Off-Grid Institutional Pool Treatment System Design for the Cambodian Children’s Fund

Jamie M. Croft, Daniel R. Ferguson, and James A. Lix

Abstract. This paper discusses the design of an off-grid pool treatment system for the Cambodian Children’s Fund for their Kid’s Camp in the Kâmpóng Cham province of Cambodia. Consulting World Health Guidelines (WHO) guidelines for safe recreational waters, disinfection, filtration, and circulation systems were designed. The system consists of 4 pumps, each coupled to a cartridge filter, a chlorine dosing unit, 4 solar tracking units, and 2 battery banks. Anticipated material and operating/maintenance costs for the system are $100,000, and $4,000 respectively.

Key words: off-grid pool, recreational water treatment, pump head loss, PV power generation

1 Introduction

The Cambodian Children’s Fund contacted the University of Guelph, School of engineering seeking a water treatment system design for a pool they had previously constructed at their Kid’s Camp in the Kâmpóng Cham province of Cambodia. The pool had an expected maximum occupancy of 50 children, primarily on weekends, and on occasion throughout the week. The existing pool structure was too large (750 m$^2$) for its intended use and did not include any circulation piping. The pool required a complete water treatment system. The system was designed to be site specific, while reliably maintaining World Health Organization (WHO) standards for water quality. The design could not rely on existing electrical power, requiring its own source for energy generation. While meeting these constraints, the team minimized capital and operating costs, and used locally available resources for a system that could be easily integrated and would be simple to operate for the end user. For the design it was assumed that the pool volume could be reduced if required, and that solar insolation at the site was consistent with NASA’s Atmospheric Science Data Centre.

2 Conceptual Design/Methodology

Initially the team evaluated available technologies for the energy generation, filtration and disinfection. Solar, wind, and diesel were considered to be possibilities for energy generation. A number of filter technologies were explored including slow and rapid sand, clay, cartridge, diatomaceous earth, and membrane filtration. The suitability of chlorine, salt, and ionization disinfection systems were also investigated. After evaluating each technology component against the listed constraints and criteria, a solar powered cartridge filtration system was specified. It was determined that the available energy was the limiting factor, and it quickly became apparent that pool volume reduction was necessary. With consideration of the maximum expected bather load and the necessary circulation energy requirements, a final pool volume of 225m$^2$ was found to be optimal in terms of cost. It is recommended to reduce the pool volume to this level. The following design assumes a 225$m^2$ pool volume. Automated chlorine dosing was specified to ensure operator safety and minimize pool maintenance requirements.

3 Detailed Design

3.1 Water Circulation

Water circulation through the treatment system will require four 48VDC Lorentz PS600 BADUTOP 12 pumps working with a 7m head loss and flows of 9.2m$^3$ per hour for each pump[2]. Two 50mm inlet suction lines, 5m long will remove untreated water from the pool’s deep end through prescreening filters via one meter deep inlets. A third 50mm line from the shallow end will direct water through a prefilter to two of the pumps. Due to head losses from the 20m suction line and associated fittings, two pumps are required on this line to maintain a daily flow volume of 675$m^3$. Each pump will discharge directly through a separate cartridge filter assembly and into a 76mm header feeding back to the pool. Six 25mm discharge lines and nozzles will direct clean water from the header back into the pool in a clockwise direction to ensure thorough mixing of untreated and treated water. Figure 1 shows the sequence of components used to treat the pool water.

3.2 Filtration

Hayward SwinClear large capacity cartridge filters will remove suspended solids as small as 10 micron from the pool water at flow rates up to 19$m^3$ per hour. Each cartridge unit holds 4 re-usable filter elements with a total effective filtration area of 21m$^2$ and a maximum head loss of 0.21m[5]. The filters are removed and manually
cleaned using clean water and require no backwashing system which conserves valuable water resources. Large capacity filters are required to minimize maintenance of filters to every two to three months depending on water quality.

3.3 Disinfection

Liquid sodium hypochlorite (12.5% NaOCl) and muriatic acid (for ph adjustment) will be injected in-line using the DULCODOS DSPa metering system (produced by Prominent Technology Inc.)[4]. The four main components of the dosing system include the controller, metering pumps, chemical analyzers and containment. The controller uses PID control to translate flow, pH and chlorine residual information into an injection rate. The metering pumps can supply 1.5L/hr of liquid sodium hypochlorite, which was determined to be the maximum system chlorine demand (approximately 190g/hr equivalent Cl₂). The injection point will be located on the 76mm discharge header (following the filters) against a maximum backpressure of 70kPa. The chemical containment will include two 1000L polyethylene containers with secondary containment provided for safety against spills. The power requirements for the dosing system will be 114W with a 1A draw. The equipment runs on 230V AC (50 Hz) which requires power inversion from the DC battery bank. Cyanuric acid (as chlorine stabilizer) and sodium bicarbonate (for Alkalinity) will also be added periodically to achieve appropriate disinfection.

4 Discussion

The most challenging (and expensive) part of this project is supplying the energy requirements associated with circulation. The original 750m² of water would have incurred even larger energy demands, effectively eliminating solar energy as a viable option. Wind and diesel power generation also proved to have high capital and operating costs, respectively. Pool volume should ideally be established based on available energy. The overall equipment cost of the design is $100,000 with $75,000 allocated to the solar energy system. After comparing alternative energy generation methods PV power and storage was determined to be the most cost effective.

Future work on this project should include investigating the possibility of extending the existing power grid to the site. Landscaping of the site to reduce exposed topsoil and solids loading to the filters should also be considered.

References