


# Chilled Water Systems - Back to Basics

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## AE Smith

- AE Smith was established in Melbourne in 1898 by Alfred Smith Senior and the company remains a family business today.
- The company employs around 700 people nationally with around 300 in Queensland.
- We believe good relationships with our customers and colleagues are extremely important and rewarding.



## AE Smith

### Recent and Current Projects

- Hospital Projects  
(QCH, GCUH, SCUPH, Townsville and Cairns Hospital)
- University Projects  
(TRI, UQ AEB and CAI)
- Green star and NABERS rated Office Towers  
(400 George Street, HQ and King George Central)
- Laboratories  
(KBRB, BPA, QIMR and Fresenius)



## AE Smith Engineering

AE Smith Queensland Engineering team consists of 13 qualified engineers, including 6 RPEQ, from both contracting and consulting backgrounds.

We have a strong commitment to training and promotion is encouraged from within the organisation.



### AE Smith Engineering Process

When a project is secured, a comprehensive design check and evaluation is carried out.

The benefits that flow from our engineering processes are many and include:

- Cost-effective, energy efficient systems
- Correction of any potential mistakes in design documents
- Removal of any ambiguity in design documents
- High quality documentation and installation
- Successful commissioning to required standards
- Satisfied customers



### AE Smith Engineering Process

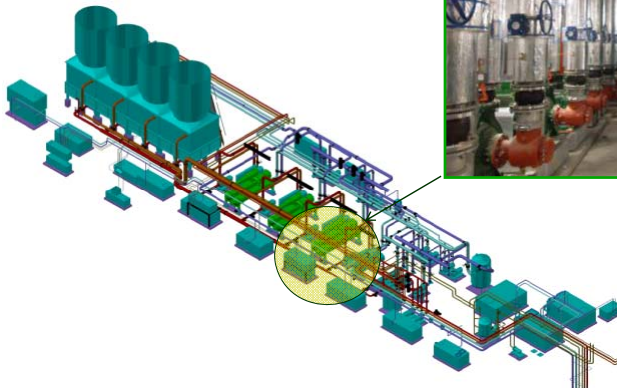
Like any other business, we have an Engineering budget to work to on every project and some of the things which put pressure on achieving the budget are:

- Specifications/drawings which are unclear or incomplete and require a lot of discussion and correspondence to clarify.
- Often a simple schematic of a system is easier to understand than one-liners in a specification. "A picture tells a thousand words".
- We appreciate the opportunity to talk to consultants at the start of a project and gain a full understanding of the requirements, constraints and objectives of the project.
- This initial project discussion often leads to a close relationship between the consultant and ourselves and a very successful project.



## Chilled Water Back to Basics

*Contractors Point of View*



**Water Chillers**



**Pumps & Pipe**



**Cooling Towers**



**AHUs and AC Equip.**



## Chillers



**Water-Cooled Centrifugal Chillers**

Capacity Range: 700 to 10,500 kW  
Refrigerant: R123 or R134A

High efficiencies  
More Plant and space Required

### **Air-Cooled Scroll Chillers**

Capacity Range: Up to 750 kW  
Refrigerant: R410A

Space savings  
Shorter operation life



## Open Circuit Cooling Towers

### **Counter Flow**

Spray Nozzles  
Small foot print



### **Cross Flow**

Gravity fed  
Large plant space and access  
platforms required.



Air-Cooled      Water-Cooled

NO YES  
Huh? Maybe  
Hmmm... WHAT?!

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PLANT LAYOUT

LIMITED INFORMATION      BIG DECISIONS

LOTS OF EXPLAINING TO DO

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### Chiller Plant Layout

- Supply ✓
- Installation ✓✓
- Commissioning ✓
- Operation & Maintenance ✗

- Different Equipment configurations
- Simplified pipe layout. Less fittings and shorter runs
- Egress and equipment access maintained

