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Improved Processing of Thermoplastics and Thermoplastic Elastomers

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Providence, RI

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Quality Additives for Performance



INTRODUCTION

The use of additives to improve the processing characteristics of all types of polymer systems is growing in order to meet the wide ranging and ever expanding requirements of processors and end users.

This presentation will serve to define and describe the types and functions of processing additives and their fit into the compounding and processing markets.

Processing

Thermoplastics and Rubber are Similar

Raw Materials

Process

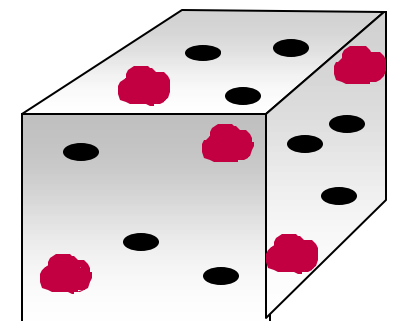
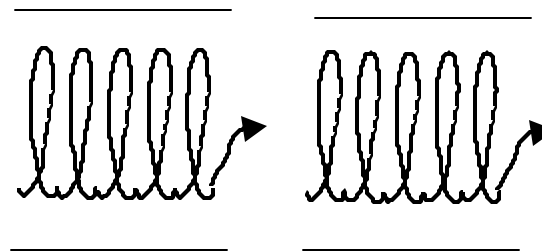
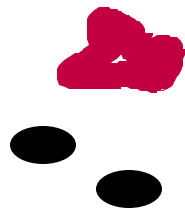
Part

Polymer(s)

**Fillers
Pigments
Additives**

**Deformation
Rate
Amount**

**Cooled or
Cured**





EPDM WINDOW CHANNEL COMPOUND FORMULATION:

<u>INGREDIENT</u>	<u>PHR</u>
EPDM	100
N774 Carbon Black	100
Mineral Oil	50
Polyethylene Wax	5
Zinc Oxide	5
Stearic Acid	1
TMTD	1
Methyl Zimate	3
Ethyl Cadmate	1
Sulfur	1
Calcium Oxide (80%)	1
Totals	277



TPV COMPOUND FORMULATION (EXAMPLE):

<u>INGREDIENT</u>	<u>PHR</u>
EP Rubber	200
Polypropylene/Polyethylene	50
Mineral Oil	30
Talc	15
Crosslinking Resin	6
Stannous Chloride Dihydrate	1.5
Zinc Oxide	4
Zinc Stearate	1.5
Antioxidant	1.5
TOTAL	309.5



PVC COMPOUND FORMULATIONS (EXAMPLE):

Rigid Exterior Application

<u>INGREDIENT</u>	<u>PHR</u>
PVC Resin	100
Impact Modifier	5
Calcium Carbonate	12
Tin Stabilizer	1
Calcium Stearate	1.2
Acrylic Process Aid	0.5
Paraffin Wax	1.1
Oxidized PE Wax	0.2
Titanium Dioxide	0.3
TOTAL	121.3

Flexible Application

<u>INGREDIENT</u>	<u>PHR</u>
PVC Resin	100
Impact Modifier	5
DOP Plasticizer	25
Epoxy Tallate	3
Calcium/Zinc Stabilizer	2
Stearic Acid	0.4
Acrylic Process Aid	0.5
Calcium Carbonate	3
TOTAL	121.3



Types and Growth Rates of Plastic Additives

1998 - 2003

High Growth (6-7%/yr.)

Coupling Agents

Light Stabilizers

Nucleating/Clarifying Agents

Medium Growth (4-5%/yr.)

Antiblocking Agents

Antioxidants

Antistats

Chemical Blowing Agents

Flame Retardants

Heat Stabilizers

Impact Modifiers/*Process Aids*

Lubricants/Mold Release Agents

Organic Peroxides

Slip Agents

Lowest Growth (<4%/yr.)

Biocides

Plasticizers

SOURCE: TownsendTarnell Inc.

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Consumption of Plastic Additives

1998

Region	Consumption, kg	Value, \$
North America	2.16 Billion	4.1 Billion
Europe	1.93 Billion	3.8 Billion
Asia-Pacific	2.70 Billion	5.3 Billion
ROW	0.92 Billion	1.8 Billion
TOTALS	7.7 Billion	15 Billion

SOURCE: TownsendTarnell Inc.



