ASHRAE Bangalore Chapter

Bureau of Energy Efficiency
Ministry of Power, Government of India

ISHRAE
Bangalore Chapter

Star Labelling Program
Chillers

Speaker Introduction

Profile

- R&D Professional in Product Design, Development & Strategy
- 12 years of experience in Commercial Airconditioning & Refrigeration Products
- B.Tech - Mechanical Engg [YMCA Institute of Engg. Faridabad]

Work Experience

Daikin Airconditioning India Pvt Ltd [2012 - till date]

- Team Lead for Applied R&D division in India
- Market study & business feasibility for new product evaluation, development & localization
- Localization of Water Cooled Centrifugal & Magnetic Bearing Centrifugal Chillers
- Lineup expansion for Water Cooled Screw Chillers in varied COP & IPLV segments
- Customization of global products according to local requirements

Carrier Airconditioning & Refrigeration Ltd [2008 - 2012]

- Joined as GET in Commercial Refrigeration R&D division
- Development of refrigeration products - Service counters, Visicoolers, Chest freezers etc.

Ravindra Rathi

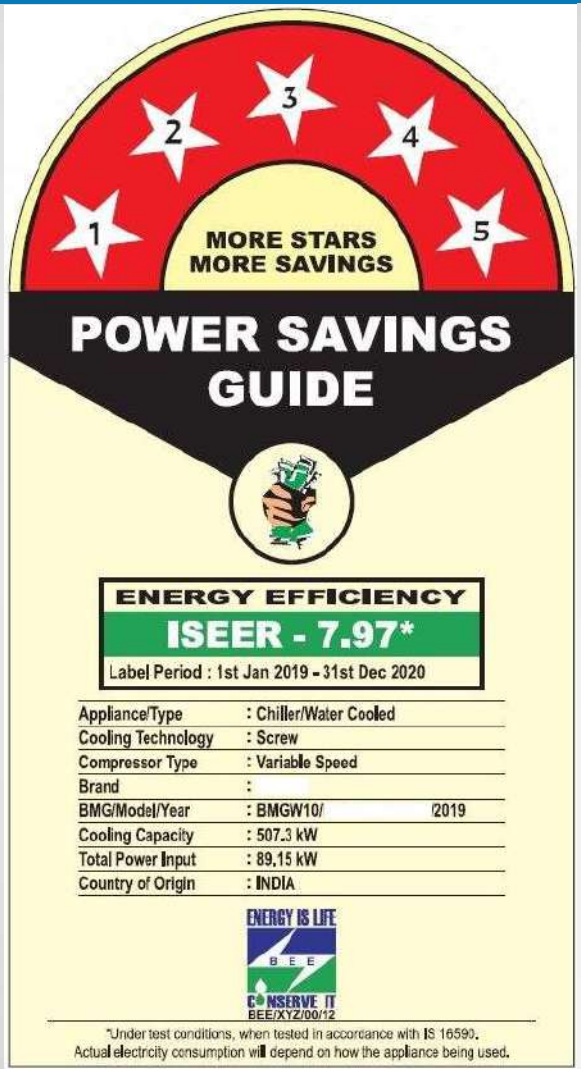
Manager – Applied (Chillers) R&D

Daikin Airconditioning India Pvt Ltd

Content

1 Program Scope & Introduction

Scope



Inclusions

Type : Air Cooled & Water Cooled

Cooling Capacity : All (No limitation)

50Hz AC Supply : 1Ph ≤250V, 3Ph ≤11kV

Origin : Local Manufactured & Imported

Exclusions

Absorption Chiller & Heat Reclaim CDU Package

Leaving Chilled Fluid Temperature < 4.4°C

Heat Pump & Evaporative cooled Condenser

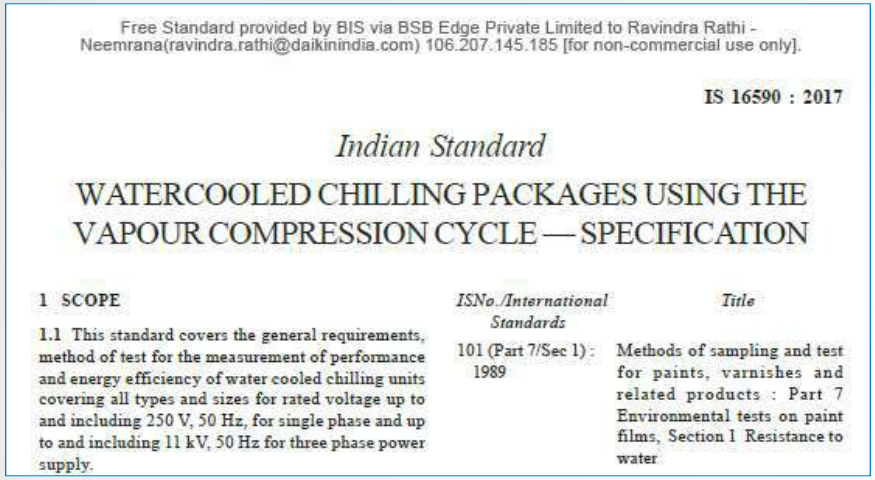
Condenser-less & Remote Condensing Unit

Key Organizations & Role

History & Timeline

Key Documents' Scope

IS 16590 – BIS



Free Standard provided by BIS via BSB Edge Private Limited to Ravindra Rathi - Neemrana(ravindra.rathi@daikinindia.com) 106.207.145.185 [for non-commercial use only].

