REPORT

ON THE IMPACT OF

EVAPORATIVE COOLING

VIA HUMIDIFIER

COLD-WATER SPRAYS

REGARDING ENERGY USE

AND

HEALTH

APS

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PREFACE

Control of relative humidity (RH) is essential for comfort as well as reducing the probability of virus and bacterial spread of disease.

The energy cost of humidification is very high with most conventional humidification methods; however, cold-water spray humidifiers have an opportunity to reuse energy in the HVAC system to achieve the humidity control in the building significantly reducing heating bills.

Many cold-water spray humidifiers have been abandoned and replaced with steam humidifiers based on the belief that they are a Legionnaires disease threat.

This threat is not possible according to the Center for Disease Control data, stating that the bacteria cannot grow in cold water below 68˚F (20˚C). Humidification is only required in cold weather when the city water and the HVAC air passing over the humidifier is well below that temperature.

Most cold-water humidifier spray systems were installed so the energy required to compensate for the 970 BTU/ pound of water required for evaporation was provided by the building’s heating system.
The thermal reference point for the mixed air dampers was up stream of the sprays, not downstream where the cooling impact of the sprays impacts the dampers' positioning.

This report presents a simple control change to reclaim the heat from the HVAC exhaust air, while maintaining the supply air at the required temperature for comfort control.

With about four hours labour and a couple of dollars in materials the Etobicoke Board of Education main office building experienced a 52.6% reduction in gas consumption by altering the system as in this report.

A humidifier sales person convinced the board’s staff to abandon the cold-spray humidifier and add steam humidification. The energy reclaim from redirecting the HVAC exhaust air was lost and the steam required electrical input. The buildings gas consumption increased to past levels.

APS became aware of the occurrence after the fact, so developed another conservation circuit that reduced the building’s gas consumption by 60% from the original rate. (Page 10)
This circuit was much more labour and material intensive, but the payback was worth the effort.

CONTENT

HUMIDITY CONTROL IMPACT ON HEALTH AND COMFORT

Information from ASHRAE regarding humification impact on human comfort and health.

Low relative humidity levels in buildings are beneficial to viruses and bacteria, but detrimental to humans.

Increasing the HVAC fresh air quantity in cold weather decreases the relative humidity level in buildings; therefore, tends to create human discomfort and increase the probability of diseases spreading.

FROM ASHRAE

IN the selection and application of humidifiers, the designer considers (1) the environmental conditions of the occupancy or process and (2) the characteristics of the building enclosure. Because these may not always be compatible, compromise is sometimes necessary, particularly in the case of existing buildings.

1. ENVIRONMENTAL CONDITIONS

A particular occupancy or process may dictate a specific relative humidity, a required range of relative humidity, or certain limiting maximum or minimum values. The following classifications explain the effects of relative humidity and provide guidance on the requirements for most applications.

Human Comfort

The complete effect of relative humidity on all aspects of human comfort has not yet been established. For thermal comfort, higher temperature is generally considered necessary to offset decreased relative humidity (see ASHRAE *Standard* 55).

Low relative humidity increases evaporation from the membranes of the nose and throat, drying the mucous membranes in the respiratory system; it also dries the skin and hair. The increased incidence of respiratory complaints during winter is often linked to low relative humidity. Epidemiological studies have found lower rates of respiratory illness reported among occupants of buildings with midrange relative humidity than among occupants of buildings with low humidity.

Extremes of humidity are the most detrimental to human comfort, productivity, and health. Figure 1 shows that the range between 30 and 60% rh (at normal room temperatures) provides the best conditions for human occupancy (Sterling et al. 1985). In this range, both the growth of bacteria and biological organisms and the speed at which chemical interactions occur are minimized.

Prevention and Treatment of Disease

Relative humidity has a significant effect on the control of airborne infection. At 50% rh, the mortality rate of certain organisms is highest, and the influenza virus loses much of its virulence. The mortality rate of these organisms decreases both above and below this value. High humidity can support the growth of pathogenic or allergenic organisms. As shown in Figure 2, humidity levels around 50% can be lethal to the *Pneumococcus* bacterium (Brundrett 1990). Similar effects can be seen in other microorganisms that cause serious health issues. Consequently, relative humidity in habitable spaces should be maintained between 30 and 60%.

Relative humidity also has a major role in the effects of different bacteria. Figure 3 shows the mortality of mice exposed to influenza under varying degrees of relative humidity (Brundrett 1990).

