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Water evaporation in swimming baths

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WATER EVAPORTATION IN SWIMMING BATHS

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SUMMARY

This paper is publishing measuring results from models and full-scale baths of the evaporation in swimming baths, both public baths and retraining baths. Moreover, the heat balance to the basin water is measured. In addition the full-scale measurements have given many experiences which are represented in instructions for carrying out and running swimming baths. If you follow the instructions you can achieve less investments, less heat consumption and a better comfort to the bathers.

INTRODUCTION

For many years design engineers have calculated the evaporation in a swimming bath with the equation:

$$W = (25+19v)(x_m \div x_r)$$

in which W = evaporation, g/m^2h
v = air velocity at the surface, m/s
x_m = water content in saturated air at the water temperature, g/kg
x_r = water content in the air, g/kg

In technical literature within the area of water evaporation you can find other equations or graphs as results of measurements. But apparently there are no measurements about the evaporation in swimming baths, and the different sources are giving very different and too large amounts of evaporation for the same situation in the bath.

In the years 1976-1982 a research in this area was done at our university. A report was published in Danish in the Scandinavian countries. Since the results were rather revolutionary the report attracted a good deal of attention. Later the directions in the report have been tried in existing swimming baths in Scandinavia. Hereby the energy consumption for dehumidifying the air was reduced to 20-50%. This is the backgound for the paper.

1. Water temperature ≤ air temperature

Swimming baths can be divided in two groups, ordinarily public or private swimming baths and baths for retraining at hospitals etc. In this section the first mentioned type will be treated. In these swimming baths the water temperature is less than the air temperature, or it ought to be as shown later.

1.1. Laboratory set-up

At figure 1 you can see the used model. The inside dimensions of the room were LxWxH = 5,43x3,60x2,42 m, but on the floor a platform at a height of 20 cm around a 7 m² basin made af a plastic film was built up. The dept of the water was about 18 cm.

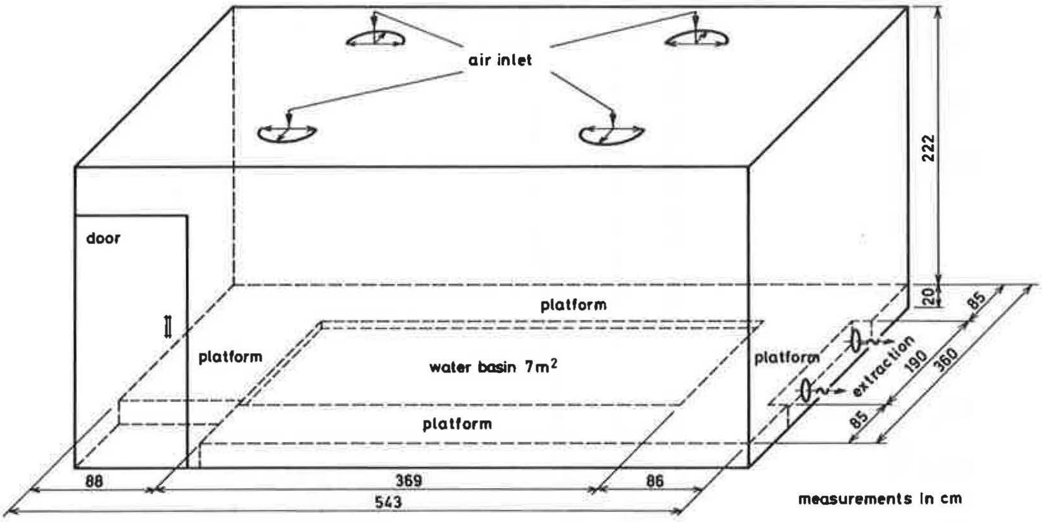

Fig. 1. Room model with "swimming pool".

The significant parameters appeared to be:

- Air temperature
- Air humidity
- Water temperature at the surface
- Air velocity above the surface

So these parameters and the evaporation had to be measured. The question was, how to make these measurements and where.

A short description of the chosen methods and the proved accuracy of the measurements will follow.

Air temperature

A test above the centre of the bassin gave examples of stratification as shown in fig. 2.

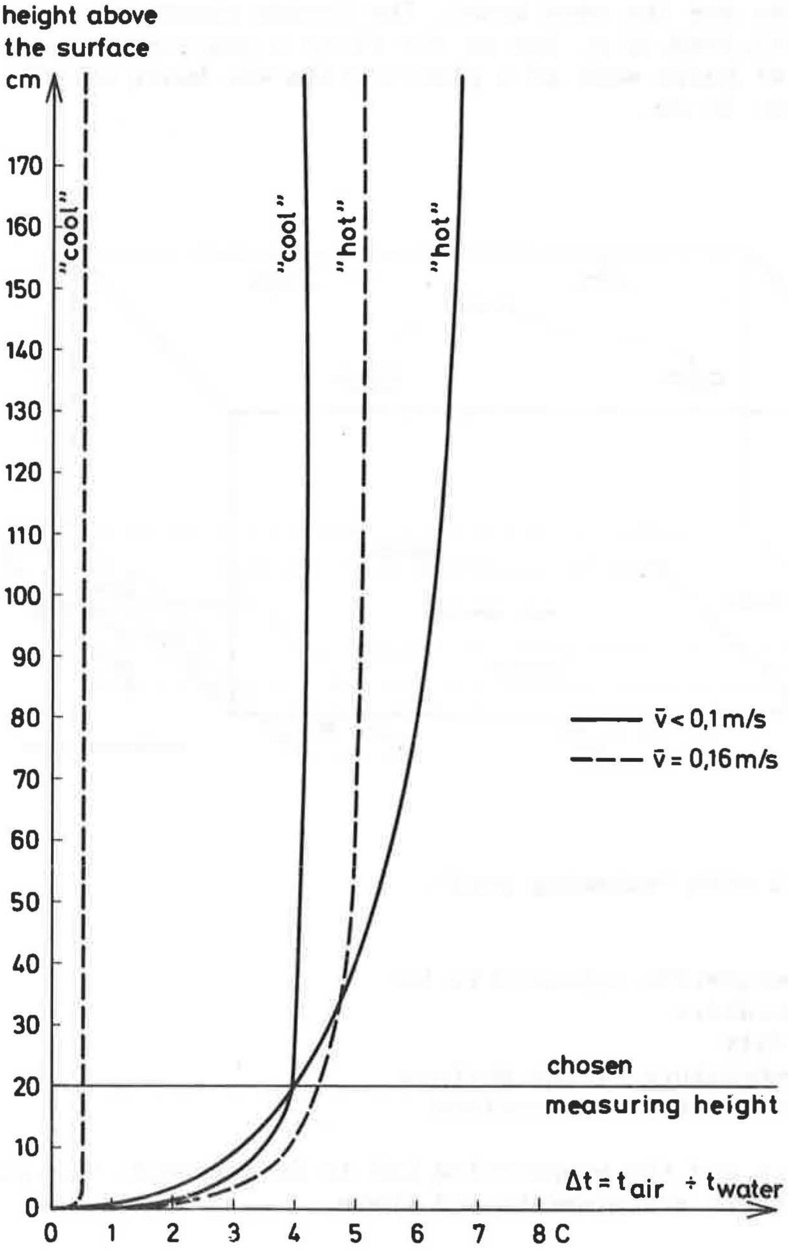

Fig. 2. Temperatures in the air above the centre of the basin. Air velocity 2 cm above the surface = v. Water temperatures between 24 and 28 C.

As seen from fig. 2 and the following humidity stratification a measuring height of 20 cm was chosen. 9 thermocouples type K were distributed 20 cm above the surface. They were scanned each 30 min. in a typical measuring period of 16 hours and a mean value was calculated. The uncertainty of the mean temperature was ± 0.2 C.

Air humidity

A test with Assmann's psychrometer above the centre of the pool showed a humidity distribution in the room as shown in fig. 3.

