Cooling water pump installation with suction diffuser

Executing a District Cooling Project

By Shankar Chatterjee

Introduction

The objective of this write up is primarily to share the experience of performing the formidable task of executing a massive District Cooling Project (DCP) in the heart of Dubai within an extremely limited timeframe, which involved several challenges and unforeseen hurdles. We will give a brief introduction of the district cooling concept prior to plunging into the project, as it could be of some interest to readers.

About the Author

Shankar Chatterjee started his career in a contracting company involved in marine air conditioning and low temperature cargo refrigeration. He joined Voltas, Kolkata in 1977 and handled challenging HVAC assignments on board naval survey vessels, LSTL and frigates built by Garden Reach Shipbuilders. Subsequently, he served Voltas in Delhi and Mumbai, handling complex projects like Semi Conductor Limited, Mohali and Maruti, Gurgaon. In 2003, he joined ETA Engineering LLC, Dubai and handled prestigious District cooling projects like The Burj Khalifa and Dubai Mall. In 2010 he joined Sterling & Wilson, Kolkata as General Manager (HVAC Projects), from where he retired at the age of 65 years in 2013. Post superannuation, he handled a special assignment for one year in Al Futtaim Engineering LLC, UAE for a District cooling project in Doha.

Why District Cooling?

The basic purpose of a District Cooling System (DCS) is to do away with the requirement of generating chilled and hot water in individual facilities, by obtaining the same from an underground distribution network originating from a centralized plant room. The most important criteria for building a DCP are the thermal load concentration of the identified location and its utility in terms of equivalent full load running hours. The higher the load concentration and full load running hours, higher is the advantage of a DCP.

Diversity of demand across users becomes an additional advantage that reduces the operating cost. In a DCS, diversity factor could vary from 10% to 90% of the peak system load. There is no fixed formula for ascertaining the diversity factor. It is more an assumption than calculation based on several considerations, e.g. the peak of different thermal

continued on page 38

continued from page 36

loads connected to a DCS will not coincide at any particular time of the day. Similarly, the peak of cooling or heating demand will not necessarily coincide with the peak of ambient conditions. Thus, in any DCS there will always be a considerable difference between the installed and the connected capacity. The connected capacity need not be restricted to the installed capacity.

Planning for developing a DCP requires devoting exhaustive innovative energy for exploring several variables like operation commensurate with design, consistency, energy efficiency, environment friendliness, need based expandability, etc.

Consumption of energy constitutes the lion's share of the overall cost of operation of a DCP. The drivers of the chillers, pumps and cooling tower fans are the major consumers of energy. Apart from the prevailing weather conditions, the major factors that influence energy consumption are performance of the chillers specially ΔT across the evaporator, and thermal load density i.e. capacity per unit area.

The use of chillers having higher capacities, low evaporator approach (3^{o}C or lower) and connecting two chilling packages in series that results in a ΔT around 10^{o}C at full load, when associated with equally high ΔT terminal devices, reduces the cost of pumping, cost and size of the low side equipment and overall cost of generating chilled water. The advantage of a series over a parallel connection is enhanced overall efficiency of the chilling modules when high ΔT is established.

Substitution of numerous smaller plants by DCP enhances thermal efficiency. The ability to modulate capacity and meet the prevailing thermal load demand by operating a precise number of chilling modules, at full or part load, permit DCPs to be more efficient and cost effective.

As a rule of thumb, chilling plants for individual buildings would be normally designed for an overall IkW of 1.2/TR and a COP around 3, whereas a DCP may require much lower energy input of 0.8kW/TR and a COP around 4.

Use of thermal storage can also drastically improve the cost of operation of a DCP by producing chilled water during off-peak electricity tariff hours i.e. in the night and making use of the same during peak tariff hours i.e. during the day. A live example of a thermal storage facility is DCP-1 of Burj Dubai, which supplies chilled water to The Dubai Mall, The Burj Khalifa and other areas.

