Carrier INTER-OFFICE LETTER

TO

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REGIONAL SERVICE MANAGERS		(C)	
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FROM MERRILL A. LEWIS DATE 6/28/73

OFFICE MSD SERVICE ENGINEERING-SYRACUSE

SUBJECT CURRENT UNBALANCE

FIELD EXPERIENCE REPORT 73-5

From time to time we run across the problem of current unbalance on 19 Series machines. Usually, it is in the form of a customer complaint or something someone notices while checking other jobsite conditions. It is our purpose here to provide guidelines for dealing with this problem; to describe its cause, effect, and limitations, and to provide a test to prove whether or not the problem originates in the motor.

1. DEFINITIONS:

Voltage or current unbalance is the percent by which the actual value deviates from the average. The exact mathematical formula for three-phase equipment gets quite complicated, but the following may be used for a workable approximation:

> "% unbalance = 100 times the sum of the three deviations from the average (without regard to sign) divided by twice the average."

For example, on a 480 volt system, let us assume that the three line-to-line voltages are 478, 483, and 479 volts. The average is:

$$\frac{478 + 483 + 479}{3} = \frac{1440}{3} = 480 \text{ volts}$$

The unbalance is:

$$\frac{(480-478)+(483-480)+(480-479)}{2 \times 480} \times 100 = \frac{2 + 3 + 1}{960} \times 100 = 0.625\%$$

-continued-

FILING INSTRUCTIONS: CENTRIFUGAL FIELD EXPERIENCE REPORTS MANUAL
TAB: CONTROLS-WIRING

Let us now say that on this same machine, the amperage readings are 612, 663, and 684 amps. The average is:

$$\frac{612 + 663 + 684}{3} = \frac{1959}{3} = 653 \text{ AMPS}$$

The unbalance is:

$$\frac{(653-612)+(663-653)+(684-653)}{2 \times 653} \times 100 = \frac{82}{1306} \times 100 = 6.28\%$$

2. CAUSE:

The most probable cause of current unbalance on any induction motor is voltage unbalance. Current unbalance rises sharply with a small voltage unbalance. Thus, in any "current unbalance" problem, source voltage unbalance should be suspected. Figure 1 shows the relationship between voltage and current unbalance.

Note that a one percent (1%) voltage unbalance, which may not even be able to be read on a standard voltmeter, may produce, depending on load, a 7% to 15% current unbalance - which is easily detected on a standard ammeter, and may cause questions to be asked.

Other possible (but not probable) causes of current unbalance are in the switchgear or load (motor). High resistance connections may cause some unbalance, but it is likely that before the unbalance is noted that the connections would overheat and fail. Shorted or mismatched motor windings could cause unbalance but, again, this is unlikely as other symptoms would come first.

3. EFFECT:

Unbalanced current in a motor winding due to voltage unbalance causes unbalanced fields in the motor leading to increased losses which get translated to overheating, and to a lesser degree, can induce apparent mechanical rotor unbalance.

4. LIMITATIONS:

A rule-of-thumb is that our motors can easily withstand anything less than 10% current unbalance. This corresponds roughly to anything less than a 1% voltage unbalance.

By-and-large, power companies endeavor to maintain their voltage unbalance at less than this figure.

Power company regulations and practices vary throughout the country, but there should be none which permit voltage unbalances greater than 2% (which corresponds to a little less than 20% current unbalance at full load).

In general, we should discourage any conditions which would permit over 10% current unbalance and take a very strong stand against conditions which would permit a 20% unbalance.

5. TEST TO ISOLATE CAUSE OF UNBALANCE

Often times we are faced with a contention that a current unbalance is being caused by our machine rather than by external causes. There is a straightforward test to isolate this cause, the results of which should be accepted by reasonable customers. Refer to Figure 2:

1. Mark the incoming leads to the starter "A", "B", and "C" corresponding with incoming terminals "L1", "L2", and "L3", respectively.