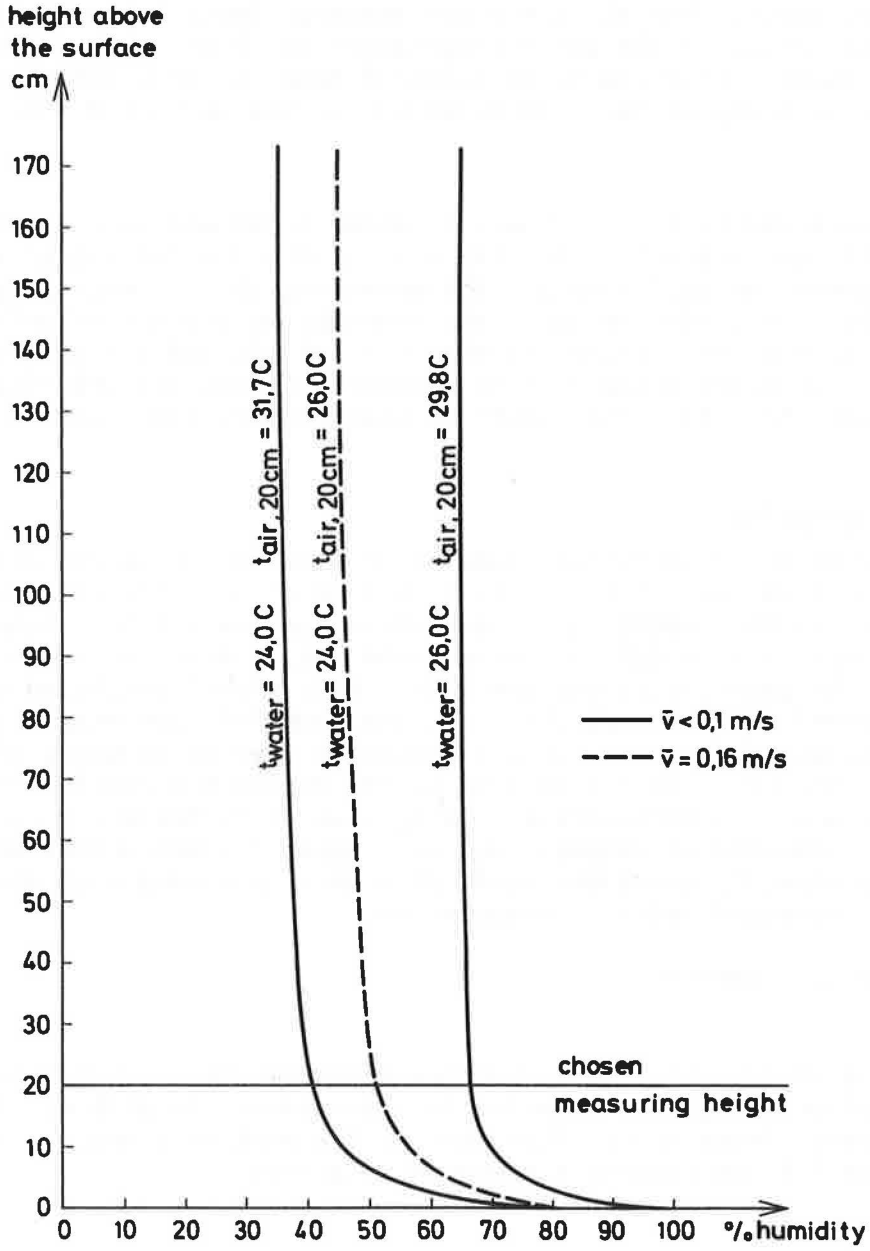

Fig. 3. Humidity in the air above the centre of the basin. Air velocity 2 cm above the surface = v.

As the humidity is varying very much near the surface but only a little in the upper regions, a measuring height of 20 cm was chosen. To measure the humidity with sufficient accuracy is difficult. So a new measuring equipment was developed and used. This new equipment had an accuracy of about ± 1% humidity, but because of the varying humidity with the time and with the position, a total accuracy of ± 5% humidity was suggested.

Water temperature

The water was taken out of the basin by a pump, heated to the desired temperature by an electrical heater controlled by a thermostat, and injected into the basin again. Thus the water was rotated slowly horizontally. You had no stratification of the water temperature which was proven. So the surface temperature could easily be measured down in the water with a thermocouple. The accuracy of the mean value was proven to be ± 0.1 C.

Air velocity

After pilot experiments it was chosen to measure the air velocity 2 cm above the water surface with a hotwire probe. 18 measuring points were distributed above the pool area and the measuring time in each point was several minutes. To avoid too much time consumption the air velocity was devided into groups, an overage velocity $v < 0.1$ m/s and $v = 0.15$ m/s. As seen later the evaporation is very dependent of the air velocity, but it was necessary to reduce the number of measurements since you had four parameters.

Amount of evaporation

Determination of the evaporation could be done by measuring the airflow and the humidity in the inlet and the exsuction of air. But this would give a low accuracy in the result. So it was chosen to measure the amount of evaporation direct. To weigh the basin could not be done, so a new method in measuring the water level was developed. This method consisted of a special submerged pipe through which air was boubbled. The supply pressure which was determined very exactly was proved to give an accuracy of ± 0.02 mm corresponding to ± 0.14 l of water. To reach a sufficient accuracy meant normally a necesssary measuring time at 16 hours i.e. a night. To measure low amounts of evaporation for example 5 g/m²h a week-end corresponding to about 62 hours was used. This gave an accuracy of about ± 6.5% of the measured value of evaporation.

1.2. Experimental results

Evaporation

About 200 measurements were made, besides measurements which had to be rejected because of too great variation in a parameter. So with all the difficulties, which always occur, this part of the work took about a year. In the figures 4-8 the results are showed in graphs.

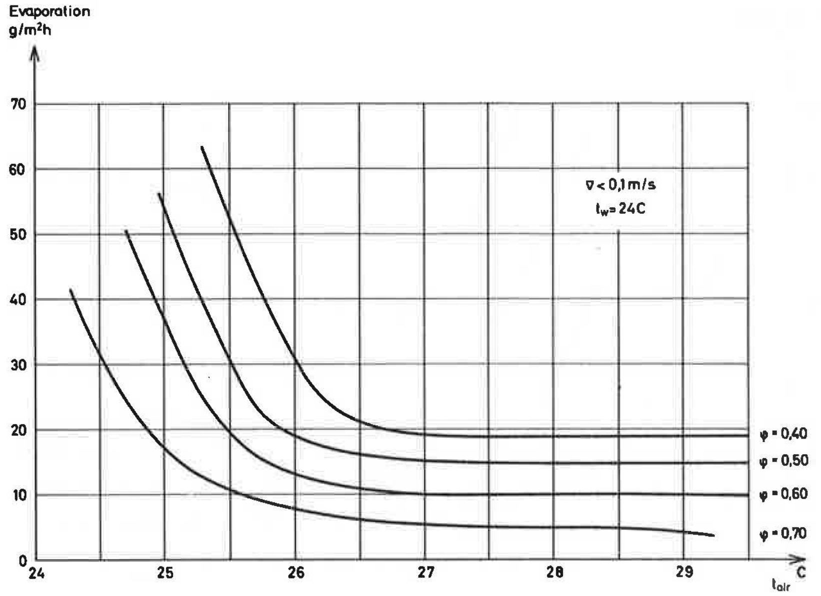

Fig. 4. Evaporation from a quiet surface of water. The air temperature t_{air} and humidity φ are measured 20 cm above the surface. The water surface temperature is t_w. The mean air velocity v is measured 2 cm above the surface. Warning: you can interpolate but not extrapolate in the diagram!

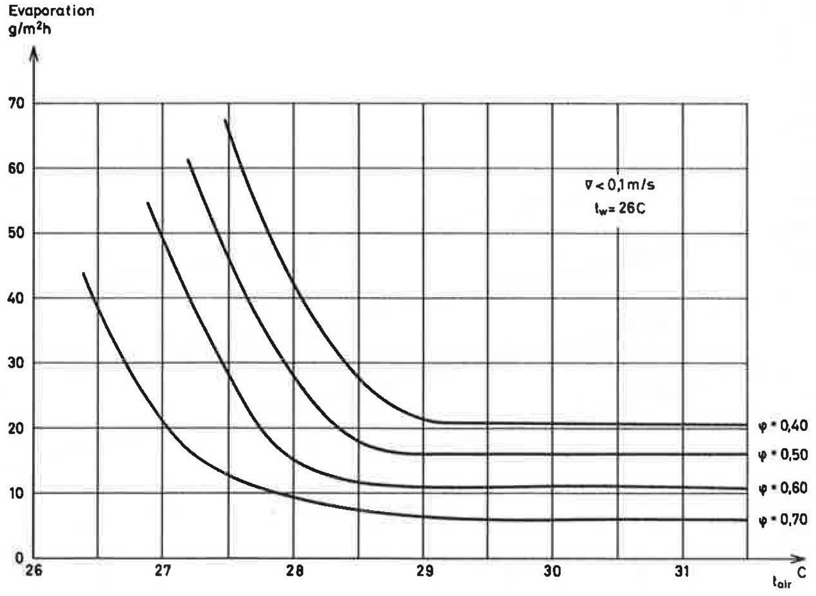

Fig. 5. Evaporation from a quiet surface of water. The air temperature t_{air} and humidity φ are measured 20 cm above the surface. The water surface temperature is t_w. The mean air velocity v is measured 2 cm above the surface. Warning: you can interpolate but not extrapolate in the diagram!

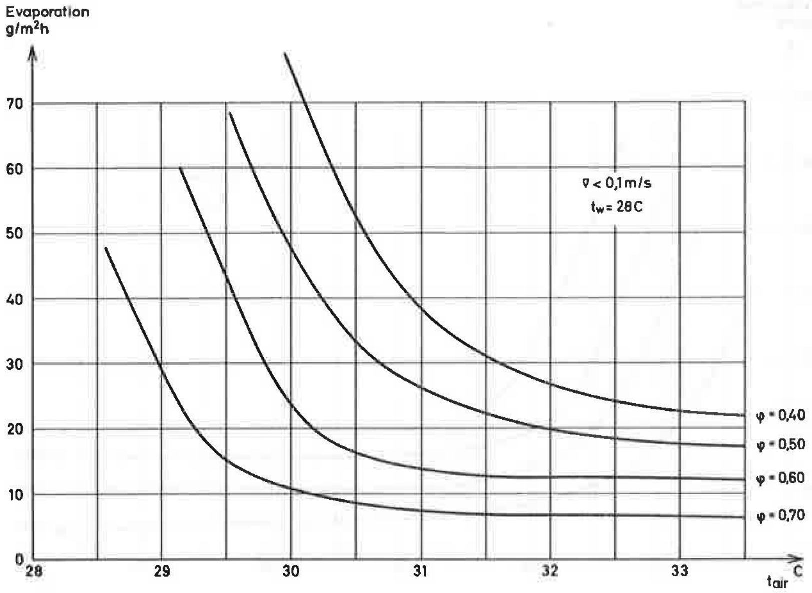

Fig. 6. Evaporation from a quiet surface of water. The air temperature t_{air} and humidity φ are measured 20 cm above the surface. The water surface temperature is t_w. The mean air velocity v is measured 2 cm above the surface. Warning: you can interpolate but not extrapolate in the diagram!

