



**Evaluation of Gun Propellants
Made with Kraft (Sulfate) Cellulose**

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COMMITMENT
& SOLUTIONS**

Act like someone's life depends on what we do.



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- In this presentation, “Kraft” and “Sulfate” used interchangeably when referring to wood pulp processing and propellants
- Kraft Cellulose
 - Dissolving wood pulp (i.e. cellulose) purified from wood sources through the Kraft process
- Kraft Nitrocellulose (NC)
 - NC produced with Kraft Cellulose
- Kraft [Propellant]
 - [Propellant] made with Kraft NC



- In both the sulfite and Kraft process, wood chips are “digested” (i.e. boiled) in a chemical solution to remove lignin, hemicellulose, and other components.
- Sulfite Process
 - Requires use of highly acidic solution of sulfurous acid
 - Tends to degrade cellulose due to acidic environment
 - Few pulp mills use this process
- Kraft Process
 - Requires use of strongly alkaline solution of sodium hydroxide and sodium sulfide
 - Accommodates a variety of tree species and recovers/reuses all pulping chemicals
 - About 98% of today’s US chemical pulping capacity uses this process



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KRAFT CELLULOSE IN GUN PROPELLANTS CONCERNS



- Unknown effects on nitration/nitrocellulose production
- In propellants, differences in fiber morphology could effect:
 - Mechanical properties
 - Safety testing
 - Long term stability
- Unknown effects on propellants/end item performance



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PROPELLANT SELECTIONS



Propellant	Ammunition	SIP Test	Rationale
M1SP/MP	M67 Propelling Charge for 105mm	4-5 years	Short SIP. It assesses the impact of Kraft cellulose on stability in a relatively short period.
AFP-001	30mm GAU-8/A	12-15 years	Difficult to make due to the exacting ratio of uncoated and coated grains required to meet ballistic requirements.
RPD596	M1002 cartridge	Recently Fielded	New propellant to replace M14 in tanks.



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TEST PROPELLANTS - END ITEMS



M1 Cartridge

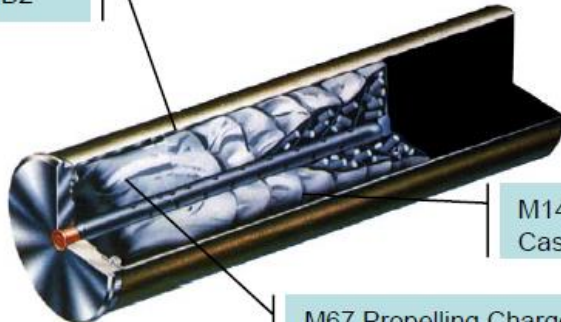
105mm Artillery
High Explosive (HE)
cartridge

M67 propelling charge
consists of seven
increments to achieve
various ranges

M1 propellant (single
based)



Percussion
Primer
M28B2



M14B4 Cartridge
Case

M67 Propelling Charge



M1002

120mm Tank
TPMP-T (Training
Round)

Near visual, weight,
and ballistic match
M830A1 tactical
round

RPD596 propellant
(multi based)

