Appendix A

Photographs from the Effects of Temperature on Stem Lubricants Testing

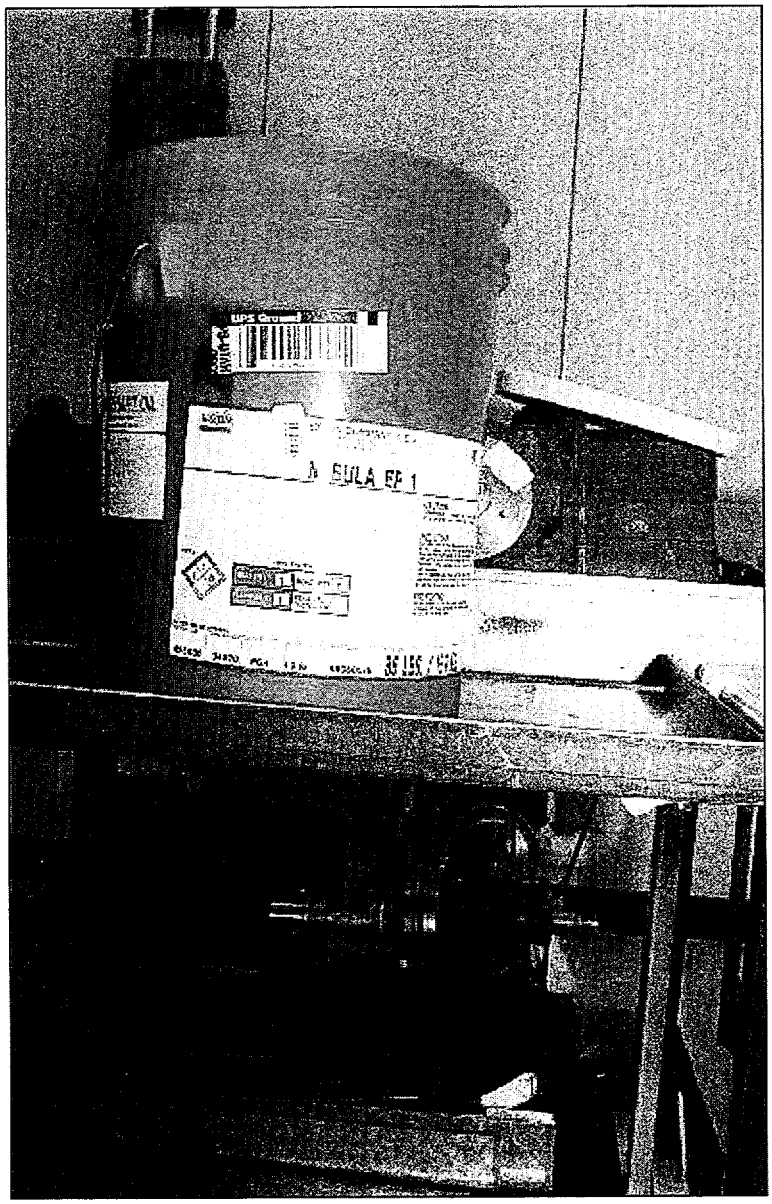

Figure A-42. New Exxon Nebula EP1 was used for the elevated temperature testing.

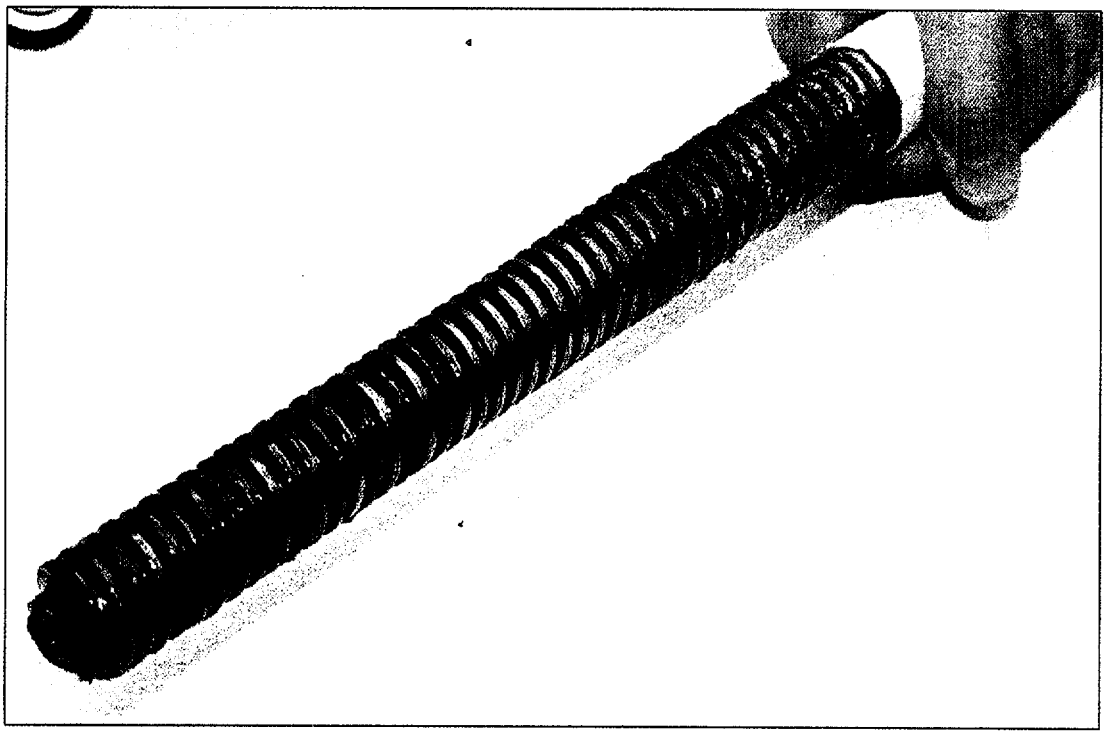

Figure A-43. After testing, the EP1 had changed from tan to brown and had hardened.

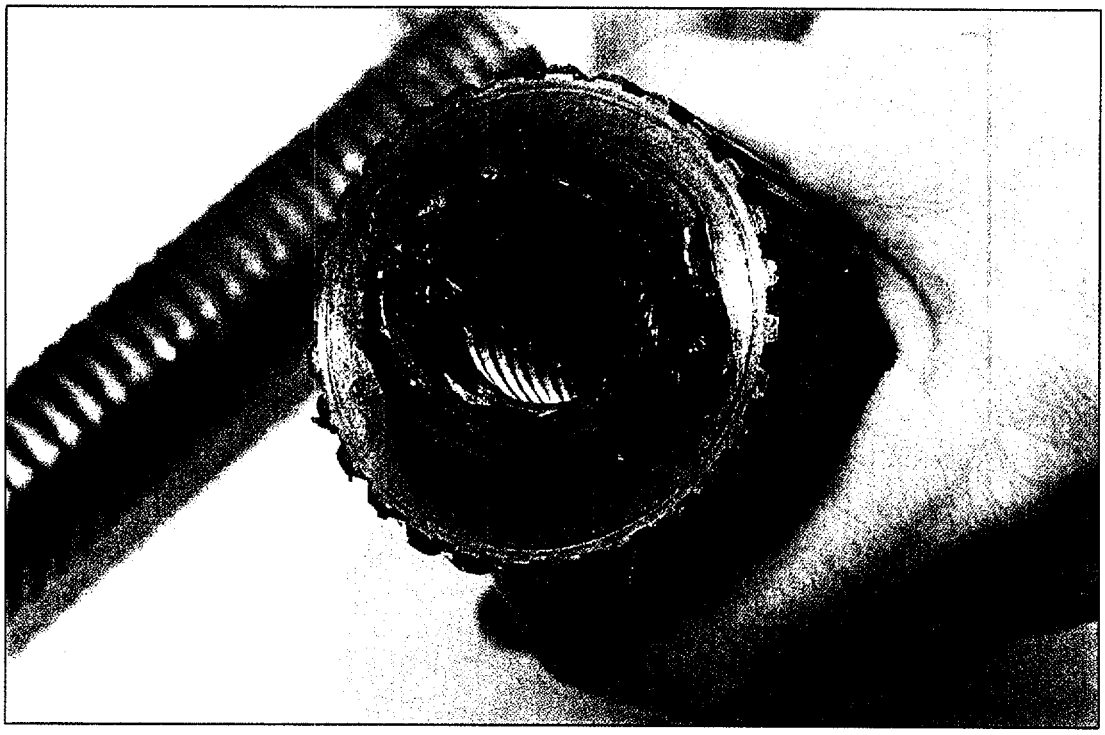

Figure A-44. After testing, the EP1 had hardened inside the stem nut.

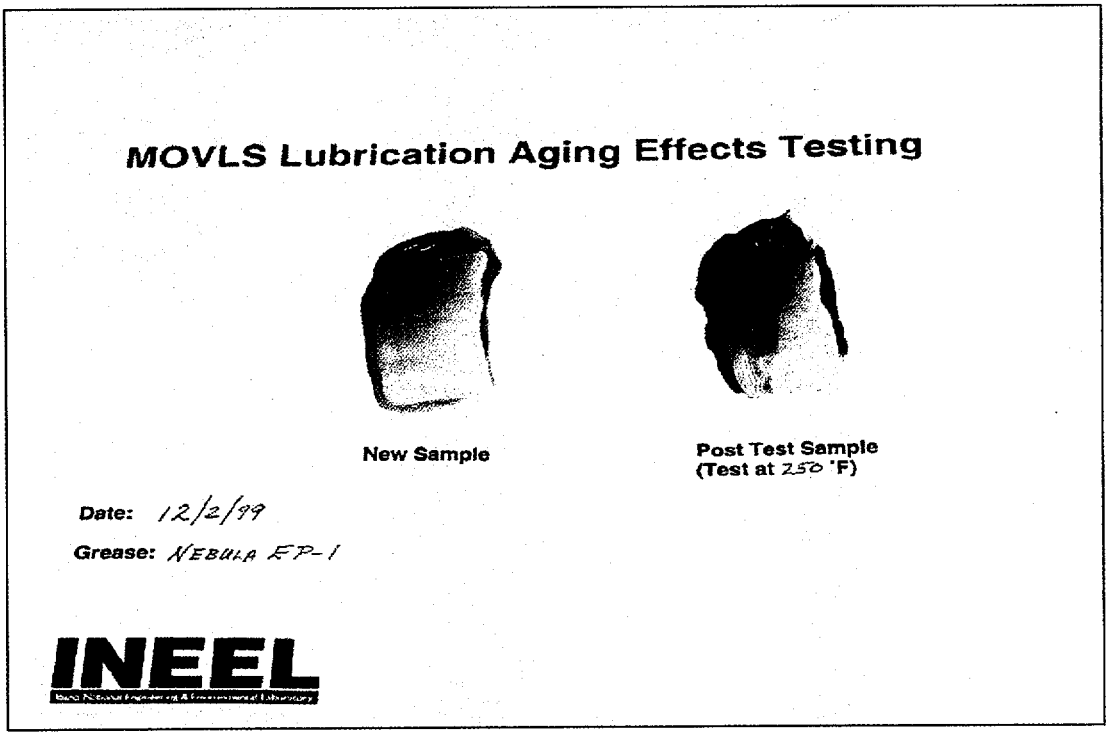

Figure A-45. Nebula EP1 smear comparison.

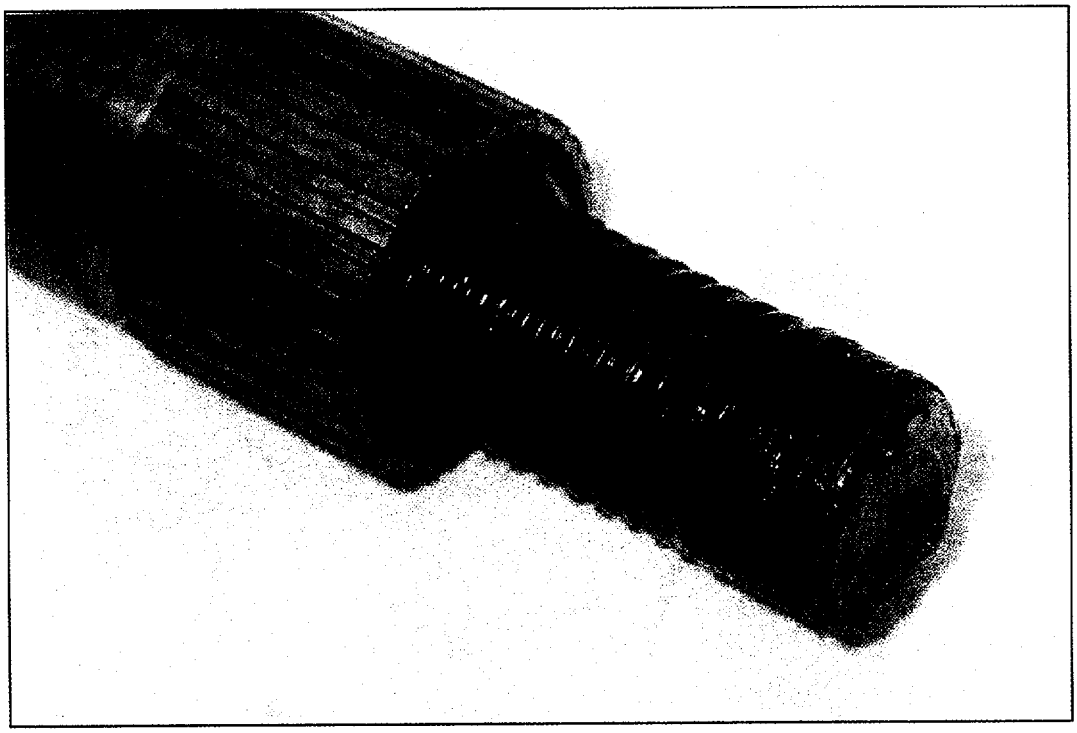

Figure A-46. After testing, the EP1 had changed from tan to brown and had hardened.

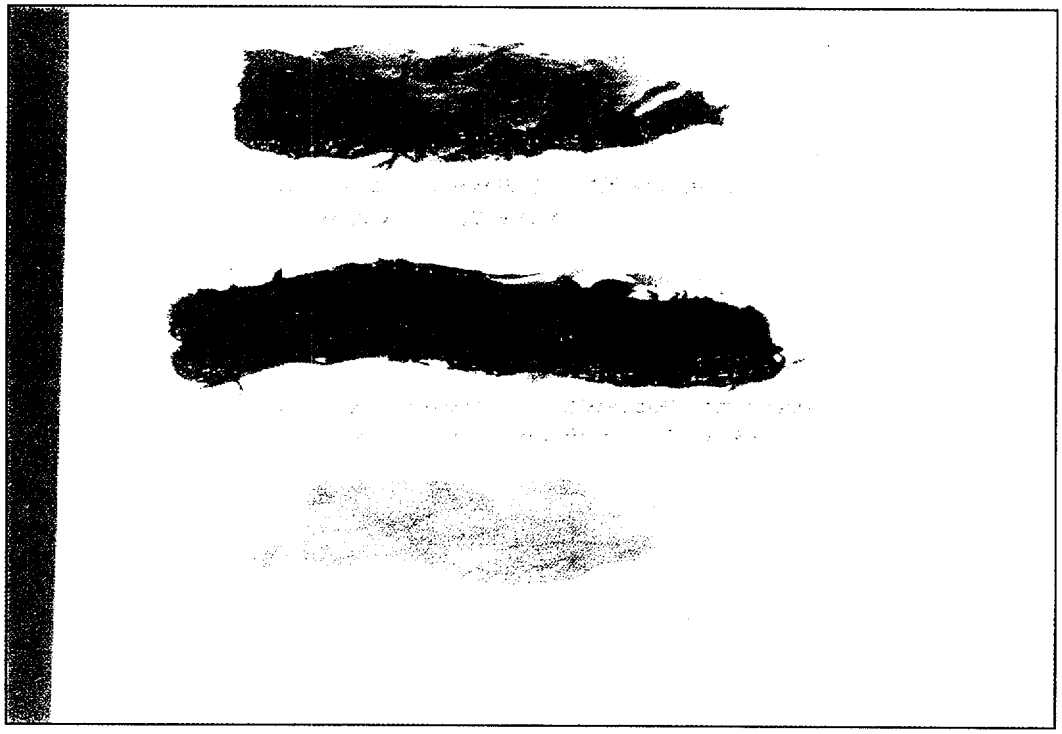

Figure A-47. EP1 smear.

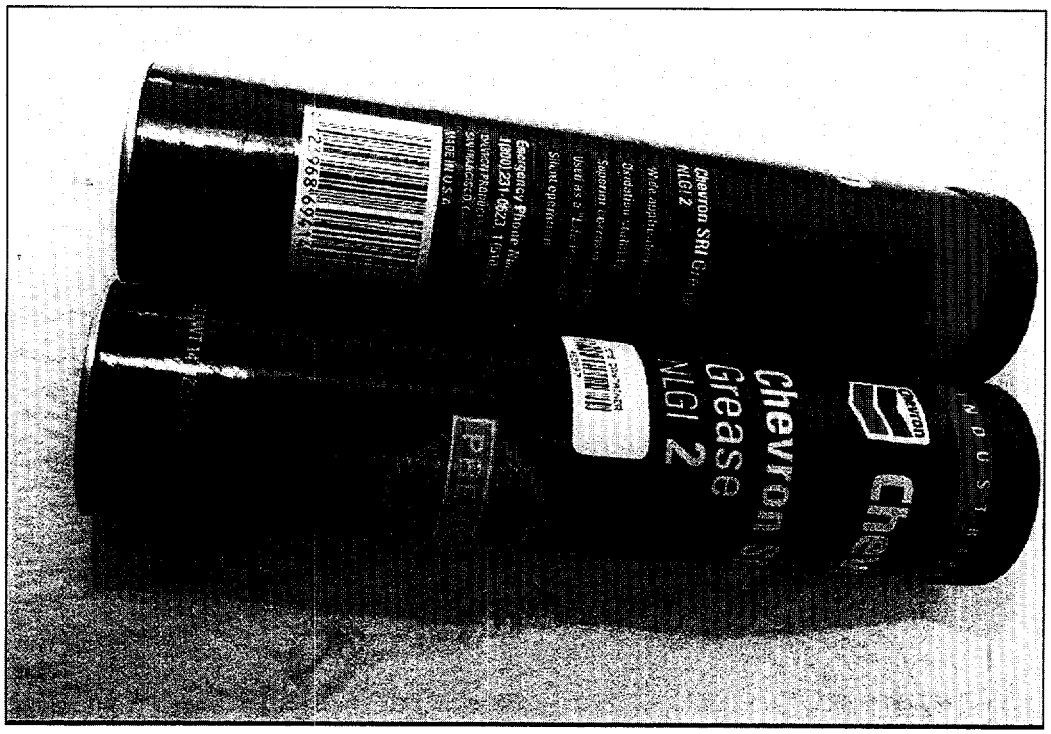

Figure A-48. New Chevron SRI was used for the elevated temperature testing.

