Minutes of Meeting
Task Force: Methodologies to Demonstrate Expected Life of Lubricants Used in Switching Devices
10:15 AM – 12:00 AM (EDT), October 18, 2022
Green Mountain B

1. Call meeting to order — Jack Harley
   At 10:17 am (edt)

2. Introduction of Members and Guests, and attendance — Doug Edwards
   Participants self-introductions with affiliations
   Attendees introduced themselves and stated their affiliations.
   - 13 of 16 voting-members present
   - 17 Guest

3. Quorum verification — Doug Edwards
   Yes – Quorum was met.

4. Approval of Meeting Agenda — Jack Harley
   Motion by Chris Jarnigan to approve meeting agenda.
   2nd by Jeff Ward.
   Approved by consent.

5. Call for patents, copyright issues — Jack Harley
   IEEE Patent slides shown.
   IEEE Copyright website shown
   No issues reported.

6. Approval of previous meeting Minutes (2022-09-22.R1) — Doug Edwards
   Motion by Jeff Ward to approve previous meeting minutes.
   2nd by John Webb.
   Approved by consent.

7. PAR — Jack Harley
   - PAR Request submitted to IEEE-SA NesCom on October 11, 2022, prior to deadline of October 13, 2022. PAR review will be on NesCom Agenda for December 1-3, 2022 IEEE-SA meetings.
   - Title: Guide For Methodologies to Demonstrate the Expected Life of Lubricants Used in Switching Devices
   - Scope of proposed standard: The information in this guide is intended to assist n developing methodologies for establishing the expected life of lubricants as used in switchgear equipment including but not limited to:
     - Automatic reclosers and sectionalizers
     - Current limiting devices
     - Fuses and cutouts
     - Gas-insulated switchgear
     - Metal-enclosed buses and all buses included in switchgear assemblies
     - Power circuit breakers
     - Switches, including pad-mounted switches
     - Switchgear assemblies
     - Switchgear devices

Lubricants used as a surface protectant, for applications other than reducing friction or wear, are not included.

PAR (R4.2022-09-30) as submitted is attached with these minutes.

Not discussed in meeting but sharing in these minutes, the document number is setup to be C37.100.8.

8. Develop concept for Table of Contents (TOC) Jack Harley
Reviewed concepts for TOC – attached with these minutes.

Highlight of discussions included:
- General considerations Potentially adding discussion of
    - Shelf life
    - Environmental issues
- Differences in lubricant types. May includes details about the composition of lubricants.
- Suggested adds to Bibliography
    - Annex A – Bibliography
    - Annex B Lubricant regimes
    - Annex C Device manufacturing factors (placeholder)
        - Application of lubricants, e.g. Packed = 30% of volume of area
        - Labeling: Initial lubricant or lubricant used during maintenance
    - Annex D – How to handle lubricant compatibility

9. Methodology: use of Arrhenius concept Jack Harley
- Arrhenius Educational presentation provided concerning Arrhenius equation methods – slides are attached with these minutes.
- Alternate aging methods might include
    - Controlled field experience.
    - Simulators

10. Test procedures & criteria for end-of-life for lubricant applications

11. Test objects:
- Full zie equipment
- Simulators
- Controlled field expensie3

12. Aging modes: cyclic or continuous

13. Diagnostic factors: (placeholder)

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14. Interpretation of data

15. Test reports
    - Annex A – Bibliography
    - Annex B Lubricant regimes
    - Annex C Device manufacturing factors (placeholder)
        - Application of lubricants, e.g. Packed = 30% of volume of area
        - Labeling: Initial lubricant or lubricant used during maintenance
    - Annex D – How to handle lubricant compatibility
    -

