

(This foreword is provided for information only and is not part of the draft addendum.)

FOREWORD

Draft Addendum 90.1 *j* – Publication Draft. ASHRAE Standard 90.1 currently references ARI Standards 550-92 and 590-92 for chillers. ARI recently revised these standards, and combined them into one volume, namely ARI-550/590-98. In the process of combining the standards, they were updated to incorporate certain revisions as described in detail in a **white paper** available from ARI (<http://www.ari.org/std/individual/550.590-98wp.pdf>). ARI member companies, consisting of the major chiller manufacturers, did extensive correlation testing between the old and new standards to determine the effects of the revisions. To correct a discrepancy between Tables 6.2.1 C and H, Table 6.2.1 H values were corrected with the COP at standard rating condition equal to the COP in Table 6.2.1 C. Other values were adjusted accordingly. The 90.1 Mechanical Subcommittee reviewed the white paper and correlation tests and agreed to accept the recommended changes, which are reflected in the proposed addenda.

Addendum 90.1 *j*

Proposed Addenda to Section 6.2.1 & Corresponding Tables 6.2.1C, H, I & J of 90.1-1989R for Chiller Efficiency Requirements

1. Change wording of 6.2.1 as shown below:

Exception to 6.2.1: Water-cooled centrifugal water-chilling packages that are not designed for operation at ARI Standard ~~550~~ 550/590 test conditions (and thus cannot be tested to meet the requirements of Table 6.2.1C) of 44°F leaving chilled water temperature and 85°F entering condenser water temperature shall have a minimum full load COP ~~and IPLV rating~~ as shown in Tables 6.2.1 H, I and J and a minimum NPLV rating as shown in Tables 6.2.1 K, L, and M beginning on 10-29-2001 (prior to 10-29-2001 there are no ~~current~~ minimum efficiency requirements for chillers that are not designed to operate at standard ARI test conditions). The table values are only applicable over the following full load design ranges:

Leaving Chiller Water Temp.:	40 to 48°F
Entering Condenser Water Temp.:	75 to 85°F
Condensing Water Temp.Rise:	5 to 15°F

Chillers designed to operate outside of these ranges are not covered by this standard.

Non-Standard Part Load Value (NPLV) is defined as a single number part-load efficiency figure of merit for chillers referenced to conditions other than IPLV conditions.

2. Change chiller efficiency tables 6.2.1C, I, & J as attached, replace table 6.2.1 H with the attached new table 6.2.1 H and add new tables 6.2.1 K, L, & M. The IP tables are attached. The corresponding SI tables require the same changes.
3. Change Section 12, Normative References, by replacing 550-92 and 590-92 with ARI 550/590-98, Water Chilling Packages Using the Vapor Compression Cycle.

[See also attached tables 6.2.1 C, H, I, J, K, L & M]

**Table 6.2.1C (I-P Units)
Water Chilling Packages, Minimum Efficiency Requirements**

Equipment Type	Size Category	Minimum Efficiency ^b	Efficiency as of 10/29/2001 ^b	Test Procedure ^a
Air Cooled, With Condenser, Electrically Operated	<150 Tons	2.70 COP <u>3.00</u> 2.80 IPLV	2.80 COP <u>3.05</u> 2.80 IPLV	ARI 550 or ARI 590 as appropriate <u>ARI 550/590</u>
	≥150 Tons	2.50 COP <u>2.75</u> 2.50 IPLV		
Air Cooled Without Condenser, Electrically Operated	All Capacities	3.10 COP <u>3.55</u> 3.20 IPLV	3.10 COP <u>3.45</u> 3.10 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating)	All Capacities	3.80 COP <u>4.25</u> 3.90 IPLV	4.20 COP <u>5.05</u> 4.65 IPLV	ARI 590 <u>ARI 550/590</u>
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	<150 Tons	3.80 COP <u>4.45</u> 3.90 IPLV	4.45 COP <u>5.20</u> 4.50 IPLV	ARI 550 or ARI 590 as appropriate <u>ARI 550/590</u>
	≥150 Tons and <300 Tons	4.20 COP <u>5.05</u> 4.50 IPLV	4.90 COP <u>5.60</u> 4.95 IPLV	
	≥300 Tons	5.20 COP <u>5.80</u> 5.30 IPLV	5.50 COP <u>6.15</u> 5.60 IPLV	
Water Cooled, Electrically Operated, Centrifugal	<150 Tons	3.80 COP <u>4.10</u> 3.90 IPLV	5.00 COP <u>5.25</u> 5.00 IPLV	ARI 550 <u>ARI 550/590</u>
	≥150 Tons and <300 Tons	4.20 COP <u>4.80</u> 4.50 IPLV	5.55 COP <u>5.90</u> 5.55 IPLV	
	≥300 Tons	5.20 COP <u>5.60</u> 5.30 IPLV	6.10 COP <u>6.40</u> 6.10 IPLV	
Air Cooled Absorption Single Effect	All Capacities	0.48 COP	0.60 COP	
Water Cooled Absorption Single Effect	All Capacities	0.60 COP	0.70 COP	