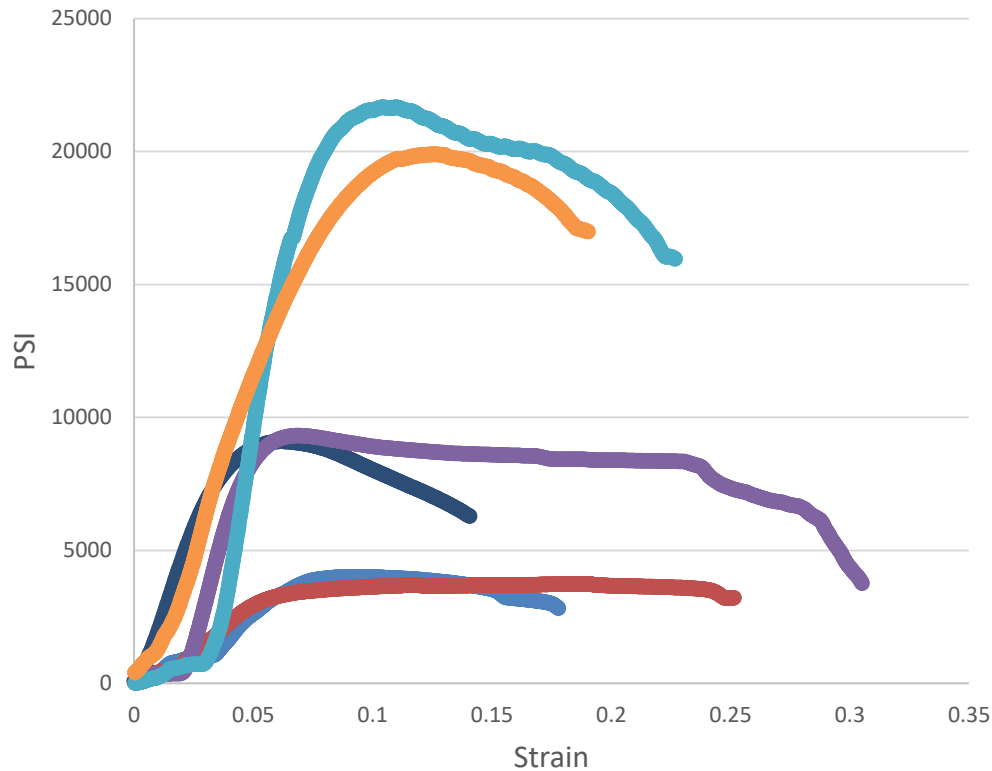


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M1 PROPELLANT MECHANICAL PROPERTIES



Stress-Strain Curves at Rate of 0.005 s⁻¹ at Temperatures



Condition	Property			
	Modulus		Peak Stress	
	Kraft	Sulfite	Kraft	Sulfite
Room Temp	259,936	336,795	9,191	9,198
Cold, -45C	585,782	515,822	21,554	22,499
Hot, 63C	149,217	140,927	4,391	3,835

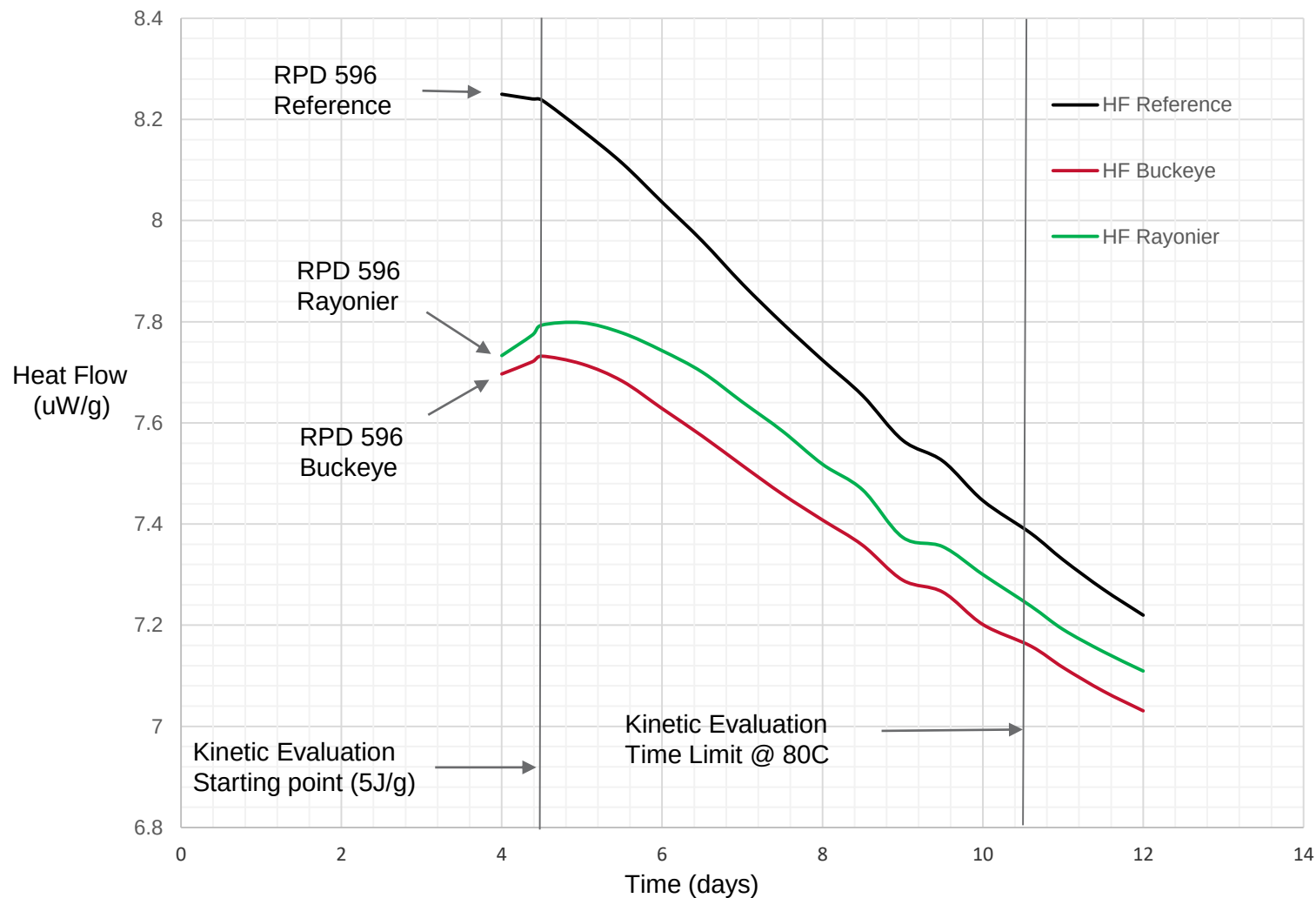
- 63C Kraft
- 63C Sulfite
- Rm T Kraft
- Rm T Sulfite
- -45C Kraft
- -45C Sulfite