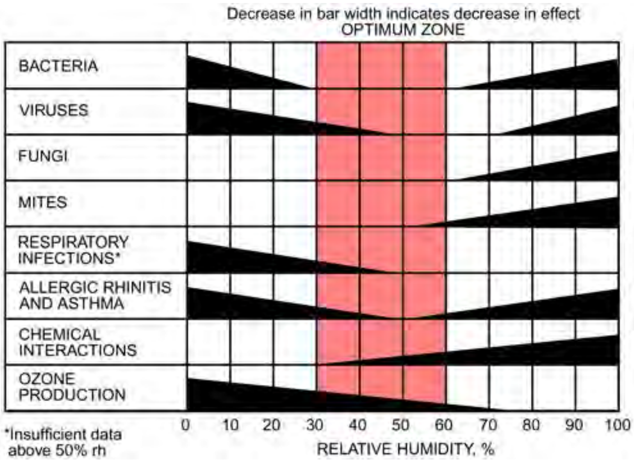


Fig. 1 Optimum Humidity Range for Human Comfort and Health
(Adapted from Sterling et al. 1985)

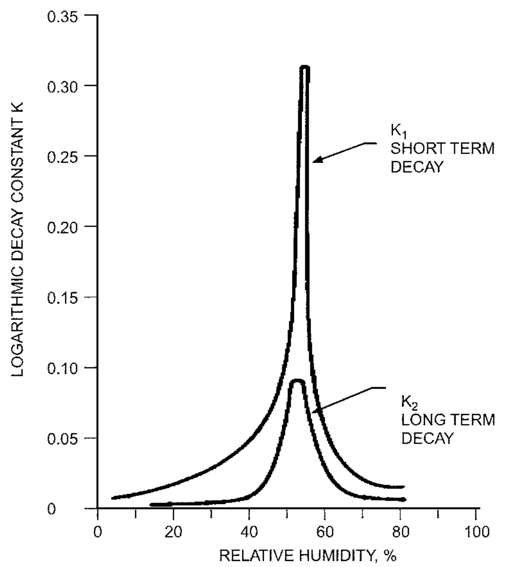


Fig. 2 Mortality of *Pneumococcus* Bacterium
Maximum mortality for airborne *Pneumococci* comes when relative humidity is held at 55% rh. [Adapted from Brundrett (1990), *Criteria for Moisture Control*. Copyright Elsevier © 1990.]

The preparation of this chapter is assigned to TC 5.11, Humidifying Equipment.

- Toolkits
- *Legionella* Training
- Research Summary
- WMP Overview
- Hospitality and Recreational Water Facilities
- Healthcare Facilities
- View All

Related Topics

- *Legionella* (Legionnaires' Disease and Pontiac Fever)
- Investigating *Legionella* Cases

View All Control *Legionella*

PAGE FROM THE CENTER FOR DISEASE CONTROL

Based on this CDC information, Legionnares disease cannot develop in water below 68˚F (20˚C).
The water in cold spray humidifiers will not raise above 60˚F (15.5˚C), because humidification only applies in cold weather; therefore, cold water humidity sprays are not a Legionnaires disease threat.
As a safety measurer an automatic lock out of the humidification pump and draining of the system is possible.
Other safety features should be considered.
Proper maintenance of the system is required.

Legionella Control Guidance for *Legionella* Control Toolkits *Legionella* Training Research Summary WMP Overview Hospitality and Recreational Water Facilities Healthcare Facilities View All

March 15, 2024

Public Health Strategies for *Legionella* Control

Key points

- Controlling *Legionella* growth and spread is the primary prevention strategy for Legionnaires' disease.
- *Legionella* can grow and spread in building water systems or certain devices.
- Building owners and managers can take steps to reduce the risk of *Legionella* growth.

Illustration of the types of devices that can spread Legionella and people who are at increased risk for getting Legionnaires' disease.

Why it's important

Naturally occurring organism

Legionella, the bacterium that causes Legionnaires' disease, occurs naturally in freshwater environments, like lakes and streams. Generally, the low amounts of these bacteria in freshwater do not lead to disease.

Can grow in building water systems

Legionella can pose a health risk when it gets into building water systems and certain other devices. Generally, to pose a health risk, *Legionella* has to

- **First**: Grow (increase in numbers)
- **Then**: Spread through small water droplets (aerosolization)A

Factors that lead to *Legionella* growth

A variety of internal and external factors can lead to a *Legionella* problem, including:

Internal factors

- Biofilm
- Favorable water temperatures

PAGE FROM THE CENTER FOR DISEASE CONTROL

Disinfectant

Lower disinfectant levels in building water systems **can allow *Legionella* growth** if steps aren't taken to stop it.

