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April 6, 2016 - PSCI Spring Meeting

Environmental and Material Effects on Container Performance

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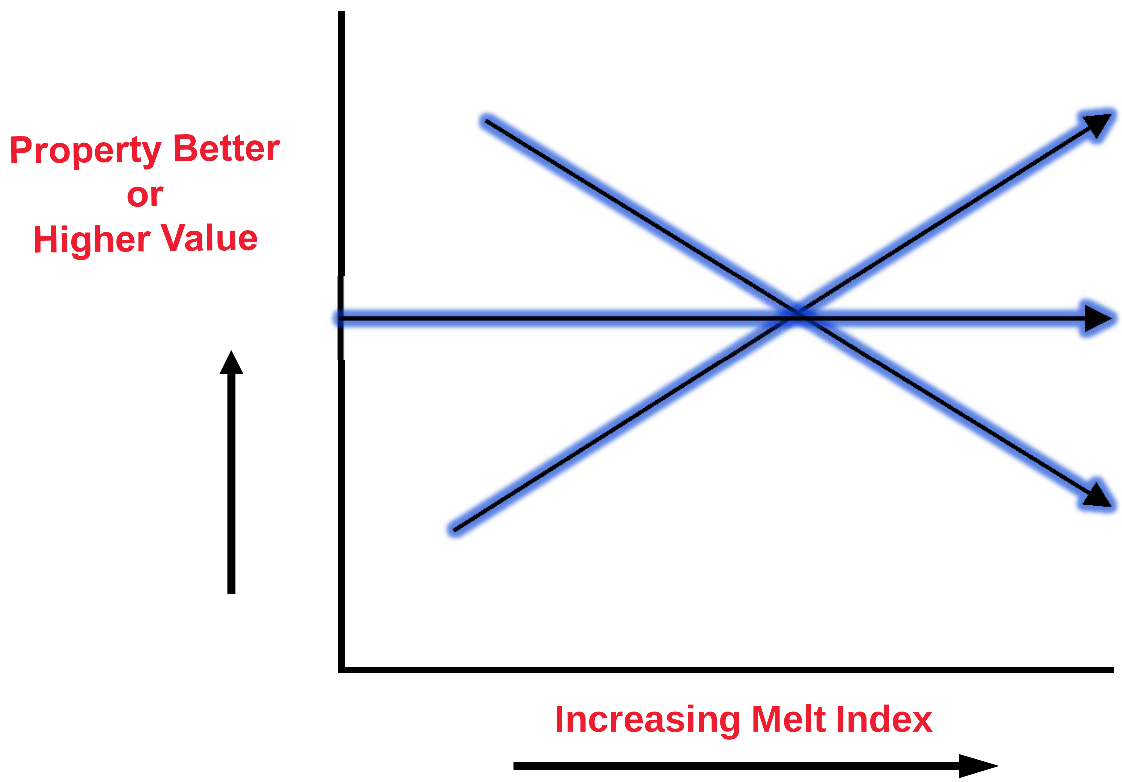
Background

- Polyethylene is an extremely versatile polymer and used extensively in container applications

- It is generally well known in the container industry that polyethylene grade selection, container thickness and the conditions that the container is exposed to during warehouse storage are important, but do you really know the magnitude of the effect?

- Having some knowledge of the magnitude these variables have on container properties will allow you to make more informed decisions and avert potential application failures