DCPs require a limited numbers of O&M staff, which reduces operation cost as the entire operation can be monitored from a centralized control room and most of the equipment is installed in the same building. Reduced or no operation and maintenance cost also benefits the building owners. DCPs call for maintaining minimum inventory of spare parts. The maintenance of major equipment can be scheduled at any point of time as it does not call for planning a shutdown of the DCP. The equipment occupies less of the valuable floor space of the plant room. For various reasons, DCPs are much more environment friendly. Thermal energy from municipal waste and treated sewage effluent for cooling tower makeup can be utilized in a DCS. Pollution of environment due to refrigerant leakage and chemicals can be controlled more efficiently. A DC provider need not incur the entire first cost in the beginning, but can afford to spread it over a wide span of time allowing the load density to go up, and extend the construction in a need based manner. He may earn revenue meanwhile from the partially commissioned DCP to meet his expenditure.

Selection of Chillers

Chillers are the largest equipment of any DCS and incur the highest cost of operation, calling for an absolutely methodical selection process. The key criteria for selecting chillers are the first cost, best efficiency and life span. Since the overall cost cannot be arrived at without taking into account various associated costs like maintenance, repairs and operation, an accurate calculation of which is complex, it is desirable that chillers are selected based on the life span.

Example of a Successful DCP

One of the oldest and most successful district cooling plants, visited by the author in 1991, was a facility with a capacity around 59,000 TR, which was re-constructed by Hitachi Appliances Ltd., Japan, for Shinjuku District Heating and Cooling Centre, situated in west Tokyo. It was built to provide chilled and hot water for air conditioning of several groups of high rise buildings in the area.

The significance of the refrigeration system of this DCP was the combined use of absorption and centrifugal chillers. The return chilled water from the load flowing in series, i.e. first through the absorption chillers (having higher COP and the ability to sustain no loss of energy due to low return water temperature at part load) and subsequently through the centrifugal chillers, thus accomplishing the overall cooling process in two steps. A pair of underground supply and return headers stretched over roughly 8000 meters was laid for circulating chilled and hot water in the buildings.

With the above briefing, as we now proceed to project execution, it will be noticed that there are several technical requirements in a DCP that are not required in any other type of air conditioning system; it is a different experience altogether.

Executing a DCP for Residential Towers

The execution pertained to a DCP having a magnitude of 40,000 TR installed capacity with 2500 TR standby capacity, forming 8 modules consisting of 2500 TR x 2 chilling packages connected in series and associated with de-coupled chilled water circuits.

The execution of the facility, which was meant for supplying chilled water to several groups of high rise towers, had commenced in the year 2008. The fully automated DCP was designed with 15% diversification of capacity. The internal volume of the in-plant primary chilled and cooling water

continued on page 40

continued from page 38

Photo 1: Evaporator and condenser water pipe connections

Photo 2: View from mezzanine floor balcony – battery of chiller modules

circuits was roughly 3200 and 3400 cubic meters, respectively. The design of the circuits included a safety factor of 10%.

The district cooling provider had placed an order on the HVAC contractor for supply, installation and commissioning, followed by a defect liability period (DLP) of 24 months. The contract also included civil construction of the DCP building starting from excavation of the soil. Despite the system having been designed by a USA based consultant and the HVAC contract pertaining only to the high side, the HVAC contractor was entrusted with the responsibility of overall performance of the DCS.

However, activities beyond the DC building such as supply, installation, testing and commissioning of plate heat exchangers in the basement of the individual towers was a part of the building contractor's scope of works. The supply, laying and flushing of the chilled water distribution piping network, construction of the valve chambers including the necessary loops to reduce system pressure drop, and installation of energy meters for monitoring energy consumption, were also in the scope of works of the building contractor.

