SCHULZ ELECTRIC
POWER SYSTEMS BY TIMKEN

Motor Insulation System Environmental Qualification Process for Harsh Environment Applications in Nuclear Power Plants

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May 20-23, 2019

EQUIPMENT QUALIFICATION IN NUCLEAR INSTALLATIONS MEETING

Prague, Czech Republic

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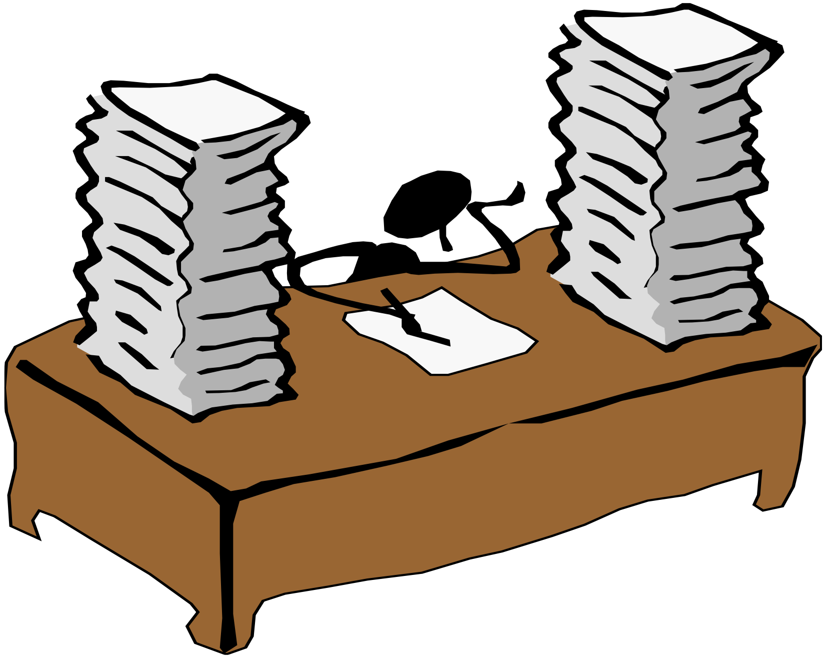
Presentation Key Topics

- Historical Overview of U.S. Nuclear EQ
- Key Concepts of EQ
- Motor Insulation Systems Design and Materials
- Motor Insulation Systems Thermal Endurance Testing
- Environmental Qualification of Motor Insulation Systems
- Lessons Learned Environmental Qualification of Motor Insulation Systems
- Overview of Schulz Electric

By Design.

U.S. Nuclear Qualification Regulations, Codes & Standards

- More Than 50 Requirements Documents Applicable to EQ
- Includes USNRC Codes & Regulations and Industry Codes, Standards, Guides and Recommended Practices

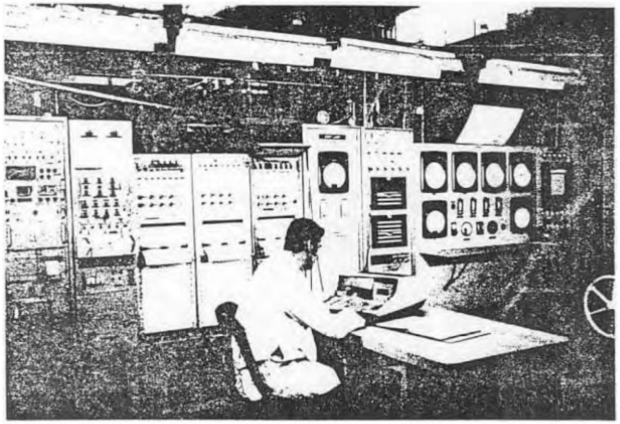


Background & History

- Between 1967 and 1974 Criteria of IEEE 279-1968, IEEE 323-1971 and GDC 4 were Developed
- IEEE-279-1967 Required that either Type Test Data or "Reasonable" Extrapolations based on Test Data Be Available to Demonstrate EQ for Reactor Protection Systems
- IEEE 323-1971 Provided More Specific Requirements
- During this Time, Other "Daughter" Standards were being Developed:
  - IEEE 344-1971, Seismic Qualification of Equipment
  - IEEE 317-1971, Qualification of Containment Penetrations
  - IEEE 334-1971, Qualification of Motors
  - IEEE 382-1972, Qualification of Valve Actuators

Background & History

- Industry EQ Testing Began in late 1960's
- Limitorque ® Corp. Performed First LOCA Test of MOV Actuators in 1968
- Blodget & Fisher Reported on Tests of Generic Cable Insulation Materials in 1969
- These Early Test Programs Focused Only on In-Containment Qualification in Response to a LOCA
- Early Test Programs Did not Include Aging Simulations Prior to Accident Test



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Background & History

- After 1974 the Criteria of 323-1974 and a Number of Daughter Standards formed the Basis for EQ
- Since then, the Fundamental Principles of EQ have Largely Remained Unchanged
- Research Results, the State of the Art, General Level of Knowledge & Sophistication have Changed Dramatically
- Process Continues to be Refined Today

U.S. Nuclear Qualification Regulations, Codes & Standards Historical Perspective

- Prior to 1971
  - Qualification Based Upon Existing Industrial Equipment Standards (IEEE, UL, NEMA)
- 1971 - 1979
  - Qualification Based Upon Evolving Nuclear Industry Specific Standards
    - IEEE 323-1971 (General EQ)
    - IEEE 323-1974 (General EQ)
    - IEEE 334-1974 (Motors)
    - IEEE 344-1975 (Seismic)
    - IEEE 383-1974 (Cables)
    - NUREG-0588
    - IEN 78-08
    - IEN 79-01 (IEN 79-01A, IEN 79-01B)
    - DOR Guidelines

U.S. Nuclear Qualification Regulations, Codes & Standards Historical Perspective

- 1980 to 2000
  - Refinement of Standards, Regulations and Guidelines
    - IEEE 323-1983
    - IEEE 344-1987
    - IEEE 334-1994
    - Numerous EPRI Documents
    - Digital Equipment Qualification Standards
    - Commercial Grade Item Dedication Standards

U.S. Nuclear Qualification Regulations, Codes & Standards Historical Perspective

- 2000 to Present
  - Continuous Refinement of Standards, Regulations and Guidelines Including IEC/IEEE Dual Logo
    - IEEE 323-2003 (General EQ)
    - IEEE 60780-323-2016 - IEC/IEEE International Standard - Nuclear facilities -- Electrical equipment important to safety – Qualification
    - IEEE 344-2004/2013/P60980-344 (Seismic)
    - IEEE 334-2006 (Motors - PAR Approved March 2019)
    - IEEE 383-2003/2015 (Cables)
    - Numerous EPRI Documents
    - Digital Equipment Qualification Standards
    - Commercial Grade Item Dedication Standards

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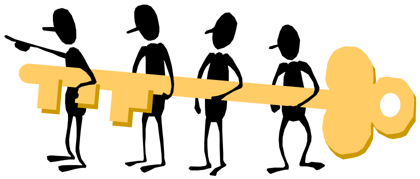
U.S. Nuclear Industry EQ Drivers USNRC/Regulatory

Document	Title	Reg. Guide	Comment
IEEE-323, 1974	Trial Use Standard General Guide for Qualifying Class 1E Equipment for Nuclear Power Generating Stations	1.89, Nov. 1974	Endorsed IEEE 323-1974 without significant clarifications.
IEEE-334, 1974	Standard for Type Test of Continuous Duty Class 1E Motors for Nuclear Power Generating Stations	1.40, March 1973	Endorsed IEEE 334-1971 without significant clarifications.
IEEE-344, 1975	Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations	1.100, August 1977	Endorsed IEEE-344, 1975.Provided clarification on Static Coefficient Method of seismic analysis.
IEEE-344, 1987	Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations	1.100, June 1988	Endorsed IEEE-344-1987. Provided extension of the standard to seismic qualification of mechanical equipment.
IEEE-382, 1974	Standard for Qualification of Safety Related Valve Actuators	1.73, Jan. 1974	Endorsed IEEE-382, 1974. Provided clarification on qualification of actuator auxiliary equipment, justification of test sequences and radiation dose calculations.
IEEE-383, 1974	Standard for Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations	1.131, August 1977	Endorsed IEEE-383, 1974 with extensive clarifications.
IEEE-383, 1980	Standard for Type Test of Class 1E Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations	1.131, August 1979	Endorsed IEEE-383, 1980 with extensive clarifications.
IEEE-317, 1983	Electrical Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations	1.63, Feb. 1987	Endorsed IEEE-317, 1983. Supplemented qualification with IEEE-741 requirements for external circuits.
IEEE-535, 1986	Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations	1.158, Feb. 1989	Endorsed IEEE-535, 1986 with minor clarifications.

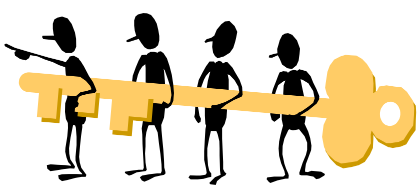
Key Concepts
Mild Environment

- Definition: "An environment expected as a result of normal service conditions and extremes (abnormal) in service conditions where seismic is the only design basis event (DBE) of consequence" (IEEE 323-1983)
- The Inherent Design Characteristics of a Component Envelops the Environmental Parameters of the End Use Application
- IEEE 323 states in part, "…equipment [for mild environment] shall be selected for application to the specific service conditions based on sound engineering practices and manufacturer's recommendations."



Key Concepts
Mild Environment

- "Typical" Mild Environment
  - Temperature — 32 - 104 °F
  - Humidity — 10-95% RH (non-condensing)
  - Pressure — Atmos (14.7 psia)
  - Radiation — < 1 x 10^4 Rad TID
  - Spray — N/A
  - Submergence — N/A



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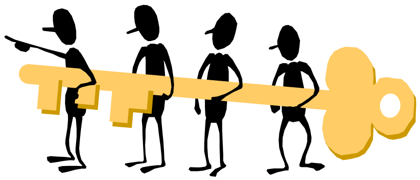
Key Concepts
Harsh Environment

- Definition, "An environment expected as the result of the postulated service conditions appropriate for the design basis and post design basis of the station. Harsh environments are the result of a loss of cooling accident (LOCA)/high energy line break (HELB) inside containment and post-LOCA or HELB outside containment."



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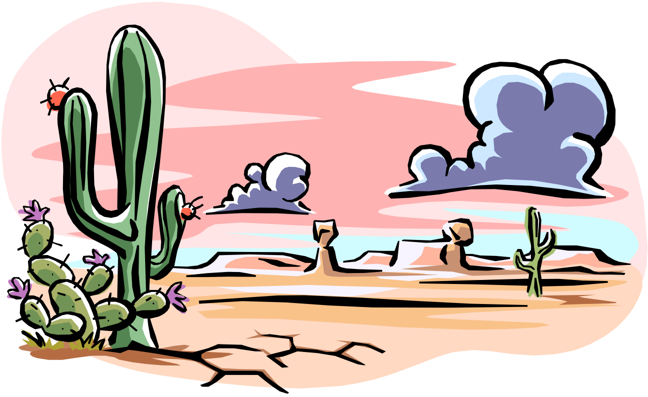
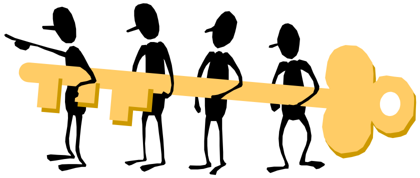
Key Concepts
Harsh Environment

- "Typical" Harsh Environment
  - Temperature (Normal) 32 - 104°F
  - Temperature (Accident) 340°F (Peak)
  - Humidity 100% RH (condensing)
  - Pressure 60 psig
  - Radiation (Normal) 2.7×10^5 Rad TID
  - Radiation (Accident) 2.0×10^8 Rad TID
  - Spray Caustic (10.5 pH)
  - Submergence None





