POOLSENTRY

Technical Note PSTN01

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A Conceptual Framework for the Evaluation of the Design of Pools with High-Flow Features

Introduction

High-flow features need to be supplied with good quality, well-treated water. Whilst this is important generally for water that bathers are exposed to, many high-flow features will create aerosols which can increase likelihood of transmission of pathogens, thereby making the need for well-disinfected water even more critical when these features are present.

In terms of water quality, the ideal solution would be to supply the features with treated water direct from a water treatment plant, either by diversion of a proportion of the water being returned to the pool tank going to the features, or alternatively for the features to have their own independent treatment plant. However, both are expensive solutions in terms of both capital cost and maintenance. The former requires that the pool water treatment system has adequate capacity to cope with the extra flow, with implications for capital cost (particularly with respect to provision of sufficient filter and UV sizing) and the consequences for ongoing costs for servicing and backwash water costs.

If it is uneconomic (or not viable for other reasons) to supply high-flow features with water direct from a water treatment plant, then the alternative is to take water from elsewhere in the pool circulation system. The purpose of this technical note is not to promote any type of design, but to illustrate how a conceptual framework based on fundamental concepts (such as the distribution of residence time of water passing through the system) can be used to evaluate pool design where features are not supplied with water direct from a treatment plant.

Options and underpinning principles

We will consider two options, which will illustrate some general principles and considerations:

1. Water taken direct from the pool tank.
2. Water taken direct from the balance tank.

Before considering each these options, there are some general points that need to be considered.

a. If there is no provision of additional water treatment capacity to provide treated water to features, then the number of bathers that can be safely sustained will be the same as if the features were not present; this should be equivalent to at least 1.7 m^3 of treated water per bather being supplied by the water treatment system. This requirement is stated in PWTAG guidelines[1], and has been supported by recent research by Pool Sentry which describes the scientific underpinning ot the relationship between circulation rate, bathing load and water quality (Simmonds et al, 2021)[2].

b. With most high-flow features, the amount of water flow through the feature per bather using the feature ('feature user') is likely to be sufficiently high that there is only a small depletion of chlorine from the water passing through the feature (e.g. a flume, a water jet or tipping bucket). Hence there would not normally be any reason to operate the feature water at a different level of disinfection to the remainder of the pool. If the nature of the feature is such that this is not the case, then this could have significant implications for the design.

Option 1 Water taken direct from the pool tank

Advantages:

- Water can be drawn from the least contaminated parts of the pool tank (e.g. from floor outlets close to pool inlets) to encourage 'short circuiting' from the pool inlets to the feature supply pumps, and so have similar quality to the freshly treated water entering the pool tank.
- Water would need to be returned to the pool tank in order to preserve the quantity of water within the pool tank. However, it needs to be recognised in the design that there should be capacity to cope with a short-term water deficit in the pool tank when a feature is first switched on and charged with water.
- The circulation of water through the features will contribute to the mixing of water within the pool. This additional mixing should ensure little variation in disinfectant concentration around the pool.
- The good mixing with the pool water will provide some buffering against fluctuations in chlorine concentration at any location which will aid the control of a stable disinfectant concentration.
- The recent PWTAG *Cryptosporidium* oocyst survey (Chalmers at al, 2021)[3] indicated that there are frequent occurrences of measurable quantities of oocysts being shed into pools (albeit from asymptomatic bathers). Our modelling of the data indicated that a pool with several thousand bathers a day could have one or more 'shedding events' on most days. We can assume that the risk of water being delivered to features becoming contaminated with *Cryptosporidium* will be proportional to the residence time of water within the pool tank as it transits from the pool inlets to the outlets feeding the features. If the water was drawn from the pool tank, and the outlets to the features were located to minimise the residence

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[1] Pool Water Treatment Advisory Group. Code of Practice for Swimming Pool Water; Pool Water Treatment Advisory Group: Loughborough, UK, 2017. Available online: https://www.pwtag.org/code-of-practice/ (accessed on 26 April 2021).

[2] Simmonds L.P., Simmonds G.E., Wood M., Marjoribanks T. I. and Amburgey J.E. (2021) Revisiting the Gage-Bidwell Law of Dilution in relation to the effectiveness of swimming pool filtration and the risk to swimming pool users from *Cryptosporidium*. *Water, 13*, 2350. https://doi.org/10.3390/w13172350

[3] Chalmers RM, Simmonds LP, Wood M, Luxford M, Miller R, Johnston R. Occurrence of Cryptosporidium oocysts in leisure pools in the UK, 2017, and modelling of oocyst contamination events. Water 2021, 13, 1503. https://doi.org/10.3390/w13111503

time of feature water in the pool tank, then this residence time could be substantially less than would be for the case for Option 2 (taking water from a balance tank).

Disadvantages:

- It is necessary to use an appropriate design to maintain the velocity of water at the outlets feeding the features is below the maximum safe threshold and to ensure there is no risk of entanglement/entrapment.
- If the flow rate through the features constitutes a significant proportion (say 50% or more) of the circulation through the water treatment system, then the same proportion of the treated water entering the pool tank would be circulating through the features. If so, then the design would need to ensure water from the features is returned to the pool tank in a way that maintains satisfactory concentrations of disinfectant throughout the pool tank (e.g. returning water at multiple locations to ensure good distribution).

Option 2 Water taken direct from Balance Tank

Advantages:

- The outlets feeding the features are away from bathers, eliminating potential entanglement/entrapment hazards.

Disadvantages:

- The water in the balance tank will be the dirtiest water in the circulation system.
- If the pool is behaving as a well-mixed pool, approximately 37% of the water flowing into the balance tank will have been in the pool for more than one turnover (and 13% will have been resident in the pool for more than two turnovers).
- From what little we understand about the residence time of water in pool tanks and the timescale of mixing, in the event of a Crypto-shedding incident much of the water reaching the balance tank in the following pool turnover time is likely to be contaminated with oocysts.
- If water is being drawn from the balance tank, consideration should be given to treating the feature water supply with UV.
- Consideration needs to be given to where the feature water returns.
    - If it is returned to the pool tank (as will inevitably be the case with many features such as tipping buckets) then this will be recycling water from the balance tank back into to the pool. This has the effect of increasing the residence time of water in the pool tank, which to all intents and purposes is extending the turnover time. It would be a very interesting to model this process, particularly with respect to the removal of *Cryptosporidium* oocysts from the pool tank following a shedding event.
    - If water is being returned to the balance tank (e.g. a flume landing zone gravity-draining into the balance tank), then there is the risk of continuously recycling the same water, especially if the beaching of the pool is compromised which would reduce the throughput of water. This might be overcome by design (e.g. have ‘clean’ and ‘dirty’ tanks, and level controls to alert if tank water levels are low.

A need to model pool water residence time

Evaluation of the design of a pool with high-flow features would benefit from analysis of the impact of the features on the residence time of water. This should consider both the residence time of water through the pool itself as well as the composition of the water feeding the features with a focus on the time (and the exposure to bathers) since this feed water last passed through the water treatment system. This can perhaps best be imagined (and modelled) in terms of how long contamination from a single event (e.g. a Crypto-shedding event) remains in the pool, and for how long water supplied to the features is exposed to such contamination. An additional benefit of this approach would be that good hydraulic design in terms of minimising the residence time of *Cryptosporidium* oocysts would also be good design for the removal of other contaminants that are removed by filtration.

Contact us

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