CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Draft Measure Information Template – Cooling Tower Efficiency and Turndown

2013 California Building Energy Efficiency Standards

California Utilities Statewide Codes and Standards Team, April 2011

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1. Overview

1.1 Measure Title

Cooling Tower Efficiency and Turndown

1.2 Description

This measure proposes to update Title 24-2013 for cooling tower efficiency and flow turndown. The current efficiencies in Title 24 2008 (Table 112-G) and ASHRAE Standard 90.1-2010 (Table 6.8.1G) were developed by the SSPC 90.1 and ASHRAE technical committee 8.6 to eliminate the bottom 5% of the cooling tower market for inclusion in the 90.1-1999 standard. Since their inclusion in they have never been revisited in either 90.1 or Title 24.

Based on the life-cycle analysis documented in this report we recommend an increased minimum efficiency of 80 gpm/hp as a prescriptive requirement for towers in new buildings or chilled water plants. For 24/7 facilities like data centers we also propose a maximum approach of 5F.

90.1-2010 added to Table 6.8.1G new requirements for closed-circuit fluid cooling towers which we propose to adopt without change in Table 112-G for Title 24 2013. In addition to the change in Table 112-G a new definition will be added for closed-circuit cooling towers and the reference performance standard.

Finally in response to feedback from the manufacturers, we are proposing to relax the requirement for 33% flow turndown for cooling towers (144(h)3), a prescriptive measure that was introduced into Title 24 in 2005.

1.3 Type of Change

This proposal includes changes to the definitions, mandatory requirements (Table 112-G), the prescriptive requirements (114(h), and corresponding changes to the ACM.

1.4 Energy Benefits

This measure proposes to increase the minimum energy efficiency requirements of cooling towers in California. Increased energy efficiency reduces the amount of cooling energy required to maintain the same cooling output.

1.5 Non-Energy Benefits

This measure has no non-energy benefits.

1.6 Environmental Impact

There are no significant potential adverse environmental impacts of this measure.

1.7 Technology Measures

This measure as written provides a preference for propeller fan towers.

1.8 Performance Verification of the Proposed Measure

There are no new proposed acceptance requirements.

1.9 Cost Effectiveness

As demonstrated below the

1.10 Analysis Tools

Currently available simulation programs such as eQuest are capable of modeling the requirements of this measure.

1.11 Relationship to Other Measures

This measure has no relation to other measures.

2 Methodology

We used the TOPP model (see references below) to model a 900 ton plant with two equally sized 500t chillers over a range of control scenarios. For this model we used 12 different 2-cell towers that represented three different efficiencies (from 50gpm/hp to 90 gpm/hp at the rating conditions of 95/85/75) and four different approaches (from 3F to about 12F). Each run represented near optimal controls for the plant. As shown in the figures below the preliminary findings indicate that a high efficiency tower was cost justified and that a maximum approach was only justified for a 24X7 facility.

2.1 Climates

The preliminary analysis was performed on 8 of the 16 climate zones (CZ 3, 6, 7, 8, 9, 10, 12, and 13). According to the Dodge database these 8 climates represent 85% of the new construction in 2013.

2.2 Load Profiles

The load profiles for the LCC were developed using an eQuest model of a 15 zone office building which was scaled for each climate to a 900 ton peak load. This building had VAV reheat with and air-side economizer.

2.3 Cooling Tower Data

The twelve cooling towers modeled were all taken from one manufacture, BAC. They were all draw-through cross-flow open towers with propeller fans. The contractor’s costs for these towers were multiplied by 28.75% for contractor’s mark-up then by 50% for an installation cost premium.