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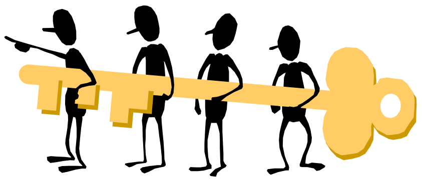
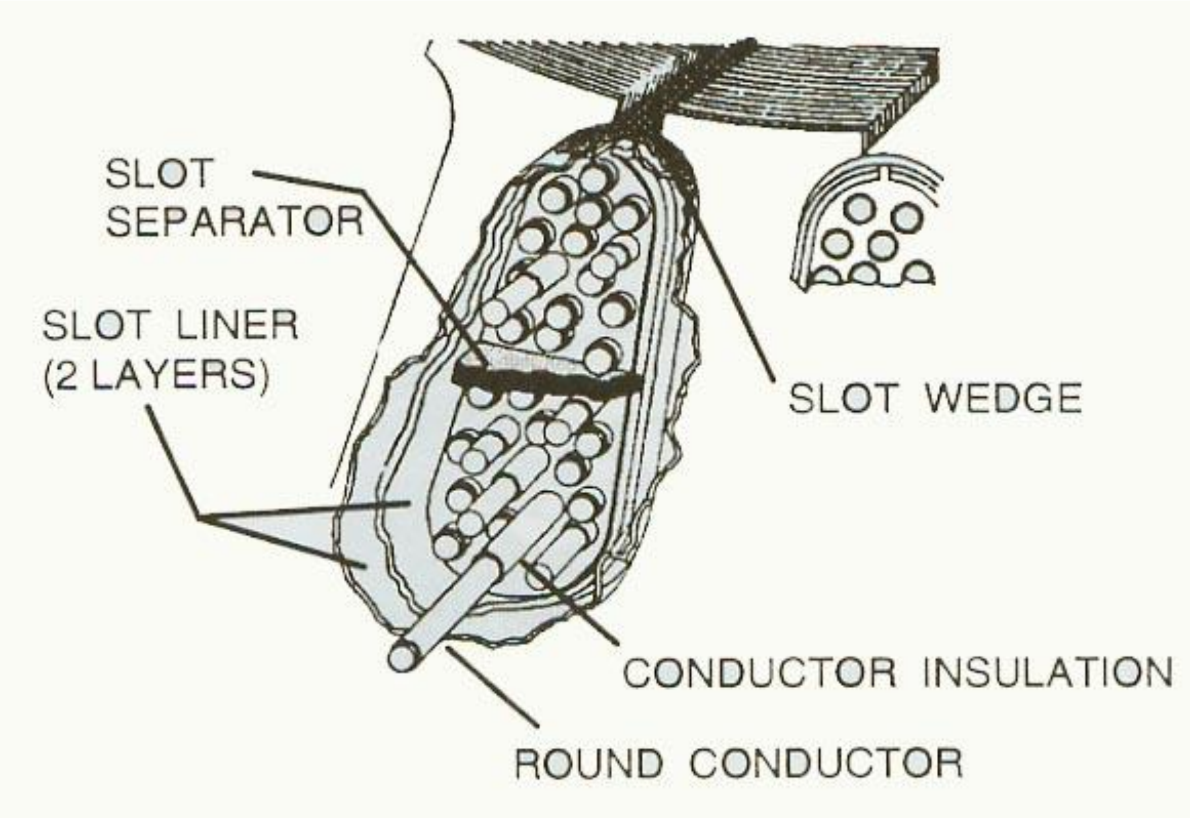
Key Concepts
Aging

- Definition, "The effect of operational, environmental and system conditions on equipment during a period of time up to, but not including design basis events, or the process of simulating these events." (IEEE 323-1983)
- Age Conditioning Does NOT have to be Applied to All Class 1E Equipment, but has to be addressed
- Motor Potential Aging Mechanisms
  - Thermal
  - Mechanical (Cyclic/Vibration)
  - Radiation
  - Voltage Stress



Random-Wound LV Insulation System

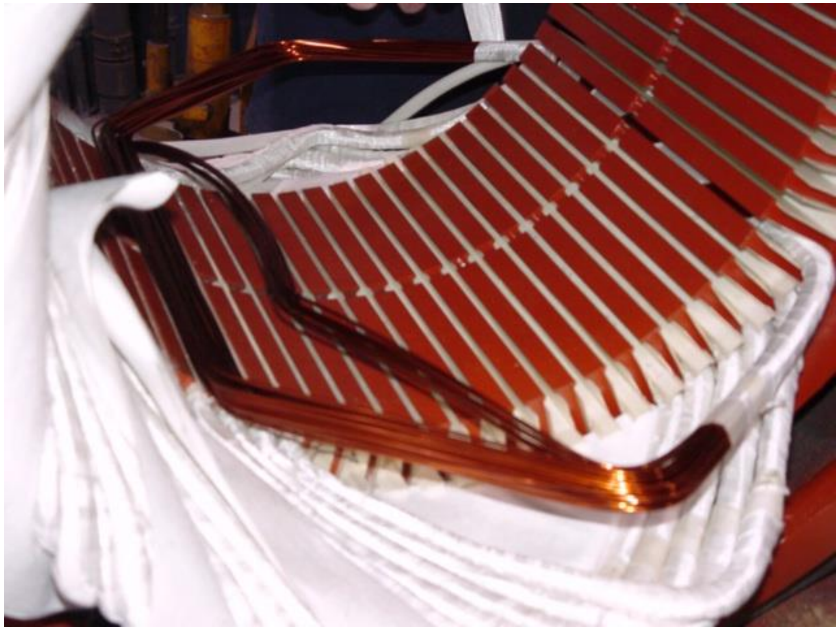


Random-Wound LV Insulation System

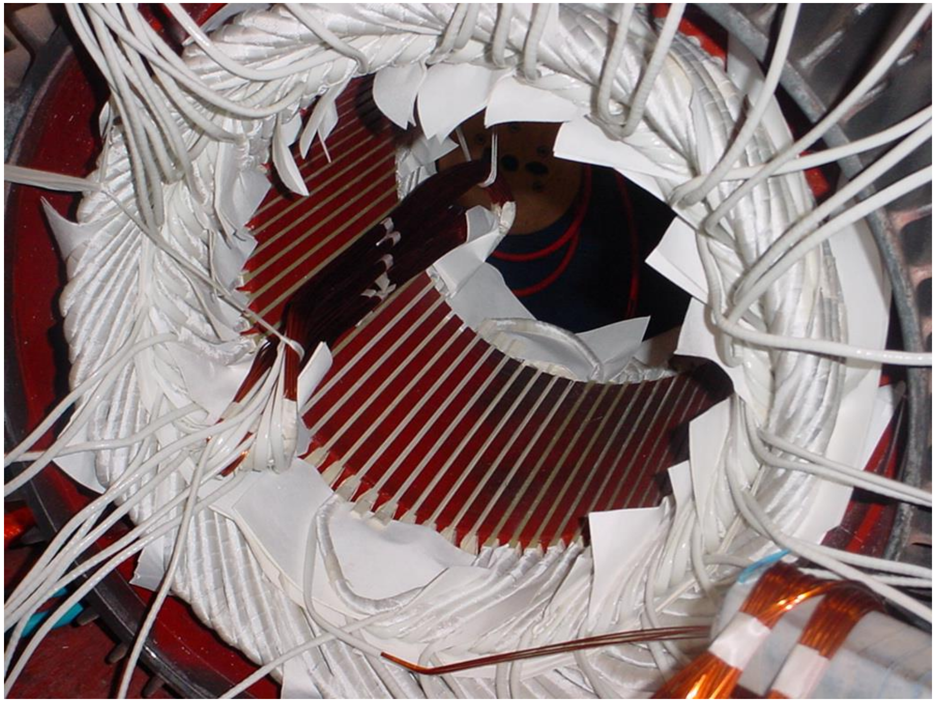
- Slot liner: Nomex-Mylar-Nomex
- Slot wedge: Nomex 410
- Phase separator: Nomex 410
- Phase paper: Nomex 411
- Magnet Wire: Enamel Coated (MW 36C, MW 15C)
- Fiberglass Support Tape
- Silicone Lead Wire
- 15% Silver Solder

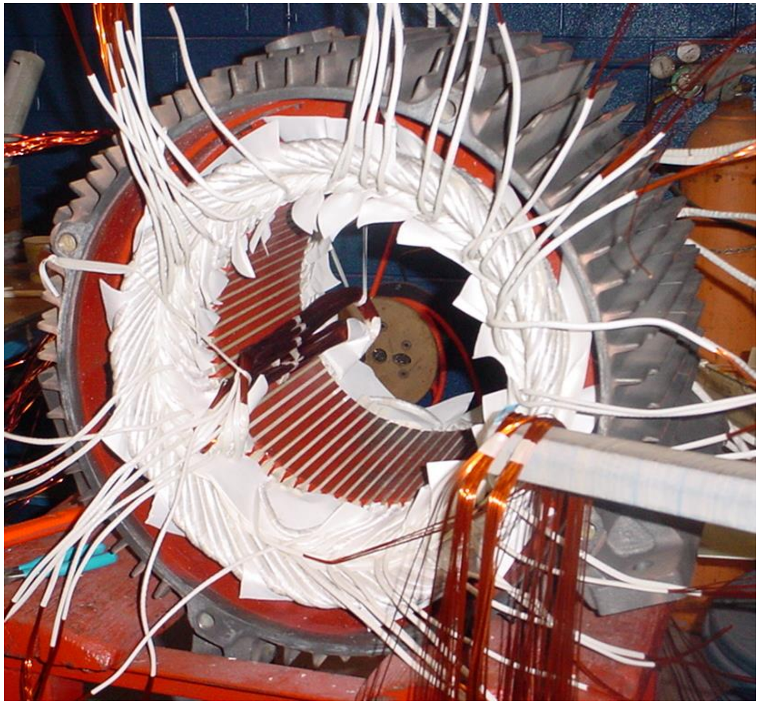
Random-Wound LV Insulation System

Random-Wound LV Insulation System



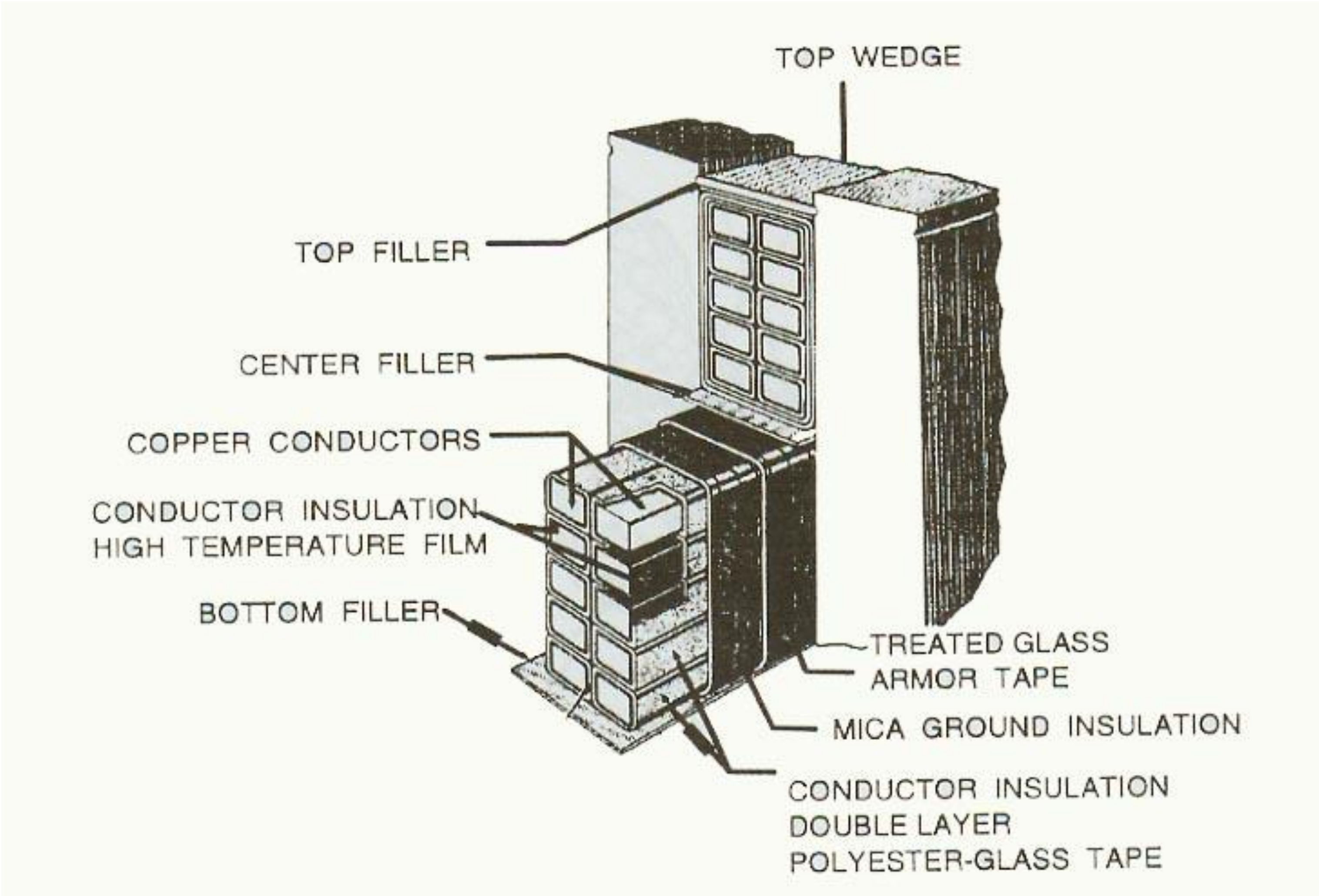
Random-Wound LV System





VPI Process

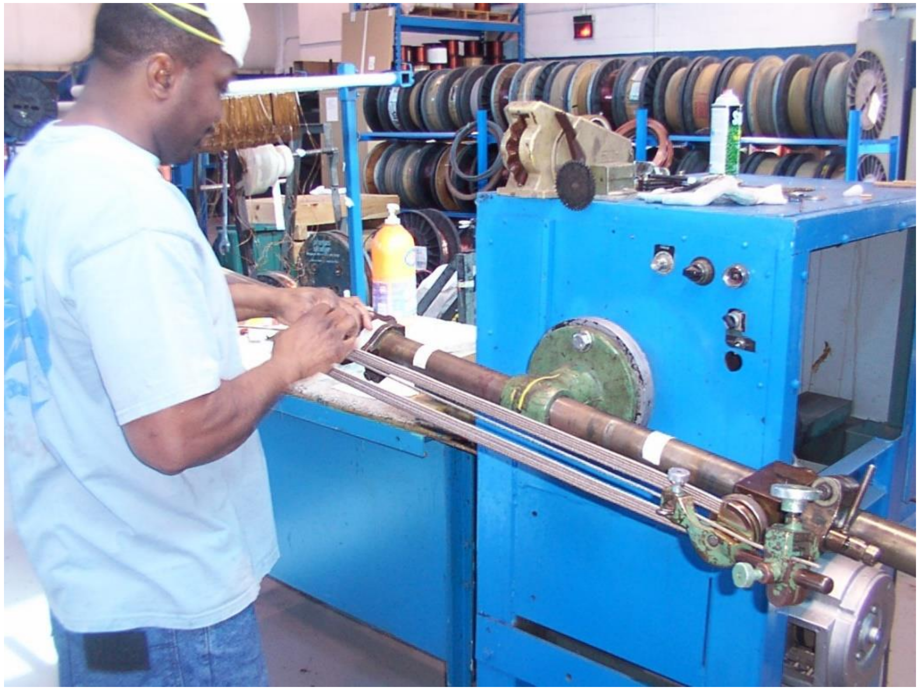
Form-Wound MV Insulation System



Form-Wound MV Insulation System

- Slot wedge: Nomex 410
- Filler Strips: Nomex 410
- Slot Wedge: G-200
- 15% Silver Solder
- Felt Blocking
- Magnet Wire: Square or Rectangular with Enamel Coating, with or without Fiberglass Coating
- Mica Insulating Tape
- Fiberglass Support Tape
- 7.5 KV EPDM Lead Wire

