Consumer Solutions

Pulp Manufacturing Antifoam and Performance Modifiers from Dow

2016 – Christophe Deglas

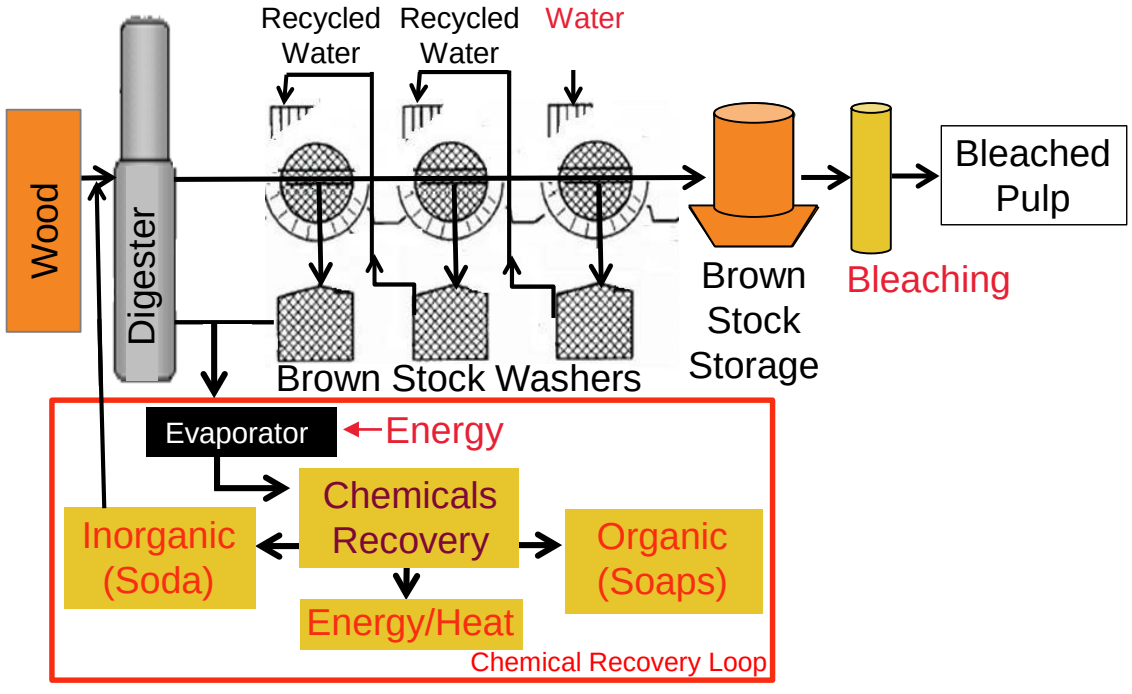
Pulp Kraft Process and Silicones

SILICONE GOALS:

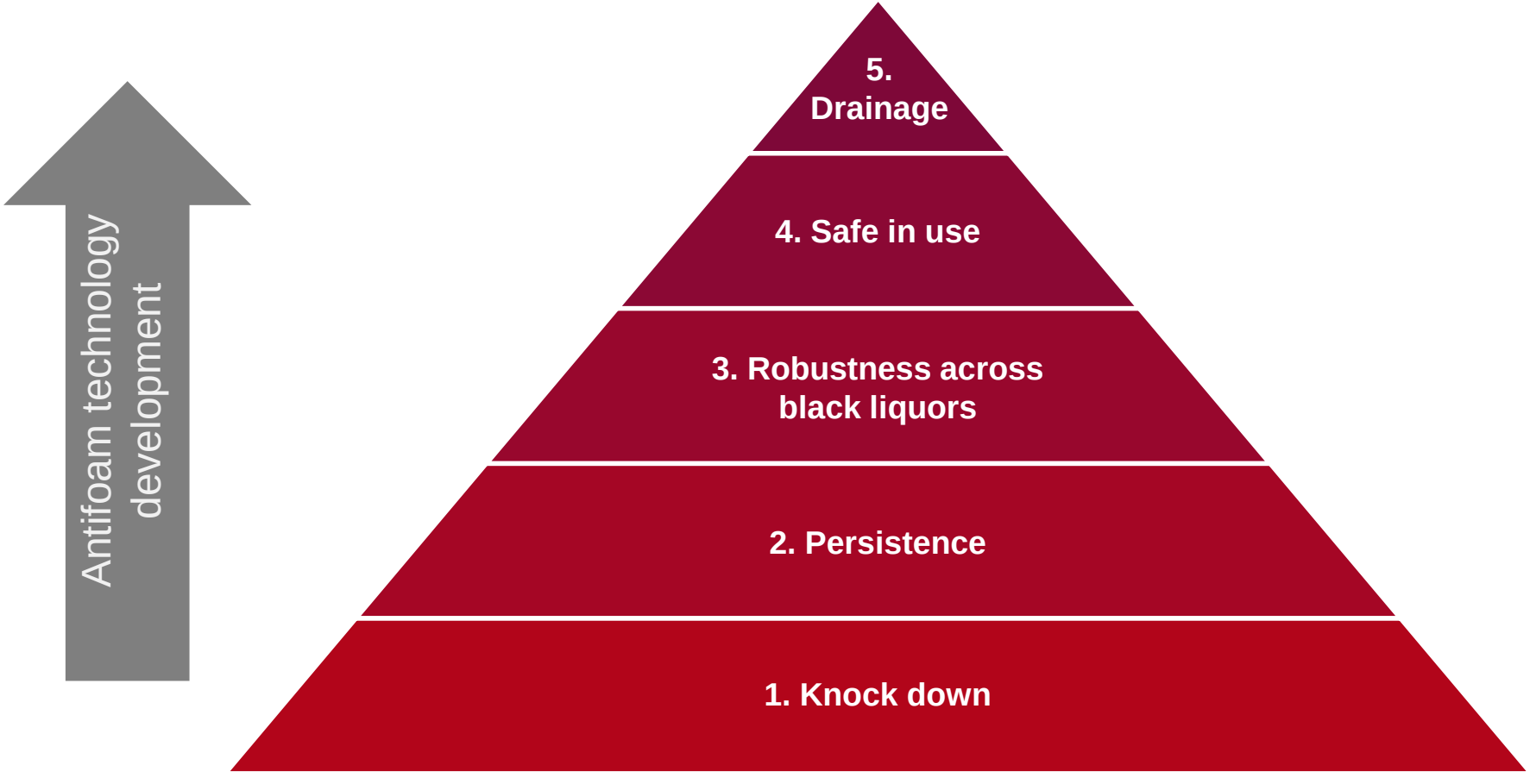
- > Production Yield
- > Pulp Quality
- > Soda Recovery
- < Bleaching Chemicals
- < Water Usage
- < Energy Usage
- > Soap Recovery

Silicone antifoam emulsions are injected in washers. Around 200 gr emulsion of 12% active silicone antifoam per ton of pulp produced

Paper Pulp Production



Antifoam Technology Development from Dow



Continuous Development

DOWSIL™ ACP-3990 Antifoam Compound (knockdown)

DOWSIL™ ACP-3056 Antifoam Compound (persistency, softwood)

DOWSIL™ AFE-3101 Antifoam Emulsion (emulsion, persistency, knockdown, softwood)

DOWSIL™ ACP-3258 Antifoam Compound (soft/hardwood, low deposition, persistency, knockdown)