Preparatory Activities

The moment the job file was handed over by the sales wing to the nominated and duly approved project head of the HVAC contractor, several activities had to be taken up within a very short span of time. These included obtaining approvals for:

- NOCs from various authorities
- Organization chart including a full time quantity surveyor and a safety officer
- Schedule of manpower required to be deployed throughout the tenure of execution
- Safety manual and mandatory site safety facilities
- Schedule of drawings
- Method statements for all types of installation
- Test procedures for all recommended onsite tests
- Welder's qualification, welding procedures and percent of joints to undergo Radiographic Test
- Pre-fabrication shop for fabrication of spool pieces as per shop drawings
- Equipment/material schedule conforming to job specifications
- 'Good for construction' drawings for commencing execution of site works
- Factory Acceptance Tests (FATs) and on-site performance test procedures and schedule
- Project execution, pre-commissioning and commissioning schedule
- Training programme for O&A staff and the schedule for imparting it

Apart from obtaining the above approvals, the other necessary urgent actions were construction of site office, site store and equipment/material storage yard in close vicinity of the site; precise quantity take-off, based on 'good for construction' drawings, of items like valves and accessories, matching weld neck/slip-on MS flanges, MS fittings, nuts and bolts of the required length, all plumbing and sundry materials, etc. and raising purchase requisitions for procurement of the same; and identifying potential sub-contractors and raising of purchase requisition for appointing them.

Third Party Involvement

Needless to mention that the entire lot of activities from day one of commencement were carried out under the direct supervision of a nominated third party stationed at the site office itself. The activities monitored by them included preparation, installation, pre-commissioning, commissioning, performance testing, staff training and documentation. Another significant area of concern for the third party was reviewing the method statements, test procedures, and preparation of formats for pre-commissioning, commissioning and performance tests.

Weekly Progress Meeting

The consultant used to conduct the meeting with the contractor's project team in the presence of the client's Project Manager and Safety Officer to evaluate work progress versus schedule, material procurement status in line with the current job requirement and safety records. Minutes of the meeting were circulated the following day.

continued on page 42

continued from page 40

Challenges and Hurdles

The execution process of the project included civil construction within the limited time frame and involved many challenges and hurdles described below.

Excavation

The hurdle started from the very first step, i.e. excavation of the rocky soil. The soil was found to be extremely hard. The project schedule had no provision for additional time required for the soil being so rocky. Obviously, the excavation period encroached into the schedule for several subsequent activities like blinding, laying of earth strips, raft binding and raft RCC casting, thereby creating a situation that called for racing against time.

Raft Foundation Casting

The most critical, tricky and time bound activity of all the civil works was the RCC raft casting. It started with binding of the 2m X 25m X 50m raft frame using MS reinforcement rods and subsequently was cast by pouring RCC mixture non-stop over 24 hours. The weight of the mass was designed to ensure that the raft would withstand the pressure exerted by the water table. Advance ordering, the need for averting rain and chain supply of RCC mixture made the programme absolutely time bound and called for deploying more than five hundred workmen at the job site for more than a week. The copper earthing network had to be completed below the raft level prior to commencing steel binding works. During the entire period of the above activities, de-watering pumps had to be run round the clock.

Simultaneous Execution of Civil and MEP Works

The schedule of the project was worked out to permit MEP works to commence only after achieving a milestone of the civil works. But the delay sustained due to the unforeseen hurdle in excavating compelled the MEP contractor to come on board prior to attaining the planned civil works progress. The situation that developed called for deploying a much larger than estimated work force, i.e. up to 1365 workmen in a day within the limited space, that was detrimental for the desired work environment. Making up the lost ground under the circumstances, without compromising with the quality of the works, was a big challenge.

Obtaining Installation Fitness Certificate

Obtaining the Dubai Civil Defence certificate constituted a part of mandatory requirements prior to regular operation of the plant. The installer must undergo a stringent inspection of the entire installation, in particular the aspects related to safety requirements such as the fire fighting system, fire alarm system, fire suppression system, earth connections, lightning protection, emergency exit, emergency lighting, etc. Besides, aspects like lift operation, staircase and lift well pressurization system and CCTV also formed part of the inspection.

