BHR Group
EXPERTS IN FLUID ENGINEERING

CLEANING UP WITH DISINFECTION DESIGN SOFTWARE: OUR EXPERT OPINION

Fast and accurate hydraulic design of baffled chlorine contact tanks (CCTs) and service reservoirs possible with the help of DISINFEX, a design software solution.

Dr Mick Dawson, Engineering Director, reports on the development of DISINFEX software for flow modelling and rapid design of chlorine contact tanks and service reservoirs.

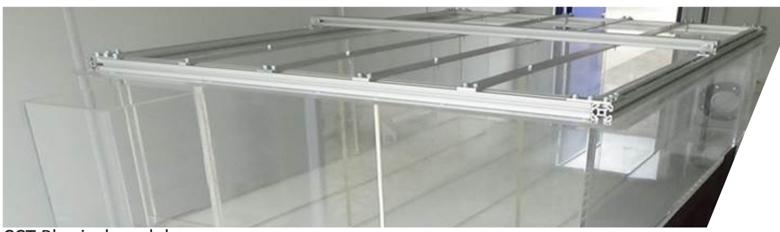
Fast and accurate hydraulic design of baffled chlorine contact tanks (CCTs) and service reservoirs is possible with the help of design software known as DISINFEX. BHR Group developed DISINFEX with partners Northern Ireland Water and Yorkshire Water.

CCTs are commonly used to provide the required contact time for chlorine dosed upstream of their inlets. The size and internal geometry of CCTs are critical in determining their efficiency. If contact times are too short, microbiological failures may occur, if contact times are too long THM formation will be promoted. THMs are potentially carcinogenic disinfection by-products currently regulated at 100µg/l. New European regulations may reduce the THM limit, to around 40µg/l.

CCTS are typically rectangular concrete chambers with single inlets and outlets. The theoretical residence time (contact time), t, of the water in the tank is simply the tank volume divided by the flow rate. If the water moved through the CCT completely uniformly as a piston or plug (ideal plug flow) every water molecule would remain in the tank for exactly the theoretical residence time. However, in practice very significant short-circuiting and dead zones occur due to non-ideal flow patterns. This results in a residence time (contact time) distribution (RTD).

The internal geometry of CCTs frequently includes one or more horizontal baffles to provide a serpentine flow path between inlet and outlet. Internal baffling can reduce the extent of short circuiting and dead zones, providing a RTD closer to ideal plug flow. Generally, the more horizontal baffles installed the closer the RTD approaches ideal plug flow. The CCT inlet design can also have a significant effect on the flow pattern and RTD. Engineers designing CCTs need to compromise between volume, baffling and inlet design. The most efficient CCTs are those with well designed inlets and baffles resulting in the minimum volume (and hence cost) required to achieve the desired contact time.

The minimum contact time in relation to an RTD is often defined as t_{10}. This is the time taken for ten per cent of a pulse of fluid injected at the inlet to arrive at the outlet and corresponds to the first ten per cent of the area under the RTD curve. The use of t_{10} is conservative as 90 per cent of the fluid leaving the CCT has a greater contact time.



CCT Physical model

In practice, RTD curves can be determined by physical measurement or computational techniques. Physical measurements can be carried out on existing full scale CCTs or on scale models of existing or planned CCTs. A tracer is injected as a pulse at the tank inlet and the tracer concentration recorded against time at the outlet. Although tracer tests are accurate they are very time consuming, especially when variations in internal geometry and flow rate need to be evaluated. Several man-days are typically required for RTD measurement on one CCT.

RTD predictions can also be made using three dimensional CFD simulations which divide the CCT volume into a large number of cells. Once boundary conditions are set, mass, energy and momentum equations are solved for each cell throughout the tank. CFD simulations require specialised operator skills and dedicated hardware and software. Again, several man-days of effort per CCT is likely, making widespread use of CFD modelling expensive.

DISINFEX was developed to provide a quick and easy tool for water industry users to assess baffled CCT and SR hydraulics. The software does not require any in-depth training or fluid dynamic skills. The overall goal of the software is to optimise the tank dimensions, number of baffles and inlet arrangement (hence minimise capital cost) to achieve the desired contact time and to have confidence that the chlorine residual and outlet THM levels are within acceptable limits.

OUR EXPERTISE

BHR's expertise is founded on 20 years of research and consultancy specific to water & wastewater mixing.

Our team of experts understands the challenges facing the water industry. We work hard to make measurable improvements to new and existing facilities through our core skills of physical and computational hydraulic modelling, chemical dosing and mixing, troubleshooting, design validation and optimisation.

Developed using CFD modelling, DISINFEX is based on the concept of constructing the overall tank RTD from two or more RTDs generated for individual channels. DISINFEX supports a database of RTDs for inlet channels, second channels, standard channels and outlet channels. For each channel type RTDs are stored for different channel length to width (2-10) and depth to width (1.5-0.275) ratios. Six inlet types and five outlet types (weirs, various orientation bellmouths, horizontal pipes) are covered. Individual channel 'building block' RTDs are combined using a mathematical procedure called convolution. The resulting RTD is then scaled to the required flow rate between 1-100+ Ml/d.

Users enter the design characteristics, number of channels, flow rate, required contact time in a physical data sheet. A RTD is then generated showing the required contact time. A table containing specific time events associated with the RTD can also be displayed. Two RTDs can be plotted together for comparative purposes and RTD data can be exported to Excel spreadsheets for further analysis.

Models for chlorine decay and THM formation which can be applied to previously generated RTDs are also featured. The user enters a range of inlet free chlorine concentrations and corresponding decay coefficients to enable a curve showing inlet vs outlet chlorine concentration to be plotted. THM levels can also be estimated following input of TOC, pH, UV absorption, temperature and bromine concentration data. The resulting curves show the range of chlorine doses required to achieve a minimum chlorine residual at the outlet and to avoid exceeding the THM limit.

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BHR Group **TEL**: +44 (0) 1234 750 422 **EMAIL:** info@bhrgroup.co.uk **www.bhrgroup.com**