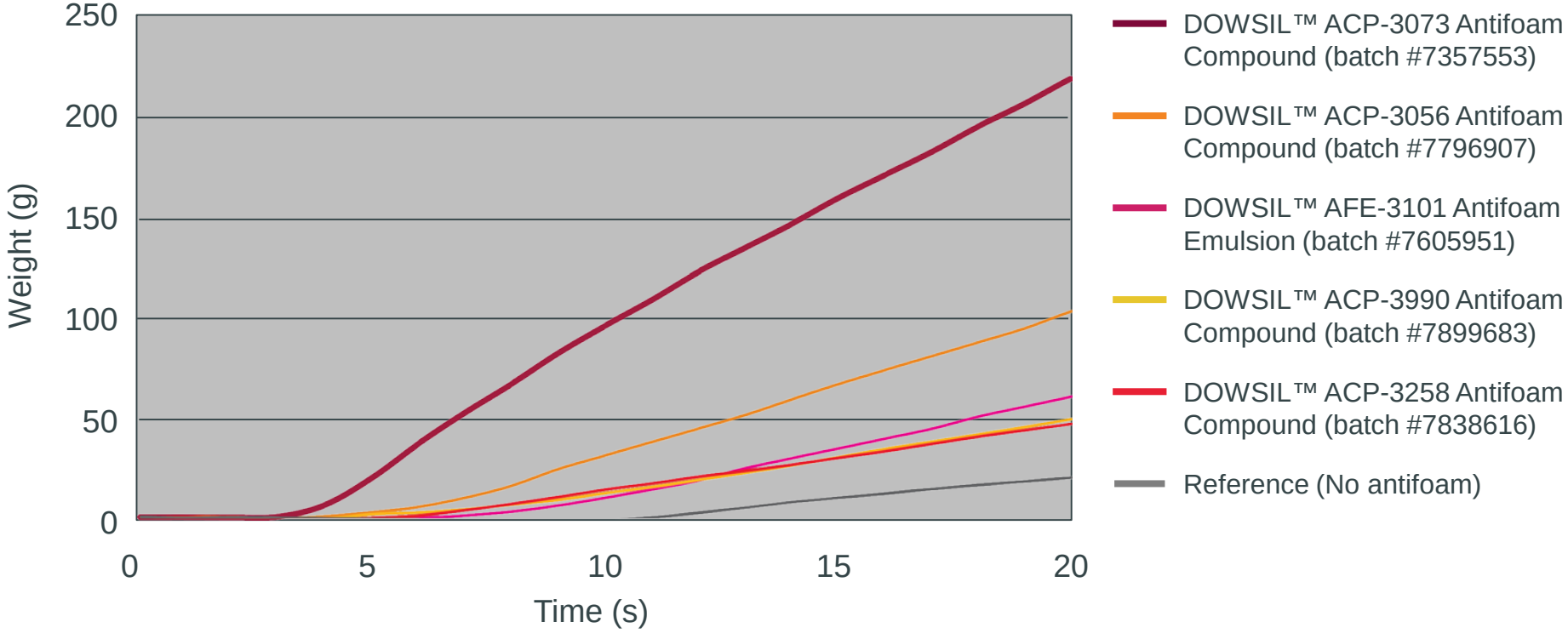
DOWSIL™ AFE-7500 Antifoam Emulsion (concentrate, low deposition, persistency, knockdown, soft/hardwood)

DOWSIL™ ACP-3073 Antifoam Compound (drainage, low deposition, persistency, knockdown, soft/hardwood)

