Benefits of Polymer Additives in Grease

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Benefits of Polymer Additives

- **G**reater Adhesion
- **R**educed Bleeding
- **E**levated Tackiness
- **A**dded Yield
- **S**uperior Shear Resistance
- **E**nhanced Water Resistance

Handling of Polymers

Forms

liquid or gel | powder or pellet

Blending

Dissolving is best accomplished with continuous agitation, at temperatures of at least 200°F (95°C) for 1-3 hours, with the cooling oil .

Polymers Evaluated

- polyisobutylene (PIB),
- ethylene-propylene copolymers (OCP)
- styrene-hydrogenated butadiene (SBR)
- styrene-hydrogenated isoprene (SI)
- radial hydrogenated polyisoprene (Star)
- acid functionalized polymers (FP)
- polyalkylmethacrylate (PMA),
- styrene ester copolymers (SE)
- styrene ethylene butylene copolymers (SEBCP)

Profile of Polymers

	MW Flory	Polydispersity
OCP	200,000	2.50
PIB	1,000,000	2.00
STAR	350,000	1.20

Additives and Polymers in Oil

- Additives regulate extreme pressure, wear, rust, corrosion, oxidation, and adhesion
- Additives affect grease in the same way as lubricant oils.
- Polymers in oil increases the viscosity of base oil and in most cases increases the viscosity index (VI).

Polymers in Grease-Theory

- Changing base oil viscosity no effect on grease mechanical properties.
- Polymers must interact with the three dimensional network of fibers created by thickeners.
- When entangled, augment the mechanical properties.

Which polymers enhance the Network?

- SEBCP due to less soluble styrene blocks
- OCP due to crystalizable ethylene blocks

Enhanced, Bimodal Network Theory

- Network of soap (A)
- Network of polymers with shorter chains between rigid blocks (B)
- Bimodal network of A and B

Bimodal Network-Improves Mechanical Properties

- Improvement in mechanical properties, such as modulus and strength,
- Very limited extensibility of the short polymer chains present in the bimodal network
- An example would be the polybutadiene block of molecules in SEBCP copolymers

Deformation of Thickener Network –A & B

- Elasticity governed by Gaussian, normal distribution (A)
- Deformation from penetration (A)
- Distance is elongated, increased penetration, lower modulus (A)
- New network is bimodal (AB), and non-Gaussian
- Shorter chains restrict the deformation of long chains (AB)

