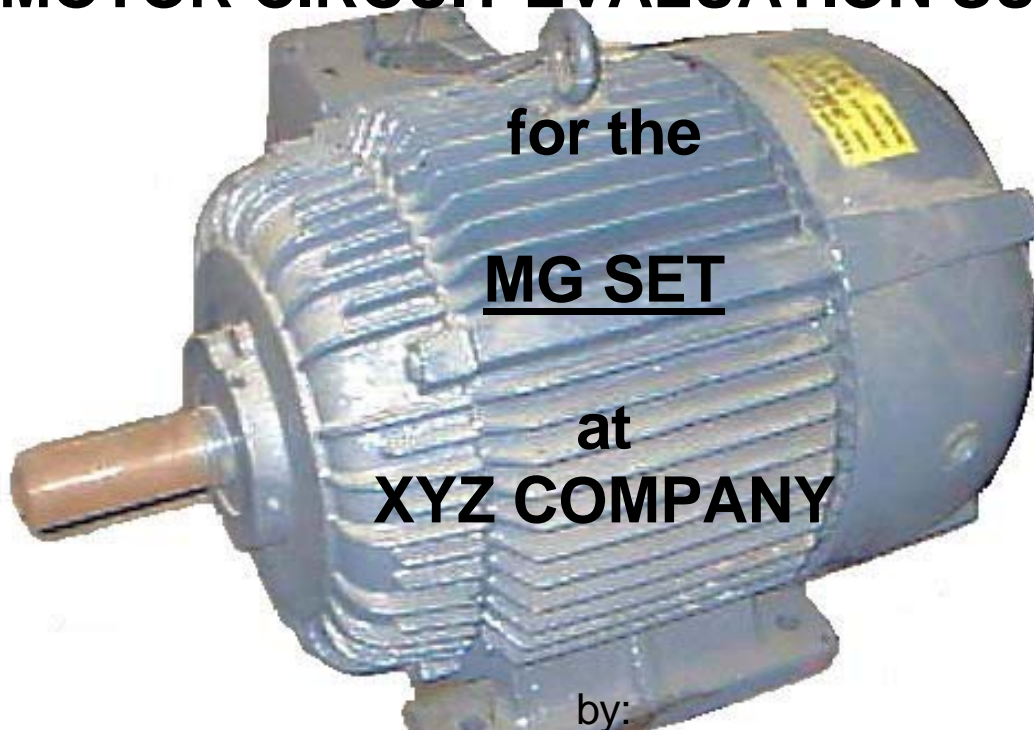


MOTOR CIRCUIT EVALUATION SURVEY



for the
MG SET
at
XYZ COMPANY

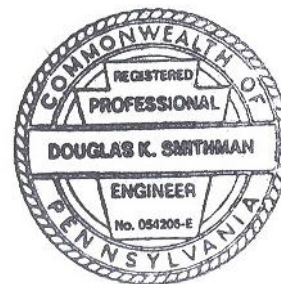
by:



Douglas K. Smithman, P.E.



September 21, 2008



- MG SET -

September 21, 2008

This is a report on the findings of a Motor Condition Evaluation (MCE) survey of the MG Set at XYZ Company. The table below summarizes the individual machines tested, their condition and any recommendations as a result of this survey. Those with exceptions are color coded to denote the severity of the exception.

high priority
medium priority
low priority

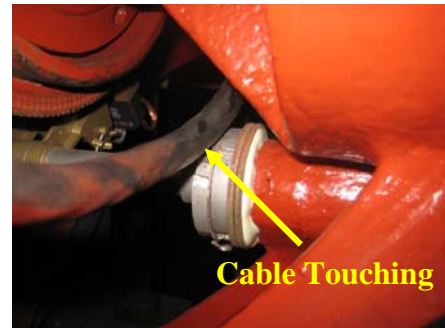
<u>MACHINE</u>	<u>CONCERN</u>	<u>RECOMMENDATIONS</u>
ISG-201 ⁽¹⁾ RM Vertical Edger-Right Adjust Generator	Low insulation resistance has been found in several circuits with the interpoles in alarm. (See note 1)	All components appear to have been rewound so the repair facility should be contacted as to final tests and rewind methods and procedures.
ISG-202 RM Vertical Edger-Left Adjust Generator	The PI curve has had a negative slope but it is becoming more pronounced. However, the overall insulation resistance is still high.	Continue to monitor the insulation resistance and wipe down exposed surfaces and conductors periodically.
ISG-203 RM Back Edger Feed Rolls Generator	None.	None.
ISG-204 350 HP Induction Motor	None.	None.
ISG-205 Spare Generator	None.	None.
ISG-206 RM Back Turntable – Far Generator	None.	None.
ISG-207 RM Back Turntable – Near Generator	None.	None.

Notes:

1. Low megger reading was isolated to the interpoles. The armature and series field were not in alarm but still on the low side for what appeared to be a freshly rewound generator.

<u>Circuit</u>	<u>Raw Megger</u>	<u>Corrected to 40°C</u>
Armature	22.4 MΩ	4.3 MΩ
Interpoles	3.3 MΩ	0.6 MΩ
Series Field	15.8 MΩ	3.0 MΩ
A1 Lead	1400 MΩ	266 MΩ
S2 Lead	2000 MΩ +	380 MΩ +

2. The RM Vertical Adjust Generator also has 2 of the brush arm inter-connection leads with no cable ties and touching other arms. These leads will be prone to rubbing and insulation failure. The problem could be solved by rotating the clamps on the brush studs to pull the cables a bit tighter.



Please find the following reports attached.

1. MCE MOTOR CONDITION SUMMARY – ‘OVR(MCE)’ in the insulation resistance category means that the measurement exceeds the upper limit of the MCE tester; 2,000MΩ - uncorrected.
2. MCE POLARIZATION INDEX AND DIELECTRIC ABSORPTION SUMMARY – If a field in blank or ‘N/C’, this indicates that the PI or DA ratio could not be calculated. This occurs when one or both of the values exceed the measurable scale of the MCE tester, 3,500 MΩ.
3. PI RAW DATA.

MCE Summary Report

Submitted By: D. K. Smithman, P.E.

Description: Aux MG #2

Date: 09/21/2008

Test Date	Resistance to Ground	Capacitance to Ground	Resistance or Resistive Imbalance	Inductance or Inductive Imbalance	Motor Condition
Motor ID 201 Right Edger Adjust					
Motor Section DC Armature					
9/21/2008 9:15:23 AM	0.6 Mohm	34000 pF	0.0765 Ohms	1.055 mH	Caution
Motor Section DC Field					
9/21/2008 10:43:55 AM	27.4 Mohm	7750 pF	2.186 Ohms	416.5 mH	Caution
Motor ID 202 Left Edger Adjust					
Motor Section DC Armature					
9/21/2008 9:20:18 AM	8.8 Mohm	27750 pF	0.0595 Ohms	0.955 mH	Good
Motor Section DC Field					
9/21/2008 9:37:17 AM	OVR (MCE) Mohm	6000 pF	1.9696 Ohms	306 mH	Good
Motor ID 203 Back Edger Feed Rolls					
Motor Section DC Armature					
9/21/2008 8:44:33 AM	OVR (MCE) Mohm	26500 pF	0.0845 Ohms	1.005 mH	Good
Motor Section DC Field					
9/21/2008 8:58:26 AM	OVR (MCE) Mohm	6000 pF	2.018 Ohms	395.5 mH	Good

Test Date	Resistance to Ground	Capacitance to Ground	Resistance or Resistive Imbalance	Inductance or Inductive Imbalance	Motor Condition
Motor ID 204 #2 Aux MG Set Motor					
Motor Section Stator					
9/21/2008 8:28:57 AM	4.5 Mohm	44250 pF	0.19%	0.5%	Good
Motor ID 205 Spare					
Motor Section DC Armature					
9/21/2008 7:38:33 AM	244 Mohm	23000 pF	0.07 Ohms	0.985 mH	Good
Motor Section DC Field					
9/21/2008 8:07:27 AM	OVR (MCE) Mohm	4000 pF	1.9488 Ohms	459.5 mH	Good
Motor ID 206 RM Back Turntable-Far					
Motor Section DC Armature					
9/21/2008 9:52:10 AM	OVR (MCE) Mohm	20000 pF	0.1135 Ohms	2.42 mH	Good
Motor Section DC Field					
9/21/2008 10:06:08 AM	OVR (MCE) Mohm	7000 pF	11.889 Ohms	1290 mH	Good
Motor ID 207 RM Back Turntable-Near					
Motor Section DC Armature					
9/21/2008 10:26:07 AM	OVR (MCE) Mohm	23500 pF	0.1575 Ohms	2.335 mH	Good
Motor Section DC Field					
9/21/2008 10:28:49 AM	OVR (MCE) Mohm	8000 pF	12.882 Ohms	1392 mH	Good

MCE Polarization Index and Dielectric Absorption Summary Report

Submitted By: D. K. Smithman, P.E.

