EUSA DRAFT PAPER

HEATING OF DOMESTIC OUTDOOR SWIMMING POOLS

INTRODUCTION

1. There are no general EU regulations and standards for outdoor swimming pool heating. Local regulations in the member countries are covering most part of the entire subject and requirements, but often guidelines do not following new technologies and developments especially on the field of energy management.

2. The temperature requirement in a swimming pool will depend on a number of factors such as use of the pool; cost considerations, personal preference etc. Therefore it is essential that this temperature requirement is set by the specifier or end user at the design stage

3. It is essential to understand that a well engineered heating system for an outdoor swimming pool using heat pumps, solar energy etc. significantly reduces operating costs, and reduces the environment-pollution. Additionally the use of a heat retention cover will add to this saving of energy and naturally energy costs.

4. **The aim of this paper is to provide accurate technical recommendations for the water heating of domestic pools.**

TERMS AND DEFINITIONS

a. Temperature measured in °Celsius [°C] or in °Kelvin [°K]
b. Heating capacity or heat loss in Watts [W]
c. Filling water: ordinary tap water or pumped well water complying with local rules and regulations used for filling up the pool.
d. Pool water: water kept in the pool for bathing and complying with local rules and regulations in terms of quality and temperature
e. Pool-water heater: equipment used for pool water heating where the heating medium is water, electricity, heat pumps or solar.

POOL WATER HEATING

5. The pool water requires heating in two circumstances:
   a. during the initial heat up, if the filling-water is not coming from a natural hot spring,
   b. when due to the ambient temperature and relative humidity in the air surrounding the pool, the pool is loosing heat as a result of evaporation, radiation, convection and/or conduction.

Filling water heating

6. The size of the pool water heater is determined among others by
   - the required pool temperature
   - the pool volume
   - the permitted and required heat-up time
   - the fact whether the heat-up is continuous or periodical (i.e. cheaper evening tariff for heating with electricity or with heat pump).
   In case of heat-pump-only or solar-only heating systems the sizing depends also on available energy resources, available equipment size.

Pool water temperatures:

7. It is well to bear in mind that chlorine is used rapidly to cope with the increase in micro organisms caused by the heat and thus chemical costs will rise proportionately, as will energy costs.

Heat up times:

8. Heat up times for any type of pool can vary depending of the owner's requirements and the available water heating method

9. Calculation method for total heating required:

$$\text{Heater (output) size (kW)} = \frac{M^3 \times 1000 \times (T2C - T1C)}{H \times 860}$$

Where T2C = required swimming pool temp ^{0}C

a. T1C = initial water temp from table (1)
b. M^3 = volume of pool
c. 1000 = weight in kgs of $1m^3$ of water
d. 860 = number of kilo calories per kW/hr
e. H = desired warm up time

Heat loss of pool water during operation

10. The exact heat demand is determined by the difference between the heat losses and the heat gains.

11. Heat losses:
    a. Volume of the pool, depth and surface area
    b. Required pool temperature vs. ambient air temperature
    c. Heat-radiation from the water surface
    d. Heat loss due to evaporation
    e. Convectional loss from the water surface
    f. Conduction loss via pool wall construction
    g. Top-up water heating-up requirements
    h. Heat losses via water features
    i. Heat loss upon uncovered pool
    j. Whether the pool shell has been built in or above the ground.
    k. Effect of a water table (moving or static) and inadequate drainage around the pool
    l. The degree of site exposure (prevailing wind direction etc).
    m. Lack of exposure to direct sunlight.

12. Heat gains:
    a. Solar gains.
    b. Top-up water temperature (in case of hot springs).
    c. The heat gain of the outdoor pool depends significantly on the geographical location, sheltering, clouding, time of the day, and season.

13. Heat balance:

Q_{hr} = $Q_{tl} - Q_g$ (W)

Where Q_{hr} = heat demand for pool water heating (W)
Q_{tl} = heat losses (W)
Q_g = heat gains (W)

General design considerations for outdoor pool heating

14. There are significant differences establishing the heating system in case of outdoor pools depending on the climatic conditions (Continental, Mediterranean, etc.)

15. It is generally accepted that outdoor pools built within northern latitudes will require a form of heat input in order for the pool water to be maintained at a comfortable temperature throughout the anticipated swimming season.