Figure 1 Cooling Tower Models

Tower Name	B.A.C GPM @ 78/85/95	Tower pumping head PSI	Tower Code Name	Motor size	GPM/HP
3781C	***2342.02***	***6.69***	L01	50	46.8
3676C	***1938.02***	***4.9***	L02	40	48.5
3482C	***1377.01***	***4.9***	L03	30	45.9
3436C	***1266.01***	***4.32***	L04	30	42.2
3728C/V	***2277.02***	***6.69***	M01	40	56.9
3618C	***1773.01***	***4.9***	M02	30	59.1
3473C	***1374.01***	***4.32***	M03	25	55.0
3455C-MM	***1212.01***	***4.9***	M04	20	60.6
3872C-OM/V	***2268.02***	***7.85***	H01	30	75.6
3728C-NM	***1884.01***	***6.69***	H02	25	75.4
3552C-MM	***1392.01***	***4.9***	H03	20	69.6
3473C-LM/V	***1212.01***	***4.32***	H04	15	80.8

3 Analysis and Results

The results of our analysis for the office building in the 8 climate zones are shown in Figure 2 and Figure 3 below. In each case the lowest life-cycle cost tower was H04, the high efficiency tower with the highest approach (see Figure 1 above). We were unable to complete our analysis for 24X7 facilities in time for this workshop.