IS 16590 : 2017

Indian Standard

WATERCOOLED CHILLING PACKAGES USING THE VAPOUR COMPRESSION CYCLE — SPECIFICATION

1 SCOPE

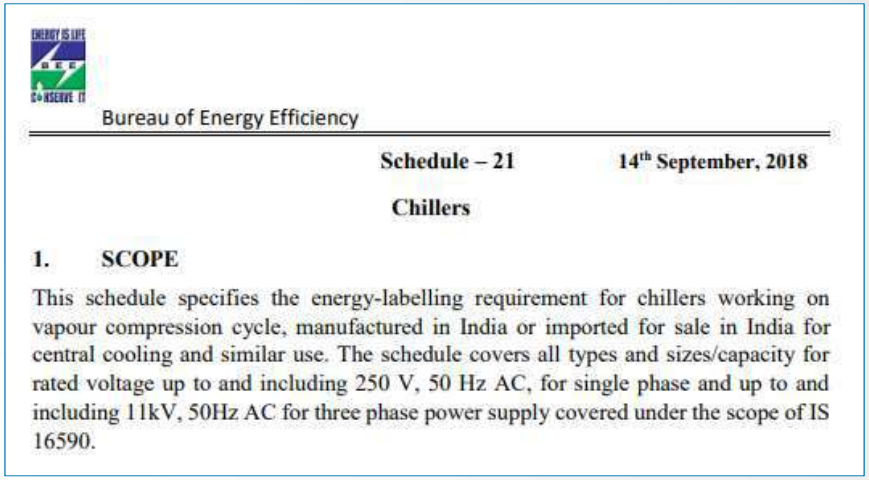
1.1 This standard covers the general requirements, method of test for the measurement of performance and energy efficiency of water cooled chilling units covering all types and sizes for rated voltage up to and including 250 V, 50 Hz, for single phase and up to and including 11 kV, 50 Hz for three phase power supply.

ISNo./International Standards	*Title*
101 (Part 7/Sec 1) : 1989	Methods of sampling and test for paints, varnishes and related products : Part 7 Environmental tests on paint films, Section 1 Resistance to water

- Defines the Performance Rating Conditions for Chillers
- Defines the Application Rating Conditions (Operating Limits)
- Defines the ISEER calculation weightages & methods
- Defines the tolerances on controlled parameters
- Defines the testing setup details, installation & accuracy
- Defines the testing procedure & data recording points
- Defines the BIS Standard marking details for Chillers

https://standardsbis.bsbedge.com/BIS_SearchStandard.aspx?Standard_Number=16590&id=0

Schedule 21 – BEE



Bureau of Energy Efficiency

Schedule – 21 **14th September, 2018**

Chillers

1. SCOPE

This schedule specifies the energy-labelling requirement for chillers working on vapour compression cycle, manufactured in India or imported for sale in India for central cooling and similar use. The schedule covers all types and sizes/capacity for rated voltage up to and including 250 V, 50 Hz AC, for single phase and up to and including 11kV, 50Hz AC for three phase power supply covered under the scope of IS 16590.

- Defines the Performance Criteria for levels of Star Rating
- Used IS 16590 standard for Rating Conditions & test method
- Overrules COP & ISEER tolerances of IS 16590 for Star Rating
- Defines the Company & Model Registration procedure
- Defines the Annual Check Testing requirements & procedure
- Defines the Fees applicable for Star Rating application
- Defines the Star Rating Label format, material & markings

http://www.beestarlabel.com/Content/Files/Chillers_schedule_21.pdf

2 Rating Conditions & Derations

Standard Rating Conditions

IS 16590 : 2017 [BIS]

Load	Evaporator				Condenser					
	Water-Cooled & Air-Cooled				Water-Cooled				Air-Cooled	
	EWT (°C)	LWT (°C)	Flow Rate	Fouling $m^2°C/kW$	EWT (°C)	LWT (°C)	Flow Rate	Fouling $m^2°C/kW$	Ambient (°C)	Fouling $m^2°C/kW$
100%	12.00	7.00	According to ΔT	0.044	30.00	35.00	According to ΔT	0.088	39.00	0.000
75%	10.75	7.00	Same as 100% load		26.00	-	Same as 100% load		32.00	
50%	9.50	7.00	Same as 100% load		23.00	-	Same as 100% load		26.00	
25%	8.25	7.00	Same as 100% load		20.00	-	Same as 100% load		20.00	

ISEER : **0.06** X $COP_{100\%}$ + **0.48** X $COP_{75\%}$ + **0.36** X $COP_{50\%}$ + **0.10** X $COP_{25\%}$

550/590 : 2018 [AHRI]

Load	Evaporator				Condenser					
	Water-Cooled & Air-Cooled				Water-Cooled				Air-Cooled	
	EWT (°C)	LWT (°C)	Flow Rate	Fouling $m^2°C/kW$	EWT (°C)	LWT (°C)	Flow Rate	Fouling $m^2°C/kW$	Ambient (°C)	Fouling $m^2°C/kW$
100%	12.22	6.67	According to ΔT	0.018	29.44	34.61	According to ΔT	0.044	35.00	0.000
75%	10.83	6.67	Same as 100% load		23.89	-	Same as 100% load		26.67	
50%	9.44	6.67	Same as 100% load		18.33	-	Same as 100% load		18.33	
25%	8.06	6.67	Same as 100% load		18.33	-	Same as 100% load		12.78	