Effect of melt index on properties

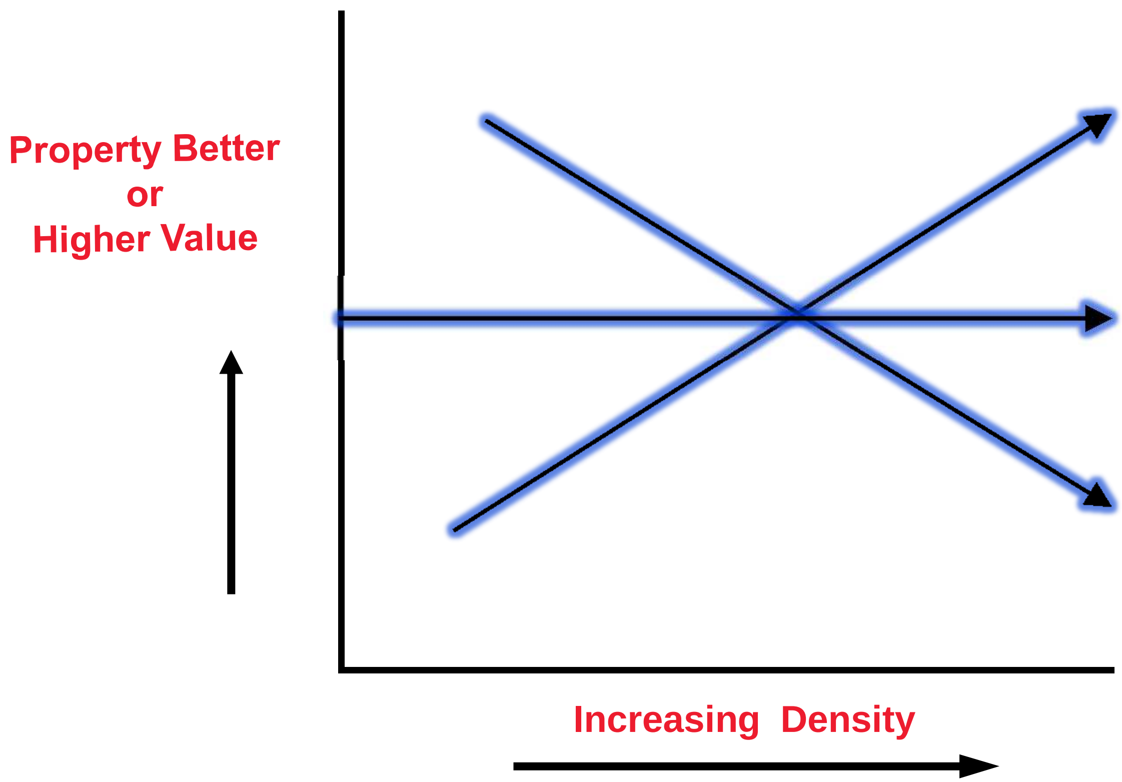


- Flow (Part Fill)
- Gloss

- **Stiffness / Rigidity**
- **Tensile Yield Strength**
- Hardness
- Transparency

- **Tensile Break Strength**
- Impact Strength
- ESCR
- Permeability Resistance
- Weatherability

Effect of density on properties



- **Stiffness / Rigidity**
- **Tensile Yield Strength**
- Shrinkage / Warpage
- Hardness
- Heat Resistance
- Gloss
- Permeability Resistance