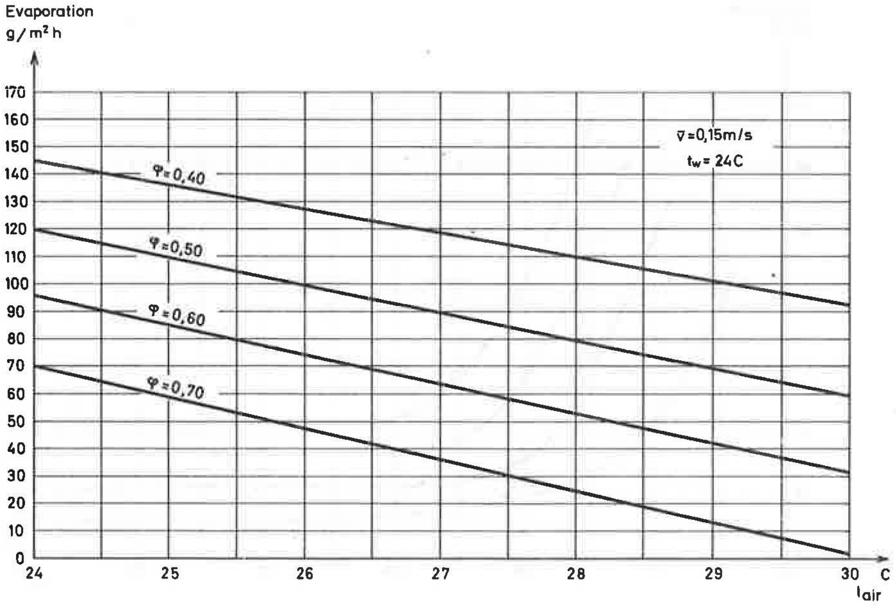

Fig. 7. Evaporation from a quiet surface of water. The air temperature t_{air} and humidity φ are measured 20 cm above the surface. The water surface temperature is t_w. The mean air velocity v is measured 2 cm above the surface. Warning: you can interpolate but not extrapolate in the diagram!

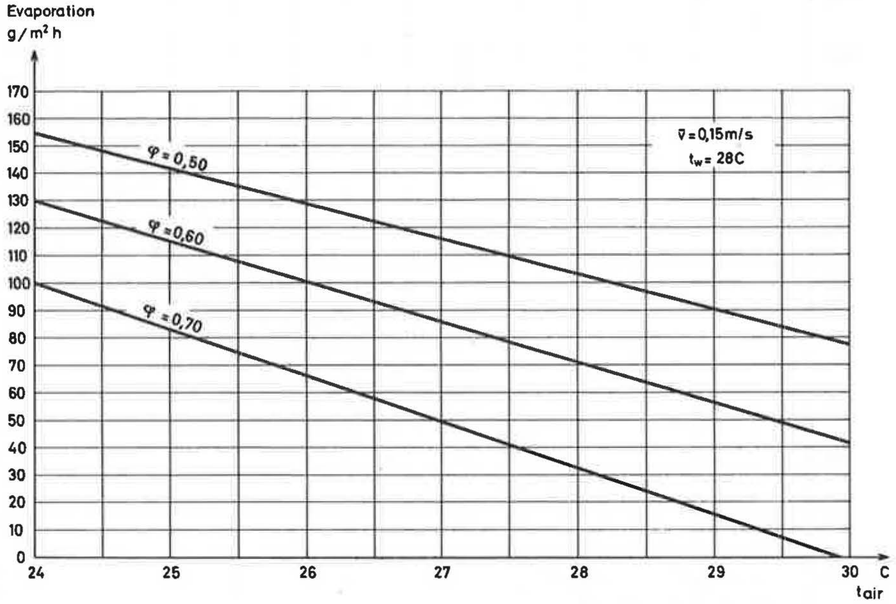

Fig. 8. Evaporation from a quiet surface of water. The air temperature t_{air} and humidity φ are measured 20 cm above the surface. The water surface temperature is t_w. The mean air velocity v is measured 2 cm above the surface. Warning: you can interpolate but not extrapolate in the diagram!

Let it be said emphatically that interpolation in the diagrams is allowed but extrapolation is absolutely inadmissible. This applies to all parameters especially the air velocity.

Also, I will not have somebody to transform the graphs to equations and forget to mention limitation areas as happened before.

Heating effect to the water

To clarify how much effect you must have to keep the basin water temperature at the wanted level, a new and smaller model of the basin was built up. It had a water surface of 1 m². The sides and the bottom were well insulated so that the heat loss could be controlled. It was proved that the evaporation was proportional to that of the 7 m² basin. Because of the time consumption the measurements were only carried out at air velocities about 0.15 m/s. The results are shown in fig. 9.

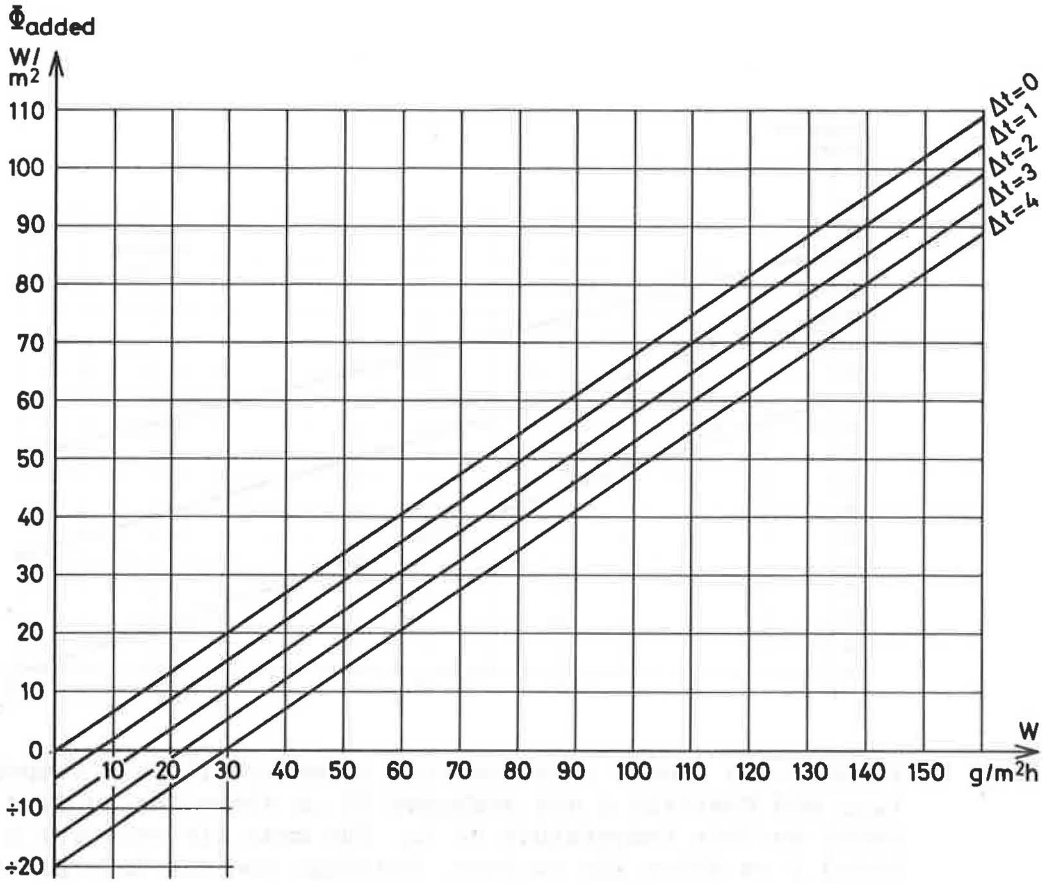

Fig. 9. Necessary heating added to the basin water Φ_{added} as a function of the evaporation W. $\Delta t = t_{air} \div t_w$ is parameter. Air velocity 2 cm above the surface = 0.15 m/s.

A very important thing to notice in fig. 9 is, that if you run your swimm ming bath rationally, for example at W = 20 g/m²h and Δt = 4 C you will have to cool the water - not to heat it. This is proved by measurement in real swimming baths, as described later.

1.3 Valuation of results

As seen the evaporation graphs are curved in the case $v < 0.1$ m/s but they are straight lines for $v = 0{,}15$ m/s. The explanation is: At low forced velocities free thermal flows at the surface matter a great deal. When the air temperature exceeds the water temperature with more than about 3 C everything is becomming quietly. In this area the density of the saturated vapour at the surface is greater than the density of the air at higher levels. At quiet circumstances of air movements you have thus a layer of saturated vapour just above the water surface and here is the determining factor for the evaporation the vapour pressure differences.