2. Run the machine and establish a constant load as near design as possible.

3. With an amprobe, record the line currents from L1, L2, and L3.

4. Stop the machine, de-energize the branch circuit, and reconnect line A to L2, B to L3, and C to L1.

5. Re-energize the circuit and start the machine. Establish the same load as in Step 2 above.

6. Again record the line currents from L1, L2, and L3.

7. If the unbalance has rotated (see Case #1 in Figure 2), the source voltage is at fault.

8. If the unbalance does not rotate (see Case #2 in Figure 2), the starter or motor is at fault. As discussed above, this is highly unlikely.

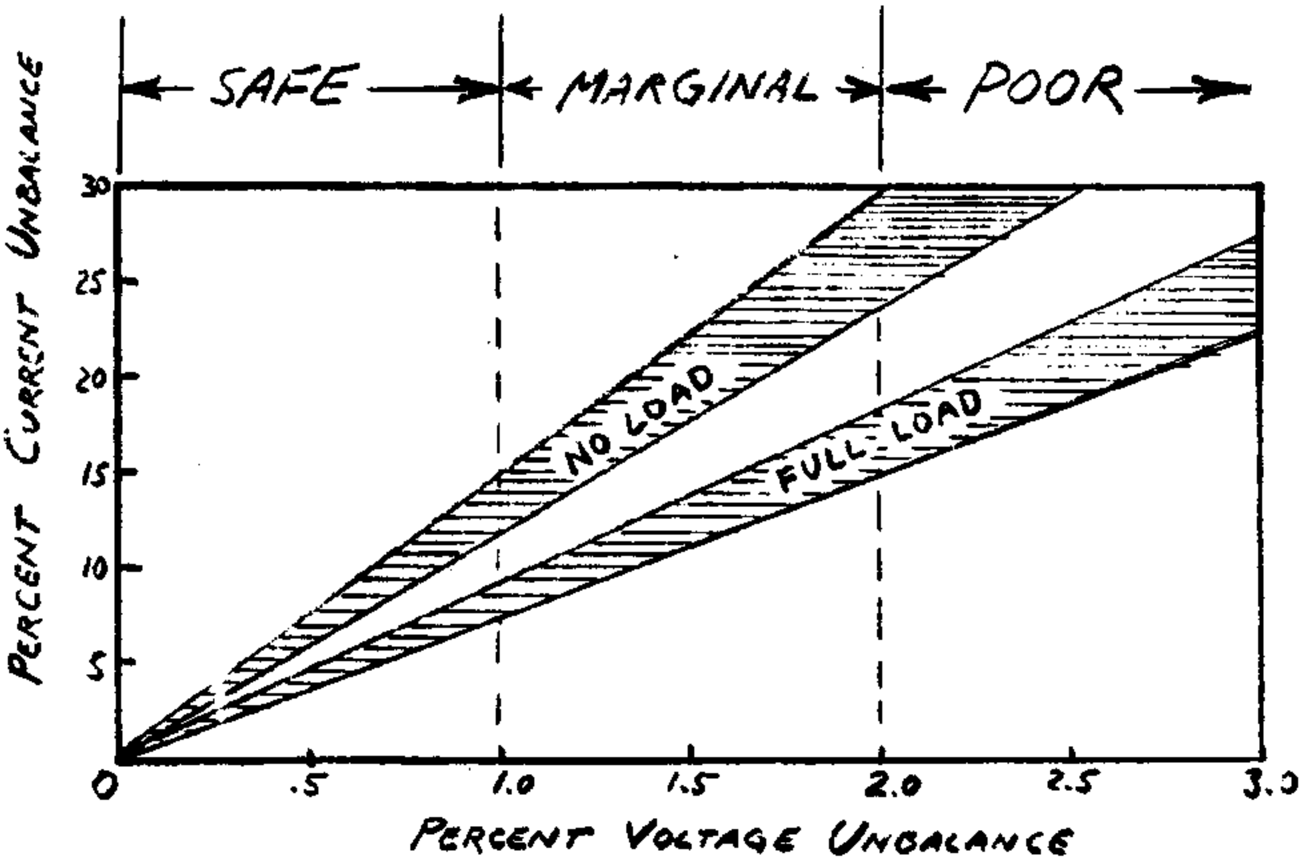
NOTES:

1. These readings should be taken with the same amprobe. Mounted ammeters, when switched, rely on different current transformers which may be the problem in the first place.