Form-Wound MV Insulation System



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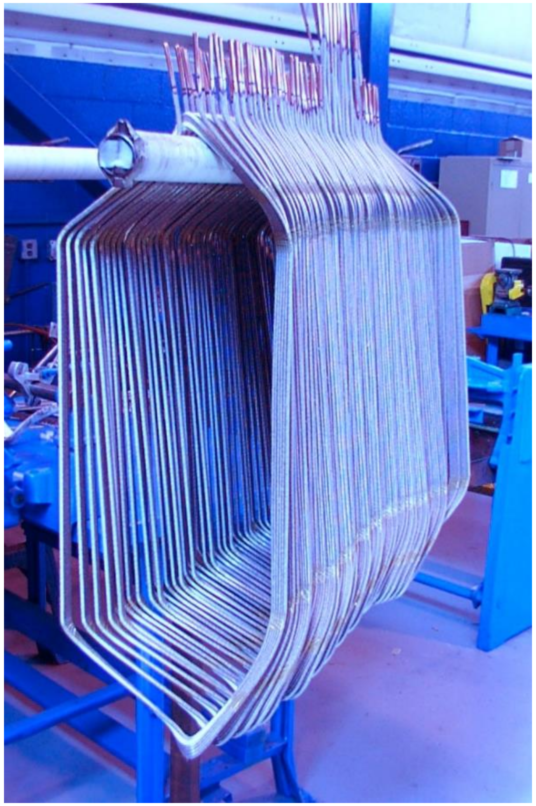
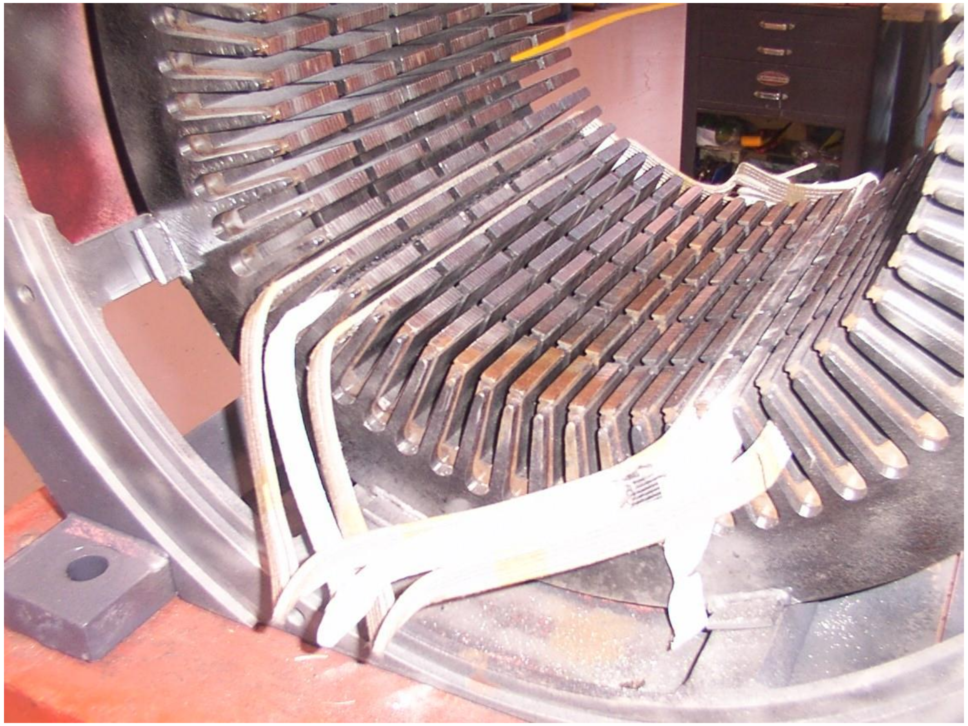
Form Wound System Trial-Fitting of Coils





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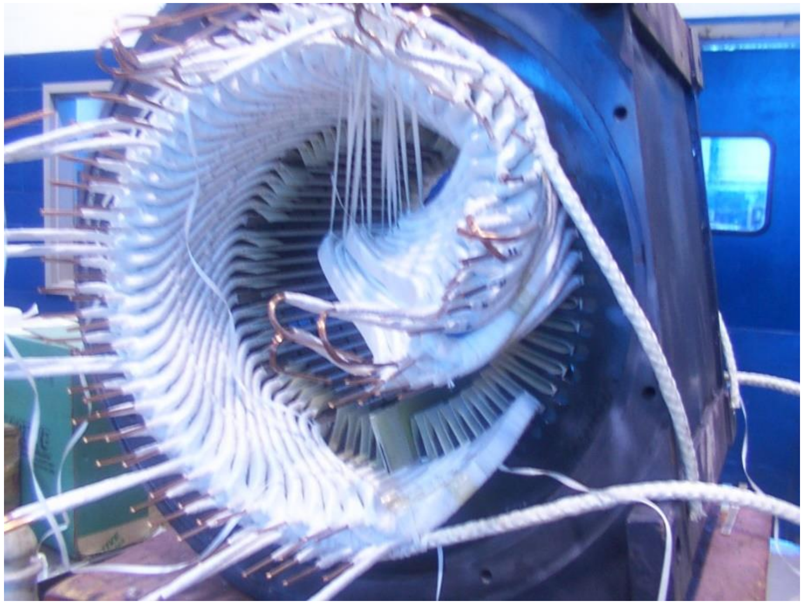
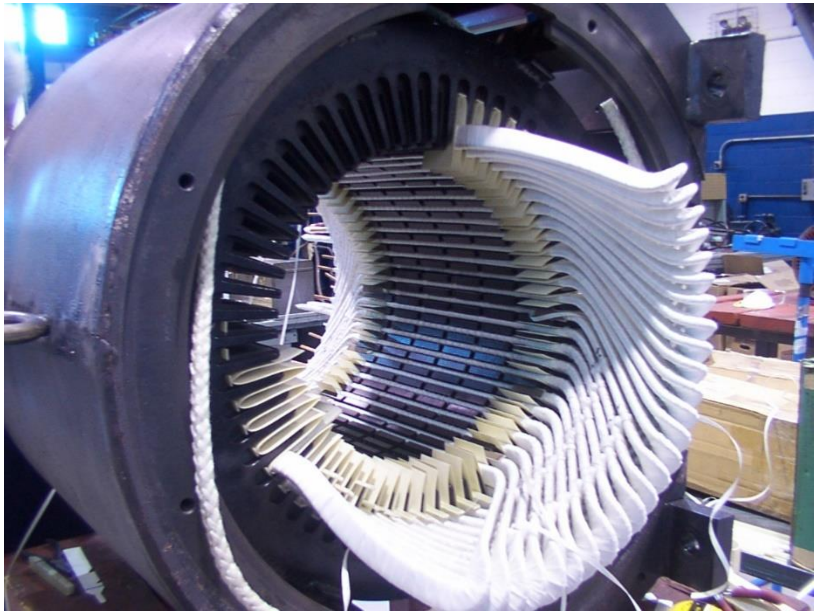
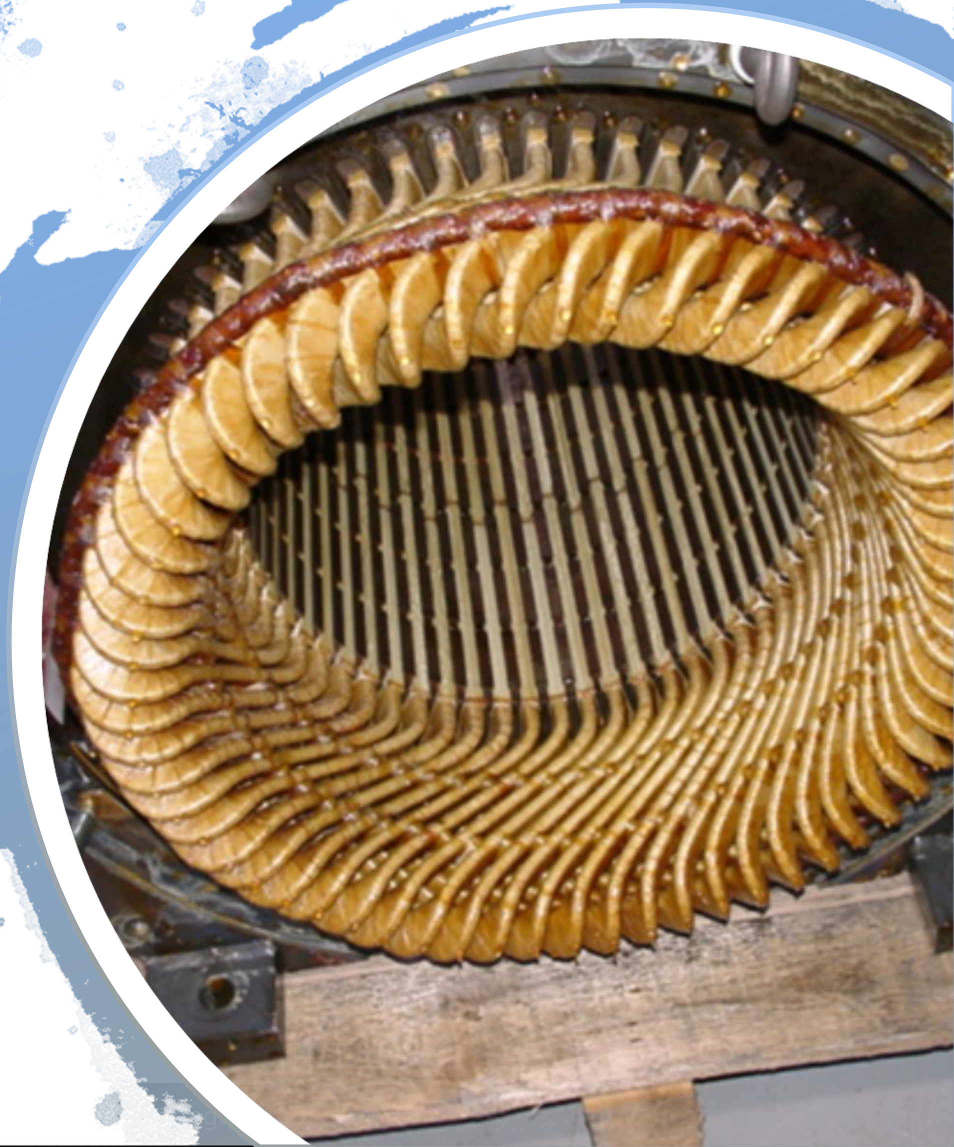
Form-Wound MV – Inserting Coils



