TECHNICAL DESCRIPTION FOR DETAILING SWIMMING POOLS AND WATER GAMES

SPORTS BASE AND AMUSEMENT PARK
DIVERTILAND WATER PARK

1. GENERAL

The scope of this report is to present and describe the technical solutions selected in order to cover the needs of filtration, water treatment and disinfection of pool and water features for the Chiajna water park.

The expected result is water of the highest quality at reasonable running and maintenance costs. All materials employed in the project should be of high quality offered by specialized suppliers with all required documentation and the appropriate CE, EN and ISO standardization.

For the current report we have taken into account:

- The project description and all relevant clarifications given by the project technical consultants.
- The characteristics of the area of development.
- The current legislation. The pools and water features should be constructed in a way that covers all international design and manufacturing norms for installations of this type, namely, DIN 19643, PAS 39:2003 / PWTAG 1999. In addition we consider as precondition the convergence with the local and European norms EN 15288-1:2008 EN 15288-2:2008.
- Additional requirements on equipment and installations are:

  Romanian legislation on electrical installations (high and low currents).
  Romanian legislation on plumping installation.

2. INSTALLATIONS

2.1. Recirculation design

2.1.1. Pool types

The geometric characteristics (size, shape, depth) of all pools are evident on the attched drawings. All operating characteristics are briefly described as follows, while their basic elements are referred to in table 1.

- **Group W:** Is a swimming and wave pool, thus, apart from its filtration and disinfection system it also includes wave generation equipment.

- **Group L:** Is an artificial river. Besides the filtration and disinfection systems it also includes artificial water flow equipment towards a specified direction.

- **Group B & C:** Are pools that include water slides. The water flowing in the slides is from a different piping and pumping network to the filtration system.

- **Group K & R:** Are shallow pools used mostly by children (toddlers). They include water games which operate independently from the filtration and recirculation network. Especially in Group R, water treatment takes place from the balance tank.
- **Group A & S:** Are wet slab type water features. Water is supplied to the outlet nozzles flows directly to the balance tank. Finally, water treatment takes place directly from the balance tank.

2.1.2. Sizing and operating principles

All calculations for the recirculations are according to the German norm DIN 19643. Recirculation rates are calculated as follows according to the type and the operating characteristics of each pool:

Swimming pools of Group B & C are shallow and expected to contain high loads from bathers. For these pools the nominal requirements for water recirculation (DIN 19643-1 table 4).:

$$Q = \frac{0.37}{m^2 \times h} \times \frac{A}{k} \qquad (1)$$

where A is the water surface area (m^2)

k the pool load(0.5 m^{-3})

Thus, Q = 0.74 X A (in m^3/h)

To the above nominal requirements 35m^3/h/slide is added to result to the final rate.

Loads for pools of Group L are in fact a lot less since the available water surface area / swimmer is 4.5 m^2. Thus, we suggest recirculation that is calculated according to the following equation:

$$Q = \frac{0.222}{m^2 \times h} \times \frac{A}{k} \qquad \text{where A is the water surface area } (m^2) \qquad (2)$$

k the pool load(0.5 m^{-3})

Thus, Q = 0.44 X A (in m^3/h)

The wave pool (Group W) is of variable depth. For the part that has depth ≤ 1.35m recirculation will be according to equation (1), while for the rest (2).

The recirculation of toddler pools (Group K & R) is calculated with significantly smaller turnover (30 min) and calculations are according to (DIN 19643-1 table 4):

$$Q = 2 \times V \quad \text{in } m^3/h \qquad (V\text{: water volume in } m^3) \qquad (3)$$

Finally, recirculation and water treatment for the balance tank of the wet slabs (Group A & S) is to take place with turnover lower than 30min.