Figure 2 Modeling Results Climate Zones 3, 6, 7 and 8

Climate Zone	TowerID	Ta	ChillerkWh	TowerkWh	CHWPkWh	CWPkWh	TotalKWh	TDV Energy Cost	Tower cost	Total LCC cost
			kWh/yr	kWh/yr	kWh/yr	kWh/yr	kWh/yr	15 year PV	First Cost installed	NPV
CZ03	H01	5.4	180,569	14,020	22,964	40,246	257,644	$ 1,103,350	$ 262,000.00	$ 1,365,350
CZ03	H02	7.0	182,346	13,521	23,000	36,827	255,532	$ 1,103,764	$ 231,612.50	$ 1,335,377
CZ03	H03	10.4	187,444	13,276	23,154	31,725	255,423	$ 1,116,114	$ 179,862.50	$ 1,295,977
CZ03	H04	12.3	189,456	12,084	23,153	30,352	254,736	$ 1,118,379	$ 156,752.50	$ 1,275,132
CZ03	L01	5.1	181,678	21,294	22,912	37,021	262,781	$ 1,121,414	$ 250,537.50	$ 1,371,951
CZ03	L02	6.7	183,925	19,130	22,922	32,167	258,006	$ 1,113,480	$ 221,825.00	$ 1,335,305
CZ03	L03	10.5	189,512	18,194	23,218	31,623	262,391	$ 1,145,187	$ 167,262.50	$ 1,312,450
CZ03	L04	11.6	191,805	19,350	23,248	30,207	264,471	$ 1,157,815	$ 152,962.50	$ 1,310,778
CZ03	M01	5.3	181,451	17,701	22,918	37,002	258,911	$ 1,109,230	$ 250,425.00	$ 1,359,655
CZ03	M02	7.6	183,871	16,056	22,971	32,065	254,788	$ 1,105,815	$ 208,375.00	$ 1,314,190
CZ03	M03	10.5	188,558	15,929	23,142	30,369	257,862	$ 1,127,638	$ 170,837.50	$ 1,298,475
CZ03	M04	12.3	191,091	14,560	23,248	31,572	260,247	$ 1,141,057	$ 156,625.00	$ 1,297,682
CZ06	H01	4.8	318,341	23,324	26,221	61,764	429,471	$ 1,340,801	$ 262,000.00	$ 1,602,801
CZ06	H02	6.4	322,553	22,260	26,305	56,133	427,009	$ 1,341,083	$ 231,612.50	$ 1,572,695
CZ06	H03	9.7	332,716	22,064	26,530	48,021	428,957	$ 1,356,798	$ 179,862.50	$ 1,536,661
CZ06	H04	11.5	336,446	20,703	26,743	45,271	428,763	$ 1,360,233	$ 156,752.50	$ 1,516,985
CZ06	L01	4.6	321,058	34,655	26,206	56,714	438,378	$ 1,365,013	$ 250,537.50	$ 1,615,551
CZ06	L02	6.1	324,504	31,704	26,207	49,211	431,397	$ 1,353,309	$ 221,825.00	$ 1,575,134
CZ06	L03	9.8	336,604	30,068	26,691	47,460	440,622	$ 1,392,354	$ 167,262.50	$ 1,559,616
CZ06	L04	10.9	340,832	31,788	26,771	45,190	444,434	$ 1,407,210	$ 152,962.50	$ 1,560,172
CZ06	M01	4.8	320,057	29,398	26,216	56,636	432,004	$ 1,348,871	$ 250,425.00	$ 1,599,296
CZ06	M02	7.0	325,705	26,250	26,267	48,956	427,006	$ 1,344,460	$ 208,375.00	$ 1,552,835
CZ06	M03	9.8	334,893	26,249	26,540	45,870	433,350	$ 1,371,124	$ 170,837.50	$ 1,541,961
CZ06	M04	11.5	340,430	23,741	26,811	47,103	437,755	$ 1,387,656	$ 156,625.00	$ 1,544,281
CZ07	H01	4.6	291,468	23,474	28,450	63,170	406,361	$ 1,261,344	$ 262,000.00	$ 1,523,344
CZ07	H02	6.2	295,670	22,170	28,520	57,532	403,543	$ 1,259,872	$ 231,612.50	$ 1,491,484
CZ07	H03	9.4	305,294	21,713	28,705	49,514	404,841	$ 1,272,814	$ 179,862.50	$ 1,452,676
CZ07	H04	11.3	308,944	20,304	28,843	47,044	404,704	$ 1,275,053	$ 156,752.50	$ 1,431,806
CZ07	L01	4.4	293,697	35,487	28,435	57,861	415,132	$ 1,284,996	$ 250,537.50	$ 1,535,534
CZ07	L02	5.9	297,513	31,904	28,446	50,211	407,923	$ 1,272,334	$ 221,825.00	$ 1,494,159
CZ07	L03	9.6	308,717	29,829	28,809	49,242	416,405	$ 1,306,531	$ 167,262.50	$ 1,473,793
CZ07	L04	10.7	313,264	31,284	28,855	47,012	420,284	$ 1,320,545	$ 152,962.50	$ 1,473,508
CZ07	M01	4.6	292,808	29,863	28,437	57,880	408,790	$ 1,269,175	$ 250,425.00	$ 1,519,600
CZ07	M02	6.8	298,432	26,390	28,482	50,092	403,167	$ 1,262,052	$ 208,375.00	$ 1,470,427
CZ07	M03	9.6	307,640	25,742	28,756	47,255	409,022	$ 1,285,993	$ 170,837.50	$ 1,456,831
CZ07	M04	11.3	312,483	23,666	28,947	48,902	413,623	$ 1,301,280	$ 156,625.00	$ 1,457,905
CZ08	H01	4.6	375,606	25,577	44,399	69,623	515,040	$ 1,643,617	$ 262,000.00	$ 1,905,617
CZ08	H02	6.2	380,396	25,381	44,486	63,880	513,926	$ 1,649,159	$ 231,612.50	$ 1,880,771
CZ08	H03	9.4	392,910	26,411	44,781	55,059	518,792	$ 1,676,482	$ 179,862.50	$ 1,856,345
CZ08	H04	11.3	397,140	25,599	44,950	52,388	519,693	$ 1,684,111	$ 156,752.50	$ 1,840,864
CZ08	L01	4.4	379,135	37,078	44,324	64,306	524,614	$ 1,670,813	$ 250,537.50	$ 1,921,351
CZ08	L02	5.9	383,669	34,876	44,350	55,875	518,581	$ 1,663,348	$ 221,825.00	$ 1,885,173
CZ08	L03	9.6	398,007	35,116	45,084	54,566	532,619	$ 1,720,686	$ 167,262.50	$ 1,887,949
CZ08	L04	10.7	403,637	37,345	45,174	52,048	538,111	$ 1,741,840	$ 152,962.50	$ 1,894,802
CZ08	M01	4.6	377,584	32,007	44,366	64,190	517,936	$ 1,653,101	$ 250,425.00	$ 1,903,526
CZ08	M02	6.8	384,801	29,752	44,393	55,773	514,483	$ 1,655,070	$ 208,375.00	$ 1,863,445
CZ08	M03	9.6	396,334	30,680	44,820	52,582	524,219	$ 1,694,642	$ 170,837.50	$ 1,865,480
CZ08	M04	11.3	402,195	28,882	45,059	54,600	530,438	$ 1,718,601	$ 156,625.00	$ 1,875,226