The following processes can reduce the amount of available disinfectant in water:

- Filtering
- Heating
- Storing

Examples of disinfectants include

- Chlorine
- Chlorine dioxide
- Monochloramine

Temperature

***Legionella* grows best** within a certain temperature range (77°F-113°F). *Legionella* may grow at temperatures as low as 68°F (20°C), as well as at temperatures above 113°F.

To keep water outside the range for *Legionella* growth, it's important to keep

- Cold water cold
- Hot water hot

In warm climates or near heat sources, water in cold water pipes may reach a temperature that allows *Legionella* growth.

Keep Reading: Monitoring Building Water: Measure Water Temperature

Stagnation

When water doesn't flow well, the areas of stagnation can

- Encourage biofilm growth
- Reduce levels of disinfectant
- Lead to water temperatures favorable for growth

Understanding a building's water flow can help identify areas at risk of *Legionella* growth.

Equipment

Maintaining and operating a building's equipment effectively will help prevent biofilm, organic debris, and corrosion from contaminating the water system. They can provide a habitat and nutrients for *Legionella*.

Strategies for special circumstances

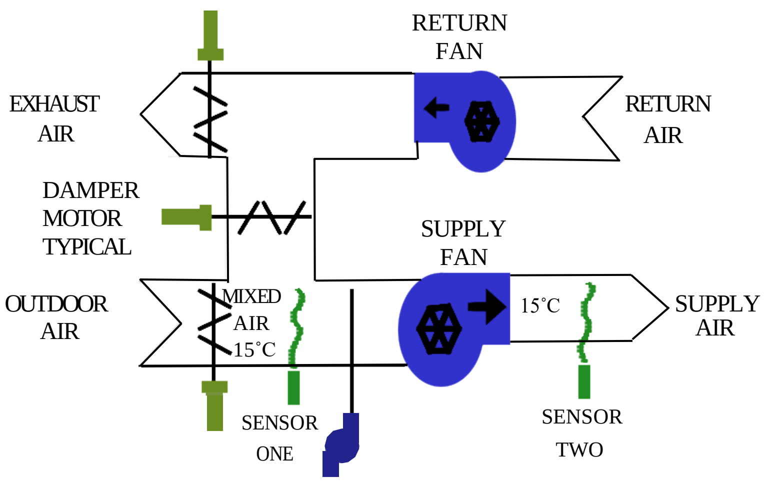
It's important to monitor external factors that may affect the water entering a building and potentially increase *Legionella* growth.

A SIMPLE LOGIC ADJUSTMENT TO USE FREE ENERGY FOR HUMIDIFICATION

BEFORE CONTROL CHANGES

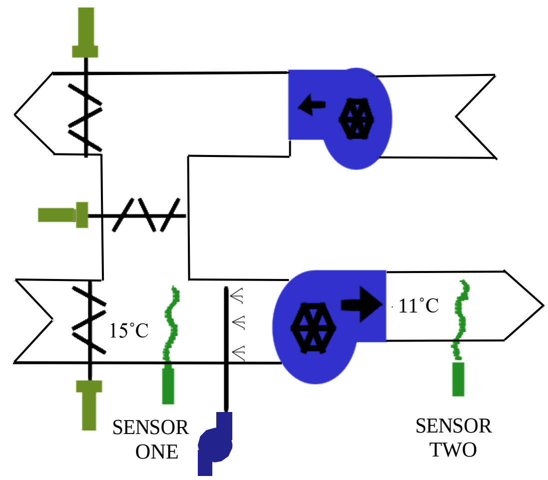
NOTE: THE DAMPER MOTORS ARE MODULATED BASED ON SENSOR ONE'S SIGNAL.