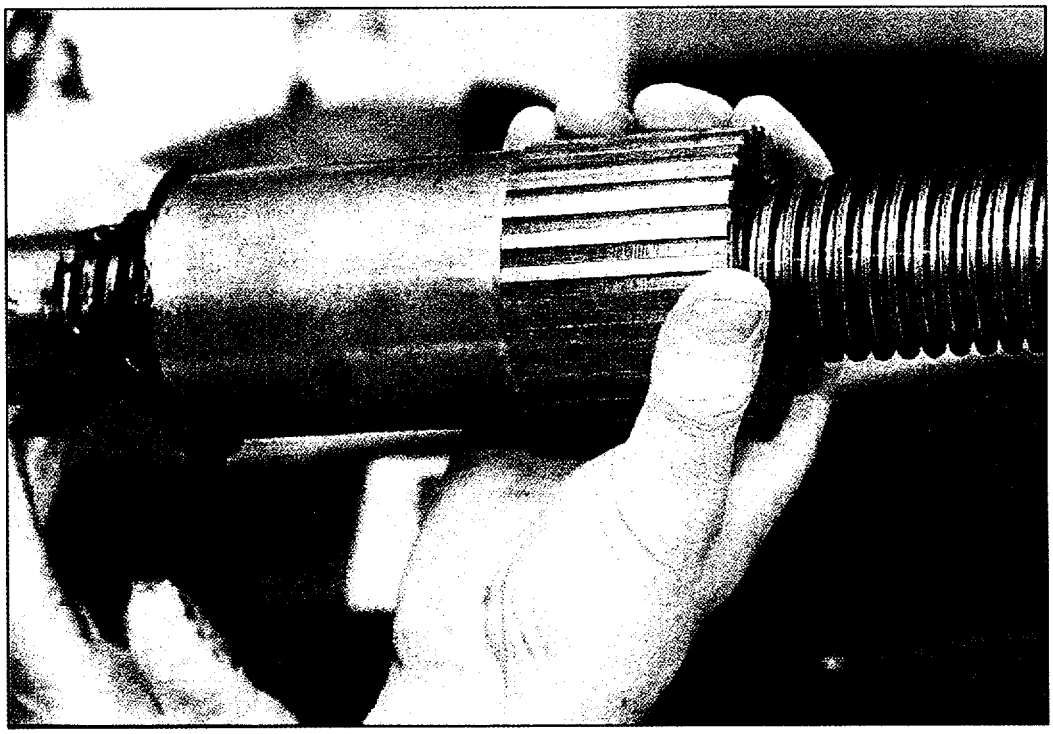

Figure A-49. A thin coat of SRI was applied each stem.

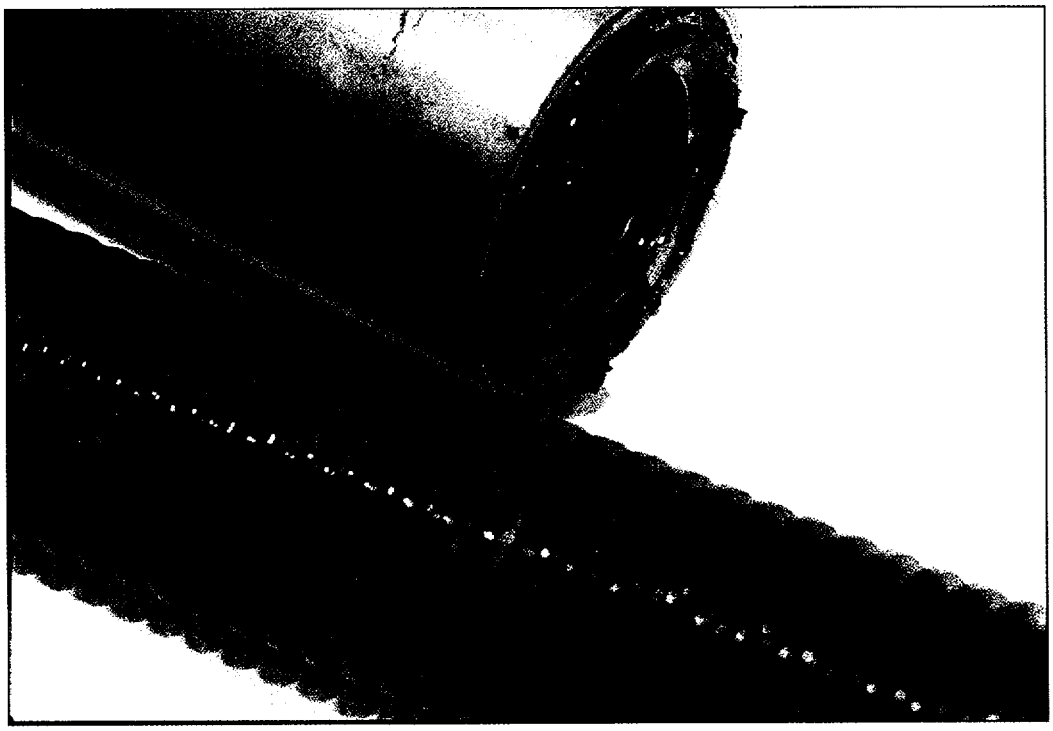

Figure A-50. After testing, the SRI had changed to dark brown and hardened.

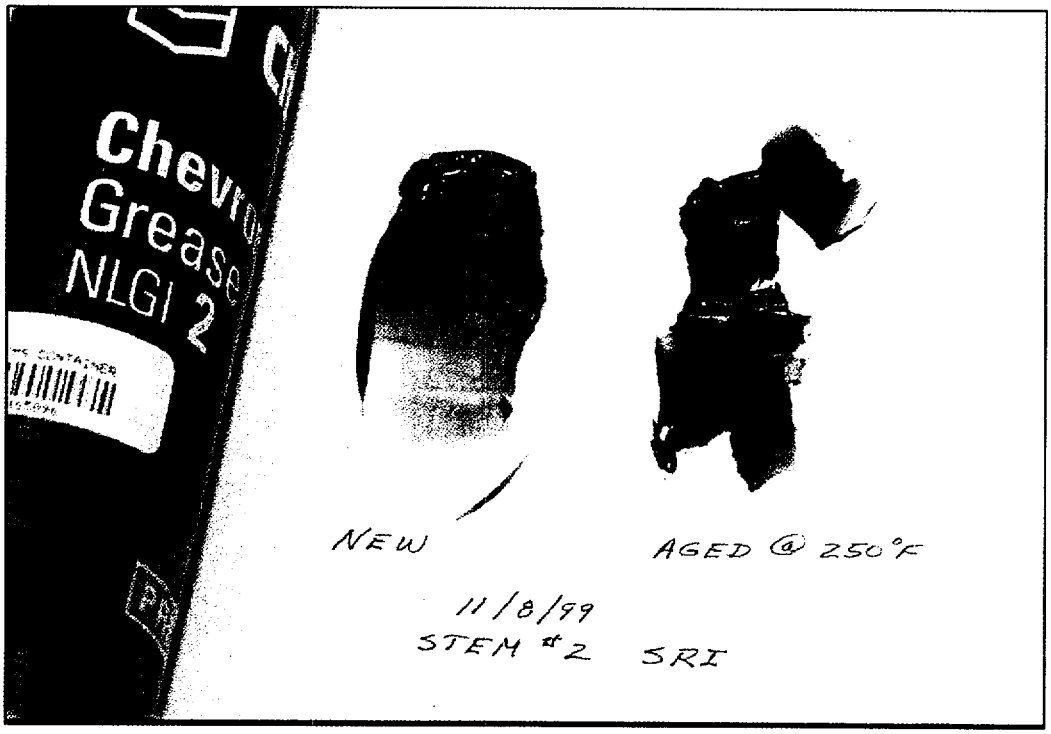

Figure A-51. Chevron SRI smear comparison.

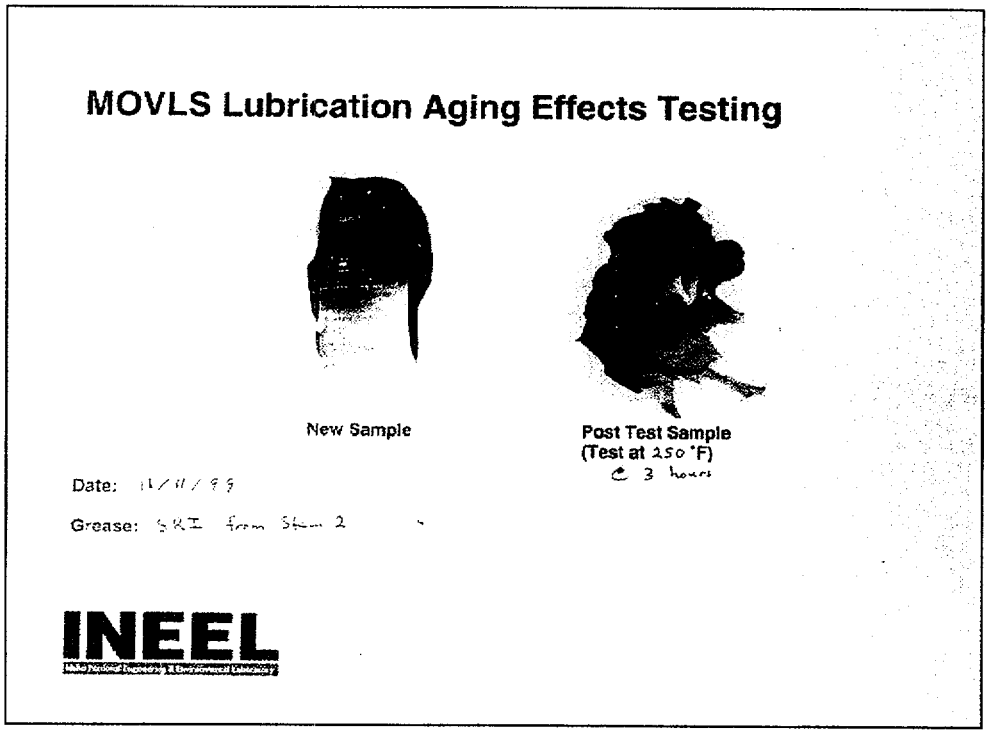

Figure A-52. After several days, the oil absorption into the paper indicates similar oil content.

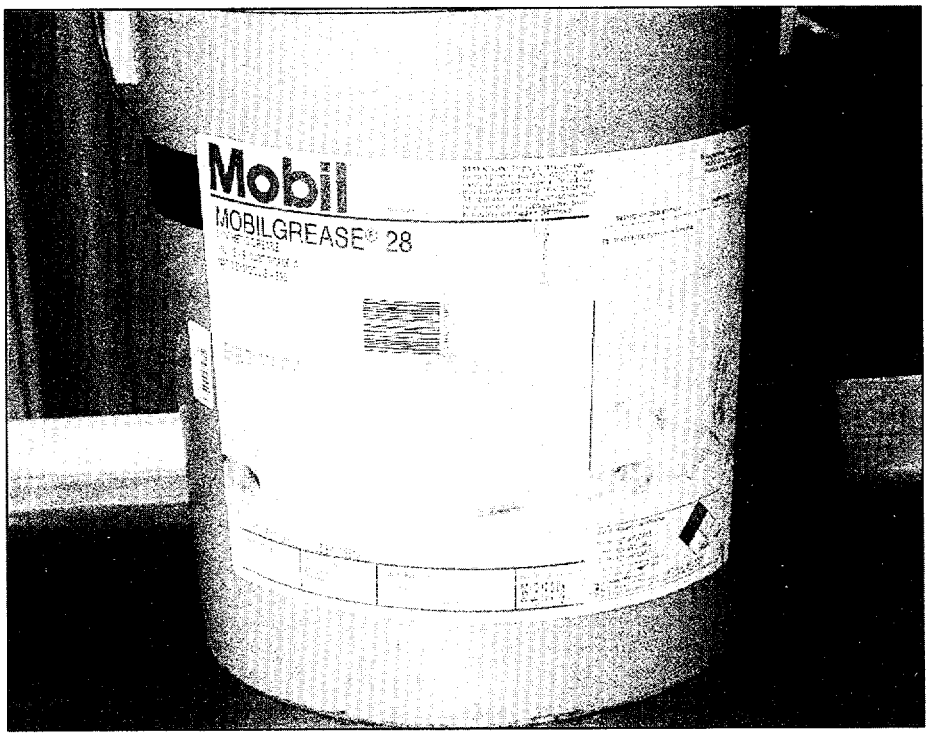

Figure A-53. New Mobil MobilGrease 28 was used for the elevated temperature testing.

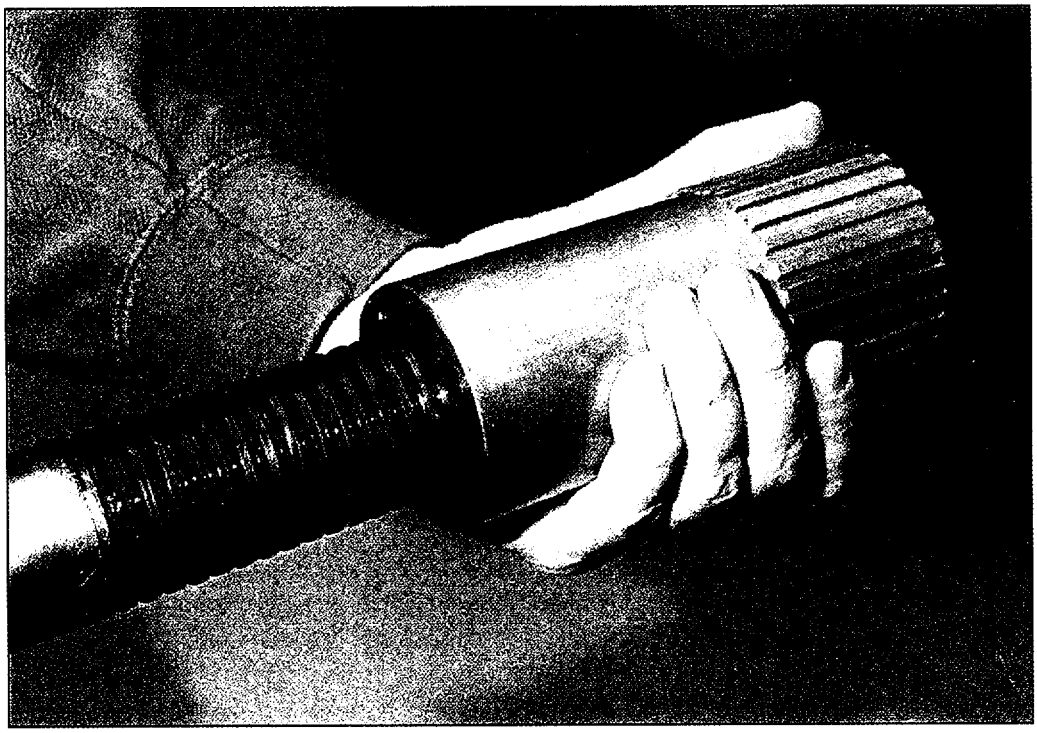

Figure A-54. A thin coat of M28 was applied to each stem.

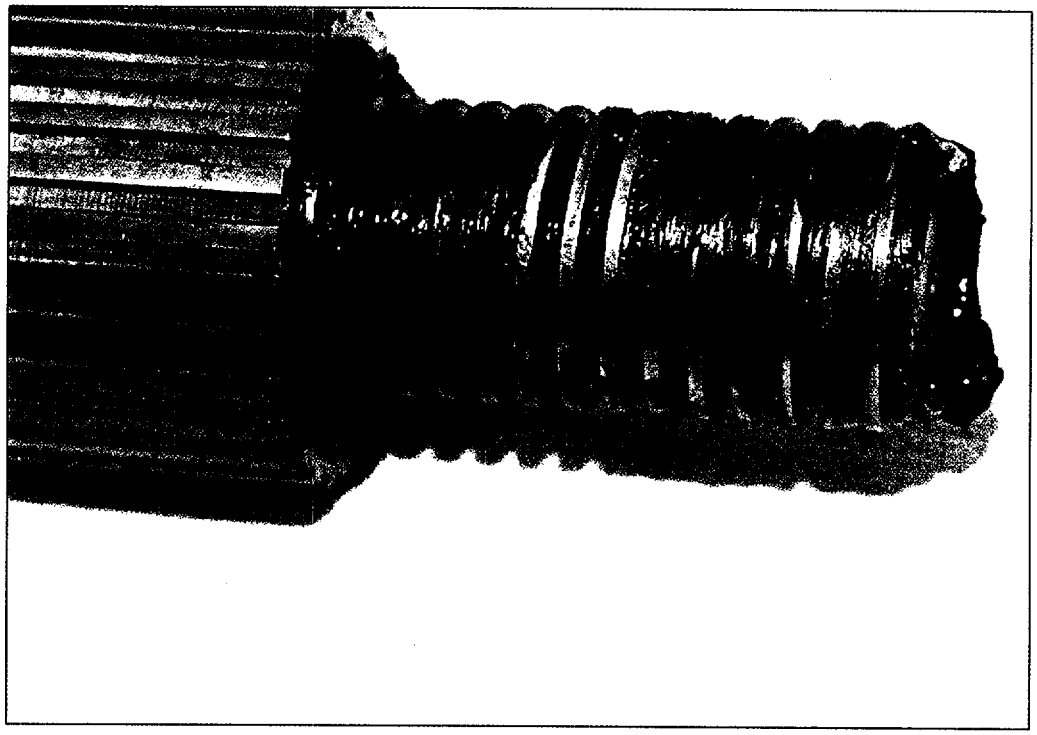

Figure A-55. After testing, the M28 had changed almost to black and had hardened.