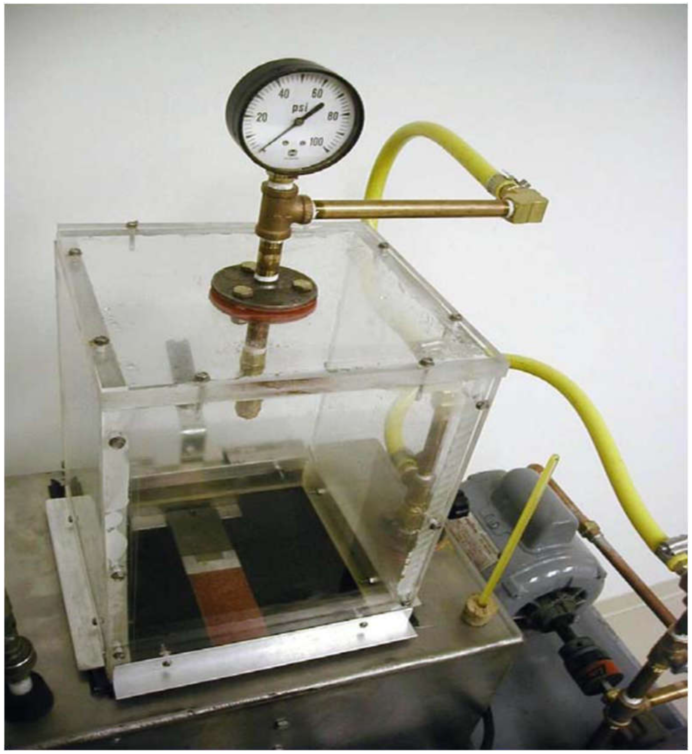
Polymer Affect on Physical Network

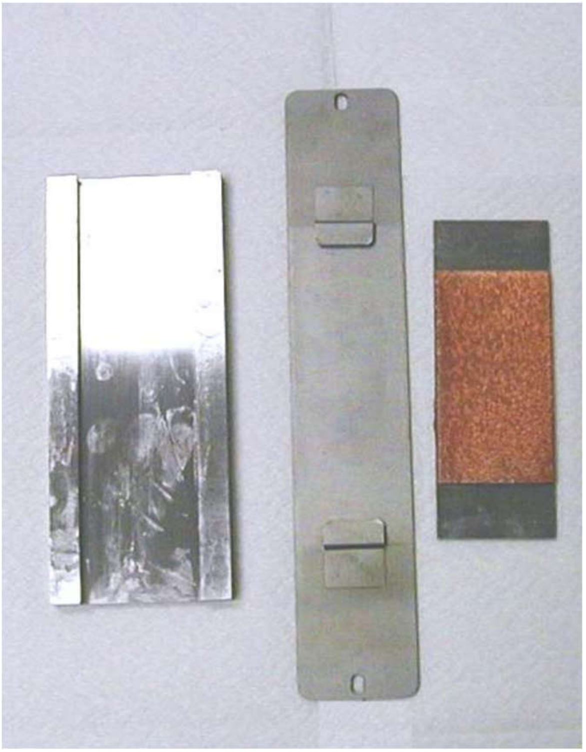
- Polymer additives in grease form a bimodal network
- Bimodal network changes the mechanism of deformation.
- Short chains in bimodal network restrict maximum elongation and increase modulus of elasticity
- At maximum elongation of bimodal network, short chains cannot increase end-to-end distance by rotation about its skeleton bonds.
- Deformation of bond angles or bond lengths is required for additional elongation, but greater energy needed for this process than for configurational changes
- Different polymers provide bimodal network: interpenetrated network OCP, SEBCP - entanglement PIB

Experiment ASTM D 217

- 77 ºF, Worked Cone Penetration
- Subjected first to 60 and then to 10,000 doubles strokes
- Three cone penetration measurements were taken using Penetrometer

Experiment ASTM D 4049





Standard Test Method for Determining the Resistance of Lubricating Grease to Water Spray

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Experiment- ASTM D-1831

STANDARD ROLL STABILITY TEST

•An approximately 50 g sample was placed in a Roll Stability Tester for 2 hours with a speed of 165 rotations per minute.

•Penetrations of the greases before and after the Roll Stability were measured, compared and the changes recorded.

Experiment- ASTM D-1403

Test Method for Cone Penetration of Lubricating Grease Using One-Quarter and One-Half Scale Cone Equipment" was used with similar procedures as above.

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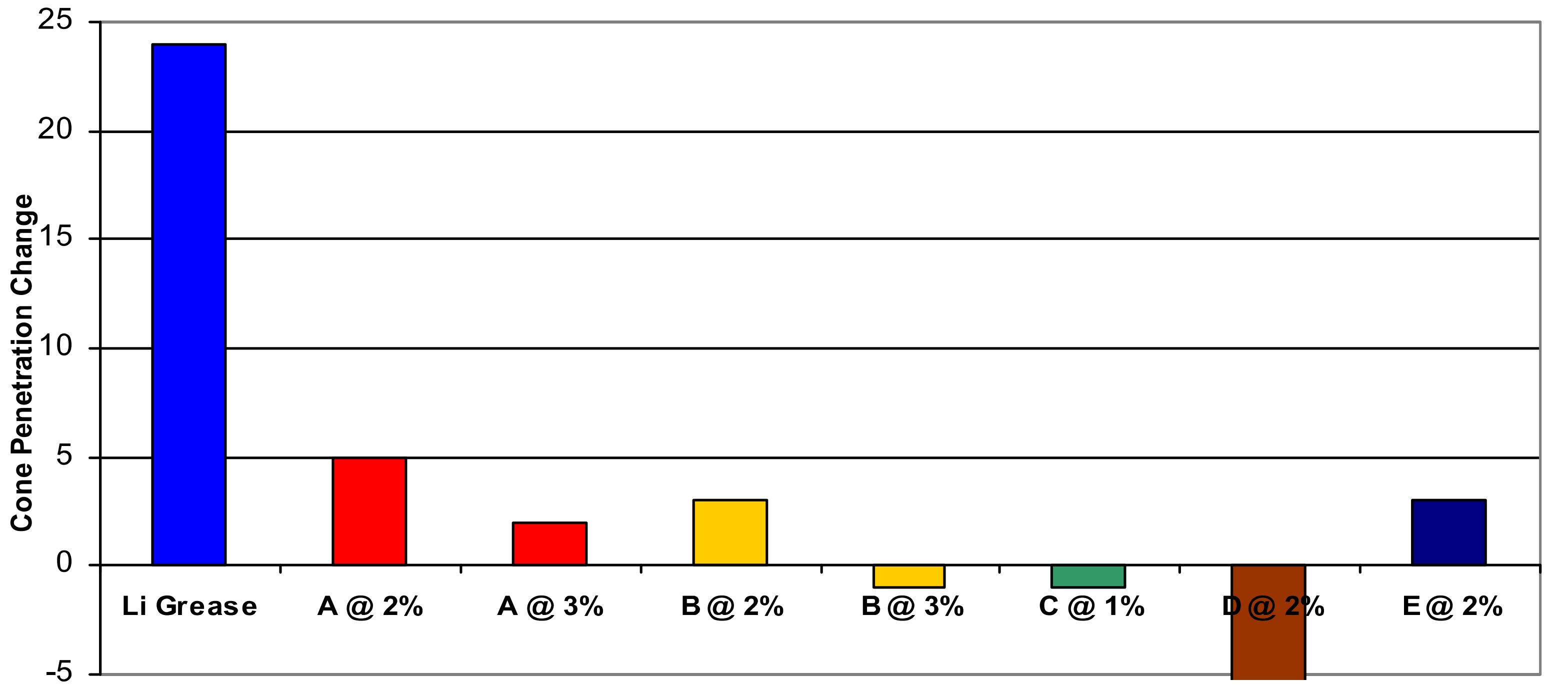
Polymer Additive Forms, Polymer Type and Treat Levels Lithium Grease