HUMIDITY SPRAYS OFF



HUMIDITY SPRAY PUMP

HUMIDITY SPRAYS ON

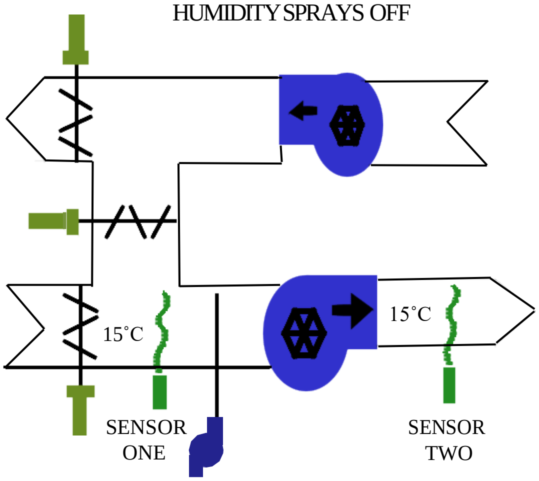


HUMIDITY SPRAY PUMP

AFTER CONTROL CHANGES

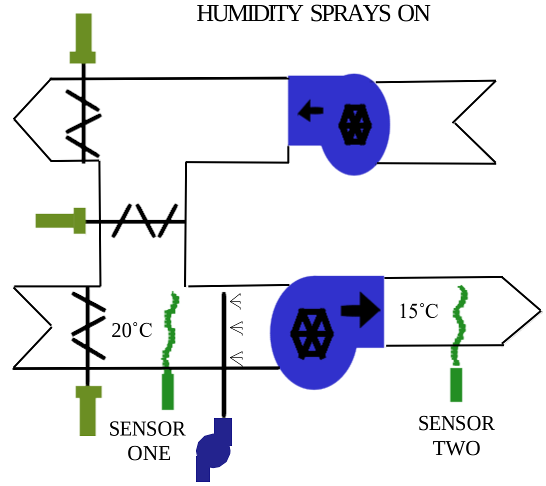
NOTE: THE DAMPER MOTORS ARE MODULATED BASED ON SENSOR TWO'S SIGNAL.

HUMIDITY SPRAYS OFF



HUMIDITY SPRAY PUMP

HUMIDITY SPRAYS ON



HUMIDITY SPRAY PUMP

NOTE

- Before the logic change the mixed air was at 15˚C constantly. The supply air was at 15˚C with the spray pump off and 11˚C with the spray pump on because of the cooling effect of the sprays.
- After the logic change the mixed air was at 15˚C with the spray pump off and 20˚C with the spray pump on. The supply was constantly at 15˚C.
- The automatic change in the mixed air caused reuse of free heat from the exhaust air to support humidification.

COLD WATER HUMIDIFIER SPRAYS WITH CONTROL LOGIC ALTERED TO USE FREE BUILDING ENERGY TO EVAPORATE THE WATER

Many HVAC systems used water sprays to satisfy the humidity demands of the building based on the return air relative humidity level. Improper control reference points can result in large losses in energy to achieve the desired humidity levels. This report graphically illustrates how the losses occur, the magnitude of the losses and a control solution to the problem.

THE PROBLEM

Many systems control the mixed air to 15˚C via averaging sensors in the mixed air plenum. The mixed air is drawn through the fan and forced into the occupied space.

If the humidity water sprays are not active, the normal discharge air temperature from the fan will be in the range of 15˚C.

If the humidity sprays are active the supply air will drop to near dew point. This will cause the heating equipment to use more heat than while the sprays are not active to prevent overcooling. Heat, which has already been paid for, is being forced out the exhaust dampers via the mixed air control loop while the building heating system supplies the heat for evaporation.

This report demonstrates the loss in one such system and clearly illustrates the savings created by causing the control logic to use heat contained in the return air for purposes of evaporating the moisture required for humidification.

The system automatically raises the mixed air temperature to compensate for the cooling effect of the humidity sprays.

This maintains a relatively constant supply air temperature while maximizing the use of energy already paid for in the building.

PERFORMANCE GRAPHS FROM AN OFFICE BUILDING

REGARDING ENERGY RECLAIM FROM EXHAUST AIR

GRAPH #1

This graph uses the black line to illustrate the mixed air temperature, which was averaging about 15˚C. The mixed air temperature was not affected by the status of humidity sprays; therefore, it remained relatively constant.

The blue line illustrates the discharge air temperature.

When the humidity sprays were not active the discharge air temperature averaged about 17˚C.