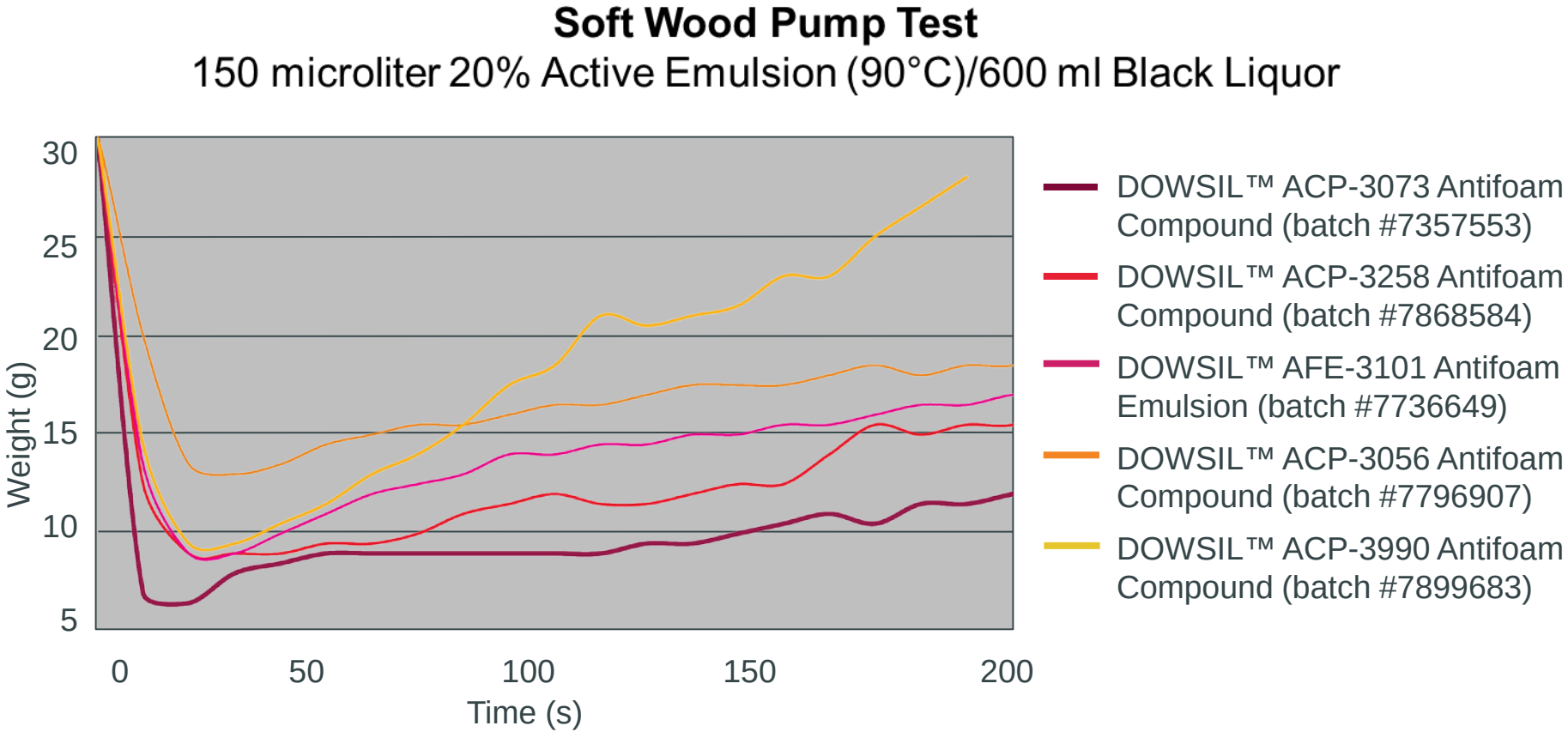
Drainage

Drainage Performance

35 ppm Compound vs. Dry Fiber Hard Wood – Synthetic Liquor



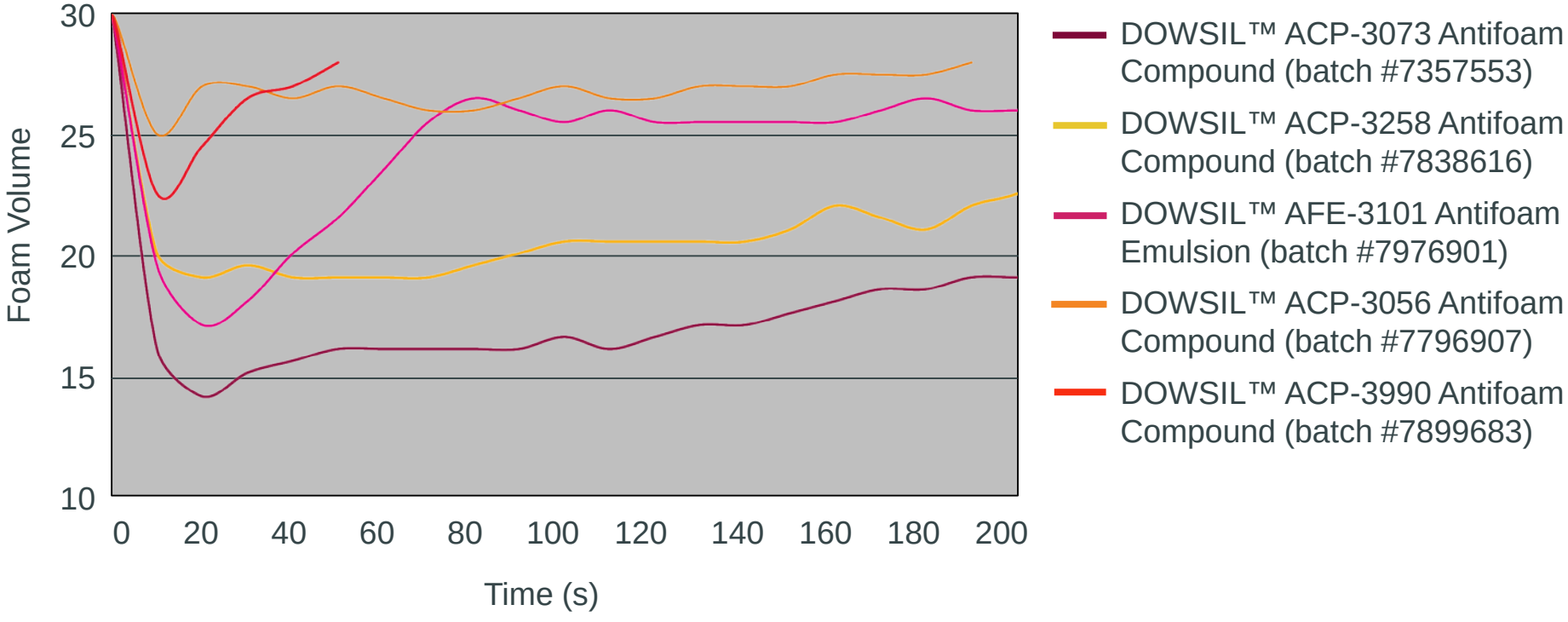
Antifoam in Softwood



Antifoam in Hardwood

Hardwood Pump Test

100 microliter 20% Active Emulsion (90˚C) in 700 ml Black Liquor

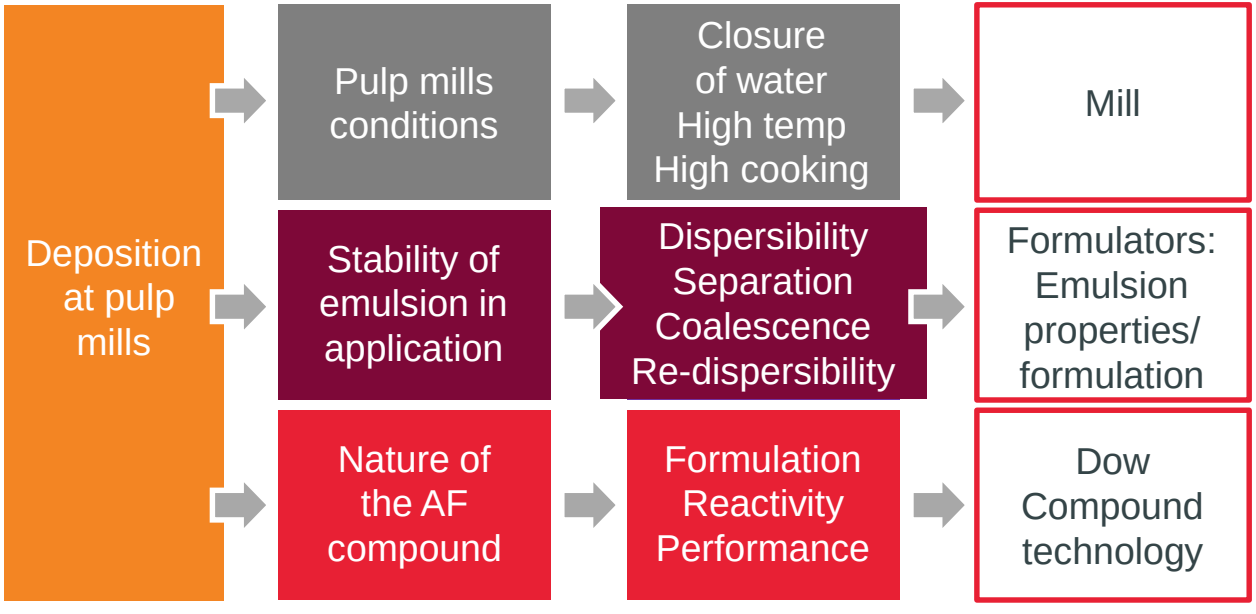


Safe in Use

- Internal test was performed to validate DOWSIL™ ACP-3073 Antifoam Compound risk
- Based on technology and validated by lab testing, from higher to lower risk of deposition:
  - DOWSIL™ ACP-3056 Antifoam Compound
  - DOWSIL™ ACP-3258 Antifoam Compound*
  - DOWSIL™ ACP-3073 Antifoam Compound*
  - DOWSIL™ ACP-3990 Antifoam Compound*

Deposition risk classification from Dow is based on the nature of the compound but:
+ Stability of emulsion
+ Mill conditions/injections
must be considered in silicone deposition and carry over risk.

* Lower risk of deposit; the order may change depending on the type of black liquor