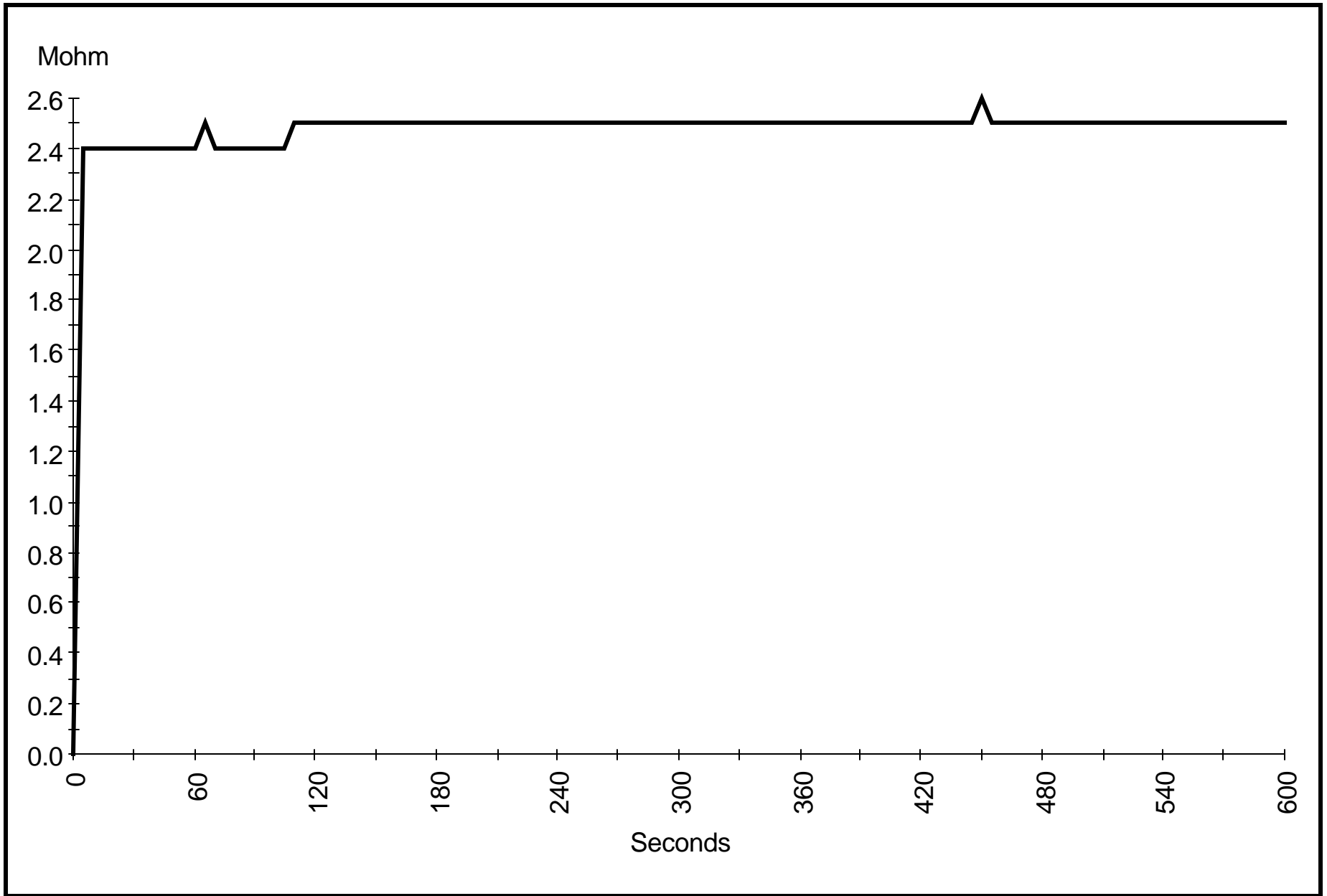
Description: Aux MG #2

Date: 09/21/2008

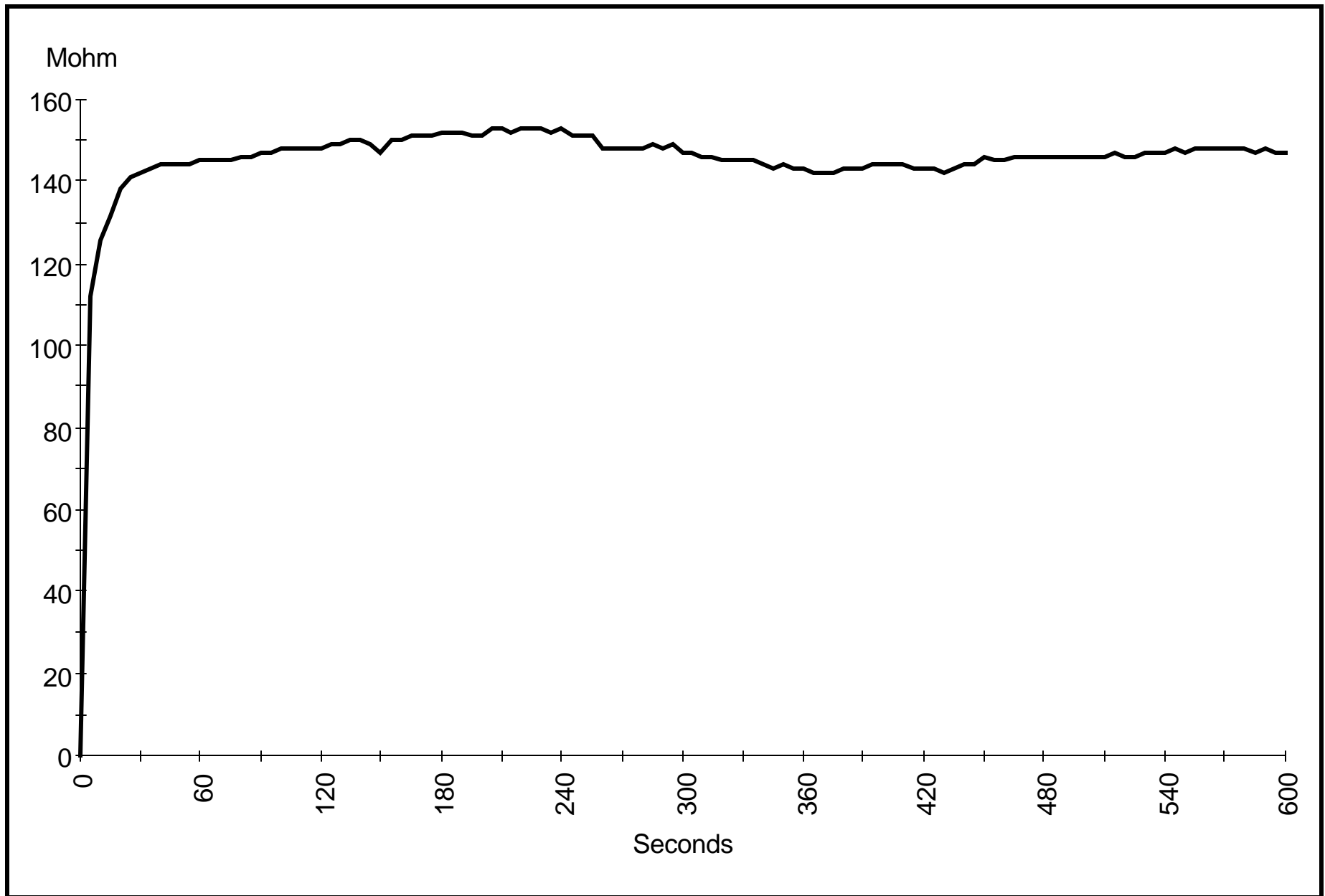
Motor Section	PI Baseline Date	Baseline Voltage	Last Test Date	Last Test Type	Result	Test Voltage	User
Location Name MCEVAM-Conshohocken#2 Aux MG							
Motor ID 201 Right Edger Adjust							
DC Armature	9/21/2008 11:25:35 AM	500	9/21/2008 11:25:35 AM	PI	1.04	500	
DC Field	9/21/2008 10:54:43 AM	500	9/21/2008 10:54:43 AM	PI	1.01	500	
Motor ID 202 Left Edger Adjust							
DC Armature	4/3/2005 8:26:12 AM	500	9/21/2008 9:30:50 AM	PI	0.75	500	
DC Field	4/3/2005 8:40:31 AM	500	9/21/2008 9:48:05 AM	PI	1	500	
Motor ID 203 Back Edger Feed Rolls							
DC Armature	3/8/2004 11:07:53 AM	500	9/21/2008 8:55:22 AM	PI	1.03	500	
DC Field	3/8/2004 11:21:35 AM	500	9/21/2008 9:11:31 AM	PI	1	500	
Motor ID 204 #2 Aux MG Set Motor							
Stator	3/23/2008 6:52:38 AM	500	9/21/2008 8:39:31 AM	PI	0.9	500	
Motor ID 205 Spare							
DC Armature	3/8/2004 12:37:10 PM	500	9/21/2008 8:02:40 AM	PI	1.42	500	