EFFECT MECHANISMS OF THE ADDITIVES:

- ▶ Tribology
 - The science of the mechanisms of friction, lubrication, and wear of interacting surfaces that are in relative motion

- ▶ Tribological Functions
 - Adhesive
 - Lubricant
 - Surfactant

EFFECT MECHANISMS OF THE ADDITIVES:

- ▶ Tribological
 - Adhesives
 - Increased interfacial forces created by surface attachment
 - Increase energy required to break adhesive bonds causing increased shear
 - Lubricants
 - Function to minimize the frictional forces between moving surfaces
 - Can be divided into internal and external
 - Internal is polymer:polymer, polymer:filler interaction
 - External is polymer:hot metal, filler:hot metal interaction
 - Surfactants
 - Create a surface active film via polar and non-polar ends
 - Polar end absorbs/bonds to a surface
 - Wetting of the filler allows for improved low energy dispersion
 - Similar to lubricants effect



DIFFERENCES IN LUBRICANT TYPES:

Taken from PVC based terminology:

▶ **External**

- Typically provide lubrication between the polymer and the metal surface of the processing equipment.

- **Types**

Polyethylene Homopolymers, Paraffins, Esters, Metallic Soaps, Amides, Fatty Acids and Oxidized Polyethylenes

▶ **Internal**

- Typically reduce bulk viscosity by being partially compatible with the PVC, thus helping to open the polymer chain with the lubricants' soluble component, while providing intermolecular lubrication with the less soluble portion of the lubricant molecule.

- **Types**

Fatty Alcohols, Esters, EVA Waxes



SPECIFIC EFFECTS OF LUBRICANTS

■ **Internal Lubricants**

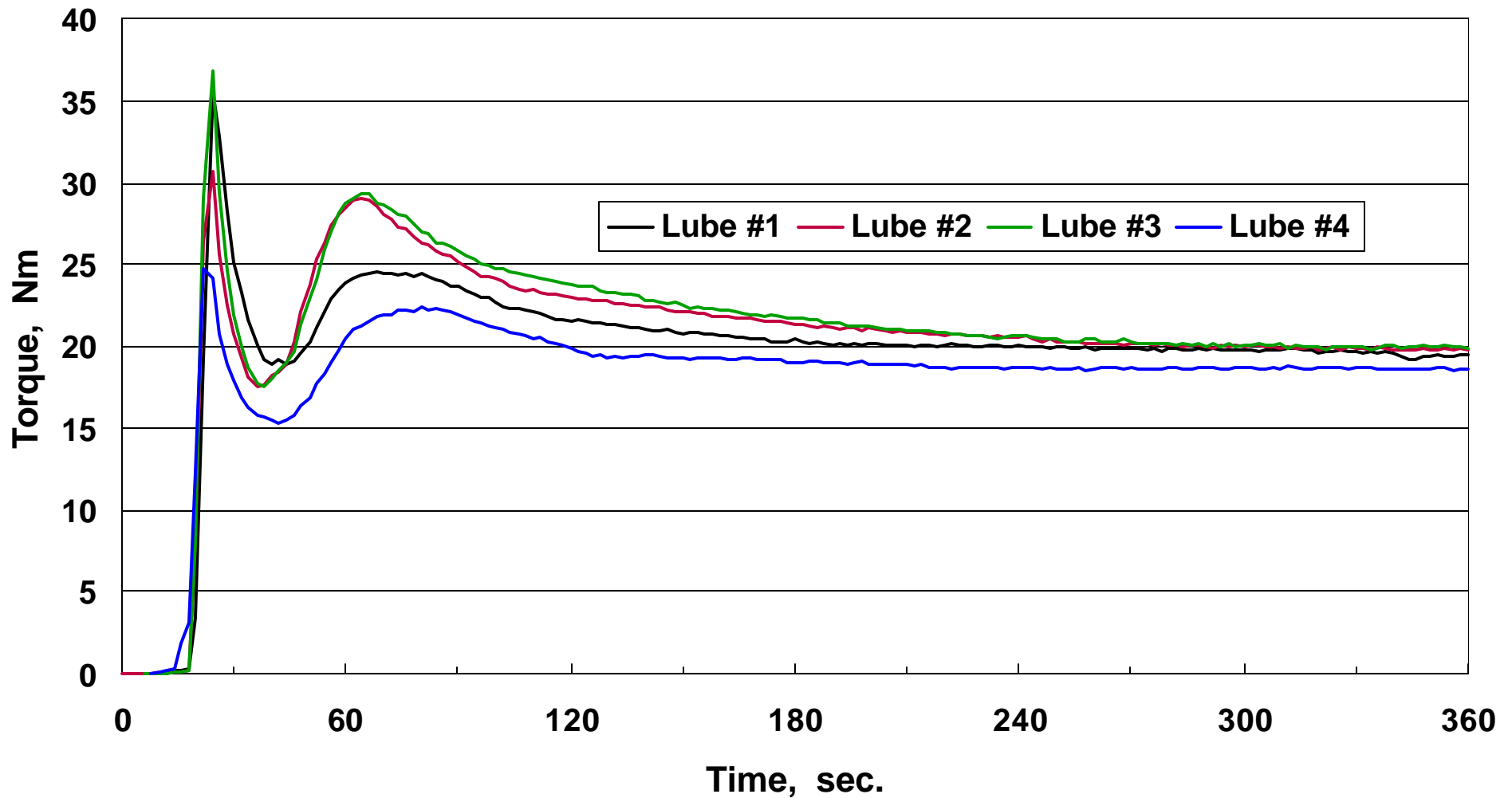
- ▶ Promote flow
- ▶ Exhibit good clarity
- ▶ Promote good weld line strength
- ▶ Minimize sink marks
- ▶ Improve die filling
- ▶ Reduce die swell
- ▶ Allow increased molding speed without shear burn
- ▶ Reduce head and back pressure
- ▶ Do not affect paintability
- ▶ Lower heat distortion