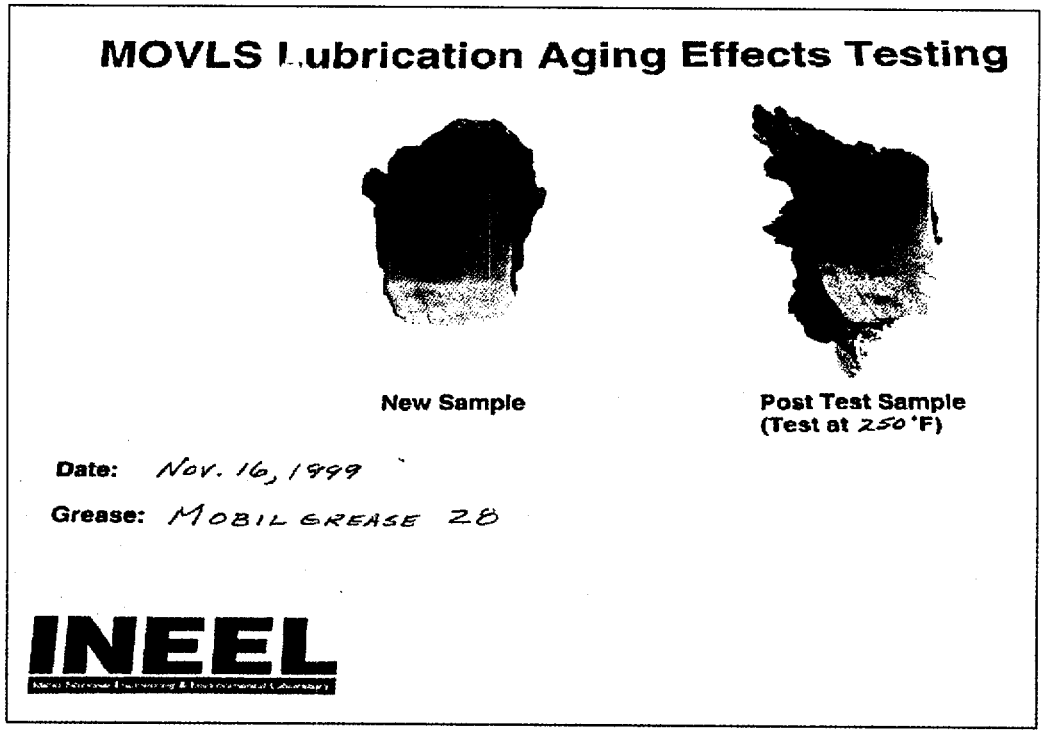

Figure A-56. Mobil 28 smear comparison.

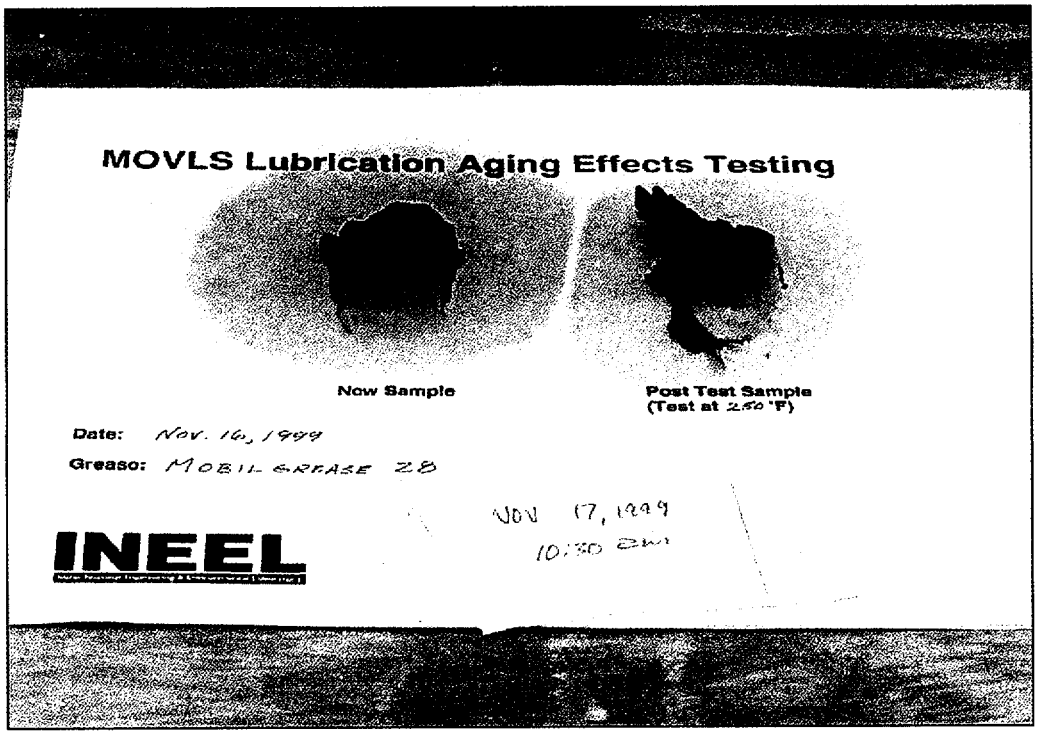

Figure A-57. After several days, the radius of absorption is half the new sample.

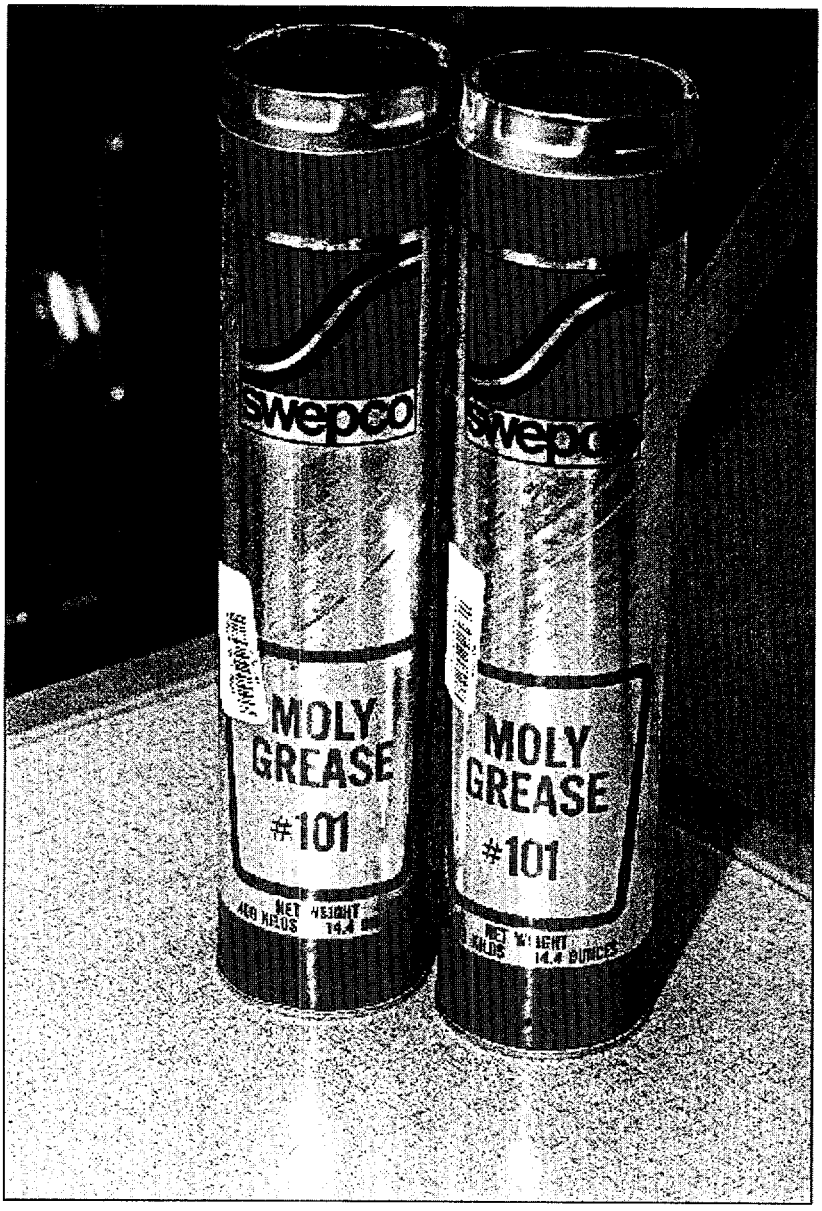

Figure A-58. New SWEPCO Moly 101 was used for the elevated temperature testing.

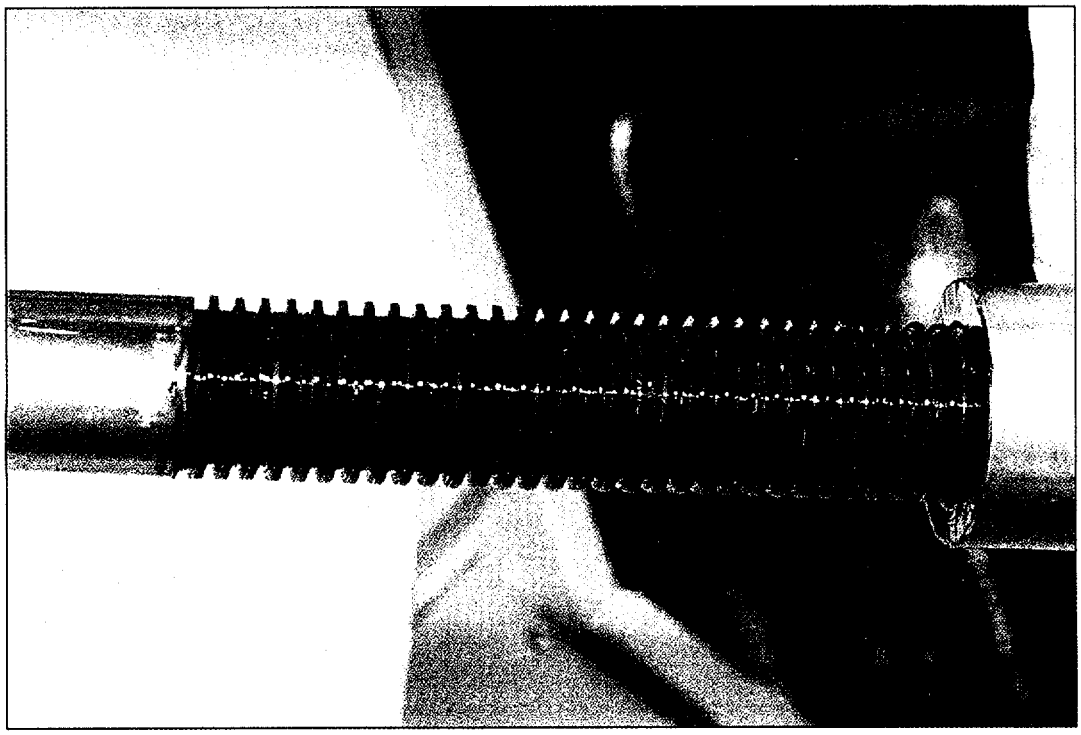

Figure A-59. A thin coat of Moly 101 was applied to each stem.

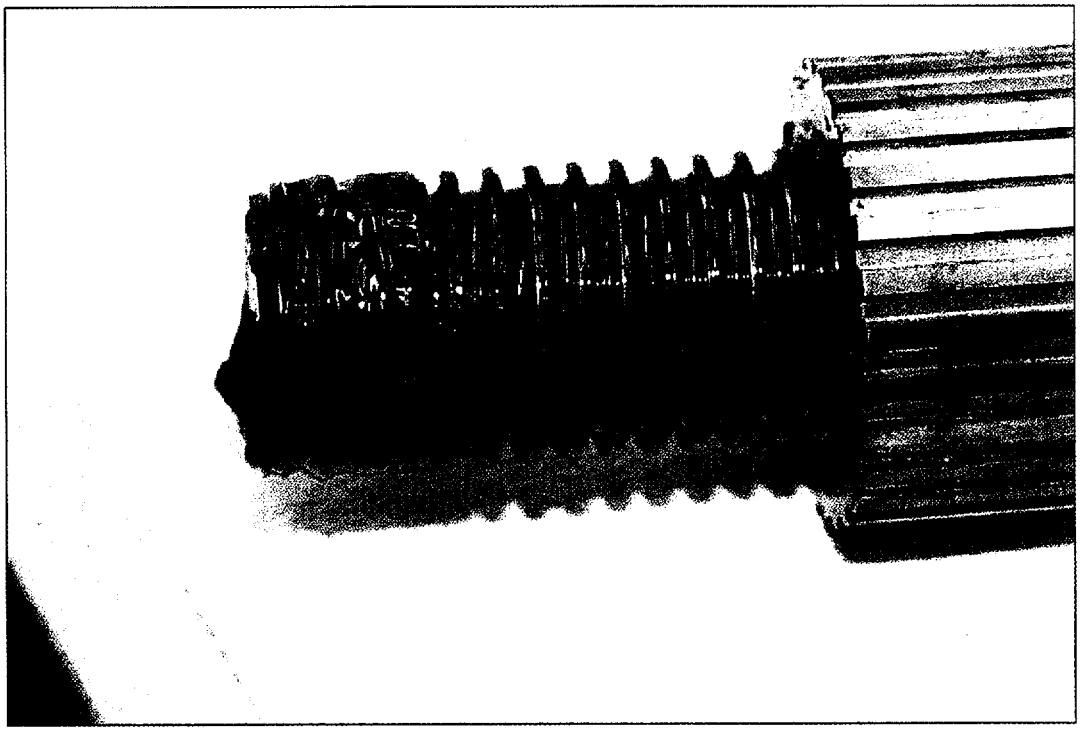

Figure A-60. After testing, the Moly 101 had thickened.

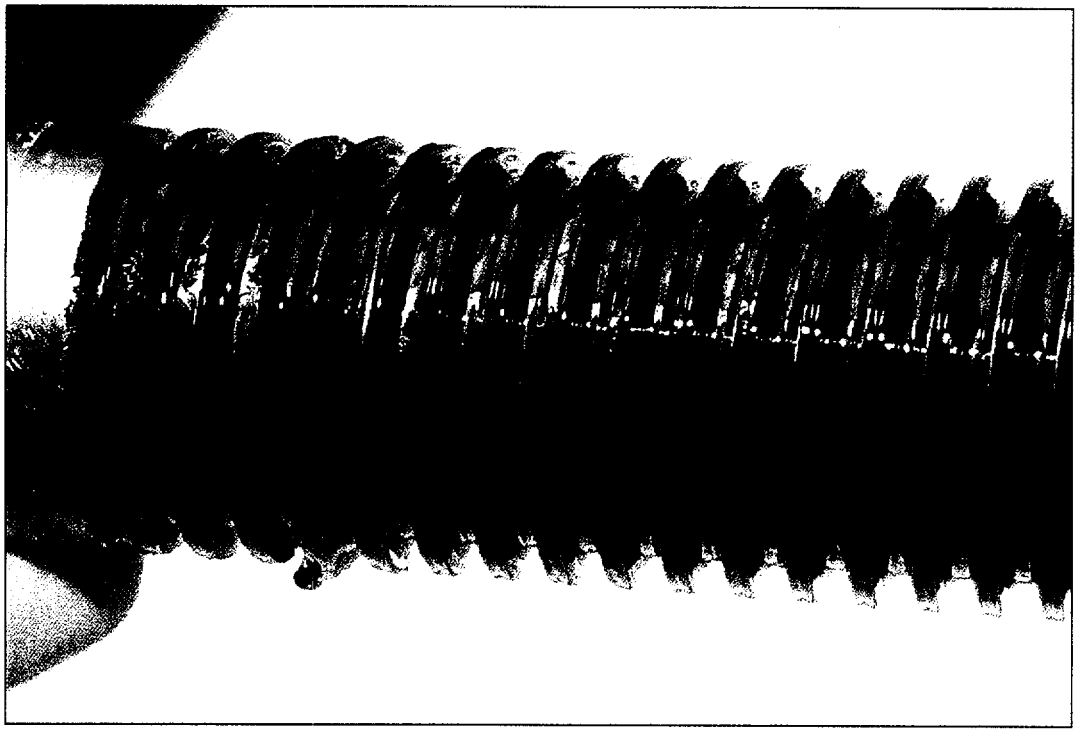

Figure A-61. After testing, the Moly 101 had thickened.

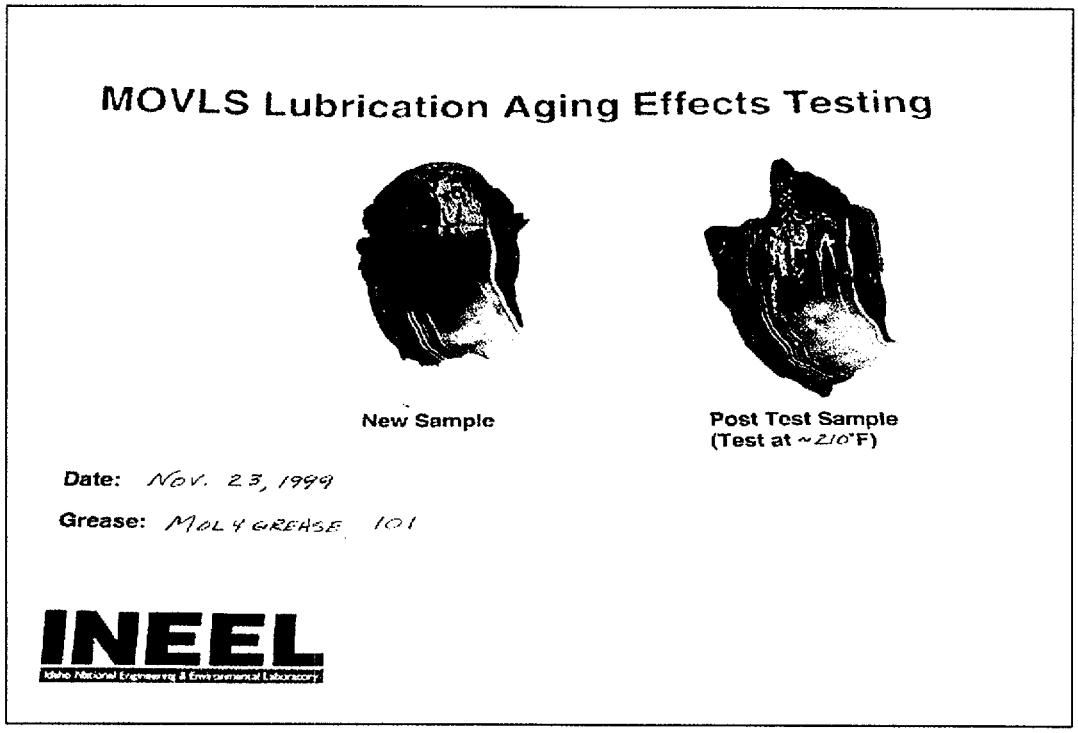

Figure A-62. Moly 101 smear comparison.

