HVAC&R ENGINEERING
update

New ARI rating allows more accurate chiller-energy specification

An accurate rating method for chiller performance is an essential tool for evaluating and comparing equipment. Now there is a new rating developed by the Air-conditioning and Refrigeration Institute (ARI) that has replaced the previous Integrated Part Load Value/Application Part Load Value (IPLV/APLV) rating. The new rating closely tracks real-world, chiller-energy performance by more accurately accounting for chiller operation at off-design conditions.

The new rating – termed IPLV/NPLV for Integrated Part Load Value/Non-standard Part Load Value – is part of the new ARI Standard 550/590-98. This standard was adopted in September 1998 by ARI, the HVAC industry's standards-setting body, which has been certifying HVAC equipment for nearly 40 years. Starting immediately, all chiller manufacturers will begin certifying chiller performance to the new standard.

The IPLV/NPLV rating is easy to use (it can be employed exactly the same way as the old IPLV/APLV rating. In fact, to incorporate the new rating into specifications, engineers can simply replace the term "APLV" with the term "NPLV", and replace any references to "ARI Standard 550-92" or "ARI Standard 590-92" with "ARI Standard 550/590-98". No other change is required.[1] The only change is in the way chiller manufacturers calculate the rating.

Why was the old rating changed?

Introduction of the new IPLV/NPLV rating solves several problems with the old IPLV/APLV rating, which was based on several less-than-realistic assumptions. Most notably, the IPLV/APLV rating failed as an accurate measure of chiller performance at off-design, "real-world" operating conditions. The IPLV/NPLV rating now provides a more realistic model of off-design performance.

Chillers rarely operate at design conditions, because design conditions mean the **simultaneous** occurrence of both 100% load and design Entering Condenser Water Temperature (ECWT) or design Entering Dry Bulb (EDB) temperature. But design ECWT/EDB occur less than 1% of chiller operating hours. That means that over 99% of potential chiller operating hours are spent at off-design conditions: reduced loads, reduced ECWT/EDB, or both. The IPLV/NPLV rating accounts for this more accurately.

How has the rating changed?

To understand the new rating, it is necessary to look at the factors involved in the old IPLV/APLV rating.

As it stood, the old IPLV/APLV rating was still a much better indicator of chiller performance than the design kW/Ton rating, because it took into account some off-design conditions. Unfortunately, the old rating was based on limited assumptions that weren't accurate for the operation of most buildings.

Old assumptions

- Atlanta weather data was used to represent the average weather for the entire U.S. The result was that the rating was somewhat skewed toward warmer and more humid weather.
- The old rating improperly represented design conditions as occurring more often than they do in the real world. Specifically, the old rating said 17% of chiller operating hours were spent at design conditions of 100% load and 85°F ECWT (for water-cooled chillers) or 95°F EDB (for air-cooled chillers). In reality, these conditions occur

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simultaneously during less than 1% of chiller operating hours.
- The old rating used an antiquated rule-of-thumb that assumed that for every 10% reduction in load, ECWT declined 2.5°F and EDB declined 4°F. However, in the real world, the ECWT decline averages 4°F and the EDB decline averages 6°F per 10% load reduction.
- The old rating assumed all buildings had an airside economizer and operated 12 hours/day, 5 days/week. However, a 1992 DOE study (combined with a BOMA study) found that only 32% of commercial buildings have both of these conditions. The result was the old rating underestimated chiller operating hours for over two-thirds of the buildings.

New assumptions

By avoiding these misleading assumptions, the new IPLV/NPLV rating overcomes the limitations of the old IPLV/APLV rating.
- The new rating uses national weather data, based on an a weighted average of the 29 cities where 80% of the chillers were purchased over a 25-year period, as reported by ARI.
- The new rating recognizes that most operating hours are spent at off-design conditions.
- The new rating factors in the effect of colder ECWT and colderEDB.
- The new rating uses weighted averages of four different building operating scenarios:
  - 24 hours/day, 7 days/week, without an airside economizer
  - 24 hours/day, 7 days/week, with an airside economizer
  - 12 hours/day, 5 days/week, without an airside economizer
  - 12 hours/day, 5 days/week, with an airside economizer

Comparison of old and new ratings

Each rating is a blending of the kW/Ton at four loading points: 100%, 75%, 50%, and 25%. The formulas used to calculate the ratings are a bit complex, making comparison difficult. It is more instructive to compare the four points that make up each rating. A comparison of the old and new rating points in Table 1 illustrates the two major changes between the old and new ratings.

First, the new rating assumes that only 1% of chiller operating hours are spent at design conditions, instead of the 17% assumed by the old rating. Second, the new rating assumes that ECWT and EDB decline more rapidly than the old rating did.

Table 1: Comparison of Old and New Rating Points

Load (%)	Hours (%)		ECWT (°F)		EDB (°F)	
	Old	New	Old	New	Old	New
100	17	1	85.00	85.00	95.00	95.00
75	39	42	78.75	75.00	85.00	80.00
50	33	45	72.50	65.00	75.00	65.00
25	11	12	66.25	65.00[1]	65.00	55.00[2]

NOTES:
1 Would have been 55°F, but industry testing facilities could not have tested.
2 Would have been 50°F, but industry testing facilities could not have tested.

What are the benefits of the new rating?