However, at lower temperature differences between the air and the water you have a changing in the relationship between the densities. Depending on the air humidity you have a change at $t_{air} \div t_w$ = one to three degrees and below this value the density of the saturated vapour is less than the density of the air at higher levels. So in this area the diffusion will be dominated by a pell-mell change which increases the evaporation strongly.

The graphs for $v < 0.1$ m/s are stopped at left where measuring of the air velocity exceeded 0.1 m/s because of the effect as described above. In this area you will have to use the figures 7 and 8.

At greater air velocities as in figure 7 and 8 you have not this dominating effect of thermal flows. The measurements did show a little break at the graphs, but since this break was very little and the curves were nearly straight lines, it was chosen to ignore it. So already at this small air velocity of 0.15 m/s the free thermal flow is loosing its influence and this corresponds to the measurements of other researchers at higher velocities.

In actual swimming baths it will be seldom to have air velocities 2 cm above the water which are > 0,15 m/s. So normally the figures 4-6 can be used if you can keep the pool water cold enough and do not have a great thermal radiation to the surface of the water as described later in section 3.

As mentioned in the introduction evaporation has been examined earlier. But apparently it was common to all this research that the method aimed to let an air flow pass a little water bowl. So it has not been possible to research the evaporation at low velocities. Some of the researchers have examined the velocity area 2-5 m/s others 0,5-4 m/s. Nobody have examined the evaporation below 0,5 m/s. Moreover, the earlier research has used high water temperatures while the air temperature in many cases is not even recorded. So this research cannot be used in a swimming bath.

In figure 10 is made a comparison between our results at $v < 0.1$ m/s and the equation mentioned in the introduction:

$$W = (25+19 \cdot v)(x_m \div x_r) \qquad (1)$$

in which W = the evaporation, g/m²h
v = the air velocity at the surface, m/s
x_m = the water content in saturated air at the water temperature, g/kg
x_r = the water content in the air, g/kg.

Just for this equation somebody has forgotten to mention limitation areas, even so the equation is a composition of researches.

Apparently the equation comes from Lurie and Michailoff [10] who examined the area:

$$1 < v < 7{,}5 \text{ m/s}$$

$$40 \text{ C} < t_{air} < 222 \text{ C}$$

$$10 \text{ g/kg} < x_{air} < 250 \text{ g/kg}$$

$$t_w \text{ "until 65 C"}$$

Moreover, it apparently comes from Thiesenhusen [13] who mentions the limitation area:

$0,5 \text{ m/s} < v < 1.5 \text{ m/s}$

$t_{air} \sim 20$ C

$\varphi_{air} \sim 0.7$

$52 \text{ C} < t_w < 83,5 \text{ C}$

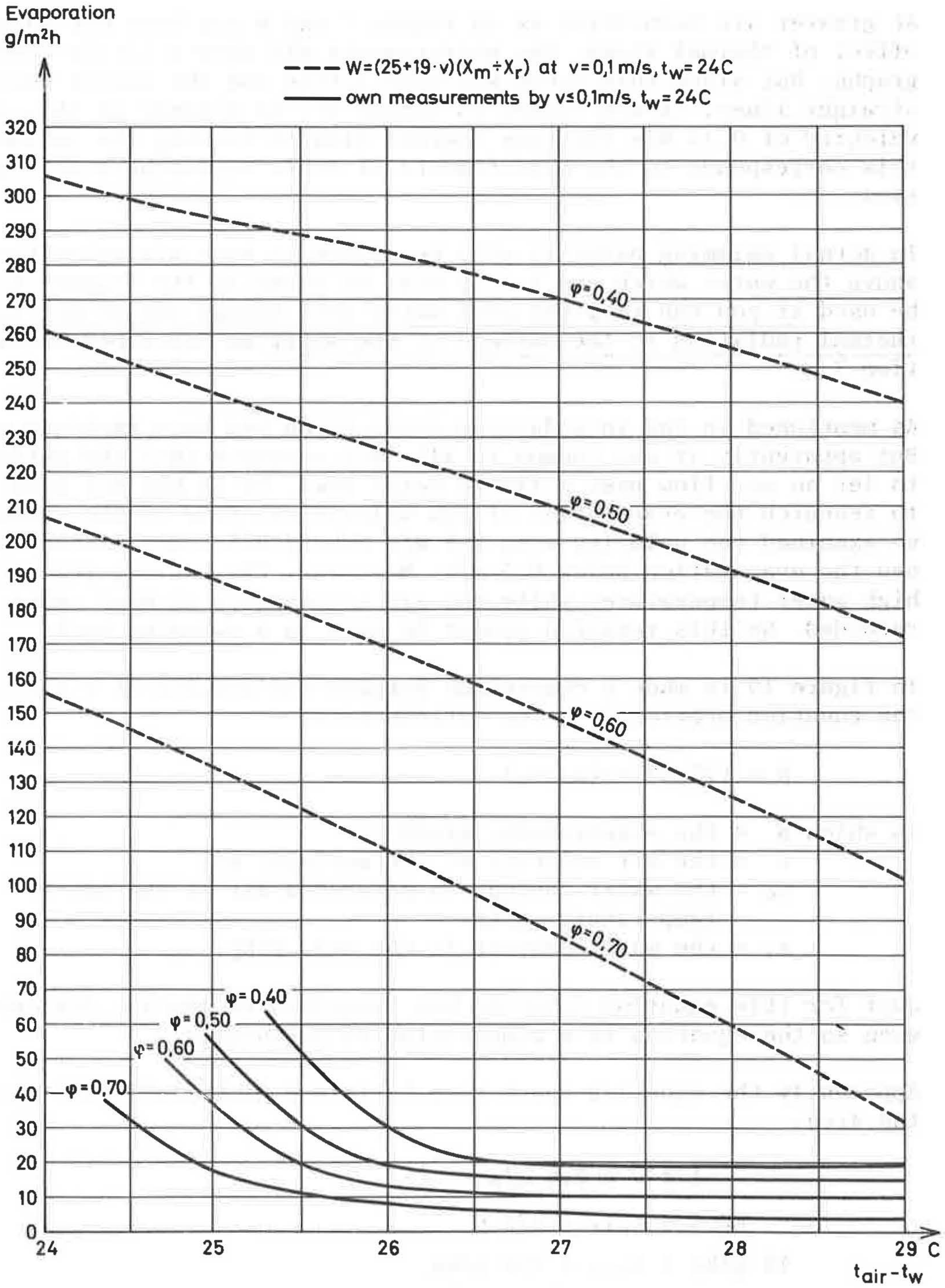

Fig. 10. Comparison with earlier equation. φ is the humidity and t_w the water temperature.

So it is proved that the equation mentioned above cannot be used to the situation in a swimming bath. This is also seen in fig. 10 where curves from the equation with the velocity v = 0.1 m/s are inserted. A comparison with our measurements shows a really great disagreement as expected.

Besides this earlier result there have been many others. They shall not be mentioned here because they are disagreeing and all of them are giving to high values of evaporation when they are used for the situation in a swimming bath.

It could be expected that waves would exceed the evaporation. To examine this, a little wave machine was used to generate waves all over the surface with a wave height of about 2 cm. Unexpectedly the small waves did not exceed the evaporation. This seems to show that waves do not disturb the layer of saturated vapour at the surface. If you are blowing smoke against the water surface you will see that it stays quietly at the surface just following the waves up and down. Only a rather powerful blow disturbs this layer as it was the case with the quiet surface. The conclusion for a swimming bath is, that waves without spray do not exceed the evaporation. The influence of the bathers will be mentioned later.

2. Water temperature > air temperature

After the publication of the results mentioned in part 1 above, many questions were received about retraining baths at hospitals, which normally were run at higher water temperatures. So new investigations were started to clarify the evaporation and the heat consumption to the water in this case.

2.1. Laboratory set-up

Since the previous mentioned measurements showed a good agreement between small models and full-scale room a plastic bowl with surface area of 1x0,5 m was chosen. The basin was placed in the middle of the climate room and was well insulated. The water could be heated with electrical heaters and the total heat exchange could be measured. The set-up was supplied with all the necessary equipment to measure the parameters.

To save time measurements were only carried out at a humidity of 60% taken 20 cm above the surface. Likely, only the water temperatures 29, 31, 33, 35 and 37 C were examined. Some pilot experiments at air velocities between 0.04 and 0.17 m/s taken 2 cm above the surface revealed a little influence of the air velocity at the evaporation at these relatively high temperatures of the water. So all the measurements named in the following were carried out at air velocities about 0.15 m/s.

2.2. Experimental results

Evaporation

In fig. 11 the measurements are shown graphically. To make a comparison with the results mentioned in part 1, a series of experiments at t_w = 28 C was done. As the agreement was good, these measurements are not presented in fig. 11.