Motor Section	PI Baseline Date	Baseline Voltage	Last Test Date	Last Test Type	Result	Test Voltage	User
DC Field	3/8/2004 11:59:36 AM	500	9/21/2008 8:17:57 AM	PI	1	500	
Motor ID	206 RM Back Turntable-Far						
DC Armature	3/23/2008 8:41:50 AM	500	9/21/2008 10:03:23 AM	PI	1	500	
DC Field	3/23/2008 8:55:29 AM	500	9/21/2008 10:16:44 AM	PI	1	500	
Motor ID	207 RM Back Turntable-Near						
DC Armature	3/8/2004 10:09:42 AM	500	3/23/2008 9:09:47 AM	PI	1	500	
DC Field	3/8/2004 10:25:13 AM	500	9/21/2008 10:39:36 AM	PI	1	500	

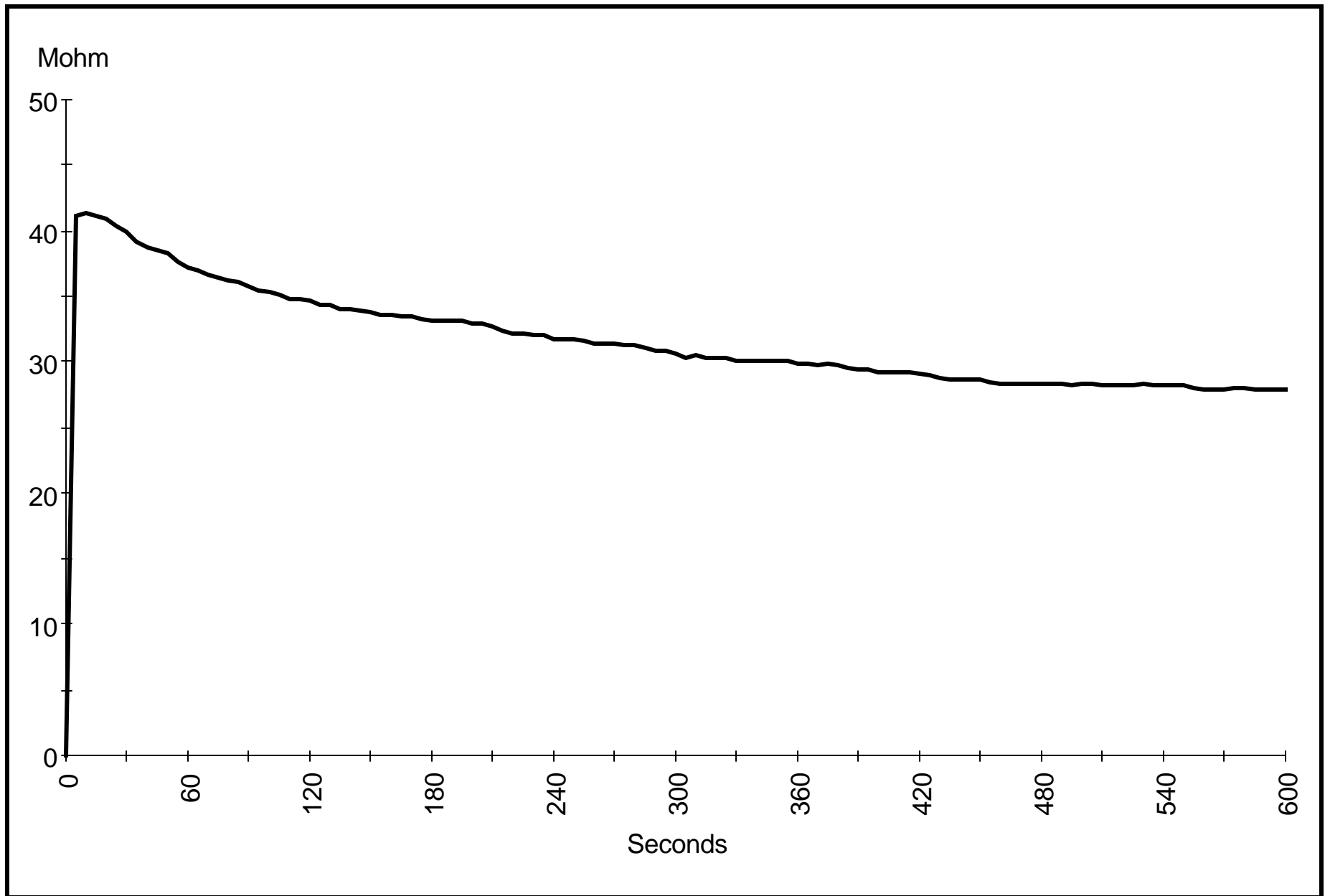
PI Test (201 Right Edger Adjust - DC Armature) 09/21/2008 11:25:35 AM