With the new IPLV/NPLV rating, engineers now have a more accurate and convenient specification tool. It is an easy way to gauge actual chiller performance, because the new rating accounts for more realistic operating conditions. In addition, only a detailed, time-consuming and expensive energy analysis could provide a more comprehensive indication of actual performance.

The new rating will allow owners to make more informed capital-investment decisions, because it will enable a more realistic estimate of actual chiller operating costs. Plus, it will help determine more accurate paybacks in both new-construction and replacement projects. The old rating would add as much as 25% more time to the chiller-investment payback period. This often influenced decision-makers to choose less-efficient chillers in new construction projects, or delay the replacement of inefficient chillers in renovation projects.

The environmental impact of such chiller-replacement decisions can be staggering. If only 10% of the existing, inefficient, CFC chillers were replaced with more efficient versions, global warming could be reduced by a half-million tons of CO_2 over a five-year period. The phase-out of CFC refrigerants would also be accelerated.

What about multiple-chiller plants?

Appendix D of the new Standard states that the new rating was developed for single-chiller plants, and is not representative of multiple-chiller plants. It further states that individual chillers in a multiple-chiller plant spend, on average, more operating hours at higher loads than would a single chiller handling the same duty.

What the Appendix doesn't say is that the investigation of multiple-chiller plants had not yet been completed at the time the new Standard was issued. So, it was unknown whether the new rating was accurate for multiple-chiller plants.

That investigation has now been conducted. The research was done by Roy Hubbard of YORK, one of the driving forces behind the development of the new rating. The investigation found that the new rating accurately tracks the performance of multiple-chiller plants as well as single-chiller plants.

The explanation is rather simple. It is true that individual chillers in a multiple-chiller plant spend, on average, more operating hours at higher loads than would a single chiller handling the same duty. However, it is also true that those additional high-load operating hours are spent at lower ECWT/EDB. The result is that chillers in a multiple-chiller plant use the same **or even less energy** than a single chiller handling the same duty.

If we put a chiller on a test block, where we have control of both the load and the ECWT/EDB, we can see why this is so. If ECWT/EDB is held constant while the load is reduced, a chiller sees relatively little change in kW/Ton – perhaps only 2 to 3%. However, if the load is held constant while the ECWT/EDB is reduced, kW/Ton can fall by as much as 50%. The use of multiple chillers in a plant only affects the load each chiller sees, not the ECWT/EDB. So multiple chillers have very little effect on chiller-plant kW/Ton.

Table 2 shows an example comparing the average plant kW/Ton for one-, two-, and three-chiller plants handling the same cooling duty, along with the new IPLV ratings. The kW/Ton at design conditions for each chiller was 0.583.

Clearly, the averages of 0.484, 0.475, and 0.476 are not only close to one another, but also close to the new IPLV rating of 0.488. This demonstrates that the rating can be used to predict chiller performance in multiple-chiller systems as well as single-chiller systems.

What should be done now?

In addition to substituting “NPLV” for “APLV”, and “550/590-98” for both “550-92” and “590-92” in their specifications, engineers can now eliminate the specification of design kW/Ton. A design kW/Ton rating is merely an efficiency at one condition – a condition that occurs during less than 1% of chiller operating hours. It provides **no indication of off-design performance**, which can vary widely from chiller to chiller. In fact, chillers with the best design kW/Ton may have the worst IPLV/NPLV performance because they were optimized for design conditions.

Instead, the specification should be written so the chiller manufacturer isn’t restricted from bidding “equal efficiency.” Doing so allows the manufacturer to meet the specified IPLV/NPLV rating, even if the chiller has a different design kW/Ton.

Nevertheless, it is still necessary to specify maximum full-load amps for wire sizing. That’s because current requirements at design conditions will dictate the wiring size required to handle the load. Thus, full-load amps should be in the specification, but it should be specified as a maximum (the same way overall equipment dimensions are specified so that all manufacturers can fit the space.

A new standard for a new era

The introduction of the new IPLV/NPLV rating is a tremendous development for engineers and owners alike. It is the best basis to-date for writing a chiller-efficiency specification. Nothing short of an expensive and detailed energy analysis is better at determining chiller performance for both single and multiple-chiller plants.

With the IPLV/NPLV rating, engineers can easily produce a more accurate specification. Simply use the IPLV/NPLV number as provided by the manufacturer.

The IPLV/NPLV rating also helps owners ascertain the best chiller for their application. Comparisons of chiller performance can be made quickly and confidently. Using the rating also makes it easy to project actual operating costs and investment payback.

For more information about the new IPLV/NPLV rating, contact your local YORK office.

1. ARI Standard 550/590-98 also specifies that evaporator fouling factor be 0.0001 h (ft^2 (°F/Btu, instead of 0.00025 as specified in Standards 550-92 and 590-92.

Table 2: Average Chiller Plant kW/Ton and IPLV

Group Num.*	Number of Chillers: One	Two	Three	New IPLV
1	0.491	0.470	0.470	0.488
2	0.476	0.477	0.477	0.488
3	0.488	0.474	0.475	0.488
4	0.479	0.480	0.481	0.488
Avg.	0.484	0.475	0.476	0.488

*NOTE:
Group 1 = 24 hours/day, 7 days/week operation, without airside economizer
Group 2 = 24 hours/day, 7 days/week operation, with airside economizer
Group 3 = 12 hours/day, 5 days/week operation, without airside economizer
Group 4 = 12 hours/day, 5 days/week operation, with airside economizer