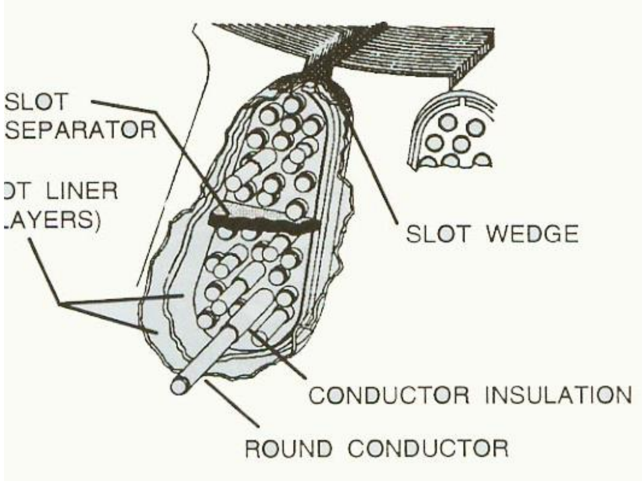


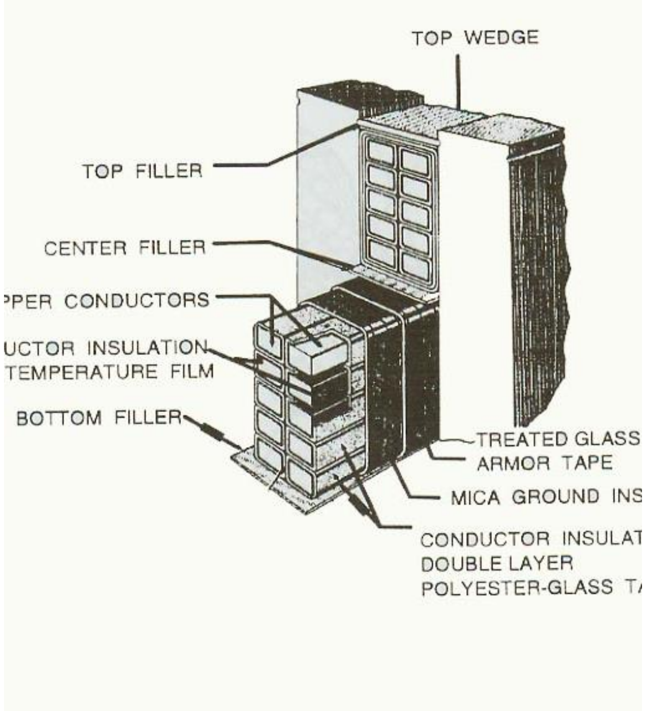


Form Wound MV Post-VPI

Motor Insulation Systems Design - Materials

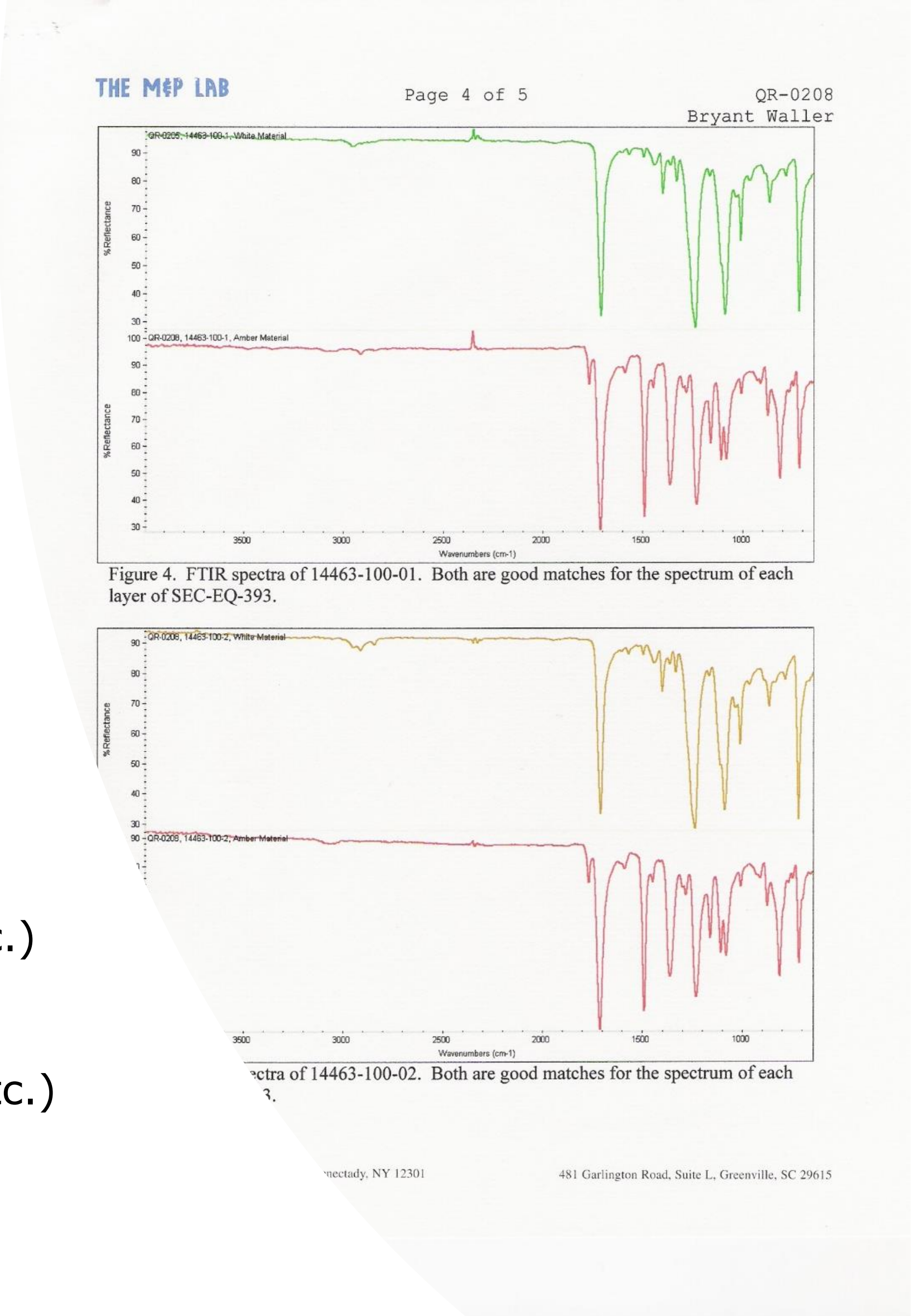
- Insulation System Selection of Materials
  - Experience – Long History of Use in Motor Insulation Systems
  - Workability – Ease of Use by Technicians
  - Availability – Stability of Supply from Known Reputable Manufacturers
  - Longevity – Reputation for Supplier/Manufacturer Consistency and Availability
  - Alternate Materials – Use Multiple Types of Materials to Facilitate Substitution and Avoid Obsolescence
  - Avoidance – Avoid Use of Cutting Edge Materials





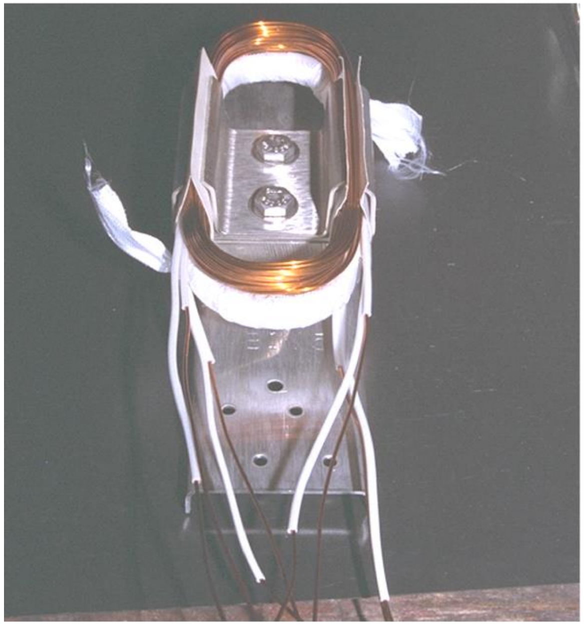
Motor Insulation Systems Design Raw Materials Tests

- Establish Motor Insulation System Design Baseline
  - Dedication and Testing of Individual Insulation System Materials
  - Electrical Tests (IR, Dielectric Strength, etc.)
  - Mechanical Tests (Compressive Strength, Flexural Strength, etc.)
  - Material Chemical Composition (FTIR)
  - Thermal Endurance (Class H, etc.)



Motor Insulation Systems Design
Thermal Endurance Test

- Insulation System Design Test Standards
  - IEEE-117 (Random Wound) Motorette Testing
  - IEEE-275 (Form Wound) Formette Testing
  - IEEE-1776 (Form Wound) Formette Testing
  - Similar Process for Random or Form Wound



Motorette with first coil installed and taped and second coil not taped (Courtesy: Schulz Electric)

Completed Formette Prior to VPI (Courtesy: Schulz Electric)

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Motor Insulation System Design Thermal Endurance Test

- 30 Total Specimens @ Three Temperatures 20°C Apart (e.g. 210°C, 230°C, 250°C) for Class H System
- Test Sequence
  - Temperature Exposure (14 Day, 4 Day, 1 Day)
  - Vibration Aging (1 Hour @ 1.5g)
  - Moisture Exposure (48 Hour Submergence or 100% RH)
  - Voltage Stress (per applicable standard requirements; e.g. 13,800 VAC for 6.9 kV Insulation System)
- Analyze Data (IEEE-101, Statistical Analysis of Thermal Life Test Data)
- Design Output Data From Test
  - Thermal Endurance Classification (Class F, Class H, etc.)
  - Insulation System Activation Energy (eV)

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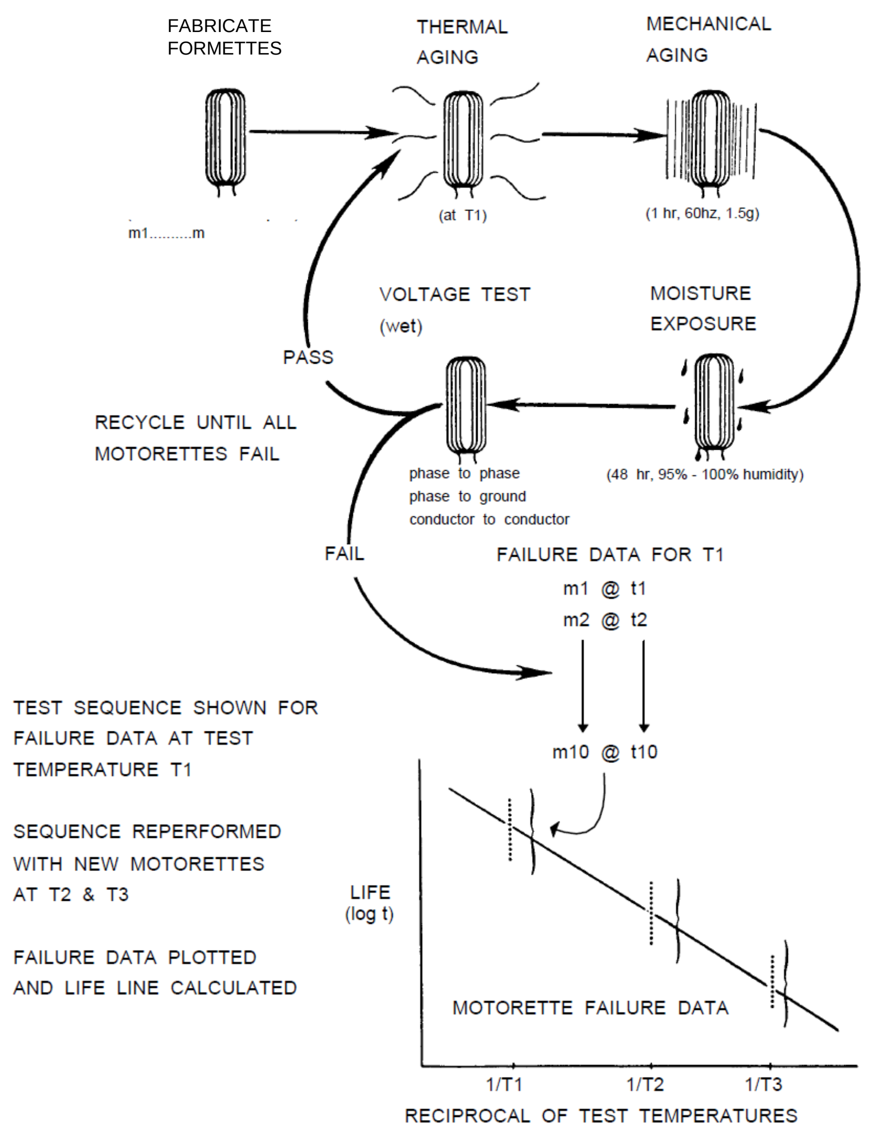
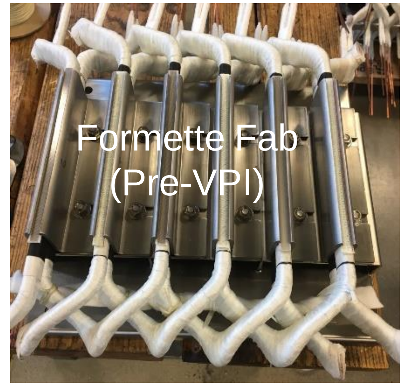
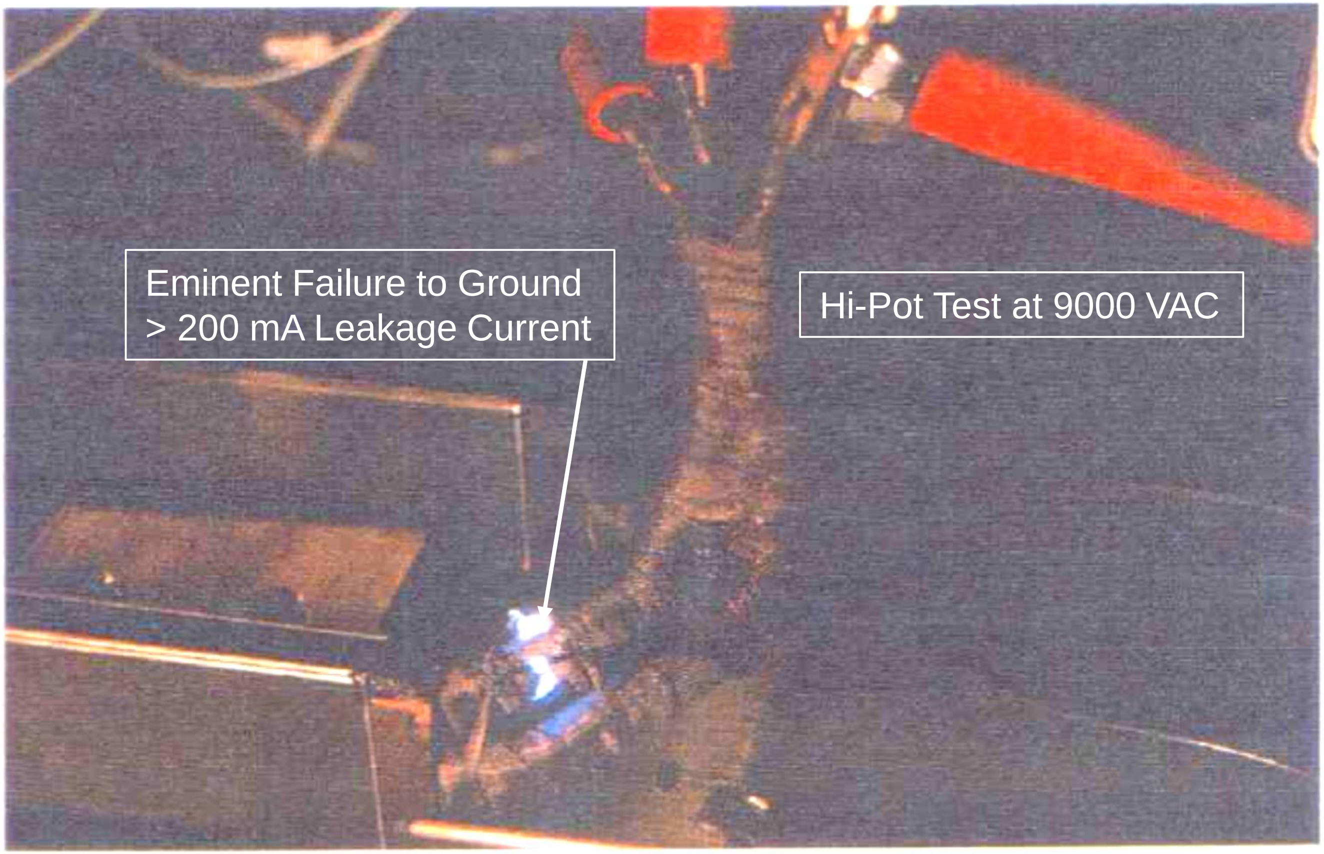
Motor Insulation System Design Thermal Endurance Test (6.9 kV)