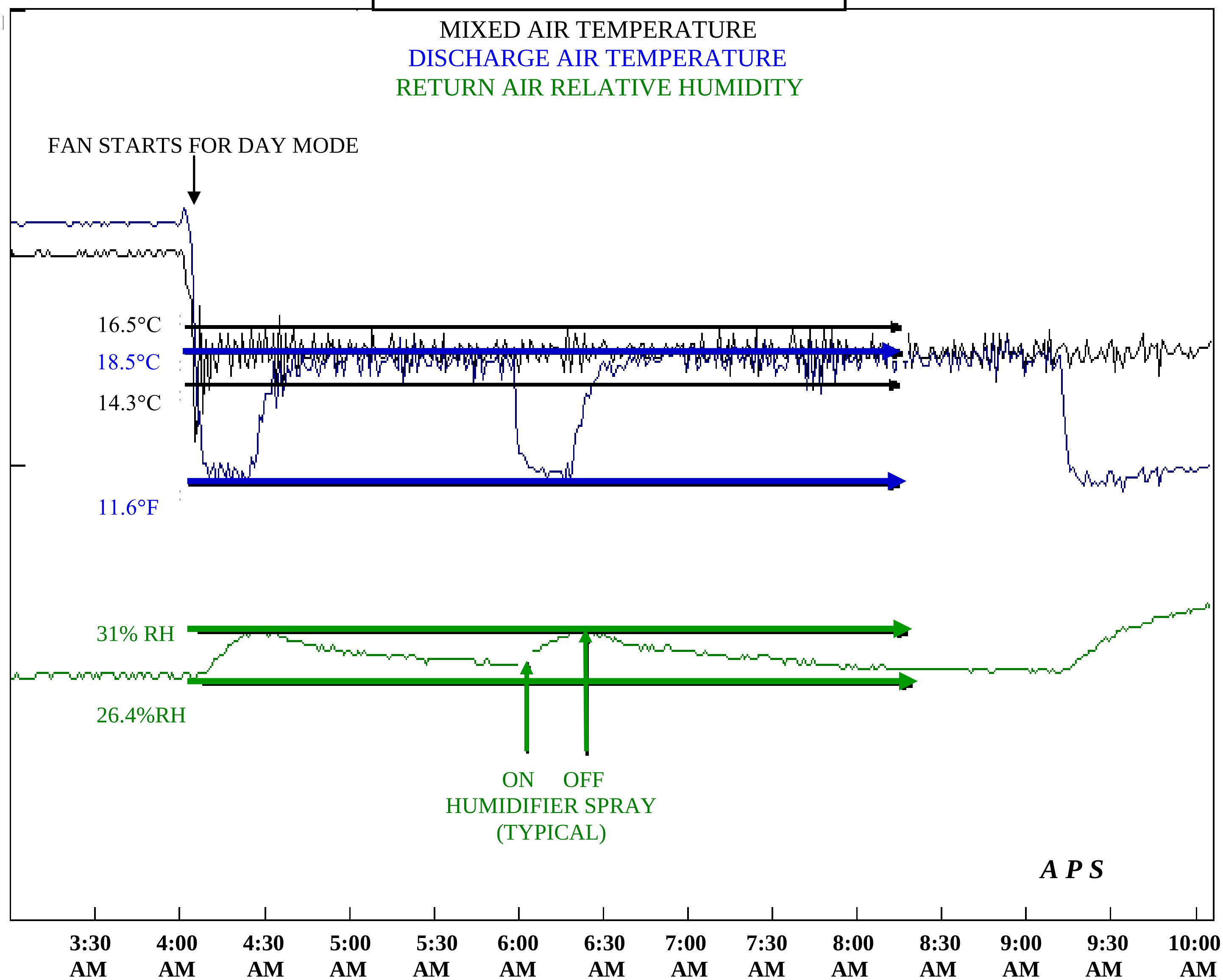
When the humidity sprays were active the discharge air temperature averaged about 12˚C.

The green line illustrates the return air relative humidity. This line indicates the run times for the humidity spray pump.

The energy loss is demonstrated by the dips in the discharge air temperature (blue line). At these times the heating system has to contend with a heating load in the fan's supply air approximately 5 C˚ greater than if the building did not have humidity sprays.

A control strategy was developed to allow the discharge air temperature controller to over-ride the mixed air controller to raise the mixed air temperature automatically when the humidity sprays were active. This was intended to keep the discharge air temperature relatively stable and remove the large dips in the discharge air temperature created by the spray activation. This would save energy and reduce the complaints of cold drafts by the occupants. The discharge air controller also retained its control over the fan system's chilled water valve for mechanical cooling.

GRAPH #1



The dips down in the discharge air temperature, caused by the evaporation of the humidifier's water, adds a further heating load to the building's heating system.

The mixed air is not impacted by the sprays being on or off.

The humidifier requires 970 BTU of heat for every pound of water evaporated.

Humidifying a building is very expensive.

<u>GRAPH #2</u>

The black line illustrates the mixed air temperature, the blue line illustrates the discharge air temperature and the green line illustrates the return air relative humidity.

The graph two shows almost an inverse situation from graph one. On graph two the mixed air temperature rises significantly while the discharge experiences only a small drop in temperature when the humidity sprays are active.