Compounds Summary

	DOWSIL™ ACP-3990 Compound	DOWSIL™ ACP-3056 Compound	DOWSIL™ ACP-3258 Compound	DOWSIL™ ACP-3073 Compound
Viscosity (mPas)	35,000	45,000	30,000	30,000
Knock Down	++++	++	++++	+++++
Persistence	++	+++	++++	+++++
AF Performance in Softwood BL	+++	++++	++++	+++++
AF Performance in Hardwood BL	++	+	+++	+++++
Safe in Use (risk of deposition)	++++	+	+++	++++
Drainage	++	+++	++	+++++

Best drainage enhancement with DOWSIL™ ACP-3073 Compound

Formulation Aid

Standard emulsion stability considerations:

- Change type/concentration of surfactants in order to generate the best adsorption around the compound droplets
- Decrease the particle size
- Increase the aqueous phase viscosity (thickener carboxylic polymers/ xanthan gum)
- Use of silicone surfactants:
  - As booster of organic surfactant: DOWSIL™ OFX-5247 Fluid, DOWSIL™ OFX-5573 Fluid, DOWSIL™ OFX-5329 Fluid, DOWSIL™ 5604 Additive and new DOWSIL™ 5290 Performance Modifier
  - As full surfactant package: DOWSIL™ FZ-2104 Fluid, DOWSIL™ FZ-2108 Fluid, DOWSIL™ FZ-5609 Fluid ratio 1/2/1

Prototype formulations guidelines available on demand

Booster considerations (R: Recommended):

	Knock Down	Persistency	Drainage	Mineral Oil	Stability
DOWSIL™ ACP-3073 Antifoam Compound	R	R	R	-	-
DOWSIL™ ACP-2000 Antifoam Compound	-	-	-	R	-
DOWSIL™ OFX-5247 Fluid	R	R	-	R	R
DOWSIL™ OFX-5329 Fluid	R	R	-	R	R
DOWSIL™ OFX-5573 Fluid	R	R	R	R	R
DOWSIL™ 5290 Performance Modifier	R	R	R	R	R
DOWSIL™ FZ-2104 Fluid	-	-	-	-	R
DOWSIL™ FZ-2108 Fluid	-	-	-	-	R
DOWSIL™ FZ-5609 Fluid	-	-	-	-	R
DOWSIL™ 5604 Additive	-	-	-	-	R

Active Prototype Emulsion

- **Ingredient Weight Percent**

Dow Antifoam Compound		17.0%
Siloxylated PolyEthers	DOWSIL™ FZ-2104 Fluid (can be solid at RT but liquid < 30ºC)	1.5%
	DOWSIL™ FZ-2108 Fluid	3.0%
	DOWSIL™ FZ-5609 Fluid	1.5%
Thickeners	Xanthan gum	0.94%
	EHEC (EthylHydroxyEthylCellulose)	0.31%
Preservatives		0.1%
Water (in several portions)		75.65%