Early obtaining of the certificate would call for making things first time right. During the inspection, if the number of defects detected is not high and not critical in nature, obtaining the certificate is hassle-free. Once the certificate is issued by the authority, liquidating the defects becomes an absolute time-bound responsibility of the installer.

Plant Operation Conforming to DCA Norms

Commencement of regular plant operation simultaneously requires monitoring of the plant round the clock by team DCA via the control panel provided at DCA facility linked to the main control panel of the DCP. Should the plant trip due to any reason, it would call for rectifying the fault and restoring the plant operation within a reasonable time frame. For any noticeable delay, the operating team of the DCP would be answerable. After a plant trip, if fault rectification and restoring the operation is delayed beyond a point, the complaint gets escalated to the higher management of the end user.

Obtaining of Building Completion Certificate from Dubai Municipality

Prior to commencement of commercial operation of the DCP, obtaining the building completion certificate is essential for the DC provider. This certificate is issued by the Dubai Municipality upon 100% completion of the DCP building.

For issuing the certificate, DM inspection begins with verification of the workmanship and physical dimensions of various aspects of the building; subsequently, it includes the finishing of interior and exterior works like FRP lining of the water storage tanks, drainage system, providing of necessary insulation, false ceiling works, providing of seismic supports for pipes above false ceilings, painting of walls and ceilings, painting of floors, cladding, tile fixing on the roof floor, providing the facade, fixing of logos, rain water system, earth pits, lightning protection and walkways.

Achieving Power ON Status

To enable Dubai Electricity & Water Authority to supply the necessary power to the DCP, the contractor is required to achieve a milestone and gear up the entire installation works to a level that qualifies the DCP to successfully undergo a final inspection by the authority prior to terminating their cables at the incomer switchgear installed in the room allocated for the Authority, which subsequently releases power. The milestone includes completion of MEP installations strictly as per the approved design, with the necessary power and control cabling, earth connections, etc. and the absolute readiness to receive and utilize power.

Transportation and Installation of Expansion Tank cum Surge Arrestor

Transporting, unloading, hoisting and positioning of the massive pressurised expansion tank having an internal volume of 80,000 litre, which also served the purpose of a surge arrestor and was specially designed for installing in the basement of the DCP building, was one the of the most critical installation issues.

The hassle started from transportation itself. An ultra low bed trailer had to be organized to transport the tank from the fabrication shop to the place of installation after conducting

continued on page 44

continued from page 42

Photo 3: Expansion tank on ultra low bed trailer

several mock drills. To turn the tank upright on the trailer bed itself, an additional supporting crane of smaller capacity had to be arranged. The tank was required to be hoisted by the main crane nearly 30 meter from the ground level prior to lowering it through the provisional cut out on the ceiling of the basement and mezzanine floors for placing on the civil foundation in the basement. For necessary prior strengthening of the foundation, a layer of 25 mm grout was applied on the top surface of the 300 mm thick RCC plinth and levelled. The tank rested on the 300 mm x 300 mm x 25 mm steel sole plates welded at the bottom of the four legs attached to the round tank 90^0 apart.

Photo 4: Expansion tank in the process of hoisting

Flushing

Another difficult task was to carry out flushing of the chilled and cooling water circuits within the DCP building in exactly 30 days by temporarily installing external pumps with enormous flexible connections for looping, as the DC provider did not allow the system pumps to be used. Besides, two break tanks for filling and discharging, one tank for adding chemical and a bypass line for the filtration unit to aid the flushing process had to be arranged.

The first hurdle was to quickly design a temporary system capable of flushing both the circuits, developing the minimum recommended velocity in the highest diameter pipe of the circuits and produce design flow through all the branch pipes, measured by the magnetic inline flow meters installed in each of the branch pipes.