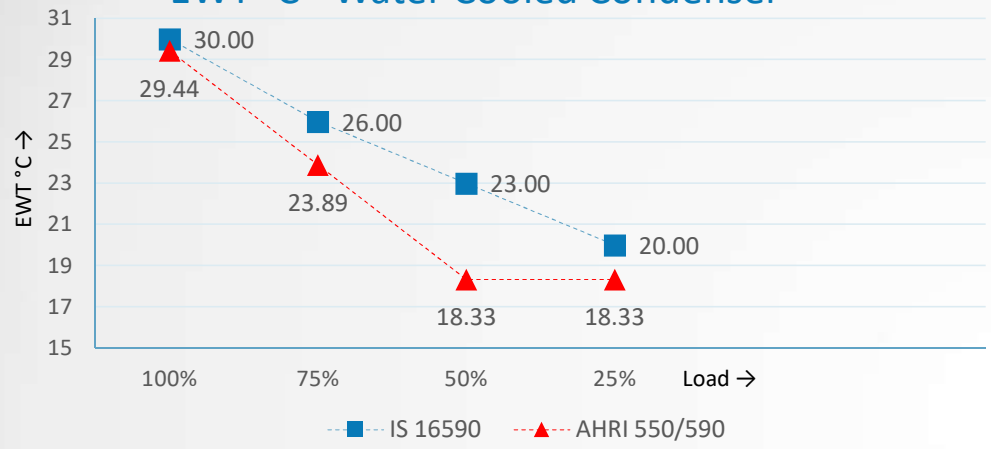
IPLV : **0.01** X $COP_{100\%}$ + **0.42** X $COP_{75\%}$ + **0.45** X $COP_{50\%}$ + **0.12** X $COP_{25\%}$

IPLV : Integrated Part Load Value
ISEER : Indian Seasonal Energy Efficiency Ratio

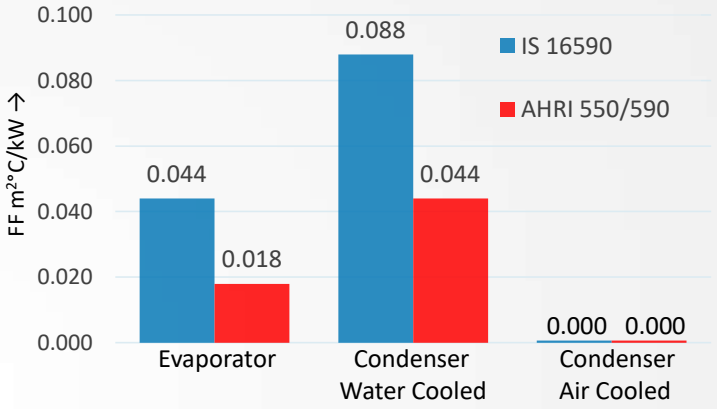
EWT : Entering Water Temperature
LWT : Leaving Water Temperature

Standard Rating Conditions

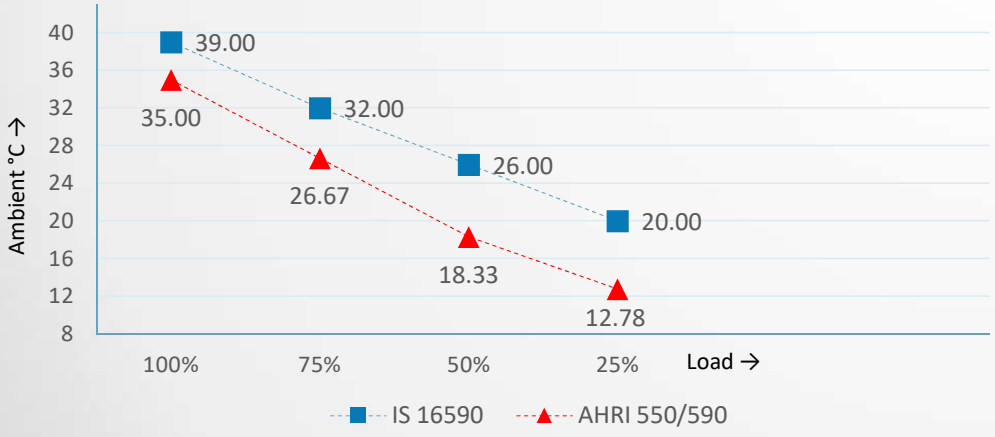
EWT °C - Water Cooled Condenser



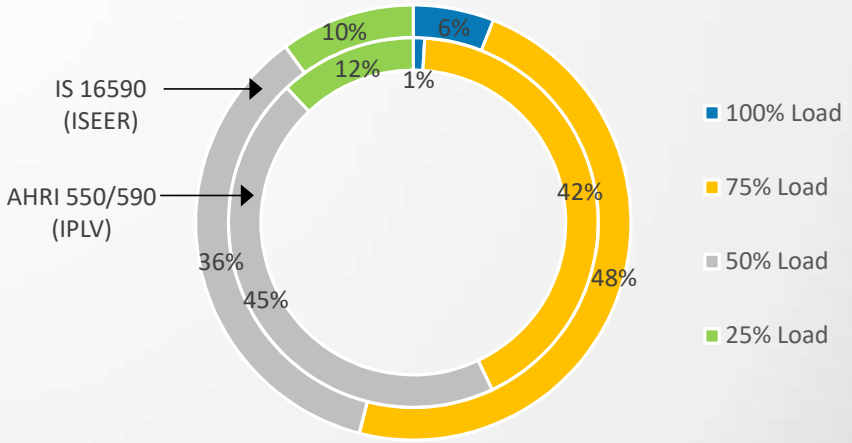
Heat Exchanger Fouling Factor $m^2°C/kW$