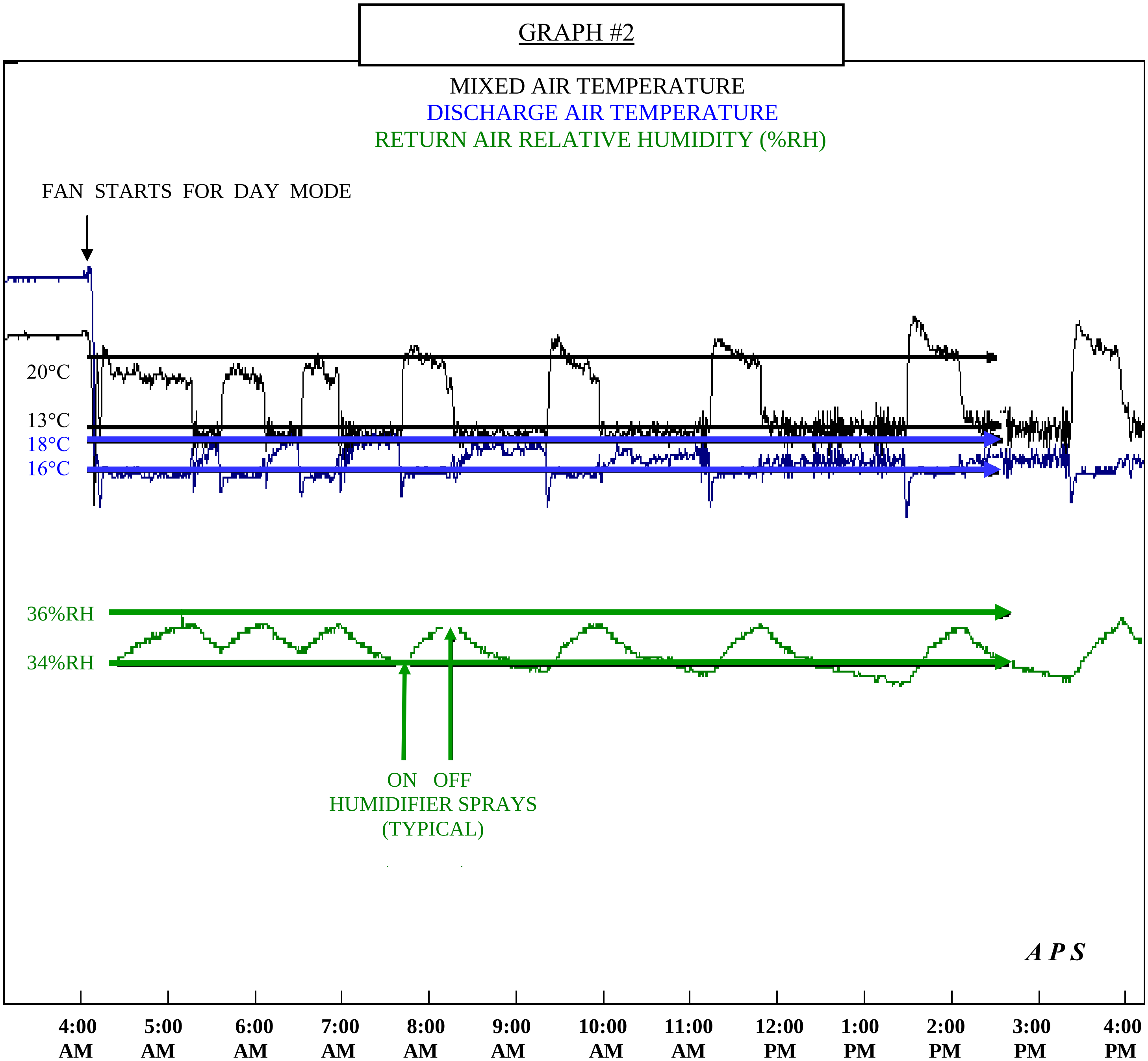
This graph illustrates the more effective use of energy where the system automatically uses heat contained in the return air to provide the energy required to evaporate the moisture for humidification demands. Prior to the control change the humidity circuit forced the heating equipment in the building to provide the heat to compensate for the evaporization.

GENERAL

The evaporative cooling has to be compensated for with heat or the space will become too cold. The heat can come from:

1. the mechanical heating system as illustrated in graph one at great expense and pollution generation from extra combustion, or
2. the return air where the heat is already paid for, which saves money and reduces pollution by reducing combustion.

The discharge air temperature could have the drop in temperature eliminated completely by automatically resetting the discharge controllers set point as required, but the range of control experienced with the sprays active and inactive was well within the acceptable limits.



The dips up in the mixed air represent the reclaimed heat from the HVAC exhaust air that was rejected from the building previously.

The discharge air is held relatively stable with the humidity sprays on or off.