The second and most crucial job was to identify a subcontractor who could source such a huge capacity diesel generator driven pumps for running 24 x 7 for 30 consecutive days. The next task was to organize the required space adjacent to the DCP building (that required prior approval of the Dubai Municipality) for accommodating all the temporary arrangements mentioned above. Besides, to carry out dynamic flushing, advance booking was required to be made for continuous supply of thousands of gallons of fresh water in tankers and simultaneous disposal of dirty water in empty tankers to the dumping yard allocated by the DM.

Having overcome the initial hurdles as mentioned above and upon concluding the initial steps, the main process of flushing commenced. After a couple of days of pump operation, it was revealed that the required velocity in the largest diameter pipes, i.e. 1200 mm CHW and 1400 mm CW, was not obtainable in any way. The problem eventually was diagnosed as inadequate capacity of the pumps engaged. Fortunately enough, the pumps could be replaced by higher capacity pumps to restore the flushing operation. The last (but not the least) critical aspect was to conclude the steps of flushing i.e. plain water pre-flushing, dynamic flushing, passivation, final chemical treatment and achieving the desired end results in each section within the scheduled time frame. The most critical requirements were to reduce total suspended solid level to <2 ppm and iron level to <1 ppm.

Pipe Supports

Providing appropriate supports for the chilled and condenser water piping throughout the installation was a matter of utmost importance. The aspect was not only related to vibration free operation and equipment safety, but also the safety of the DCP building itself. The crucial factor was to provide supports for 2 x 1200 mm chilled water and 2 x 1400 mm cooling water headers that were running parallel in the basement. The initial design

Photo 5: Pipe header supports in basement

continued on page 46

continued from page 44

was to place the headers on galvanized steel I-shaped beams installed between each set of RCC columns by anchoring the steel plates welded at both ends of the beams using chemical stud bolts. Prior to implementation, the idea was rejected by the structural consultant considering that the point load on the RCC columns would exceed the limit and become unsafe for the DCP building.

Eventually, it was decided to fabricate structures out of square G I steel tubes and angles (as shown in *Photo 5*), then anchor the attached steel plates of the structures on both the sides (not in between) of the RCC columns using adequate number of chemical stud bolts.

For permissible sliding against expansion and contraction, sliding supports with anti-friction isolation pads were provided along with protection against sidewise movement. Necessary fixed supports were also provided at regular intervals.

Apart from the piping, pump suction and discharge connections, accessories like suction diffusers and NRVs were also provided with appropriately designed supports with anti-friction isolation pads that absorb vibration and permit limited movement.

Installing Link Seals

This was another crucial and tricky piece of work. Link seals are used in DCPs to prevent penetration of outside water into the plant room through any improper sealing between the exterior walls of the building and the outgoing/incoming pipe headers due to the pressure of the prevailing water table. The installation, thus, calls for precision alignment of the pipes, accurate and uniform tightening of the bolts of the link seals that will conform to the necessary sealing between the inner surface of the wall openings and the outer surface of the insulated chilled water pipes, and at the same time will not exert undue pressure on the insulation.

Connecting Supply and Return Headers with CHW Network

Joining the supply and return header pipes with the pipes to and from the chilled water network by welding was a very risky work. This was due to the fact that the portion of the headers projecting out of the exterior wall of the building was hardly one meter long. Due to the heat generated during arc welding of such high diameter and wall thickness pipes, it was required to prevent them from travelling towards the link seals and damaging the neoprene packing.

Conducting Radiographic Tests of Weld Joints

The job specification called for carrying out at least 10% RT of the weld joints of each diameter of carbon steel pipes and flanges. Apart from the tedious process, the activity required prior scheduling each time the test was conducted. The most crucial of all was vacating the place and suspending all other activities in the recommended vicinity for adhering to safety rules. Scrutiny of the X-ray film by the specially appointed third party, rectification of defects and generating comprehensive records was another critical activity.

Highlights of Residential Towers DCP

The highlights of this project are described hereunder.