■ **External Lubricants**

- ▶ Provide metal release
- ▶ Help reduce process temperature
- ▶ Can plate out
- ▶ Slow fusion
- ▶ Can cause delamination
- ▶ Can lower weld line strength
- ▶ Can cause surging



Effects of Lubricants on a Rigid PVC Formulation



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TYPICAL PROPERTIES OF HIGHLY FILLED COMPOUNDS:

- ▶ Increased:
 - ✓ Viscosity
 - ✓ Flexural modulus
 - ✓ Heat deflection temperature (HDT)
 - ✓ Dimensional stability

- ▶ Decreased:
 - ✓ Izod Impact
 - ✓ Mold shrinkage
 - ✓ Thermal expansion
 - ✓ Part cost

- ▶ Goals:
 - ✓ Decreased wall thickness = decreased part weight
 - ✓ Equivalent properties
 - ✓ **Lower Cost!!!**



BRABENDER MIXING DATA:

40% Wood Flour Composites

	<u>Cont.</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>
Peak Torque, Nm	90	68	57	67	62	65	55
Torque @ 2', Nm	11	13	10	12	12	11	9
Torque @ 3', Nm	9	11	8	11	11	10	6
Torque @ 4', Nm	9	11	7	11	10	10	5
Equilibrium Temp, °C	174	172	171	175	172	173	169
Metal Release Rating	+	++++	++++	+++	+++	+++	++

	<u>H</u>	<u>I</u>	<u>J</u>	<u>K</u>	<u>L</u>	<u>M</u>	<u>N</u>
Peak Torque, Nm	100	68	57	59	58	65	64
Torque @ 2', Nm	16	15	15	16	14	14	9
Torque @ 3', Nm	13	13	13	14	13	13	7
Torque @ 4', Nm	11	13	12	13	12	12	6
Equilibrium Temp, °C	184	181	180	181	180	179	171
Metal Release Rating	+	+++	++++	+++	+++	+++	++



CAPILLARY RHEOMETER DATA:

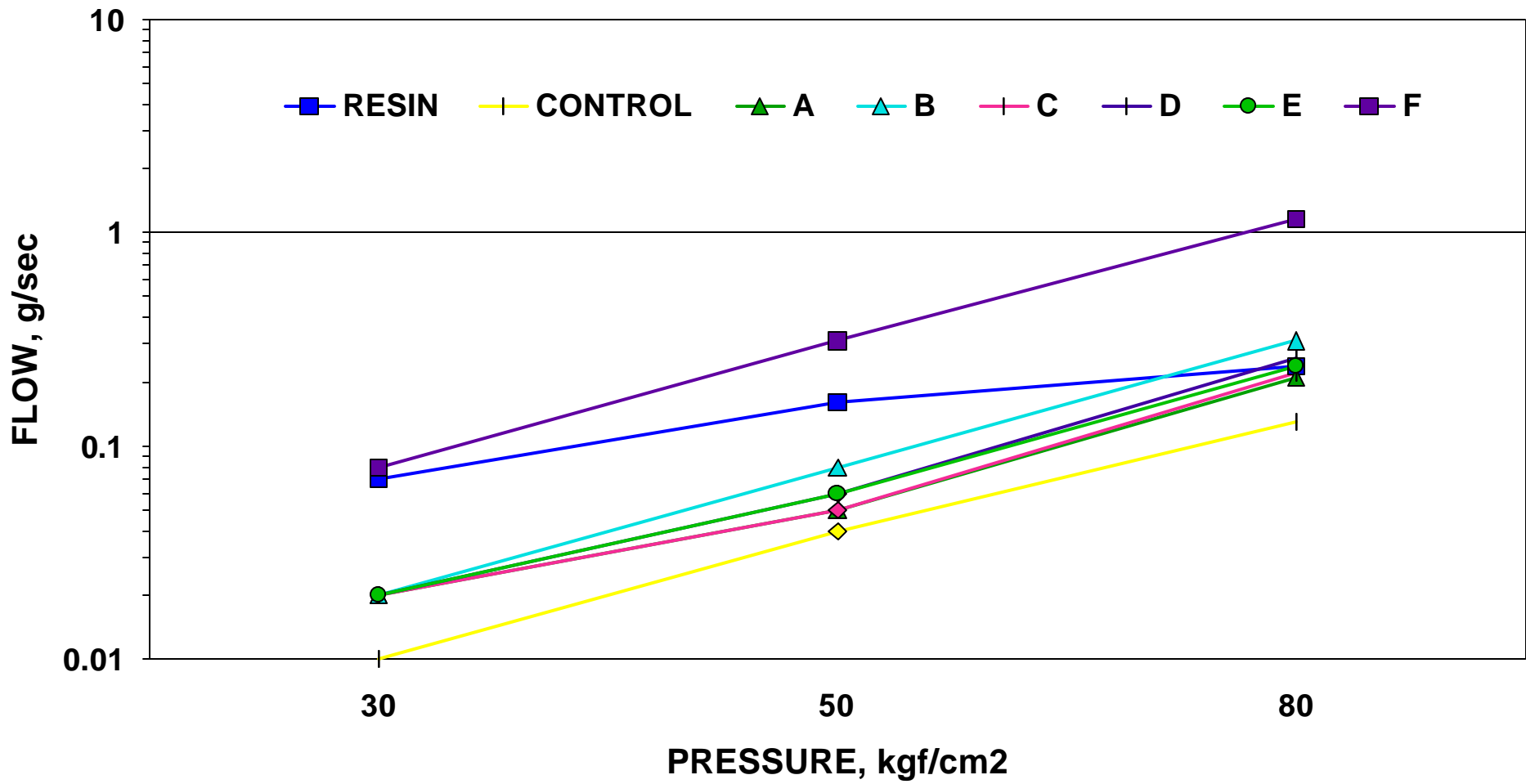
40% Wood Flour Composites comparing lubricants, adhesives and surfactants

	<u>Resin</u>	<u>Cont.</u>	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>	<u>F</u>
30 kgf/cm ² @ 190°C								
Flow, g/sec	0.07	0.01	0.02	0.02	0.02	0.02	0.02	0.08
Viscosity, Pa·s	102	564	423	305	382	350	387	89
Shear, sec ⁻¹	718	130	173	240	192	209	190	822
50 kgf/cm ² @ 190°C								
Flow, g/sec	0.16	0.04	0.05	0.08	0.05	0.06	0.06	0.31
Viscosity, Pa·s	68	274	216	139	382	183	199	39
Shear, sec ⁻¹	1792	446	567	879	192	668	615	3126
80 kgf/cm ² @ 190°C								
Flow, g/sec	0.24	0.13	0.21	0.31	0.22	0.26	0.24	1.16
Viscosity, Pa·s	79	152	90	62	89	74	82	17
Shear, sec ⁻¹	2482	1283	2167	3146	2209	2637	2394	11770



