COOLING TOWER THERMAL CAPABILITY

Are You Getting 100%?

"Cooling towers never work properly!" Such is the perception of these much maligned pieces of equipment that engineers often over-specify the design capacity or entering air wet bulb temperature, or both, in an effort to obtain a machine that will perform without problems.

What can be done to ensure that the purchased tower does perform according to its quoted ratings? This paper will attempt to address the issues of poor performance and the available solutions.

Capacity vs. Capability

a) <u>Capacity.</u>

The selection of a cooling tower is dependent on the design *Capacity,* which is the flow rate of water that is to be cooled; the entering or hot water temperature; the leaving or cold water temperature; and the entering air wet bulb temperature.

If a cooling tower is under sized, a misconception is that the tower somehow or other rejects less heat than is applied to it. In reality, a cooling tower will dissipate all the heat transmitted to it, but an undersized tower will do so at higher temperatures than design.

For example, a cooling tower selected with an approach of 5 degrees and a range of 5 degrees, would if it had a 25% deficiency in its sizing have an actual approach of approximately 7 degrees, which is approximately 40% higher than the original design requirements.

b) <u>Capability.</u>

A term that is often confused with Capacity is the Capability of a tower. This term applies to the measure of a tower's ability to handle the applied loading in relation to its original design parameters.

The term is defined as the percentage of the design water flow that the tower is actually capable of cooling, at the design conditions. It is the quantity that is arrived at when giving results for a test conducted under the test codes.

Thermal Performance Assessment.

It would be immediately apparent if you were to receive a shortfall in your salary, or in the payment of one of your invoices, but it is not so easy to detect a shortfall in the performance of your cooling tower. It may be suspected that a tower is not performing as it should, but proving that suspicion is another matter. What makes it difficult to assess, is that the performance of a tower is affected by such variables as water flow rate, air temperatures, and heat load. If checking a tower's performance involved having to wait for a day when all these variables matched the design conditions, then it would be a long wait indeed. Fortunately, methods do exist for assessing the tower's performance at conditions that vary from design.

To test a tower with any degree of accuracy requires more than waving a sling psychrometer in the general vicinity of the tower, assessing water flow by reference to the pump curves, and taking water temperatures with a thermometer graduated in half-degree divisions. High accuracy is required, for the temperature differences involved with the cooling range and approach are small, but the accuracy of the measurement of these temperature differences has a large impact on the test result.

For example, the table projected on the screen gives a set of design conditions for a cooling tower. Opposed to the design figures are two sets of test conditions, *Test A* and *Test B.*

	DESIGN	TEST A	TEST B
Water Flow Rate (m^3/h)	907	842	878
Hot Water Temp. (°C)	37.0	31.6	31.7
Cold Water Temp. (°C)	32.0	27.2	27.1
Wet Bulb Temp. (°C)	27.0	20.1	20.2
Range (K)	5.0	4.4	4.6
Approach (K)	5.0	7.1	6.9
Heat Load (kW)	5276	4311	4700
Capability (%)		86.0	96.5

Test A is the set of figures from a carefully run test. Test B gives conditions where a mistake of 4% has been made in the water flow calculations, and errors of 0.1 °C have been made in the temperature readings for the hot and cold water, and also for the wet bulb reading. These errors may not seem to be significant. However, their impact on the test result is to give a final Capability for Test A of 86.0%, against that for Test B of 96.5%, more than a ten percent difference.

Test B results would generally be judged a pass, for it has a Capability of 95%. However, when it is considered that a tower to meet the design conditions detailed above would cost in the order of $US30,000, the real shortfall of 14% in capability in the example above is worth some $US4,000. Consider what the cost difference that a tower that delivers only 70% or less in capability is worth! It is a cause for concern that despite the existence of a number of different thermal test standards for towers, this situation still occurs.

Effects of an Undersized Cooling Tower.