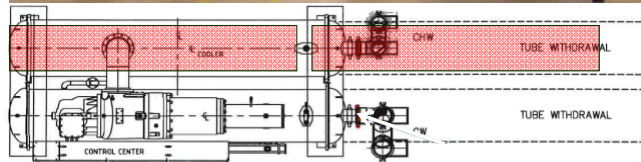
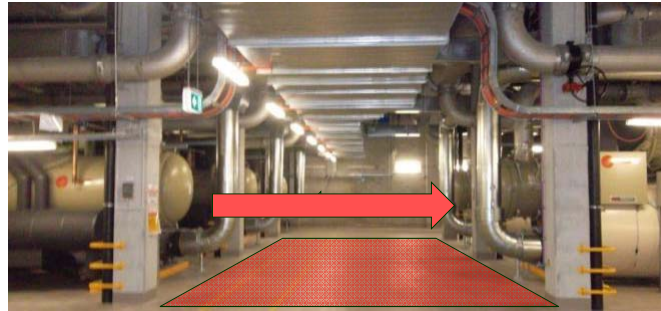
### Cooling Tower Plant Layout

- Simplified pipe layout from different Equipment connections
- Ensure safe and sufficient access is provided to all equipment



### Condenser Cleaning Access

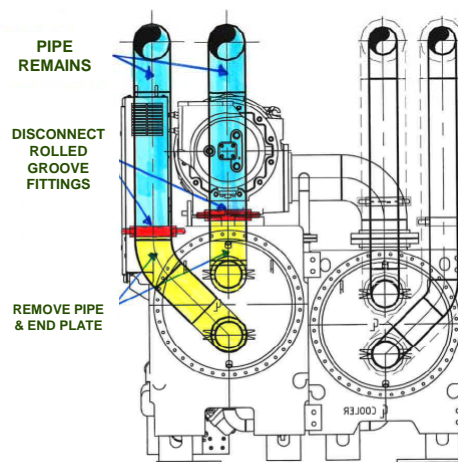
Access for tube removal must be provided for cleaning / removal of the condenser vessel tubes



### Marine Water Box

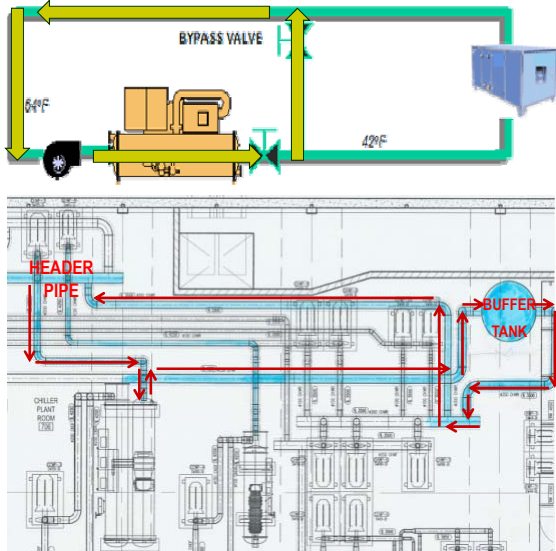


### Removable Pipe Spools






### Minimum Loop Volume



**WARRANTY**

- (1) Move bypass
- (2) Increase Pipe/Header sizes
- (3) Buffer tank

120secs X Flow Rate  
e.g. 10 l/s flow needs 1200 L



### Increasing Chilled Water $\Delta T$



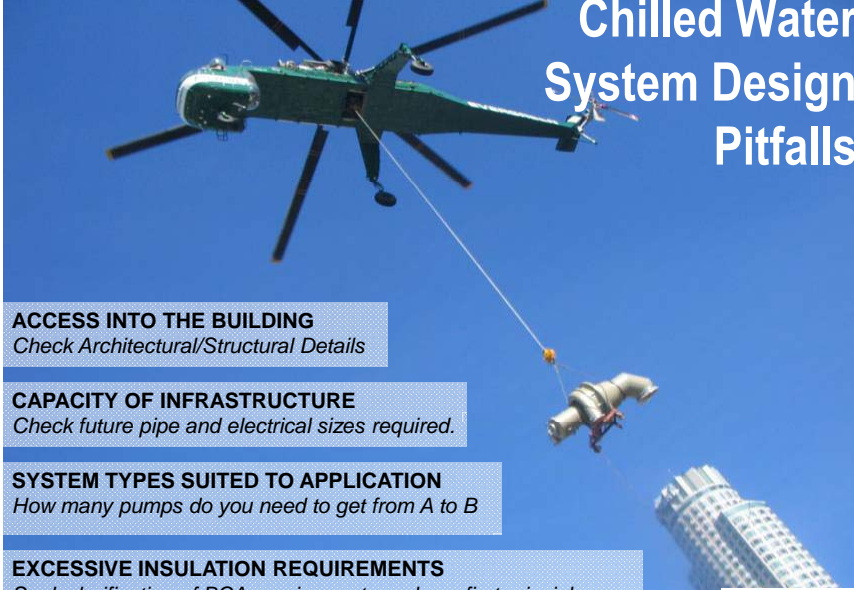
**REDUCTION IN PIPE SIZING  
= CAPITAL COST SAVINGS**

