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STANDARD OF ENERGY CONSUMPTION AND ENERGY LABELING IN EVAPORATIVE AIR COOLER IN IRAN

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Abstract- This paper presents new method for energy labeling of evaporative air coolers in Iran with national standard number of 4910-2. Procedure of test has been developed typically in Iranian standard IS3315-1974 and Australian Standard AS 2913-1987. The criteria are calculated based on energy consumption and evaporative air cooler test results in the past three years and has developed experimentally and analytically. *EER* (Energy Efficiency Ratio) is defined for energy labeling in Iran. Index of the previous standard of energy consumption and cooler label is used sensible cooling capacity of air power of the total input. *EER* is the sensible cooling capacity of air power of the total input power as well.

Keywords: Evaporative Air Cooler, Energy Labeling, Energy Efficiency, Energy Saving.

I. INTRODUCTION

Based on searches, Iran is one of the first countries that determined energy consumption standard. Because the country is in dry weather conditions and therefore using air cooler devices are high. Of course, some countries like the US are using the devices. Working with other countries in regard to evaporative air cooler standard, it is obvious that more research has been done in improving the performance of cooling system.

II. PROCEDURE

It is considerable that the research topic is related to all of the *EER* indices which are used for comparison. It should be noted that the indices as the classical density are defined for the system, but the performance of the cooling evaporative air cooler, as evaporative air cooler should be also defined. Therefore, the choice of the indices as criteria for comparing the appropriate evaporative air cooler will also be used as in other countries. The National Standard No. 4910-2 is used in this project and the energy index based on equation (1) is determined.

Terms and definitions:

• Air flow (Q) - The amount of air system pressure time volume is expressed in time units. Besides, this amount should be determined by the temperature and pressure in normal states.

• Sensible cooling capacity - The amount of heat is noticeably cooler which can be a time interval determined by an air space absorbs.

• Energy efficiency ratio (*EER*) - Sensible cooling capacity to air ratio input is called the total energy efficiency. When value of *EER* is declared after the code known as the value of the ratio is determined in watts.

• Total input power (total power consumption) (P_t) - Function of input power for all electrical components will be cooler.

• Dry bubble temperature (t_d) - Air temperature by the thermometer of any sensitive dry (such as a mercury thermometer mercury bubble) that is protected from radiation rays is determined.

• Wet bubble temperature (t_w) - Air temperature by the thermometer sensitive to any moisture (usually by a Fatly with distilled water is wet and the air speed of passing on not less than 5/3 meter is second) is determined. Temperature measured according to the rate of evaporation any sensitive.

• Specific heat (C_p) - Amount of heat that is given to unit mass of the substance one degree Celsius of temperature increase.

• Air density - Ratio of the mass amount of air per unit volume

Determining the energy efficiency index and the quantity of energy efficiency indicators of energy efficiency ratio (EER) are used to measuring of units of energy consumption and is achieved by the following equation:

$$EER = \frac{q_s - Q.\rho.C_p.(t_{do} - t_{di})}{P_t} \quad (1)$$

in which: q_s sensible cooling capacity kW times; P_t power consumption kW cooler times; Q air flow cubic meter per hour or cubic foot per minute; ρ air density according kg per square meter; C_p specific heat of air at constant pressure, kJ.kg Kelvin times; t_{di} dry air

temperature input according to degrees Celsius; t_{do} dry air output temperature according to degrees Celsius.

For determining sensible cooling capacity the amount of sensible cooling capacity is calculated by the following equation in kW.

$$q_s = Q\ \rho\ C_p(t_{di} - t_{do}) \quad (2)$$

For determining the amount of power consumption cooler, the measured power consumption value based on device and according to the National Standard of the 4910 number has been calculated.

III. SAMPLES OF COOLER WATER AND ENERGY CONSUMPTION TEST

As also mentioned previously, new standard test how changes in energy consumption index will be created. Referring to the published statistics from the Ministry of Industry regarding to critical evaporative air cooler manufacturers were extracted.