16. In case of Continental climate, where the temperature can be well below frozen point, in winter the water level has to be lowered and frost-bodies are to be applied. All pipelines above frost line and outdoor plant-rooms are to be de-watered before the winter period.

17. Due consideration must be given to winterisation by fitting breakable couplings to disconnect the heating during the winter. Alternatively frost stats should be fitted to ensure water is constantly passing through the heater when outside temperatures fall below 3^oC. If this method is adopted, it is important to ensure that the pool water chemical balance is maintained throughout the winter.

18. Heating systems should be installed such that they do not restrict the pool water flow below design turnover rates. If necessary an auxiliary pump should be fitted.

19. Boilers and electric flow heaters should be fitted with a suitable pressure valve set at 2.1 kg/cm^2.

20. Thermostats used to sense pool temperature for the purposes of controlling a heater should have a maximum differential of 1^oC.

21. Wherever possible heaters should be positioned as close as practical to the pool filtration equipment. However this should not compromise noise, heater efficiency and accessibility.

22. In the event that a heater is below the level of the pool:

23. Isolating valves must be fitted such that maintenance can be carried out without draining the pool.

24. If in a plant room, a submersible pump capable of delivering water at a rate equal to the full bore flow of the main pump must be fitted.
25. Where a heater is connected to flexible pipes, the heater must be firmly fixed to a solid foundation.

26. Pool chemicals must not be stored in the same space as an atmospheric flue boiler. Due considerations must be given to the corrosive and toxic nature of chemicals such that controls, heaters and other associated components are not affected by chemical vapours.

27. Heaters must not be run until fully commissioned in accordance with manufacturer’s instructions.

28. **It is important to establish client’s expectations of temperature and swimming season before offering a specific heating system.**

29. **<u>Any chosen system must be compatible with swimming pool water and installed to manufacturer’s instructions and relevant standards.</u>**

HEATING EQUIPMENT

30. There are five commonly used systems to provide outdoor pool heating. Each system has differing characteristics, installation requirements and sizing methods.

Fuel Fired Heaters – Gas Heating

31. Gas heaters fall into two categories:
    a. direct swimming pool heaters where the pool water flows through the boiler,
    b. central heating boilers (indirect), which are connected to the pool water via a secondary heat exchanger.

32. Gas boilers should only be installed/services by registered and certified installers.

33. Direct boilers are normally supplied with thermostatic control. Indirect boilers will require a control scheme to be designed for the specific site requirements. As a minimum this will include a pool water temperature sensor to control the boiler/primary water flow.

34. Gas boilers should be connected to the pool filtration circuit via breakable thermal couplings with the following considerations:
    a. Correct pool water flow
    b. A flow switch to stop the boiler in the event of low pool water flow
    c. If an automatic chemical feeder is used, installed within the system such that concentrated pool chemicals cannot enter the boilers heat exchanger.
    d. Be installed with service access in mind.
    e. Be provided with isolating valves and a bypass for servicing.
    f. Be installed for convenient winterising.

35. If boilers are sited in a plant room, the room must be ventilated to manufacturer's recommendations. The plant room should also comply with national regulations for rooms containing boilers.

Fuel Fired Heaters – Oil Heating

36. As with gas heaters, oil fired heaters are available in either direct or indirect configuration. The design considerations mentioned above are relevant to oil boilers. Specific appliance installation needs should be referred to the manufacturers installation/servicing instructions. In the event that an existing house heating system is linked to a pool heat exchanger, priority should be given to the house heating/hot water. It is also important to establish that the existing heater is compatible with the pool-heating load.

37. Fuel Fired Heating Sizing

38. Fuel fired heaters are normally sized to heat pool water from cold to design temperature in a prescribed time.

$$Q_{HO} = \frac{M \times 1000 \times (T_{2C} - T_{1C})}{H \times 860} \text{ (kW)}$$

Where :

a. Q_{HO} = Heater output (kW)
b. T_{2C} = required swimming pool temp (^{0}C)
c. T_{1C} = initial water temp from tap (^{0}C)
d. M = volume of pool (m^3)

e. 1000 = weight in kgs of $1m^3$ of water
f. 860 = number of kilo calories per kW/hr
g. H = desired warm up time (hours)

Notes

39. These calculations assume the pool is covered during heat up. For uncovered pools or pools sited in a water table, multiply heater output by 1.4.

