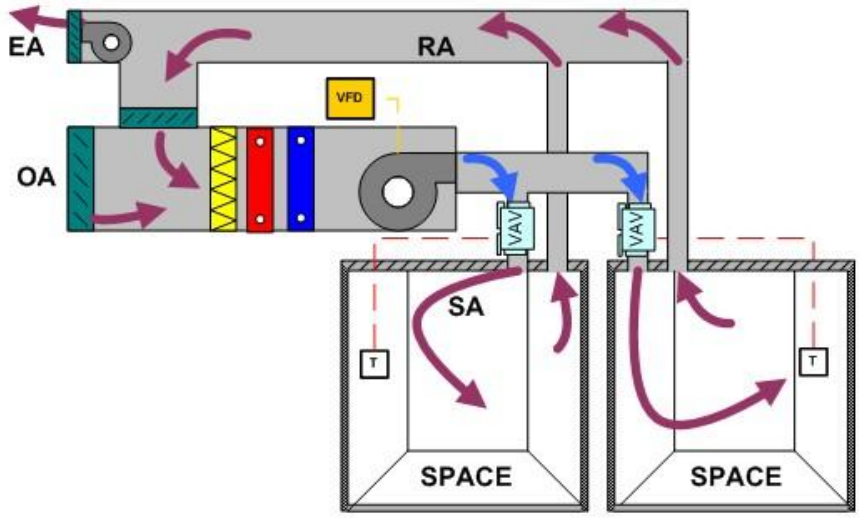

Figure 5. Temperature Control in Zone.

For single-path VAV systems [7], the worst-case condition for ventilation in the cooling mode usually occurs when the VAV primary airflow for the system is at its highest value. Since almost all VAV systems exhibit load diversity (all zones don't require peak cooling airflow simultaneously), the critical zone can be assumed to be delivering minimum primary airflow or block the primary airflow. If a system doesn't have much load diversity and if the critical zone requires a lot of primary airflow then the central fan may or may not be at block airflow when the critical zone is at minimum primary airflow.