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LONG TERM STABILITY HEAT FLOW CALORIMETRY





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BALLISTIC ASSESSMENTS



M119A2 Howitzer
Lightweight, 105mm Towed Howitzer

M1A1 Main Battle Tank
120mm Smoothbore Cannon





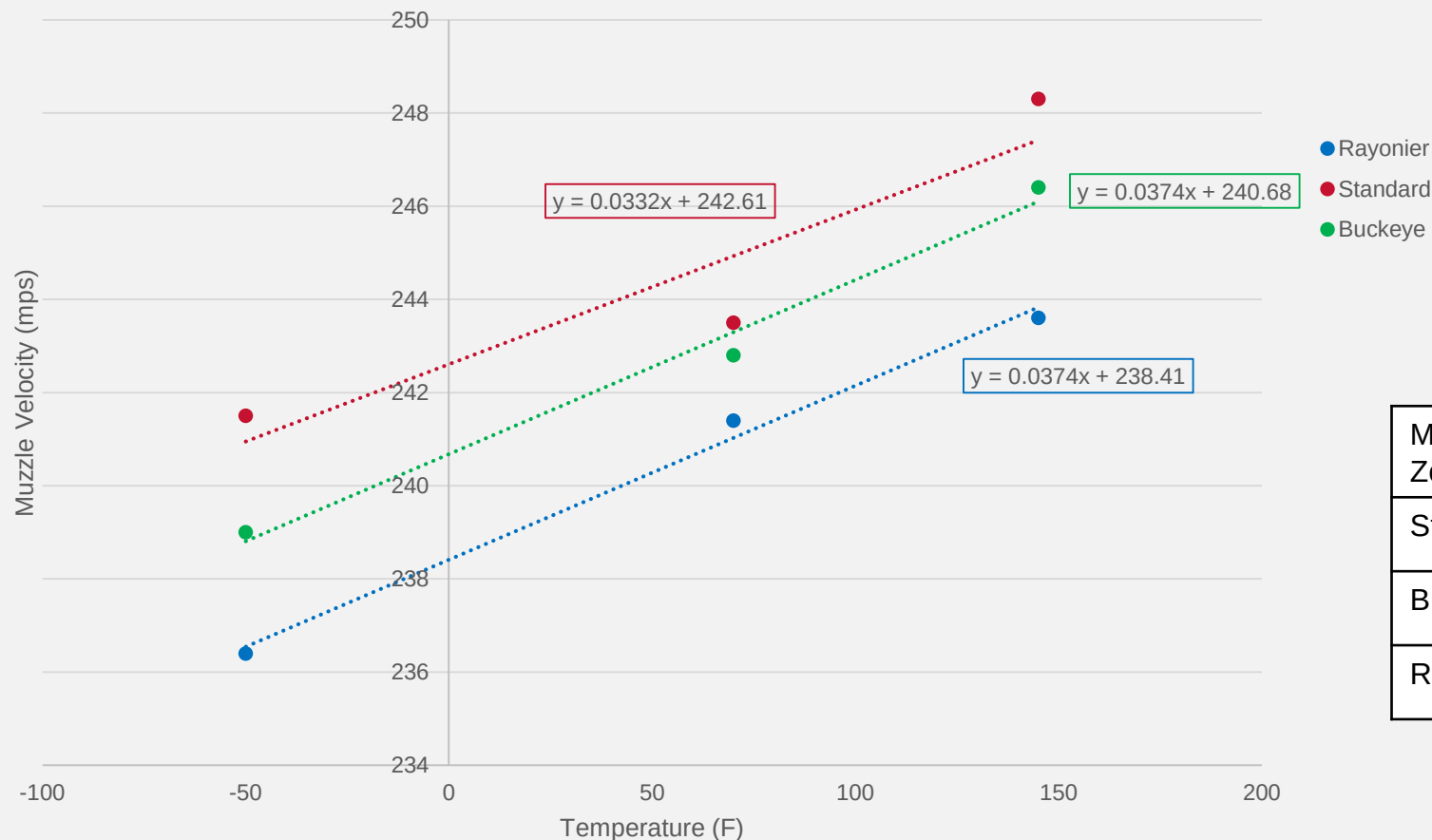
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M1 BALLISTIC EVALUATIONS