ACTUAL GAS CONSUMPTION AMOUNTS FOR THE ETOBICOKE EDUCATION CENTRE ILLUSTRATING THE IMPACT OF EVAPORATIVE COOLING AND LOAD ANALYZING TECHNIQUES

READING DATE	GAS CONSUMPTION (X 100)
AUG. 29/75	1,324.8
SEPT. 30/75	2,069.8
OCT. 30/75	1,965.1
DEC. 01/75	1,776.8
DEC. 30/75	1,930.1
JAN. 30/76	2,806.9
FEB. 27/76	2,308.1
MAR. 30/76	2,624.8
APRIL 29/76	1,749.6
MAY 28/76	1,676.1
JUNE 29/76	1,053.2
JULY 28/76	924.6
JAN. 26/77	9,168.4
FEB. 21/77	1,276.8
MAR. 22/77	1,192.7
APRIL 21/77	613.6
MAY 20/77	522.5
JUNE 21/77	609.2
JULY 21/77	683.7
AUG. 22/77	1,066.6
SEPT. 22/77	1,156.2
OCT. 21/77	1,328.5
NOV. 22/77	1,224.2
DEC. 21/77	815.1
JAN. 20/78	927.5
FEB. 20/78	1,078.8
MAR. 22/78	920.5
APRIL 21/78	771.2
MAY 19/78	526.8

WHEN COMPARING THE GAS CONSUMPTION FOR THESE TWO SETS OF MONTHS, ONE FINDS JUNE AND JULY REQUIRED 13.5% MORE GAS BEFORE THE CHANGES, THAN DECEMBER AND JANUARY REQUIRED AFTER THE CHANGES.

INITIAL CONSERVATION DESIGN EMPLOYING EVAPORATIVE COOLING EFFECT OF THE HUMIDITY WATER SPRAYS. OTHER TECHNIQUES WERE IMPLEMENTED SIMULTANEOUSLY. (FEB. 21/77 – JULY 21/77)

THE WATER SPRAYS WERE REPLACED WITH STEAM HUMIDIFIERS CAUSING THE COOLING EFFECT TO BE LOST. (AUG. 22/77 – NOV. 22/77)

AN ALTERNATE CONSERVATION CONTROL TECHNIQUE WAS DESIGNED AND INSTALLED. LOAD ANALYSING FROM THE WARMEST SAMPLE THERMOSTAT RE-ESTABLISHED THE CONSUMPTION REDUCTION. (DEC. 21/77 – MAY 19/78)

52.6% REDUCTION WITH EVAPORATIVE COOLING TECHNIQUE.

60% REDUCTION WITH ALTERNATE TECHNIQUE.

NOTE: The 52.6% reduction in gas consumption only involved a change to control the fan system's mixing dampers from a sensing point after the humidity sprays, so the system could sense the cooling impact of the water being evaporated. This only took a few hours and a few dollars to achieve.

The mixed air temperature up stream of the sprays was automatically raised by directing return air to the mixing plenum rather than out the exhaust dampers. This was free heat to evaporate the water.