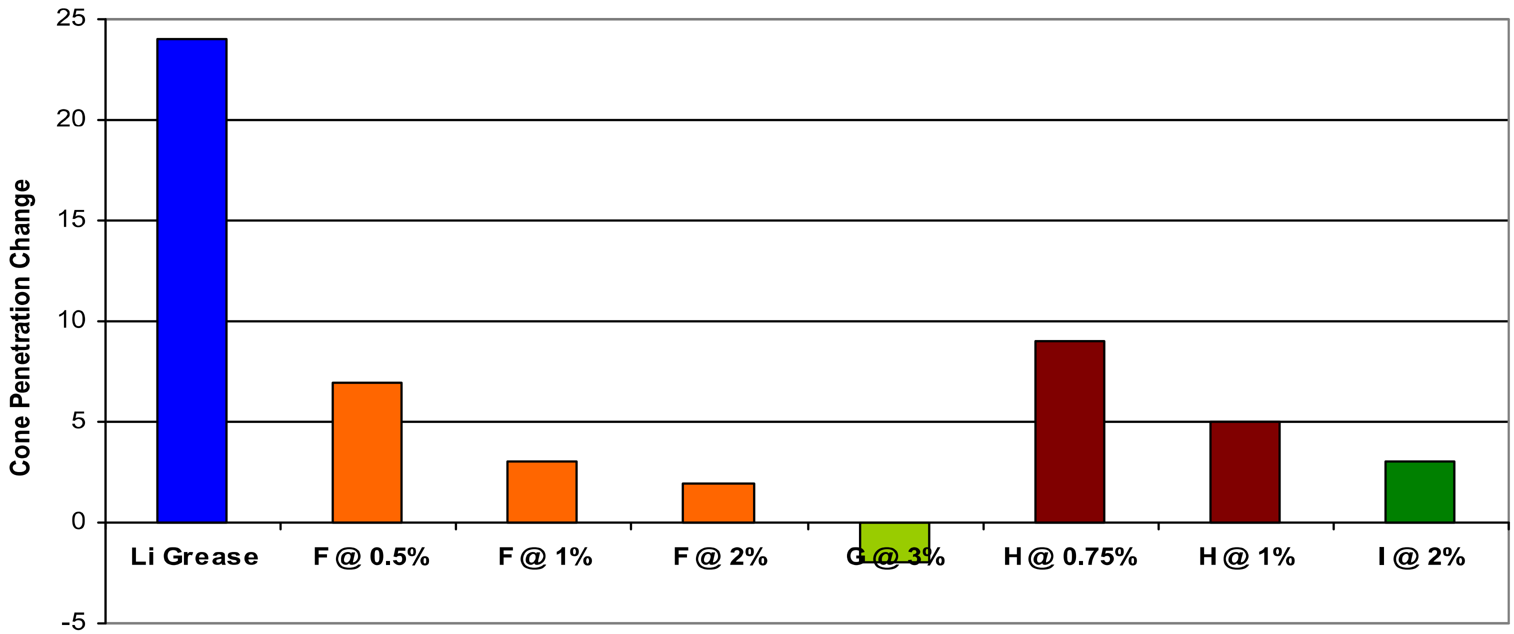
Sample	Polymer Additive Form	Polymer Type	Treat Level (%)
Li Grease	--	--	0
Li Base + **A**	Gel	Proprietary	2
Li Base + **A**	Gel	Proprietary	3
Li Base + **B**	Liquid	Proprietary	2
Li Base + **B**	Liquid	Proprietary	3
Li Base + **C**	Pellet	Proprietary	1
Li Base + **D**	Liquid	PIB	2
Li Base + **E**	Liquid	PIB	2
Li Base + **F**	Powder	SEBCP	0.5
Li Base + **F**	Powder	SEBCP	1
Li Base + **F**	Powder	SEBCP	2
Li Base + **G**	Pellet	OCP	3
Li Base + **H**	Powder	OCP	0.75
Li Base + **H**	Powder	OCP	1
Li Base + **I**	Liquid	OCP	2