**LOWER  $\Delta P$  ACROSS CHILLER VESSEL  
= SMALLER PUMP HEADS**

**SMALLER PUMPS  
= ENERGY SAVINGS**


<p>Conventional</p> <p>CHW ENT: 12 CHW LEAV: 6 <math>\Delta T = 6</math></p>	 <p><b>30% Flow reduction 65% Pump Energy reduction</b></p>	<p>Adjusted</p> <p>CHW ENT: 15 CHW LEAV: 5 <math>\Delta T = 10</math></p>
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## Chilled Water System Design Pitfalls

- ACCESS INTO THE BUILDING**  
*Check Architectural/Structural Details*
- CAPACITY OF INFRASTRUCTURE**  
*Check future pipe and electrical sizes required.*
- SYSTEM TYPES SUITED TO APPLICATION**  
*How many pumps do you need to get from A to B*
- EXCESSIVE INSULATION REQUIREMENTS**  
*Seek clarification of BCA requirements and use first principles.*



ARE THE  
CLOSE T



## Pumps

There are various types of pumps used in HVAC projects depending on

- Capacity required
- Energy efficiency requirements
- Space available
- Cost
- Pipework arrangement



### Horizontal Split Casing Centrifugal (HSC) Pumps



- High flow capacity > 250 l/s
- High energy efficiency
- Highest cost
- Large space required

### End Suction, Back Pull Out Centrifugal (BPO) Pumps



- Wide flow capacity (Up to 250 l/s)
- Compact and easy to overhaul
- Lower cost
- Lower efficiency than HSC
- Most common

### In-line Circulating (ILC) Pumps



- Low to Med flow capacity
- Very compact
- Limited to small systems



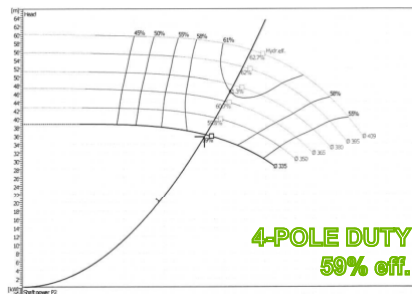
### Pump Type/Speed

4 pole (1450 RPM) is the most common speed specified based on expectations of longer life and quieter operation.

However, often a 2 pole (2900 RPM) pump will provide the following benefits:

Speed: 1450 1/min    Frequency: 50Hz    Duty point: Q =18 l/s    H =35.7 m    Suction port: DN 125 / PN 16    Discharge: DN 80

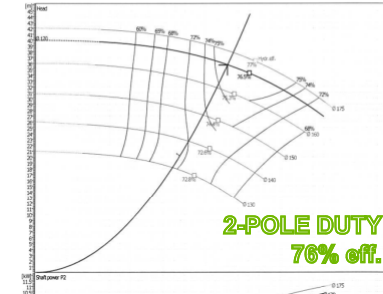
Power data referred to: Water, pure (100%); 20°C; 0.99819kg/dm<sup>3</sup>; 1.0008mm<sup>2</sup>/s



- Stable pump curve
- Higher energy-efficiency
- Smaller size pump

Speed: 2900 1/min    Frequency: 50Hz    Duty point: Q =18 l/s    H =35.7 m    Suction port: DN 65 / PN 16    Discharge port: DN 50 / PN