- Two R134a, low approach chillers connected in series in each module to produce high ΔT commensurate with temperature rise of the chilled water through various terminal devices.

Photo 6: Two chillers of each module connected in series

- De-coupled chilled water circuits to facilitate automatic balancing against varying cooling load.
- VFD driven centrifugal compressor motors, secondary pump motors and cooling tower fan motors.
- In-plant independent chilled water filtration unit for continuous filtration of return chilled water.
- Dedicated cooling water pumps with bypass line and accessories for need based diverting.
- Use of factory fabricated pre-insulated chilled water pipes and fittings i.e. moulded polyurethane in glass reinforced plastic (GRP) casing, having superior insulating property and long life.
- Unique secondary chilled water pump design that ensures no back surge from the network, even when a single secondary pump is in operation at minimum speed.
- NRVs for secondary pumps provided with electro mechanical time delay device, to permit a preset time lag prior to opening as well as to ensure gradual closing without banging the valve seat.

Photo 7: Compact and efficient air separators

continued on page 48

continued from page 46

- Bladderless design, highly effective expansion tank cum surge and thermal shock arrestor.
- Spring mounted, steel frame RCC filled, inertia bases for all the pump-sets for absorbing vibration.
- Compact, high efficiency air separators that occupy less floor space and ensure optimum separation of the entrained air from the return chilled water, which in turn reduces oxygen based corrosion and pump cavitations, and enhances heat exchange
- Chilled and cooling water headers as well as all branch lines provided with magnetic, in-line flow meters for accurate balancing of flow all over the circuits.
- Individual cells of cooling tower provided with continuous sump sweeping arrangement and independent filtration unit for instant cleaning.
- Independent filtration unit for individual cooling tower cells.

Photo 8: Independent filtration unit for individual cooling tower cells

- Chilled (*Photo 9*) and cooling (see title photo) water pumps provided with L shaped suction diffusers with fine strainers to diffuse turbulence and straighten flow at pump suction, resulting in smooth compression and fine straining of water, thus enhancing the life span of precision mechanical seals of pumps. L shaped diffuser further permits elimination of one 90^0 bend in each pump suction line.

Photo 9: Primary chilled water pump installation with suction diffuser

- Elbow volutes directly connected to cooling water pump discharge, permitting smooth transition.

Photo 10: Cooling water pump installation with NRVs, discharge volutes and flexible connections

- Precision chemical analysis units for periodic analysis of chilled and cooling water samples and necessary upgradation by adding the prescribed chemicals.
- Use of digital controls instead of pneumatic controls and strict adherence to designed set points by incorporating means of protecting original set points from tampering.
- Refrigerant leakage monitoring system.
- BMS, centralized control room having 16 work stations and a giant LCD screen, displaying complete schematic flow diagram of DCS and individual equipment for remote monitoring.

Photo 11: Service space around chillers

- Adequate service space all around the modules of chilling packages for proper servicing.

Order of Equipment Location

The designated order of locating various equipment was a four tier concept, i.e. basement, ground floor, mezzanine and terrace floor.

Basement

All the pumps i.e. primary and secondary chilled water pumps, in-plant secondary chilled water pumps, cooling water pumps, makeup water pumps, booster pumps, supply water

continued on page 50

continued from page 48

jockey pump, chilled water filtration pumps, cooling water recovery pumps, fire pumps (diesel), fire pump (electric) and fire pump (jockey) were located in the basement.

Apart from the pumps, the expansion tank, filtration unit, air separators, generator, fuel oil system, RCC reservoirs for storing makeup water, air compressor units for expansion tank, staircase pressurising unit and AHUs for basement AC were also accommodated in the basement.

Ground Floor

The modules of hermetic centrifugal chilling packages, transformers, switchgear, electrical panels for equipment installed at the basement and ground floor, exhaust fans, BMS panels, chemical dozing system and chemicals storing area were located on the ground floor.