Shear Stability – Proprietary and PIB Polymer Samples



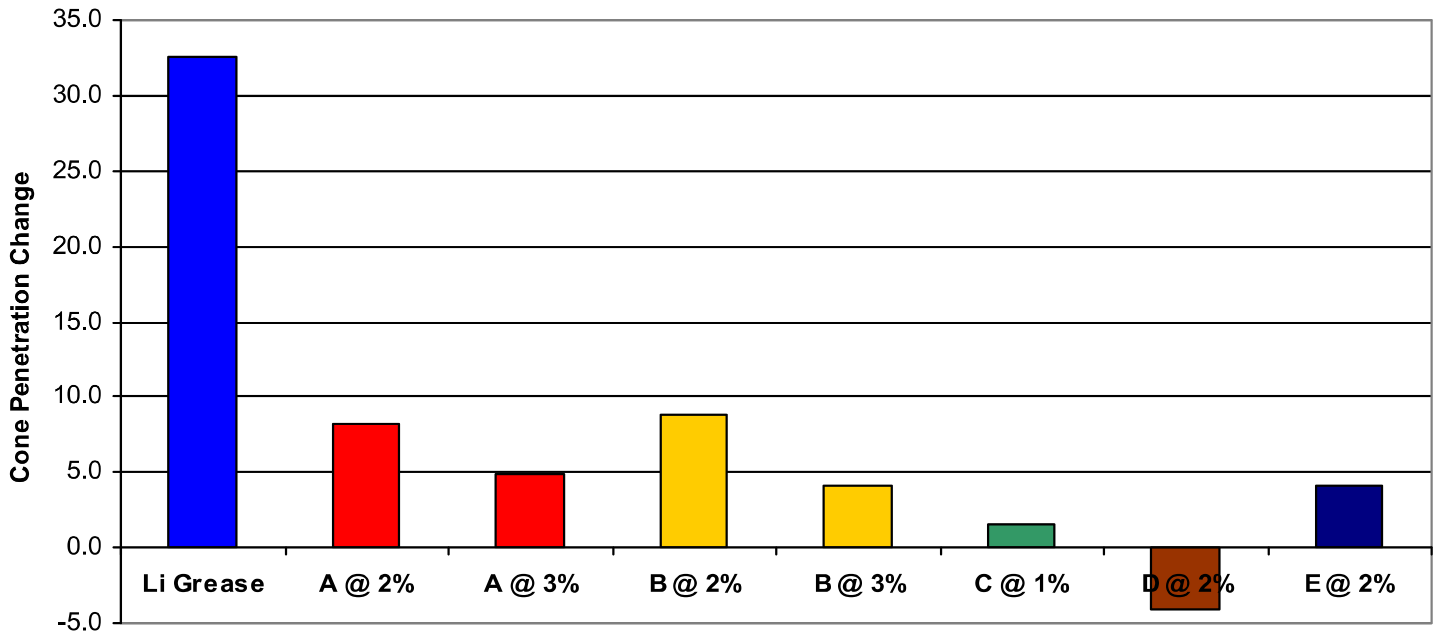
•Polymer A, B, C are proprietary.
•Polymer D, E are PIBs