- Flow (Part Fill)
- Weatherability

- Impact Strength
- ESCR
- Transparency

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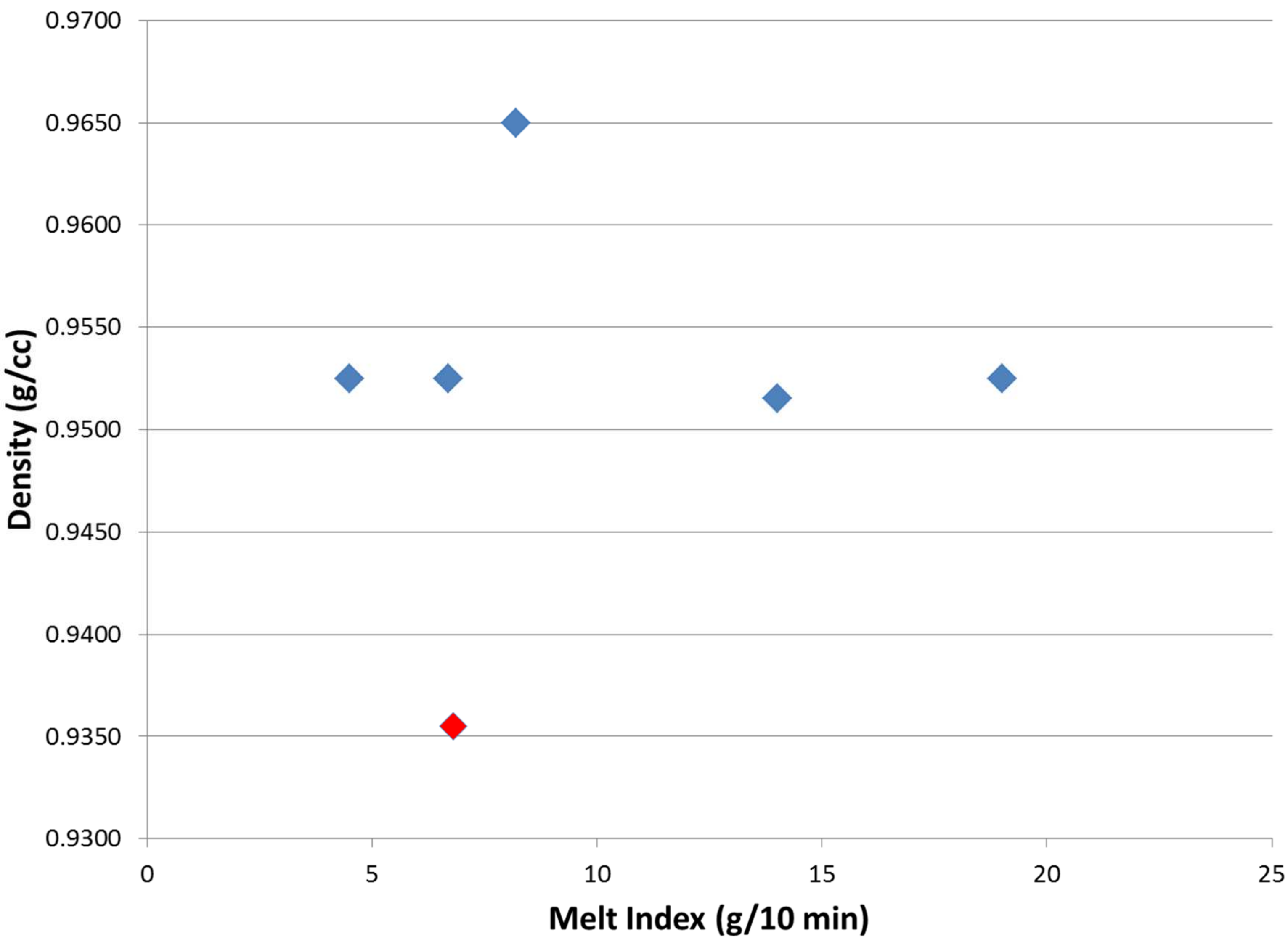