Recirculation for all pools and water features in this project takes place via balance tanks to be constructed according to the attached drawings. The balance tanks are situated in the technical rooms. Sizing of balance tanks will be according to DIN 19643-1 par. 9-5:

$$V = V_V + V_W + V_R$$

Where:

$V_V = 0.075 \times A/\alpha$

$V_W = 0.052 \times A \times 10^{-0.144\, Q/L}$

V is the active water volume in m^3.
V_V is the displaced water volume from swimmers m^3.
V_W is the capacity of the overflow network m^3.
V_R is the required water volume for backwash in m^3.
A is the pool are in m^2
α is the required pool are per bather in m^2
Q is the recirculation m^3/h
L is the length of the overflow channel in m

Each balance tank has a drain line as well as an overflow line. Filling is performed via an automated system consisting of a linear pressure transducer (sensor) and a solenoid electrically actuated valve.

Each pool has an independent sampling network (samples are taken from different points inside the pools). Sampling is performed according to DIN 19643-1 par. 11.4.1. Dosing of chemicals takes place separately for each pool.

Water recirculation for each pool will take place via overflow and balance tanks as well as through water inlets on the pool bottom.
After treatment water returns to the pool basin through outlets on the pool bottom (vertical flow). The design specifies 1 outlet per 6m^2 water surface area. Supply water outlets are not installed close to areas of return water inlets. Especially for the lazy river pool (Group L) water supply takes place through side outlets in a way that promotes river-like water flow.

Design and sizing of pipe networks is such that ensures the correct water distribution in all pool areas with no idle areas.

Recirculation pumps will be vertical type with cast iron impellers. Water flow will be regulated via an inductive type flow meters. The flow meters measure the true flow and feedback analogue signals to frequency converters which then regulate the pump frequencies.

Filters will be of horizontal type – multilayer (sand – hydro anthracite) with 1.2m filtration beds and free board according to DIN 19643-1. Filtration velocity will be 30m/h, while backwash velocity is approximately double. At times where the establishment has no guests the recirculation rates will be reduced to 50% of their nominal values (economy mode). Diaphragm type pressure transducers will be installed on the filter inlets and outlets, in order to monitor the filter load. Backwash will be automated via pneumatic actuators according to a pre-set schedule.

Data on all recirculations are given in table 1.

2.1.3. Filtration system specifications

Recirculation rates for each pools were specified previously. In all cases filtration velocities are 30 m/h. The total required filtration area is calculated according to the following formula:

$$\Sigma A_p = Q/v \qquad (\text{ in } m^2)$$

If N is the number of filters then the minimum filtration area and corresponding filter diameter is:

$$A_p = \Sigma A_p / N \ \ (\text{in } m^2) \qquad \text{and} \qquad D = \sqrt{\frac{4.Ap}{\pi}} \ \ (\text{in m})$$

Multilayer filters specified for swimming pools are designed and manufactured so that all operating specifications of DIN 19643 are fully met. In this project horizontal type filters are the preferred choice due their relatively smaller space requirements.

Manufactured from reinforced polyester of exceptional mechanical strength and varying diameters according to the requirements of every recirculation all filters contain specialized diffusers, top and side manhole, inspection side glass, air vent, drain and differential pressure sensors. The minimum operating pressure is 2.5 bar and the maximum test pressure 3.75 bar.

Filter operation (filtration, backwash, rinsing modes) will be automated via 5 pneumatic valves (per filter). All solenoid actuators for pneumatic valves will be 24 VDC. Air compressors with dryers and accumulators will be installed in each technical room in order to drive pneumatic actuators.

Filtration and backwashing will be according to DIN 19643-2 par. 4.5.

The total depth of sand will be 600mm while the total depth of hydro anthracite will be 600mm.

Table 1 gives the filter types to be used in the project.

- Filter type: Astral Rodas or equivalent
- Pneumatic type: EBRO or equivalent

2.1.4. Recirculation pump specifications

Recirculation pumps will be manufactured from corrosion resistant materials suitable for continuous operation. Pumps will be of vertical type with cast iron impellers will be cast iron. All pumps will incorporate pre-filters (stainless steel).

Pump selection will meet both recirculation as well as backwash requirements and where needed they will be driven via frequency converters. Flow set points will include recirculation, backwashing and economy operation.

Pump maximum operating pressure (static) will be 4 bar and should incorporate silicon carbide shaft seals (100% sealing).