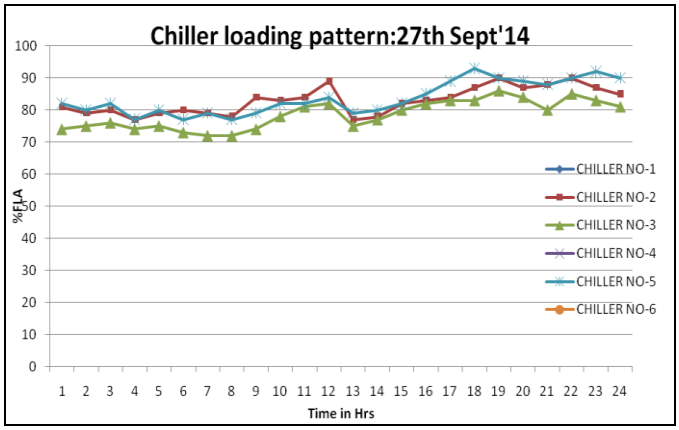

Figure 6. Chiller loading pattern on 27th sept'14

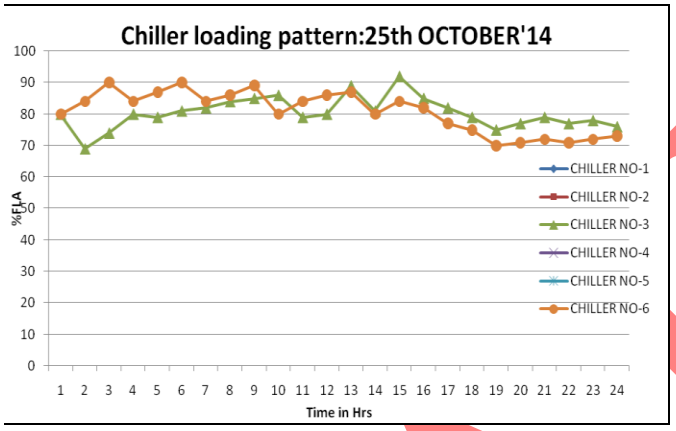

Figure 7. Chiller loading pattern on 25th October'14

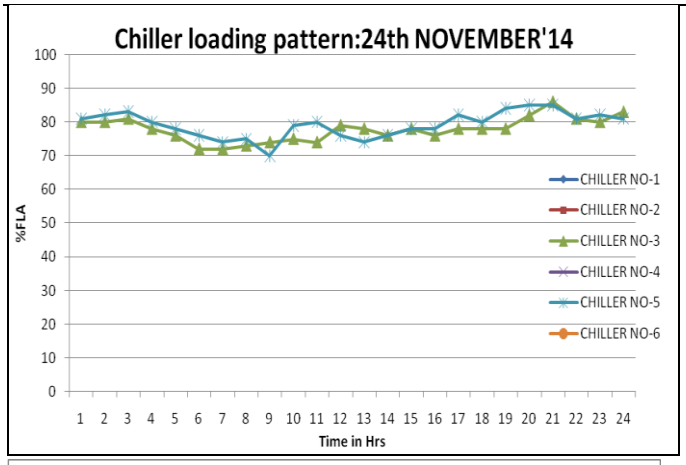

Figure 8. Chiller loading pattern on 24th November'14

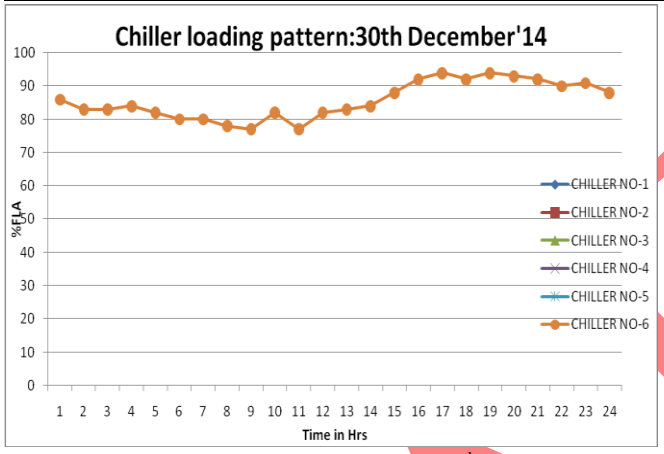

Figure 9. Chiller loading pattern on 30th December'14

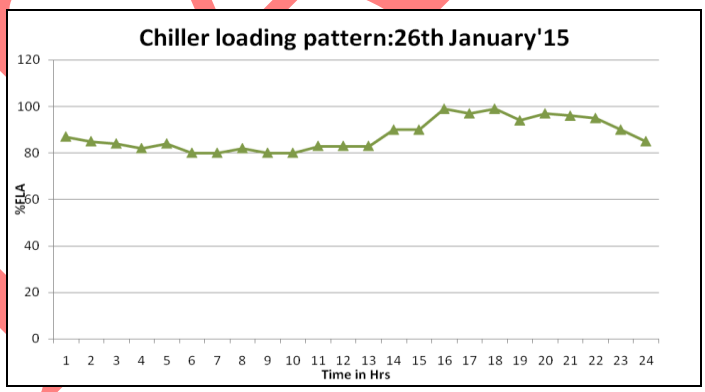

Figure 10. Chiller loading pattern on 26th January'15

We stated to bring VAV to auto mode from October 2014 by considering the zone temperatures. From the graph we can see that as the number of VAV brought into auto mode increased the load on the chiller is reduced and hence number of chiller required to provide cooling level is also reduced hence saving in the energy consumption from chiller side can be observed.

CONCLUSIONS

HVAC zoning allows user to maintain comfort in every room or zone. Zone controls will maintain the desired temperature in each and every zone according to the set temperature defined for a particular zone. Zoning is great way to decrease the monthly energy bills. Adding zoning to the existing HVAC system can save up to 15% on monthly bill. With zoning we can shut off room that is not being occupied. Hence can save chilled water flow into that particular zone, which will result in less load on chiller.

By using the signals given by the sensing elements such as sensors, control system will perform full automatic control of HVAC system by comparing the current temperature with temperature defined in the Building Management system hence regulate the flow of chilled air into the zone by adjusting the Variable air volume throttle which acts as a gate to the chilled air into the specified zone. Hence we can maintain desired comfort level inside the building. Hence can save chilled water flow into the building, which will result in less load on chiller. Hence we can some amount of energy which consumed by the chiller, so we can reduce the cost which is spent on the energy. Improvement of energy efficiency i.e. reduction in energy consumption will result in the reduction of energy cost which will benefits in profitability of the company.

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