Ambient °C - Air Cooled Condenser



IPLV-ISEER Part Load Weightage Factors



Derations – Water Cooled Chillers

Model-X rated at IS 16590 Standard Rating Conditions

IS 16590 Condition

Capacity	Input (kW)	Efficiency (COP)	RLA	↓13.0% ISEER	75%Load	50%Load	25%Load	Evaporator PD	Evaporator Tin	Condenser PD	Condenser Tout
1120	200.2	5.593	303.3	8.147	7.401	9.363	8.883	52.9	12.00	61.4	35.00

P#	% Full Load	Capacity	Input	Efficiency ↓3.1%	RLA	Evaporator Flow	Evaporator Tin	Evaporator Tout	Evaporator PD	Condenser Flow	Condenser Tin	Condenser Tout	Condenser PD
		kW	kW	COP	A	L/s	°C	°C	kPa	L/s	°C	°C	kPa
1	100	1120	200.2	5.593	303.3	53.58	12.00	7.00	52.9	63.16	30.00	35.00	61.4

Model-X rated at AHRI 550/590 Standard Rating Conditions

AHRI 550/590

Capacity kW	Input KW	Cooling COP	RLA A	IPLV.SI kW/kW	75%Load kW/kW	50%Load kW/kW	25%Load kW/kW	Evaporator PD kPa	Evaporator Tin °C	Condenser PD kPa	Condenser Tout °C
1127	195.1	5.774	296.8	9.367	8.089	10.67	9.250	44.3	12.22	58.2	34.61

P#	%Load	Capacity	Input	Cooling COP	RLA	Evaporator Flow	Evaporator Tin	Evaporator Tout	Evaporator PD	Condenser Flow	Condenser Tin	Condenser Tout	Condenser PD
		kW	kW	kW/kW	A	L/s	°C	°C	kPa	L/s	°C	°C	kPa
1	100	1127	195.1	5.774	296.8	48.51	12.22	6.67	44.3	61.19	29.44	34.61	58.2

Approx* Deration
AHRI Standard Performance
↓
IS Standard Performance

Full Load
COP
~3% ↓

Part Load
ISEER
~12% ↓

** Indicative values only – calculated by an average of >25 models' performance comparison at AHRI & IS Standard Rating conditions for 1 manufacturer. Actual deration will vary based on various factors like type of starters, compressors, heat exchanger, compressor performance equations etc.*

Derations – Air Cooled Chillers

Model-Y rated at IS 16590 Standard Rating Conditions

Load [%]	100		75	50	25
Cooling Capacity [kW]	613.9		460.0	307.0	153.0
Power Input [kW]	232.3		137.3	77.49	32.25
EER [kW/kW]	2.643	↓10.1%	3.355	3.961	4.759
Evap. Water IN/OUT [°C]	12.00/7.00		10.75/7.00	9.50/7.00	8.25/7.00
Evap. Water flow [l/s]	29.30		29.30	29.30	29.30
Evap. pressure drops [kPa]	66.5 kPa		66.5 kPa	66.5 kPa	66.5 kPa
Ambient temp. [°C]	39.0		32.0	26.0	20.0

ISEER : 3.671 ↓15.0%

Model-Y rated at AHRI 550/590 Standard Rating Conditions

Load [%]	100	75	50	25
Cooling Capacity [kW]	646.1	484.6	323.0	161.5
Power Input [kW]	219.4	130.7	68.67	31.52
EER [kW/kW]	2.940	3.710	4.700	5.120
Evap. Water IN/OUT [°C]	12.20/6.67	10.83/6.67	9.45/6.67	8.08/6.67
Evap. pressure drops [kPa]	61.4 kPa	61.4 kPa	61.4 kPa	61.4 kPa
Ambient temp. [°C]	35.0	26.7	18.3	12.8

IPLV : 4.317

Approx* Deration
AHRI Standard Performance
↓
IS Standard Performance

Full Load
COP
~10% ↓

Part Load
ISEER
~18% ↓

** Indicative values only – calculated by an average of >20 models' performance comparison at AHRI & IS Standard Rating conditions for 1 manufacturer. Actual deration will vary based on various factors like type of starters, compressors, heat exchanger, compressor performance equations etc.*

3 Star Rating Table

Star Rating Table

Water Cooled Chillers

Cooling Capacity		Minimum COP	Minimum ISEER				
			1 ☆	2 ☆	3 ☆	4 ☆	5 ☆
kW < 260	TR < 73.9	4.20	4.80	5.20	5.60	6.10	6.60
260 ≤ kW < 530	73.9 ≤ TR < 150.7	4.70	5.00	5.60	6.20	6.80	7.40
530 ≤ kW < 1050	150.7 ≤ TR < 298.6	5.00	5.50	6.10	6.70	7.40	8.20
1050 ≤ kW < 1580	298.6 ≤ TR < 449.3	5.20	5.80	6.50	7.20	7.90	8.70
kW ≥ 1580	TR ≥ 449.3	5.60	6.00	6.70	7.40	8.20	9.00