Absorption Double Effect Indirect-Fired	All Capacities	0.95 COP 1.00 IPLV	1.00 COP 1.05 IPLV	ARI 560
Absorption Double Effect Direct-Fired	All Capacities	0.95 COP 1.00 IPLV	1.00 COP 1.00 IPLV	

^a Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

^b The chiller equipment requirements do not apply for chillers used in low temperature applications where the design leaving fluid temperature is less than or equal to 40°F.

**Table 6.2.1C (S-I Units)
Water Chilling Packages, Minimum Efficiency Requirements**

Equipment Type	Size Category	Minimum Efficiency ^b	Efficiency as of 10/29/2001 ^b	Test Procedure ^a
Air Cooled, With Condenser, Electrically Operated	<528 KW	2.70 COP <u>3.00</u> 2.80 IPLV	2.80 COP <u>3.05</u> 2.80 IPLV	ARI 550 or ARI 590 as appropriate <u>ARI 550/590</u>
	≥528 KW	2.50 COP <u>2.75</u> 2.50 IPLV		
Air Cooled Without Condenser, Electrically Operated	All Capacities	3.10 COP <u>3.55</u> 3.20 IPLV	3.10 COP <u>3.45</u> 3.10 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating)	All Capacities	3.80 COP <u>4.25</u> 3.90 IPLV	4.20 COP <u>5.05</u> 4.65 IPLV	ARI 590 <u>ARI 550/590</u>
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	<528 KW	3.80 COP <u>4.45</u> 3.90 IPLV	4.45 COP <u>5.20</u> 4.50 IPLV	ARI 550 or ARI 590 as appropriate <u>ARI 550/590</u>
	≥528 KW and <1055 KW	4.20 COP <u>5.05</u> 4.50 IPLV	4.90 COP <u>5.60</u> 4.95 IPLV	
	≥1055 KW	5.20 COP <u>5.80</u> 5.30 IPLV	5.50 COP <u>6.15</u> 5.60 IPLV	
Water Cooled, Electrically Operated, Centrifugal	<528 KW	3.80 COP <u>4.10</u> 3.90 IPLV	5.00 COP <u>5.25</u> 5.00 IPLV	ARI 550 <u>ARI 550/590</u>
	≥528 KW and <1055 KW	4.20 COP <u>4.80</u> 4.50 IPLV	5.55 COP <u>5.90</u> 5.55 IPLV	
	≥1055 KW	5.20 COP <u>5.60</u> 5.30 IPLV	6.10 COP <u>6.40</u> 6.10 IPLV	
Air Cooled Absorption Single Effect	All Capacities	0.48 COP	0.60 COP	
Water Cooled Absorption Single Effect	All Capacities	0.60 COP	0.70 COP	

Absorption Double Effect Indirect-Fired	All Capacities	0.95 COP 1.00 IPLV	1.00 COP 1.05 IPLV	ARI 560
Absorption Double Effect Direct-Fired	All Capacities	0.95 COP 1.00 IPLV	1.00 COP 1.00 IPLV	

^a Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

^b The chiller equipment requirements do not apply for chillers used in low temperature applications where the design leaving fluid temperature is less than or equal to 4.4°C.