As previously mentioned, this project results conducted in laboratory tests and label the energy consumption at the evaporative air cooler of Institute of Standards has been used. This laboratory according to National Standard Number 4911 is fully equipped in 2000 and the test is started the same year. Standard test of any of three main evaporative air cooler is made. Firstly, any cooler is placed in the metal chamber in 6 meters long and 3 meters in width height of 3.4 meters. This warm air through a handling chamber and a torch that will warm the air enters the booth. This damper which is a chamber with air pressure inside the air pressure keeps the same atmosphere.

Insuring that the chamber is a channel length of 5.6 meters and 40 cm inside the chamber and 5.2 m outside the chamber is attached. The channel diameter is 50 cm. Finally, this channel is connected to the discharge chamber. The chamber of a normal room to shape metal edges is 4.8 cubic meters. The chamber during the test window air conditioner should be open to creating positive pressure in the chamber prevents. To measure Watts consumed cooler, coolers are in vitro by electrical measurement devices and volt-watt consumption and flow is achieved. In general, performed test, including parameters Watt intake air volume passing efficiency, and finally evaporation cooling capacity than energy efficiency for evaporative air cooler has been determined.

Figure1. Laboratory of evaporative cooler test

IV. PROVIDE TEST RESULTS

The laboratory information of Institute of Standards and Industrial Research were extracted, including 54 samples from 13 test information. The test company was a cooler manufacture in the country. The information model was tested under used data. The received information in the tables will be provided. Before an example the method of *EER* calculation is performed under the following data:

Power consumption measured according to Watt $P[\mathrm{W}] = 825$; Air flow volume measured in cubic meters times seconds $Vol[\mathrm{m}^3/\mathrm{s}] = 1.86$; Temperature (dry air bubble output) $t_{do}[°\mathrm{C}] = 18.6$; Calculated heat capacity of dry air temperature output $C_P[\mathrm{J/kg°C}] = 1007$; Rising gas $R[\mathrm{J/Kg°K}] = 287$; Measured pressure $P_b - P_P[\mathrm{Pa}] = 87200$; Density of air output $\rho_o[\mathrm{Kg/m}^3] = \dfrac{P_b - P_P}{R(273.2 + t_{do})} = \dfrac{87200}{287(273.2 + 18.6)} = 1.04$;

Energy efficiency ratio $EER = \dfrac{\rho_O.Vol.C_P \times 12}{P} = \dfrac{1.04 \times 1.86 \times 1007 \times 12}{767} = 30.47$.

In above example, the standard relations are used in the base. Category of energy consumption in the previous version was 4910-2 standard, based on energy consumption and energy efficiency. According to the Table 1 from A (minimum consumption) to G (most used) the list is determined. Using the Table 1 according to following samples tested in cooler F and G categories were disqualified or met.

Table 1. Energy groups cooler (previous standard)

Energy Ranking	*EER*
A	$\boldsymbol{EER} \geq 65$
B	$59 \leq \boldsymbol{EER} < 65$
C	$52 \leq \boldsymbol{EER} < 59$
D	$46 \leq \boldsymbol{EER} < 52$
E	$39 \leq \boldsymbol{EER} < 46$
F	$33 \leq \boldsymbol{EER} < 39$
G	$26 \leq \boldsymbol{EER} < 33$

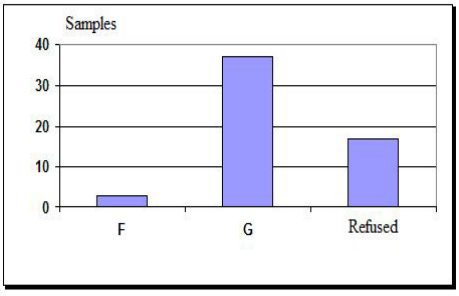

Figure 2. Distribution of category obtaining by tested samples of cooler according to previous year

During the project, a meeting in order to obtain comments cooler manufacturers was held. In this session, all producers cooler *EER* index of knowledge, but how appropriate classification standards and obtaining previous protests had lower ranks were assigned in the new standard.