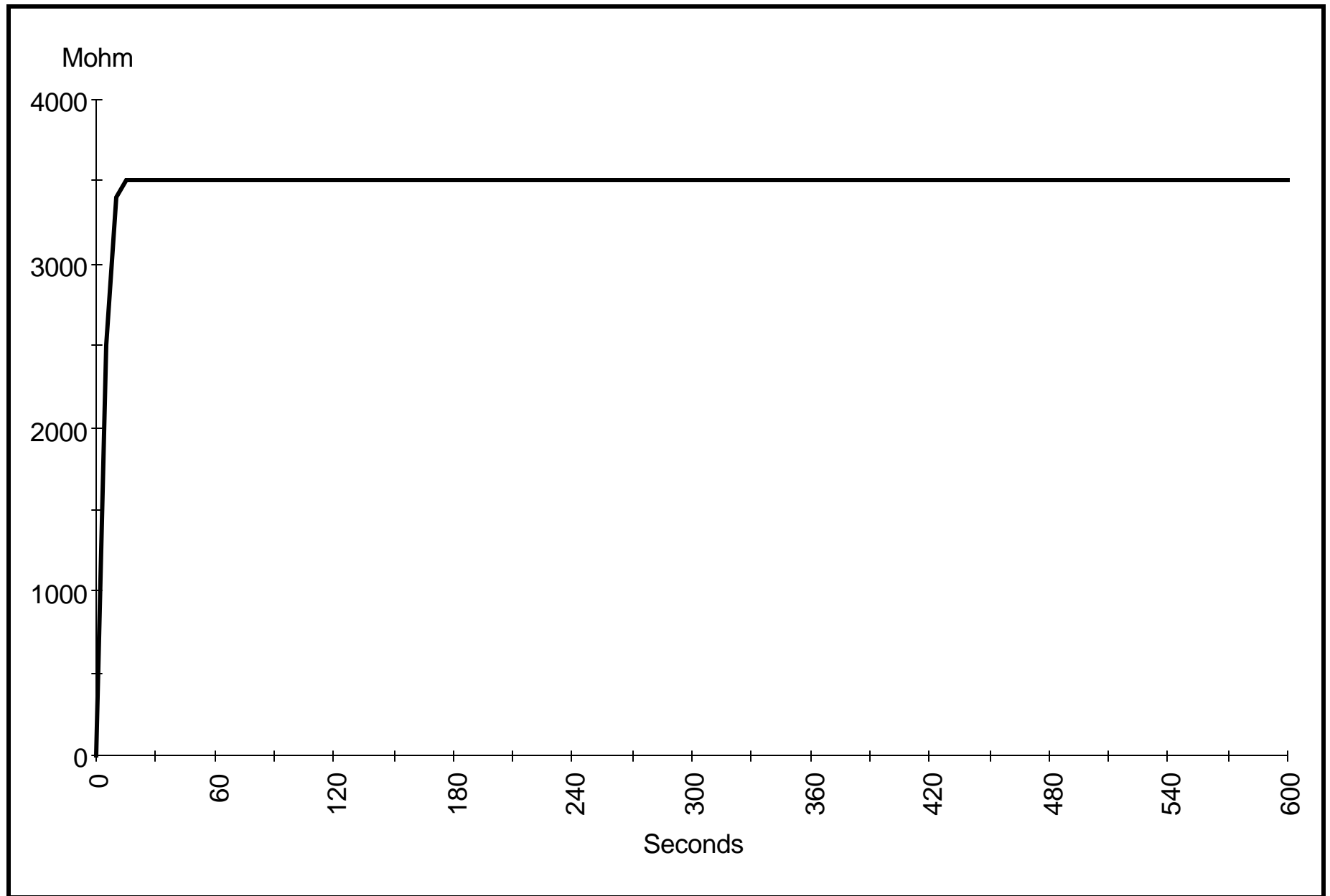


PI Test (201 Right Edger Adjust - DC Field) 09/21/2008 10:54:43 AM

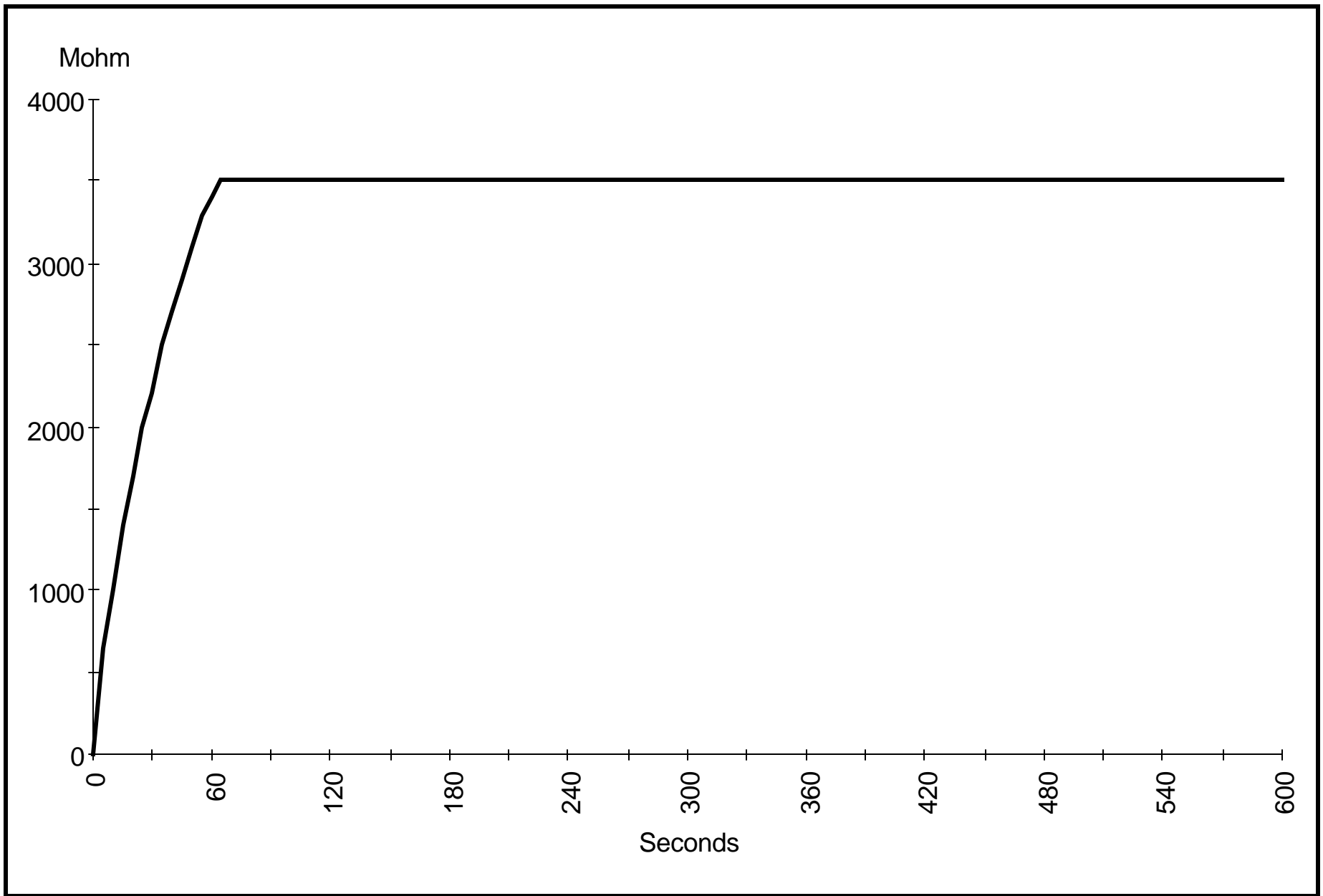


PI Test (202 Left Edger Adjust - DC Armature) 09/21/2008 09:30:50 AM

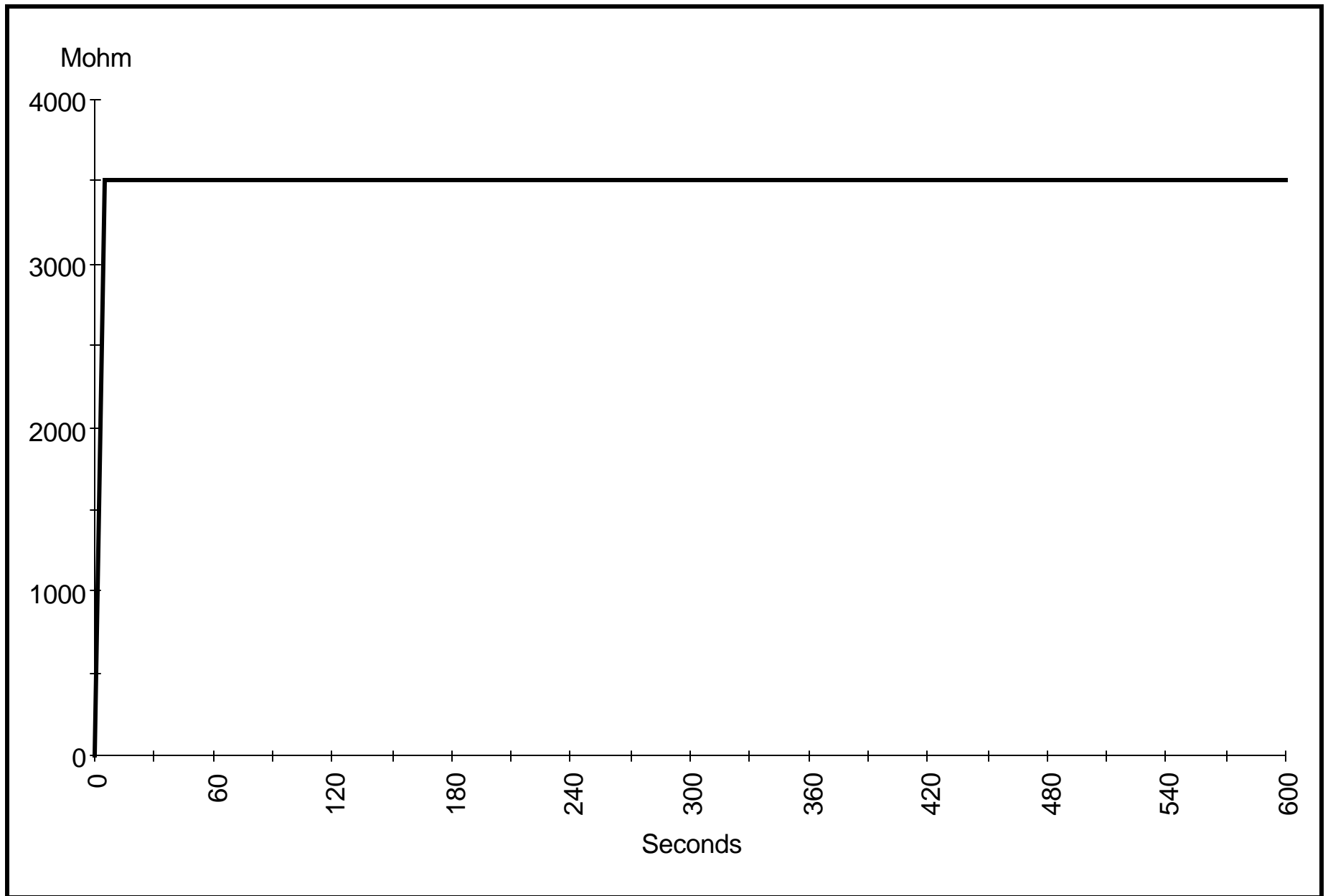