16. Adjourn Adjourned at 11:37 am (edt). Jack Harley

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Attendance

LastName, FirstName	Company	10/18/2022
Harley, John	FirstPower Group LLC	M
Edwards, Doug	Siemens Industry, Inc.	M
Burse, Ted	Powell Industries, Inc	M
Carne, Clint	Schneider Electric	M
Flowers, Keith	Siemens Industry, Inc.	
Grahor, Lou	Eaton Corporation	M
Hartzel, Ronald	Eaton Corporation	
Jarnigan, Christopher	Southern Company Services	M
Leccia, Brad	Eaton	M
Livshitz, Albert	Qualus Power Services	M
Moser, Darryl	ABB	
Orosz, Miklos	CBT&S LLC	M
Ricciuti, Anthony	Eaton Corporation	M
Ward, Jeffrey	Doble Engineering Company	M
Webb, John	ABB	M
Weishuhn, William	ABB	M
Alexander, Brian	S&C Electric Canada	G
Ambrose, Chris	Federal Pacific	G
Barfield III, Walter	Electric Power Research Institute	
Blake, Randy	Hubbell	
Boyce, Russell	Eaton	G
Bray, Elizabeth	Southern Company	
Brunke, John	Power Engineers	
Christian, Michael	ABB	G
Di Lillo, Patrick	Consolidated Edison Co. of NY, Inc.	
Dunne, David	Schneider Electric	
Dwyer, Bernie	PECO	
Eftink, Emily	Burns & McDonnell	
Esco, Tanner	Eaton Corporation	
French, Christopher	Eaton Corporation	
Grein, Paul	Group CBS	G
Hall, John	Tennessee Valley Authority	
Hawkins, Tom	Siemens Industry, Inc.	
Hensberger, Jeremy	MEPPI	G
Hetzer, Matthew	PEPCO	
Hohnstadt, Benjamin	DTE	
Hook, Dan	Group CBS	G
Hunt, Terry	Westinghouse	G
Hutchins, Roy	Southern Company Services	
Irwin, Todd	GE Grid Solutions	

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LastName, FirstName	Company	10/18/2022
Jala, Roopendra Hemanth	S&C Electric Company	
Keels, Thomas	kEElectric Engineering	
Lanning, Scott	S&C Electric	
Marzec, Peter	S&C Electric Co.	
May, Steven	Southern Company	G
Meyer, Peter	S&C Electric Company	G
Monroe, Andrew	Southern Company	
Nenning, Andrew	Omicron Electronics	G
Owens, John	3M	
Owens, Mary	Eaton	
Parks, Owen	ABB	G
Peterson, Alan	Utility Service Corporation	
Peterson, Andrew	ABB	
Rakus, Paul	Eaton	G
Reid, Laura	Hubbell Power Systems	
Riffe, Dave	Westinghouse Electric Company	
Rohr, Richard	Powell Electrical Systems	
Salinas, Alex	Doble/Vanguard	
Shiller, Paul	FirstPower Group LLC	G
Sippel, Kevin	Eaton Electric	
Stemmerich, Joe	Trayer Engineering Corp.	
Sullivan, Paul	Dupont	
Thomas, Christo	Schneider Electric	
Weeks, Casey	Siemens Energy	G
Weisker, Jan	Siemens Energy	
Wen, Jerry	BC Hydro	
Wolfe, Dan	MEPPI	G
Worthington, Charles	Hubbell Power Systems	
Zaharko, Sam	MEPPI	G
Zehnder, Lukas	Hitachi	
Zhang, Wei	Hitachi	
Zia, Danish	UL LLC	

IEEE SA STANDARDS ASSOCIATION

IEEE

PC37.100.8

Type of Project: New IEEE Standard
Project Request Type: Initiation / New
PAR Request Date: 11 Oct 2022
PAR Approval Date:
PAR Expiration Date:
PAR Status: Submitted

1.1 Project Number: PC37.100.8
1.2 Type of Document: Guide
1.3 Life Cycle: Full Use

2.1 Project Title: Guide For Methodologies to Demonstrate the Expected Life of Lubricants Used in Switching Devices

3.1 Working Group: AdsCom - Guide for Methodologies to Demonstrate the Expected Life of Lubricants Used in Switching Devices(PE/SWG/C37.100.8)

3.1.1 Contact Information for Working Group Chair:
Name: John Harley
Email Address: jack@harleyinc.com

3.1.2 Contact Information for Working Group Vice Chair:
Name: Douglas J Edwards
Email Address: doug.edwards@ieee.org

3.2 Society and Committee: IEEE Power and Energy Society/Switchgear(PE/SWG)

3.2.1 Contact Information for Standards Committee Chair:
Name: Keith Flowers
Email Address: keith.flowers@ieee.org

3.2.2 Contact Information for Standards Committee Vice Chair:
Name: Douglas J Edwards
Email Address: doug.edwards@ieee.org