Resins serving the container market



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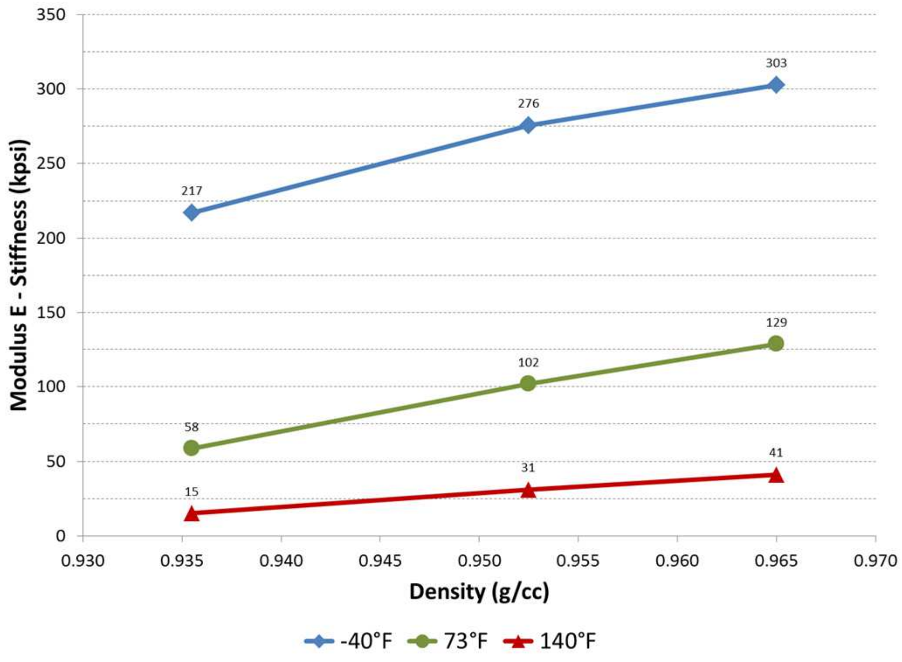
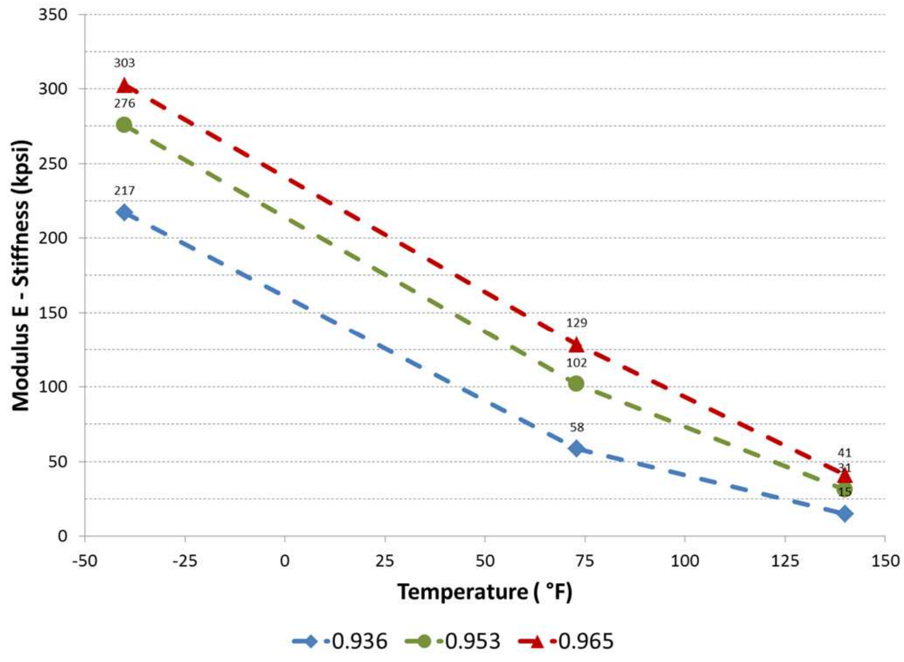
Two definitions…

