APPLICATION NOTE

Trends in energy efficient HVAC equipment and the need for true-rms meters

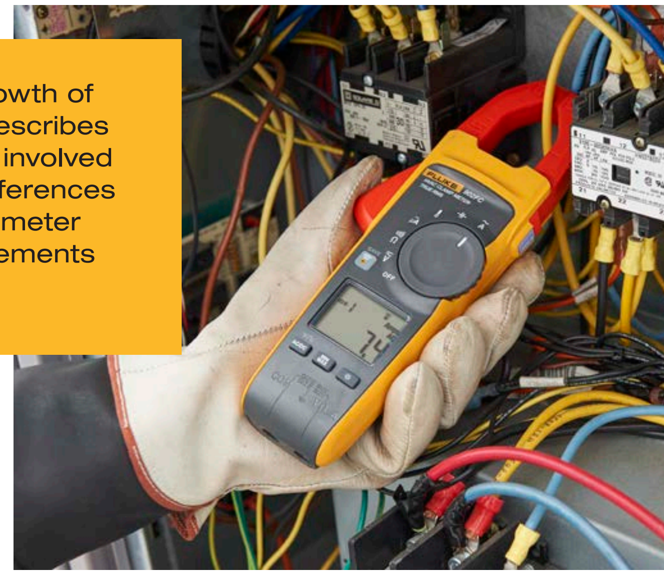
Today's green energy movement has stimulated the growth of new ultra-high-efficient HVAC equipment. This article describes some of these energy efficiency trends, the equipment involved and the maintenance impact. We will also clarify the differences between a true-rms meter and the standard averaging meter while explaining a couple of common electrical measurements on energy efficient equipment.

Energy efficiency standards and terminology

The federal government has spurred HVAC growth by mandating a minimum standard of 13 SEER or high on ac equipment and a minimum HSPF of 7.7 or higher. Fortunately, these are only the minimum energy levels as required by the government on new equipment installations. Several HVAC equipment manufacturers have released products with up to a 24 SEER in the cooling mode, a 10 HSPF on heat pumps in the heating mode, and up to 97 % AFUE efficiency on gas furnaces.

One of the trends in HVAC equipment is to build truly high efficiency units, compared to standard efficiency equipment. Unfortunately, increased efficiencies are not without increased costs and complexity. For example, several manufacturers of heat pumps have fully computerized every function within the equipment, with some units containing up to nine solid state microprocessor controllers. These microprocessors control everything within the unit electronically, including fan speeds on the indoor and outdoor blowers, compressor speed, both EXVs (electronic expansion valves) on indoor and outdoor coils, RH-Relative Humidity, temperature and cfm.

Needless to say, these units are fully electronic and, for the average HVAC tech, not easy to service. Even the thermostat is fully electronic, with only



Modern HVAC equipment is managed through a series of complex control signals, which require a true-rms meter to get accurate measurements.

4 wires on the sub-base. One set of wires on the base is for AC power, and the other two wires are for the communications cable between the indoor controller and the outdoor controller.

Older thermostat terminology, such as R=24 V Supply, W-Heat, G=Fan, and Y=Cooling or Compressor, is not used with modern modulating HVAC thermostats, since these thermostats are analog controllers, not simply automatic on or off switches.

Plus, these new thermostats with a variable signal can fully modulate system capacities from 40 % to 115 %.

As this new equipment gets into the field, install and service techs need to fully understand the operation and service procedures of each piece of equipment. Most times this requires techs to get certified specifically by factory representatives on each manufacturer's unit. Plus, they need to be

Definitions

SEER (Seasonal Energy Efficiency Ratio) is used to rate HVAC equipment in the cooling mode. The higher the SEER rating, the more energy efficient the equipment is. A higher SEER can result in lower energy costs.

HSPF (Heating Seasonal Performance Factor) is used in the heating and cooling industry to measure the efficiency of air source heat pumps. The higher the HSPF rating of a unit, the more energy efficient it is. HSPF is a ratio of BTU heat output over the heating season to watt-hours of electricity used. It has units of BTU/watt-hr.