V. REVISION OF DETERMINED CATEGORY OF ENERGY CONSUMPTION, EVAPORATIVE AIR COOLER

The method used in previous standards, equal distances between categories were chosen. Figure 3 shows the *EER* air conditioner testing samples with increasing while *CFM* increases. This form uses the linear method with the lowest total mean square error. So that we know the main consumer of energy in electric cooler, the fan and electric elements which finally they are smaller engines, less efficiency and are similar to larger engines. Therefore, in the cooler, the air is also less with lower *EER*. Then, it seems that it is better to determine the category of *CFM*.

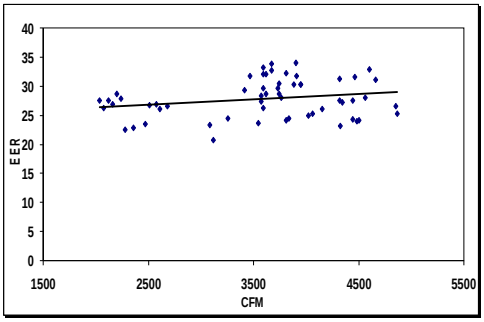

Figure 3. Distribution of test samples *EER* times *CFM*

Restrictive policies of the Ministry of Energy projects reviewing can be pointed out that this issue should not have any sample groups A and B. Generally, based on the consumer category without considering air, the method is not precise. In other words, comparing with a cooler, air cooler with less air seems more correct. So, taking considering the effect of *CFM* were determined according to the following form. In this way, the limitations of existing practice and equal distances between categories were used (per *CFM*).

Accordingly, the equations can be used above lines within the category which can be specified as Table 2. Using Table 2, *CFM* (air) and measured Watts consumed evaporative air cooler looking *EER* values are calculated for the cooler and then using the *CFM* value ranges specified above and *EER* position is finally determined. Therefore, the frequency samples tested were determined as Figures 5 and 6. The cases contained the energy label which each of the signs given in the form 5 were as follows:

- Mark standard label
- Energy efficiency indicators
- Energy efficiency ratio
- Air flow volume measured in cubic meters per hour or cubic foot per minute
- Name of manufacturer and Model

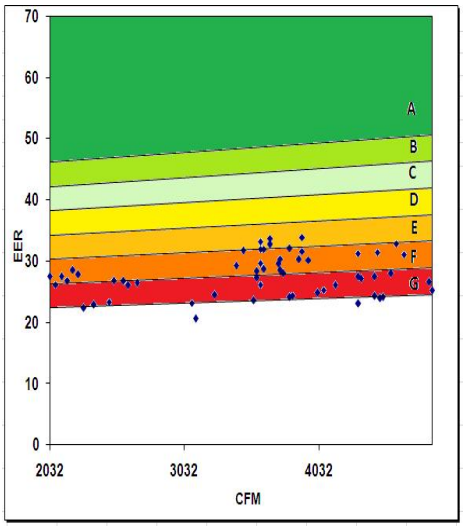

Figure 4. Determined category based on consumption test results

Table 2. Range category of energy consumption

Energy Ranking	*EER*
A	$EER \geq (0.00158 cfm + 43.02165)$
B	$(0.00144\ cfm + 39.33408) \leq EER < (0.00158\ cfm + 43.02165)$
C	$(0.00131\ cfm + 35.64651) \leq EER < (0.00144\ cfm + 39.33408)$
D	$(0.00117\ cfm + 31.95894) \leq EER < (0.00131\ cfm + 35.64651)$
E	$(0.00104\ cfm + 28.27137) \leq EER < (0.00117\ cfm + 31.95894)$
F	$(0.00090\ cfm + 24.58380) \leq EER < (0.00104\ cfm + 28.27137)$