Figure 3 Modeling Results Climate Zones 9, 10, 12 and 13

Climate Zone	TowerID	Ta	ChillerkWh	TowerkWh	CHWPkWh	CWPkWh	TotalKWh	TDV Energy Cost	Tower cost	Total LCC cost
			kWh/yr	kWh/yr	kWh/yr	kWh/yr	kWh/yr	15 year PV	First Cost installed	NPV
CZ09	H01	4.4	331,167	22,319	35,891	61,193	450,389	$ 1,623,254	$ 262,000.00	$ 1,885,254
CZ09	H02	6.0	335,003	22,274	36,146	55,487	448,677	$ 1,629,768	$ 231,612.50	$ 1,861,381
CZ09	H03	9.2	345,866	22,838	36,486	47,590	452,461	$ 1,660,487	$ 179,862.50	$ 1,840,350
CZ09	H04	11.0	349,197	22,105	36,728	45,085	452,799	$ 1,668,651	$ 156,752.50	$ 1,825,403
CZ09	L01	4.2	333,184	33,178	35,724	56,669	458,570	$ 1,649,520	$ 250,537.50	$ 1,900,058
CZ09	L02	5.7	337,318	30,870	35,872	48,848	452,812	$ 1,645,508	$ 221,825.00	$ 1,867,333
CZ09	L03	9.3	350,534	30,179	36,781	47,012	464,348	$ 1,704,094	$ 167,262.50	$ 1,871,357
CZ09	L04	10.4	355,859	31,659	37,009	44,600	468,976	$ 1,726,197	$ 152,962.50	$ 1,879,159
CZ09	M01	4.4	332,494	28,260	35,854	56,320	452,777	$ 1,633,036	$ 250,425.00	$ 1,883,461
CZ09	M02	6.6	338,620	25,940	35,939	48,678	448,974	$ 1,637,609	$ 208,375.00	$ 1,845,984
CZ09	M03	9.4	348,995	26,404	36,598	45,312	457,105	$ 1,679,428	$ 170,837.50	$ 1,850,266
CZ09	M04	11.0	353,741	24,937	36,907	46,825	462,129	$ 1,702,196	$ 156,625.00	$ 1,858,821
CZ10	H01	4.6	446,094	27,879	72,944	84,499	631,323	$ 1,930,418	$ 262,000.00	$ 2,192,418
CZ10	H02	6.2	453,801	27,844	72,942	78,453	632,836	$ 1,941,966	$ 231,612.50	$ 2,173,578
CZ10	H03	9.4	469,707	30,879	72,942	68,412	641,740	$ 1,979,060	$ 179,862.50	$ 2,158,923
CZ10	H04	11.3	474,636	31,115	72,942	65,334	643,786	$ 1,990,020	$ 156,752.50	$ 2,146,772
CZ10	L01	4.4	450,311	39,165	72,946	78,589	640,847	$ 1,958,043	$ 250,537.50	$ 2,208,581
CZ10	L02	5.9	458,214	36,715	72,877	68,514	636,155	$ 1,955,246	$ 221,825.00	$ 2,177,071
CZ10	L03	9.6	475,414	41,360	72,942	68,412	657,945	$ 2,030,096	$ 167,262.50	$ 2,197,358
CZ10	L04	10.7	482,036	45,187	72,942	65,334	665,391	$ 2,056,501	$ 152,962.50	$ 2,209,464
CZ10	M01	4.6	449,899	33,031	72,944	78,511	634,262	$ 1,940,940	$ 250,425.00	$ 2,191,365
CZ10	M02	6.8	460,491	31,626	72,875	68,514	633,385	$ 1,949,601	$ 208,375.00	$ 2,157,976
CZ10	M03	9.6	472,894	36,693	72,942	65,334	647,758	$ 2,000,203	$ 170,837.50	$ 2,171,040
CZ10	M04	11.3	479,907	36,139	72,942	68,412	657,128	$ 2,030,142	$ 156,625.00	$ 2,186,767