Power data referred to: Water, pure (100%); 20°C; 0.99819kg/dm<sup>3</sup>; 1.0008mm<sup>2</sup>/s

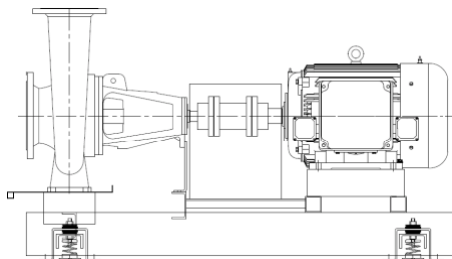


- Similar life expectancy to 4 pole speed
- Lower cost



### Pump Base

- Sometimes inertia bases are specified where the base is filled with concrete and then mounted on springs.
- They can be very large, heavy, expensive and may be unnecessary if a VSD is used.





## Cavitation

Can cause the following problems;

- Noisy pump operation
- Reduction in performance and efficiency
- Mechanical damage to the pump

### IMPORTANT

- Ensure NPSH required is available (Assess losses at inlet).
- Provide flooded suction - don't rely on check valves
- Avoid bends, valves or other restrictions at the pump inlet which can cause turbulence
- Provide straight pipe of about 4 diameters length at the pump inlet  
OR  
Use a roll groove suction diffuser to straighten the flow into the pump



## Pump Pitfalls

Final pump head calculations are the contractor's responsibility.

However, specified pump heads are sometimes too low, the designer should calculate and specify a reasonably accurate duty so that plant space and electrical infrastructure are adequate.

Many designers specify a requirement for 10% increase in flow which corresponds to 33% additional power. This is expensive in terms of equipment and electrical infrastructure and may be unwarranted.



## Pump Pitfalls

- Some specifications call for insulation of chilled water pumps. We would recommend against this as the insulation restricts access and is likely to be damaged during maintenance. A better solution is to provide a stainless steel drip tray under the pump. This is then drained to a tundish.

- Pumps located too far away from chillers require more pipework and additional isolation valves. This also increases system head and energy consumption

- Insufficient space provided at the pump suction to enable satisfactory performance



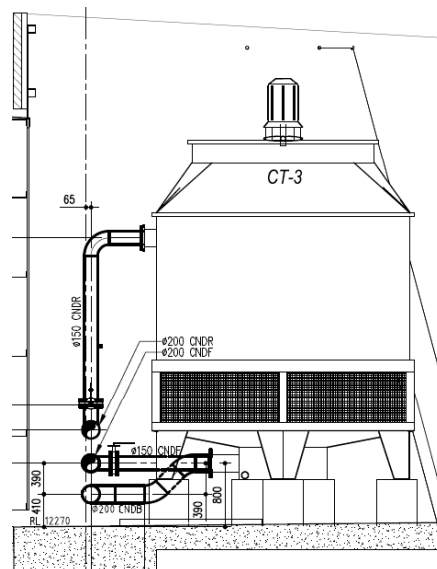
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## Pump Pitfalls

- Provide flooded suction to condenser water pumps (cooling tower sump should be at least 500 mm above the top of the pump volute)

- Be aware of access requirements as heights increase.

- Don't forget that it is quite OK to install pumps outside, close to the cooling towers, which reduces the losses in the suction line



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## Pipework



### Copper

- Used up to Ø125mm
- Easy to handle & install
- Very expensive above Ø125mm

### Steel

- Used above Ø125mm for CHW systems

### Stainless Steel

- Used for CCW systems (can also use plastic but this requires much more support and is more difficult to install)



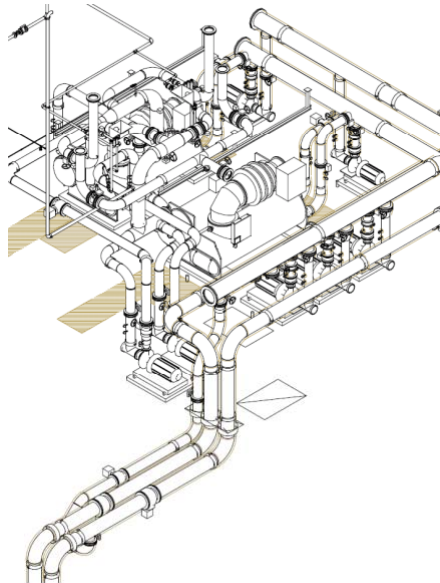
## Copper

- Type B normally used for HVAC applications
- Type A used for refrigeration (higher pressure rating)
- Joints are silver-soldered or flanged
- Can interface with steel using "copper-mate" flanges
- Easy to handle and install but very expensive above 125 diameter