3.2.3 Contact Information for Standards Representative:
Name: Michael Wactor
Email Address: mwactor@ieee.org

4.1 Type of Ballot: Individual
4.2 Expected Date of submission of draft to the IEEE SA for Initial Standards Committee Ballot: Oct 2025
4.3 Projected Completion Date for Submittal to RevCom: Oct 2026

5.1 Approximate number of people expected to be actively involved in the development of this project: 12
5.2 Scope of proposed standard: The information in this guide is intended to assist in developing methodologies for establishing the expected life of lubricants as used in switchgear equipment including but not limited to:
- Automatic reclosers and sectionalizers
- Current limiting devices
- Fuses and cutouts
- Gas-insulated switchgear
- Metal-enclosed buses and all buses included in switchgear assemblies
- Power circuit breakers
- Switches, including pad-mounted switches
- Switchgear assemblies
- Switchgear devices

Lubricants used as a surface protectant, for applications other than reducing friction or wear, are not included.

5.3 Is the completion of this standard contingent upon the completion of another standard? No
5.4 Purpose: This document will not include a purpose clause.
5.5 Need for the Project: There is currently no IEEE standard about how the expected life of lubricants used in switchgear equipment is established. There is need to standardize expected life information for

planning and to provide methodologies that may be used to establish the expected life.

5.6 Stakeholders for the Standard: Users and manufacturers of switchgear equipment

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6.1 Intellectual Property

6.1.1 Is the Standards Committee aware of any copyright permissions needed for this project?
Yes

Explanation: Pending requests to share copyrighted documents within Working Group include:
- IEC 60947-1 (2020-04), LV Swgr and Controlgrear - Part 1 General Rules
- EN 50326 (2002-08), Conductors for overhead lines - Characteristics for greases

6.1.2 Is the Standards Committee aware of possible registration activity related to this project?
No

7.1 Are there other standards or projects with a similar scope? No

7.2 Is it the intent to develop this document jointly with another organization? No

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8.1 Additional Explanatory Notes:

Task Force: Methodologies to Demonstrate the Expected Life of Lubricants Used in Switching Devices

DRAFT TABLE OF CONTENTS

Expected Life of Lubricants
Methodology Discussion: Arrhenius Rate Model

Jack Harley – FirstPower Group LLC
Paul Shiller – FirstPower Group LLC

Overview

- Background Information
- Chemistry of oxidation of grease and significance of:
  - ASTM D942 Standard Test Method for Oxidation Stability of Lubricating Greases by the Oxygen Pressure Vessel Method
  - ASTM D5483 Standard Test Method for Oxidation Induction Time of Lubricating Greases by Pressure Differential Scanning Calorimetry
- Arrhenius’ contribution – the rate model
- Determining rate of degradation of a sample grease - Mobilgrease 28

Background Information

- It is desired to obtain a grease which could last maintenance free for a specified amount of time.
- In order to accomplish this, the mechanism in which the grease degrades should be understood.

  - What is the failure mode?

  - What does this mean on a chemical basis?

  For example: If the grease is oxidizing and forming varnishes, a major cause of loss of grease life, focus should be on modeling the rate of oxidation and varnish formation.

Oxidation Reaction Basics

Oxidation of grease has multiple initiators. Two common ones are oxygen and moisture

- Oxygen causes oxidation of hydrocarbon greases through reaction with unsaturated bonds. This is the case with surfaces mostly at rest.
- Moisture oxidizes grease in bearings due to the catalytic decomposition of water into OH and H on the iron surfaces of the raceway. This is the case with surfaces mostly in motion.

Oxidation Reaction Basics (cont.

ASTM D5483 and ASTM D942 are two standards for rating antioxidant packages of greases for quality control purposes.

- This oxidation reaction is detected by a sudden change in temperature (ASTM D5483) or pressure (ASTM D942).

When the anti-oxidant is used up by the temperature or pressure, the oil begins to oxidize.

Arrhenius’ Contributions

Svante Arrhenius, a Swedish scientist, introduced the term activation energy in 1889.