When a cooling tower is undersized for whatever reason, be it a mistake in selection, poor installation practices, or optimistic ratings by the manufacturer, it can have a number of effects as follows:

a) Initial Cost
All things being equal, a cooling tower that is providing only 80% capability can be expected to be around 20% cheaper in its original cost than a 100% tower. In a competitive situation when bidding for a project, a small price difference can win or lose a job.

b) Running Costs
Towers that are undersized will produce higher water temperatures than specified, and thus contribute to a less efficient operation of the total plant. A less efficient plant equates to a longer running time, causing higher energy costs.

c) Critical Plant Operations
For critical conditions such as computer rooms, air-conditioning temperatures that are higher than design can cause problems with computer operational malfunctions. In industrial applications, loss of production, or a downgraded product can be the result of high water temperatures.

d) Plant Life
Add to the above the reduced life that can be expected from a plant because of the additional stresses caused by higher operational temperatures, and the benefit of the lower initial cost of an undersized cooling tower quickly diminishes.

Protection against Undersized Cooling Towers.

What protection is there to ensure that the installation performs satisfactorily?

- Does the manufacturer or his representative stating *Of course we guarantee the tower's capacity* afford any protection?

- Does the use of a *Member of the Cooling Tower Institute* (CTI) sticker on the cooling tower or on technical bulletins give a guarantee of performance?

- Does the claim that the tower is *tested in accordance with the Japanese Standard JIS B 8609* guarantee the performance?

- Does the claim that the tower is *tested in accordance with the Chinese Standard GB7190.1 " guarantee the performance?*

- Does a site test carried out by the manufacturer, usually with minimal instrumentation give any guarantee?

Unfortunately, even if all of the above conditions apply, the tower's capability cannot be guaranteed. Consider the following:

- If a manufacturer quotes a particular sized cooling tower to a set of design conditions, it could be assumed that the manufacturer is guaranteeing that the tower will perform to those conditions. Unfortunately this is not always the case and some manufacturers are over-rating their towers as much as 40%.

- A number of manufacturers belong to the *Cooling Tower Institute,* a worldwide organisation headquartered in the USA. More than any other organisation, the CTI has played a part in elevating the status of cooling towers, by promoting the truthful rating of them. Being a member of the CTI allows the member to use the CTI logo with *Member* printed under it on letterheads and promotional information. The use of the CTI logo in such a way does not provide a guarantee of performance of the manufacturer's range of products.

- The Japanese Industrial Standard, *JIS B 8609 - Performance Tests of Mechanical Draft Cooling Tower* covers Thermal Performance, Sound, Drift and Electrical Power. Some cooling tower manufacturers proclaim that their towers are tested in accordance with JIS B 8609. This standard states that it is for use with cooling towers of capacity of 233 kW or less, at standard design conditions. This is an approximate water flow rate of 11L/s, which is a small machine indeed, though there is nothing to prevent the principles outlined in the standard from being used for larger towers.

  JIS B 8609 is a code for laboratory practice and is not suitable for field-testing cooling towers.

In JIS B 8609, once having found the performance of the tower, there is no requirement, compulsory or voluntary to use the actual capacity found from testing in the published ratings for that tower.

- As with the Japanese standard discussed above, the Chinese Standard, *GB 7190.1* covers thermal performance requirements and other matters pertaining to cooling towers. Different to the Japanese standard is that this Chinese standard also covers a form of certification of the cooling tower's thermal performance.

  However, it is my belief that this standard has a number of problems with its approach to thermal performance testing. Some problems that I note are:

  - Having a test tolerance of 10% is in my opinion too high; because I believe that the end user deserves to get what they paid for.

  - The required instrument precision is not high enough to provide confidence in the end result, and I previously discussed that seemingly small measurement tolerances can lead to large errors in the final calculated capability of the cooling tower under test.

  Apart from my concern with the accuracy of the test results, it is also my opinion that the certification provided under the auspices of the Chinese standard is not rigorous enough. This standard falls short of being able to provide confidence to the purchaser that they will obtain the cooling tower performance that they specify.

- To overcome the problems caused by undersized cooling towers, some consultants are specifying that a site test shall be carried out on the cooling tower to verify its Capability. However, should a manufacturer offer and have accepted a proposal to test the tower themselves, then the whole purpose of the test may be defeated.

  Most manufacturers would do a test using minimal equipment of dubious quality. In such circumstances, errors are common, and usually favour the manufacturer. Referring to the table given earlier, it can be seen how small differences in the measured quantities can make a large difference in the end result. Not only can errors be made in reading off quantities, but there are other tricks of the trade that can be used to bias a test result in the favour of the tower manufacturer. So, even specifying a site test with all the best intentions will not necessarily ensure that the end result is a tower delivering the performance that is required.