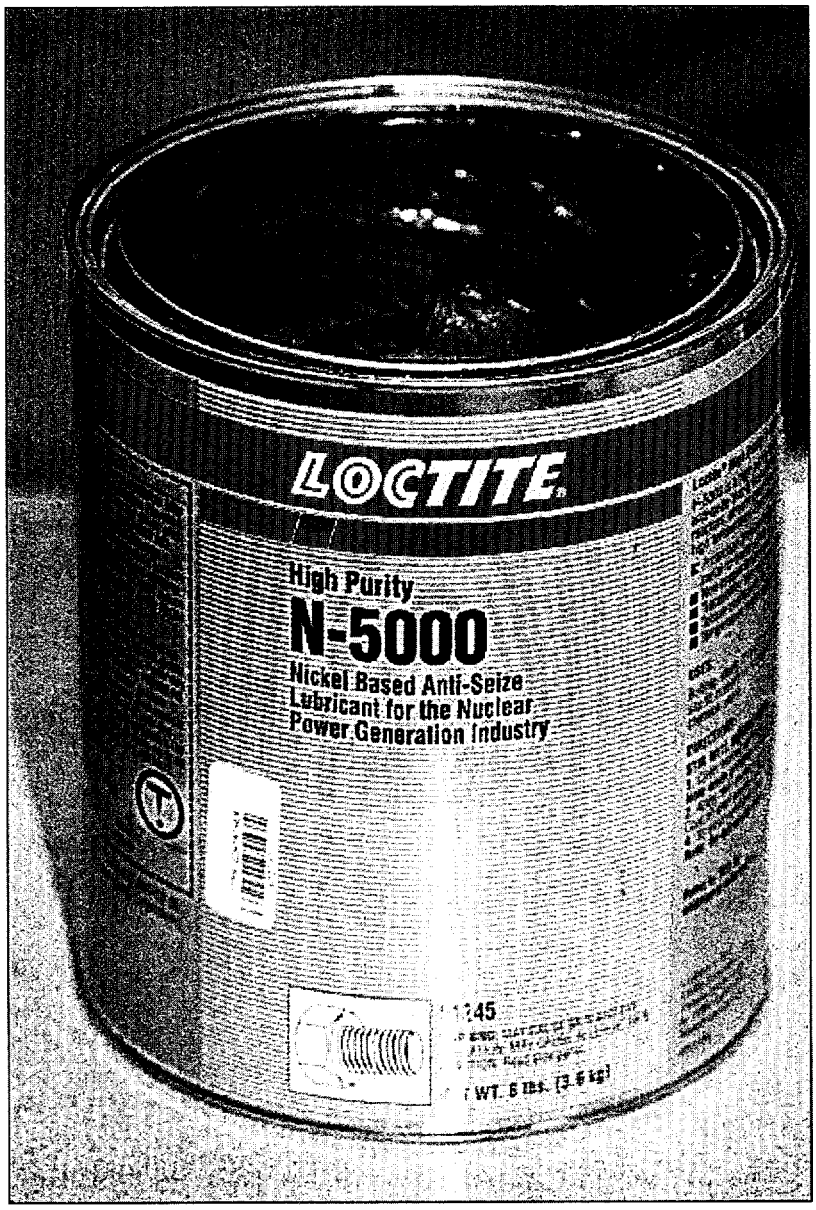

Figure A-63. New LOCTITE N-5000 Anti-Seize was used for the elevated temperature testing.

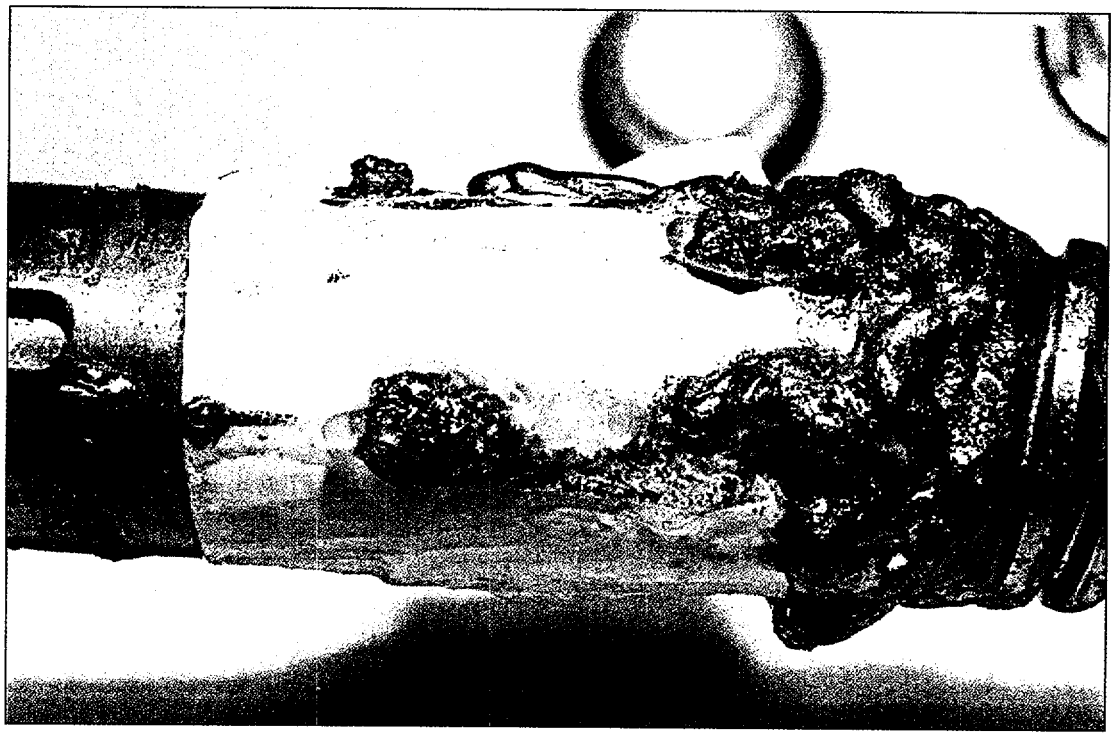

Figure A-64. After testing, the N-5000 had separated and moved down the stem.

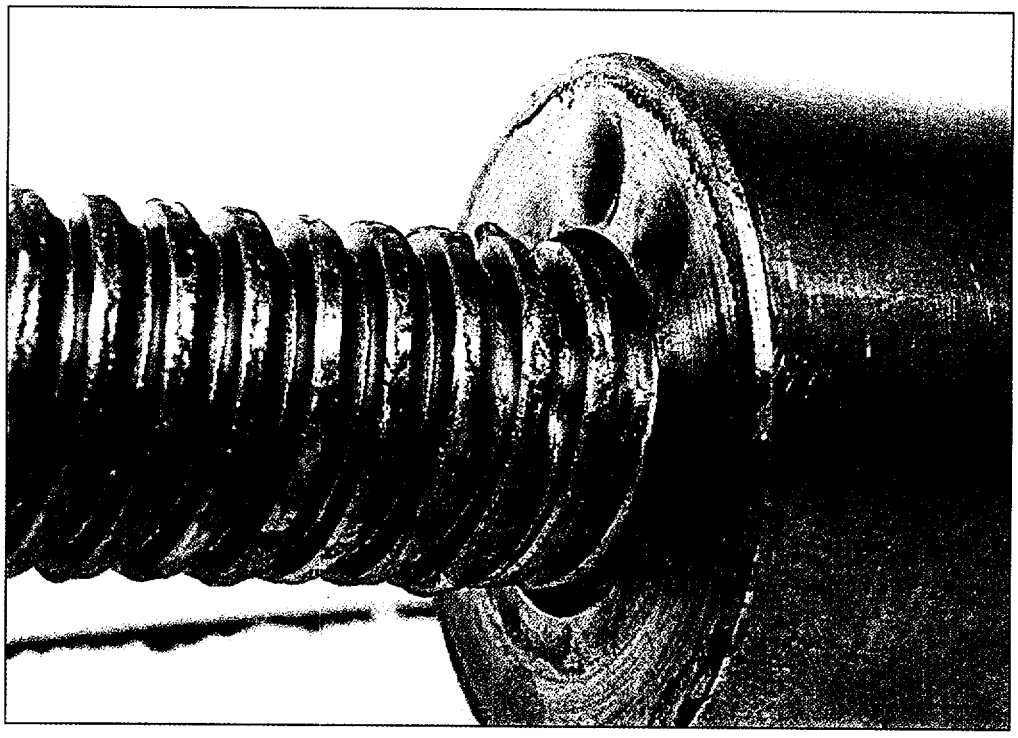

Figure A-65. After testing, the N-5000 had separated and dripped from the stem nut.

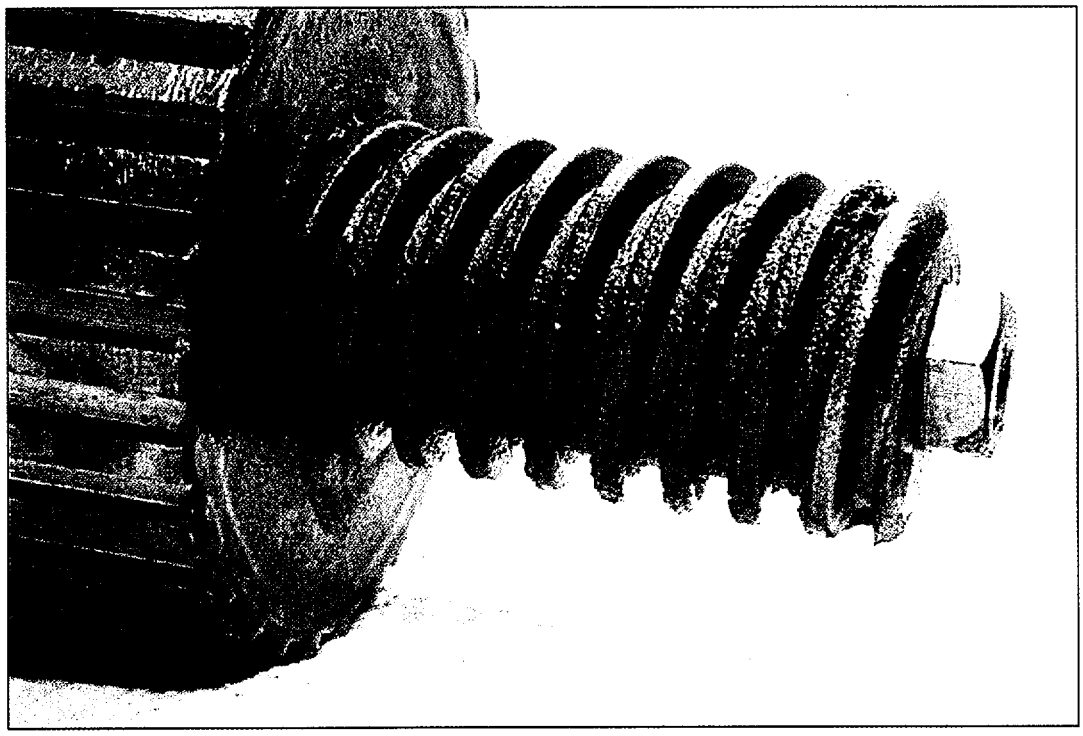

Figure A-66. The N-5000 above the stem nut travel appeared to be unchanged.

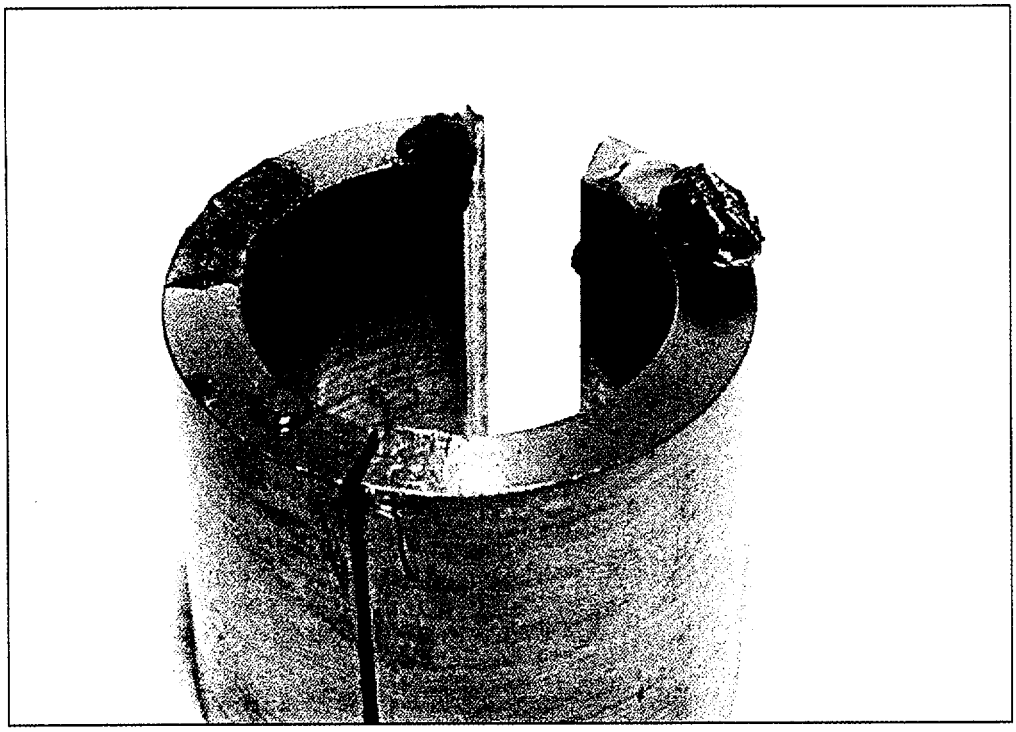

Figure A-67. Several drips of clear and silver-colored portions of the N-5000 landed on the stem spacer.

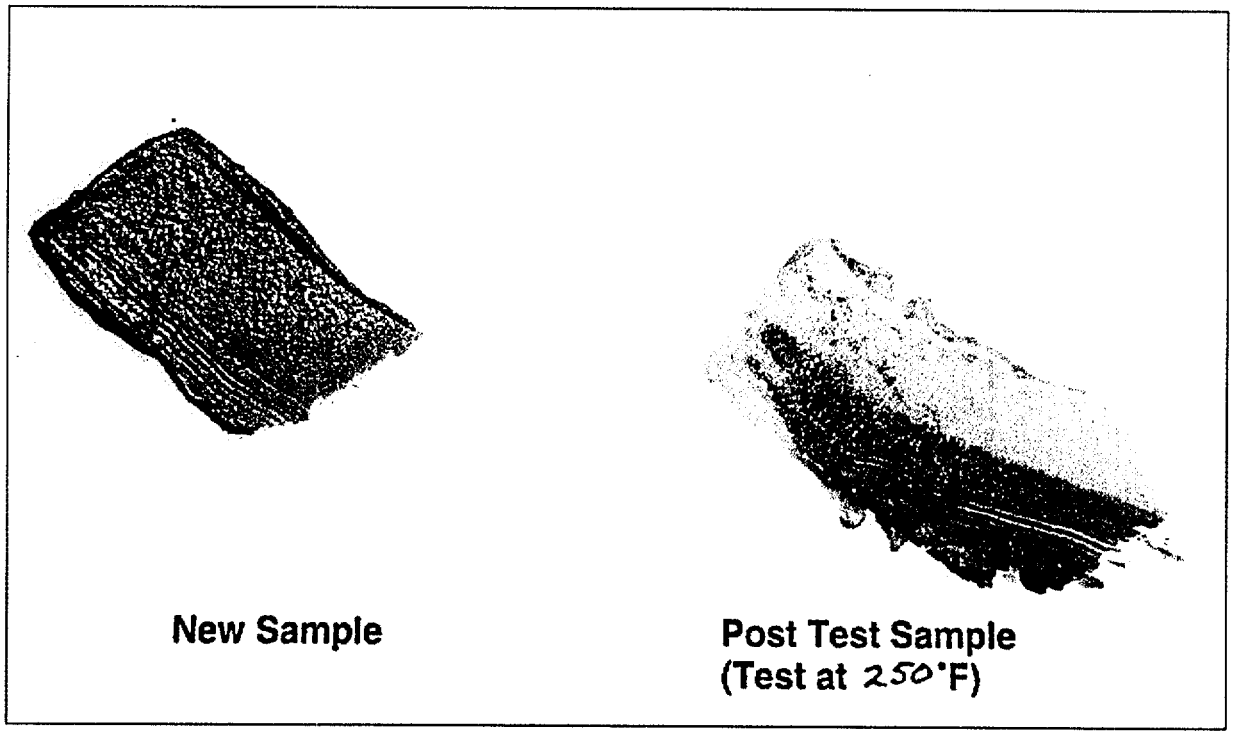

Figure A-68. N-5000 smear comparison.