40% WOOD FLOUR COMPOSITE RHEOLOGY

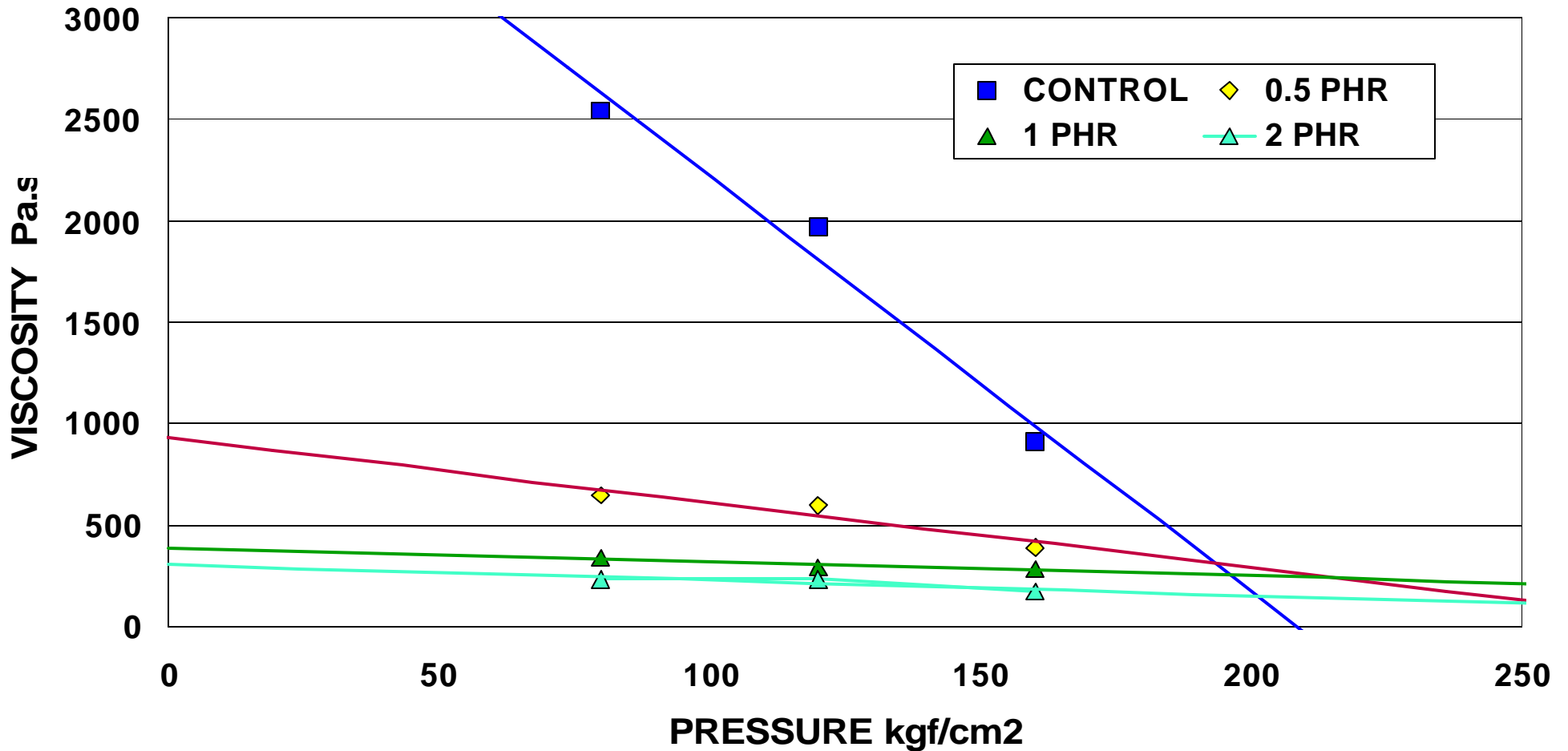
LOG FLOW VS. PRESSURE



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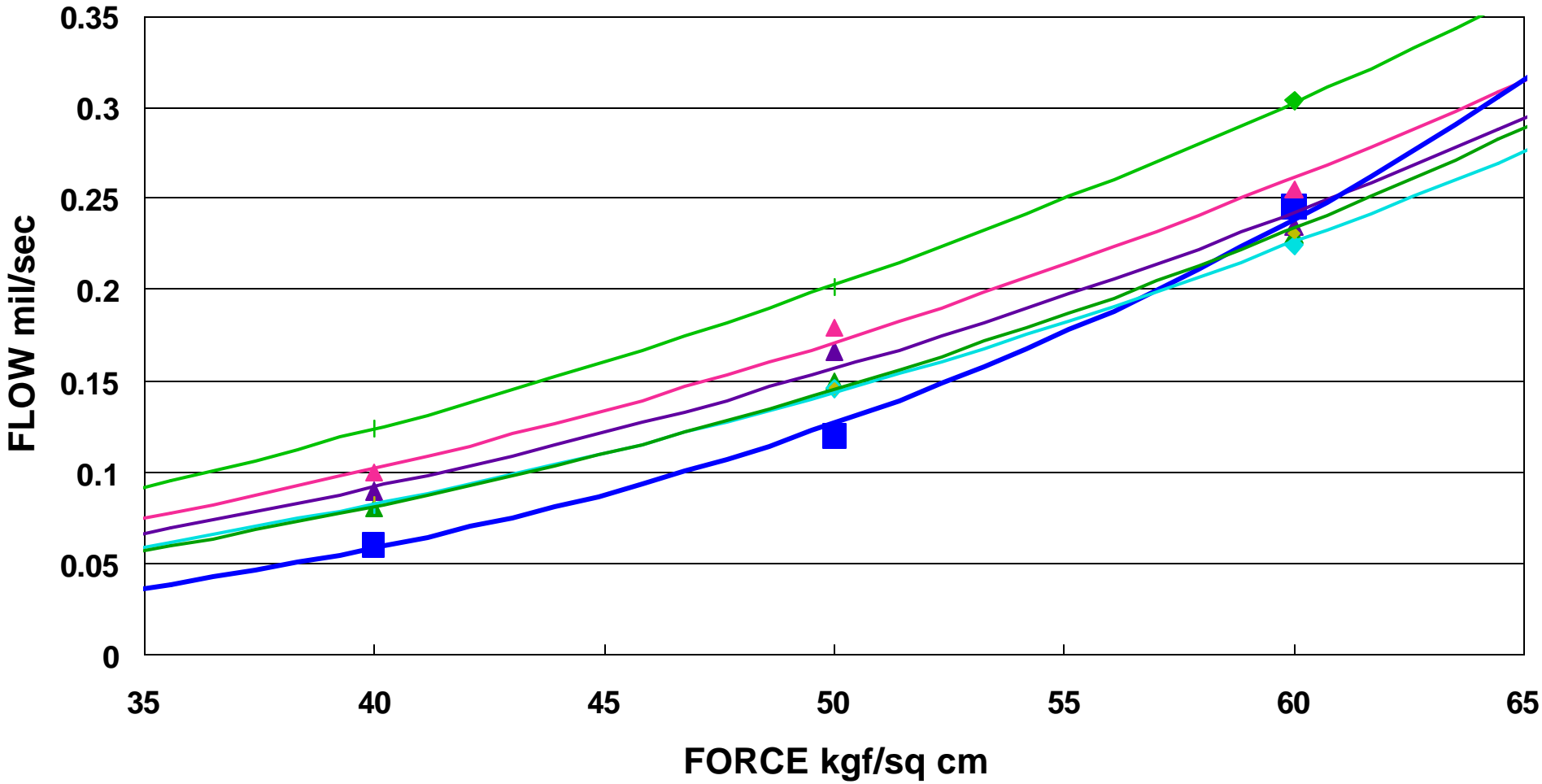
Polycarbonate Flow Characteristics Non-lubricated vs. Ester-based Lubricant



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Improved Processing of Low Hardness TPV 35 Shore A Injection Molding Grade



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BENEFITS/APPLICATIONS FOR IMPROVED FLOW/PROCESSING:

Benefits:

- ★ Thinner wall molding
- ★ Longer flow lengths
- ★ More intricate shapes/designs
- ★ Improved foamability/cell size control?

Applications:

- ★ Over molding for soft touch grips (e.g. appliances, toothbrush, etc.)
 - Dipped PVC plastisol replacement?
- ★ Glass/window encapsulation
- ★ Small parts
- ★ Seals, weatherstripping



CONCLUSIONS:

- Many types of processing problems and or difficulties can be solved through the use of additives.
- Changing the processing characteristics of compounds and resins can open up windows of opportunity in many applications.
- Improved processing **always** leads to cost reduction.