Pump motors will be three phase, water tight with stainless steel shaft, protection IP 55, 50Hz frequency and maximum rotational speed of 1500 rpm, insulation ICL B according to VDE 0530

Pumps for water slides and other water features will be of the same specification driven through frequency converters.

The pump bill of quantities is given in table 1.

- Pump type: Herborner Unibad, Speck Badu Block or equivalent
- Flowmeter type: Burkert 8045 or equivalent

2.1.5. Pipe network design and specifications

2.1.5.1. Design principles

Embedded pipe networks will be manufactured either from PVC (10ATM) or PE100 (SDR11) according to pool size (see attached drawings). Fluid velocities will not exceed 1.5m/s in supply networks and 1.0m/s in return networks. All routings will be manufactured from PE100 (SDR11). Inside technical rooms pipe materials are exclusively PVC (10ATM) with 16 ATM fittings. Extra attention should be given in areas of material transition (from PE100 to PVC).

2.1.5.2. Calculations

Pipe diameters are calculated separately for each network branch by dividing total flows at interconnections. The fundamental fluid mechanics equations for pipe sizing are given as follows:

$$Q = \frac{\pi D^2}{4} V$$ (Continuity equation) [1]

$$J = \frac{\Delta h}{L} = \frac{\lambda}{D} \times \frac{V^2}{2g}$$ (Darcy equation) [2]

$$\frac{1}{\sqrt{\lambda}} = -2\log\left(\frac{k}{3.7D} + \frac{2.51}{\mathrm{Re}\sqrt{\lambda}}\right)$$ (Colebrook equation) [3]

$$\mathrm{Re} = \frac{VD}{v}$$ (Reynolds No) [4]

where

Q: flow in m^3/h

D: internal pipe diameter in m

V: average pipe velocity in m/s

J: Pressure losses per unit length in m/m

Δh: Pressure head losses m
L: pipe length in m
λ: friction coefficient
k: absolute roughness in σε mm
Re: Reynolds no
v: kinematic viscosity m^2/s

Friction across fittings are calculated according to:

$$J = \frac{1}{2}\sum \zeta \rho V^2 \quad [5]$$

where
Σζ : sum of friction in all fittings
ρ: density of fluid (water).

Sizing for pool pipe networks (supply, overflow and sampling) was performed for uniform distribution with even pressure drops per pipe pranch (almost equal differential pressure at terminal units).

2.1.5.3. Embedded pipe networks

- **PVC**

All PVC-u PN10 to be used should be according to DIN 8061, DIN 8062, DIN19532.

All pipe networks must be constructed according to the application study and should converge to the following norms DIN 1988-1. DIN 1988-2, DIN 19532 (DVGW Code of Practice)

Horizontal pipeworks should be installed with inclination no less than 1%.

All connections should be performed with appropriate fittings. (tees, elbows, etc.) from PVC-u PN16 at 20ºC according ISO 9001, EN 29001, UNE 66901. Connection procedures should be according to the fitting manufacturers.

Pipe networks horizontal or vertical should be supported densely so that pipe works are extremely rigid. Arcs that can introduced creed must be avoided. All supports should be anchored at building elements.

- **HDPE**

Polyethylene embedded pipe networks or routings that should be out of PE 100 (SDR11) according to DIN EN 13244-1. For all pool networks pipeline materials should be of potable grade. Color pigmentation should be from non cadmium containing organic dyes.

Fusion- Adhesion of fittings

Fusion of polyethylene to polyethylene

Fusion of polyethylene pipes and fittings will be either butt-fusion in large diameters or electrofusion for smaller diameters. All corresponding methods are described in DIN ENV 1046. All fittings used should be appropriate and compatible to the pipelines.

Transition from PE to PVC

Transition from PVC to PE and vice versa should be in most cases embedded in concrete and should take place through specialized flanged mechanical joint adapters. In cases of pipe expansion due to thermal effects the adapters should be able to deform and absorb the corresponding expansion lengths without causing pipe deformation and creep. All works of the above type should be according to DIN ENV 1046.

Underground (Buried) pipe networks

Installation protocols DIN ENV 1046:2001, ASTM D2321 and ASTM 2774 describe methodologies for the construction of underground pipe routings.