Appendix B

Change in Friction at Elevated Temperature

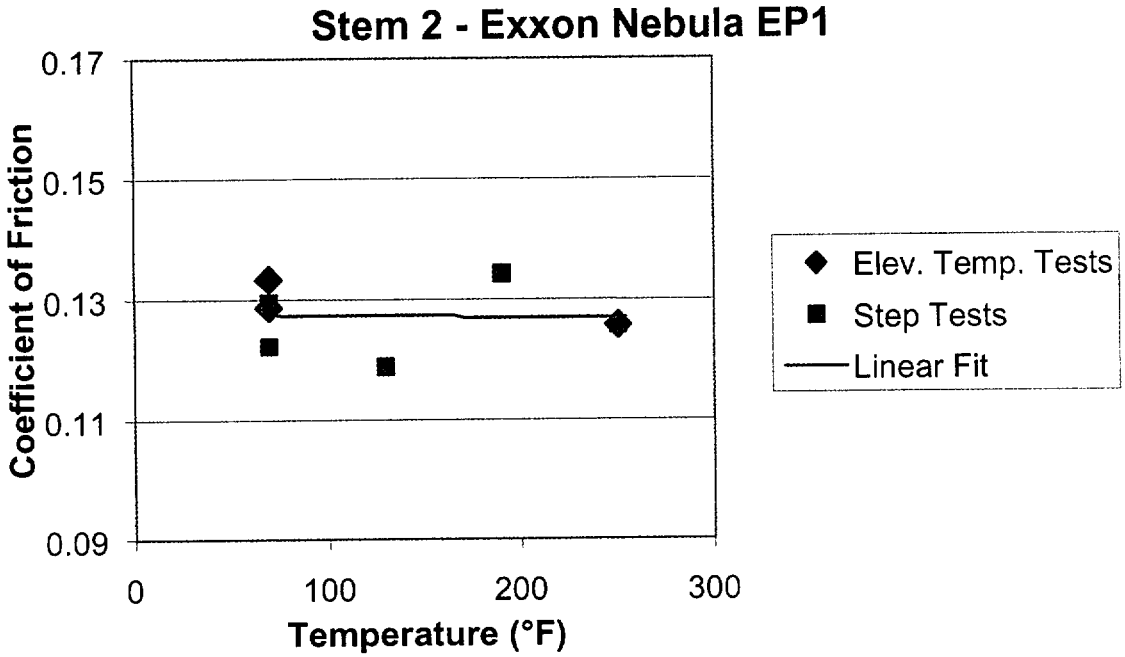

Figure B-1. The change in stem nut friction for stem 2 with EP1 at elevated temperature.

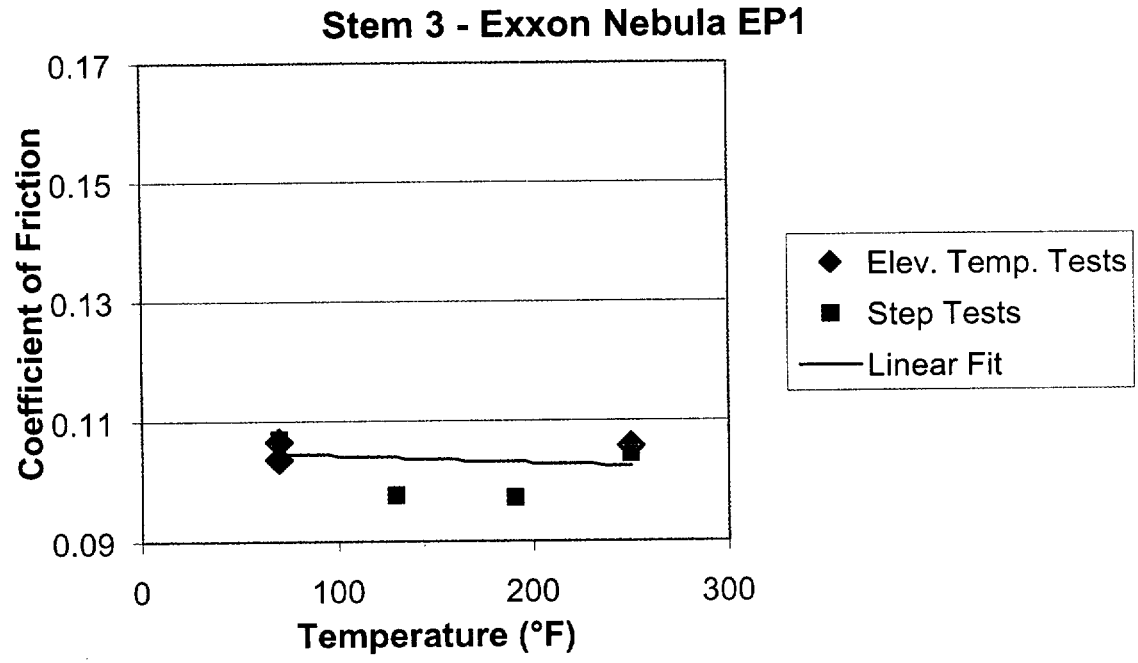

Figure B-2. The change in stem nut friction for stem 3 with EP1 at elevated temperature.

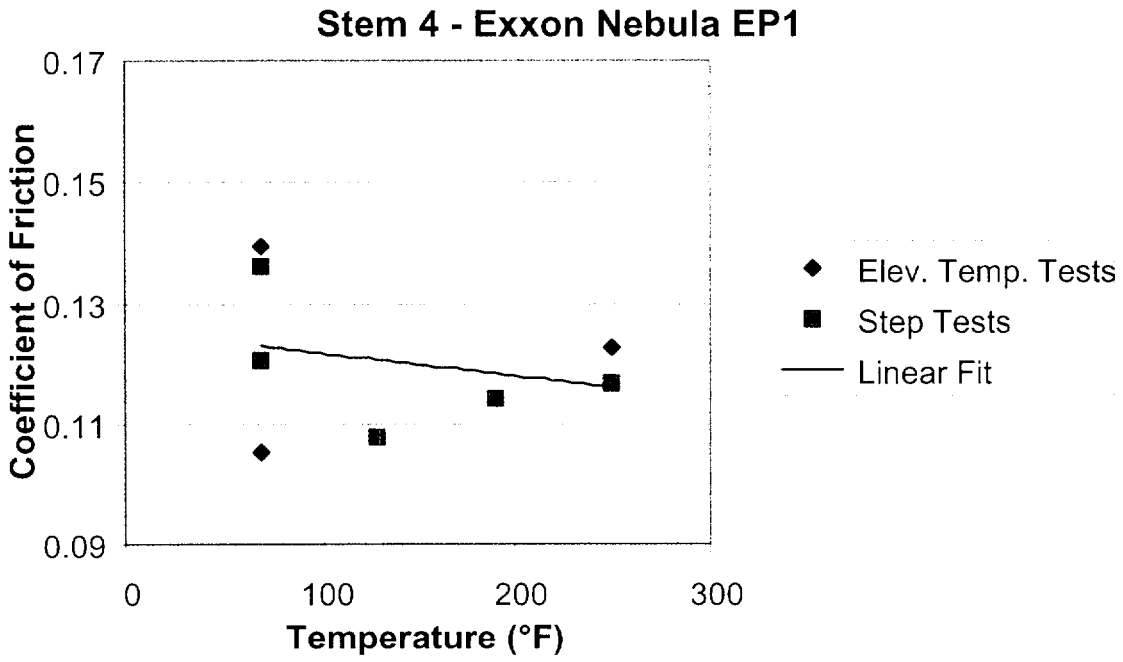

Figure B-3. The change in stem nut friction for stem 4 with EP1 at elevated temperature.

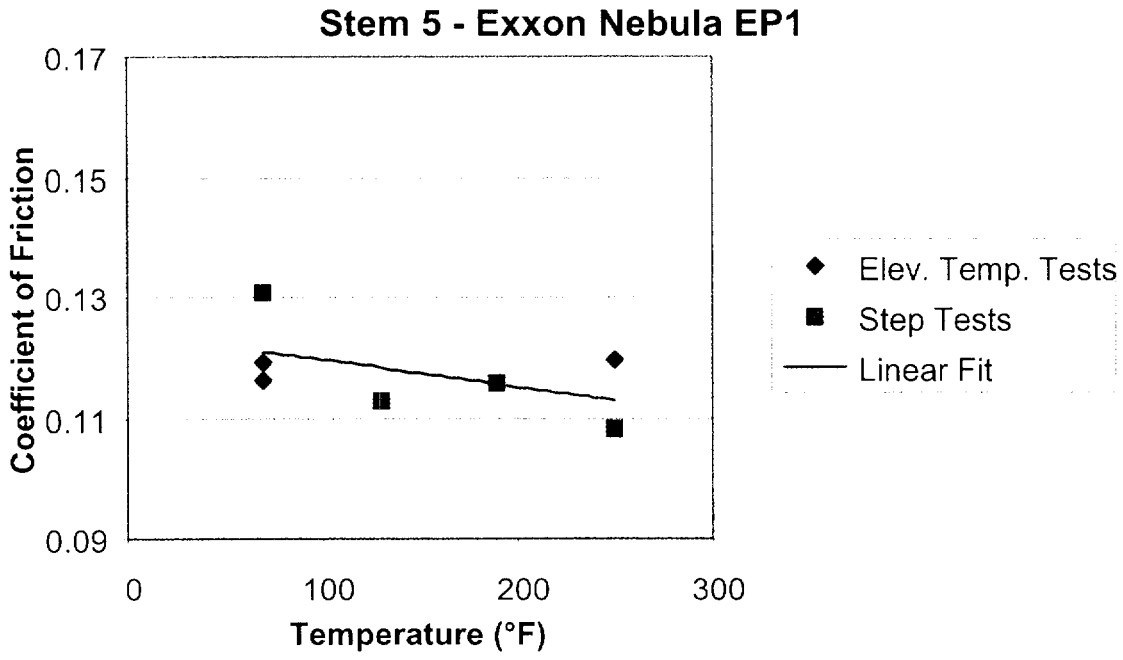

Figure B-4. The change in stem nut friction for stem 5 with EP1 at elevated temperature.

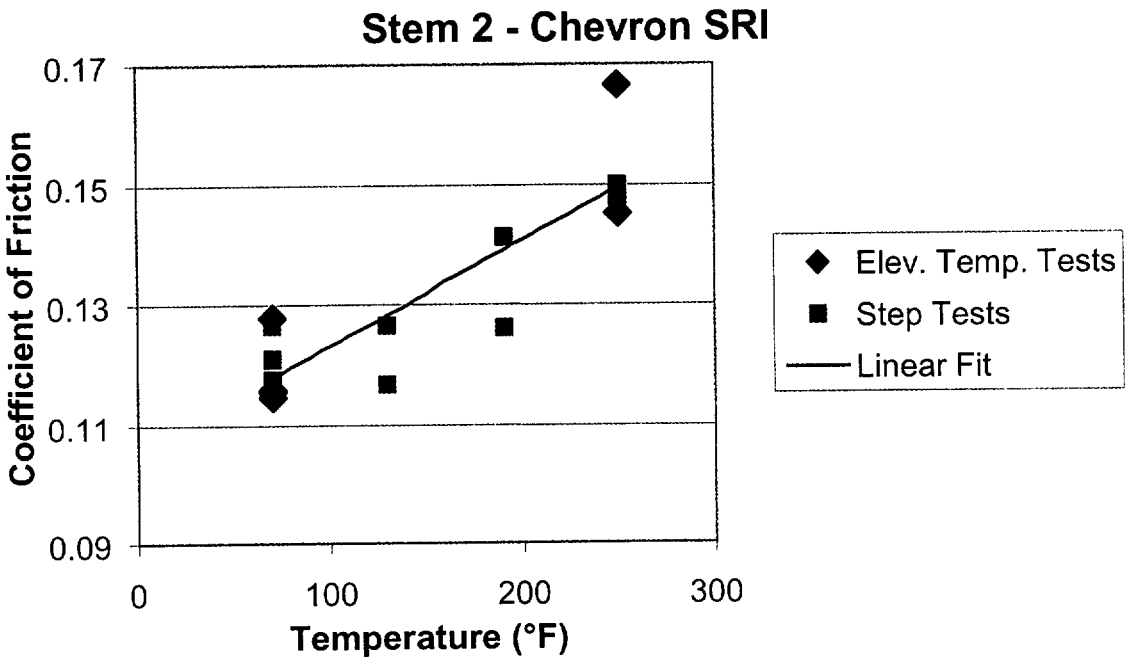

Figure B-5. The change in stem nut friction for stem 2 with SRI at elevated temperature.

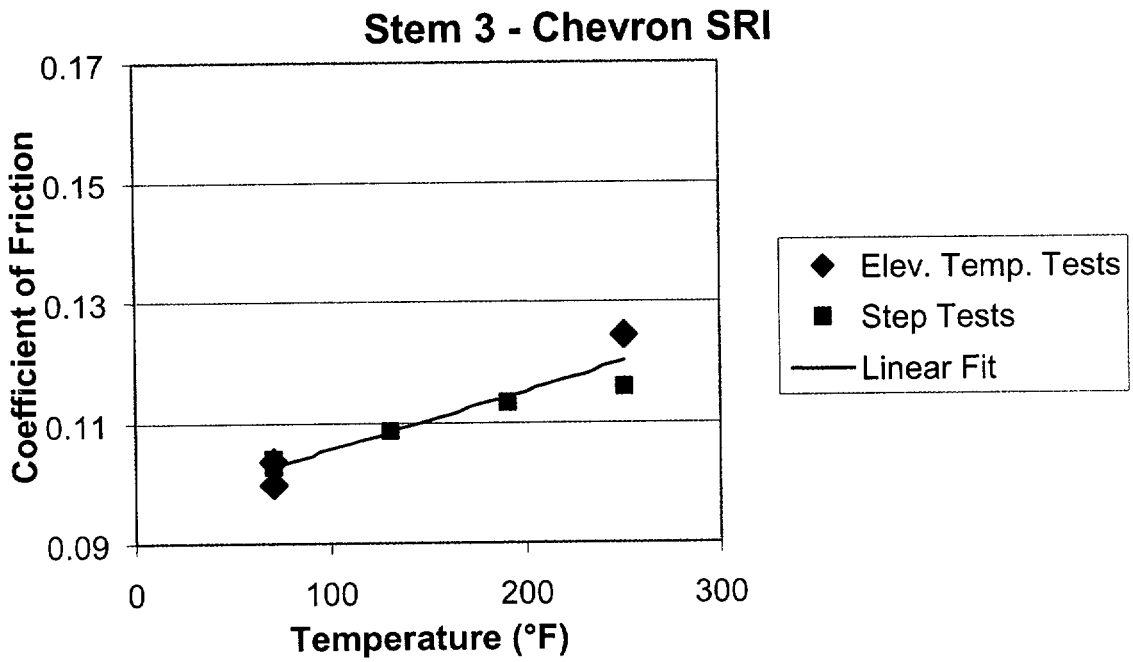

Figure B-6. The change in stem nut friction for stem 3 with SRI at elevated temperature.

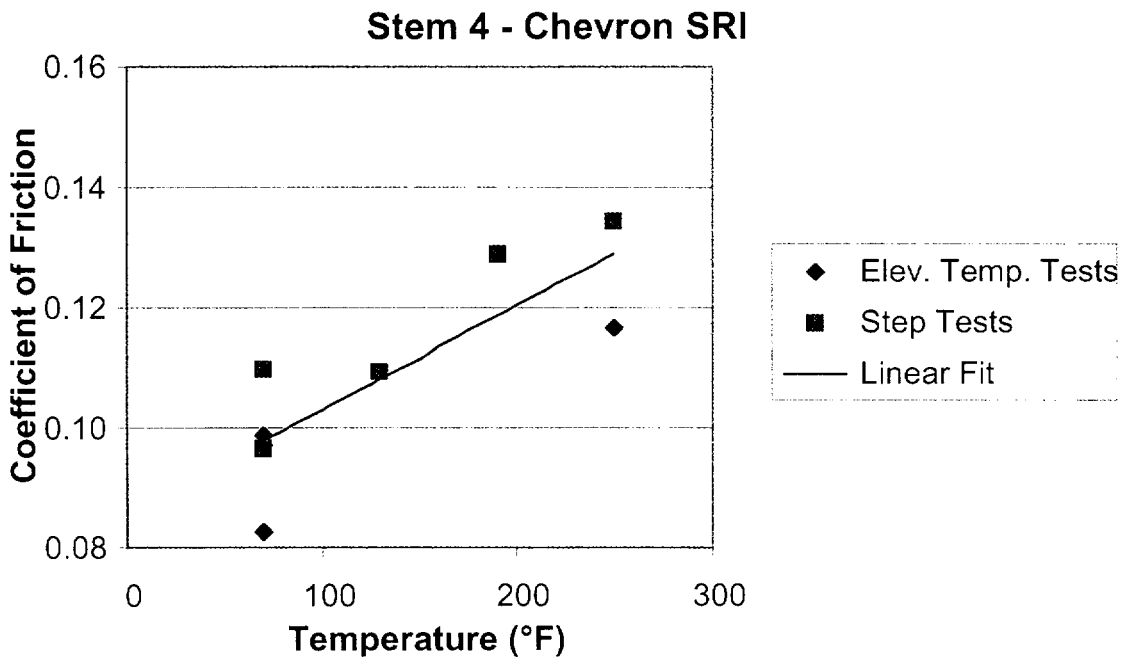

Figure B-7. The change in stem nut friction for stem 4 with SRI at elevated temperature.