Table 6.2.1 H (I-P Units)
COPs for Centrifugal Chillers < 150 Tons

COP_{std} = 5.0

Leaving Chilled Water Temperature(F)	Entering Condenser Water Temperature(F)	LIFT ^a	Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
46	75	29	5.58	5.83	6.03	6.32	6.54	6.70
45	75	30	5.50	5.74	5.92	6.19	6.38	6.53
44	75	31	5.42	5.65	5.82	6.07	6.24	6.37
43	75	32	5.35	5.57	5.72	5.95	6.11	6.23
42	75	33	5.27	5.49	5.64	5.85	6.00	6.11
41	75	34	5.19	5.41	5.56	5.75	5.89	5.99
46	80	34	5.19	5.41	5.56	5.75	5.89	5.99
40	75	35	5.11	5.33	5.48	5.67	5.79	5.88
45	80	35	5.11	5.33	5.48	5.67	5.79	5.88
44	80	36	5.03	5.26	5.40	5.58	5.70	5.79
43	80	37	4.94	5.18	5.32	5.50	5.62	5.70
42	80	38	4.84	5.10	5.25	5.43	5.53	5.61
41	80	39	4.73	5.01	5.17	5.35	5.46	5.53
46	85	39	4.73	5.01	5.17	5.35	5.46	5.53
40	80	40	4.62	4.92	5.09	5.27	5.38	5.45
45	85	40	4.62	4.92	5.09	5.27	5.38	5.45
44	85	41	4.49	4.82	5.00	5.20	5.30	5.38
43	85	42	4.35	4.71	4.91	5.12	5.23	5.30
42	85	43	4.19	4.59	4.81	5.03	5.15	5.22
41	85	44	4.02	4.46	4.70	4.94	5.06	5.14
40	85	45	3.84	4.32	4.58	4.84	4.98	5.06

Cond DT ^b	14.04	11.23	9.36	7.02	5.62	4.68
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^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature(F) - Entering Condenser Water Temperature(F)

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

Table 6.2.11 (I-P Units)

COPs and IPLVs for Non-Standard Centrifugal Chillers > 150 Tons ≤ 300 Tons

COP_{std} = 5.55

			Condenser Flow Rate						
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton	
Leaving Chilled Water Temperature(F)	Entering Condenser Water Temperature(F)	LIFT ^a	Required COP and IPLV						
46	75	29	6.17	6.44	6.66	6.99	7.23	7.40	
45	75	30	6.08	6.34	6.54	6.84	7.06	7.22	
44	75	31	6.00	6.24	6.43	6.71	6.90	7.05	
43	75	32	5.91	6.15	6.33	6.58	6.76	6.89	
42	75	33	5.83	6.07	6.23	6.47	6.63	6.75	
41	75	34	5.74	5.98	6.14	6.36	6.51	6.62	
46	80	34	5.74	5.98	6.14	6.36	6.51	6.62	
40	75	35	5.65	5.90	6.05	6.26	6.40	6.51	
45	80	35	5.65	5.90	6.05	6.26	6.40	6.51	
44	80	36	5.56	5.81	5.97	6.17	6.30	6.40	
43	80	37	5.46	5.73	5.89	6.08	6.21	6.30	
42	80	38	5.35	5.64	5.80	6.00	6.12	6.20	
41	80	39	5.23	5.54	5.71	5.91	6.03	6.11	
46	85	39	5.23	5.54	5.71	5.91	6.03	6.11	
40	80	40	5.10	5.44	5.62	5.83	5.95	6.03	
45	85	40	5.10	5.44	5.62	5.83	5.95	6.03	
44	85	41	4.96	5.33	5.55	5.74	5.86	5.94	
43	85	42	4.81	5.21	5.42	5.66	5.78	5.86	
42	85	43	4.63	5.08	5.31	5.56	5.69	5.77	
41	85	44	4.45	4.93	5.19	5.46	5.60	5.69	
40	85	45	4.24	4.77	5.06	5.35	5.50	5.59	
			Cond DT ^b	14.04	11.23	9.36	7.02	5.62	4.68

^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature(F) - Entering Condenser Water Temperature(F)

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

Table 6.2.1J (I-P Units)
COPs and IPLVs for Non-Standard Centrifugal Chillers > 300 Tons