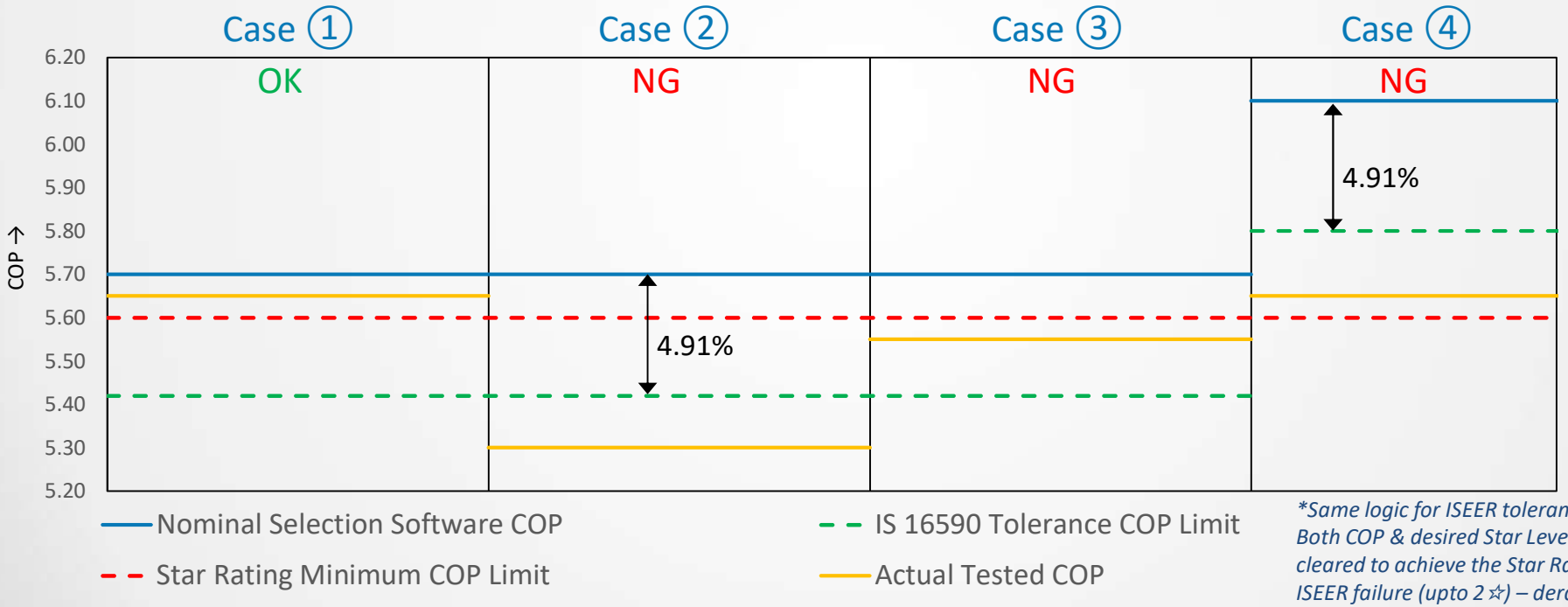
Air Cooled Chillers

Cooling Capacity		Minimum COP	Minimum ISEER				
			1 ☆	2 ☆	3 ☆	4 ☆	5 ☆
kW < 260	TR < 73.9	2.40	3.00	3.30	3.60	4.00	4.40
kW ≥ 260	TR ≥ 73.9	2.60	3.10	3.50	3.90	4.30	4.70

- Performance Table Validity : 01st Jan 2019 – 31st Dec 2020
- Performance criteria are upgraded every 2 years by BEE in order to strive for higher energy efficiencies
- COP is a Pre-qualification criteria i.e. minimum COP needs to be achieved according to capacity band
- The Star Rating level will be assigned based on the ISEER levels i.e. part load efficiency of the unit

NO Negative Tolerance

Case	Cooling Capacity	Nominal Selection Software COP	IS 16590 Tolerance COP Limit (-4.91%)	Star Rating Minimum COP Limit (Schedule 21)	Actual Tested COP	Star Rating Result	IS Standard Result	Final Result
		[A]	[B] = [A] - 4.91%[A]	[C]	[D]	[D] ≥ [C]	[D] ≥ [B]	
①	500 TR	5.70	5.42	5.60	5.65	OK	OK	**OK**
②	500 TR	5.70	5.42	5.60	5.30	NG	NG	**NG**
③	500 TR	5.70	5.42	5.60	5.55	NG	OK	**NG**
④	500 TR	6.10	5.80	5.60	5.65	OK	NG	**NG**



**Same logic for ISEER tolerances.*
Both COP & desired Star Level's ISEER to be cleared to achieve the Star Rating.
ISEER failure (upto 2 ☆) – deration to lower levels
COP failure – disqualification

Configurable Units

Configurable Unit : A chiller that has been selected to run at a full load point less than its maximum possible Capacity

Packaged Unit : A chiller that has been selected to run at full load at its maximum Capacity

Model-Y (Water Cooled Screw Chiller) rated at AHRI Standard Rating Conditions

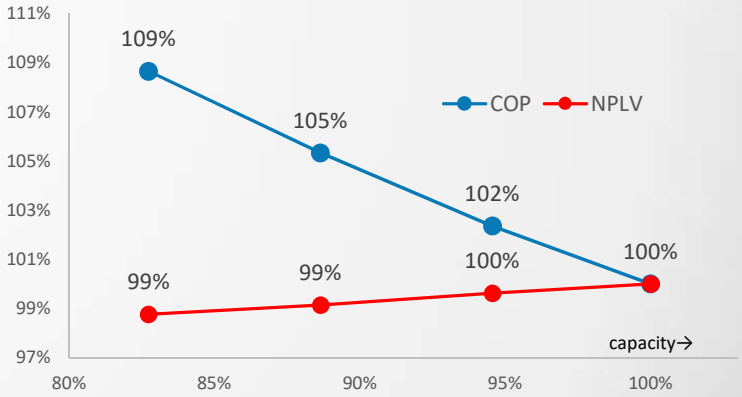
User Condition	NPLV.IP(kW/kW): 10.49			NPLV(GB)(kW/kW): 8.913					Compressor Hertz 56.0Hz				
P#	%Full Load	Capacity kW	Input kW	Cooling COP kW/kW	RLA A	Evaporator Flow l/s	Tin °C	Tout °C	PD kPa	Condenser Flow l/s	Tin °C	Tout °C	PD kPa
1	100	1488	255.7	5.818	374.9	64.06	12.22	6.67	71.3	80.72	29.44	34.61	60.1