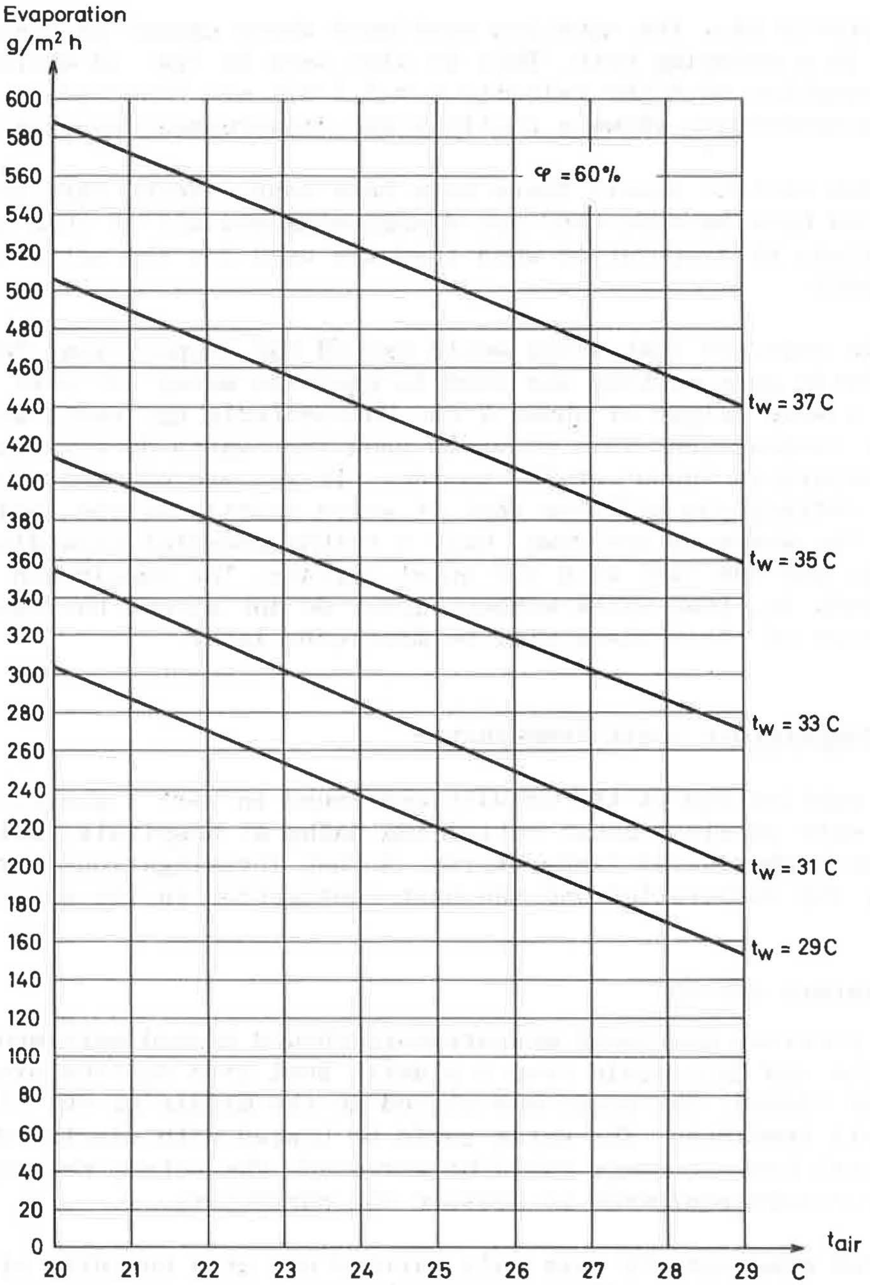

Fig. 11. Evaporation from a quiet water surface. The air temperature t_{air} and humidity φ are measured 20 cm above the surface. The water surface temperature is t_w. The mean air velocity measured 2 cm above the surface is $v = 0.15$ m/s. Warning: you can interpolate but not extrapolate in the diagram.

Heating effect to the water. As mentioned before the heating effect added to the water was measured exactly. The heat loss is consisting of heat conduction through the sides and the bottom, heat of evaporation, heat radiation from the surface to the surroundings and convection to the room air.

The heat conduction through sides and bottom was calculated in the light of the measured temperature stratification in the insulation. This part came to about only 6% of the added effect.

The heat of evaporation could easily be calculated in the light of the known evaporation, since the heat of evaporation for water Φ_{ev} is:

$$\Phi_{ev} = 2500 \div 2.26 \cdot t \quad (kJ/kg) \qquad (2)$$

Since the temperature t (C) of the water only has a little influence, the heat of evaporation is everywhere set to 2420 kJ/kg.

The temperatures of the water surface and of the surroundings were measured and the heat radiation calculated by the equation:

$$\Phi_r = \sigma_w \cdot A_w \, [T_w^4 \div T_s^4] \qquad (3)$$

where σ_w = 5.54 $10^{\div 8}$ W/m²K⁴ for a water surface
A_w = area of the water surface, m²
T_w = water surface temperature, K
T_s = surrounding surface temperature, K

By subtraction of the heat losses mentioned above from the added heat, the heat loss by convection was calculated. Of course this way is not an exact one to determine the convection, but the tendency was α_c = 6-7 W/m²C at the used circumstances.

In the figures 12 to 16 is seen the measured added heat effect, the effect used to the evaporation and heat loss by radiation and convection. The heat conduction is taken out of the heat balance.

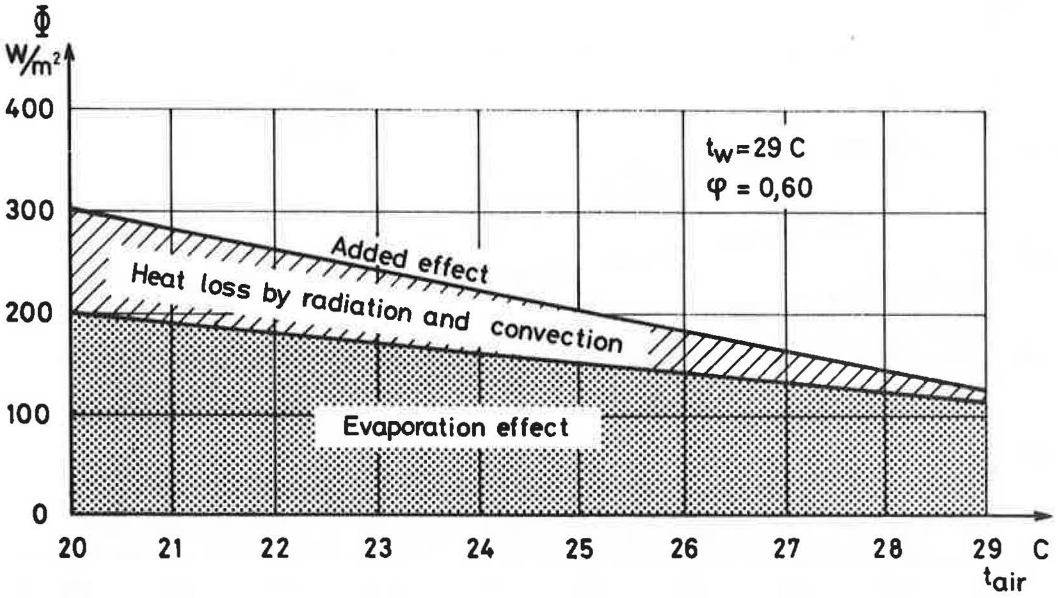

Fig. 12. Water heat balance at 29 C.

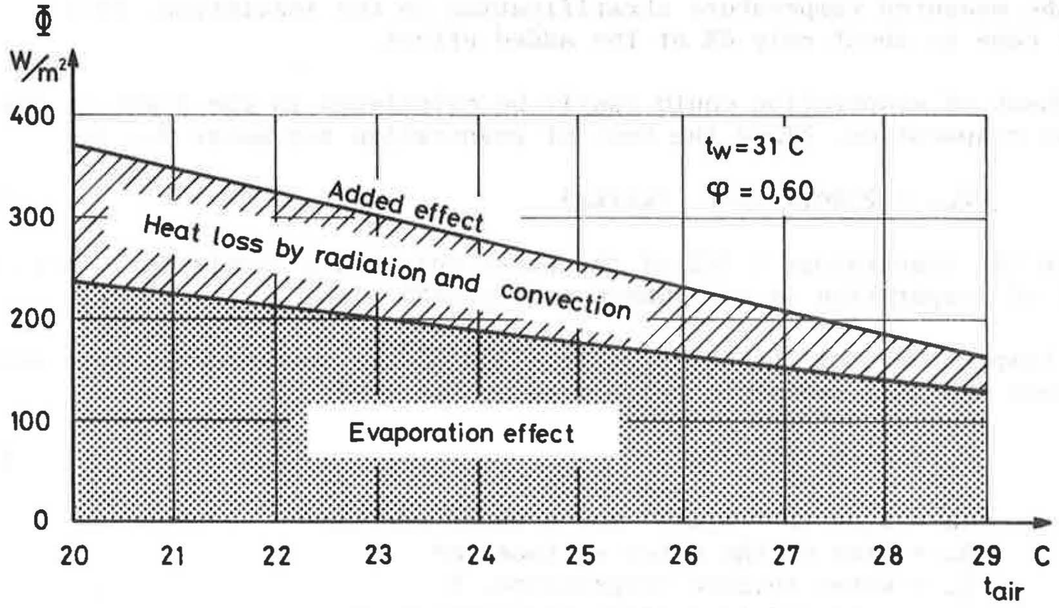

Fig. 13. Water heat balance at 31 C.