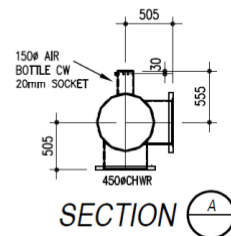
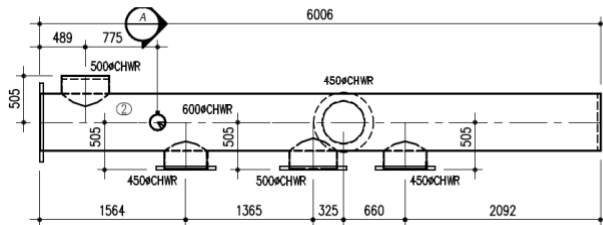
### Steel Pipe



- Available in seamless or welded seam (ERW)
- ERW is the most economical solution for steel pipe in closed systems
- Seamless is imported and very expensive but has a higher resistance to corrosion (although this is not a major issue with chilled water)
- Dimensional consistency with seamless pipe can vary due to the manufacturing process. This can cause a problem with the vapour barrier due to the air gap between the insulation and pipe



- With steel pipe, joints can be flanged, welded or roll-grooved
- (roll-grooved enables off-site pre-fabrication and quicker installation on site)



### Stainless Steel Pipe

- Available in 304 and 316 grade
- 304 is the most economical solution for stainless steel pipe in open systems
- 316 is very expensive but has a higher resistance to corrosion
- With stainless steel pipe, roll-grooved or flanged joints are used. Roll-grooved couplings must be galvanised



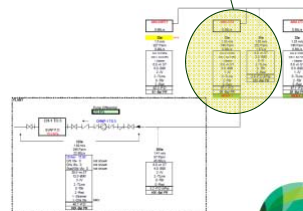
### Pipe Sizing

- Many designers tend to oversize pipework to allow for future capacity or low system resistance.

**At AE Smith, we use a computer spreadsheet developed in-house which provides the following benefits:**

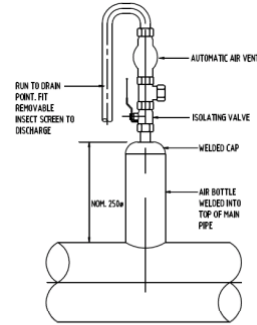
- Determination of the Index Run (highest pressure loss branch in the system)
- Optimisation of pipe sizes without affecting total pump head
- Determining pre-sets for balancing valves to simplify commissioning
- Calculation of the required pump head

<b>AHU-4-1</b>	
10.16L/s	
100ø	125ø
1.35 m/s	1.64 m/s
175 Pa/m	191 Pa/m
10.16L/s	19.78L/s
Coil 45.0 kPa	6.0 -m ST
Ctn V. 55.7 kPa	4.0 -B90
1 Strainer	0 -IV
6.0 -m ST	2 -TLine
6.0 -B90	0 -TBr
1 -IV	0 -Red
0 -TLine	<u>3.9 -P.D (kPa)</u>
2 -TBr	<u>147 -Bal PR</u>
2 -Red	
<u>110.4 -P.D</u>	
<u>37 -Bal PR</u>	



## Air Vents

- Air trapped in pipes causes noise to be transmitted through the pipes and reduces system performance
- Air in the pipes can also promote corrosion, particularly in steel pipe
- Air vents are required at high points in the pipework to enable removal of air from the system. The air vents can be manual or automatic



## Condensate Drains



- Condensation from cooling coils must be drained to an open collection point or tundish
- PVC pipe is the lowest cost option but some designers may specify copper for durability or Green Star requirements. Copper is very expensive and may need insulation to avoid sweating
- Tundishes should be located as close as possible to the AHU/FCU to minimise pipe runs and ensure the pipe falls to the tundish
- Long drain pipes may not work effectively and could pose a tripping hazard in the plantroom
- The condensate drain must be trapped