- Modulus E – Also referred to as Young's Modulus
  - In simple terms, think of it as stiffness
- Yield Point - Point at which the material begins to permanently deform when a stress is applied
  - Prior to the yield point, the material will deform elastically and will return to its original shape when the applied stress is removed

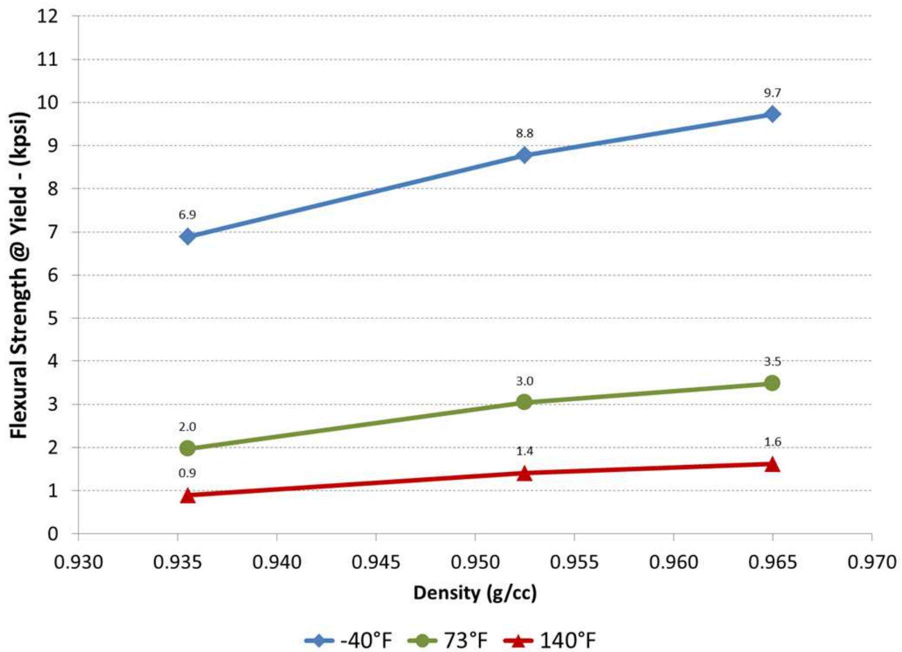
Stiffness response

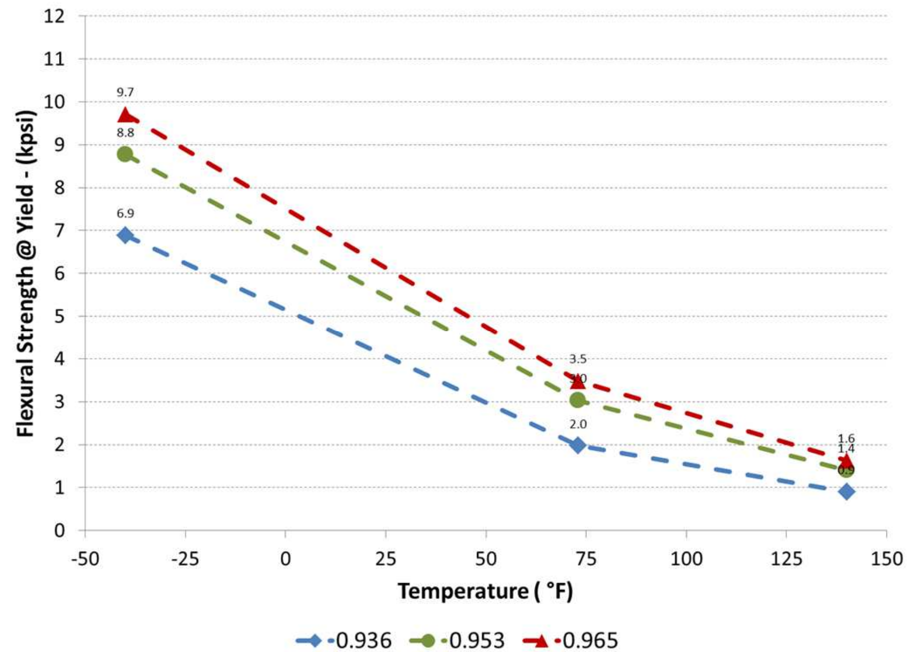




- Effect of temperature on stiffness is significantly greater than that of resin density