COP_{std} = 6.1

Leaving Chilled Water Temperature(F)	Entering Condenser Water Temperature(F)	LIFT ^a	Condenser Flow Rate						
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton	
			Required COP and IPLV						
46	75	29	6.80	7.11	7.35	7.71	7.97	8.16	
45	75	30	6.71	6.99	7.21	7.55	7.78	7.96	
44	75	31	6.61	6.89	7.09	7.40	7.61	7.77	
43	75	32	6.52	6.79	6.98	7.26	7.45	7.60	
42	75	33	6.43	6.69	6.87	7.13	7.31	7.44	
41	75	34	6.33	6.60	6.77	7.02	7.18	7.30	
46	80	34	6.33	6.60	6.77	7.02	7.18	7.30	
40	75	35	6.23	6.50	6.68	6.91	7.06	7.17	
45	80	35	6.23	6.50	6.68	6.91	7.06	7.17	
44	80	36	6.13	6.41	6.58	6.81	6.95	7.05	
43	80	37	6.02	6.31	6.49	6.71	6.85	6.94	
42	80	38	5.90	6.21	6.40	6.61	6.75	6.84	
41	80	39	5.77	6.11	6.30	6.52	6.65	6.74	
46	85	39	5.77	6.11	6.30	6.52	6.65	6.74	
40	80	40	5.63	6.00	6.20	6.43	6.56	6.65	
45	85	40	5.63	6.00	6.20	6.43	6.56	6.65	
44	85	41	5.47	5.87	6.10	6.33	6.47	6.55	
43	85	42	5.30	5.74	5.98	6.24	6.37	6.46	
42	85	43	5.11	5.60	5.86	6.13	6.28	6.37	
41	85	44	4.90	5.44	5.72	6.02	6.17	6.27	
40	85	45	4.68	5.26	5.58	5.90	6.07	6.17	
			Cond DT ^b	14.04	11.23	9.36	7.02	5.62	4.68

^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature(F) - Entering Condenser Water Temperature(F)

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

Table 6.2.1K
IPLV/NPLV for Centrifugal Chillers < 150 Tons

IPLV_{std} = 5.25

Condenser Flow Rate

2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
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Leaving Chilled Water Temperature(F)	Entering Condenser Water Temperature(F)	LIFT ^a	Required IPLV/NPLV						
46	75	29	5.84	6.10	6.30	6.61	6.84	7.00	
45	75	30	5.75	6.00	6.19	6.47	6.68	6.83	
44	75	31	5.67	5.91	6.08	6.34	6.53	6.67	
43	75	32	5.59	5.82	5.99	6.23	6.39	6.52	
42	75	33	5.51	5.74	5.90	6.12	6.27	6.39	
41	75	34	5.43	5.66	5.81	6.02	6.16	6.26	
46	80	34	5.43	5.66	5.81	6.02	6.16	6.26	
40	75	35	5.35	5.58	5.73	5.93	6.06	6.15	
45	80	35	5.35	5.58	5.73	5.93	6.06	6.15	
44	80	36	5.26	5.50	5.65	5.84	5.96	6.05	
43	80	37	5.16	5.42	5.57	5.76	5.87	5.96	
42	80	38	5.06	5.33	5.49	5.67	5.79	5.87	
41	80	39	4.95	5.24	5.41	5.60	5.71	5.78	
46	85	39	4.95	5.24	5.41	5.60	5.71	5.78	
40	80	40	4.83	5.14	5.32	5.52	5.63	5.70	
45	85	40	4.83	5.14	5.32	5.52	5.63	5.70	
44	85	41	4.69	5.04	5.25^c	5.43	5.55	5.62	
43	85	42	4.55	4.93	5.13	5.35	5.47	5.54	
42	85	43	4.38	4.80	5.03	5.26	5.38	5.46	
41	85	44	4.21	4.67	4.91	5.17	5.30	5.38	
40	85	45	4.01	4.52	4.79	5.06	5.20	5.29	
			Cond DT ^b	14.04	11.23	9.36	7.02	5.62	4.68

^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature(F) - Entering Condenser Water Temperature(F)

^c All values shown are NPLV except at conditions of 3 gpm/ton and 41F LIFT which is IPLV.

