ISHRAE and IGBC Technical Committee for

Recommendations for Standard Operating Characteristics for Base Case in Energy Simulation for Green Buildings in India

Overview:

IGBC had formulated a Task Force on "Energy Simulation Protocol for Green Buildings in India" for identifying key areas of improvements in practice of energy simulation being done for green building certification. Based on recommendations of this committee (meeting held on 28 March 2016 at IGBC, at CII GBC Hyderabad) to define the part load performance curve for chillers to be used in base case, another committee was formed by ISHRAE to Propose "Recommendations for Standard Operating Curves/Characteristics for Base Case in Energy Simulation for Green Buildings in India". The committee defined its scope of work to chillers only, as its first step.

Broad objective: To minimise variation in approaches for simulating HVAC equipment in the base case for green buildings

Specific objective of this task: To define method for simulating chillers for use in base case, defining part load performance for base case.

Approach:

1. A template of data relate to part-load performance of chillers was prepared by the committee.
2. The template was sent to all chiller manufacturers, explaining them the purpose of this exercise, inviting them to share their data purely on voluntary basis.
3. Many chiller manufacturers shared their data, which was analysed by the committee.
4. Statistical analysis was carried out for the collected data to identify representative behaviour of chillers.
5. The representative chiller was studies by committee members, especially with regard to possible deviation from their chillers.
6. After finding the deviation acceptable, details of representative chiller were prepared.

It has been found that some software directly require coefficients of chiller curves as input to model, whereas others require raw data, and some even give user a choice to describe chiller behaviour through coefficients or raw data. Considering the variation, following two alternative approaches are suggested:

Option-1:

1. Three curves are to be specified for modelling the chiller used in base case:
   a) Capacity as a function of chilled water supply and condenser water entry temperature (DBT for air cooled): bi-quadratic curve
   b) EIR as a function of chilled water supply and condenser water entry temperature (DBT for air cooled): bi-quadratic curve
   c) EIR as a function of Part Load Ratio: quadratic curve

   Whichever software accepts coefficients as inputs, following equations are to be used for defining the performance of base case chillers:

   a) CAPFT = a + b*T_{CHWS} + c*T_{CHWS}^2 + d*T_{CWS} + e*T_{CWS}^2 + f*T_{CHWS}*T_{CWS}

	a	b	c	d	e	f
Centrifugal	1.0134403	0.02877747	-0.00515769	-0.00789717	-0.00036541	0.00290253

   b) EIRFT = a + b*T_{CHWS} + c*T_{CHWS}^2 + d*T_{CWS} + e*T_{CWS}^2 + f*T_{CHWS}*T_{CWS}

	a	b	c	d	e	f
Centrifugal	0.63163359	0.0693597	-0.00699799	-0.02056757	0.00084974	0.00018348

   c) EIRFPLR = a + b*PLR + c*PLR^2

	a	b	c
Centrifugal	0.25943802	0.40096126	0.39505996

   Where: Power Calculated (kW) = Power (Rated) * CAPFT * EIRFT * EIRPLR

   NOTE: The above coefficients are calculated on the basis of temperature in ^{o}C

Option-2:

Only for the case, in which simulation software does not directly accepts coefficients for the three curves or uses other method for specifying chiller part load performance, users can find the part load performance of the chiller to be modelled in base case, using the following table:

Table-1: Data table for simulation of base case centrifugal chiller:

S No.	CHWS (°C)	CWS (°C)	PLR	Capacity factor	Capacity (TR)	EIR Part load multiplying factor	Power (kW)
1	6.67	29.44	100%	1		1	
2	6.67	29.44	90%	0.9		0.99	
3	6.67	29.44	80%	0.8		0.99	
4	6.67	29.44	70%	0.7		0.99	
5	6.67	29.44	60%	0.6		1.01	
6	6.67	29.44	50%	0.5		1.06	
7	6.67	29.44	40%	0.4		1.14	
8	6.67	29.44	30%	0.3		1.31	
9	6.67	29.44	25%	0.2		1.68	
10	6.67	29.44	15%	0.15		2.07	
11	6.67	26.67	100%	1.02		0.92	
12	6.67	26.67	90%	0.92		0.91	
13	6.67	26.67	80%	0.82		0.91	
14	6.67	26.67	70%	0.71		0.92	
15	6.67	26.67	60%	0.61		0.93	
16	6.67	26.67	50%	0.51		0.98	
17	6.67	26.67	40%	0.41		1.05	
18	6.67	26.67	30%	0.31		1.21	
19	6.67	26.67	20%	0.2		1.55	
20	6.67	26.67	15%	0.15		1.91	
21	6.67	23.89	100%	1.04		0.85	
22	6.67	23.89	90%	0.94		0.84	
23	6.67	23.89	80%	0.83		0.84	
24	6.67	23.89	70%	0.73		0.85	
25	6.67	23.89	60%	0.62		0.86	
26	6.67	23.89	50%	0.52		0.9	
27	6.67	23.89	40%	0.42		0.97	
28	6.67	23.89	30%	0.31		1.12	
29	6.67	23.89	20%	0.21		1.43	
30	6.67	23.89	15%	0.16		1.77	
31	6.67	21.11	100%	1.05		0.79	
32	6.67	21.11	90%	0.95		0.78	
33	6.67	21.11	80%	0.84		0.78	

34	6.67	21.11	70%	0.74		0.79	
35	6.67	21.11	60%	0.63		0.8	
36	6.67	21.11	50%	0.53		0.84	
37	6.67	21.11	40%	0.42		0.91	
38	6.67	21.11	30%	0.32		1.04	
39	6.67	21.11	20%	0.21		1.33	
40	6.67	21.11	15%	0.16		1.64	
40	6.67	18.33	100%	1.06		0.76	
42	6.67	18.33	90%	0.95		0.75	
43	6.67	18.33	80%	0.85		0.75	
44	6.67	18.33	70%	0.74		0.75	
45	6.67	18.33	60%	0.64		0.77	
46	6.67	18.33	50%	0.53		0.8	
47	6.67	18.33	40%	0.42		0.87	
48	6.67	18.33	30%	0.32		0.99	
49	6.67	18.33	20%	0.21		1.27	
50	6.67	18.33	15%	0.16		1.57	
51	6.67	15.56	100%	1.07		0.72	
52	6.67	15.56	90%	0.96		0.72	
53	6.67	15.56	80%	0.86		0.71	
54	6.67	15.56	70%	0.75		0.72	
55	6.67	15.56	60%	0.64		0.73	
56	6.67	15.56	50%	0.54		0.77	
57	6.67	15.56	40%	0.43		0.83	
58	6.67	15.56	30%	0.32		0.95	
59	6.67	15.56	20%	0.21		1.22	
60	6.67	15.56	15%	0.16		1.5	
61	6.67	12.78	100%	1.06		0.71	
62	6.67	12.78	90%	0.95		0.71	
63	6.67	12.78	80%	0.85		0.7	
64	6.67	12.78	70%	0.74		0.71	
65	6.67	12.78	60%	0.64		0.72	
66	6.67	12.78	50%	0.53		0.76	
67	6.67	12.78	40%	0.42		0.82	
68	6.67	12.78	30%	0.32		0.94	
69	6.67	12.78	20%	0.21		1.2	
70	6.67	12.78	15%	0.16		1.48	

Example of using Table-1:

If part load performance for base case chiller (centrifugal) with 300TR capacity is to be determined, the blank columns of the table are to be filled using the following method:

Step-1: Pick up any part load condition for filling capacity and power consumption, say, it is 6.67 degree CHWS, 29.44 degree CWS and PLR as 50% load.

Step-2: Read the value of EIR Part load multiplying factor from Table-1, in this case it is 1.06.

Step-3: Using the EIR at rated condition (say 0.6 kW/TR), and PLR (50% in this case), kW/TR for the part load condition can be calculated as:

kW/TR (part load) = kW/TR (rated) * EIR Part load multiplying factor
kW/TR (part load) = 0.6 * 1.06= 0.636

Step-4: Hence, kW for part load condition can be calculated as:
kW (part load) = kW/TR (for part load) * Capacity ratio * Rated capacity

In this case:

kW (50% load at 44-85 condition) = 0.636 *.5* 300 = 95.4

Using the above method, last two columns of Table-1 can be filled by users for subsequent usage.

In all the cases, either Option-1 or Option-2, nature of curves should remain same as mentioned in Option-1.