Mezzanine

Air handling units for air conditioning of the DCP building (excluding those for the basement), FCUs, VAVs, tower basin filtration units, electrical panels for equipment installed at the roof level and mezzanine, battery banks for emergency power, UPS, fire alarm system and panel, FM 200 fire suppression system, etc. were located on the mezzanine. In addition, the main control room, having multiple work stations and a giant LCD screen, was located on the mezzanine floor.

Terrace Floor

The cooling tower, ventilation fans and heat recovery wheel were located on the terrace floor.

Sequence of Moving in and Placement of Equipment

As soon as the plinths for mounting the chillers and pump-sets were ready, civil and MEP works had to be carried out simultaneously. The requirement had called for absolute foolproof advance planning of the sequence of placement of each equipment and its appropriate time of entry in the DCP building from the place of storage.

All the 38 skid-mounted pump-sets including the huge secondary pumps, air separators, air pressurizing unit, filtration unit, etc. were required to be hoisted above the roof level by crane and subsequently dropped right up to the basement, first through the temporary civil opening on the roof and then through the permanent cut-out on the ground floor slab of the DCP building.

The centrifugal chilling packages shipped from the USA, fully factory charged with R134a, were transported to the job site from the port in low bed trailers. Having received the chillers in fully charged condition, unloading of the same, moving into the plant room and placing on the respective plinths was a risky affair.

The activity called for engaging a specialist contractor with the relevant experience and necessary gadgets and special tools. Each chilling package was placed on four sets of wheel mounts one after another, which were, in turn, placed on a pair of steel rails laid adjacent to the trailers and up to the place of installation. The chillers were then pulled by a hand crane to move close to the respective plinths avoiding the least damage. Thereafter, the chillers were jacked to the level of spring mount assemblies that were prefixed on the plinths and rested on temporary supports of heavy pieces of wood at four corners below the steel frame. Subsequently, the chillers were moved to their final position. Obviously, the brick work of the respective exterior wall of the plant room at the ground floor level had to be kept on hold till all the chillers were moved inside the plant room.

Erection of Cooling Tower Cells

The cooling tower was located on the roof top. Erection of 8 individual cells over the FRP lined multiple-cell RCC basin was an independent activity and did not clash with the erection schedule of any other equipment.

However, hoisting, laying and supporting of the massive 1400mm diameter return cooling water and equalizing the headers below the RCC basin was an extremely hard task. The only other large equipment installed nearby was the heat recovery wheel in a separate room. Besides, the application of FRP over RCC and the subsequent testing for leaks was a tricky and tedious work.

Pre-commissioning

Upon successful flushing of the circuits, the system was geared up for pre-commissioning. Amongst the enormous pre-commissioning checks, the most critical ones were aspects like checking insulation values and the direction of rotation of all the drive motors, earth resistances, levelling and alignment of the pump-sets, functioning of motorized valves, NRVs, VFDs, fire fighting system, fire suppression system, fire alarm system, diesel generator set , emergency lighting, controls of pressurized expansion tank, cooling tower sump sweepers and filtration units, flow meters, etc. Very importantly, water balancing was a part of pre-commissioning. Needless to add that calibration of gauges, thermometers and other measuring instruments was done in advance.

Commissioning and Handing Over

Commissioning

The heart of the DCP, i.e. the chilling packages, was factory charged and performance-tested prior to shipment. The second largest and important equipment, i.e. the pump-sets, passed the Factory Acceptance Test in ITT works, USA. The transformers were also performance-tested in the OEM's factory.

Under the circumstances, commissioning of the rest of the equipment was quite smooth and trouble free. The refrigeration capacity that was commissioned initially to meet the prevailing cooling load of 1000 TR was two modules consisting of 2500 TR x 4 chillers. The operating refrigeration

continued on page 52

continued from page 50

capacity was gradually enhanced along with the increase of the cooling load on the system. However, conducting the performance test of the cooling tower by CTI was decided to be done at an appropriate time and ambient condition in future.