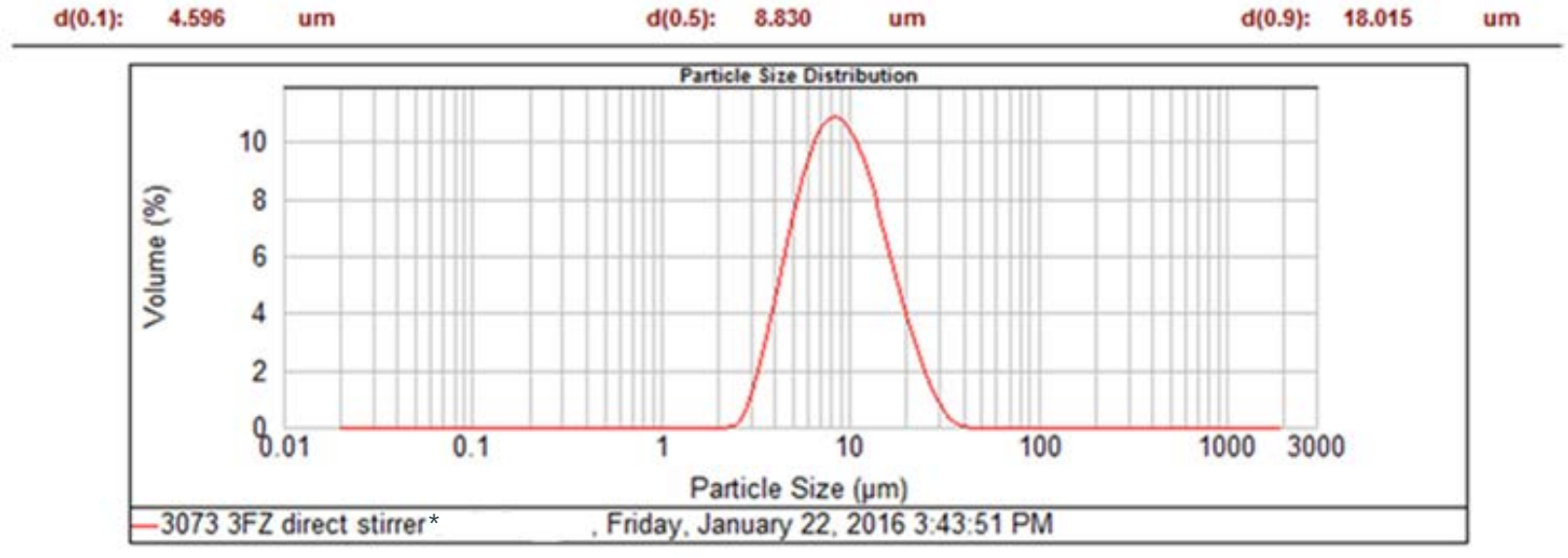
- **Procedure by Inversion Phase**
  - Add the Antifoam compound to the kettle. While stirring, add the SPEs. After agitation add thickener solution (= 45.65% water with thickeners with biocide) in three steps and stir until homogeneous. Finally, with stirring, add the second addition water (30%).

- **Procedure by Direct Emulsification**
  - Add first thickener solution in the kettle. SPEs must be premixed to compound prior to addition.
  - Rest of water must be added in multiples (three steps)

Note: The formulation and procedure are provided as a starting point for development work. Optimization will be required based on the raw materials selected, processing equipment, desired particle size and performance. Ratio between the three SPEs can be optimized according to the antifoam compound selected.

Particle Size Distribution

20% active prototype emulsion based on DOWSIL™ ACP-3073 Antifoam Compound and DOWSIL™ FZ-2104 Fluid, DOWSIL™ FZ-2108 Fluid, DOWSIL™ FZ-5609 Fluid with direct emulsification



Note: The formulation and procedure are provided as a starting point for development work. Optimization will be required based on the raw materials selected, processing equipment, desired particle size and performance. Ratio between the three SPEs can be optimized according to the antifoam compound selected.