CZ12	H01	4.3	274,646	18,377	32,318	50,653	375,837	$ 1,417,565	$ 262,000.00	$ 1,679,565
CZ12	H02	5.8	278,910	17,919	32,464	46,259	375,326	$ 1,425,026	$ 231,612.50	$ 1,656,639
CZ12	H03	9.0	287,833	19,271	32,817	39,602	379,268	$ 1,451,953	$ 179,862.50	$ 1,631,815
CZ12	H04	10.8	290,455	19,390	33,119	37,402	380,160	$ 1,459,439	$ 156,752.50	$ 1,616,191
CZ12	L01	4.0	276,928	26,748	32,310	46,685	382,516	$ 1,440,014	$ 250,537.50	$ 1,690,552
CZ12	L02	5.5	280,564	25,234	32,284	40,605	378,604	$ 1,436,805	$ 221,825.00	$ 1,658,630
CZ12	L03	9.1	292,064	25,032	33,016	39,262	389,258	$ 1,490,150	$ 167,262.50	$ 1,657,412
CZ12	L04	10.2	296,584	26,517	33,172	37,321	393,449	$ 1,509,746	$ 152,962.50	$ 1,662,709
CZ12	M01	4.2	275,896	23,123	32,339	46,589	377,846	$ 1,425,876	$ 250,425.00	$ 1,676,301
CZ12	M02	6.4	281,836	21,440	32,483	40,231	375,833	$ 1,431,035	$ 208,375.00	$ 1,639,410
CZ12	M03	9.1	290,663	22,058	32,879	37,774	383,170	$ 1,467,874	$ 170,837.50	$ 1,638,712
CZ12	M04	10.8	295,402	20,814	33,298	38,837	388,155	$ 1,490,542	$ 156,625.00	$ 1,647,167
CZ13	H01	4.3	348,205	22,801	58,995	71,107	501,038	$ 1,606,974	$ 262,000.00	$ 1,868,974
CZ13	H02	5.8	354,755	22,932	58,995	66,058	502,509	$ 1,617,588	$ 231,612.50	$ 1,849,200
CZ13	H03	9.0	367,985	25,399	58,994	57,584	509,724	$ 1,649,429	$ 179,862.50	$ 1,829,292
CZ13	H04	10.8	372,211	25,654	58,994	54,994	511,668	$ 1,660,321	$ 156,752.50	$ 1,817,074
CZ13	L01	4.0	351,057	32,590	58,990	66,077	508,612	$ 1,629,990	$ 250,537.50	$ 1,880,528
CZ13	L02	5.5	357,882	30,718	58,990	57,618	505,046	$ 1,627,273	$ 221,825.00	$ 1,849,098
CZ13	L03	9.1	372,860	33,664	58,994	57,584	522,968	$ 1,692,756	$ 167,262.50	$ 1,860,019
CZ13	L04	10.2	379,015	36,287	58,994	54,994	529,187	$ 1,715,050	$ 152,962.50	$ 1,868,013
CZ13	M01	4.2	351,067	27,328	58,995	66,058	503,348	$ 1,615,291	$ 250,425.00	$ 1,865,716
CZ13	M02	6.4	359,969	26,093	58,990	57,601	502,538	$ 1,622,742	$ 208,375.00	$ 1,831,117
CZ13	M03	9.1	371,458	29,385	58,994	54,994	514,686	$ 1,666,883	$ 170,837.50	$ 1,837,720
CZ13	M04	10.8	376,365	30,074	58,994	57,584	522,704	$ 1,694,299	$ 156,625.00	$ 1,850,924

4 Recommended Language for the Standards Document, ACM Manuals, and the Reference Appendices

4.1 Standard

4.1.1 Definitions

CTI ATC-105 is the Cooling Technology Institute document entitled "Acceptance Test Code for Water Cooling Towers," 2000 (CTI ATC-105-00).