40. There is a significant difference between heater input and output capacities. When selecting an appropriate heater, ensure manufacturer's output date is used.

41. Fuel fired heaters are normally sized to heat pool water from cold to design temperature: see 3.1.3

Electric Heating: Electrical Resistance Heating

42. Electrical resistance heaters are normally of the direct type encompassing a heater element, which is compatible with swimming pool water. Installation into a pool filtration circuit carries the same considerations as fuel fired heaters.

43. It is important that the proposed site has an adequate electrical supply to cater for the heater and due consideration is given to cable sizing between main supply and plant room. All electric heaters must be installed in accordance with current national regulations

Electrical Resistance Heater Sizing

44. These heaters are normally sized to provide the pools daily heating needs during nighttime tariffs. In selecting an electric heater the surface area of the pool, the temperature required, the months of use and hours of low cost electricity available establish the required heater size.

45. Electric heater size in kW = $\dfrac{M^2 \text{ x (kW/hrs/}M^2\text{ max loss per 24 hours)}}{\text{Hours of low cost tariff}}$

46. Electric Heating: Heat Pumps

47. Heat pumps are usually electrically driven but differ from other dynamic heating devices by providing most of their heat output from energy they have recovered from a low-grade source. Depending on geographical condition (Mediterranean, Continental, mountains or plane, etc) two basic type of heat pumps can be considered for pool heating:

    a. air-to-water, where the heat content of the environmental air is utilized (most common, as relative low investment).

    b. water/soil-to-water, where wells up to –100m depths are bored, or coils are laid into the soil in a depth of –0,5 to –3,0 meters for utilizing the heat-gain from the earth (more efficient, but high investment).

48. Heat pumps are characterized with the COP-value (Coefficient Of Performance): it's the ratio of the heat output and the electric power input, both measured in Watts or Kilowatts. A heat pump is efficient if the COP value is higher than the ratio of the electricity price/kW hour vs. gas/oil price/kW hour.

49. In case of a good quality heat pump, the COP value is depending of air/soil temperature as well of the air humidity: the higher the values are, the better the COP becomes.

50. Installation considerations are as electric flow heaters. Consideration for airflow through the heat pump must be taken into account. If installed within a plant room, the room should be ventilated and air discharged from the heat pump should be rejected directly outside. The heat pump will also require a condensate drain to waste. Heat pumps are often sited outside. Under these circumstances they should not be sited such that air, which is drawn through them, can recirculate.

Heat Pump Sizing

51. Heat pumps are usually sized to allow for the average pool heat loss over the coldest month of operation.
52. For correct sizing see the local available Handbooks or Software or contact local suppliers. The correct formula requires the knowledge of dozens of factors, like height above see level, max/min/average temperature, humidity, wind velocity, etc.

Solar Heating

53. A solar heating system will provide a means of passively heating pool water by harnessing energy from the sun. Solar collectors are connected to the pool filtration circuit such that water flowing through them is heated as a result of their ability to absorb energy from the sun. Solar heating systems fall into ‘direct’ and indirect categories. In both cases a control system must be used, preferably automatic. It is important to understand that the control of solar heating systems is more complex than other systems and should be designed such that; the collectors will not act as emitters. It is advisable to consult with the collector manufacturer before choosing a suitable means of control.

54. There are two types of solar collectors:

    a. Glazed solar collector (high pressure and high temperature)
    b. Unglazed solar collectors (low pressure and low temperature)

Location

55. The location of collectors is critical to their performance. For maximum output they should be sited in a sheltered area facing between 30^{o} east and 40^{o} west of the south. They should be inclined from the horizontal between 20^{o} and 50^{o}
56. It should be noted that in some countries planning permission may be required and that installations should take into account wind and snow loadings.

Sizing

57. It is virtually impossible to practically calculate the size of the panel needed to maintain a specific pool temperature. It is generally accepted that the following factors will provide a comfortable temperature between May and September providing a pool cover is used.

Location	Ratio of collector area to pool area
Sheltered	0.5
Exposed	0.8

58. Should it be deemed necessary to hold constant pool temperatures throughout the swimming season, it is advisable to fit an auxiliary form of heating, controlled to operate during times when the solar heating cannot maintain conditions.