Shear Stability –SEBC and OCP



- **F** styrene ethylene butylene copolymers
- **G, H, I** ethylene-propylene copolymers

Roll Stability- Proprietary and PIB Polymer Samples



Polymer A, B, C are proprietary.
Polymer D, E are PIBs

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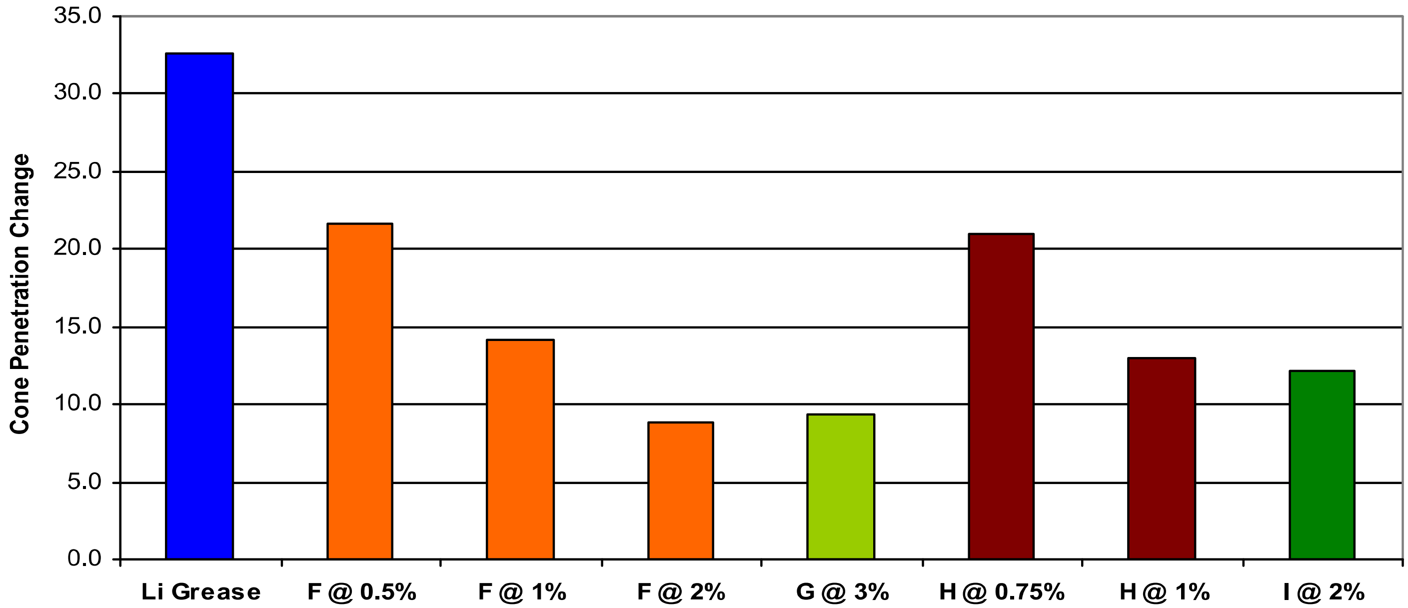
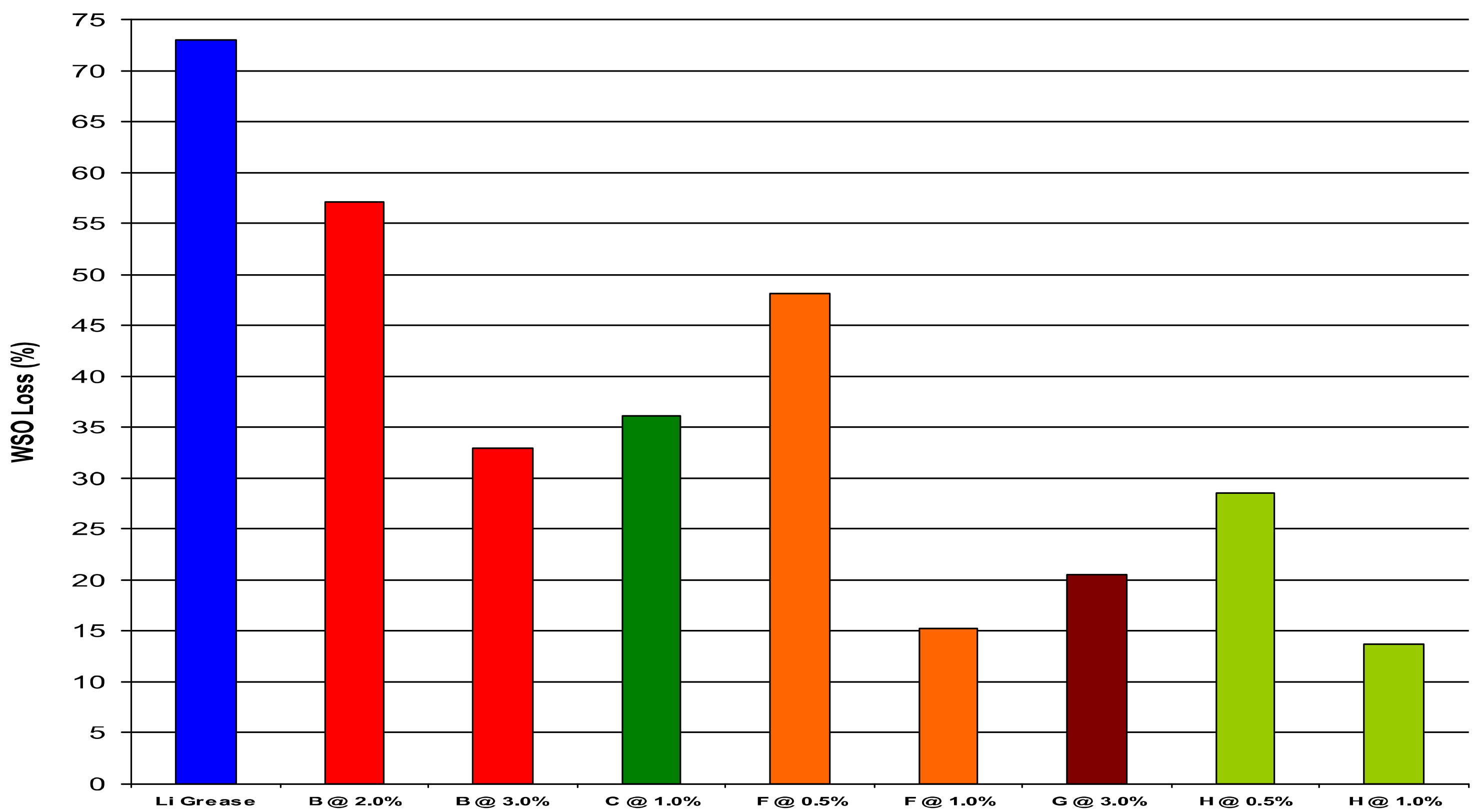
Roll Stability – SEBC and OCP