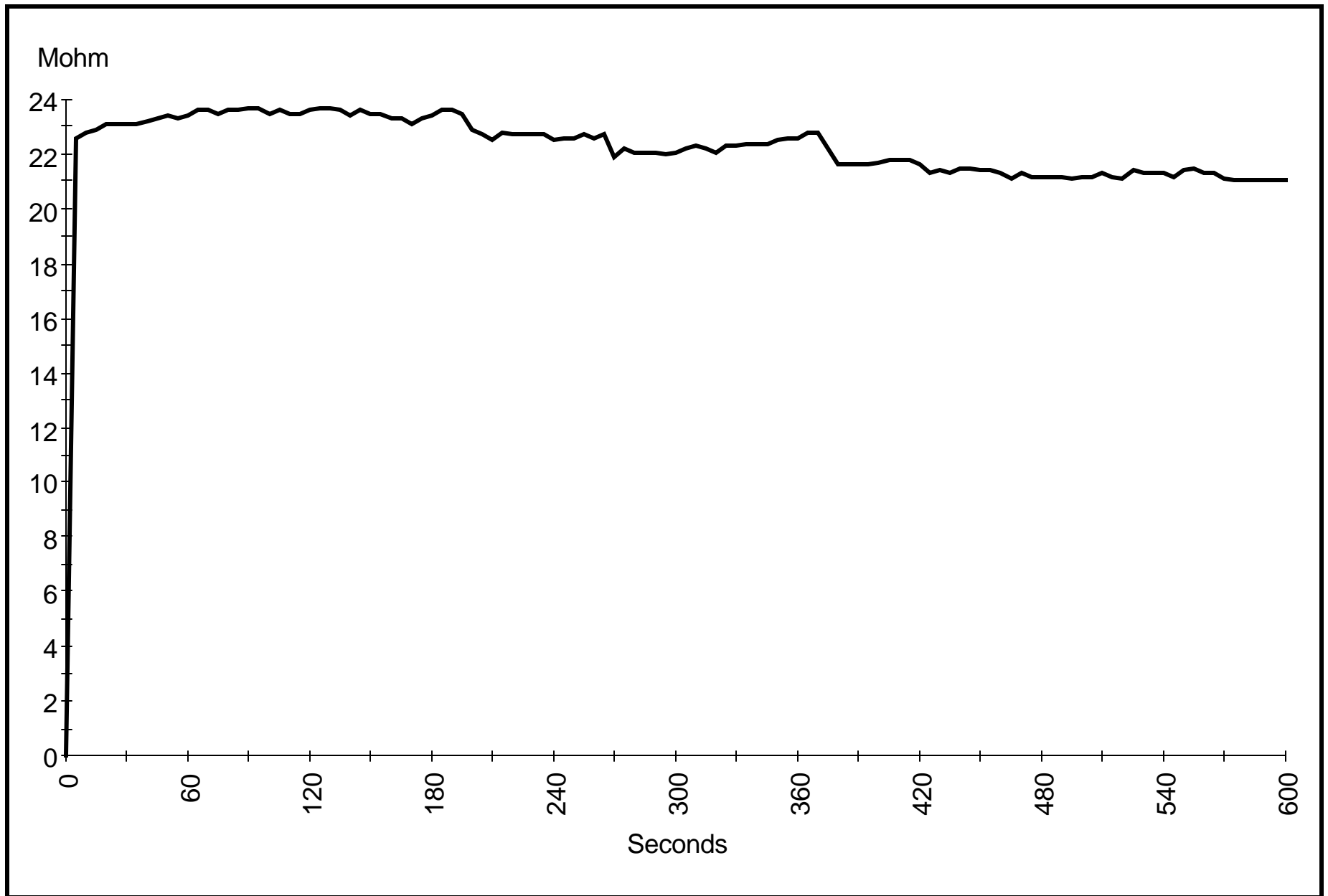
PI Test (203 Back Edger Feed Rolls - DC Armature) 09/21/2008 08:55:22 AM



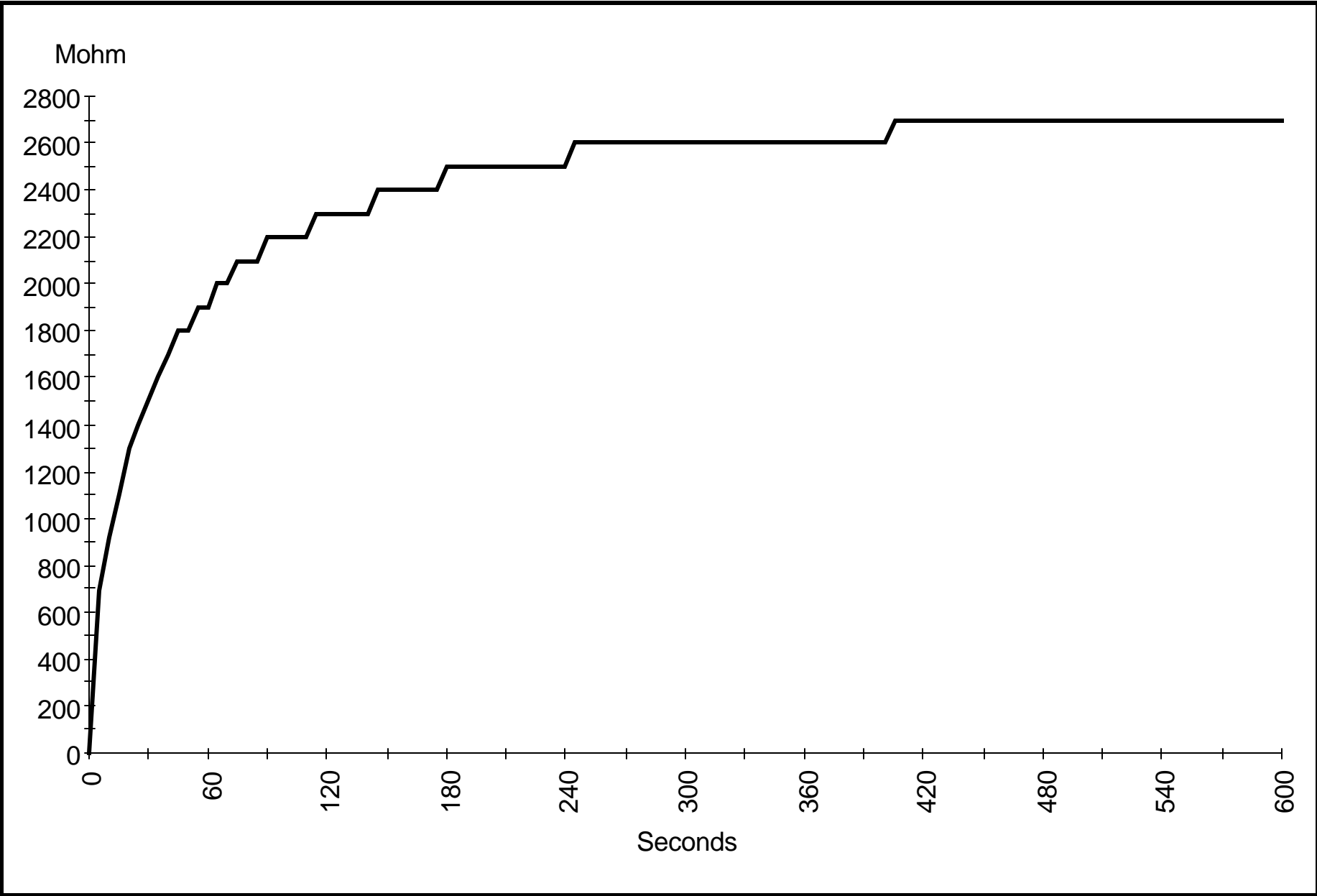
PI Test (203 Back Edger Feed Rolls - DC Field) 09/21/2008 09:11:31 AM