Motor Insulation System Design
Voltage Stress Test 4.16 kV



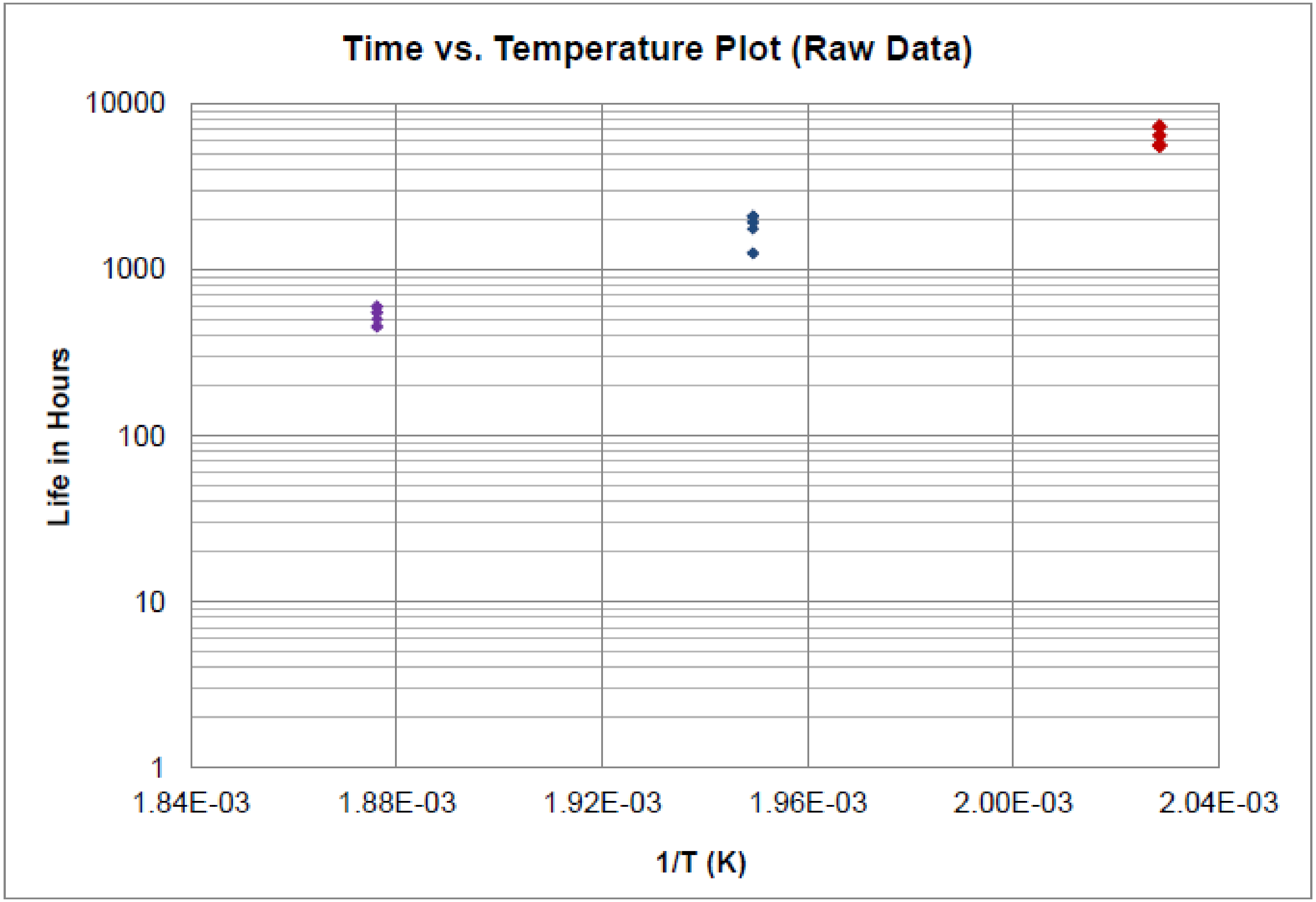
Motor Insulation System Design
Thermal Endurance Test Data Results

Aging Temperature	Initial Aging Cycle	Schulz Electric ID Number	Eltek ID Number
260ºC	48 hours	N-8409-F1	1505-2
		N-8409-F7	1505-1
240ºC	168 hours	N-8409-F5	1506-4
		N-8409-F6	1506-3
220ºC	504 hours [1]	N-8409-F2	1507-5
		N-8409-F3	1507-6

Note: 1. Increased to 840 Hours After 2nd Cycle

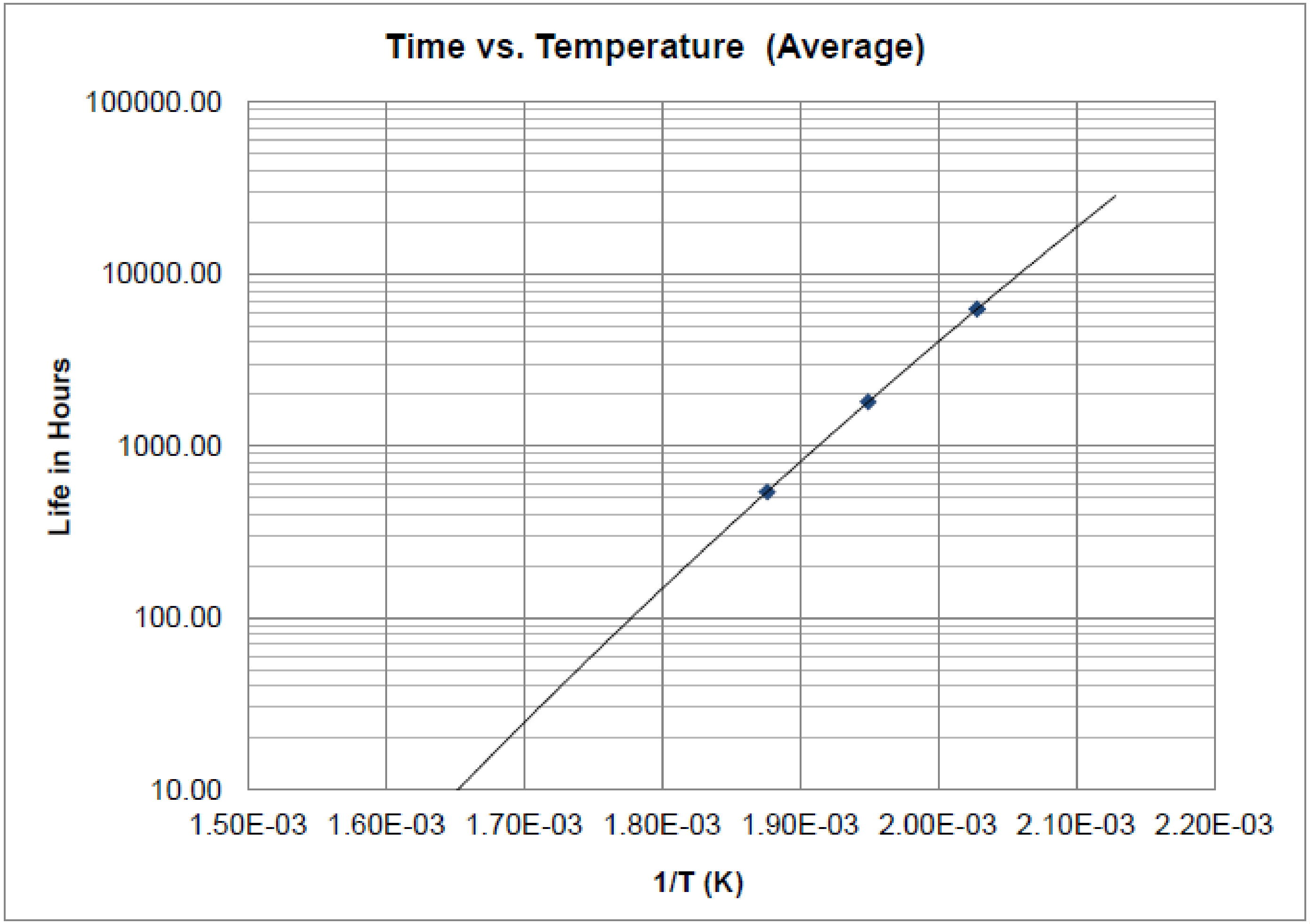
220ºC Formettes			240ºC Formettes			260ºC Formettes		
Specimen	Temp (ºC)	Life (hrs)	Specimen	Temp (ºC)	Life (hrs)	Specimen	Temp (ºC)	Life (hrs)
1507-1 Coil 2	220	5628	1506-4 Coil 5	240	1260	1505-1 Coil 2	260	456
1507-2 Coil 6	220	5628	1506-4 Coil 7	240	1260	1505-2 Coil 6	260	456
1507-2 Coil 7	220	5628	1506-4 Coil 6	240	1764	1505-2 Coil 7	260	504
1507-1 Coil 4	220	5628	1506-3 Coil 1	240	1932	1505-1 Coil 4	260	552
1507-2 Coil 5	220	6468	1506-4 Coil 8	240	1932	1505-2 Coil 5	260	552
1507-1 Coil 1	220	6468	1506-3 Coil 2	240	2100	1505-1 Coil 1	260	600
1507-1 Coil 3	220	7308	1506-3 Coil 3	240	2100	1505-1 Coil 3	260	600
150-2 Coil 8	220	7308	1506-3 Coil 4	240	2100	1505-2 Coil 8	260	600

Motor Insulation System Design
Thermal Endurance Test Data Results



Log-Life in Hours versus Inverse of Temperature in Kelvin (Ref: IEEE-101)

