Motor Circuit Analysis (MCA) Testing of Traction Motors on Locomotives Using the AT5™

Introduction

Electric traction motors are used for propulsion of rail transport vehicles such as locomotives. These traction motors can be either alternating current (AC) or direct current (DC) types. Newer locomotives use alternating current (AC) traction motors. AC traction motors provide higher reliability and reduced maintenance requirements. A variable frequency drive (VFD) is often used to allow the speed of traction motors to be controlled by adjusting the frequency output of the VFD, so the traction motor can run from 0 rpm to its maximum rated speed. This application note is to show the capabilities and testing procedures of AC traction motors using the AT5™ instrument.

Technology

The AT5™ instrument can detect the problem before a catastrophic failure. The AT5™ is the fastest and easiest tool to use when evaluating both AC and DC electric traction motors. A single two-minute test evaluates the condition of an AC traction motor: stator windings, rotor, connections, and the insulation resistance to ground. With respect to DC electric traction motors the testing process is different from that of an AC motor, which will be covered in a separate application note.

Fault detection includes:

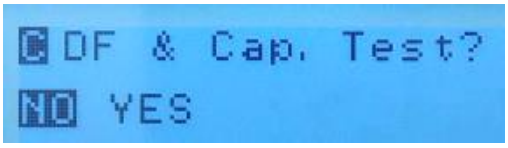
Stator windings- open phase, turn and coil faults (before windings fail to ground).
Rotor- cracked/fractured rotor bars
Connections- high resistance unbalances
Insulation to ground- contamination & shorts to ground

The AT5™ can be used for troubleshooting, incoming inspection, and predictive maintenance.

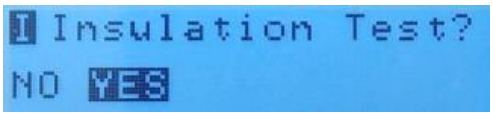
Testing Procedure for Uninstalled AC Traction Motor

1. Determine the test procedure.
   a. Can the shaft of the motor be rotated by hand in a slow and steady manner?
      -If yes, the preferred test is the IND test mode.
      -If no, select the Z/Fi test mode.
      -If a Reference TVS value has been saved from an exact same manufacturer, model, manufacturing tolerances, etc. then select the IND test mode.

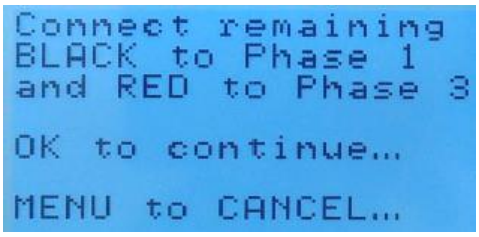
2. Connect the blue test lead to phase two and the yellow test lead to ground.
3. Use the right arrow key to move the cursor to “YES” and press the OK key to perform the Dissipation Factor and Capacitance test.



4. After the test is complete and results displayed, Press OK to continue.
5. Use the right arrow key to move the cursor to “YES” and press the OK key to continue. When the three lines are displayed, press and hold the “TEST” key until a stable result is obtained. Then release the “TEST” key and press OK to continue.

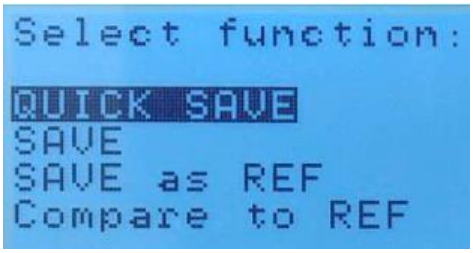


6. Connect the black lead to phase one and the red lead to phase three. Press the OK key to begin the static phase to phase test. If the Z/Fi test mode was selected go to step 8.



7. If the IND test mode was used, select “Yes” for the Dynamic test and perform the test.

8. View and Save the results (using the Z/Fi test mode).



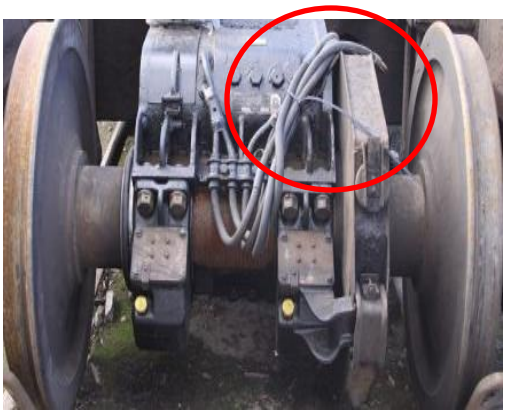
Testing Procedure for Installed AC Traction Motors

1. Follow your company's safety procedures before working on any components of an installed traction motor. ALL voltage must be removed from the circuit, or personal injury or instrument damage will occur.
2. Remove the cleat that secures the motor leads to the car body.
3. Remove the rubber boot and all three phases connected to the incoming power.

Remove cleat from carbody

Disconnect incoming power leads

4. Test from the motor leads going to the motor connection box, begin step 1 procedure for testing an un-installed traction motor.

