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Compressor Control Panel

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COMPRESSOR CONTROL PANEL

Abstract

Every air compressor motor manufacturer is familiar with the inherent conflict between the need to produce compressors quickly and efficiently and the need to provide adequate testing. Because of the potential hazards that can be caused by defeated products, private and governmental testing agencies have set standards. Dielectric strength, leakage current, insulation resistance, power measurement, resistance measurement, efficiency, leak pressure decay and noise testing should be performed on compressors before leaving the factory.

A computer-controlled compressor panel can easily be configured to comply with ISO9000 and to test compressors in less than 14 seconds.

Introduction

Most people who design, build or sell compressors are unfamiliar with testing the safety and the good working of their products. Manufacturers of testing instruments and the agents responsible for establishing test procedures are sometimes at a loss to explain the how and why of a test and the true meaning of the test results. The compressor control fields seem to be huge, but only few of them are useful. In fact, the power consumption, the efficiency, the leakage, the noise and vibration analysis and electrical safety should be performed on the compressor before leaving the factory.

1. Electrical safety

As a women reached for a cold juice, she made contact with her refrigerator and was electrocuted. The faulty insulation of the compressor caused the electrocution. The manufacturer have to prevent compressors with faulty insulation from leaving their factory.

Three tests are used to be performed: the insulation resistance, the dielectric strength and the leakage current tests.

1.1. Insulation resistance

For this test, we connect two points that are separated by insulation and take a measurement. The measured value represents the equivalent resistance of all the insulation that exists between the two points and any component resistance that might also be connected between the two points. So, we can check the condition of the wiring. For 120V circuits, wiring is used to be stressed with a voltage of 500V DC (fig.1) and it is commonly considered acceptable if it reads at least 2 megohms to ground.

![Fig. 1. Insulation resistance test](image-url)
Those who manufacture, install, use and repair compressors find the Insulation Resistance testing very useful in
determining the quality of the insulation in this type of motor.
To an experienced individual who know how to interpret readings, a single insulation resistance measurement
can indicate whether a motor is fit for use.

This test can be performed either in an air compressor motor final assembling step or before installing
components in the compressor. Wire, connectors and resistors are specified to have a certain minimum
insulation resistance and it is sometimes necessary to verify that these components meet the specification.

The figure 2 shows the actual reading obtained on a air compressor motor over several years (dashed lines) and
the same readings corrected to a common 40°C reference (solid lines). Note the gradual decline that signifies the
motor's normal aging process as well as the sharp drop that occurred in late 1993. That drop signaled a problem
with insulation that would probably lead to a costly insulation failure. Based on these findings, the air
compressor motor was sent out for rewinding at the earliest opportunity. The rewinding restored the high
resistance readings, and again the gradual decline resumed.

In addition to temperature, moisture also affects the insulation resistance reading.
Usually, compressors are tested for one second at
500VDC. The insulation resistance may exceed 20MΩ.
However, in many compressors, insulation resistance tests may not detect pinholes in insulation or conductors
that are spaced too closely together, making the high potential test absolute.

1.2. High potential test
The high potential test, or Hipot, or dielectric strength, is designed to stress insulation far beyond what it will
encounter during normal use.
The assumption is that if the insulation can withstand the much higher voltage for a given period of time, it will
be able to function adequately at its normal voltage level. In addition to overstressing the insulation, the test also
will detects material and workmanship defects that result in conductor spacings that are too close.

The design tests are performed on a product sample or more commonly in air compressor motor factories in the
final assembly production lines for all pieces. In this case, the conditions are less stringent than those applied on
some samples. In fact, the voltage and the amount of time high voltage are respectively for the line production
tests 3000V AC and one second. However, a sample is stressed for one minute with 1240V AC (= 2.UL+1000).
These conditions are specified by the UL standards. Recently, the UL has started requiring that Hipot test
instruments meet certain output voltage regulation specifications to ensure that the device under test is stressed at the correct voltage. The failure condition is an excessive leakage current (fig. 4.)

![Graph showing leakage current vs. high voltage](image)

**Fig. 4.** Failure condition in Hipot test.

Because Hipot testing instantly applies high voltage to a compressor, it may cause electrical damage to components. Several new techniques have been developed to eliminate this problem. For example, the technique used by ATEQ is to ramp the voltage. A ramping circuit gradually increases the voltage over a preselected period of time. However, the distortion of the sinusoidal output that ramping creates has been a long-standing technological barrier. To comply with UL requirements, the ATEQ Hipot tester maintains by using a special inverter, a consistent sinusoidal output wave-form.