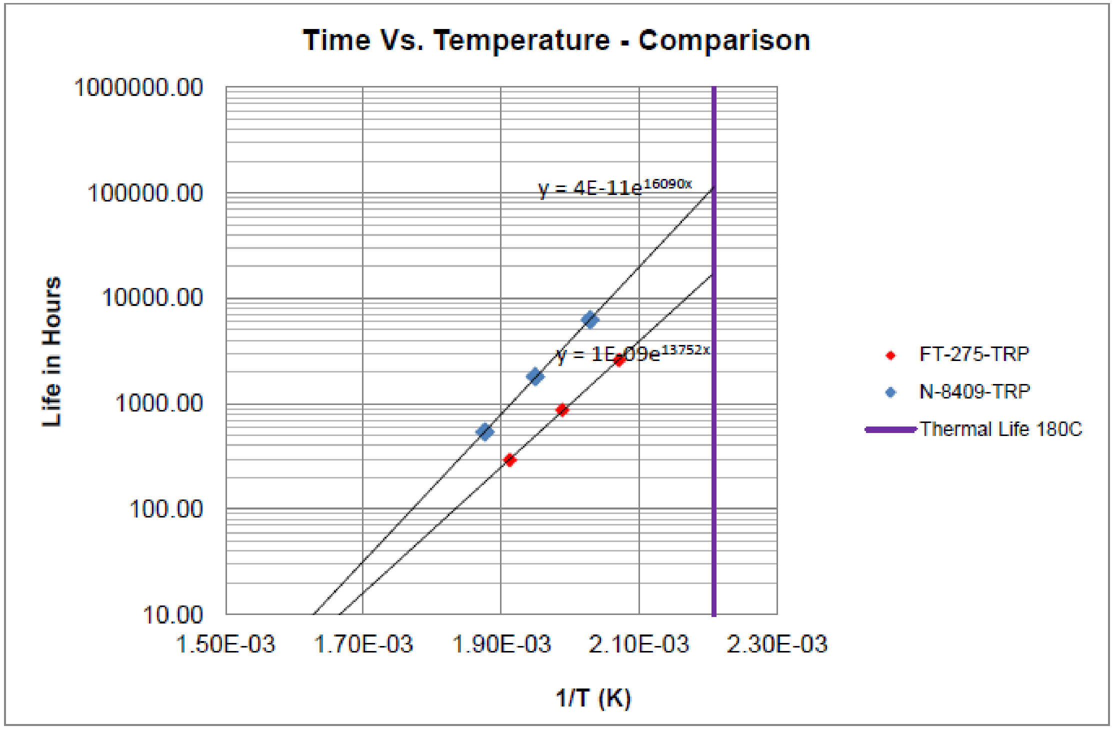
Motor Insulation System Design
Thermal Endurance Test Data Results



Time in Hours (Average) versus Inverse of Temperature with Regression Trendline

Motor Insulaiton System Design
Thermal Endurance Test Data Results

- **Thermal life line of 6.9 kV Motor Insulation System is above the Known 4.16 kV Motor Insulation System Yielding a Higher Mean Life at Rated Temperature of 180ºC (Similar Insulation System Materials)**
- **Resulting Activation Energy and High Correlation Efficient of the 6.9 kV Insulation System, Coupled with Favorable Comparison of the Data to the Known 4.16 kV Insulation System Shows the Data is Reliable and Accurate**
- **Similar Trendline and Final Data Results Provides Supporting Evidence that No Additional Failure Modes Have Been Introduced with Addition of Corona Tape**

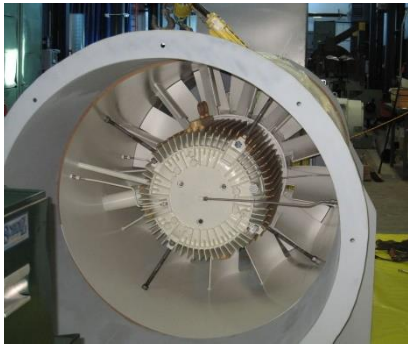


Comparison of Candidate Insulation System With Known Insulation System

Insulation System	4.16 kV	6.9 kV
Activation Energy (eV)	1.192	1.3872
Intercept (A)	-9.01	-10.38
Slope (B)	6002.97	6988.32
Correlation Coefficient (r)	+0.994053	+0.98921

ENVIRONMENTAL QUALIFICATION MOTOR INSULATION SYSTEMS

- Three Unique Insulation Systems for NPP
  - Form Wound Motors (MV Outside Containment)
  - Random Wound Motors (LV Continuous Duty)
  - MOV Motors (LV Random Wound Intermittent Duty)



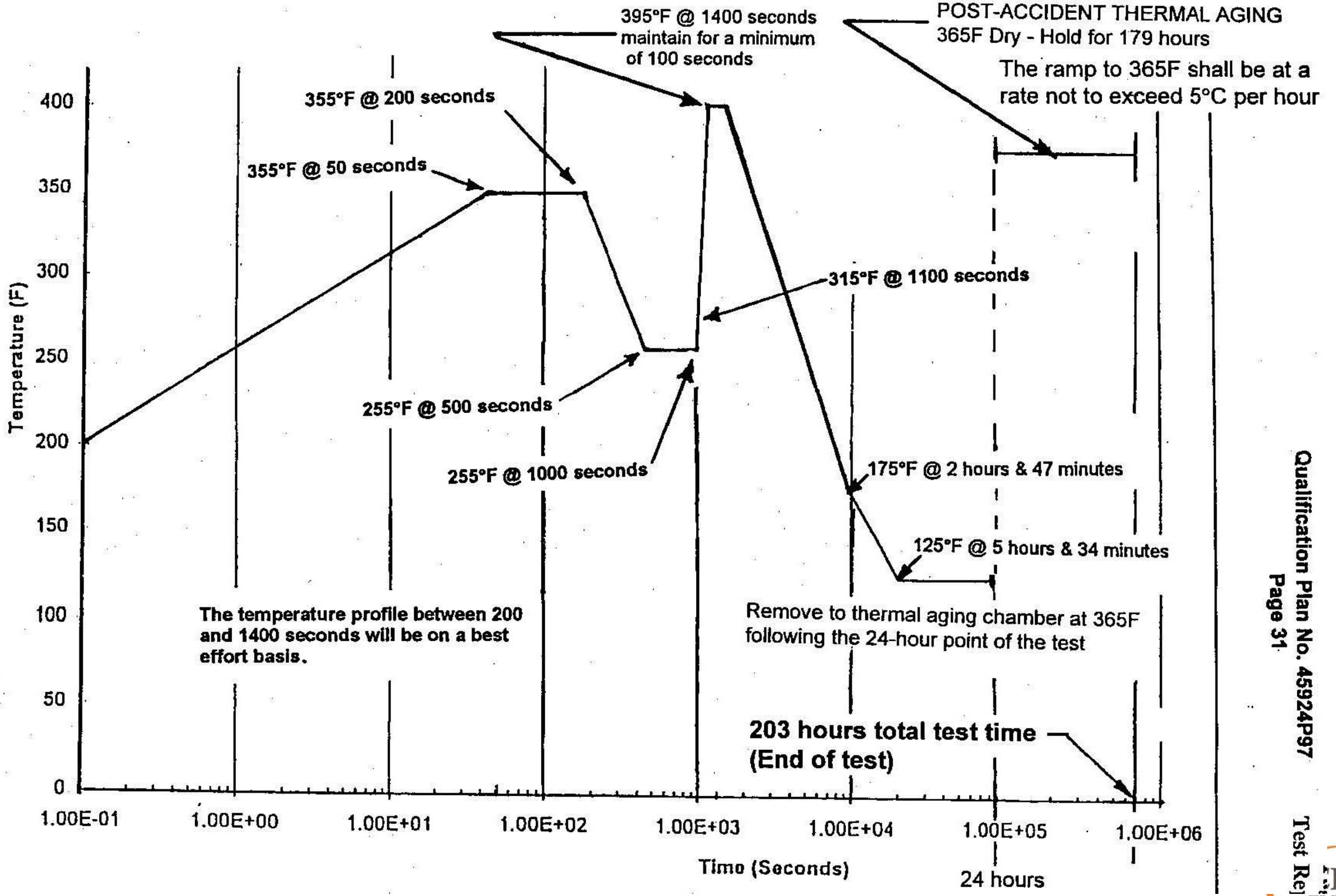
Environmental Qualification Motor Insulation Systems

- Governed by IEEE-323 (1974 or 1983)
- IEEE 334-1974/1994, Motors
- IEEE 344-1974/1987, Seismic
- IEEE 383-1974, Cables/Motor Lead Wire
- IEEE 382-1972/1980, Actuators (MOV)

Considerations Prior To EQ Test

- Determine Normal and Accident Environmental Profiles
- Inside or Outside Containment End Use Application
- Continuous Duty or Standby Normal Operation
- Number of Prototype Test Specimens
- Type of Prototype Test Specimens
  - Form Wound
  - Random Wound (MOV or Fan/Pump)
  - Complete Motor
  - Formette, Motorette or Complete Motor
- Qualified Life Goal (40/60/80 Years?)
- Thermal Aging Time/Temperatures Based Upon eV, Schedule and Test Lab Capabilities
- Generic or Application Specific End Use Application
- Budget and Schedule
- Include Motor Lead Wire or Not
- Internal/External Resources
- Test Lab Limitations/Restrictions

Considerations Prior to EQ Test
Accident Temperature Profile

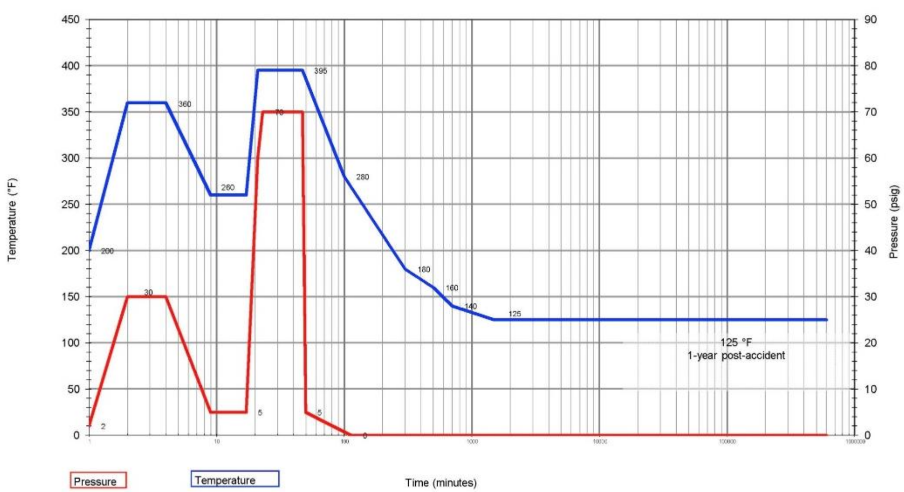


Source: Schulz Electric EQ Report N4446EQFWCD, Rev. 2

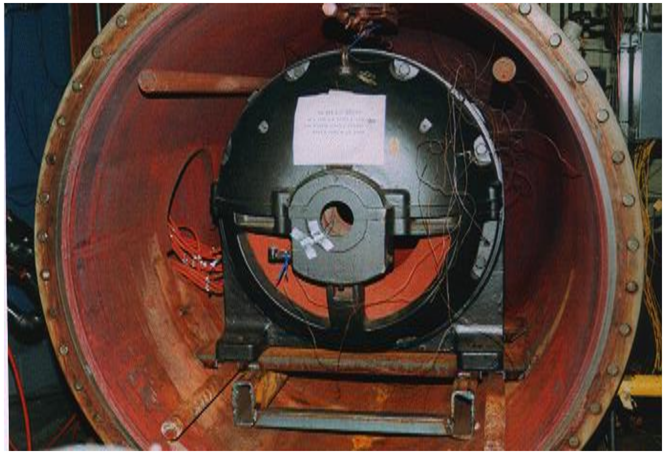
Sample LWR Motor EQ Test Parameters Outside Containment

Qualification Parameters:

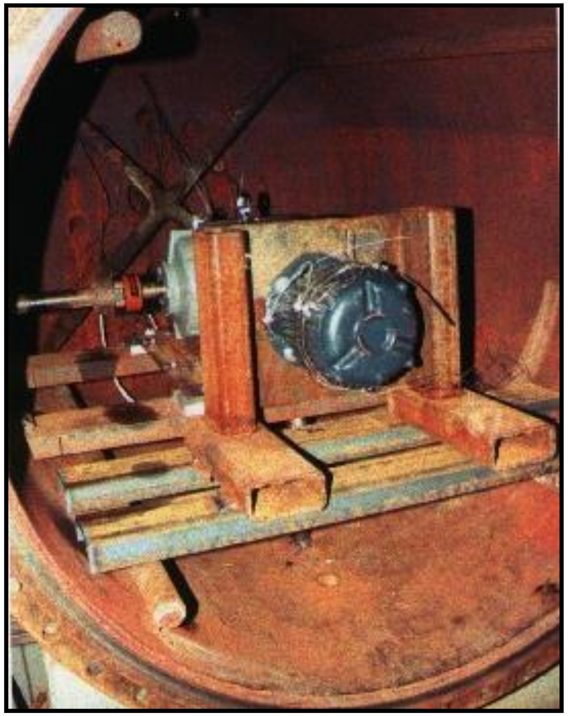
Parameter	Value
Radiation	6.534×10^7 Rads TID
Seismic (IEEE-344)	10g SSE, 6.67g OBE
MSLB/HELB Peak Temp	$395\ ^{o}F$
MSLB/HELB Peak Pressure	70 psig
Humidity	100%
Spray	None (Outside Containment)
Post Accident	1 year
Qualified Life	20 years @ $50\ ^{o}C$, $80\ ^{o}C$ Rise