The simplest standardized methodology for the construction underground PE pipe networks includes the following layers:

- Sublayer: Trench bottoms should be compacted by mechanical means into a rigid substrate. This may be gravel or the trench earth itself. This zone should be flat and provide uniform pipe support.
- Pipe zone - backfill: For backfill, the quality of earth should be such that pipe support is optimum so that any deformation is avoided. It can be out of gravel (85 – 95% SPV) so that after compression high rigidity is ensured. The depth of backfill should be 1,5 × the nominal pipe diameter
- Final layer: It is of less importance and than the previous two layers. The material of the final layer can be the ones of the trench after having removed large stones or rocks.

The distance of pipe walls and the edges of the trench b_s are defined according to DIN ENV 1046:2001 in table A. Also, gravel diameter for backfilling in relation to maximum pipe diameter is defined in table b.

Pipe diameter DN	b_s (mm)
DN ≤300	200
300≤DN≤900	20
1600≤DN≤2400	30
2400≤DN≤3400	40

Table a: Typical distances of trench walls to pipe walls.

Pipe diameter DN	Max gravel diameter (mm)
DN < 100	15
100≤DN≤300	20
300≤DN≤600	30
600≤DN	40

Table b: Max gravel diameter / pipe diameter

Routings under concrete slabs

In cases of pipe routings passing under concrete slabs, pipelines should be supported at the reinforcement of concrete (using specialized supports that will allow small movements). Thus, pipe rigidity and support is ensured even when the surrounding earth movement takes place.

2.1.5.4. Pipe works inside technical rooms

Piping networks inside technical rooms will be exclusively from PVC 10 ATM according to the attached drawings and according to DIN 1986. Pipe connections and connections of equipment should be made with appropriate fittings from PVC 16 ATM at 20ºC according to SO 9001, EN 29001, UNE 66901.

- Valves

All valves should be plastic from hard PVC 16 ATM at 20ºC.
Valves up to Ø63 will be ball valves. All valves higher than Ø75 will be plastic flanged type butterfly.

 - Indicative type: Cepex

- Non return valves

Non return valves will be manufactured from PVC they should be of disc type from PVC 16ATM, suitable for horizontal or vertical installation.

- Indicative type: Cepex

- Pipe supports

All supports will be of antivibration type, galvanized, suitable for diameters up to Ø400. They should have suitable connectors for M8, M10, or M12 rods. Their maximum allowable load should be 5.000N. When required, supports will be mounted on specialized consoles.

- Indicative type: Mupro, Wallraven or equivalent

2.2. Water treatment – disinfection

2.2.1. Measurement of chemical parameters and dosing of chemicals

2.2.1.1. General

Chemical treatment for pool water will be conducted automatically via specialized equipment. Measurement and recording of free chlorine, Redox and pH will be performed for all pools.

2.2.1.2. Sampling

Sampling will be according to DIN 19643-1 par. 11.4.1. Correct treatment is ensured via independent (to the recirculation) dosing pumps and separate networks. For safety a special uptake grill will be installed according to DIN EN 13451-3. All water samples will result to the measurement chambers where potensiostatic or amperometric measurements will take place. Samples will then be directed to the balance tanks.

2.2.1.3. pH regulation and flocculent dosing

Flocculent dosing is a process that precedes filtration so that it enhances its performance. The process is conducted via a dosing pump which adds the required amount of flocculent chemical. These dosing pumps are of peristaltic type and can perform the dosing process with exceptional accuracy. The dosing time between flocculent inlet and entrance to filter is at least 10 s. For this reason and for better mixing flocculent dosing is performed exactly before the recirculation pump.

For effective flocculation, water acidity should be regulated ($K_{S4,3}$ at least 0.7mmo/l) and pH should ideally be 7.0 – 7.2.

Control and regulation of pH should under any circumstance be performed via a PID–controller. The dosing of acid for pH regulation is performed via a dedicated dosing pump resistant to a sulphuric acid solution 25% or commercial hydrochloric acid.
All the above processes fully comply with DIN 19643-2.