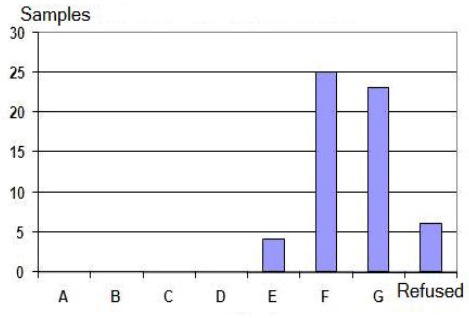

Figure 5. Rank samples tested according to the new evaporative air cooler

Table 3. Production of household evaporative air cooler during different

Year	Number of Evaporative Air Cooler in Domestic Production (Thousand Units)	Percent Compared to Previous Year
2000	415.1	----------
2001	432.3	4.14
2002	431.6	-0.16
2003	571.3	32.36
2004	630.7	10.39

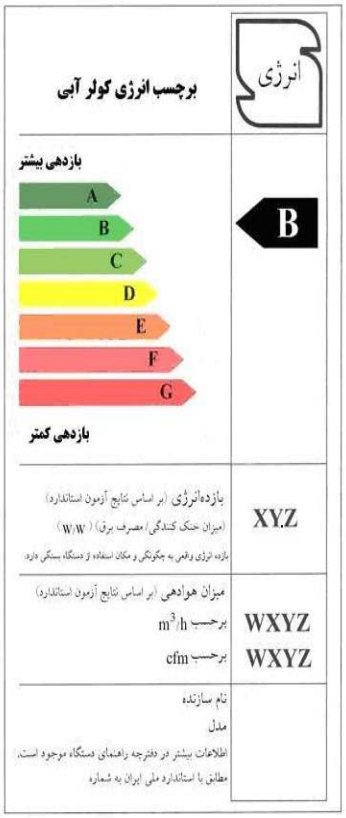

Figure 6. Energy labeling for evaporative air cooler

VI. ECONOMIC ANALYSIS

In order to estimate the rate of energy saving, the annual increase in the number of coolers desired information is used to diffuse the Ministry of Industry.

Number of evaporative air cooler in domestic production percentage (thousand units) compared to previous year cases. Based on Tables 3 and 4 the average growth rate 11.68 percent of the number is cooler. So, the production of the annual evaporative air cooler for future years can be calculated.

Table 4. Prediction of annual production for evaporative air cooler

Year	Production Evaporative Air Cooler (Million Units)
2008	0.981
2009	1.096
2010	1.224
2011	1.367

Based on the experimental testing results of coolers, the average amount of air *CFM*, the average *EER* and consumption are equal to is 3582, 27 and 758 Watts respectively and belong to the F category. Therefore, the country produced an average air cooler (3582) from F to E category and *EER* should be upgraded and increased from 27 to 30. You can rate annual electrical energy savings and government savings from the viewpoints of Rials and the consumer can be considered as cumulative. The calculation of electricity production cost per kilo Watt of energy for the Ministry of Energy are740 Rials to 150 Rials and domestic electricity sales are considered. Also the air period is assumed for 4 months of the year and 12 hours. Therefore, the amounts of annual savings are calculated by the following relationship:

Number of annual working hours of cooler r = Total cumulative amount × a × decreased power consumption rate of annual savings

The number of hours of operation for 4 months and 12 hours of work per day is calculated to 1440. Percent reduced power consumption also increases the *EER* than 3 units, and assumes fixed air is about 10 percent.

Table 5. The rate of electrical energy savings and savings due to increased Rials cooler energy category as a cumulative

Year	Energy Savings (Mega Watt Hours)	Saving Rials (Billion Rials) from the Viewpoints of Government	Savings Rials (Billion Rials) from the Viewpoints of Consumers
2008	107117	79	16
2009	226753	167	34
2010	360371	266	54
2011	509604	377	76t

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BIOGRAPHY

Reza Effatnejad has Ph.D. in electrical engineering. Now, he has published more than 38 papers in journals and international conferences. His main field of study is in power and energy. Labeling of home appliances was the first of him activity. Dr. Effatnejad is an expert in energy auditing in the Iranian industries. He is a faculty member of Islamic Azad University, Karaj Branch, Karaj, Iran.