CTI ATC-105S(96) is the Cooling Technology Institute document entitled "Acceptance Test Code for Closed-Circuit Cooling Towers," 1996 (CTI ATC-105-96).

CTI STD-201 is the Cooling Technology Institute document entitled "Standard for the Certification of Water-Cooling Tower Thermal Performance," 2004 (CTI STD-201-04).

4.1.2 Changes to Table 112G

TABLE 112-G PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT[d]

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Subcategory or Rating Condition	Performance Required [a,b]	Test Procedure [c]
Propeller or Axial Fan Open Cooling Towers	All	95°F Entering Water 85°F Leaving Water 75 °F wb Outdoor Air	≥ 38.2 gpm/hp	CTI ATC-105 and CTI STD-201
Centrifugal Fan Open Cooling Towers	All	95°F Entering Water 85°F Leaving Water 75 °F wb Outdoor Air	≥ 20.0 gpm/hp	CTI ATC-105 and CTI STD-201
Propeller or axial fan closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F *entering wb*	≥14.0 gpm/hp	CTI ATC-105S and CTI STD-201
Centrifugal closed-circuit cooling towers	All	102°F entering water 90°F leaving water 75°F *entering wb*	≥7.0 gpm/hp	CTI ATC-105S and CTI STD-201

Air Cooled Condensers	All	125°F Condensing Temperature R22 Test Fluid 190°F Entering Gas Temperature 15°F Subcooling 95°F Entering Drybulb	≥ 176,000 Btu/h·hp	ARI 460

[a] For purposes of this table, open cooling tower performance is defined as the maximum flow rating of the tower divided by the fan nameplate rated motor power.

[b] For purposes of this table air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.

[c] Open cooling towers shall be tested using the test procedures in CTI ATC-105. Performance of factory assembled open cooling towers shall be either certified as base models as specified in CTI STD-201 or verified by testing in the field by a CTI approved testing agency. Open factory assembled cooling towers with custom options added to a CTI certified base model for the purpose of safe maintenance or to reduce environmental or noise impact shall be rated at 90% of the CTI certified performance of the associated base model or at the manufacturer's stated performance, whichever is less. Base models of open factory assembled cooling towers are open cooling towers configured in exact accordance with the Data of Record submitted to CTI as specified by CTI STD-201. There are no certification requirements for field erected cooling towers.

[d] The efficiencies for open cooling towers listed in Table 112-G are not applicable for closed-circuit cooling towers.

4.1.3 Change to 144(h)

144(h) Heat Rejection Systems.

1 General. Subsection 144(h) applies to heat rejection equipment used in comfort cooling systems such as aircooled condensers, open cooling towers, closed-circuit cooling towers, and evaporative condensers.

2 Fan Speed Control. Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at 2/3 of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

EXCEPTION 1 to Section 144(h)2: Heat rejection devices included as an integral part of the equipment listed in Table 112-A through Table 112-E.

EXCEPTION 2 to Section 144(h)2: Condenser fans serving multiple refrigerant circuits.

EXCEPTION 3 to Section 144(h)2: Condenser fans serving flooded condensers.

EXCEPTION 4 to Section 144(h)2: Up to 1/3 of the fans on a condenser or tower with multiple fans where the lead fans comply with the speed control requirement.

