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LIGHT FLICKER DURING AIR CONDITIONER START

Summary

Some consumers of residential air conditioners and heat pumps complain about **dimming** or **flickering lights** when the unit starts. ***Often they unjustly blame the equipment for their problems***. This report provides background to identify power supply problems and point out the need to address them with the help of the Electric Power Utility providing the service.

When a complaint occurs, check the charge of the unit in addition to proper wire size from the service panel to the unit and all wire connections and breaker contacts for tightness and integrity. Then check the voltage at the meter to be certain it is within 5% of the nominal distribution voltage. By elimination of these potential light flicker sources, what is left is likely to be an undersized transformer.

Introduction

Light Flicker is any perceptible change in the light output of a light fixture caused by voltage fluctuations in the power supply.[1] This report follows the outline below and explains causes and contributors to the phenomenon:

I. Light Flicker History and Background
II. Supply Transformer Sizing Information
III. Exposing Power Supply Problems
IV. High Efficiency Motor/Starting Current Relationship
V. Effect of Start Gear

I. Light Flicker History and Background

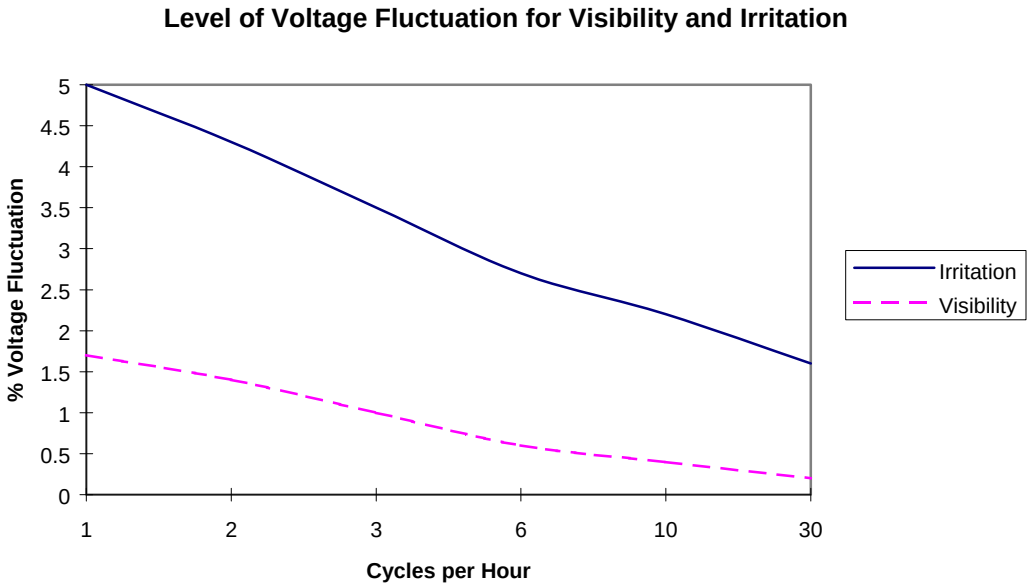
When an air conditioner or heat pump starts, momentary light dimming may occur. This light flicker happens because the system voltage drops during starting. Extra current is needed to accelerate the compressor motor up to speed. Once running speed is reached, the current decreases to a much lower level and the line voltage returns to the higher level. Not all people respond the same to light flicker. Some may not even notice what other are offended by.

Light flicker is not known to be a harmful to the unit or lighting. Standards for light flicker date back to the 1930's. If the voltage drop is so great that the motor will not start then there is a problem. This is not the case with light flicker that occurs when an air conditioner or heat pump starts. The problem is of a perceived nature. When light flicker occurs, it is

[1] Power Electronics Applications Center, Power Quality Test Facility, "Lamp Flicker Caused by Voltage Fluctuations," Task 10 of the System Compatibility Research Project, 1995

perceived that something is wrong. The air conditioner is often blamed. The light flicker was not there before the air conditioner was installed. We assume that it must be caused by the air conditioner.

The chart below shows both border lines of visibility and border lines of irritation. Two to three cycles per hour was used for our residential product. [2]



Utilities are local companies, each with their own procedures and rules. Most want quality service for their customers and most will spend the necessary money to ensure that their customers are well served. If you encounter a light flicker the utility is your best source of help. Contact your utility quality manager or distribution manager or engineer and explain the light flicker with information on the customer and equipment, including model and locked rotor current. Explain that this is a unique situation and needs special attention.

Similar light flickering occurs with competitors' equipment since similar types of compressors and motor efficiencies are used. Light flickering occurs where the transformer is too small or the impedance is too high. The transformer may meet the load requirements and the utility's obligation. The utility may not consider lights flicker a problem.

With the deregulation of power companies, the competition of distribution companies may become more intense with cost cutting. The future is a little uncertain. Homes show no sign of getting smaller. In some areas, multiple units are already used for redundancy and efficiency in distribution. The concept of two small units to replace one large unit may help light flicker.

[2] IEEE Std.519-1992 10.5.1 Limits of Flicker.