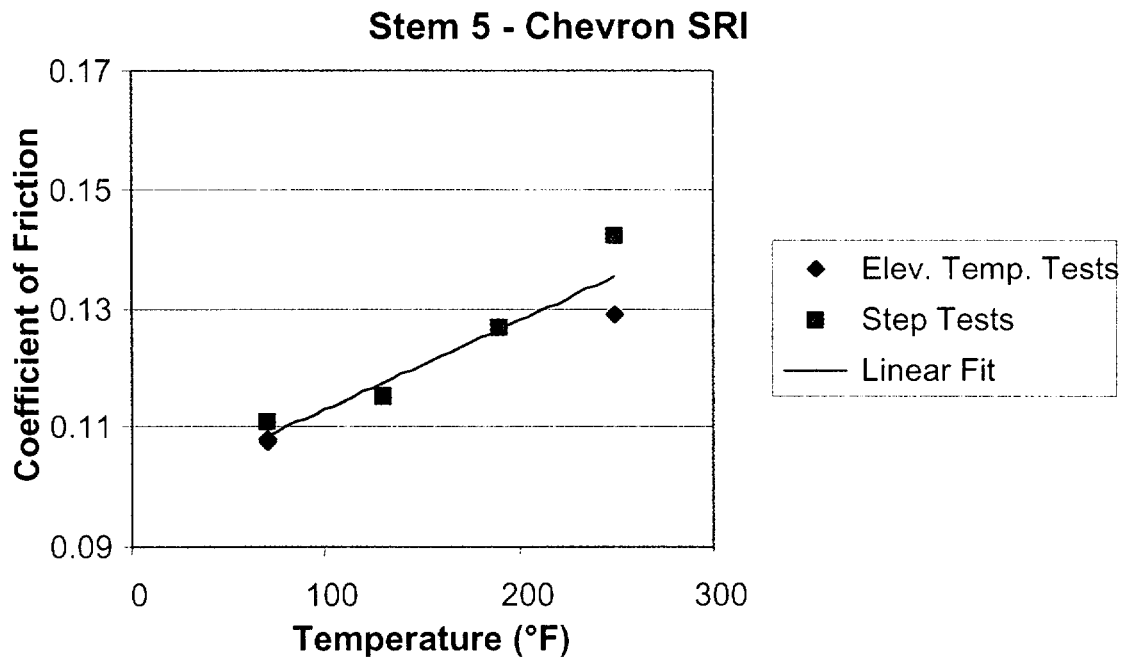

Figure B-8. The change in stem nut friction for stem 5 with SRI at elevated temperature.

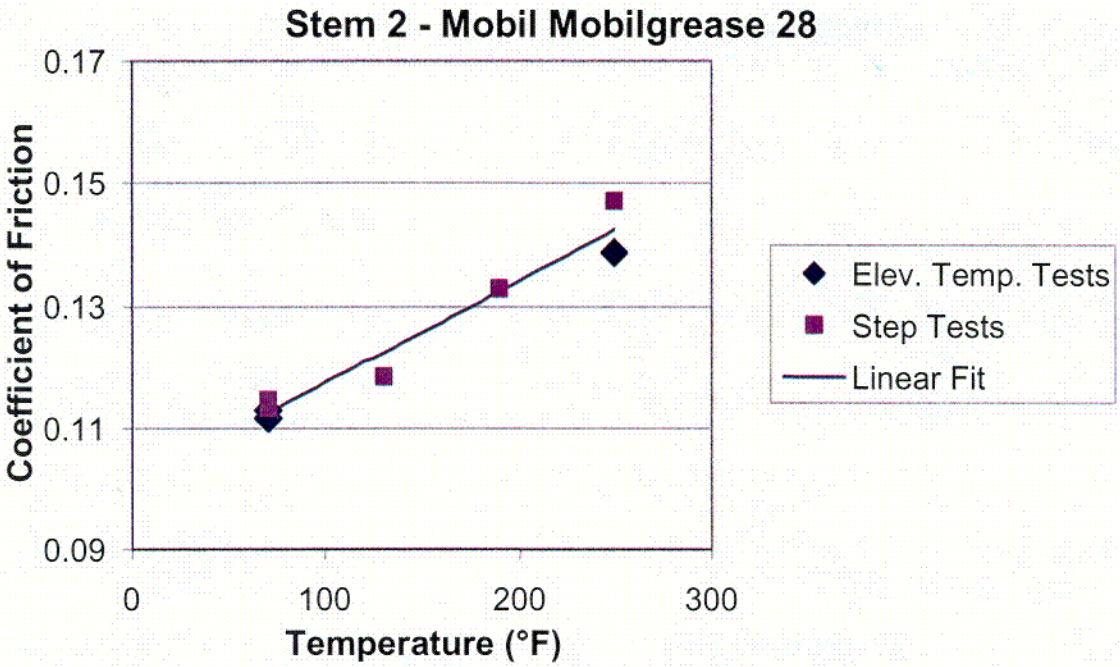

Figure B-9. The change in stem nut friction for stem 2 with Mobil 28 at elevated temperature.

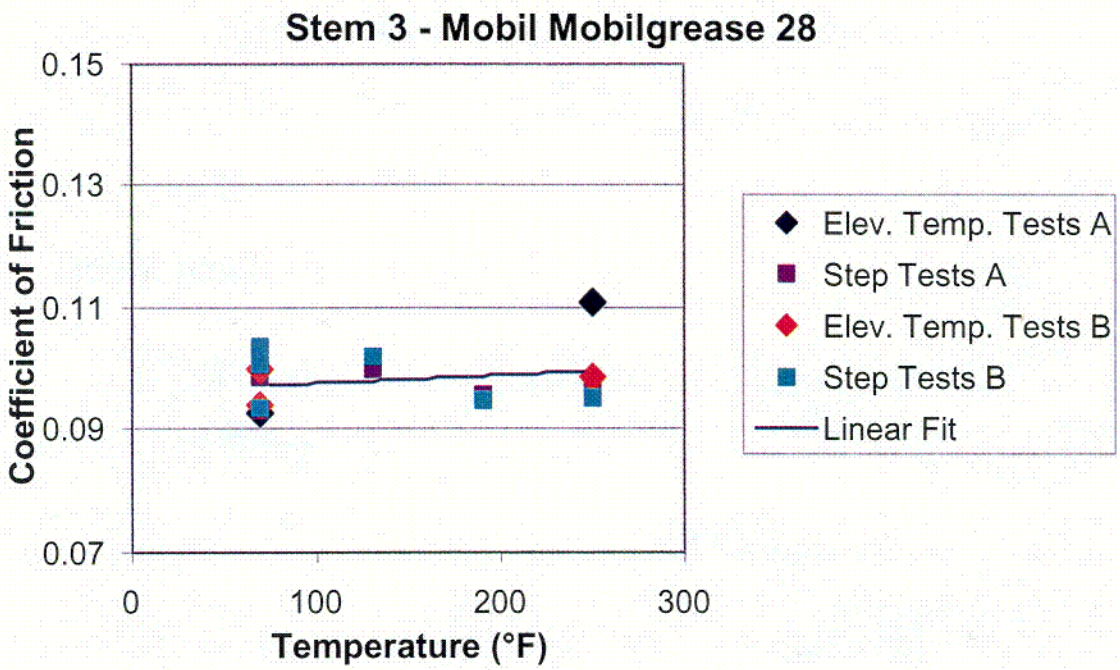

Figure B-10. The change in stem nut friction for stem 3 with Mobil 28 at elevated temperature.

C01

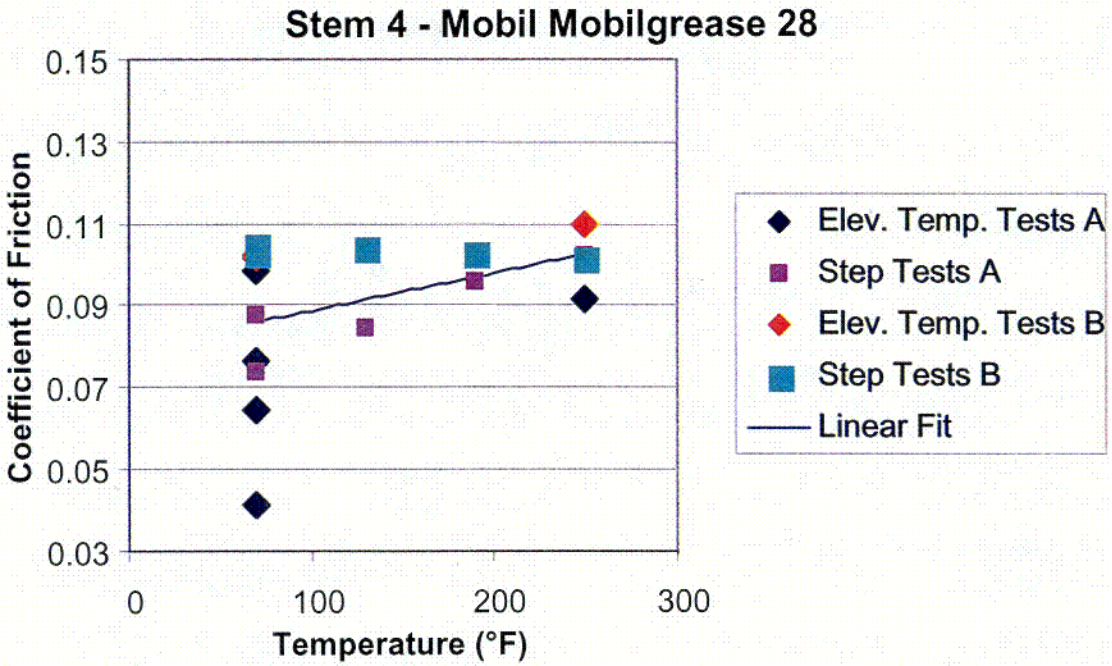

Figure B-11. The change in stem nut friction for stem 4 with Mobil 28 at elevated temperature.

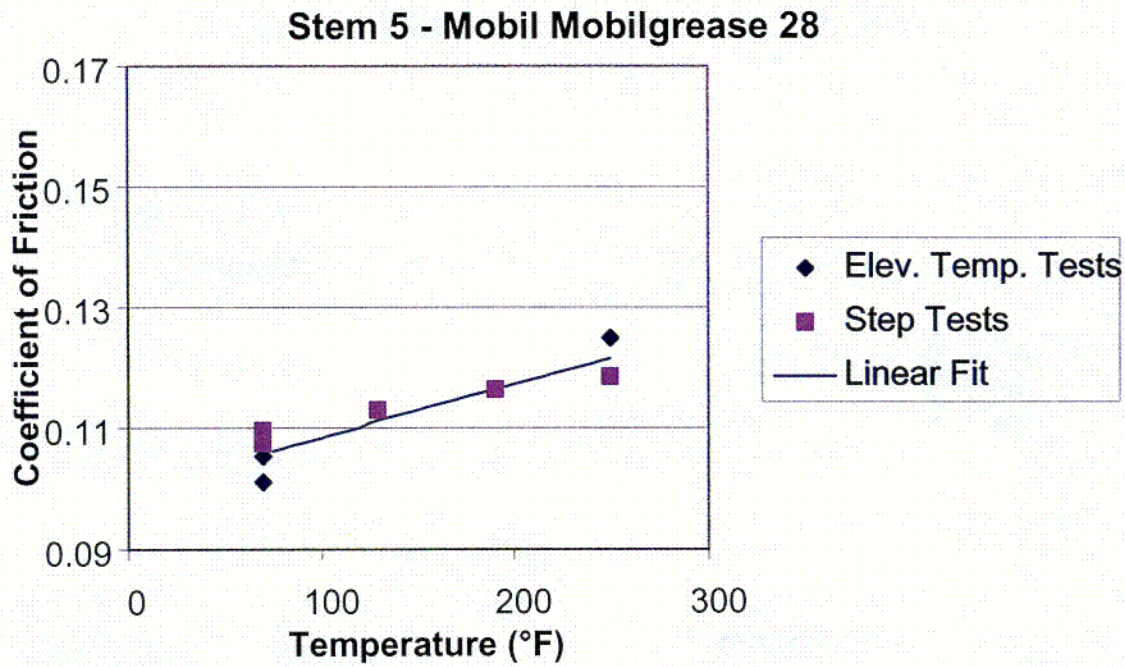

Figure B-12. The change in stem nut friction for stem 5 with Mobil 28 at elevated temperature.

C02

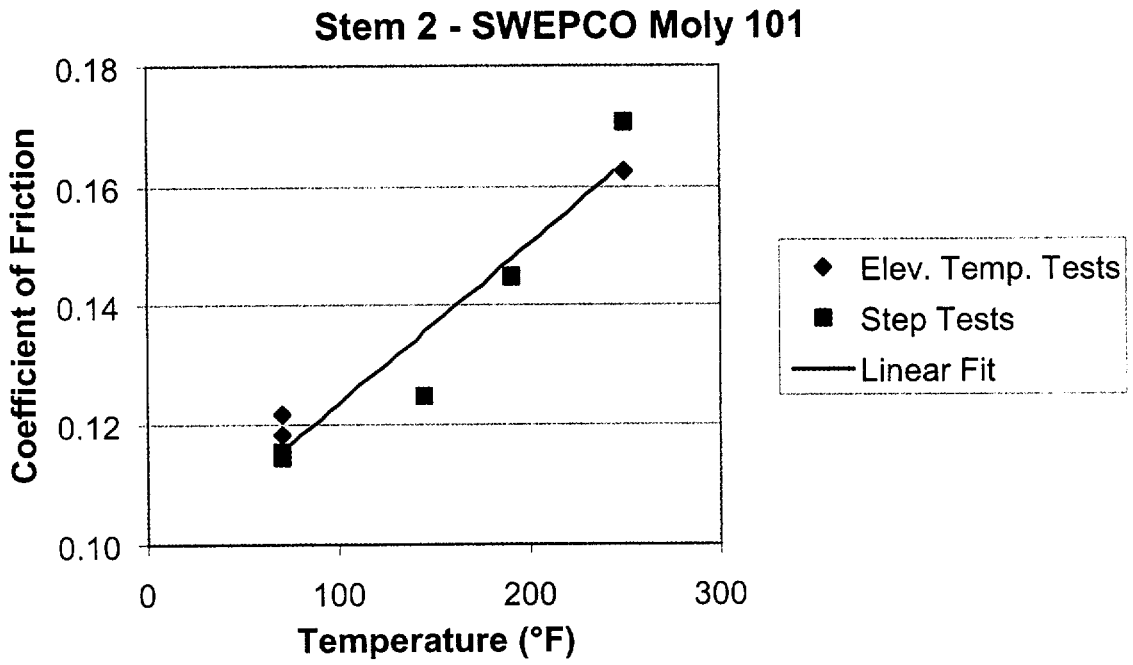

Figure B-13. The change in stem nut friction for stem 2 with Moly 101 at elevated temperature.

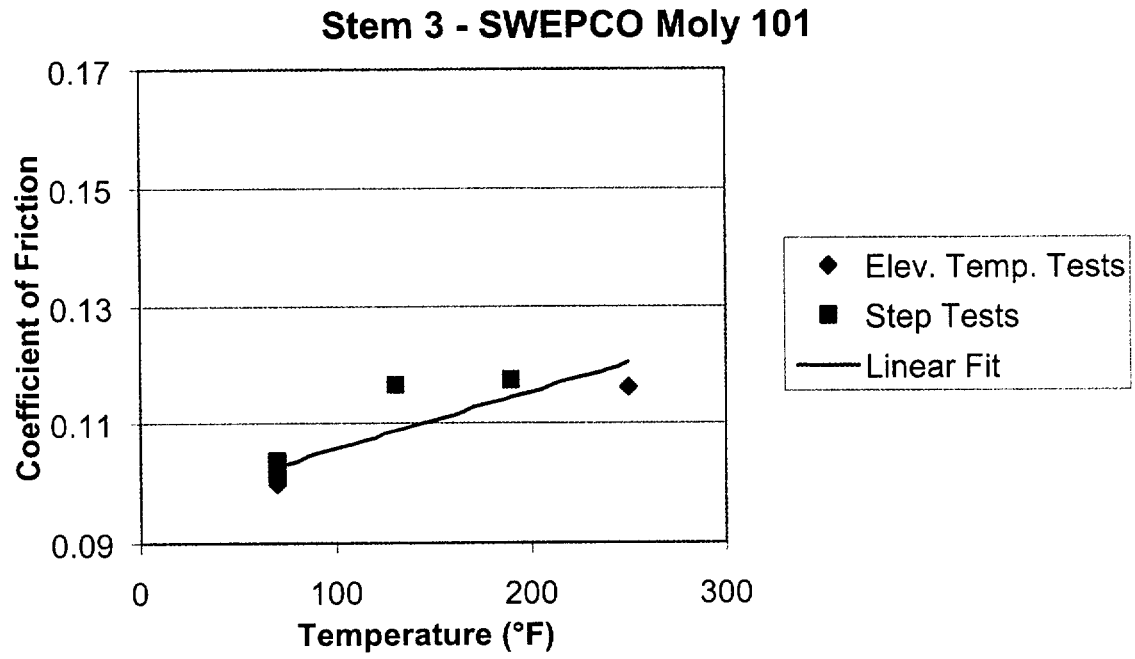

Figure B-14. The change in stem nut friction for stem 3 with Moly 101 at elevated temperature.

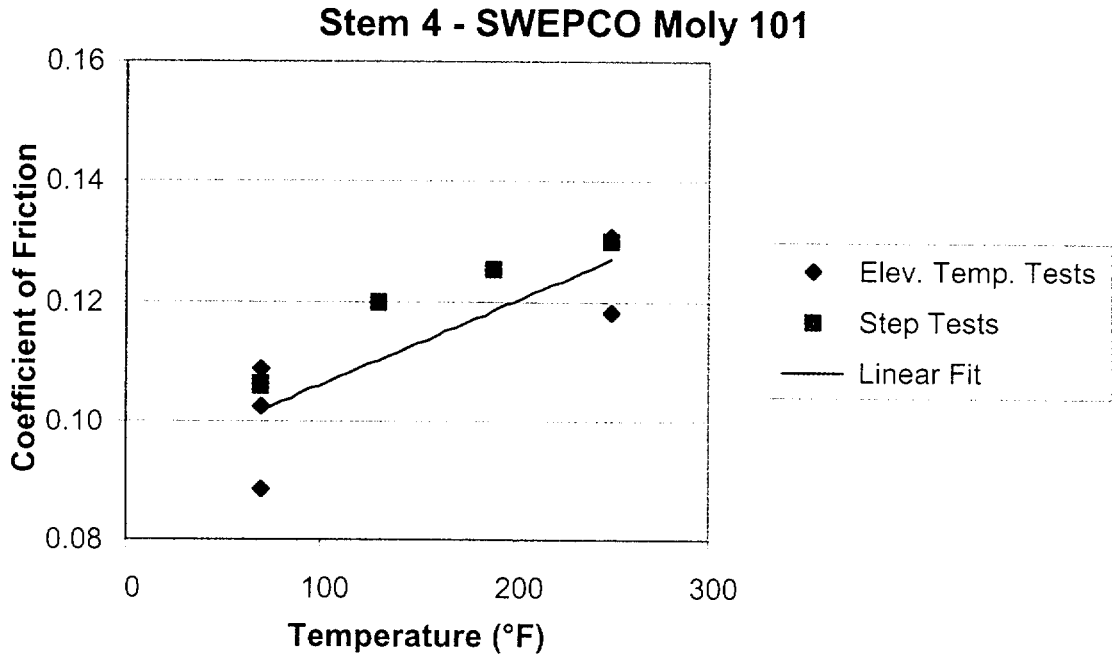

Figure B-15. The change in stem nut friction for stem 4 with Moly 101 at elevated temperature.