3 Tower Flow Turndown. Open cooling towers configured with multiple condenser water pumps shall be designed so that all cells can be run in parallel with the larger of:

A. The flow that's produced by the smallest pump, or

B. 3350 percent of the design flow for the cell.

4 ~~Limitation on Centrifugal Fan Cooling Towers. Open cooling towers with a combined rated capacity of 900 gpm and greater at 95°F condenser water return, 85°F condenser water supply and 75°F outdoor wet-bulb temperature shall use propeller fans and shall not use centrifugal fans.~~

~~EXCEPTION 1 to Section 144(h)4: Cooling towers that are ducted (inlet or discharge) or have an external sound trap that requires external static pressure capability.~~

~~EXCEPTION 2 to Section 144(h)4: Cooling towers that meet the energy efficiency requirement for propeller fan towers in Section 112, Table 112-G.~~ Efficiency. Open cooling towers shall have a minimum efficiency of 80 gpm/hp when rated at the test conditions and procedures in Table 112-G

5 Approach. Open cooling towers serving 24/7 facilities shall be selected for a maximum approach of 5F at design conditions.

4.2 ACM

Towers in the budget design shall use the minimum efficiency and approach from 144(h).

4.3 Reference appendices

None.

5 Bibliography and Other Research

5.1 TOPP Model:

Mark Hydeman and Anna Zhou. Optimizing Chilled Water Plant Controls. ASHRAE Journal, June 2007.

5.2 Modified DOE2 (chiller) model:

Mark Hydeman, et alia. Development and Testing of a Reformulated Regression Based Electric Chiller Model. ASHRAE Transaction, HI-02-18-02, 2002

5.3 DOE 2.2 Cooling Tower Model:

DOE 2.2 Engineering Manual

Mark Hydeman and Dudley Benton. An Improved Cooling Tower Algorithm for the CoolTools™ Simulation Model. ASHRAE Transaction, AC-02-9-04, 2002

All papers available from http://tinyurl.com/23xegku

6 Appendices

6.1 Comments from TC 8.6

ASHRAE TC08.06 (Cooling Towers and Evaporative Condensers) Response to Title 24 Proposal on Minimum Efficiency Ratings for Cooling Towers

December 21, 2010

TC08.06 applauds efforts to increase energy efficiency and supports cost justified increases to the minimum efficiency and approach requirements that are in the best interests of our customers, our industry, and society in general. The TC08.06 Standards Subcommittee feels that it is critical that any such increases for evaporatively cooled systems are accomplished in conjunction with increased efficiency requirements for other equipment, such as air-cooled chillers, packaged DX systems, VRV systems, and water source heat pumps.

Based on our review of the information provided, the Subcommittee has serious concerns about this specific proposal and the rationale in developing it. First and foremost, this proposal will have a significant negative impact on the industry in terms of product offering. Second, and just as important, singling out highly efficient evaporatively cooled systems for further costly efficiency increases will have the unintended consequence of driving customers to less efficient system choices. Indeed, a water cooled chiller system with even the lowest minimum cooling tower efficiency currently allowed by Title 24 will have lower peak and annual energy consumption than most, if not all, alternative cooling systems. Third, the presentation available for review for the proposed Title 24 efficiency changes to open circuit cooling towers was incomplete and lacked sufficient detail for a proper review. As such, it is important that all data be made available for review by the industry so that proper comments can be submitted.

As we understand it, what is being proposed is an increase to 100 gpm/hp for 24/7 installations and 80 gpm/hp for all others. This is a huge - 210% to 261% - jump from the current 38.2 gpm/hp level for axial fan cooling towers. This of course assumes that these new minimum efficiency levels are at the standard conditions of 95°F/85°F/75°F and not the gpm/hp for the specific selection. It also appears from the limited data on the charts in the presentation, "Cooling Tower Energy Efficiency Stakeholder Meeting 2" that the large increase in the cooling tower efficiency is assumed to have only a very small impact on life cycle costs. This is not realistic to expect no cost increase from such a large increase in the minimum efficiency rating for the cooling towers. In addition, the first costs appear to be equal between the alternative efficiency levels, which is surprising, and insufficient data is presented to know if all costs have been properly accounted for. The proposed approach requirement also appears to promote smaller cooling towers, contradicting the desire to increase the system efficiency. Finally, no market data has been offered to evaluate the overall energy savings from this proposal nor has the potential impact for market shifts to alternative systems been evaluated.