## Headers

- Incoming and outgoing flows are at opposite ends of the header to ensure stable flow and good mixing
- Each circuit can be isolated at the header to enable work to be carried out on one circuit while others can continue to operate
- Headers are not recommended for condenser water systems due to the potential for legionella to grow in stagnant pipe sections

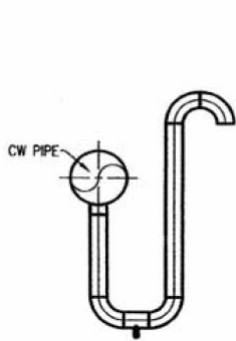


## Air and Dirt Separators

- Commonly specified now but often there is no indication of where they are required, what size, what type etc.
- Often, too many are specified and can be rationalised with significant savings (they are very expensive)
- Instead of installing line size separators, they work effectively in a bypass arrangement and can be moved to different locations to assist with system flushing



### Vacuum Breakers



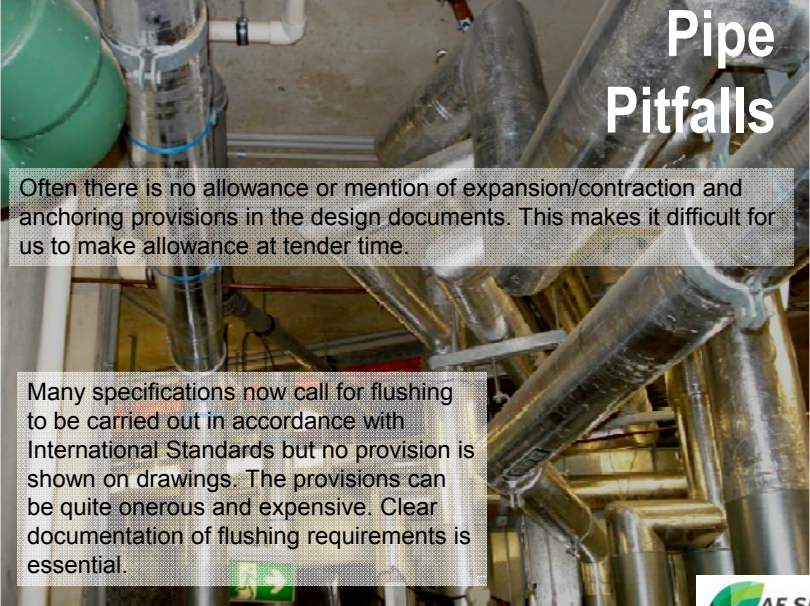
- When using stainless steel or copper there is a risk of pipe implosion if a cooling tower isolation valve is shut while the pump is running.
- To prevent this occurring, a vacuum breaker is required. This takes the form of a standing pipe in the pump suction line which will allow air to enter the system and prevent collapse if an isolation valve is shut while the pump is running.



### Imploded Pipe








## Pipe Pitfalls

Often there is no allowance or mention of expansion/contraction and anchoring provisions in the design documents. This makes it difficult for us to make allowance at tender time.

Many specifications now call for flushing to be carried out in accordance with International Standards but no provision is shown on drawings. The provisions can be quite onerous and expensive. Clear documentation of flushing requirements is essential.




### Pipe Installation - Important Points

- Install condenser water pipes below cooling tower sump level to minimise water and chemical losses when the pump is not running. This also helps to prevent air locks. Don't rely on check valves to prevent back flow





- Often we see three way control valves shown in systems that also have bypasses. Two way valves are more energy-efficient as they close when the AHU is off and pumps can slow down. Three way valves allow water to circulate at all times.
- Contradictions often appear between specified pipe sizing criteria and sizes shown on consultants' drawings



- Often there are too many isolation valves shown around equipment in plantrooms. Locating pumps close to equipment served can reduce this requirement and reduce cost
- Typical piping connections to AHU's etc often show strainers and unnecessary additional isolation valves. Use common strainers for plantroom areas or groups of AHU's. This will reduce cost and maintenance requirements.