### 1.3. Leakage current

Various studies show that the human body’s threshold for perceiving electric current is approximately 1mA. Because body weights differ, some people feel current at different levels. Because of the potential hazards these low-level currents presents to human body, UL, CSA, IEC... have set standards for the maximum amount of current that may leak from a non-defective product operating at its normal line voltage. Usually, compressors are tested for one second at 1.06 times the nominal voltage (1.06x120V=128V). The leakage current may not exceed 0.5mA.

![Dynamic leakage current test diagram](image)

**Fig. 5.** The dynamic leakage current test.
2. Efficiency testing

The air compressor have to be waterproof and gastight. So, both efficiency control and leak pressure decay measurement should be performed.

The figure 6 shows the different phases of testing the efficiency of a compressor. At first (phase 1), the compressor is filled with an external pressure source and we started the test when we reach 2 bars (for example). Then (phase 2), while the compressor is pumping, an external 8 bars air pressure is connected to reach the final pressure of 8 bars quickly. In the third phase, the external source is disconnected. We measure the time taken by the compressor to reach 8,5 bars. Afterwards, the leak pressure decay measurement is performed: the compressor is stopped and the initial and the final pressure is measured for a given time. The last phase is for dumping the compressor.

\[
\text{Efficiency} = \tan \alpha = \frac{\delta p}{\delta t}
\]

Fig. 6. The efficiency test.
3. Noise and vibration test

Many materials, workmanship defects or component assembling defects can be detected by listening to the compressor when it works. A microphone or an accelerometer will be located close to the compressor. The frequency range is going to 10kHz divided in 64 bands. Usually, all mechanical movements or oscillations are detected till a frequency of 6kHz. Typical assembling problems like suspension problem, discharge loop problem, small gasket problem and muffler problem can be detected be by some characteristic peaks in given frequencies.

![Image](image.png)

Fig. 7. Noise test of good compressors.

4. Compressor control panel

Every manufacturer of compressors is familiar with the inherent conflict between the need to produce products quickly and efficiently and the need to provide adequate testing. Fortunately, modern test instruments finally have reached a level of sophistication. Integrated and automated test systems can perform all required tests on compressors quickly, accurately and through few connections. Test information can be stored and retrieved. Automation and PC fulfill that need. Many compressor manufacturers collect and analyze the data they gather from successive testing and use it as information to make their compressors safer and more reliable, as well as to comply with ISO, UL or CE requirements.

A compressor control panel (fig. 8) supervised by PC is used in order to control air compressor motors in different step of the manufacturing, from the qualification to the final assembling. The system can be adapted to control small compressors assembled afterwards in domestic or industrial refrigerators. All control operation listed in the table below can be performed in less than 14 seconds.

<table>
<thead>
<tr>
<th>Control</th>
<th>Most common range</th>
<th>Required Precision</th>
<th>Testing time</th>
</tr>
</thead>
<tbody>
<tr>
<td>High potential</td>
<td>0-4000V AC/DC</td>
<td>1%</td>
<td>2s</td>
</tr>
<tr>
<td>Insulation resistance</td>
<td>50-1000V DC</td>
<td>1%</td>
<td>1s</td>
</tr>
<tr>
<td></td>
<td>50-400V AC</td>
<td>1%</td>
<td>1s</td>
</tr>
<tr>
<td>Power</td>
<td>0-500V / 0-20A</td>
<td>1,5%</td>
<td>1s</td>
</tr>
<tr>
<td>Leakage pressure</td>
<td>0-500 g/ cm²</td>
<td>1%</td>
<td>2s</td>
</tr>
<tr>
<td>Efficiency</td>
<td>0-500 kg/ cm²</td>
<td>1%</td>
<td>3s</td>
</tr>
<tr>
<td>Noise</td>
<td>0-10 kHz</td>
<td>1%</td>
<td>1s</td>
</tr>
<tr>
<td>Voltage control</td>
<td>50-400V</td>
<td>1%</td>
<td>-</td>
</tr>
</tbody>
</table>

Total = 11s
A computer-controlled compressor test system can easily be configured to follow the production synchronization (fig. 9). In addition to the storage, the supervision, the retrieval and the analysis, another important reason for the growing need to PC is ISO 9000. One of the ISO 9000's main objectives is to ensure that manufacturers can prove that their compressors have been adequately tested and documented.