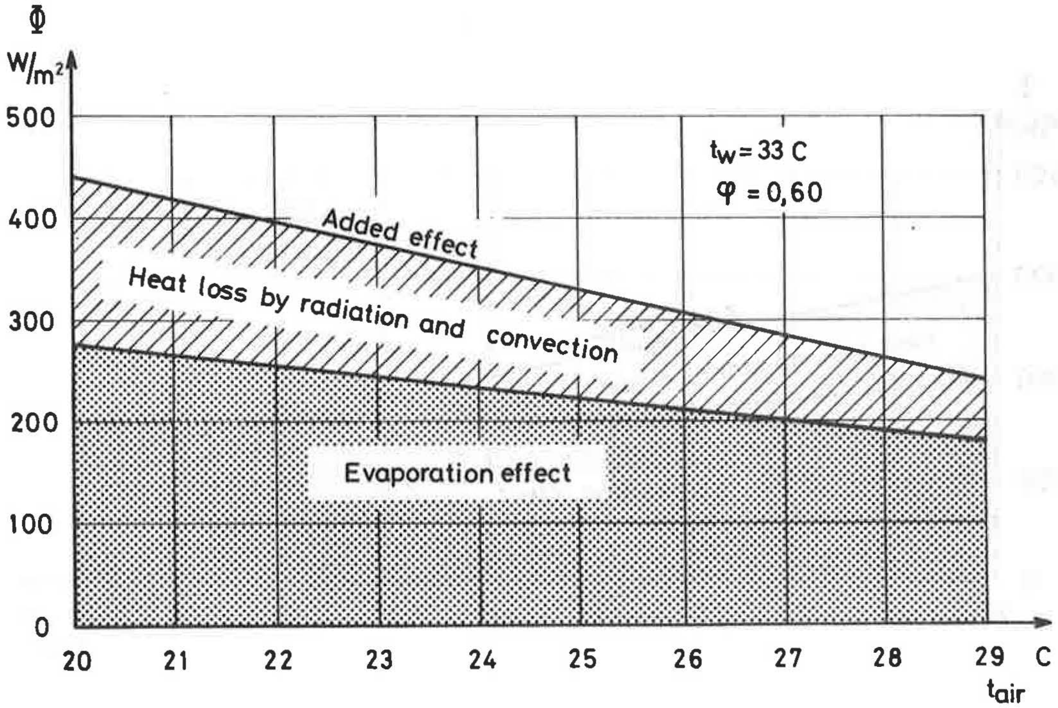

Fig. 14. Water heat balance at 33 C.

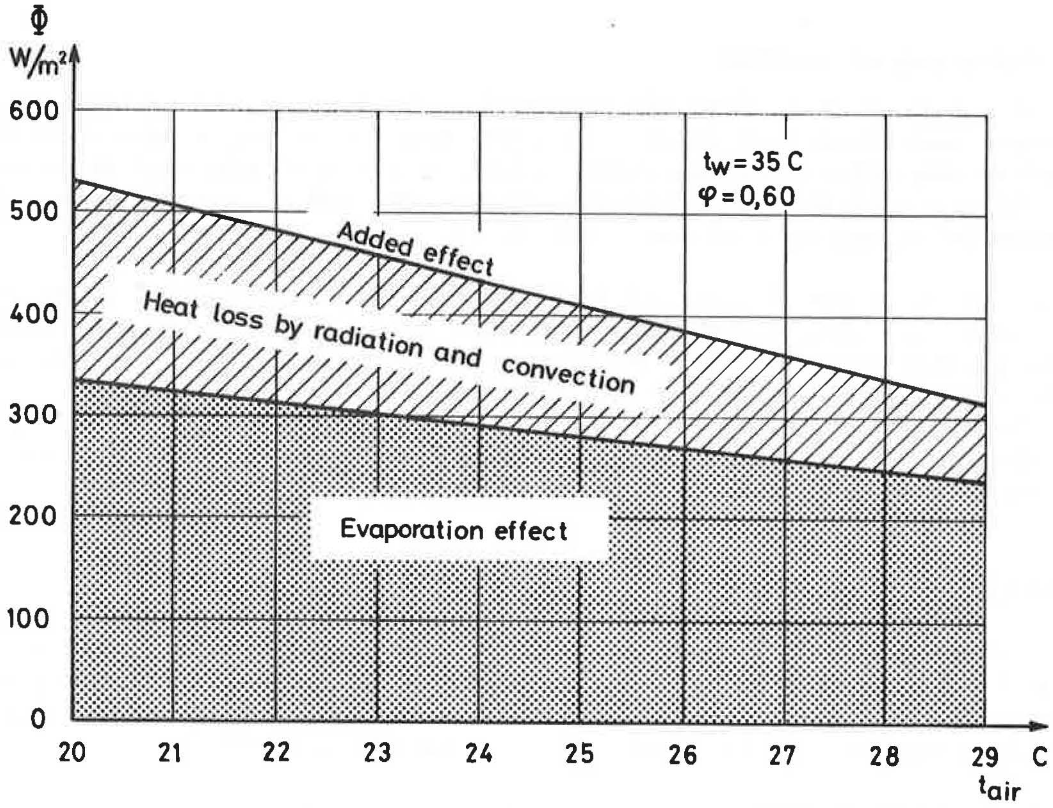

Fig. 15. Water heat balance at 35 C.

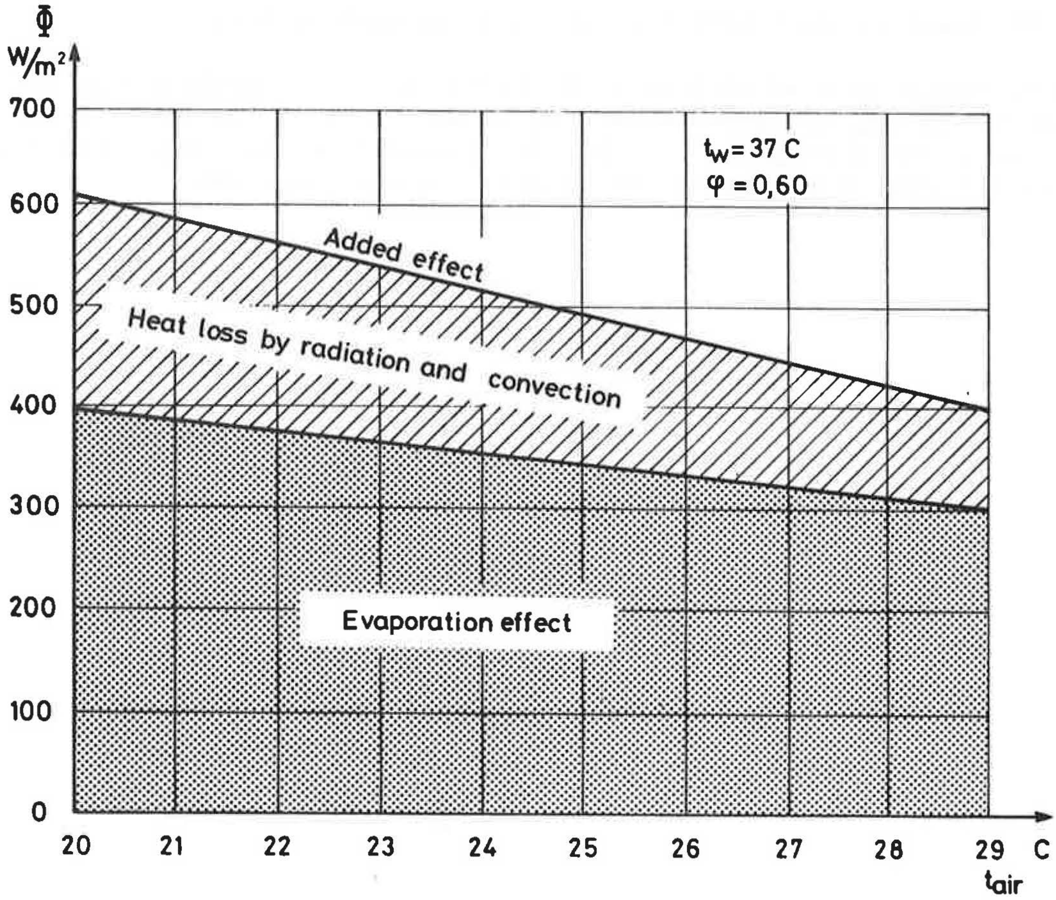

Fig. 16. Water heat balance at 37 C.

2.3. Valuation of results

Fig. 11 can be used to find the evaporation from a retraining bath. You might want values at lower velocities but the strong evaporation does not allow low velocities, so these values at v = 0.15 m/s must be reasonable. Also you might want other humidities, but 60% is resonable when energy consumption and moisture are considered.

If you are using the figures 12-16 to find out the necessary heating to the pool water, you must remember that in full-scale the heat loss by radiation can be greater than in the model where surrounding surfaces have had nearly the air temperature. If the surrounding surfaces have a temperature less than the air temperature you must correct for this by using the equation (3). Also in current cases the heat conduction from the basin must be calculated and added to the reading.