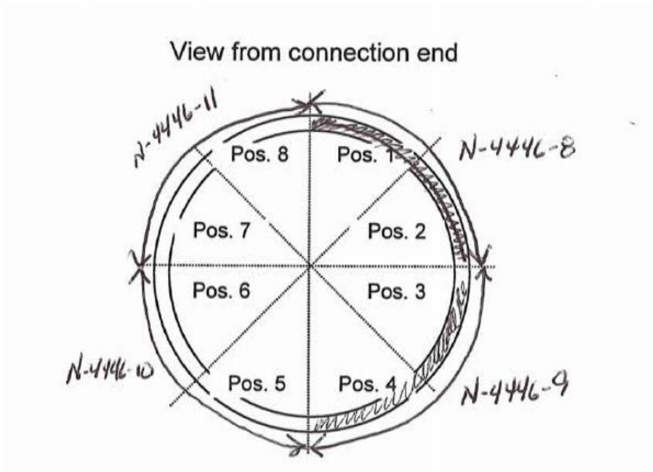
Considerations Prior to EQ Test
Accident Test Specimen Design and Limitations



Form-Wound Motor Specimen inside LOCA Chamber Prior to MSLB/HELB



MOV Motor Specimen inside LOCA Chamber Prior to MSLB/HELB



Form Wound Specimen Arrangement

EQ Test Variations

- Form Wound Motor Test Specimens Typically Formettes vs Complete Motors
  - LOCA Chamber Physical Size Limitations
  - Ability to Load and Drive Motor to FL Requirements
- MOV Motor Test Specimens Require Capability to Reverse Direction to Simulate In-Situ Operation
- MOV Motor Test Specimens Require Seismic Sine Beat/RIM Test to Simulate In-Situ Pipe Mounted Installation
- Inclusion of Motor Lead Wire as Test Specimen

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POWER SYSTEMS BY TIMKEN

EQ Test Margins

- To Account for Normal Variations in Production of Equipment and Variations in Service Conditions (Ref: IEEE 323-1983)
- Temp: +15°F on Peak Accident Temperature
- Pressure: +10% of Gage on Peak Accident Pressure
- Radiation: +10% on Accident Dose
- Voltage: +10% of Rated Voltage
- Time: +10% of Total Time
- Seismic: +10% on Acceleration Requirements

EQ Test Sequence

- Baseline Functional Test
- Normal Radiation Aging
- Post-Normal Radiation Functional Test
- Thermal Aging
- Post-Thermal Aging Functional Test
- Vibration Aging
- Post-Vibration Aging Functional Test
- Seismic Simulation
- Post-Seismic Functional Test
- Accident Radiation Exposure
- Post-Accident Radiation Exposure Functional Test
- Accident Simulation (MSLB/HELB/LOCA)
- Post-Accident Functional Test
- Post-Accident Test Inspection

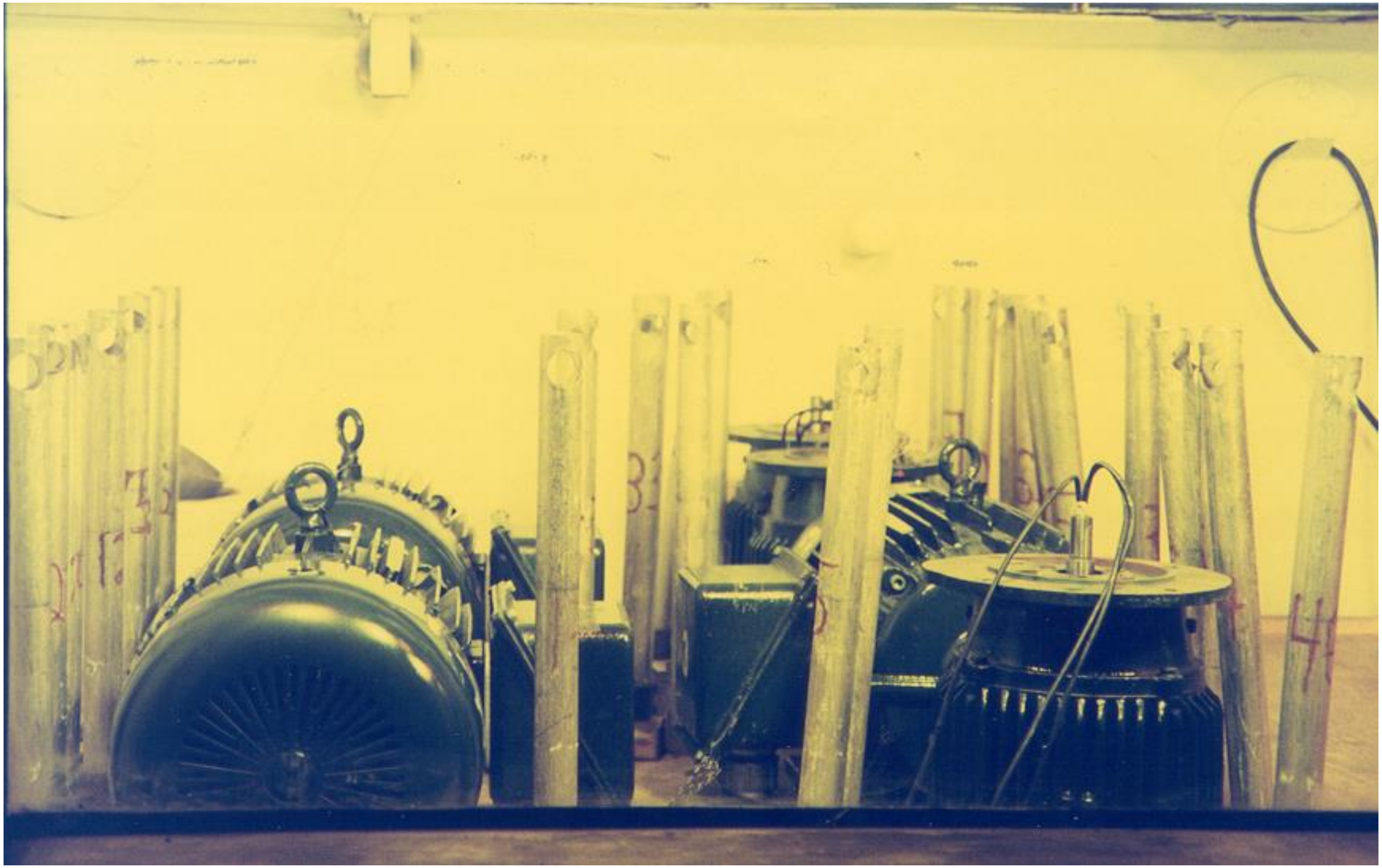
Baseline Functional Test

- Tests Repeated After Each Phase of EQ Testing to Demonstrate Motor Operability and Capability to Perform Safety Function
- Test Protocol Dependent Upon Test Specimen Type (Formette/Motorette/Full Motor)
- Examples:
  - Insulation resistance testing in accordance with IEEE Std 43-2000
  - Step DC high-potential testing in accordance with IEEE Std 95-2002
  - Surge comparison testing
  - Winding resistance testing in accordance with IEEE Std 112-2004
  - Temperature Rise Under Full Load Current

Radiation Aging

- Normal Radiation Service Life Dose Can be Combined with Accident Radiation Dose at This Stage
- Saves Time, Cost and Lowers Logistical Risks
- Sandia Laboratories Report SAND-80-2149C Establishes Thermal Aging AFTER Irradiation is the Most Conservative Test Sequence
- EPRI NP-2129 States Dose Rates of 1.0×10^4 to 1.0×10^7 Rad/Hour - Differences in Degradation are Minor for Materials Such as Motor Insulation Materials
- No Known Synergistic Effects or Dose Rate Effects Exist for Motor Insulation System Materials
- Only Gamma Radiation is Included
- Alpha and Beta Radiation Would be 100% Shielded by Motor Frame

Radiation Aging



Random Wound Motor Specimen Undergoing Radiation Aging
Courtesy: Schulz Electric

Thermal Aging

- Thermal Aging is the Most Critical and Complex Aging Protocol
- Many Interdependent Factors to Consider
  - Insulation System Activation Energy (eV)
  - Normal Service Ambient Temperature and Time
  - Post-Accident Ambient Temperature and Time
  - Assumed Duty Cycle of Motor
  - Thermal Endurance Rating of Motor Insulation System
  - Temperature Rise of Motor During Operation
  - Assumed Motor Load During Operation
  - Capability of Test Lab
  - Schedule and Cost Factors

Thermal Aging

Random Wound Motor Specimen Undergoing Thermal Aging
Courtesy: EPRI

Vibration/Mechanical Aging

- Provide Vibratory Environment Representative of Normal Plant-Induced Vibration
- Includes System Operating Transients and Other Dynamic Vibratory Environments
- Mechanically Age Motor Test Specimen at 60 Hz for 1 Hour at 1.5 Times Acceleration of Gravity (Ref: IEEE-334)
- Motion Perpendicular to Horizontal Plane of Motor Test Specimen

Random and Form Wound Motor Specimen Undergoing Vibration Aging - Courtesy: Schulz Electric and EPRI

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POWER SYSTEMS BY TIMKEN

SEISMIC TESTING

- Seismic Testing per IEEE-344
- 5 Operating Basis Earthquakes (OBE)
- 1 Safe Shutdown Earthquake (SSE)
- Can be Performed on Same Shake Table as Mechanical/Vibration Aging

Random and Form Wound Motor Specimen Undergoing Seismic Test Courtesy: Schulz Electric

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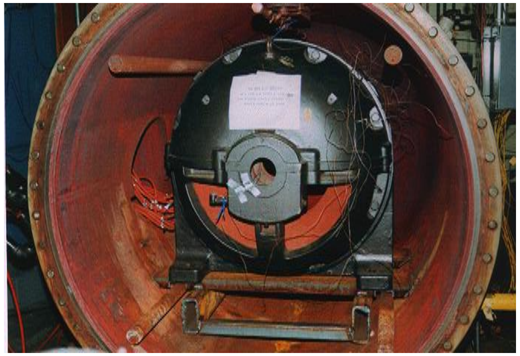
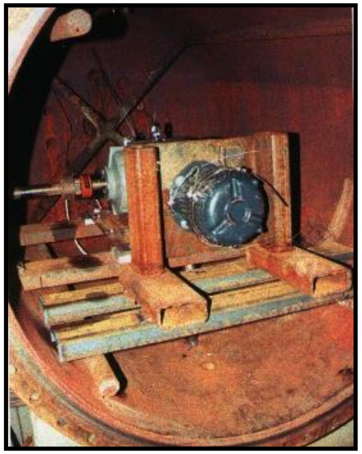
POWER SYSTEMS BY TIMKEN

DBE Accident Testing

- LOCA/HELB/MSLB
- Inside/Outside Containment Profile
- Chemical Spray for Inside Containment Test
- Most Conservative Test is to Allow Environment to Enter Motor
- Start/Stop and Energize/De-Energize for Full Operational Demonstration
- Utilize Arrhenius Methodology to Accelerate Post-Accident Time Period





Post-Accident Functional and Inspections

- Perform Final Functional Test
- Must Meet Acceptance Criteria Established in Baseline Functional Tests
- Address Test Anomalies
- Develop Test Report Including All Detailed Test Data

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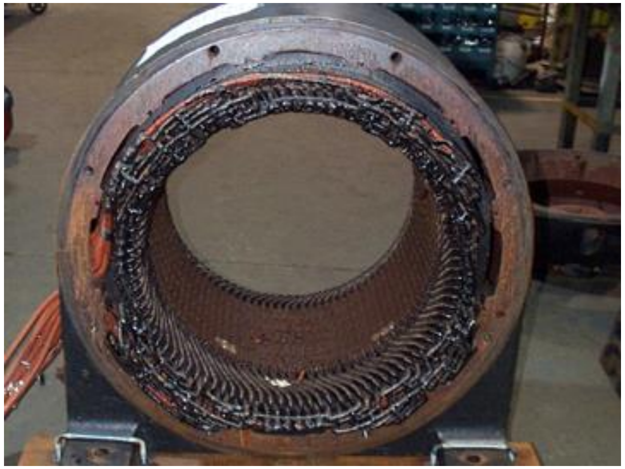
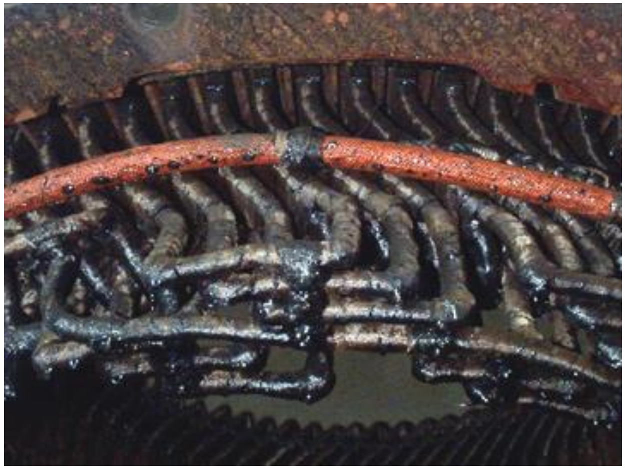
POWER SYSTEMS BY TIMKEN