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

Table 6.2.1L
IPLV/NPLV for Centrifugal Chillers > 150 Tons ≤ 300 Tons

IPLV_{std}= 5.9

Condenser Flow Rate

2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
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Leaving Chilled Water Temperature(F)	Entering Condenser Water Temperature(F)	LIFT ^a	Required IPLV/NPLV					
46	75	29	6.58	6.87	7.11	7.46	7.71	7.90
45	75	30	6.49	6.76	6.98	7.30	7.53	7.70
44	75	31	6.40	6.66	6.86	7.15	7.36	7.52
43	75	32	6.31	6.56	6.75	7.02	7.21	7.35
42	75	33	6.22	6.47	6.65	6.90	7.07	7.20
41	75	34	6.13	6.38	6.55	6.79	6.95	7.06
46	80	34	6.13	6.38	6.55	6.79	6.95	7.06
40	75	35	6.03	6.29	6.46	6.68	6.83	6.94
45	80	35	6.03	6.29	6.46	6.68	6.83	6.94
44	80	36	5.93	6.20	6.37	6.58	6.72	6.82
43	80	37	5.82	6.11	6.28	6.49	6.62	6.72
42	80	38	5.71	6.01	6.19	6.40	6.53	6.62
41	80	39	5.58	5.91	6.10	6.31	6.44	6.52
46	85	39	5.58	5.91	6.10	6.31	6.44	6.52
40	80	40	5.44	5.80	6.00	6.22	6.35	6.43
45	85	40	5.44	5.80	6.00	6.22	6.35	6.43
44	85	41	5.29	5.68	5.90^c	6.13	6.26	6.34
43	85	42	5.13	5.55	5.79	6.03	6.16	6.25
42	85	43	4.94	5.41	5.67	5.93	6.07	6.16
41	85	44	4.74	5.26	5.54	5.82	5.97	6.07
40	85	45	4.52	5.09	5.40	5.71	5.87	5.97

Cond DT ^b	14.04	11.23	9.36	7.02	5.62	4.68
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^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature(F) - Entering Condenser Water Temperature(F)

^c All values shown are NPLV except at conditions of 3 gpm/ton and 41F LIFT which is IPLV.

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$

Table 6.2.1M
IPLV/NPLV for Centrifugal Chillers > 300 Tons

IPLV_{std} = 6.4

			Condenser Flow Rate						
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton	
Leaving Chilled Water Temperature(F)	Entering Condenser Water Temperature(F)	LIFT ^a	Required IPLV/NPLV						
46	75	29	7.15	7.47	7.72	8.10	8.37	8.58	
45	75	30	7.05	7.35	7.58	7.93	8.18	8.36	
44	75	31	6.95	7.23	7.45	7.77	8.00	8.16	
43	75	32	6.85	7.13	7.33	7.63	7.83	7.98	
42	75	33	6.75	7.03	7.22	7.49	7.68	7.82	
41	75	34	6.65	6.93	7.12	7.37	7.55	7.67	
46	80	34	6.65	6.93	7.12	7.37	7.55	7.67	
40	75	35	6.55	6.83	7.01	7.26	7.42	7.54	
45	80	35	6.55	6.83	7.01	7.26	7.42	7.54	
44	80	36	6.44	6.73	6.92	7.15	7.30	7.41	
43	80	37	6.32	6.63	6.82	7.05	7.19	7.30	
42	80	38	6.20	6.53	6.72	6.95	7.09	7.19	
41	80	39	6.06	6.42	6.62	6.85	6.99	7.08	
46	85	39	6.06	6.42	6.62	6.85	6.99	7.08	
40	80	40	5.91	6.30	6.52	6.76	6.89	6.98	
45	85	40	5.91	6.30	6.52	6.76	6.89	6.98	
44	85	41	5.75	6.17	6.40^c	6.66	6.79	6.89	
43	85	42	5.57	6.03	6.28	6.55	6.70	6.79	
42	85	43	5.37	5.88	6.16	6.44	6.59	6.69	
41	85	44	5.15	5.71	6.01	6.33	6.49	6.59	
40	85	45	4.91	5.53	5.86	6.20	6.37	6.48	
			Cond DT ^b	14.04	11.23	9.36	7.02	5.62	4.68

^a LIFT = Entering Condenser Water Temperature - Leaving Chilled Water Temperature

^b Cond DT = Leaving Condenser Water Temperature(F) - Entering Condenser Water Temperature(F)

^c All values shown are NPLV except at conditions of 3 gpm/ton and 41F LIFT which is IPLV.

$$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$$

where X = Cond. DT + LIFT

$$COP_{adj} = K_{adj} * COP_{std}$$