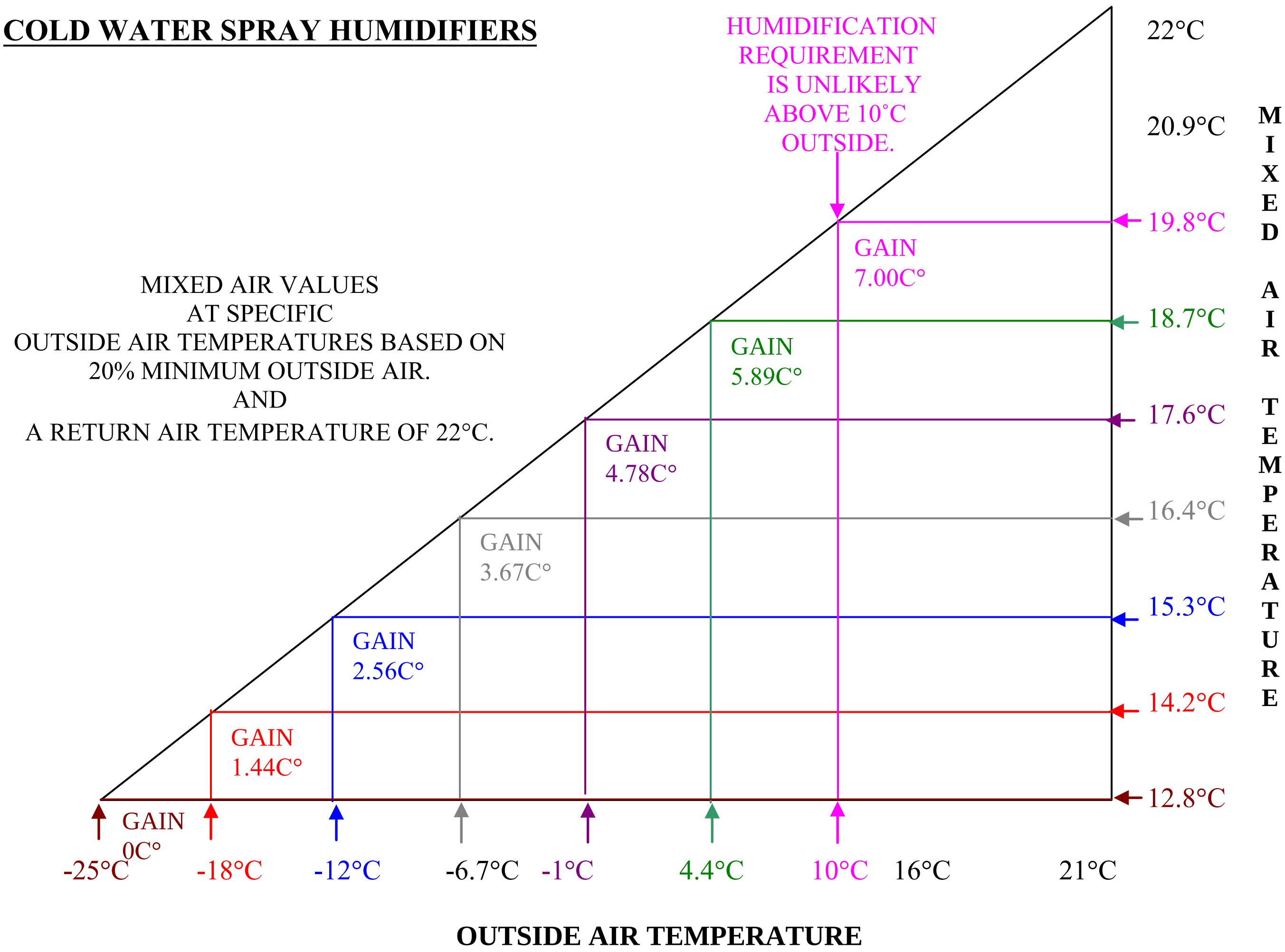
The minimum fresh air met code requirements by fixed dampers both before and after the APS changes.

The Board's staff was convinced, by others, to replace the water sprays with steam humidifiers that increased the gas consumption to the level before APS was involved and required a lot of electricity to produce the steam.

The 60% reduction from before APS was involved was achieved by a different APS design. This design was much more expensive to install.

RETURN AIR THERMAL RECOVERY VIA

COLD WATER SPRAY HUMIDIFIERS



NOTES:

-1- The mixed air set point is normally 13°C. Proportional controllers will droop below 13°C in cold weather conditions increasing the potential heat recovery.

-2- If the outside air is -25°C, the return air is 22°C and the required quantity of minimum fresh air is 20%, the mixed air temperature will be 13°C. At this outside air temperature, or below, there is no savings available, via sequencing logic with the humidity sprays as the system is on minimum ventilation only.

-3-The energy savings available, when the sprays are active, at outside air temperatures above -25°C, gradually increases as the outside air temperature rises.

Example: At -6.7°C outside the control logic will automatically raise the mixed air from its normally controlled value of 13°C to 16.5°C. The humidification system will use the energy contained in the 3.5C° gain to evaporate the moisture in the sprays.

-4- When the fan system is on 100% outside air at 13°C and 100%RH the air will drop to 35%RH when the temperature rises to 22°C, if no other moisture is introduced into the air.

SUMMARY

- ASHRAE states that low humidity levels in buildings is beneficial to viruses and bacteria; therefore, increases infections and causes human discomfort.
- Cold-water humidity spray has been abandoned based on false conclusions regarding Legionnaires Disease based on data from the Center for Disease Control.
- Incorrect reference locations for controlling cold-water spray humidifiers missed an opportunity to attain much of the evaporation energy from the HVAC’s exhaust air.
- Altering the sensing point to control the fan’s mixing dampers from upstream of the humidity sprays to down stream of the humidity sprays allows significant energy reclaim. (Etobicoke Board of Education office had a reduction of 52.6%)
- Logical sequencing of the controlled events is required.
- Proper maintenance of the all humidifiers is critical.
- Automatic draining of the humidifier pan based on water temperature, flushing, etc. should be considered.

OPERATIONAL CONSIDERATION

Mineral buildup on the surface receiving the spray may be reduced by keeping that surface wet as much as possible.

Spraying water on three solenoid controlled levels with the lowest level being first cycled and the middle second cycled if the first cannot provide enough humidification and the top last, if the other two cannot provide enough humidification.

Each building has its own unique characteristics which must be considered by any person applying this concept.