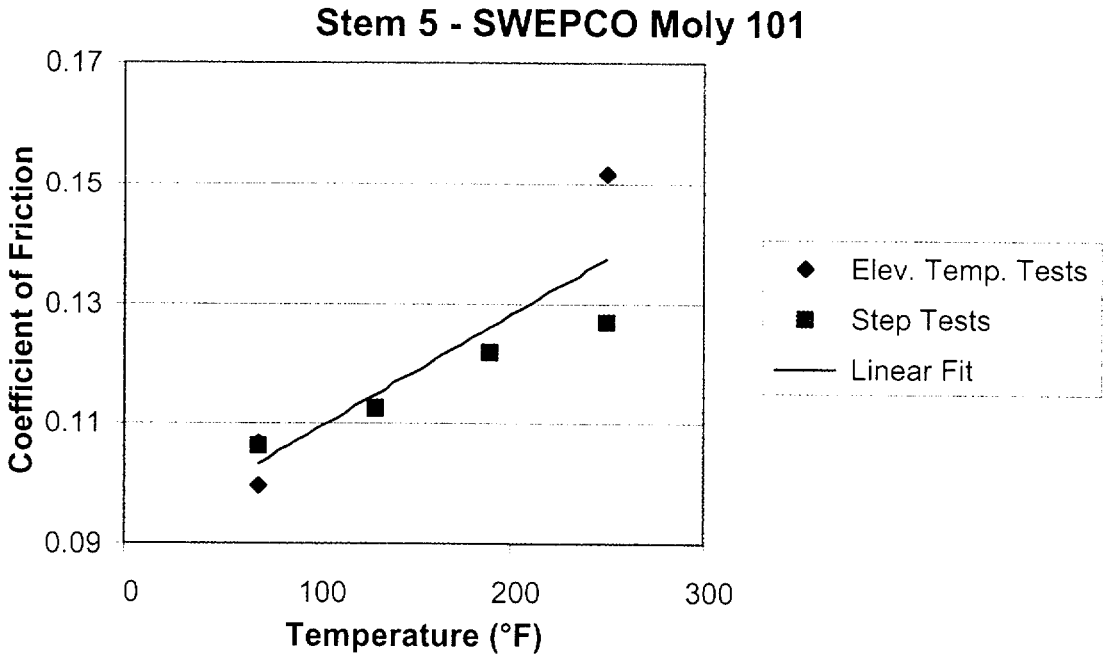

Figure B-16. The change in stem nut friction for stem 5 with Moly 101 at elevated temperature.

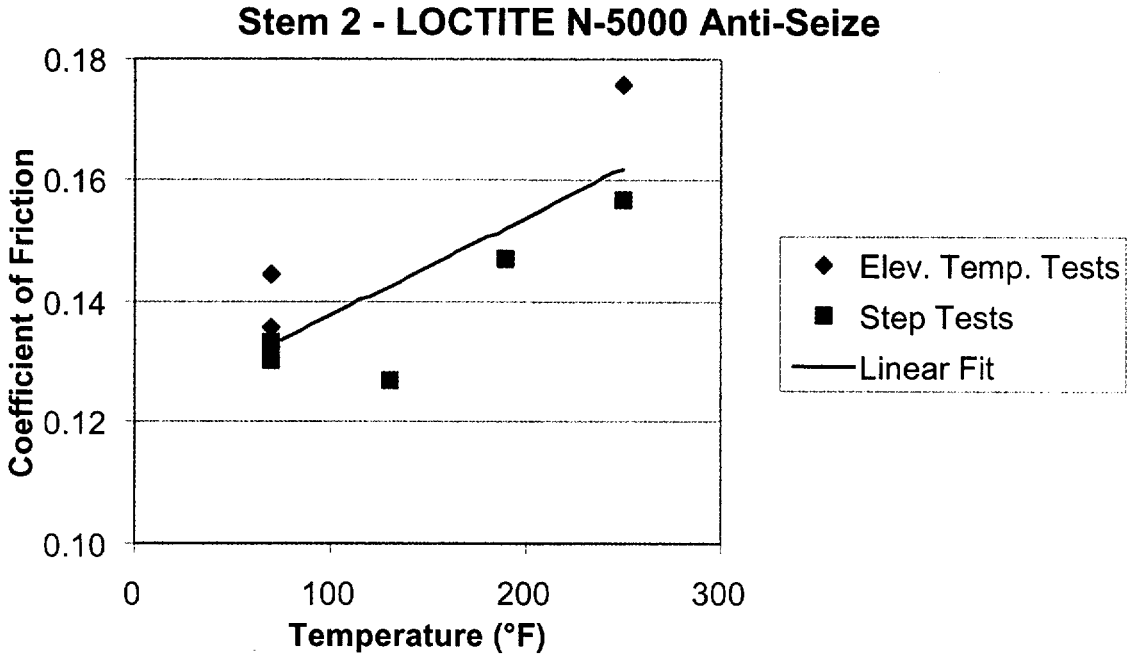

Figure B-17. The change in stem nut friction for stem 2 with N-5000 at elevated temperature.

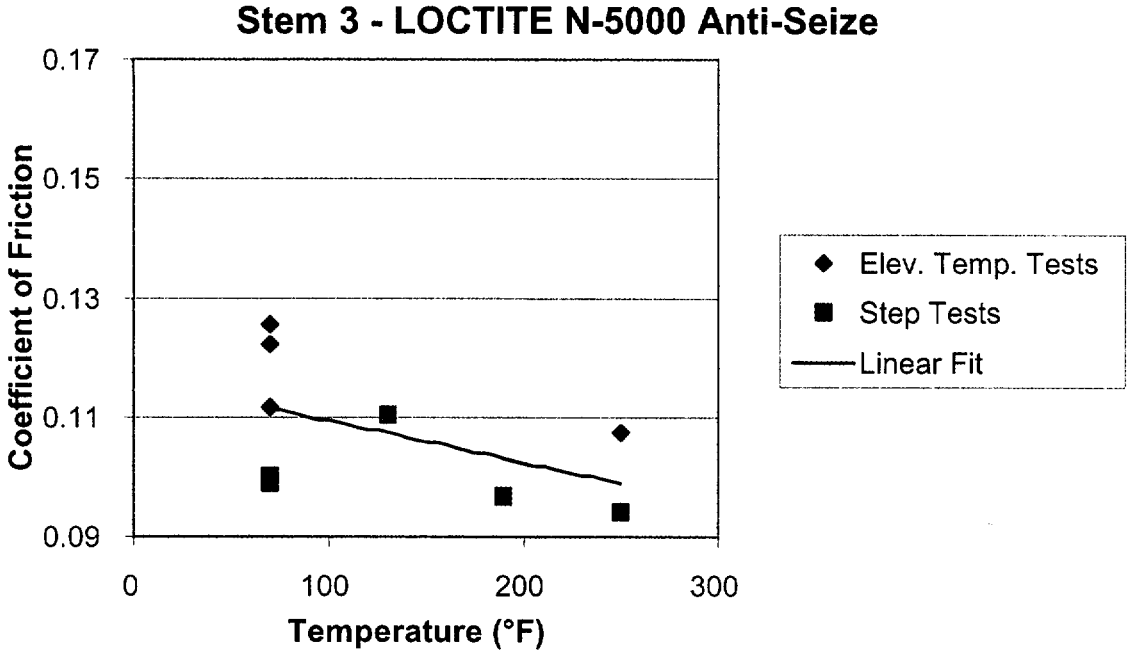

Figure B-18. The change in stem nut friction for stem 3 with N-5000 at elevated temperature.

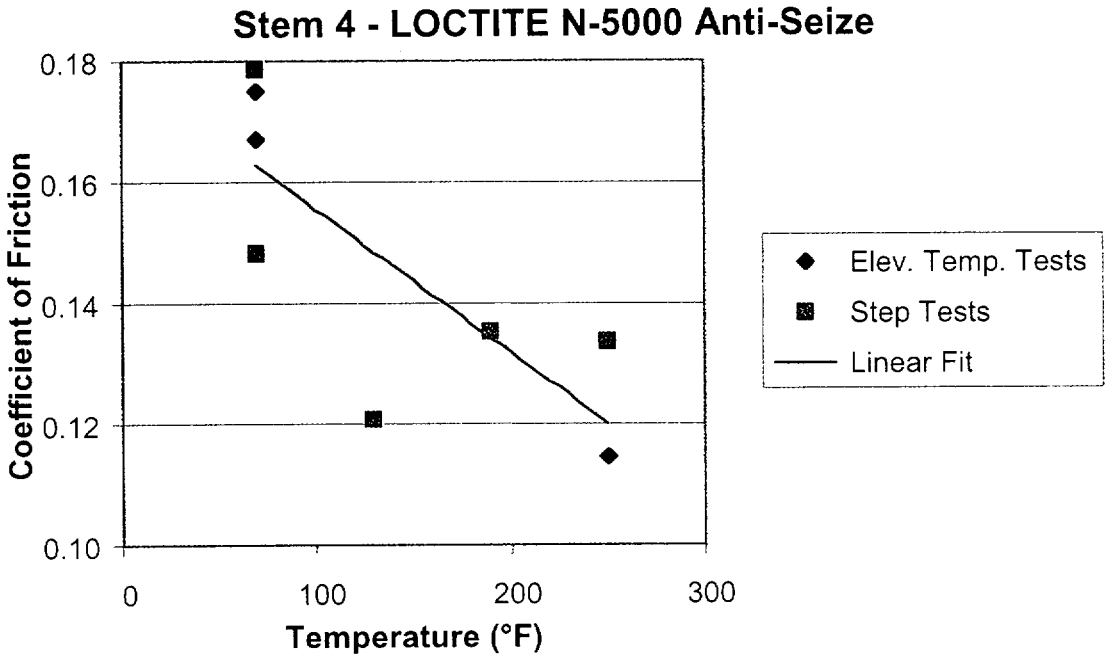

Figure B-19. The change in stem nut friction for stem 4 with N-5000 at elevated temperature.

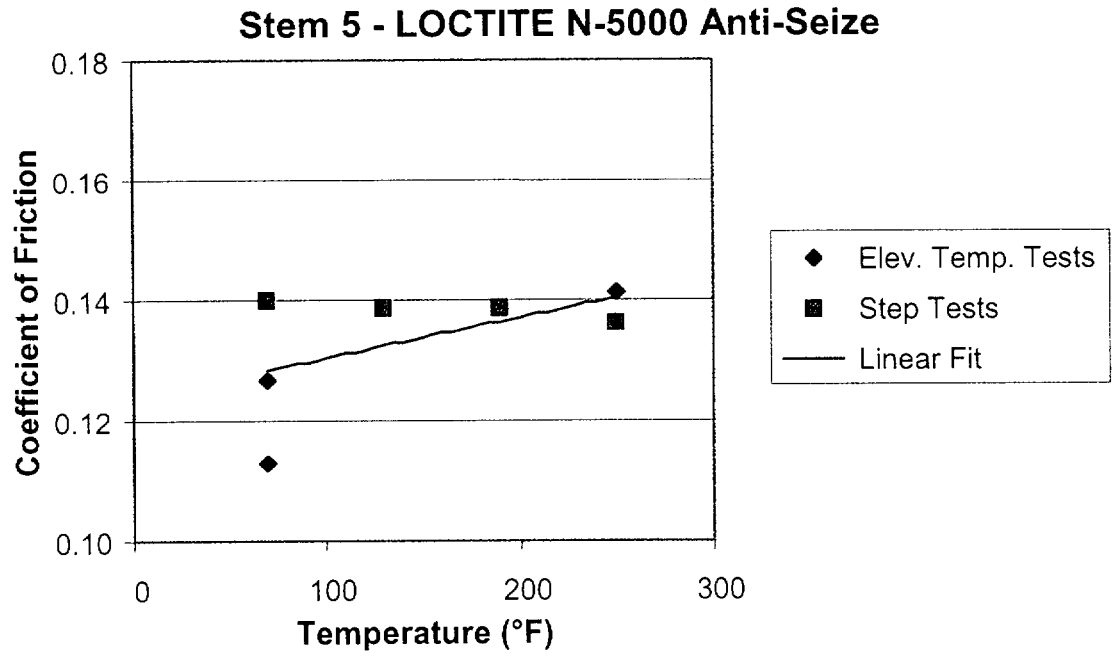

Figure B-20. The change in stem nut friction for stem 5 with N-5000 at elevated temperature.

Appendix C

End of Stroke Friction Behavior

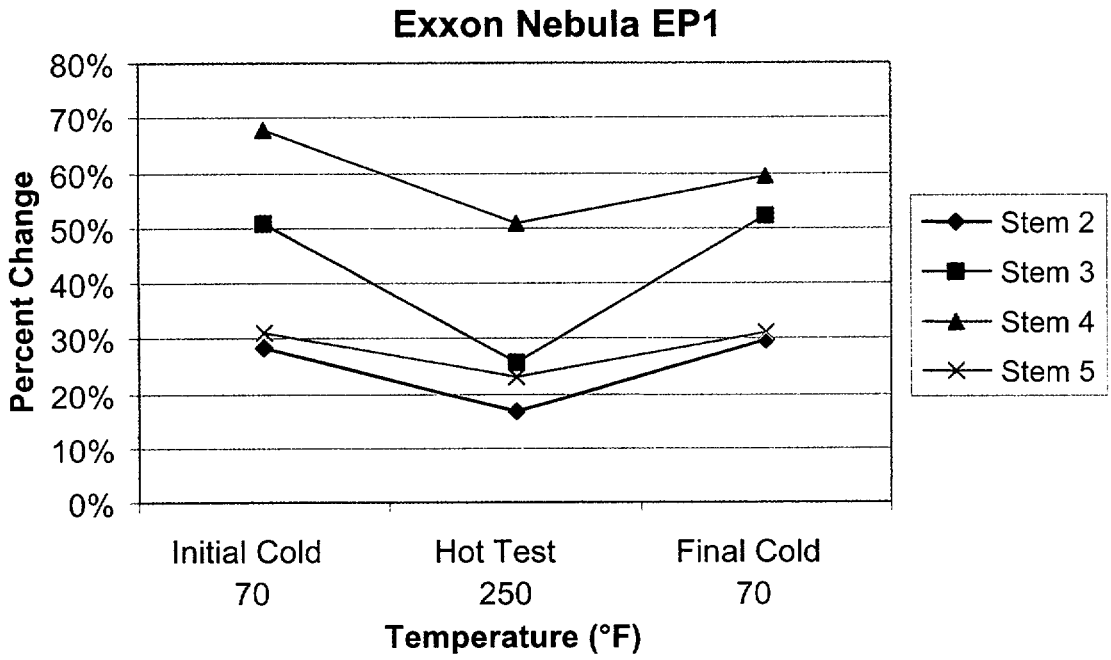

Figure C-1. End of stroke friction behavior for the single step tests with Exxon Nebula EP1.

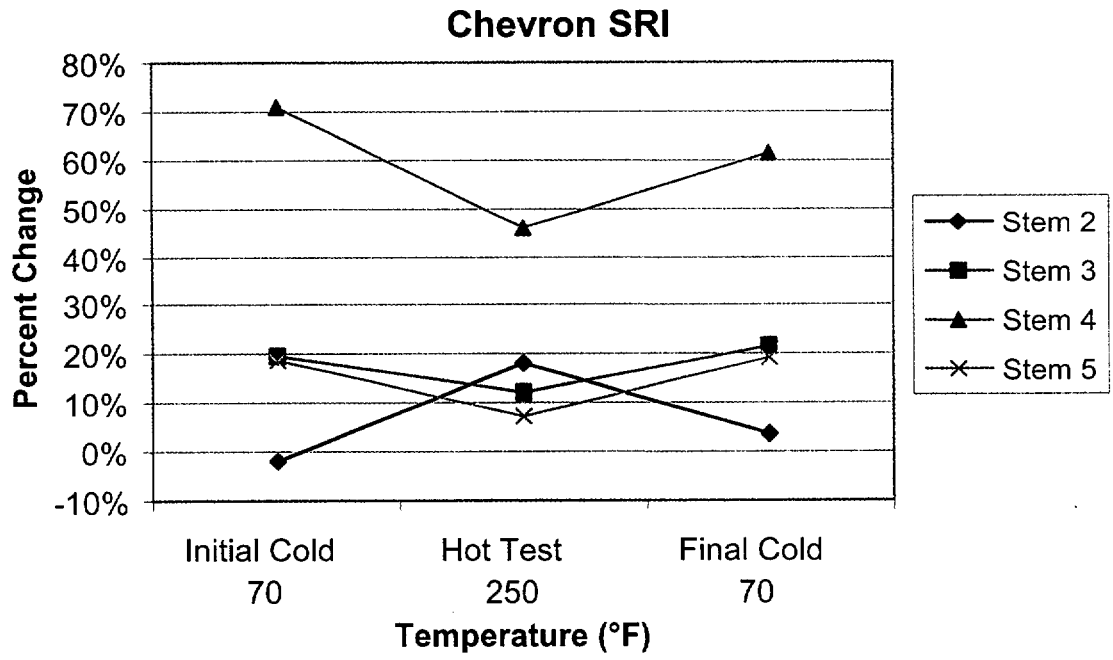

Figure C-2. End of stroke friction behavior for the single step tests with Chevron SRI.