2. If results are in doubt (because load has varied during the test), repeat the test.

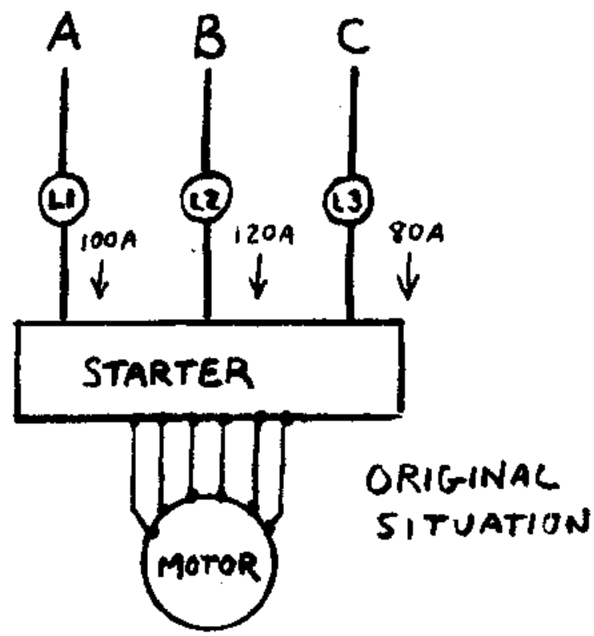
MAL/ama
Attachments

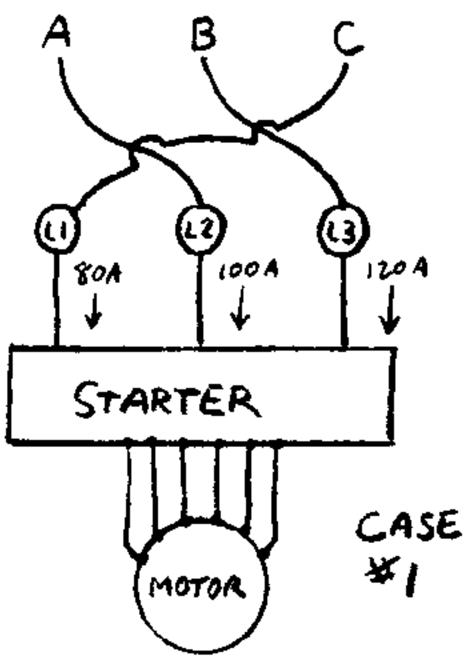
FILE INSTRUCTIONS:

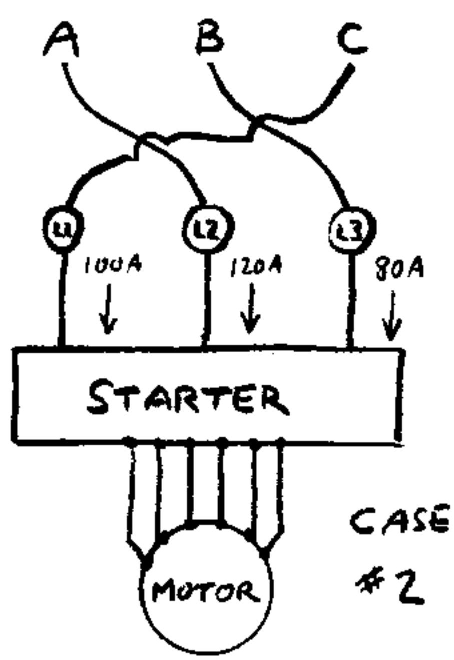


EFFECT OF VOLTAGE UNBALANCE ON CURRENT UNBALANCE

FOR ANY TYPE OF THREE PHASE INDUCTION MOTOR. THE BAND INDICATES THE SPREAD THAT IS LIKELY TO BE ENCOUNTERED. NOTE THAT FOR A GIVEN VOLTAGE UNBALANCE, THE CURRENT UNBALANCE WILL INCREASE AS LOAD DECREASES.


A
B
C
L1
L2
L3
100A
120A
80A
STARTER
MOTOR
ORIGINAL SITUATION


A
B
C
L1
L2
L3
80A
100A
120A
STARTER
MOTOR
CASE #1


A
B
C
L1
L2
L3
100A
120A
80A
STARTER
MOTOR
CASE #2