Based on the Subcommittee's review, the primary areas of concern with this proposal are summarized as follows (preliminary, based on the incomplete data currently available):

1. Tower Availability: At the proposed 100 gpm/hp level, the number of models available to satisfy the cooling duty will be reduced by approximately 90%. This will leave very large gaps between models and will lead to difficulty matching towers to the required cooling duty. Cooling towers will be overpriced, competition will be uneven and overall monetary and space efficiency will be poor relative to lower efficiency alternative systems.

2. Enforcement: Having different efficiency requirements for identical buildings that may have different operating schedules makes it difficult to determine the correct requirement, consequently making it harder to enforce. If an increased efficiency requirement is justified, it may be better to settle on one number that applies to all buildings. Users can then choose to upgrade to larger, lower HP cooling towers when justified.
3. Customer Costs: Initial costs will be dramatically increased for the cooling tower. For a 900 Ton application, increasing the efficiency from 50 gpm/hp to 90 gpm/hp will increase the first cost of the tower by about $30,000. Yet this large first cost increase does not appear to be reflected in the "Tower Efficiency" chart, and will more than offset the value of any power cost reductions.
4. Footprint Requirements: Plan area requirements will increase dramatically with the efficiency increase. For a 900 ton application, an increase in efficiency requirement from the current minimum efficiency of 38.2 gpm/hp to 80 or 100 gpm/hp would increase the plan area of the cooling towers by 40% to 50%. It is rare that this area is available to the building, either on the rooftop or at ground level. Increased steel grillage, larger crane size, and other installation costs, offset by generally lower electrical costs, will likely further aggravate the cost penalty mentioned above.
5. System Controls: To achieve the energy savings shown, a sophisticated, more expensive control system would be required. This adds to the cost of the water cooled system without a complementary requirement for alternative systems.
6. Water Loading: Increasing the efficiency and plan area will also decrease the typical gpm/ft^2 water loading by approximately one third. When combined with unit turndown requirements, the cooling tower could be forced to operate at extremely low water loadings which may lead to scaling in the cooling tower fill and subsequent "real world" decreases in capacity and overall efficiency. This would result in an increase in life cycle energy usage that is not properly captured in computerized energy models.
7. Air cooled Unit Energy Use: Increasing the costs of the evaporative cooling systems will make the overall capital costs rise unreasonably compared to air cooled (dry) systems unless such systems are also comparably challenged to increase their efficiencies. These cost increases will have the undesired effect of motivating contractors to find ways to exploit the allowed exceptions to apply more dry cooling, thus actually increasing energy use in practice.
8. Maximum Approach Requirements: The lack of a maximum approach limit is concerning as this encourages smaller cooling towers for all buildings except data centers (note that the approach limit is referred to as the minimum approach in the proposal, rather than a maximum approach limit). This appears to contradict the intent of the minimum efficiency proposal. We also believe that this will result in smaller, less efficient evaporatively cooled systems in actual practice.
9. Performance Certification: Water cooled chillers are AHRI certified to 2,000+ tons and cooling towers are CTI certified with individual cell sizes over 1,400 tons. However, air cooled chillers are currently only certified below 200 tons capacity, yet Manufacturers routinely offer models with capacities of 500 tons and above. Other systems, such as VRV systems, have no current certification programs. Thus caution must be exercised when comparing certified and uncertified equipment.

From the charts in the Stakeholder meeting slides it is obvious that specifying increases in the cooling tower efficiency has very limited direct impact on the overall building efficiency. If the goal is to reduce overall system energy usage, why not specify the use of the appropriate modeling system and limit total building energy usage directly? A building energy target will allow designers to use their expertise to select system types and equipment to achieve an overall building efficiency versus a prescriptive system that limits a designer's expertise and creativity.

After the Industry has had a chance to review the complete study, its assumptions, and results, as well as consider complementary proposals for increases in the minimum efficiency requirements for other equipment alternatives, we will be glad to work with the CEC to make a more informed decision as to an appropriate level for the minimum efficiency for open circuit cooling towers as well as for other equipment used in alternative cooling systems.

Respectfully submitted,

TC08.06 Subcommittee on Standards & Codes