If it is critical that a tower provides the performance that is specified (and shouldn't all installations be considered as such?), there are two ways to ensure receipt of a full sized tower. These are:

Specify a test to a competent standard such as the CTI Test Code ATC-105, with the test to be carried out by an independent testing authority that possesses the necessary skills and high quality instrumentation.

Purchase a cooling tower that has certified thermal performance. At this point of time, the only certification scheme of merit in existence is the one conducted by the CTI.

Independent Cooling Tower Thermal Performance Testing.

A well conducted site test to the test codes involves the measurement of such things as water flow rate; hot and cold water temperatures; entering air wet bulb temperatures; fan motor electrical characteristics; and wind speed and direction. These quantities are specified to be within certain limits of the design conditions. Because water cooling towers rely on both heat and mass transfer to affect the cooling function, they are rated at steady state conditions. While it is impossible to obtain a steady state condition on site, the test codes stipulate the maximum rate of change that the various measured quantities can vary over the test period

Instrumentation is of paramount importance, and of course should be calibrated to an acceptable standard. Logging of test measurements should preferably be automatic, particularly for larger towers where there are a large number of instruments used in the gathering of information.

It is essential to the interests of all parties, that confidence exists in the ability of the tester to conduct the test and interpret the accumulated data. To ensure confidence, the CTI has a scheme where it licenses testing agencies to conduct thermal performance testing under their auspices. Such a licence is only granted after rigorous examination by the CTI of the applicant. The aim of the examination is to assure quality in the conduct of the test, the reporting of results, and the complete independence of the licensee without the possibility of any conflict of interest.

I do not promote that every cooling tower be tested. However, for larger towers, and for towers on critical installations, the test price can be justified when compared with the initial cost of the tower, and the impact on the life cycle costs of the overall plant that an undersized tower can have.

Should a test prove that the tower is deficient in its capability by more than 5%, then as part of the contractual obligations, the tower manufacturer should be required to upgrade the tower and retest at their expense. Should the tower still be deficient, then further upgrading and re-testing is to be carried out. It is not surprising that where such specifications are invoked, the chance of an undersized cooling tower being installed considerably diminishes.

Certified Cooling Tower Thermal Performance.

In an effort to reduce the cost of site thermal performance tests, and to give an assurance that the purchased tower does perform to its ratings, particularly for the smaller modular style of tower, the CTI introduced a certification scheme as outlined in the CTI standard STD-201.

The conduct of the scheme is rigorous, and to date there are now ten manufacturers (including two Chinese companies: Mesan being the first) who have had a range of towers certified. It would be in the interests of cooling tower users everywhere if industry pressure was brought to bear on local manufacturers to make use of this scheme.

The CTI certification scheme involves an interested manufacturer in submitting:

- A general description of the cooling tower line to be certified, including catalogues if available.
- A copy of the "published ratings" for each cooling tower model comprising the line.
- A Physical Data Sheet for each cooling tower model comprising the line.

From the line of models, the CTI selects a model and has a thermal performance test carried out to their test code ATC-I05. The tower may be tested in a laboratory or in the field. Should the test pass, the line of proposed towers gains certification. Should the test fail, the manufacturer is given the option of revising the tower's ratings, or making modifications to the line, or both. Further testing then takes place to verify the performance.

After certification of a line of towers, it is a requirement that the manufacturer annually re-verify the performance by test, such testing to be conducted by the CTI.

Such a scheme gives purchasers of cooling towers the confidence that they are obtaining machines that will perform according to their ratings. The scheme has a lot to commend it.

Conclusion.

Cooling towers have a poor reputation. It is generally believed that they do not deliver the performance that they are rated at. To overcome the possibility of a low performing tower, design conditions are specified which are higher than required. This "solution" may be contributing to the perpetuation of the original problem.

It is possible to demand and obtain cooling towers that have 100% capability, either by specifying a site test conducted by an independent and experienced testing agency, or by the purchase of a tower with certified thermal ratings. Both of these options are obtainable under, programs conducted by the Cooling Tower Institute. A more widespread adoption of these practices can only ensure that operating problems with cooling towers are reduced.

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