Post-Accident Test Inspections





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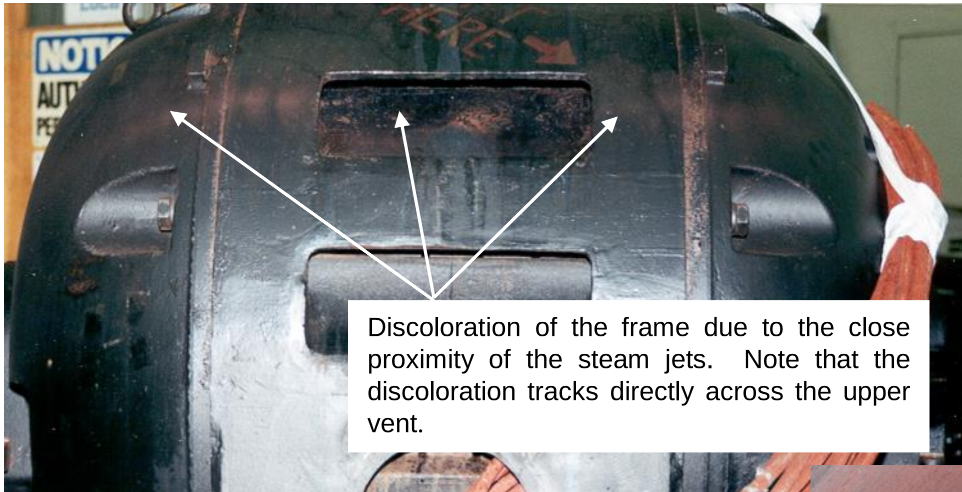
Post-Accident Test Inspections

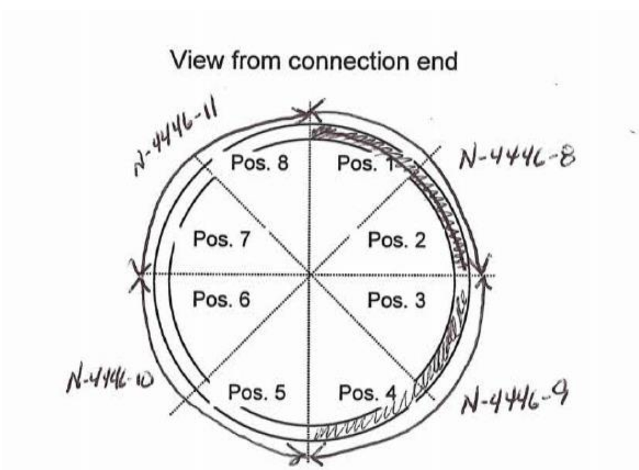
Opposite connection end "butterfly" tying/bracing.

Surge ring material and ties on the opposite connection end

EQ Test Anomaly Resolution

LOCA Chamber Configuration Induced Failure





Lessons Learned

- Thermal Aging is Most Detrimental Aging Mechanism for Motor Insulation Systems
- Bearing Oil/Grease will Not Survive Normal Thermal Aging Time/Temperature Profiles Required for Motor Insulation Systems
- Do Not Use "Open" Style Formettes/Motorettes for Motor Insulation System Qualification Test Specimen Configuration
- Radiation Aging Prior to Thermal Aging Considered Most Conservative Sequence (Ref: Sandia Laboratories Report SAND-80-2149C)
- Total Time to Design, Test and Qualify Motor Insulation System $\underset{\sim}{}$ 5 Years

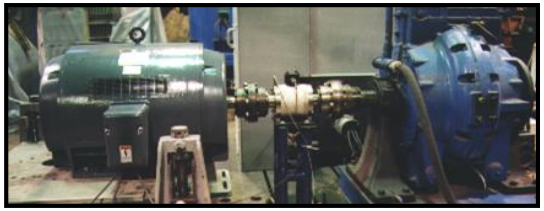
Schulz Electric Overview

- Founded 1927 – 91 Years of Motor Experience
- 25 Years Nuclear Safety Related Motor Experience
- Acquired by The Timken Company April 2014
- Now Part of Timken Power Systems (TPS)
- Overhaul
- Rewind
- Repair
- Decon
- Testing
- New Motors

SCHULZ ELECTRIC
POWER SYSTEMS BY TIMKEN

SCHULZ ELECTRIC OVERVIEW

- Full Service Supplier for Safety Related Motors
  - ➲ Rewind and Overhaul
  - ➲ Bearing Replacement
  - ➲ Shaft Repair & Replacement
  - ➲ Dynamometer Full Load Testing (Up to 1500HP)
  - ➲ Contaminated Motor Repair/Rewind
  - ➲ New and Repair of Environmentally Qualified (EQ) Motors (Random/Form Wound AND MOV Motors)
  - ➲ New Safety Related Motors
  - ➲ Emergency Diesel Generator (EDG) Repair
  - ➲ MG Set Repair and Supply
  - ➲ Motor Seismic Qualification by Analysis or Test
  - ➲ Supporting NPP LTO, PLEX and PLiM
  - ➲ Expanding Repair Services and Equipment Supply to Europe and Beyond



SCHULZ ELECTRIC
POWER SYSTEMS BY TIMKEN

Nuclear Industry Commitment & Support

EPRI NP-6407, Guidelines for the Repair of Nuclear Power Plant Safety-Related Motors

EPRI TR-103585, Guidelines for the Selection, Procurement, and Acceptance of Nuclear Safety Related Mild Environment Motor Insulation for Rewinds

EPRI TR-104872, Guidelines for the Qualification of Insulation Systems for Use in Rewinding Nuclear Safety Related Harsh Environment Motors

EPRI TR-1003481, Qualification of Motors for Harsh Environment Task Group

EPRI TR-107372, Guideline for Reverse Engineering at Nuclear Power Plants

IEEE SC-2, IEEE-334 (SC 2.2) Chairman, Vice-Chair, Secretary

LEADING THE NUCLEAR INDUSTRY

First Independent Motor Repair Facility to Qualify Motor EQ Insulation Systems

First Independent Motor Repair Facility Capable of Motor Radiological Decon

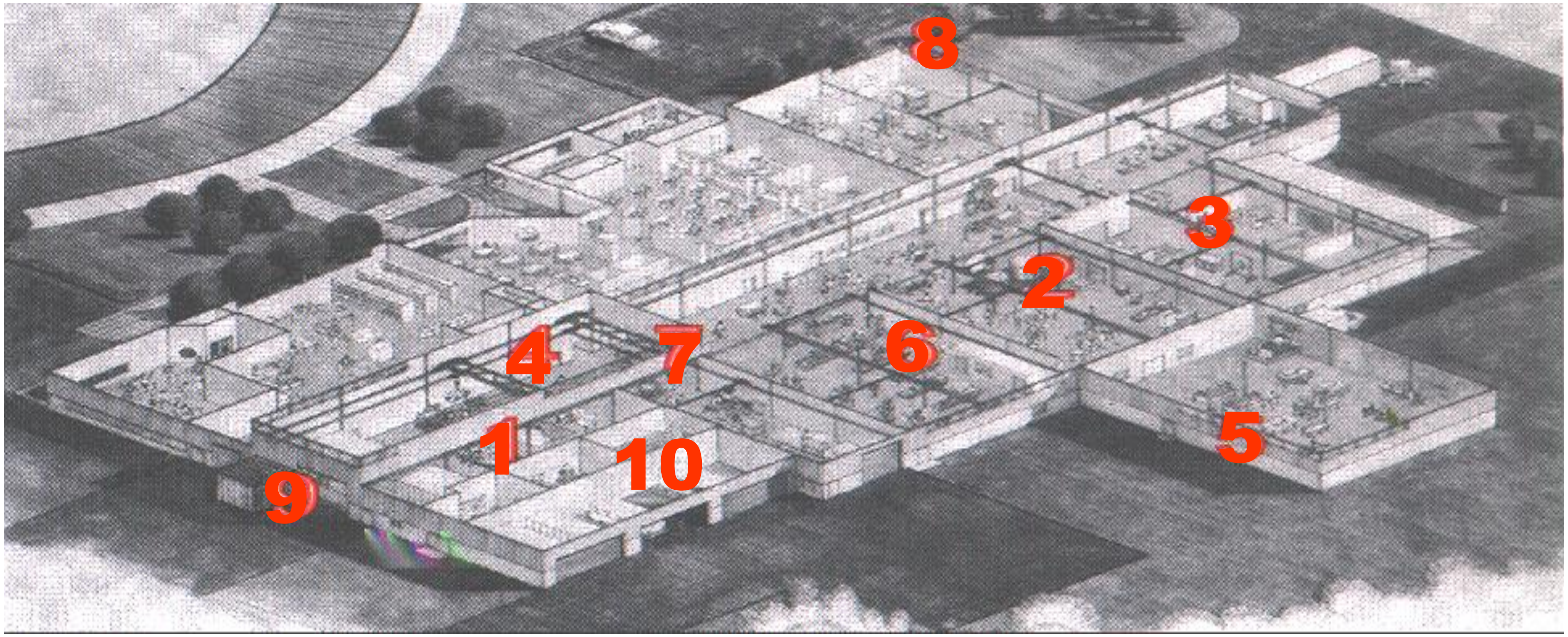
First and Only Nuclear Motor Repair Facility for EQ, Safety Related and Non-EQ/Non-safety Related MOV Motors

Developed Nuclear MOV Magnesium Motor Rotor Inspection and Re-Coating Program

First Independent Motor Repair Facility to Utilize EPRI Random Wound Continuous Duty EQ Insulation System

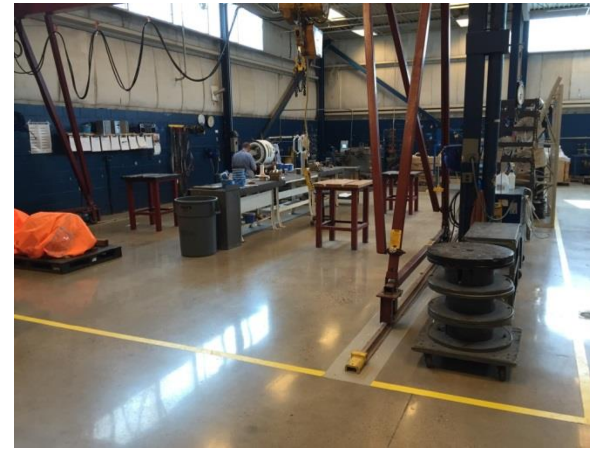
SCHULZ ELECTRIC
POWER SYSTEMS BY TIMKEN

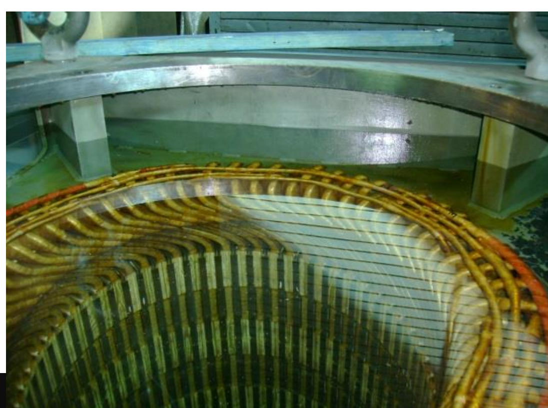
SCHULZ ELECTRIC OVERVIEW
FACILITY LAYOUT



1. 9' Epoxy VPI Tank
2. 6' Polyester VPI Tank
3. Curing and Drying Ovens
4. 72" Dia Lathe, 22' Centers
5. Coil Forming Dept.
6. Dynamic Balancing
7. Motor Test Stand (7000V)
8. Custom Mfg. Area
9. 10' X 10' X 10' Temperature Controlled, Water-Quenched Burnout Oven
10. Onsite Decon Facility

SCHULZ ELECTRIC
POWER SYSTEMS BY TIMKEN





HULZ
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EQ & Safety Related Pump & Fan Motor Repair

- Emergency Service Water
- Service Water
- Component Cooling Water
- Residual Heat Removal
- Core Spray
- Containment Spray
- Safety Injection
- Joy Fan
- Containment Cooling Fans
- FCU Motor

Motor Decontamination Services

- Radioactive Materials License by USNRC 2006
- Motors are Deconned to Free Release Prior to Repair/Rewind
- Schulz Electric is Responsible for Disposal of Radioactive Materials
- Complements Schulz's EQ Insulation Systems

SCHULZ ELECTRIC
POWER SYSTEMS BY TIMKEN

Nuclear QA Program

- QA Program Meets NRC Requirements of 10 CFR 50 Appendix B, ASME NQA-1 & 10 CFR Part 21 and CSA Z299.2-85
- Audited by NUPIC, NRC Vendor Inspection Branch (VIB) and Multiple Nuclear Utilities
- NIAC Member – Audited for EQ Motor Repair/New Motors
- Dedication Program Meets EPRI NP-5652 and NP-6406
- Shipping, Storage, Handling IAW ANSI N45.2.2
- ISO-9001:2000 QA Program Utilized for Non-Safety Related Motor Projects
- Comprehensive NSR Motor Program for Reliability, Operation and Generation Related Motors

Strategic Nuclear Alliances

Exelon.

FPL.

Dominion

Entergy.

ENTERGY NUCLEAR

USA
UTILITIES SERVICE ALLIANCE

STARS Alliance

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Questions?

Mockrát děkuju!

Thank You!

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