User Condition	NPLV.IP(kW/kW): 10.45			NPLV(GB)(kW/kW): 8.888					Compressor Hertz 52.7Hz				
P#	%Full Load	Capacity kW	Input kW	Cooling COP kW/kW	RLA A	Evaporator Flow l/s	Tin °C	Tout °C	PD kPa	Condenser Flow l/s	Tin °C	Tout °C	PD kPa
1	100	1407	236.2	5.955	347.0	60.56	12.22	6.67	64.6	76.06	29.44	34.61	54.4

User Condition	NPLV.IP(kW/kW): 10.40			NPLV(GB)(kW/kW): 8.856					Compressor Hertz 49.2Hz				
P#	%Full Load	Capacity kW	Input kW	Cooling COP kW/kW	RLA A	Evaporator Flow l/s	Tin °C	Tout °C	PD kPa	Condenser Flow l/s	Tin °C	Tout °C	PD kPa
1	100	1319	215.2	6.128	317.5	56.78	12.22	6.67	57.6	71.02	29.44	34.61	48.4

User Condition	NPLV.IP(kW/kW): 10.36			NPLV(GB)(kW/kW): 8.838					Compressor Hertz 45.7Hz				
P#	%Full Load	Capacity kW	Input kW	Cooling COP kW/kW	RLA A	Evaporator Flow l/s	Tin °C	Tout °C	PD kPa	Condenser Flow l/s	Tin °C	Tout °C	PD kPa
1	100	1231	194.7	6.321	288.3	53.00	12.22	6.67	51.0	66.00	29.44	34.61	42.8

Capacity		kW/kW	
kW	TR	COP	NPLV
1488	423	5.818	10.49
1407	400	5.955	10.45
1319	375	6.128	10.40
1231	350	6.321	10.36



Unloading the units (VFD modulation) provide improvement in COP but there is hardly any impact on IPLV/NPLV/ISEER. Hence for Star Label registration, the unit's performance is to be rated at full load

4 Certification Process

Certification Process

1
Company Registration

Company to be registered
for Chillers product
[Application by manufacturer]

2
Model Registration

Each model to be registered
[Parent of BMG : 4pt test report]
[Child of BMG : Selection report]

3
Application Verification

Verification of physical test
report and/or selection report
[Verification by BEE]

4
Approval Letter

Approval letter issuance by
BEE & model to be updated
on BEE website public portal

Annual Check Testing

- BEE representative to witness check testing in presence of AHRI/Eurovent/ Client
- 30% BMG check testing each year

Check Testing Failure

- Failed model's registration cancellation
- Failed model/brand publish in newspapers
- Adjudication proceeding under Section 27
- Re-register all models in that BMG with derated COP/ISEER

Basic Model Group

Basic Model Group [BMG]

A BMG is a set of models that share characteristics which allow the performance of one model to be generally representative of the performance of other models within the group.
This group of products does not necessarily have to share discrete performance.

Chillers with Water Cooled Condensers

KW of cooling	1 Star	2 Star	3 Star	4 Star	5 Star
<260	BMGW1 (Model : 0)	BMGW2 (Model : 0)	BMGW3 (Model : 0)	BMGW4 (Model : 0)	BMGW5 (Model : 0)
>=260&<530	BMGW6 (Model : 0)	BMGW7 (Model : 0)	BMGW8 (Model : 0)	BMGW9 (Model : 0)	BMGW10 (Model : 1)
>=530&<1050	BMGW11 (Model : 0)	BMGW12 (Model : 0)	BMGW13 (Model : 0)	BMGW14 (Model : 0)	BMGW15 (Model : 0)
>=1050&<1580	BMGW16 (Model : 0)	BMGW17 (Model : 0)	BMGW18 (Model : 0)	BMGW19 (Model : 0)	BMGW20 (Model : 0)
>=1580	BMGW21 (Model : 0)	BMGW22 (Model : 0)	BMGW23 (Model : 0)	BMGW24 (Model : 0)	BMGW25 (Model : 0)

Water Cooled
Max BMG : 25

Chillers with Air Cooled Condensers

KW of cooling	1 Star	2 Star	3 Star	4 Star	5 Star
<260	BMGA1 (Model : 0)	BMGA2 (Model : 0)	BMGA3 (Model : 0)	BMGA4 (Model : 0)	BMGA5 (Model : 0)
>=260&<530	BMGA6 (Model : 0)	BMGA7 (Model : 0)	BMGA8 (Model : 0)	BMGA9 (Model : 0)	BMGA10 (Model : 0)

Air Cooled
Max BMG : 10

Physical Test Reports

4 point physical test report required for parent model registration in each BMG

If new model capacity < Parent model of BMG; need to submit only selection software report

If new model capacity > Parent model of BMG; need to submit 4 point physical test report

Physical test report is with 4 sets of readings at every 5 minutes interval (old AHRI method)

- Physical test report should be from NABL/ILAC/APLAC accredited test stand
- AHRI/EUROVENT/COFRAC accredited test stand's Physical test report also acceptable
- Above test stand should get their local accreditation within a period of 1 year