2.2.1.4. Chlorination

Pool water disinfection is achieved by chlorination. Liquid chlorine (sodium hypochlorite) will be used that can be produced via electrolysis or is commercially available.

Dosing of bleach is conducted via chlorine dosing pumps sized according to the pool demands. DIN 19642-1 par. 11.3.1 dictates 10g Cl_2/m^3 of recirculation for open air swimming pools.
Free chlorine monitoring and regulation is achieved via a PID –controller.

- Indicative type of dosing and chemical treatment equipment: Dulcomarin Prominent or NET+ Dinotec

2.3. Pool management system

The projects' extensive water volume demands central automated management via a dedicated automation system. All operations, recirculation, filtration, backwash, water make up, chemical treatment, and heating should be regulated as such. Central monitoring will also take place through the above system.

A power and automation switchboard will be situated in each technical room. This will service all local recirculations and corresponding operations. Apart from local control, centralized monitoring and control will also take place in the establishment's central control station. Also every switchboard will have the ability to operate as stand alone in case of central network malfunction.

- **Filtration and Recirculation automations**

The switchboard of every technical room should contain a BMS or SCADA – like PLC through which local control will take place. The control operations are:

A. Recirculation pumps

- Pump operation (auto-manual mode, alarm etc.)

- Frequency regulation via a dedicated converter via the flow meter's analogue signal to the following modes:
  - i) Recirculation (normal mode)
  - ii) Economy (partial load operation)
  - iii) Backwash mode

B. Sampling pumps

- Pump operation (auto-manual mode, alarm etc.)
- Interconnection with the recirculation of each pool, off during backwash.
- Motorized valve control

C. Filtration

- Filter differential pressure measurement (normal, alarm)
- Pneumatic valve control (filtration, backwash, rinse, waste, closed) with time adjustment for backwashing and rinsing. Alarms for the correct position of pneumatic valves.

D. Overflow / Balance tank

- Level control at 4 positions (High High, Normal operation, Low, Low Low level.)
- Automated make up through pressure transducer signal and motorized valve.

➢ **CHEMICAL TREATMENT AUTOMATIONS**

Each recirculation will have a pH/Rx/Cl/T controller with P, PI, PID control options. All controllers should be connected to a master unit via BAS. All local operations will take place via the master controller (monitoring station). All master controllers will be connected to a maintenance over/IP network in order to be viewed centrally through a PC at the control room of the establishment.

➢ **POWER SWITCHBOARD**

The power switchboard supplies all technical room equipment, all recirculation and water feature pumps as well as the filtration and chemical dosing systems. Power distribution switchboards will be air tight wall or floor mounted manufactured from prefabricated standard dimension boxes and should comply with all local regulations. They will consists of switches, relays, fuses and all other appropriate instrumentation. All cables should arrive and depart from designated (with coding) connectors. Phases will color coded.

- Nominal voltage will be: 380V, 50Hz.
- Insulation class according to VDE 0110, unit C.
- Operating conditions: Internal installation maximum temperature 40^{o}C.
- Protection IP 55 according to DIN 40050 / IEC 144.