AFUE (Annual Fuel Utilization Efficiency) measures the amount of fuel converted to space heat in proportion to the amount of fuel entering the furnace.

sure to use true-rms meters on equipment startup and servicing.

True-rms multimeters and other test tools respond accurately to ac current and voltage values regardless of whether the waveform is linear. If a test tool is labeled and specified to respond to the true-rms value, it means that the tool's internal circuit calculates the heating value according to the rms formula. This method will give the correct heating value regardless of the current wave shape.

Average responding tools don't have true-rms circuitry. Instead, they use a shortcut method to find the rms value. These meters capture the rectified average of an ac waveform and multiply the number by 1.1 to calculate the rms value. In other words, the value they display is not a true value, but rather is a calculated value based on an assumption about the wave shape. The average responding method works for pure sine waves, but can lead to large reading errors (up to 40 percent) when a waveform is distorted by nonlinear loads such as variable speed drives or computerized controls. The table below gives some examples of the way the two different types of meters respond to different wave shapes.

A comparison of average responding and true-rms units

Multimeter type	**Response to sine wave**	**Response to square wave**	**Response to single phase diode rectifier**	**Response to 3 Δ phase diode rectifier**
Average responding	Correct	10 % high	40 % low	5 % to 30 % low
True-rms	Correct	Correct	Correct	Correct

What does true rms really mean to the HVAC service tech?

Rms stands for root mean square. It comes from a mathematical formula that calculates the effective value (or heating value) of any ac wave shape. In electrical terms, the ac rms value is equivalent to the dc heating value of a particular waveform—voltage or current. For example, if a resistive heating element in an electric furnace is rated at 15 kW of heat at 240 V ac rms, then we would get the same amount of heat if we applied 240 V of dc instead of ac. From a measurement perspective, the rms value is equal to .707 of the peak value of the sine waveform which is Vrms = Vpeak x .707. For example, say an ac voltage source has a positive peak value of 165 V:

Vrms = Vpeak x .707
Vrms = 165 x .707
Vrms = 116.655 V

True-rms meter implications for energy efficient HVAC equipment

It is important to remember that not all the problems found on new HVAC units are complex. A full range of basic mechanical issues—such as air flow, duct leakage, dirty filters and proper refrigerant charge (which typically requires accurate superheat and subcooling measurements)—impacts the unit's efficiency. Proper refrigerant charge typically require accurate superheat and subcooling measurements. But there are also sophisticated control system problems and measurements which need to be addressed during routine maintenance and service.

Now bear in mind, many of these electronic controls involve nonlinear loads. Essentially, any control system containing semiconductors in the power supply or in the controllers would be considered a nonlinear load. Normally, when troubleshooting an HVAC equipment failure or nuisance trips due to an electrical problem, your first instinct would be to check the panel for tripped circuit breakers or overloading.

However, if a nonlinear load, such as a new high efficiency heat pump, is on that circuit, you'll need a true-rms test tool to accurately measure the true load current to determine where the problem is—is the circuit faulty, is it overloaded, or is the problem with the load itself? The photographs demonstrate a standard averaging meter and a true-rms meter. Notice that the difference between the two meter readings is approximately 32 percent.

HVAC electrical measurements on energy efficient equipment

Here's a quick review of the HVAC electrical measurements that require a quality and accurate test tool on new HVAC energy efficient equipment.

- Electronic temperature sensors for superheat, subcooling and air temperatures.
  - Most of these sensors are thermistor temperature sensor types with an NTC-Negative Temperature Sensor response. This means that when the temperature goes down, the resistance goes up.

One current—two readings. Which do you trust? This demonstration shows a non-sinusoidal waveform passed through a coil. The true-rms clamp meter shows an accurate current reading. The averaging responding clamp shows a reading more than 25% low.

  - To test these sensors, you must refer to the manufacturer's data sheets to test for a known resistance reading at a given temperature. For example, a temperature sensor at w32 °F (0 °C) in ice water would read 50,664 Ω (ohms), but the same sensor at 50 °F (10 °C) would read 30,343 Ω.