* 3073 = DOWSIL™ ACP-3073 Antifoam Compound

Drainage Boosters General Market

- ACP (Antifoam Compound) and OFX (Organofunctional Siloxane)
- Drainage (D) booster also impacts Knock Down (KD) and Persistency (P).
- Impact can be positive or negative and will depend on the compound technologies → Customer-specific formulation validation is required.
- DOWSIL™ ACP-3073 Antifoam Compound remains Drainage top performer without negative impact on KD and P.

95% ACP/5% OFX		No Booster	DOWSIL™ OFX-5573 Fluid	DOWSIL™ 5290 Performance Modifier
DOWSIL™ ACP-3073 Antifoam Compound	D	+++++++	+++++++++	+++++++
	KD	++	++	+
	P	++	+++	+
DOWSIL™ ACP-3258 Antifoam Compound	D	o	+	+++++
	KD	o	o	o
	P	o	+	+++
DOWSIL™ ACP-3056 Antifoam Compound	D	+++	++++++	++++++
	KD	-	o	-
	P	o	o	---
DOWSIL™ ACP-3990 Antifoam Compound	D	o	++	++
	KD	o	o	--
	P	----	---	-----

DOWSIL™ ACP-3258 Antifoam Compound selected as reference (o)
For testing conditions refer to slides 5-6.

Drainage Boosters Detailed

DOWSIL™ ACP-3258 Antifoam Compound selected as reference (o). For testing conditions, refer to slides 5-6. NE = Not Evaluated.

95% ACP/5% OFX		No Booster	Competitor 1	Competitor 2	DOWSIL™ OFX-5573 Fluid	DOWSIL™ 5290 Performance Modifier
DOWSIL™ ACP-3073 Antifoam Compound	D	+++++++	+++++++++	++++++++	+++++++++	+++++++
	KD	++	+++	++	++	+
	P	++	++	++++	+++	+
DOWSIL™ ACP-3258 Antifoam Compound	D	0	+	++	+	+++++
	KD	0	0	+	0	0
	P	0	0	+	+	+++
DOWSIL™ ACP-3056 Antifoam Compound	D	+++	+++++	++++++	++++++	++++++
	KD	-	-	-	0	-
	P	0	+	++	0	---
DOWSIL™ ACP-3990 Antifoam Compound	D	0	++++	+++	++	++
	KD	0	0	0	0	--
	P	----	---	----	---	-----

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- DOWSIL™ ACP-3073 Antifoam Compound remains Drainage top performer without negative impact on KD and P.

Dow Offerings in Pulp Process

- Dow does not provide:
  - Pulp mill day-to-day control and service
  - Pulp mill antifoam test evaluation and customized formulation
  - Pulp mill full chemicals package
- Dow does provide:
  - Ready-to-use emulsions for formulator and service company (DOWSIL™ AFE-3101 Antifoam Emulsion, DOWSIL™ AFE-7610 Antifoam Emulsion, DOWSIL™ AFE-7620 Antifoam Emulsion)
  - Concentrated emulsions for formulator dilution (DOWSIL™ AFE-7500 Antifoam Emulsion, DOWSIL™ AFE-7600 Antifoam Emulsion)
  - Self-dispersible compound for formulator emulsification (DOWSIL™ ACP-3472 Antifoam Compound, DOWSIL™ ACP-3379 Antifoam Compound)
  - Compound for formulator emulsification (DOWSIL™ ACP-3073 Antifoam Compound, DOWSIL™ ACP-3258 Antifoam Compound, DOWSIL™ ACP-3056 Antifoam Compound, DOWSIL™ ACP-3990 Antifoam Compound, DOWSIL™ ACP-3000 Antifoam Compound)
  - Additive/booster for formulator (silicone polyether to improve knockdown, persistency, drainage, stability: DOWSIL™ 5290 Performance Modifier, DOWSIL™ OFX-5247 Fluid, DOWSIL™ OFX-5573 Fluid, DOWSIL™ OFX-5329 Fluid, etc.)
  - Booster for organic antifoam formulator (DOWSIL™ ACP-3000 Antifoam Compound)
  - Antifoam and drainage lab testing
  - Silicone antifoam development and formulator partnership
- Local compliance (FDA, BfR, GB) must be checked as not all products are global

Questions?

Thank You

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