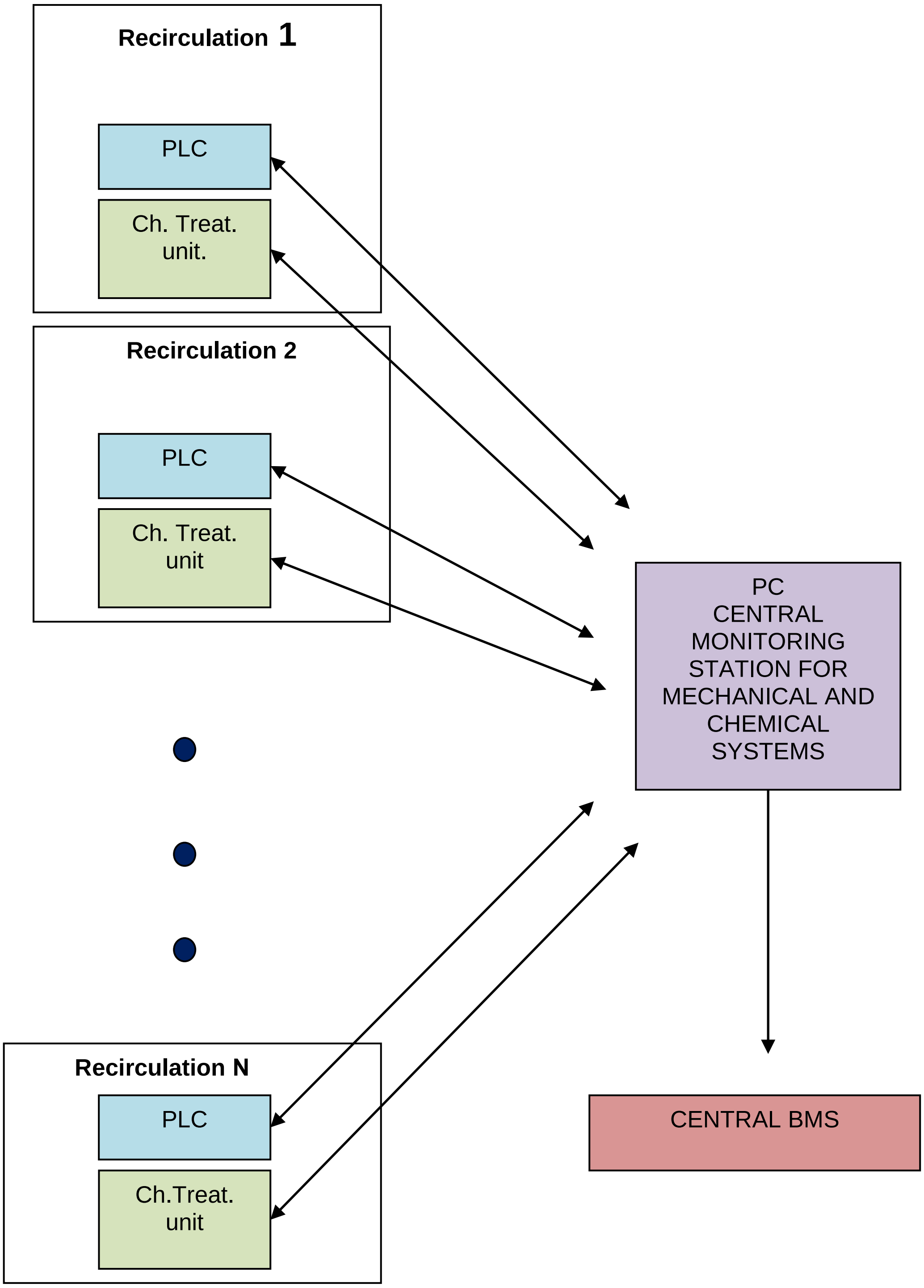
- **USER PROGRAMMING**

  Regarding filtration and recirculation it is desirable for the user to be able to select appropriate set points for the following:

- Pump water flow for all operating modes, time periods for economy operation.
- Backwash programming. Programming will be time related with the ability to input time, day and week, Backwashing is suggested to take place at nights. Also, the user will have the ability to perform backwash on demand.

- Suggested suppliers for automation equipment: Siemens, Vipa
- Suggested suppliers for power equipment: Siemens, ABB
- Suggested suppliers for boxes: Rittal
- Suggested suppliers for frequency converters: Danfoss, Invertec
- Suggested suppliers for sensors and actuators: Burkert, Siemens

➢ **SYSTEM ARCHITECTURE – POOL MANAGEMENT SYSTEM**



- **PRESENTATION AND GRAPHICS**

All technical rooms will be centrally graphically displayed at the control station. There will be options for the recording of all operating parameters (operating, statistics, cost management). All will take place on Windows environment.

Presentation on PC will be as simple as possible via a central menu for all technical rooms. All operating parameters, alarms as well as reports and trends (maintenance etc.) will be available there.

Locally, at technical room level, through a separate touch panel, the maintenance personnel will be able to perform all required operations. At central as well as local level monitoring of all required parameters and operations will take place.

A third monitor (at central level) will inform the user for the status of the chemical treatment system