3. Full-scale measurements

It was planned to carry out measurings in three real swimming baths, partly to control the model results, partly to clarify the influence of the bathers. But difficulties in measuring airflow and humidity in the air supply and extraction did that only one of them was usefull.

3.1. Aars swimming bath

Briefing

Fig. 17 shows a sketch plan for the swimming bath in Aars.

The measurings in this bath were succesful. The only handicap was that measurings of the airflows could only be made with intake of fresh air i.e., no recirculating air, so that the humidity in the room could not be controlled when measuring of the evaporation was going on.

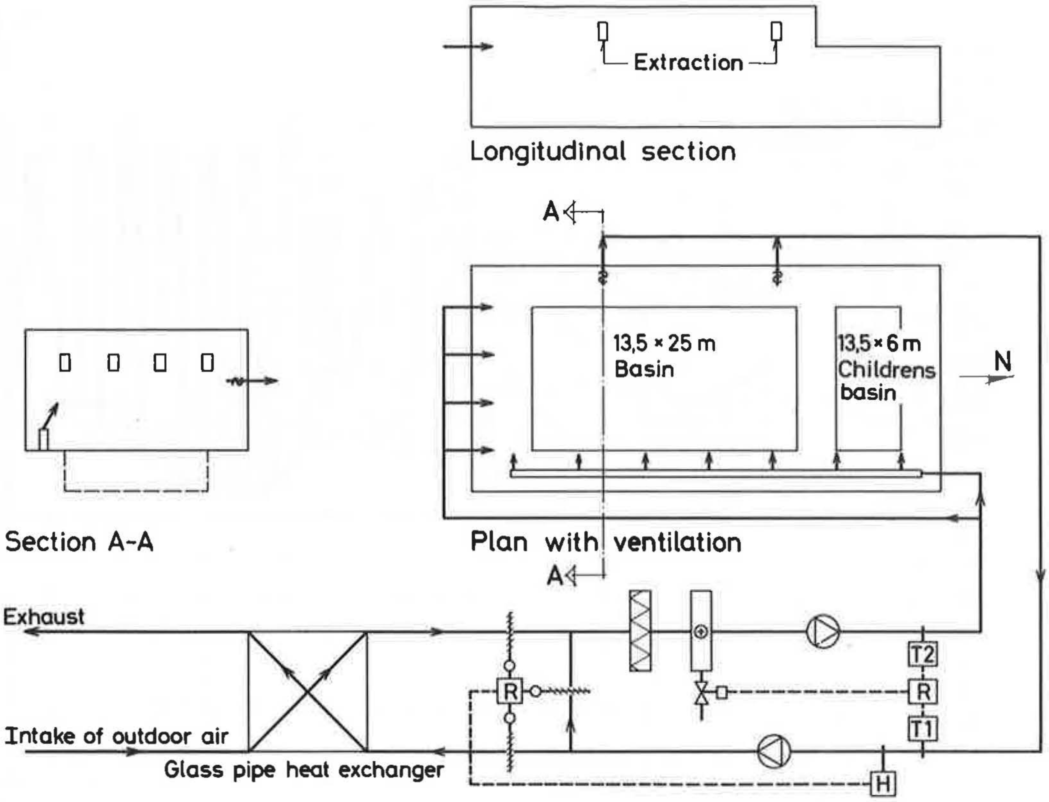

Fig. 17. Ventilation plan for Aars swimming bath. The flow of fresh air is controlled by the humidity probe H placed in the extraction pipe. The temperature in the room is controlled by the thermostat T1 placed in the extraction pipe, yet the minimum thermostat T2 is setting the lower limit to the inlet temperature.

Oscillation

However, the first measurings in this bath showed the same great problem as in the others. The inlet temperature was oscillating very much. And it was not the bathers who caused it. In fig. 18 you can see an example, made in a week-end, where the bath was not open to bathers. The temperature of the outdoor air was 10-15 C.

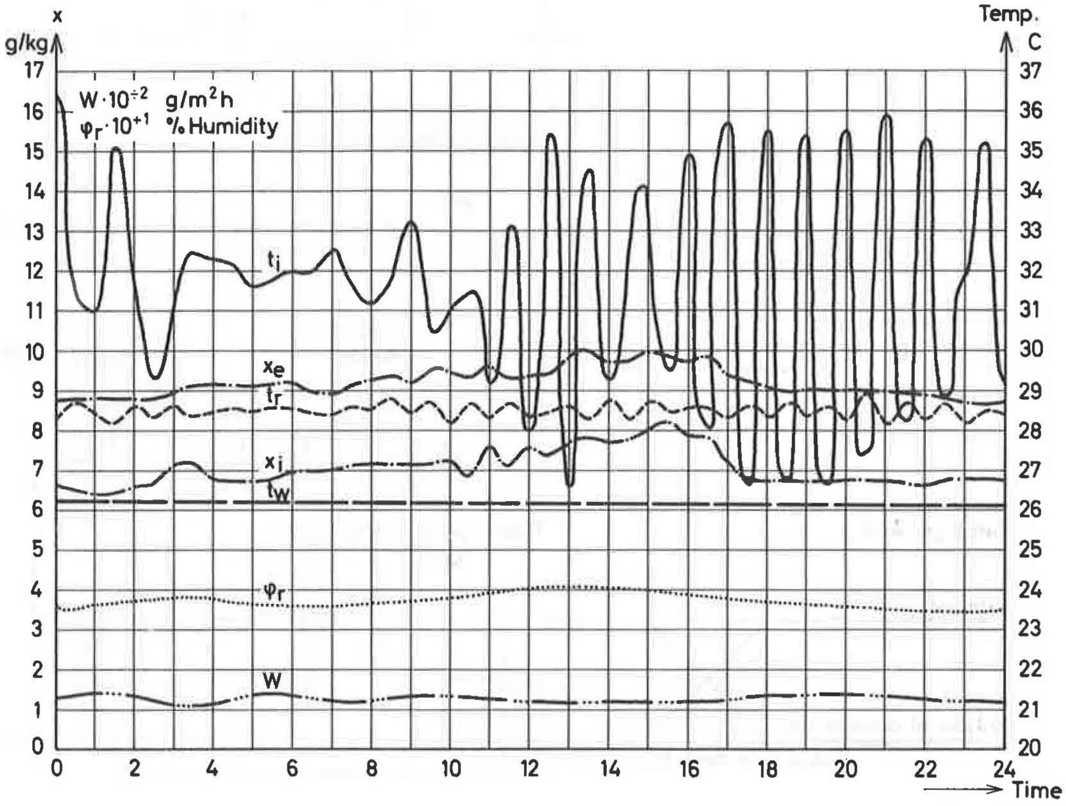

Fig. 18. Conditions in Aars swimming bath on a Saturday with no bathers and 100 % fresh air intake. t_w = temperature of the water, t_r = room air temperature measured 1.5 m above the water, t_i = inlet temperature, x_i = water content in the inlet air, x_e = water content in the extraction, φ_r = humidity. W = amount of evaporation.

Fig. 18 shows that the system can be quiet for example from 03.00 to 11.00 a.m. but then for one reason or another the system is oscillating. A slow oscillating with an oscillation time of about one hour is noticed just as it was the case in the other swimming baths.

From experiences with the model it was tried to stop this oscillation by raising $t_{i,minimum}$. The result was exceeding the expectations. The system was not oscillating any more with 100% intake if fresch air. To see if the system was in balance at normal running i.e. humidity controlled recirculation and night stop unless the humidity was too high this was tried too. One of the analog results is seen in fig. 19. Here is the reference for t_r = 29 C, and the reference for the humidity $_r$ is changed from 50% to 60% at 4.p.m. $t_{i,minimum}$ is set to 30 C.