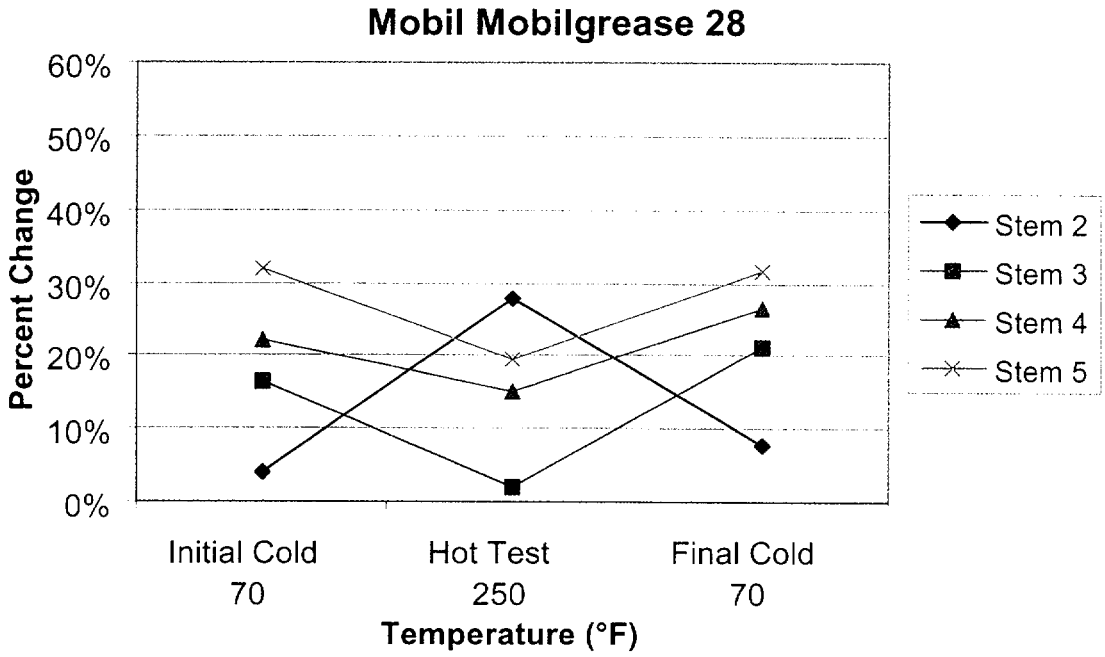

Figure C-3. End of stroke friction behavior for the single step tests with Mobil Mobilgrease 28.

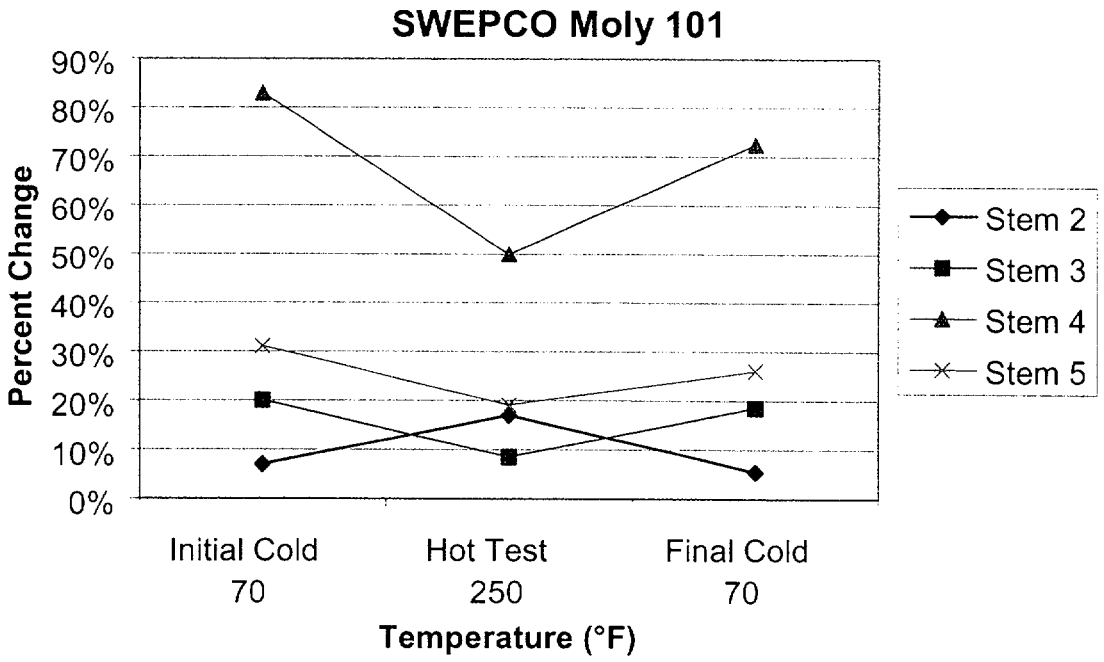

Figure C-4. End of stroke friction behavior for the single step tests with SWEPCO Moly 101.

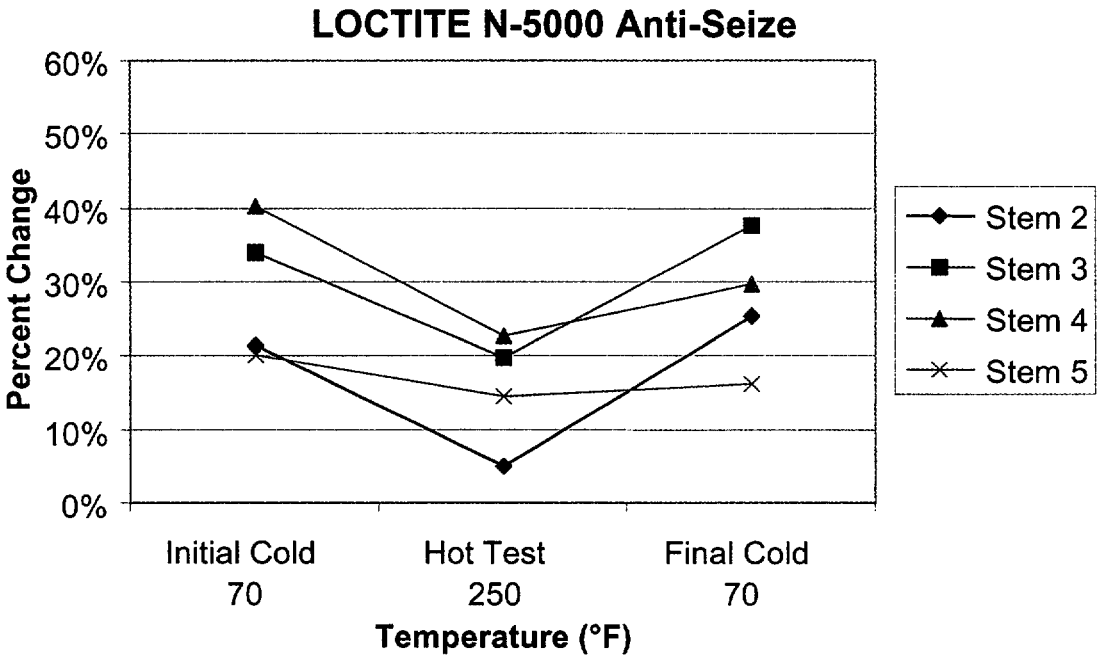

Figure C-5. End of stroke friction behavior for the single step tests with LOCTITE N-5000 Anti-Seize.

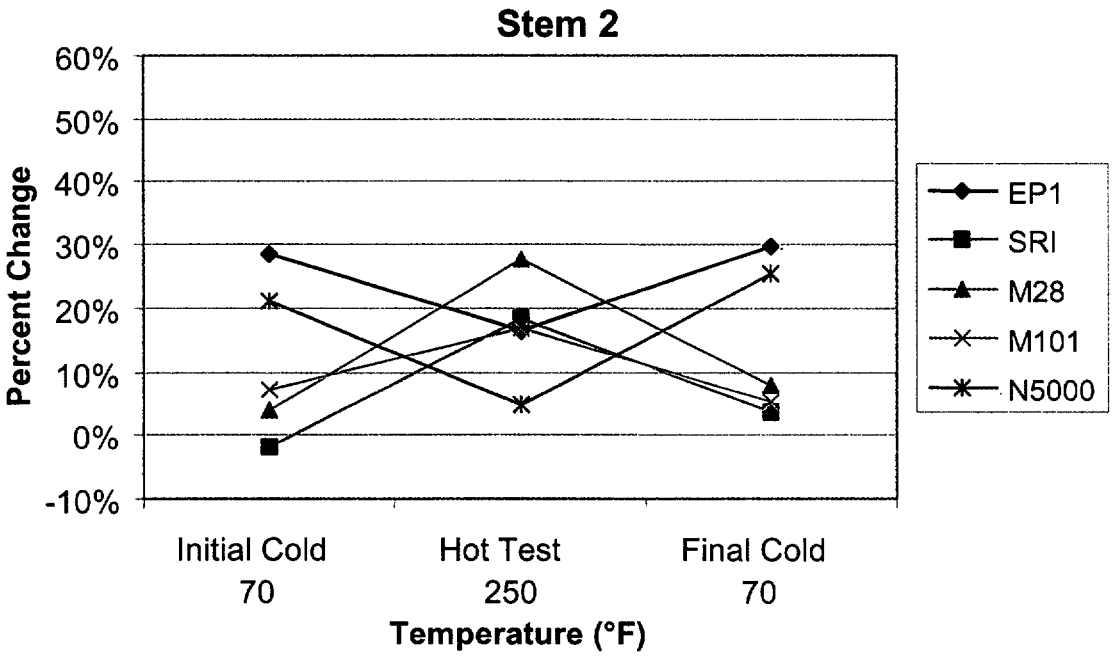

Figure C-6. End of stroke friction behavior for the single step tests with Stem 2.

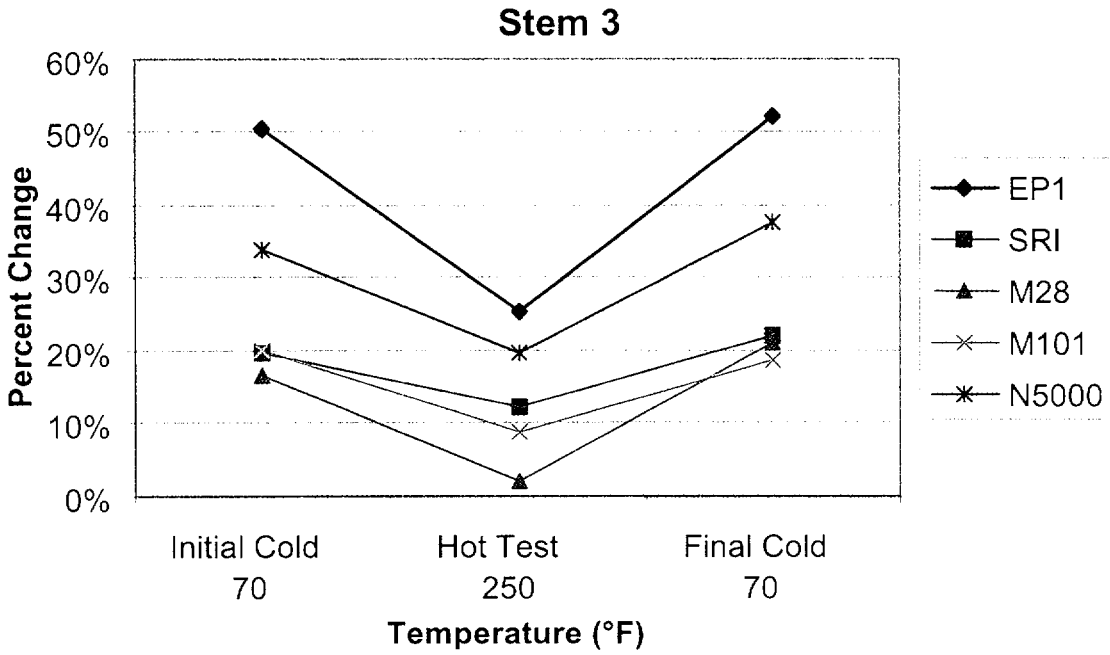

Figure C-7. End of stroke friction behavior for the single step tests with Stem 3.

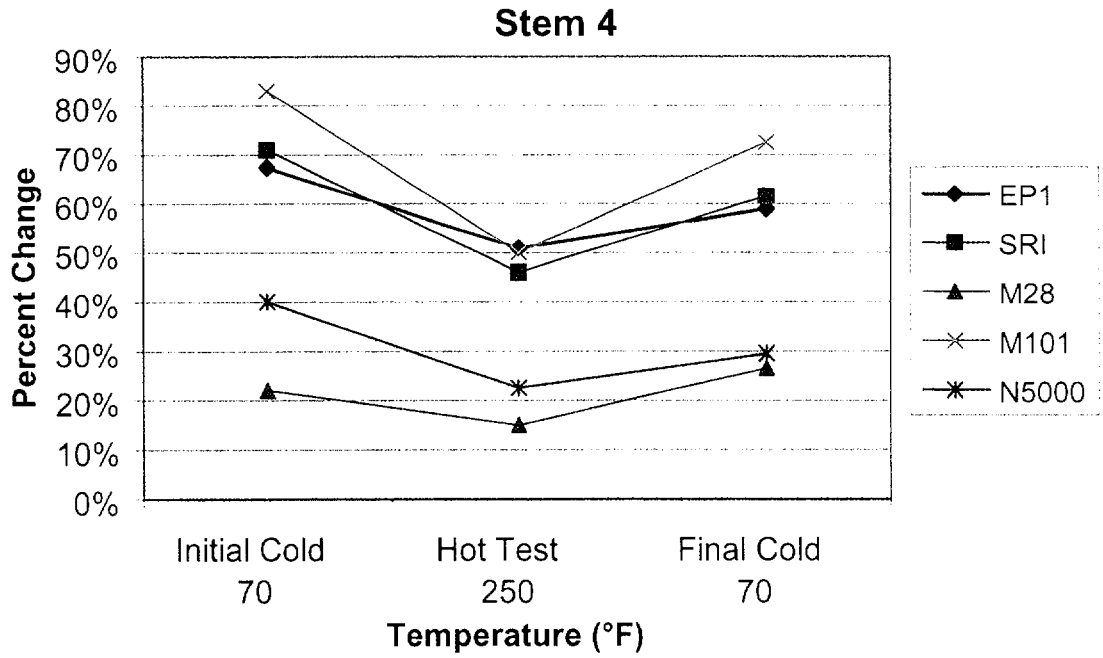

Figure C-8. End of stroke friction behavior for the single step tests with Stem 4.

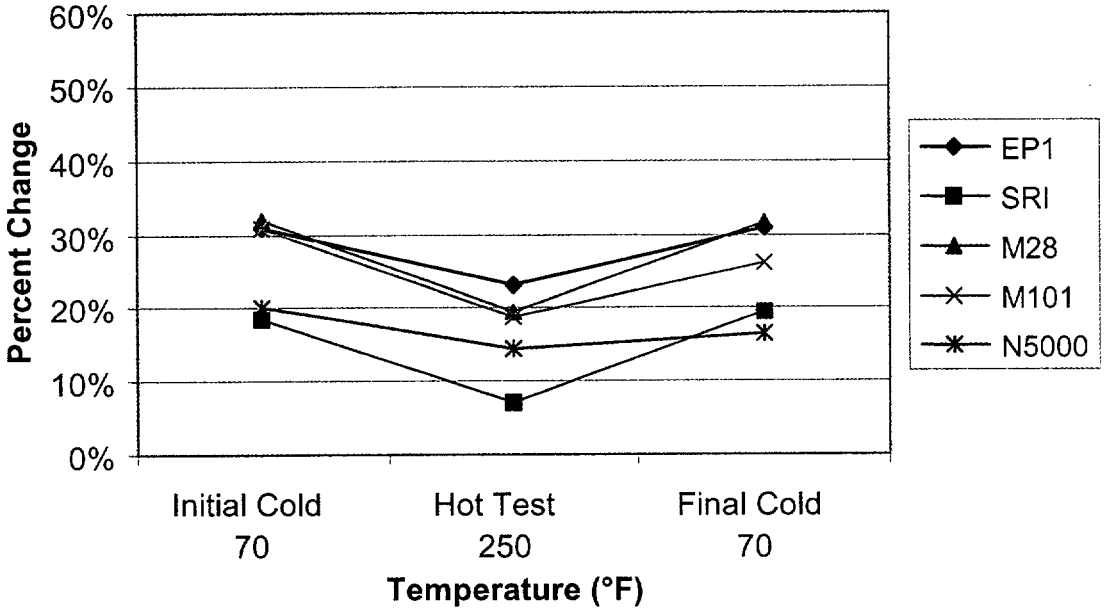

Figure C-9. End of stroke friction behavior for the single step tests with Stem 5.

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J.E. Jackson, NRC Project Manager

11. ABSTRACT *(200 words or less)*

This report documents the results of recent tests sponsored by the Nuclear Regulatory Commission (NRC) and performed by the Idaho National Engineering and Environmental Laboratory (INEEL). These tests address the effectiveness of the lubricant used on the threaded portion of the valve stem, where the stem nut turns on the stem, when subjected to design basis temperature. Recent testing indicates that an elevated temperature environment can lead to significant increases in the friction coefficient at the stem/stem-nut interface. Laboratory experience and field experience both indicate that after long periods in elevated temperature environments, the lubricants may lose their lubrication qualities. The results from an earlier accelerated aging test are presented. The accelerated aging test identified the concerns that led to the elevated temperature testing.

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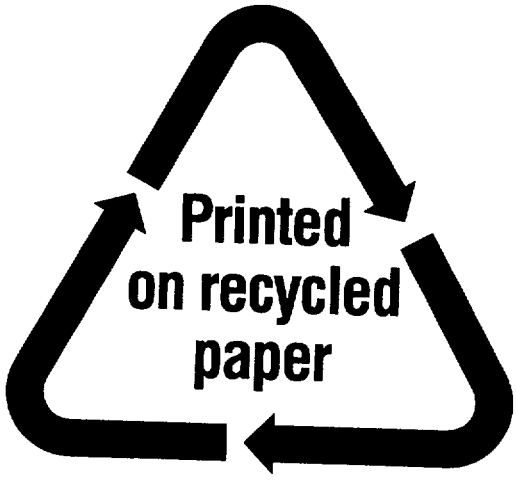

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