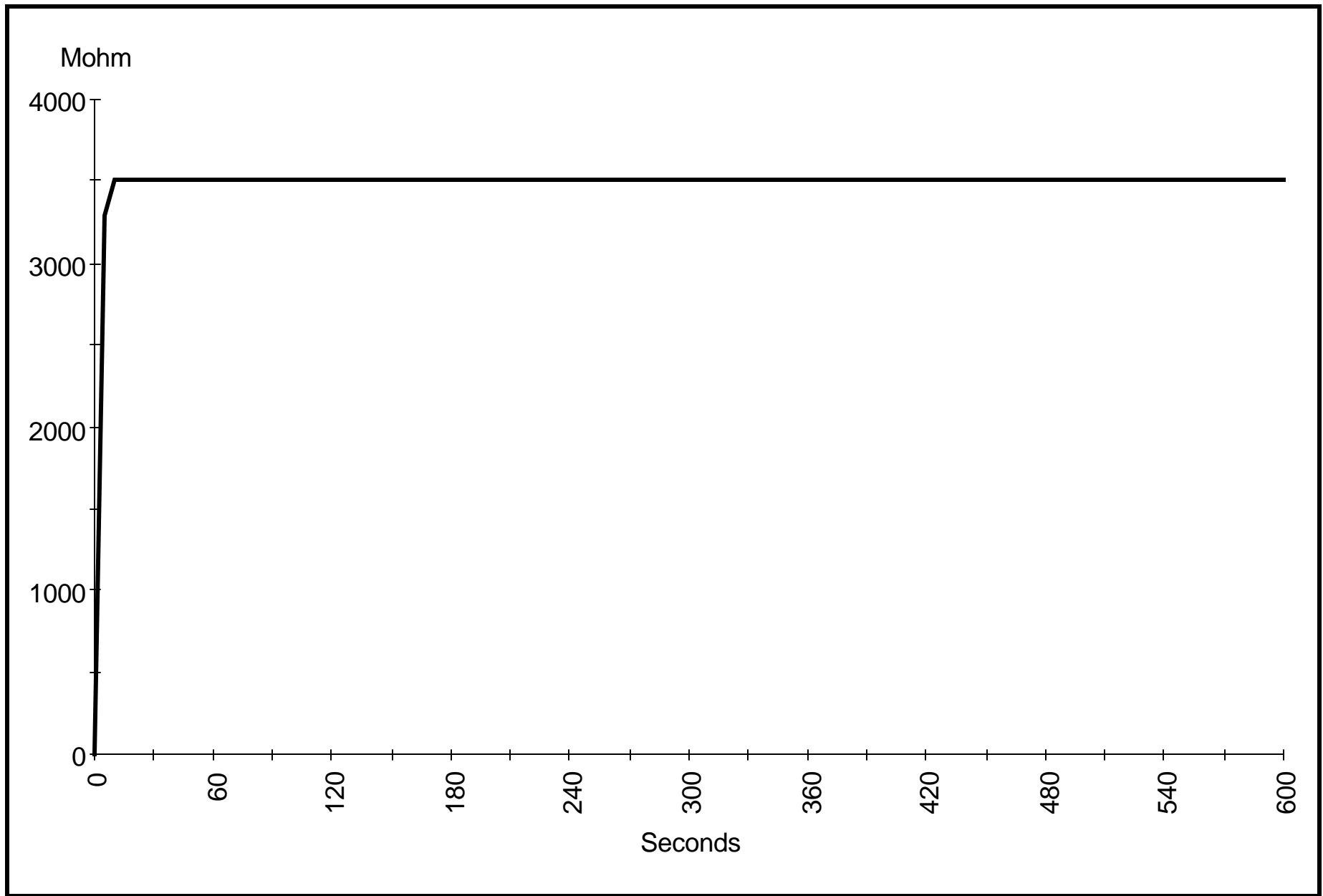
PI Test (204 #2 Aux MG Set Motor - Stator) 09/21/2008 08:39:31 AM

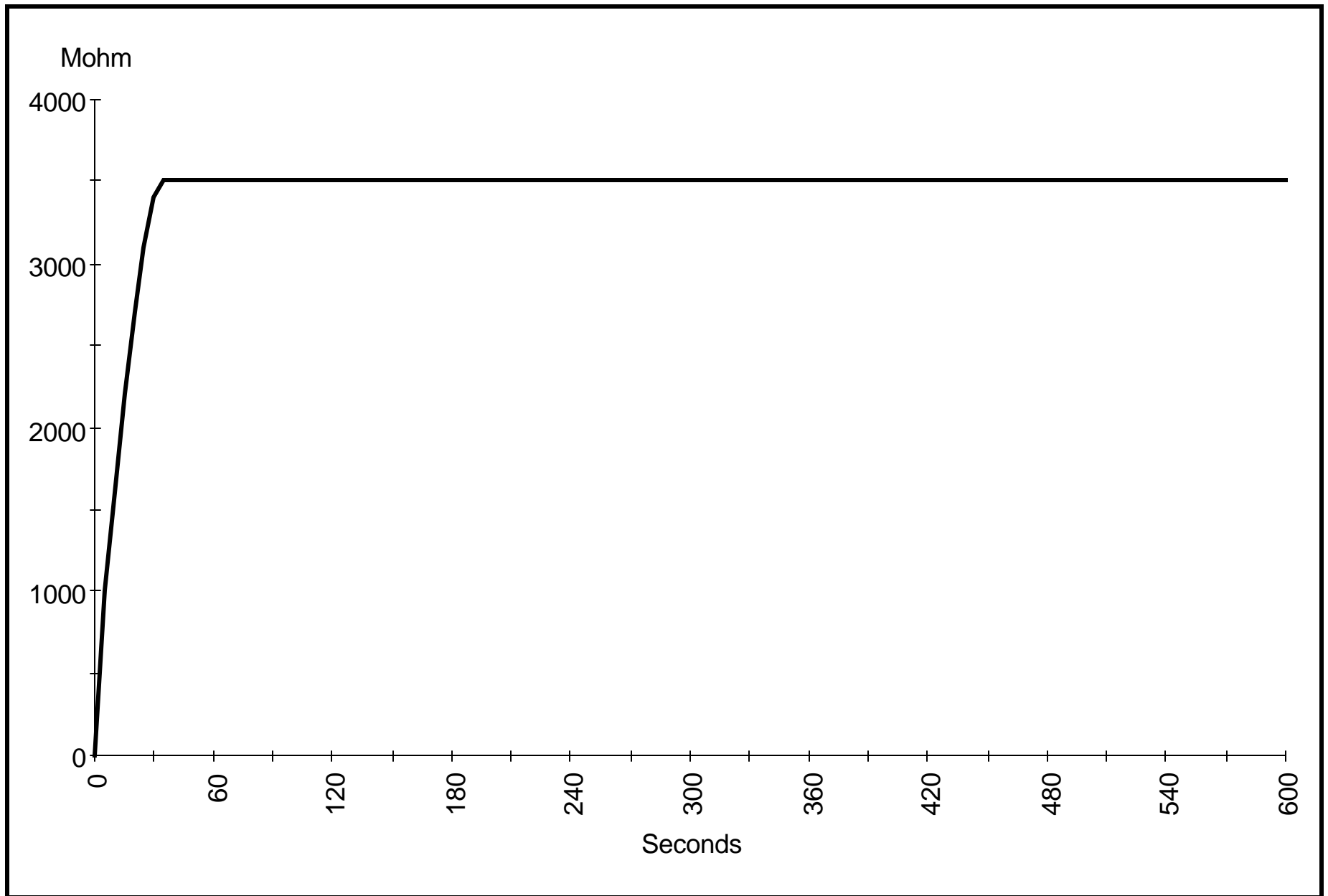


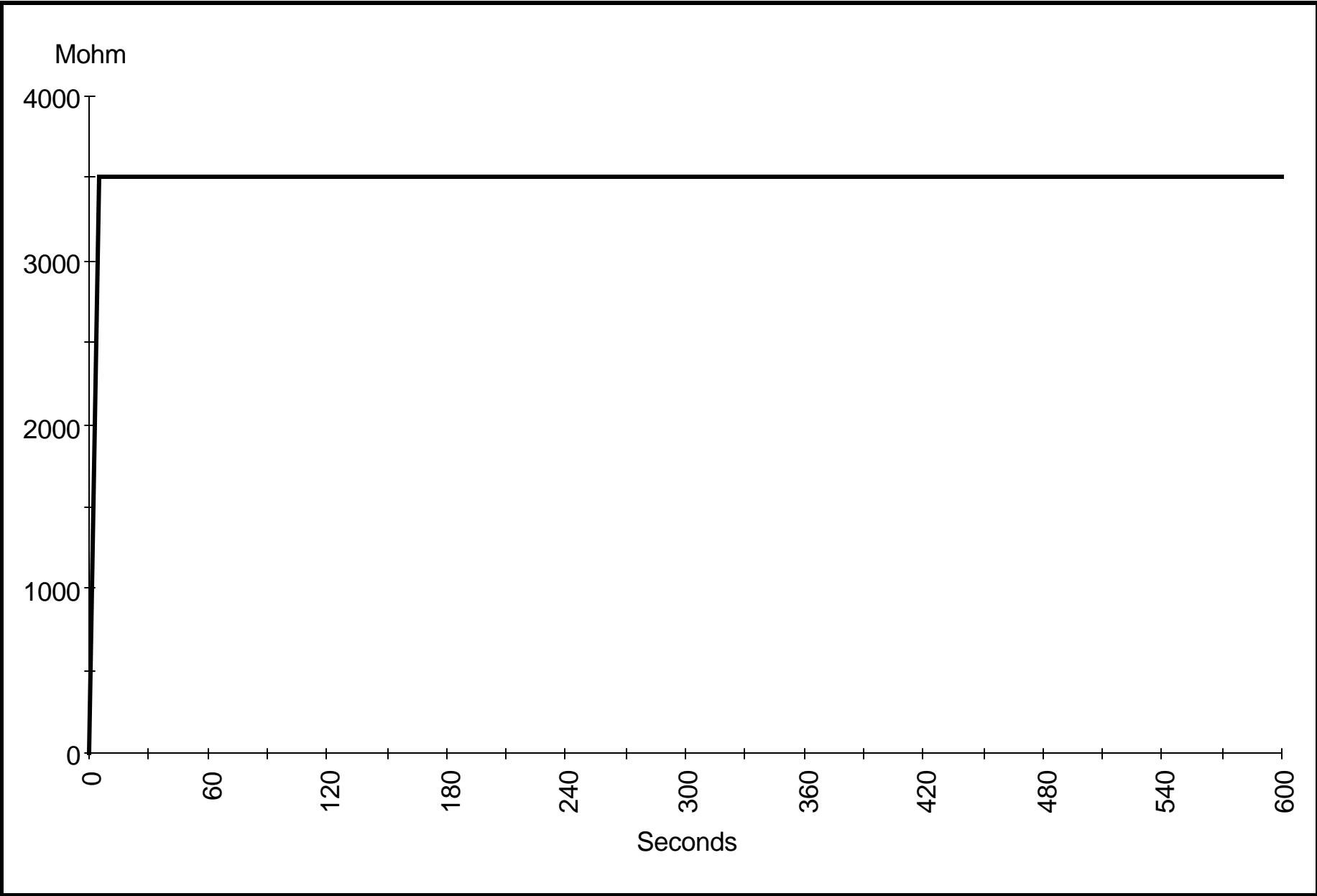
PI Test (205 Spare - DC Armature) 09/21/2008 08:02:40 AM