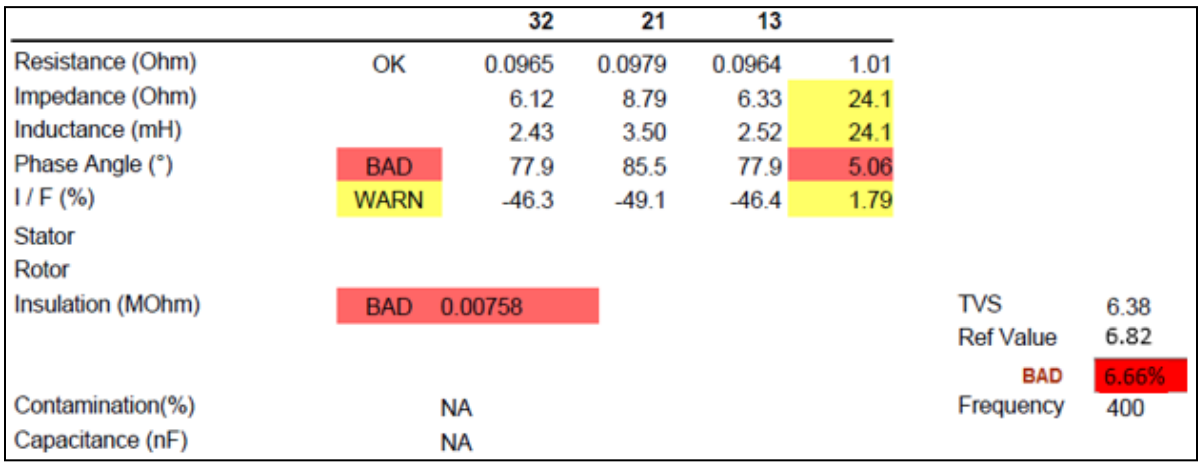


Reporting

The AT5™ instrument comes with the Motor Circuit Analysis (MCA) software. This allows users to produce reports and trend equipment over time. Below are sample reports from two AC traction motors of the exact same make and model.

			32	21	13			
Resistance (Ohm)	OK		0.0949	0.0947	0.0949	0.159		
Impedance (Ohm)			8.49	8.45	8.43	0.357		
Inductance (mH)			3.38	3.36	3.36	0.357		
Phase Angle (°)	OK		84.8	84.7	84.7	0.0600		
I / F (%)	OK		-49.0	-48.9	-48.9	0.0699		
Stator								
Rotor								
Insulation (MOhm)	OK	278					TVS Ref Value	6.82
Contamination(%)	OK	1.49%					Frequency	400
Capacitance (nF)		52.9						

A known good AC traction motor report using the Z/Fi test mode.



		32	21	13			
Resistance (Ohm)	OK	0.0965	0.0979	0.0964	1.01		
Impedance (Ohm)		6.12	8.79	6.33	24.1		
Inductance (mH)		2.43	3.50	2.52	24.1		
Phase Angle (°)	BAD	77.9	85.5	77.9	5.06		
I / F (%)	WARN	-46.3	-49.1	-46.4	1.79		
Stator							
Rotor							
Insulation (MOhm)	BAD	0.00758				TVS	6.38
						Ref Value	6.82
						BAD	6.66%
Contamination(%)		NA				Frequency	400
Capacitance (nF)		NA					

A bad AC Traction Motor report using the Z/Fi test mode indicates a fault described below.

Overview

The reports above illustrate the difference between a good and bad traction motor.

1. **Phase Angle (Fi)** is the amount of lag between the applied voltage and the resulting current in the basic motor circuit. Fi is used to detect winding faults in the motor circuit. Fi is usually one of the first measurements to change when the insulation system degrades (Winding Short). Unbalances of >1 degree from the average indicates a winding short. The Fi readings should be ≥ 15° and < 90°.
2. **Current Frequency Response (I/F)** Degraded winding insulation systems respond differently at different frequencies. The I/F measurement is an indication of winding system degradation. The I/F readings should be between -15 to -50. All I/F readings should be balanced within 2 digits (percent). Unbalances of >2 digits from the average indicates a winding short. A spread of >4 digits between maximum and minimum I/F measurements, also indicates winding faults. These readings are for non-compensated rotor position at the motor. However, if a winding fault is indicated additional testing may be necessary to verify the winding fault.
3. **Test Value Static (TVS)** Makes measurements on all three phases and calculates a “Test Value Static”, which when compared to a baseline “Reference Value Static”, becomes a powerful combined fault indicator for Rotor and Stator faults. The “Reference Value Static” is normally saved from the first time the motor is tested (a baseline test) or can be saved from a known good motor of the exact same motor type (manufacturer, model, manufacturing tolerances, etc.).
4. **Dynamic Test (Test Signature)** Measures, in real time during manual rotation. Several measurement values in the three phases together form the “Test Signature” for the rotor and stator. The “Test Signature” is then automatically analyzed in the AT5 and gives the user immediate results for the Stator and Rotor status. The “Test Signature” can also be uploaded to the MCA software and evaluated further.

5. **Insulation Resistance to Ground (IRG)** is the most common electrical test performed on electrical systems to test the insulations capability to withstand voltage. The IRG test is performed by applying a high DC voltage between de energized current-carrying conductors and the machine casing or Earth. A motor can have a good IRG reading but fail other phase-to-phase test methods discussed above.

Results

The test results indicate that the motor has failed because of an insulation resistance to ground fault (BAD insulation reading) and a stator winding fault visible by the unbalances of Fi, I/F, and TVS.

For more information visit our website www.alltestpro.com or email info@alltestpro.com.