II. Supply Transformer Sizing Information

The power company sizes the transformer to handle the load and to provide power at the meter within 5% of the nominal distribution voltage. A larger transformer and lower impedance of the transformer reduce the light flicker. A transformer is rated in two ways. One is the load capabilities expressed in KVA or kilovolt amperes and the other is the impedance expressed in ohms or percentage. The impedance is equal to the resistance in a direct current circuit. The voltage drop when an air conditioner starts is directly proportional to the transformer impedance. The voltage drop of a 50 KVA transformer with an impedance of 2.5% may be no better than a 25 KVA transformer with an impedance of 2%. Impedance is an indicator of the stiffness of the voltage output. Usually a transformer of 50 or 75 KVA with an impedance of 2% will ensure the customer that objectionable light flicker does not occur. The magic number for voltage drop for objectionable light flicker is about 4%, or about 10 volts. It is likely that a transformer of about 25 KVA and 2% impedance sized for a single dwelling will have a voltage drop of about 10 volts during starting of a 5 ton compressor. In a neighborhood where multiple homes are served from a single transformer, it will be larger and less likely to cause flicker. Overload of a transformer has little effect on flicker and is routinely permitted in accordance with transformer manufacturer recommendations. The table below shows the voltage drop that occurs when a 5 ton air conditioner or heat pump starts.[3]

Transformer Size	Trans Impedance	% Voltage Drop	Voltage Drop
25 KVA	2 %	4.0	9.6
50 KVA	2 %	2.0	4.6
75 KVA	2 %	1.4	3.2
100 KVA	2%	1.1	2.5

The power company can increase the voltage according to load to compensate for the drop on an average or long time basis. Voltage may drop a lot or just a little for the same current depending on the size and impedance of the transformer. The transformer just outside the home is by far the largest voltage drop in the system when starting current is applied.

III. Exposing Power Supply Problems

An effective method of showing the customer that the problem is in the transformer in a multiple dwelling distribution system is to measure the voltage in a neighbor's home while the air conditioner in the original dwelling is cycled. The excessive voltage drop should be at the transformer and not in the drop line and not in the house wiring. Normally the power company sizes the drop line in conjunction with the size and impedance of the power transformer, the length of the drop line and the available voltage. The customer does not pay for the losses in the drop line but too long and too small of drop line can cause light flicker on start up.

[3] Data from Hien D. Duong,Indianapolis Power and Light Company

Breaker panel wiring can be arranged to off set to some extent the flicker from the air conditioner starting. The motor loads should be on one buss and the lighting loads on the other buss. The air conditioner goes to both busses. If the furnace or fan coil fan motor is on the buss opposite the lights then when the furnace starts the lights will get brighter due to neutral voltage shift. Since this occurs at the same time the compressor starts, the light dimming caused by the compressor will be offset by the light brightening caused by the fan motor.

IV. High Efficiency Motor / Starting Current Relationship

Motors in air conditioners have undergone some changes in the past few years resulting in higher starting currents. The increase has been slight. Homes are larger with larger air conditioners so that we are seeing more 4 and 5 ton units. Most complaints come from 4 and 5 ton systems. The increase in starting current due to the change to larger units is great.[4]

AC OR HP SIZE-TONS	LRA- HIGH EFF COMP	LRA-STANDARD EFF COMP
1.5	47	52
2.0	62.5	60
2.5	76	75
3.0	90.5	96
3.5	107	95.4
4	129	114
5	169	142

Higher efficiency air conditioners are mandated by congress. They make good sense as an investment. Even power companies give rebate incentives to the customer for buying high efficiency air conditioners. Part of the cost of higher efficiency air conditioners is higher starting current. Part of the cost is also slightly more light flicker.

The locked rotor amps printed in the literature and on the unit rating plate is the starting current as measured in a UL test. It may not represent the value measured by the power company. This does not mean that something is wrong with the compressor. It just means that the test method was different. Even with the same method of measurement the value can change according to rotor position. Variations of 20% are possible. The response time of the instrumentation will have an even greater effect. Generally, a slow response time more nearly simulates the light flicker problem. Very short time transients are not seen as light flicker.

The March 1, 1993, Air Conditioning, Heating & Refrigeration News contains an article on increasing starting current. The increase in compressor efficiency is due to improvements in the compressor valves, reduced clearance volume, lower drag and improved motor

[4] Data taken from Copeland HCFC-22 form 2.201

efficiency. Light flicker is not due to the fact that the compressor is a scroll. It is due to the motor design. The scroll unloads when it stops. The pressures are equal when the compressor restarts.

A reciprocating compressor must have time to equalize pressures before a restart. If restart occurs before pressures are equal the compressor may stall and stay on locked rotor until the overloads open. The scroll is ready to restart when rotation stops. A reciprocating may need 5 minutes. Hard starting problems are much worse for a reciprocating compressor. So is the opportunity for light flicker.

The perceived annoyance of light flicker compares to the annoyance of noise. Neither will affect the performance. Light flicker does not hurt anything. Of course there is a limit to the amount of voltage regulation that can be tolerated.

V. Effect of Start Gear

Starting components can be added to the air conditioner that shortens the time the lights are dim. Start components may reduce the noticeably of the flicker but may not eliminate it. This is the standard fix for jobs with noticeable light dimming. More complicated starting systems that start the air conditioner with reduced voltage are being considered.

If the voltage drops so low that the motor will not start, then there is a problem. With reciprocating compressors this has been a common problem due to equalization. The addition of starting components is common. Occasionally this also happens to scroll compressors and start components must be added. It seems likely that there will always be a small percentage of homes with poor entrance connections and marginal internal and marginal power distribution that will result in too much voltage drop during starting. Start components are needed to save this customer.

Typical time for a 5 ton compressor to start on a minimum rated voltage is somewhere around 300 milliseconds. The time to start with a 88-108 capacitor and start relay will drop the start time to about 150 milliseconds. A 270-324 Mfd/330 volt capacitor will further reduce the start time to about 65 milliseconds. This large capacitor increases the starting torque and shortens the time the compressor takes to start. The shortened time reduces the duration of the flicker. The current draw does not change. Each step improves the perceived light flicker.