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Investigation of Air Quality Complaints in Two Indoor Swimming Facilities

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Two class A indoor swimming pool facilities were investigated by the Ontario Ministry of Labour, as staff and bathers were experiencing health symptoms including headache, nausea, lethargy and irritation of the eyes, nose and throat while on the premises. In both cases, pool chemistry was initially suspected as the cause of the complaints. However, it was learned on initial investigation that the reporting of health symptoms coincided with the installation of a closed-loop dehumidification system, designed to control ambient and water temperature as well as relative humidity within the pool structures. Hence, further efforts focused on air quality within the buildings.

Air quality at both locations was deemed unacceptable, and suspected as being the cause of complaints. Carbon dioxide levels of up to 2600 parts per million, as well as temperature and relative humidity readings outside recommended thermal comfort parameters were documented.

Activity at one of the pools had to be severely curtailed until the problem could be adequately addressed.

In both operations, measures were taken to provide adequate tempered replacement air, which has reduced carbon dioxide levels and eliminated the health complaints previously experienced by staff and bathers.

Introduction

Over the last decade, indoor air quality has become a major concern for occupants of non-industrial environments. Consequently, government agencies, university groups, and private consulting firms are receiving a vast number of requests to investigate health complaints in such settings. Swimming pools are an environment where the potential for problems is great, as indoor facilities have high ambient temperatures and relative humidity. Excessive humidity can potentially have adverse effects on the indoor environment, promoting the growth of pathogenic or allergenic organisms, and causing serious structural damage to building materials (1). In an effort to control ambient conditions, and implement energy conservation measures, several indoor pool facilities in Ontario have installed dehumidification systems. These efforts in some cases have led to elevated carbon dioxide (CO_2) levels, and relative humidity (RH) and indoor air temperatures outside recommended thermal comfort guidelines. This has resulted in health complaints by both staff and bathers.

The investigations described were undertaken by members of the Occupational Health and Safety Division of the Ontario Ministry of Labour (MOL). Swimming pool facilities in Ontario are considered industrial establishments, and are governed by the Occupational Health and Safety Act and the Regulations for Industrial Establishments. Recently in 2 class A pools, to which the general public is admitted, the MOL has been involved as a result of staff and swimmer complaints of headache, nausea, lethargy, and irritation of the eyes, nose and throat while on the premises.

<u>Investigations</u>

In both cases, pool chemistry was initially suspected as the causes of the complaints. In a municipal pool in Sault Ste Marie, the water was chlorinated with a gaseous chlorine system. The second facility, located in Hamilton, was using a sodium hypochlorite solution. During initial investigations at both locations, it was learned that the health symptoms in each case had started soon after the installation of a dehumidification system. Hence, further MOL efforts focused on air quality within these facilities, not pool chemistry. Pool chemistry is regulated under the Health Protection and Promotion Act, enforced by the Ministry of Health. Pool chemistry was, however, verified and found to be acceptable.

Carbon dioxide levels are being widely used as a marker for insufficient fresh air supply. Normally, outdoor air contains 300-350 parts per million (ppm) CO_2. Through respiration, cigarette smoking, etc. CO_2 levels in a building may increase if sufficient fresh air is not continually introduced. As it is difficult to correctly measure fresh air supply, CO_2 is used as a marker. In previous investigations conducted by the MOL, an association between the symptoms typical of the Tight Building Syndrome (i.e. headache, drowsiness, stuffiness, etc.), and increasing CO_2 concentrations has been shown (2). At less than 600 ppm CO_2, symptoms are usually not prevalent. With CO_2 levels between 600 and 1000 ppm there are occasional complaints. At CO_2 levels greater than 1000 ppm there are widespread complaints from occupants of the area. ASHRAE, in the recent standard, Ventilation for Acceptable Indoor Air Quality (3), also recommends a limit of 1000 ppm CO_2 to satisfy comfort criteria.

The ASHRAE Handbook, 1982 Applications recommends design conditions for pools to be the following: indoor air for pleasure swimming 75 - 85° F (24 - 29°C) with 50 - 60% relative humidity. The pool water for pleasure swimming should be 75 - 80° F (24 - 27°C) and for competitive swimming 72 - 75° F (22 - 24°C). ASHRAE stipulates that humidities higher than those recommended encourage corrosion and condensation problems as well as occupant discomfort (3).

The dehumidification system installed at both locations is a dehumidifier and pool water heater, closed-loop energy recycler. The package unit includes a compressor evaporator (dehumidifier), condenser (air reheat), water heater, fan, motor, starters and control, all in one complete enclosure. The principal of operation is that the warm, humid air from the pool area passes through the dehumidifier coil and is cooled below its dew point, thereby condensing air moisture. The heat captured by the process and the heat generated from the compressor power consumption are absorbed by a mechanical refrigeration system. The heat is then distributed through a water cooled condenser to heat or maintain the pool water temperature. All remaining heat is then transferred to the air and contributed to the pool enclosure heating requirement. As per design specifications the unit will maintain air temperature at 29.4°C, relative humidity between 50 - 60%, and pool water temperature at 28.3° C.