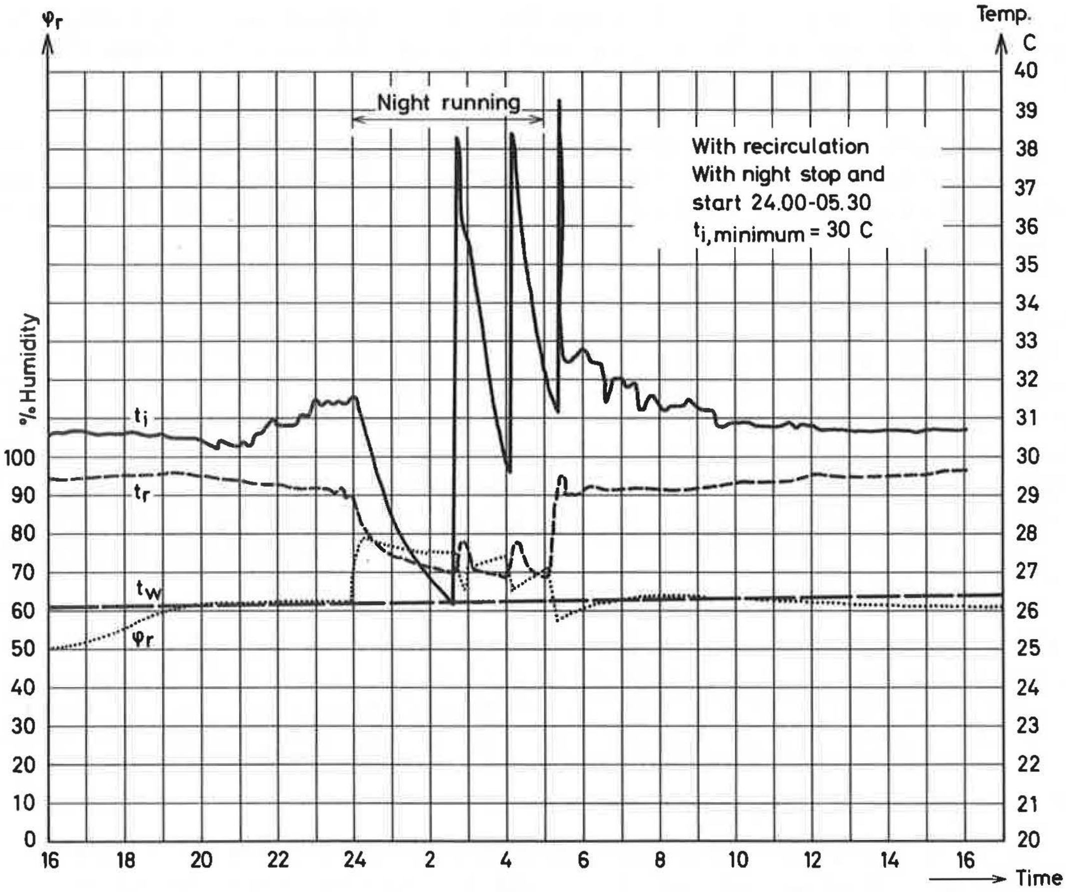

Fig. 19. Conditions in Aars swimming bath at normal running. t_w = water temperature, t_r = room air temperature 1.5 m above the water, t_i = temperature of inlet air and φ_r = humidity.

It is seen in fig. 19 that when the night running is started at midnight the room air temperature is decreasing as expected and φ_r is exceeding. t_i is decreasing because the probe is cooled by the surroundings when the ventilation is stopped. When the humidity probe is demanding ventilation start at 02.30 and 04.00 a.m. the inlet temperature of course is at maximum. When day run is started 05.30 a.m. the inlet temperature is starting at maximum but becomes quickly steady, even after this chock.

How oscillation is avoided

By other measurements is was clarified, that when the minimum inlet temperature was at least about two degrees above the room air temperature oscillations were avoided. The explanation of the pendling problem is: If t_i at decreasing load happens to get less than the room air tempereature, the air inlet is falling down because of greater density. This makes, no matter what type of inlet, in every swimming bath an increasing in air velocity by the water surface and hereby an increasing evaporation. The increasing evaporation causes a yet greater cooling of the room air. When the temperature control system is reacting the inlet temperature is increased, the air velocity at the surface is decreasing, the evaporation is getting less, the cooling of the air is decreasing and by this the room air temperature is increasing still more, and so on.

Of course many swimming baths will be able to get a better comfort and at the same time a decreasing energy consumption by using this discovery. The reaction to the first published report indicates, that the oscillation is a common problem.

The evaporation

In fig. 18 is seen, that the evaporation is 110-140 g/m^2h with no bathers. A comparison with the evaporation curves indicates a mean velocity at the surfaces a little below 0.15 m/s. Smoke tests were indicating a rather high mean velocity at the surfaces. After having reduced the airflow to 88% the evaporation was at first reduced to 90 g/m^2h at the same conditions as before. But with less evaporation the water temperature was increasing until $\Delta t = t_{air} \div t_w$ = about 1.5 C at $\varphi_r = 0.40$ while the balance condition was $\Delta t = t_{air} \div t_w = 2.5$ C at $\varphi_r = 0.40$ before.

So the evaporation could not be reduced so much as wanted because the water could not be cooled enough in spite of the water heat exchanger was stopped. An example of the same problem can be seen in fig. 19 where the water temperature is increasing in spite of the water heater is stopped.

3.2. Valuation of full-scale results

If you in a public swimming bath want a low evaporation, for example below 20 g/m^2h as shown in fig. 4, 5 and 6, you must cool the water in the basin. This can be done cheaply by preheating the tap water. Besides you must take care that the radiation to the surface of the water is as low as possible, and that the heating of the basin water caused by the filter circulation pump and underwater lights are not too large. So, just set op the energy balance to the water and cool it if necessary. If you are heating the water as usual, you are in fact increasing the evaporation and the energy consumption. A good advice is using $t_w = 26$ C and $t_{air} = 29$ C. $\varphi_{air} = 0.60$ in public swimming baths. And then you can avoid covering the water at night.

The evaporation caused by the bathers will depend on many things, among them the activity of the bathers and the water level in the basin. Our measurements indicated an enlarged evaporation caused by bathers, whether they were children or grown-up, of about 0.8 kg per visit. This number however must depend on the swimming bath, the conditions and so on.

4. Conclusion

The described results should hopefully cause radical changes in carrying out and run of swimming baths. It is remarkable that both investments and working expences can be reduced and in addition a better comfort to the bathers can be achieved. The following instructions are valid for public swimming baths and retraining baths.

4.1. Instructions for public swimming baths

Windows are unwanted in a swimming bath. If windows still are mounted they must be small and facing north or shielded, so that sunshine at the water surface is avoided. In this way you will achieve two things, reduced working expences and a possibility that the lifeguard can see the bottom of the basin.

Technical gallery all around the basin is a good thing. Inspection of installations and leakages in the basin are necessary. If ventilation pipes are following the technical gallery this is getting a temperature so that expensive floor heating of the platforms around the pool can be avoided. Besides floor heating pipes in swimming baths are corroded in a few years. Remember installation of floor drain in the technical gallery.

Water circulation. The inlets for purified water to the pool is placed about 20 cm above the bottom, also in the deep part of the basin. In this way you can achieve very small temperature differences in the water and a good stirring. Placing inlets just below the surface can give a bad stirring and temperature differences of 6-8 C in deep basins.

Heat exchanger for pool water. To heat the pool water for the first time will take about 7 weeks without heat exchanger but with ventilation and purifying pump running. So if you cannot accept this period you must have a heat exchanger for this first time heating. Later you must have a heat exchanger for cooling the pool water. This can be done cheaply by preheating the tap water. Automatic control of the cooling is not necessary because of the great volume of water in the pool, manual control is sufficient. The heat balance for the water in the pool will cause, that a wanted water temperature can be achieved by regulating the air temperature.

The ventilation plant is carried out with humidity controlled recirculation of air. An air to air heat exchanger outside the recirculation is normally a good investment. The inlet temperature can be controlled by a phial in the extraction pipe but with a minimum thermostat placed in the inlet. The minimum thermostat is set 2-3 degrees higher than the room air temperature.

The air change rate must ensure a good stirring of the room air but on the other side low velocities above the water surface is very important. So a tune up of the air change rate and eventually the air supply devices are necessary. Adjust the inlet temperature to its maximum in the winter case, add smoke to the ventilating air, and control that the smoke is distributed all over the room in a few minutes. In this case the stirring of the room air is sufficient but it can be too strong. Whether it is too large can be seen by measuring the air velocity above the water. But this is a difficult matter because of the changes with the place and time. A better way is to add smoke along the beach around the pool and thus estimate the air velocity. It demands some experience, but generally it is so, that if the air is moving promptly in the expected direction the velocity is too high. If the air sometimes is hesitating or moving up and down the velocity is suitable.

Adjusting temperature and humidity. With recording instruments measuring temperatures of water, air inlet, and room air respectively, and besides humidity the adjusting is easy. The room air thermostat is set to the wanted value and the minimum thermostat 2-3 degrees higher. The humidity can for instance be set to 60%. Control that the air inlet temperature is not oscillating and the minimum value is not passed. Without bathers the air inlet temperature shall be total quiet, with bathers it will move about 2-3 degrees if the system is not oscillating. Is the system oscillating quickly something is wrong in the control device. The proportional band can be too narrow or the integrating time too little. If the system is oscillating slowly with an oscillation time of 1-1.5 hours the minimum inlet temperature has to be raised. The temperature of the water ought to be at least 2-3 degrees below the room air temperature and this can only be reached by cooling the pool water. Do not think you will have to heat it!

So you could for instance chose these values for a public bath:

t_w = 26 C
t_{air} = 29 C
$t_{i,min.}$ = 28-29 C
φ_{air} = 60 %

This will give a good comfort to the bathers (not to the lifeguard if he/she is wearing too much clothes).

4.2. Instructions for retraining baths

Some of the things said about public baths cannot be used about retraining baths. In this case you must heat the pool water to achieve high temperatures of the water without raising the air temperature. But as seen in the figures 12-16 it is still a good idea to have a relatively high temperature of the room air for example 29 C. It is still a bad idea to lower the air temperature to save energy because the heat conduction through the climate shield does not mean so much as the evaporation. Therefore, it is a better idea to keep the air temperature and to stop the heat exchange to the water in periods, where the pool is out of use. As cooling down and reheating are taking time, this can only be done for longer periods. Perhaps it would be a good idea to cover the water at night, and it will probably be profitably to use a heat pump to dehumidify the room air and return the heat effect to the water.

So in the case of a retraining bath you can use fig. 11 to get the evaporation and the figures 12-16 to get the necessary heat effect to the water. Correct this effect to your case, choose a suitable ventilating plant and suitable conditions, and adjust the system. This last thing is the most important, just as it was in the case of a public swimming bath.

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