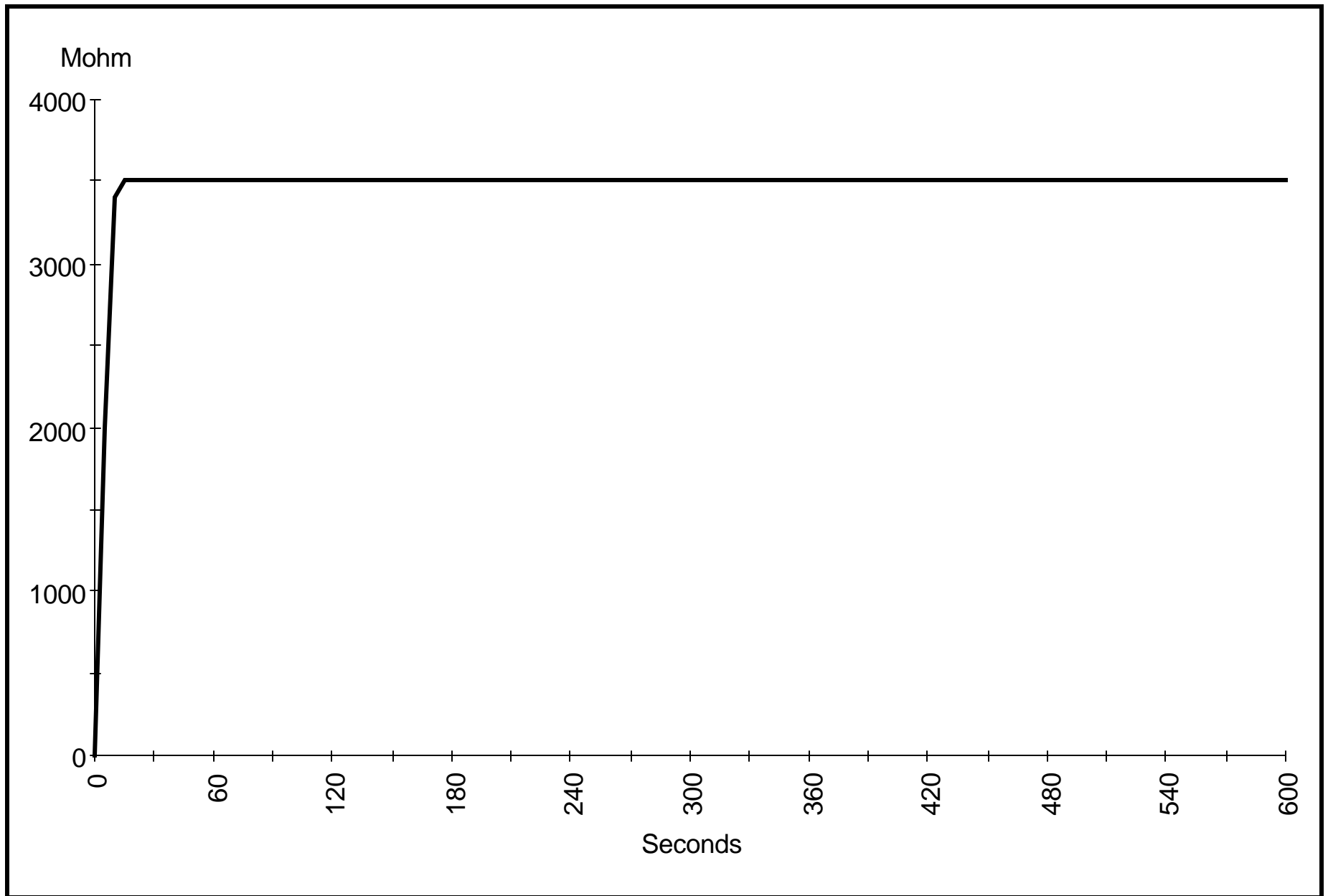


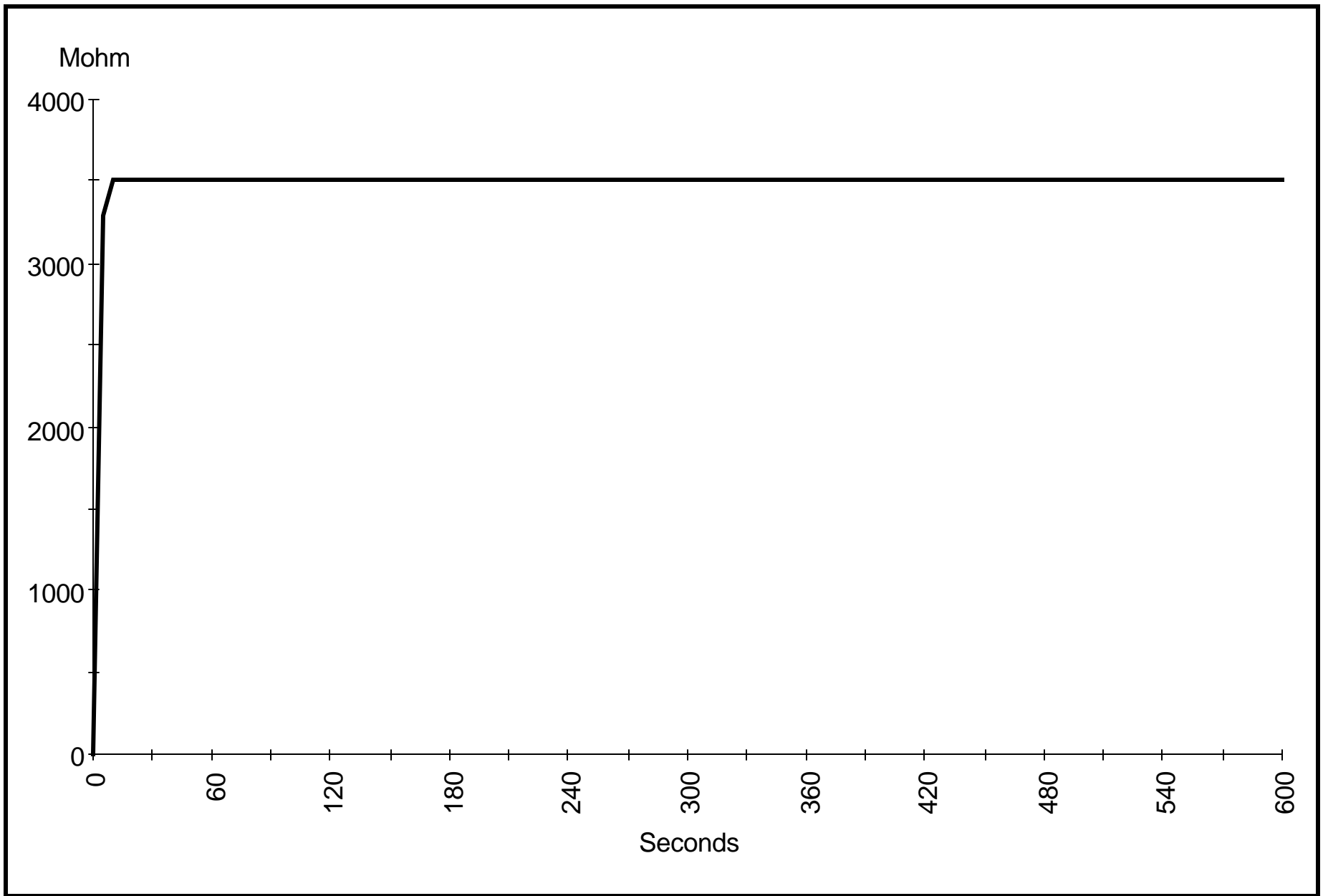
PI Test (205 Spare - DC Field) 09/21/2008 08:17:57 AM











MOTOR CIRCUIT EVALUATION SURVEYS

This report documents the findings of a Motor Circuit Evaluation (MCE) survey. This survey was conducted using an MCE tester. MCE testers measure several physical parameters of electrical circuits in a highly accurate and repeatable fashion. This results in a quantum increase in measurement quality over conventional ‘megger’ testing. The quality of the data makes it possible to trend each of the measured parameters over time to spot deteriorating conditions long before they interfere with circuit operation.