- Activation Energy is defined as the minimum energy required to start a chemical reaction. Usually shown as $\mathbf{E_a}$ with units kilojoules per mole
- He used $\mathbf{E_a}$ to show the dependence of the rate **k** per second of chemical reactions on temperature **T**, absolute kelvin.
- **A** is the pre-exponential factor or frequency factor
- **R** is the universal gas constant

Arrhenius Equation

Putting the factors together:

$$k = Ae^{\left(-E_A/_{RT}\right)}$$

k is number of collisions that result in a reaction per second

A is the total number of collisions per second leading to a reaction or not

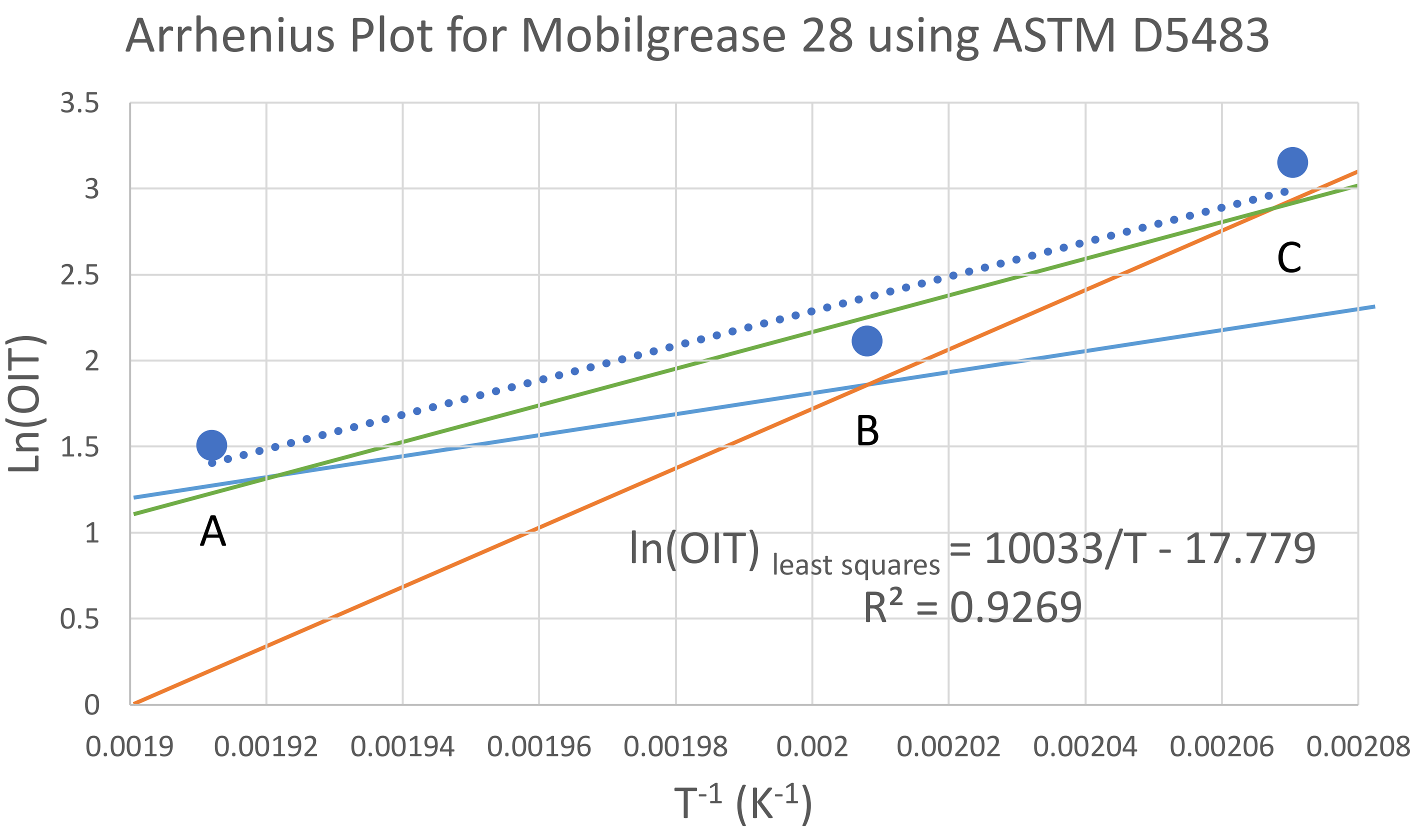
$e^{\left(-E_A/_{RT}\right)}$ is the probability that any given collision will result in a reaction

Increasing the temperature or decreasing the activation energy, e.g. through exposure to catalysts, results in an increase in the rate of reaction.