F styrene ethylene butylene copolymers
G, H, I ethylene-propylene copolymers

Water Spray Test- Proprietary Polymer, SEBCP and OCP Additives



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GREASE: IMPROVED SHEAR STABILITY

ROLL STABILITY - ASTM D1831; 60 and 10,000 STROKES CONE PENETRATION - ASTM D217

PRODUCT	Polymer Additive Form	Treat Level, %	60 and 10,000 Strokes Penetration Change	Roll Stability, % Change
Li Complex Base Grease		0	-24	11.0
Li Base + **Tackifier A**	Liquid	2.0	6	-1.4
Li Base + **Tackifier B**	Liquid	2.0	-3	1.4
Li Base + **Tackifier C**	Liquid	2.0	-3	4.1

Economic Benefit

Sample	Treat Level (%)	WK 60 Penetration	Oil Adjustment (%)	WK 60 Penetration
Base Grease	**0**	**296**		
Li Base + **B**	3	268	17	294
Li Base + **F**	1	278	15	297
Li Base + **H**	1	272	16	294

- **Yield Increase with Polymer Additives**
- **B is proprietary, F is SEBCP, and H is OCP**
- **Increased yield approximately 15%**
- **Plan for yield increase- increased additives**

Summary

- The theory of improvement of grease performance in terms of changing network structure from the addition of polymer was discussed.
- A bimodal network of polymers and grease soap matrix was presented.
- Polymer additives have been shown to provide significant grease performance benefits at low treat levels
- Polymer additives can improve shear stability and water resistance.
- Select polymer additives may increase yield.