Parameters measured in the standard test are:

1. Resistance to ground (temperature corrected)
2. Capacitance to ground
3. Circuit resistance (temperature corrected) or resistive imbalance
4. Circuit inductance or inductive imbalance

In addition to the standard test, the customer may choose to include Polarization Index testing and/or Rotor Influence Coefficient testing. Polarization Index testing provides a valuable second opinion to insulation health. IEEE 43-2000 notes:

9.4 Machines rated at 10 000 kVA and less, to be considered in suitable condition for operation or for over potential tests, should have either a value of the polarization index or a value of the insulation resistance (at 40 °C) at least as large as the recommended values.

9.5 Machines rated above 10 000 kVA should have both the polarization index and insulation resistance above the minimum values.

Rotor Influence Coefficient testing is not an IEEE specified test, however it does provide valuable insight into the condition of induction, synchronous and wound-rotor motors.

MEASUREMENT METHOD

The circuit temperature is measured and entered into the MCE to be used for temperature correction. Temperature correction removes the ‘apples and oranges’ comparisons common in insulation measurement programs. The relationship between insulation resistance and temperature is approximately two-to-one for every 10°C change in temperature. This makes trending of uncorrected data virtually meaningless. It also precludes comparison with IEEE and other published minimum levels.

The attention to quality measurements continues with the connections to the circuit being tested. Each measurement clip actually contains to legs of a circuit, one attached to each side of the clip. When testing is initiated, resistance through the entire circuit on each measurement lead is measured. If the resistance is greater than 1 Ω , the test is terminated until the connection is corrected. This ensures that rust, surface dirt or other connection errors do not contaminate the values being measured.

Upon completion of the test, the lead resistances are re-checked to ensure that they haven't come loose during the test. If they have, the test is automatically aborted.

The test results are compared against alarm values during the test. This allows the operator to make an immediate assessment of anomalous conditions and to re-test or perform further investigations as needed. The alarm levels are either absolutes or historical averages or both.

Upon completion of a test, the values are archived for reporting and future reference.

RESISTANCE-TO-GROUND TESTS

Resistance-to-ground tests, commonly known as 'Megger' tests, are done to evaluate the condition of insulation systems. MCE resistance-to-ground testing is a temperature compensated megger test. Insulation resistance values are extremely sensitive to winding temperature. As noted earlier, this sensitivity results in approximately a two-to-one error for every 10 °C in temperature change. By mathematically compensating for winding temperature, MCE eliminates this error automatically. IEEE43-2000 recommendations for test voltage and minimum insulation resistance are shown below.

Guidelines For Test Voltages

<u>Winding Rated Voltage</u>	<u>Insulation Resistance Test Direct Voltage</u>
<1,000	500
1,000-2,500	500-1,000
2,501-5,000	1,000-2,500
5,001-12,000	2,500-5,000
>12,000	5,000-10,000

Minimum Insulation Resistance Values, Corrected to 40°C

Resistance values are in MΩ	
$IR_{1 \min} = kV+1$	For most windings made before about 1970, all field windings, and others not described below.
$IR_{1 \min} = 100$	For most DC armature and AC windings built after 1970 (form wound coils).
$IR_{1 \min} = 5$	For most machines with random wound stator coils and form wound coils rated below 1kV.

CAPACITANCE-TO-GROUND TESTS

Resistance-to-ground testing and PI measurement are time proven methods of determining insulation health and quality. However, changes in capacitance-to-ground provide another good indicator of contaminant build-up. This measurement provides a 'second opinion' of sorts and improves the level of confidence in decision-making based on these tests. Standard practice is to increase monitoring frequency for changes of more than 10% from a statistical baseline and schedule a cleaning for changes greater than 100%. Also, a very high (>999,999 pF) value combined with a 0.00 value of resistance-to-ground, is an indication of a 'hard' ground, as opposed to carbon tracking or generally deteriorated insulation. This is important in floating systems such as DC power circuits and is a strong indicator that immediate action is required.

A point of confusion sometimes arises when we state that a high capacitance indicates poor insulation. This is easily explained by the mathematical definition of capacitance in an alternating circuit;

$$C = \frac{i}{de/dt}$$

This shows that capacitance equals the charging current divided by the rate of potential change. It also shows that for a given potential change, de/dt , capacitance and current are proportional. Since the highest current exists in a grounded situation, this also produces the greatest capacitance. Please keep in mind that this explanation neglects inductive and resistive affects in alternating circuits.

RESISTANCE AND INDUCTANCE TESTS

Insulation to ground failures are certainly a major cause of motor failures; however they are not the only cause. Coils and circuits can also fail when the insulation between the windings fails or when conductors themselves fail. Magnetic circuit components such as laminations, air gap and amortisseur windings can also fail. Measuring and trending resistance and inductance can often provide early warnings of pending problems before they result in overheating and catastrophic failure. Used together, these parameters reinforce conclusions and provide a higher level of confidence in results than either measurement would by itself. Standard practice is to increase monitoring frequency for resistance changes of more than 3% from a statistical baseline and to inspect for defects for changes greater than 5%. For inductance measurements, the limits are 8% and 15%, respectively.

POLARIZATION INDEX TESTS

An additional property of insulation that has a significant effect on its quality is how it builds up a charge. In a good, clean insulation system, the resistance-to-ground value will continue to rise while voltage is applied and the insulation polarizes. However, if significant amounts of water, dirt, or oil are present, the resistance-to-ground will hold steady or even drop over time. The polarization index (PI) is a good method of measuring the cleanliness of an insulation system. It is the ratio of the ten-minute resistance-to-ground measurement to the one-minute measurement. IEEE 43-2000, paragraph 9.2 recommends a PI of 2.0 or better for Class B or Class F insulation systems, which covers most modern motors. Paragraph 4.3.5 notes that temperature

correction is not required for PI calculation. This is because PI is a ratio and the temperature corrections cancel out mathematically.

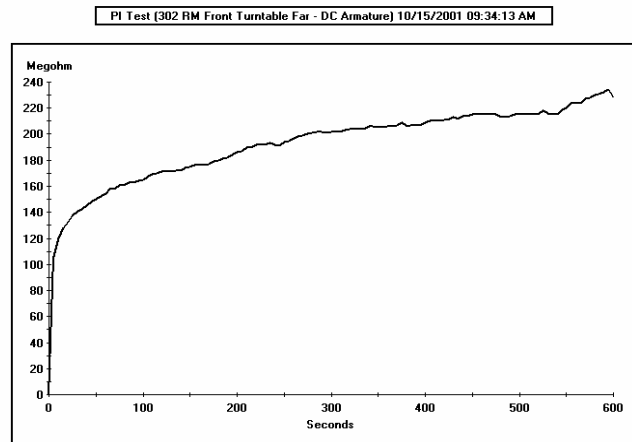
IEEE43-2000 minimums for PI are shown below.

Recommended Minimum PI Values

Note: If the one-minute insulation resistance value is above 5,000 MΩ the
calculated PI may not be meaningful

<u>Thermal Class Rating</u>	<u>Minimum PI</u>
Class A	1.5
Class B	2.0
Class F	2.0
Class H	2.0

Plots of the data recorded during a PI test, called PI profiles, are also insightful. An ideal profile will rise quickly at first and then at a slower rate through the entire test. Leveling off or dropping values often indicate marginal insulation or contamination build-up. Also, a jittery profile indicates partial discharging is taking place, that is, the voltage builds to a high enough potential to partially discharge, does so and builds up again. This cyclical discharging may take place at the same potential or at increasing potentials as the insulation gradually polarizes.



ROTOR INFLUENCE COEFFICIENT TESTS

The Rotor Influence Coefficient (RIC) test is designed to find faults in the rotor and air gap in induction motors. It will also identify loose connections. Phase-to-phase inductance is measured every five electrical degrees as the rotor is manually rotated through 90 degrees. For a perfect rotor, this data will produce three offset sine waves. Faults will be shown by spikes, skewing and baseline offsets of the data.