Fees Details

New Company Registration	➢ One time fee applicable for new company registration ➢ Company registration is product specific i.e. Even if a company is already registered for Room Air conditioners with BEE, it needs to re-register for Chillers	**INR 1,00,000** **USD 1,333.3**
New Model Registration	➢ One time fee applicable for new model registration ➢ Centrifugal chillers with different motor codes, gear codes etc. need to be treated as different models	**INR 2,000** **USD 26.7**
Existing Model Renewal/Degradation	➢ Renewal of all registered models required after every 2 years ➢ If any performance deviation is observed during annual check testing, then degradation is required for all models in BMG	**INR 1,000** **USD 13.3**
Labelling Fee Production Unit	➢ Recurring fee for each production unit ➢ Applicable for all chillers within the scope of Schedule-21 other than the listed exclusions	**INR 3/kW** **USD 0.04/kW**

5 Way Forward

ASHRAE 90.1 & ECBC

ASHRAE 90.1

Air Cooled Chillers

	Path A		Path B	
Capacity	COP	IPLV	COP	IPLV
<528kW	2.96	4.02	2.84	4.63
≥528kW	2.96	4.10	2.84	4.72

Water Cooled Positive Displacement

	Path A		Path B	
Capacity	COP	IPLV	COP	IPLV
<527kW	5.77	6.39	5.06	7.99
≥527kW & <1055kW	5.77	6.39	5.54	8.79
≥1055kW & <1407kW	6.28	6.76	5.91	9.02
≥1407kW	6.28	7.03	6.01	9.25

Water Cooled Centrifugal

	Path A		Path B	
Capacity	COP	IPLV	COP	IPLV
<264kW	4.69	5.86	4.51	7.03
≥264kW & <527kW	4.88	6.28	4.69	7.18
≥527kW & <1055kW	5.33	6.51	5.17	7.99
≥1055kW & <2110kW	5.77	6.76	5.63	8.58
≥2110kW	6.28	7.03	6.01	9.25

- ASHRAE & ECBC allow tolerance on COP & IPLV values specified above in accordance with AHRI 550/590 standard
- BEE Star Labelling Program allows IS 16590 tolerances; but without breaching minimum levels of Star Rating Table