Case 1

Fifty staff, 10 of whom are full time are employed at the Hamilton facility. The pool area was built in 1975 and houses a 22.9 metre (25 yard) pool. Health complaints mentioned previously were prevalent among pool staff after November of 1988, at which time closed-loop dehumidification system was installed. During the first 12 days that the unit was functioning, severe problems were encountered with temperature and relative humidity on the premises. Humidity was high (70 - 88%), and water temperature was about 23.3°C. Fresh make-up air was not being introduced into the facility at this time.

A faulty part was noted in the unit at the end of November, however, once this was corrected, ambient temperatures became exceedingly warm (32°C). By mid-December, staff were continuously monitoring and recording temperature and relative humidity which was averaging 28.3°C and 43%. By mid-January the situation had not improved and staff deemed it necessary to involve the MOL.

The facility was visited by Division staff in February and temperature measurements in the pool area ranged from 29.5 to 32° C and relative humidity was between 50 and 63%. Carbon dioxide measurements made with a Dräger, Colourmetric Detector Tube, revealed CO_2 concentrations of 1000 to 1100 ppm.

Case 2

This facility which consists of a 25 metre swimming pool and a 10 metre wading pool was constructed in 1972. A dehumidifier was added to the ventilation system in October, 1988 and the building air temperature and relative humidity was set at 27.8°C and 50 - 60% respectively. The water in the swimming pool was maintained at 28.3°C and 34°C in the wading pool.

As soon as the dehumidifier was installed, pool staff and swimmers began to complain of eye irritation, and with time the symptoms became more varied (headache, lethargy, etc.).

In January, 1989 the MOL identified elevated CO_2 concentrations in the building (800 - 900 ppm) and suggested that the complaints may be due to insufficient fresh make-up air being introduced to the building. The ventilation system was examined and found to be a recirculating system with dehumidified air distributed through slot diffusers around the perimeter of the building and returned to the fan unit through a single 4 foot by 8 foot grill. An outside air vent was incorporated but control dampers limited the flow rate to 1200 cubic feet per minute (cfm). During the investigation the control dampers were closed and no outside air was being admitted.

During a swimming competition on February 4, 1989, attended by more than 200 swimmers and spectators, the CO_2 concentration was as high as 2600 ppm. Further measurements, made under normal occupancy conditions, using a Fuji model ZFP-5 Carbon Dioxide Monitor, revealed CO_2 concentrations between 1000 and 1100 ppm. Temperature ranged from 29.5 to 32°C, and relative humidity varied from 50 to 60%.

Discussion & Recommendations

Following orders issued by the Industrial Health & Safety Branch to improve ventilation, the Hamilton facility engaged the services of a private consultant to monitor airborne concentrations of CO_2 following modifications to the ventilation system. In this particular case, fresh air dampers at one end of the facility were opened 10% and a roof exhaust fan was operating continuously during the day. The average CO_2 concentration in the pool area during the 23.3 hours of continuous monitoring was 472 ppm. Average wet and dry bulb temperatures were 23.9 and 29.9°C, respectively. The consultant noted that temperature was approaching a level where discomfort would be experienced by instructors who were not in the pool. However, the ventilation changes have resulted in a reduction of CO_2 concentrations, and complaints.

As a result of the high CO_2 measurements during the swim meet, orders were issued to improve the ventilation in the Sault Ste. Marie pool building, and to implement interim operating conditions until the ventilation improvements could be made. The interim measures consisted of: prohibiting spectators; regular monitoring of CO_2 levels on the pool deck; and closing the pool should CO_2 levels reach 1500 ppm. The engineering company which had designed the ventilation modifications, prepared a proposal to install a roof-mounted supply air unit capable of applying up to 8000 cfm of tempered outside air to the building. This unit was installed during the summer of 1989 and staff complaints have subsequently ceased.

In both investigations, air quality was deemed unacceptable, as carbon dioxide levels were elevated, and temperature and relative humidity, for the most part, were outside the recommended ambient comfort guidelines. It is interesting to note that even with CO_2 concentrations in the range of 1000 ppm, complaints of irritation of the eyes, nose and throat and headache were prevalent in the two facilities. However, with sufficient fresh make-up air being introduced to the structures to lower CO_2 levels even further (<600 ppm), complaints subsided. This is consistent with previous investigations conducted by the MOL (2) that have shown that it is preferable to maintain CO_2 concentrations below 600 ppm, to achieve occupant satisfaction with regards to air quality.

Air quality problems are also aggravated by temperature and relative humidity readings outside recommended comfort ranges. In both facilities, prior to ventilation adjustments, temperature was above that recommended by ASHRAE (4). Relative humidity, in the Hamilton pool, fell below that recommended by ASHRAE (4).

Energy conservation in indoor structures, such as pools, should not be made at the expense of occupant comfort. Hence, it is to be ensured that ventilation systems within pool structures are capable of maintaining an acceptable air quality and appropriate ambient conditions. With the use of a closed-loop dehumidification system, this necessitates, in our experience, the provision of fresh tempered make-up air to the occupied areas.

References

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