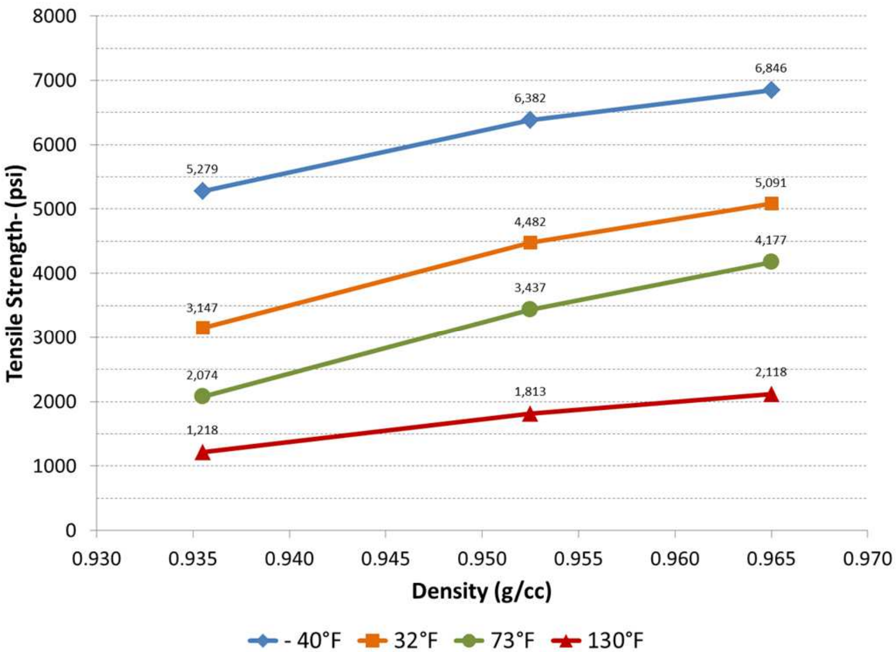
Flexural strength at yield response

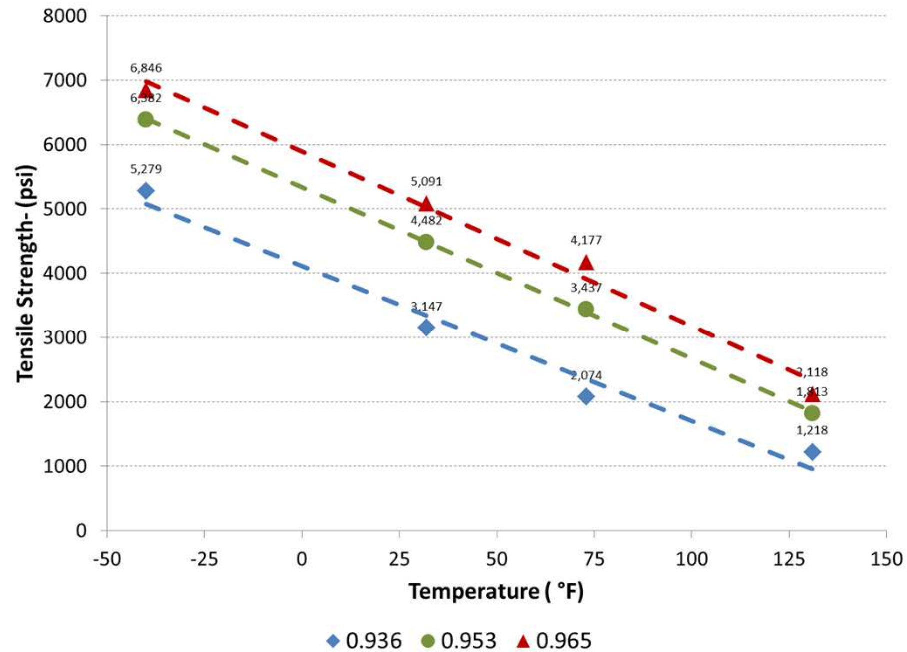




- Effect of temperature on flexural strength at yield is significantly greater than that of resin density

Tensile strength response





- Effect of temperature on tensile strength is significantly greater than that of resin density

What is the effect on the container?

- Stiffness is proportional to resin density

  Stiffness $\propto$ resin density

- Stiffness is proportional to the cube of part thickness

  Stiffness $\propto$ part thickness^3

- So how much stiffer is a 100 mil pail than a 90 mil pail?

  Thickness increased by ~10%

  Stiffness (100 mil pail) = stiffness (90 mil pail) x $(1.10)^3$

  Stiffness (100 mil pail) = 1.33 x stiffness (90 mil pail)

How does temperature effect container performance?

- Based on the previous data, a 10°F rise in temperature results in a 17% decrease in stiffness
  - So for equivalent container stiffness, if the warehouse temperature increases by 20°F, then the wall thickness of your container should be increased by 10%
    - Alternatively, if pail thickness is maintained equivalent, then the stiffness "cushion" in your container design is reduced by 34%

- A 10°F rise in temperature results in a 15% decrease in flex strength prior to the container yielding
  - So for equivalent flex strength prior to yielding, if the warehouse temperature increases by 20°F, then the wall thickness of your container should be increased by 10%
    - Alternatively, if pail thickness is maintained equivalent, then the flex strength prior to yielding "cushion" in your container design is reduced by 30%

How does temperature effect container performance?

- A 10°F rise in temperature results in a 10% decrease in tensile strength
  - So for equivalent container tensile strength , if the temperature increases by 20°F, then the wall thickness of your container should be increased by 6%
    - Alternatively, if pail thickness is maintained equivalent, then the tensile strength “cushion” in your container design is reduced by 20%

- So container toughness is less sensitive to temperature than either stiffness and flex strength prior to the container yielding

What about resin density?

- A 0.0010 difference in resin density results in a 2.4% decrease in container stiffness
  - So a 0.0030 g/cc difference in resin density, the effect on pail thickness is 2%
    - At equivalent stiffness
- So container stiffness is significantly more sensitive to temperature than resin density

Summary

- Temperature has a significant effect on container stiffness, flex strength prior to yielding and tensile strength
  - During filling, use, warehouse storage and transport
- Resin density effect is minor compared to temperature
- Hopefully this presentation has increased your understanding of the magnitude these variables have on these container properties in order to make more informed decisions and avert potential application failures

Measured properties and test methods used

Measured Property	Test Method	Description
Modulus E Stiffness	ASTM D 790	Flexural Properties of Unreinforced and Reinforced Plastics
Flexural Strength at Yield	ASTM D 790	Flexural Properties of Unreinforced and Reinforced Plastics
Tensile Strength	ASTM D 638	Standard Test Method for Tensile Properties of Plastics

Thank you…

Questions…

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