What Can Go Wrong?

- ASTM D5482 and ASTM D942 are designed to determine if the antioxidant package for a specific grease has lost its potency.
- The tests do not provide an accurate model for the formation of varnishes or the destabilization of grease thickeners because the test is designed specifically to ignore them.
- Exponential modelling requires very high precision, which is not adequately done with these generalized models.

Example: Arrhenius Precision Requirements
The scattering in this graph illustrates the accuracy



- OIT is "Oxidation Induction Time" in minutes.
- A minimum of 2 data points is required to determine the regression model. This enables 4 regression lines to be generated:
  - $\ln(OIT)_{AB} = 16669.44/T - 31.3626$
  - $\ln(OIT)_{BC} = 6291.694/T - 10.52371$
  - $\ln(OIT)_{AC} = 10378.71/T - 18.33828$
  - $\ln(OIT)_{\text{least squares}} = 10033/T - 17.779$

P. Bessette. "Testing Greases to Determine their Suitability for the Long Term Lubrication of Electric Grid Circuit Breakers." European Lubricating Grease Institute Annual General Meeting. 2012.

Example: Arrhenius Precision Requirements - Data

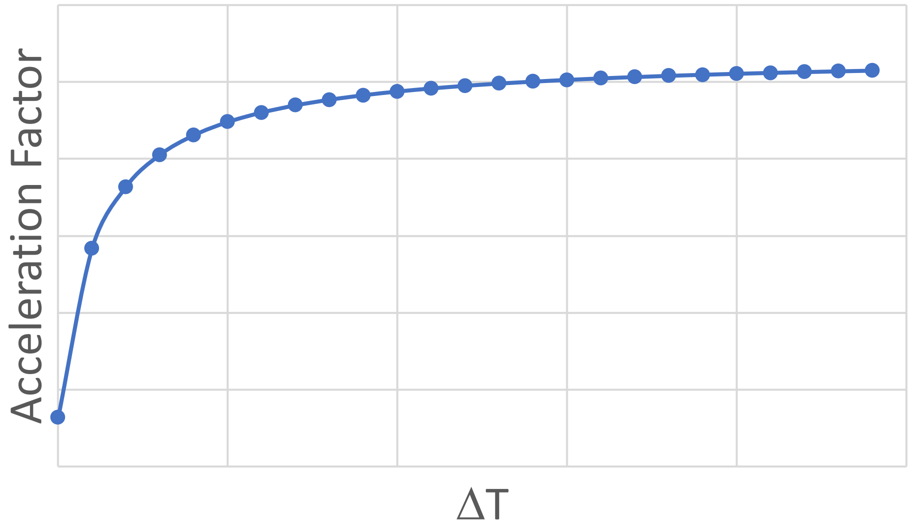
Regression Equation	Activation Energy (J/mol)	Ln(OIT) at 40°C (313K)	"Years to Failure" at 40°C
$\ln(OIT)_{AB} = 16669.44/T - 31.3626$	-138590	21.89	6137
$\ln(OIT)_{BC} = 6291.694/T - 10.52371$	-52309	9.578	0.02746
$\ln(OIT)_{AC} = 10378.71/T - 18.33828$	-86289	14.82	5.198
$\ln(OIT)_{\text{least squares}} = 10033/T - 17.779$	-83414	14.28	3.013

- **Given the precision of the test data, Mobilgrease 28 could be expected to last somewhere between 9.88 days and 6137 years.**

- The test data needs to be very precise to accomplish this, which goes beyond the scope of the ASTM test.

Keys to a good Arrhenius Model

1. Know the reaction mechanism.
   - ASTM D5483 and ASTM D942 use a dry environment, which negates the catalytic effects of moisture as an oxidizer.
2. Keep accelerated temperatures as close to operating temperatures as possible.
   - As ΔT increases, the level of precision needed increases.
   - At higher temps, mechanism may change.



References

- https://polymerdatabase.com/polymer%20chemistry/Phenolic%20Antioxidants.html
- https://patentimages.storage.googleapis.com/c9/ad/49/b987e501415fc7/US3116247.pdf
- https://www.machinerylubrication.com/Read/192/water-contaminant-oil

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