- Pressure transducers

  - Most of these sensors are pressure transducers with a DC voltage signal out at a corresponding pressure.

  - To test these transducers, again you must refer to the manufacturer's data sheets to test for a known voltage at a given pressure. For example, a pressure transducer at 45 psig using R-410a refrigerant (-4 °F, -20 °C) would read 1.1 V dc (volts direct current), but the same transducer at 60 psig (8 °F, -13 °C) would read 1.3 V dc.

- Measuring current and voltage

  - Measuring the current when nonlinear loads exist will always require using a true-rms meter. For most newer indoor and outdoor high efficiency units, these measurements occur largely on the main power supply. The compressor and the fans are controlled by a variable speed control, so the only amps to be checked are on the supply side of each unit. For example, the total amps for the outdoor unit might be rated at 22 FLA (full load amps). This means that on a hot day under a heavy load, the amps to the unit should not exceed 22 amps. Checking the individual amps to the compressor is no longer possible, due to the ECM (electronically commutated motor) control system in place on the unit.

  - Measuring the voltage directly at the compressor is also no longer possible, due to the types of ECM controllers on the motor. However, the technician should learn to check the supply voltage to the outside unit and expect a +/- of 10 % of the supply voltage.

The best tool for the job

In today's high tech HVAC environment, the best move is to use only true-rms test tools for the best results. For today's HVAC technician working on high efficiency HVAC equipment, successfully troubleshooting electrical problems relies equally on good tech manuals from the manufacturer and a high quality, true-rms test tool. This is due in part to the proliferation of new solid state variable frequency drives, ECM controlled motors, and sophisticated electronic and computerized HVAC controls. Be sure to always use true-rms meters and you will consistently get accurate readings.

Fluke 902 FC True-rms Wireless HVAC Clamp Meter

Fluke understands you need to safely, accurately, and quickly troubleshoot and maintain HVAC equipment. That is why we present the Fluke 902 FC HVAC Clamp Meter with Fluke Connect®. The Fluke 902 FC True-rms HVAC Clamp Meter delivers what you need to diagnose and repair HVAC systems. Key features include:

- Capture and trend measurements safely from outside the arc blast zone and easily create and send reports from the field with Fluke Connect®
- 600 A ac current measurement
- Resistance measurement to 60 kΩ
- 600 V ac and dc voltage measurement
- Temperature measurement from -10 °C to 400 °C (14 °F to 752 °F)
- 1000 µF capacitance measurement
- DC current measurement to 200 µA
- True-rms voltage and current for accurate measurements on non-linear signals
- Min and max recording to capture variations automatically
- Compatible with ToolPak™ magnetic hanging strap

Applications for HVAC

- 200 µA DC current measurements to measure flame rod
- Extended resistance range to measure thermistors up to 60 kΩ
- Capture flue gas temperature
- Measure start and run motor capacitors
- Measure performance of variable frequency drives

Get more power from your clamp meter with Fluke Connect®

Save time – eliminate data entry by wirelessly syncing measurements directly from your tool to an asset record or work order using the Fluke Connect® system. Having access to maintenance records simultaneously at the inspection site and from the office or an off-site location enables faster decision making and real time collaboration between team members.

- Maximize uptime and make confident maintenance decisions with data you can trust and trace.
- Save measurements to the FlukeCloud™ and associate with an asset so your team can consult baseline, historical and current measurements from one location.
- Collaborate with ease by sharing your data with others with ShareLive™ video calls and emails.
- Wireless one-step measurement transfer with AutoRecord™ measurements eliminates transcription errors, clipboards, notebooks and multiple spreadsheets.
- Generate reports and work orders with multiple measurement types to provide status or work recommendations.

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Fluke Corporation
PO Box 9090, Everett, WA 98206 U.S.A.

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
Web access: http://www.fluke.com

Printed in U.S.A. 2/2016 3850210b_en-n