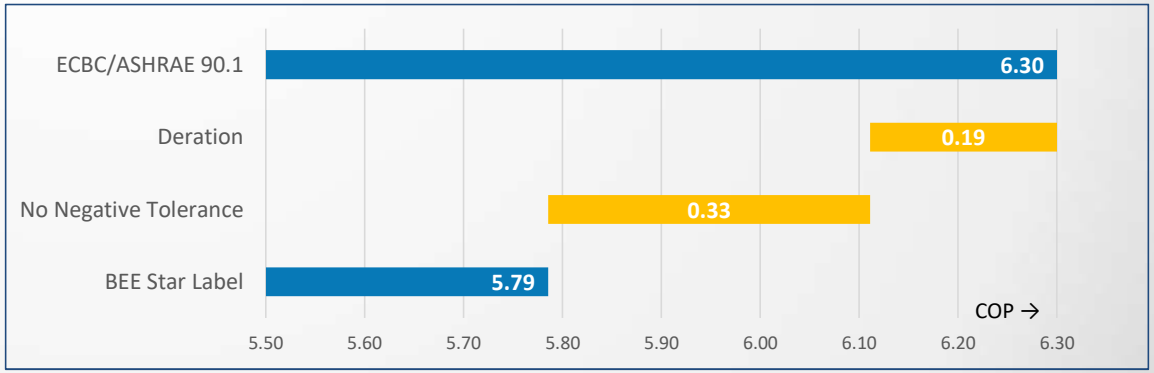
ECBC

Air Cooled Chillers

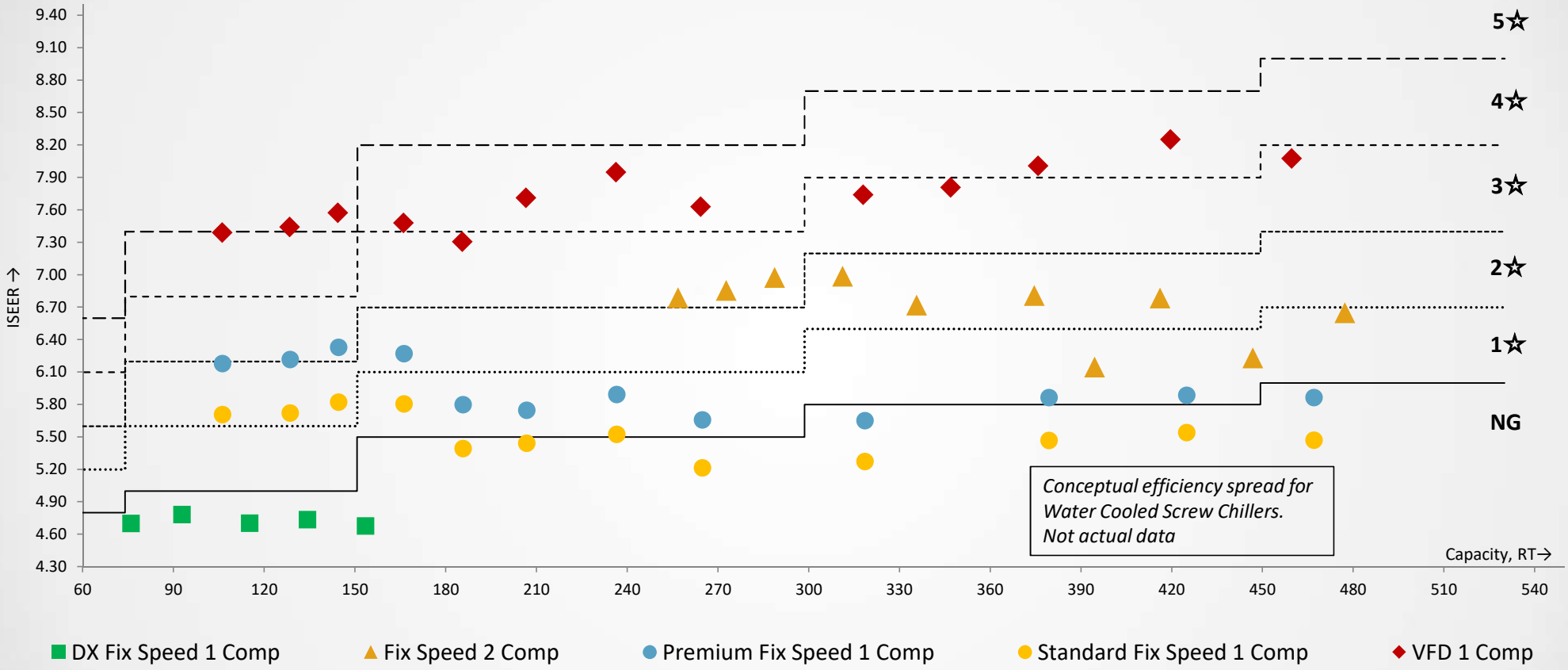
	ECBC		ECBC+		Super ECBC	
Capacity	COP	IPLV	COP	IPLV	COP	IPLV
<260kW	2.8	3.5	3.0	4.0	N/A	
≥260kW	3.0	3.7	3.2	5.0	N/A	

Water Cooled Chillers

	ECBC		ECBC+		Super ECBC	
Capacity	COP	IPLV	COP	IPLV	COP	IPLV
<260kW	5.8	6.4	5.1	8.0	5.1	8.0
≥260kW & <530kW	5.8	6.4	5.5	8.8	5.5	8.8
≥530kW & <1050kW	6.3	6.8	5.9	9.0	5.9	9.0
≥1050kW & <1580kW	6.3	6.8	5.9	9.0	5.9	9.0
≥1580kW	6.3	7.0	6.0	9.3	6.0	9.3



Development Concept



- As the criteria for achieving higher Star Rating is wrt high ISEER, VFD and Multi-compressor units will be the products for premium segments
- Fix speeds units will lie at the middle level or entry level segments depending upon the corresponding capacity band
- Low/standard efficiency product lineups (like DX evaporator units etc) will become obsolete if not fitted with VFD or alternative development

6 Industry Progress

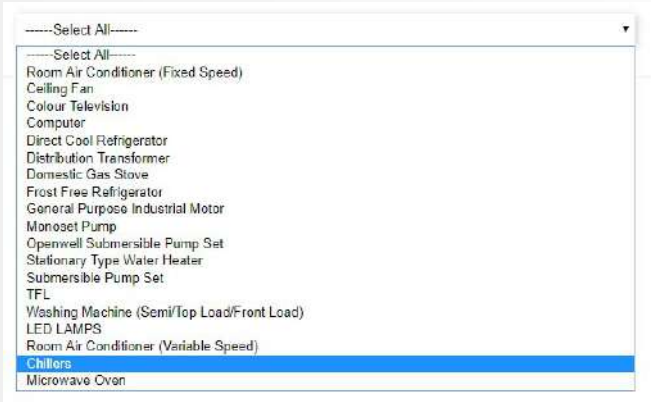
Progress so far…..

< Registered Model Listing (BEE Public Portal) >

weblink

http://www.beestarlabel.com/SearchCompare

dropdown



< Sample Listing on BEE portal >

VOLTAS ACEGWFVXR1501MLP2	Daikin PFS1501DBRYV	BLUE STAR LCW1-075T1	Blue Box EPSILON REV 37	CARRIER 30XW-V408
Type: Water Cooled	Type: Water Cooled	Type: Water Cooled	Type: Air Cooled	Type: Water Cooled
Technology: Screw	Technology: Screw	Technology: Centrifugal	Technology: Scroll	Technology: Screw
COP (100%): 5.01	COP (100%): 5.690	COP (100%): 4.80	COP (100%): 2.73	COP (100%): 5.90
ISEER: 7.46	ISEER: 7.97	ISEER: 6.66	ISEER: 3.5	ISEER: 7.82
Ton: 142.21	Ton: 144.2	Ton: 73.25	Ton: 8.63	Ton: 406.14
Cooling Capacity(W): 515.24	Cooling Capacity(W): 507.3	Cooling Capacity(W): 257.54	Cooling Capacity(W): 30.35	Cooling Capacity(W): 1428
Power Cons: 102.8	Power Cons: 89.15	Power Cons: 53.65	Power Cons: 11.12	Power Cons: 242.0
Valid Till Date: 31-12-2020	Valid Till Date: 31-12-2020	Valid Till Date: 31-12-2020	Valid Till Date: 31-12-2020	Valid Till Date: 31-12-2020

BlueBox by Swegon

BLUE STAR

DAIKIN

Carrier

VOLTAS

Registration Details

Manufacturer : 5 No

Registered Models

Water-cooled : 11 No

Air-cooled : 32 No

Questions

Thank you