Post-commissioning Observation

During the post-commissioning stage, the critical aspects that warranted continued monitoring were the overall functioning of the centralized control room and BMS, sequence of operation of the chiller modules, cooling tower performance, operating parameters of chilled and cooling water, etc. However, the aspect that called for special attention was the performance of secondary pumps combined with the de-coupler that constantly modulates the chilled water flow to strike a balance between demand and supply.

On-site Performance Testing

The items for which performance testing was conducted on site were all the pumps, air handling units, filtration units, fire fighting, fire alarm and fire suppressing systems, expansion tank and its pressurising units, diesel generator set, heat recovery wheel, etc.

Performance Excellence

Apart from optimum thermodynamic performance of the chilling modules and the balanced hydraulic performance of the chilled water circuit as a whole, the most remarkable of all was the virtually noise and vibration free operation of the pumps. Making sure if a particular pump is running would literally call for touching the pump physically.

Training of Owner's O&M Personnel

A comprehensive one month training programme was organised for the O&M staff of the DC provider prior to taking over independent charge. Class room as well as hands-on training was imparted to the personnel by the engineers of HVAC contractor, specialist contractors, engineers of the OEMs and suppliers of various items. Hard and soft copies of the complete training material were given to all the trainees. The programme was concluded with a Q&A and feedback session.

Timing of Key Milestones Achieved

While the masonry plinths for installation of the chillers and pumps were constructed within a year, erection and pre-commissioning of the HVAC system, including inspection for fitness certification of the total installation by Dubai Civil Defence Authority to qualify for the POWER ON status, was completed in 27 months from the date of receiving the LOI.

However, it took a few months more to commission the plant as permanent power supply was not available. The finishing works pertaining to civil construction, i.e. providing the glass facade on the exterior of the DCP building, fixing of logos, etc. and obtaining the building completion certificate from Dubai Municipality was completed in 33 months from the date of LOI.

Subsequently, having successfully carried out 3 months of trial operation, the Defect Liability Period of the plant commenced exactly 36 months from the date of LOI.

Handing-over Documentation

Handing over a DCP of such magnitude and significance required preparation and submission of exhaustive volumes of documentation as a part of the contractual agreement with the DC provider. Multiple copies of the most important pre-approved documents that were required to be furnished are listed below:

O&M Manual

Instruction manuals of all the OEMs including the cooling tower supplier, electrical and BMS panel manufacturers, technical literature of the valves, accessories and various controls, plumbing materials, etc., comprehensive records of pressure tests, flushing, pre-commissioning checks, FATs and on-site performance tests.

As-built and Co-ordinated Drawings

Because of very high volume, copies of approved as-built and co-ordinated drawings incorporating all the 11th hour changes were furnished in separate folders.

Weld Map with RT Reports

Complete weld map, certified RT reports and X- ray films were handed over.

Contract and Specification

Copies of the contract agreement and comprehensive material specifications formed a part of the documentation.

List of OEM Recommended Spare Parts

The recommended list of emergency spare parts and the detailed inventory to be maintained were furnished.

Handing-over Letter

A formal letter of handing over along with the consultant's recommendation for provisional handing over, indicating dates of achieving significant milestones and the actual date of commencing the defect liability period, was a part of the documentation.

Apart from the above, framed diagrams recommended for display on the respective floors of the building in accordance with equipment layout to facilitate O&M team were furnished.

Conclusion

At the end of the execution, the comment made by the USA based designer (who was quite apprehensive about the fate of the DCP in the beginning), was "Excellent Installation". Besides, the excellence of the execution process and the all out efforts made by the HVAC contractor persuaded the consultant to recommend waiver of LD. During the process of execution, the facility was visited by several VIPs like the President and Director-Sales of ITT, USA (pump supplier), President of GWA Research, and a team from ASHRAE.

(All photos in this article are sourced from ETA Dubai.)