Zone 3 Muzzle Velocities of Kraft & Standard M1 Propellant at Different Temperatures



M1MP CHWTs (oz)
Zone 3 only

Standard	2.54
Buckeye	2.27
Rayonier	2.32

Muzzle velocities corrected with calibration rounds

Buckeye M1 Test conducted in 2014

Rayonier M1 Test conducted in 2016



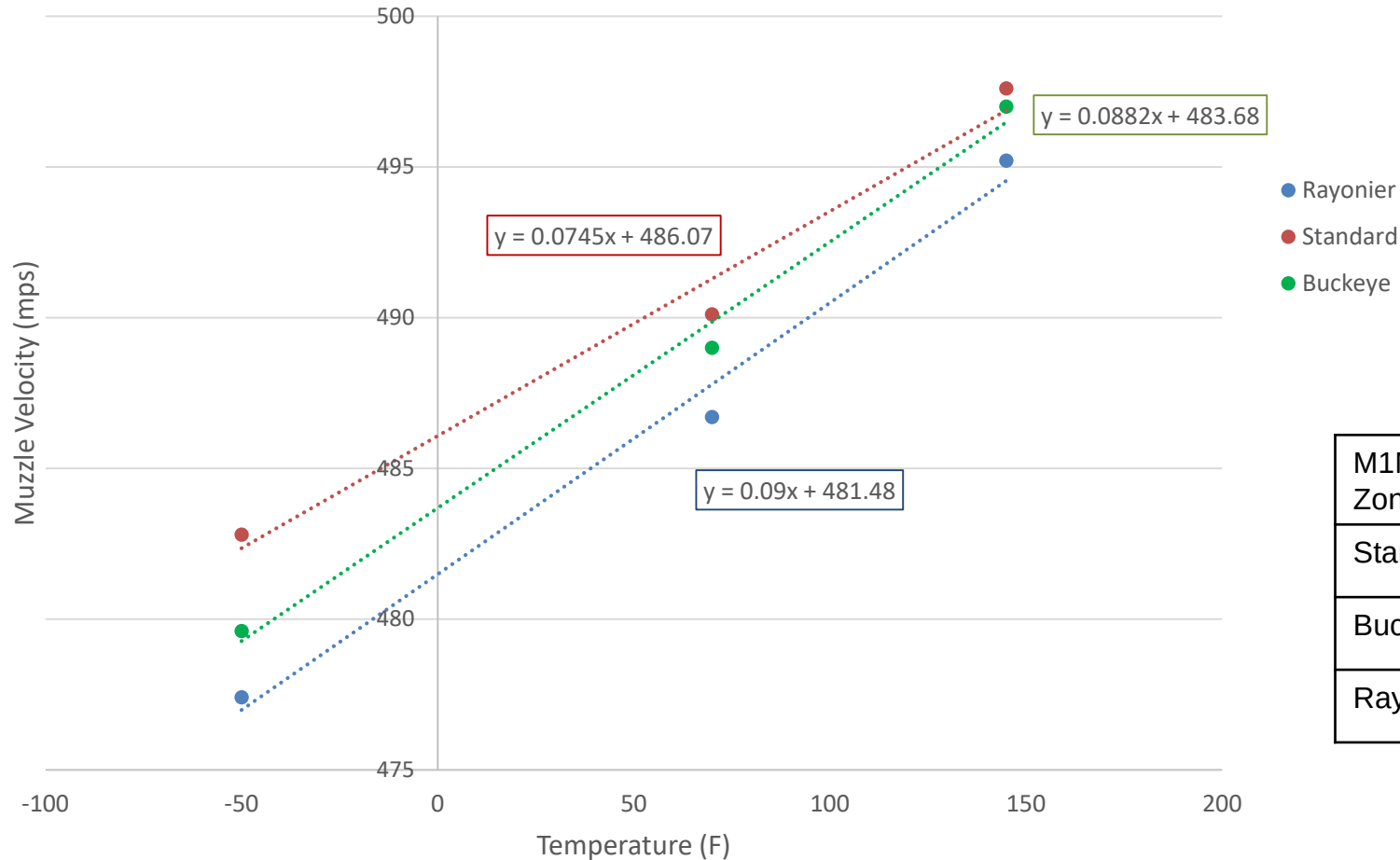
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M1 BALLISTIC EVALUATIONS



Zone 7 Muzzle Velocities of Kraft & Standard M1 Propellant at Temperatures



M1MP CHWTs (oz)
Zones 3-7

Standard	34.18
Buckeye	32.77
Rayonier	33.45

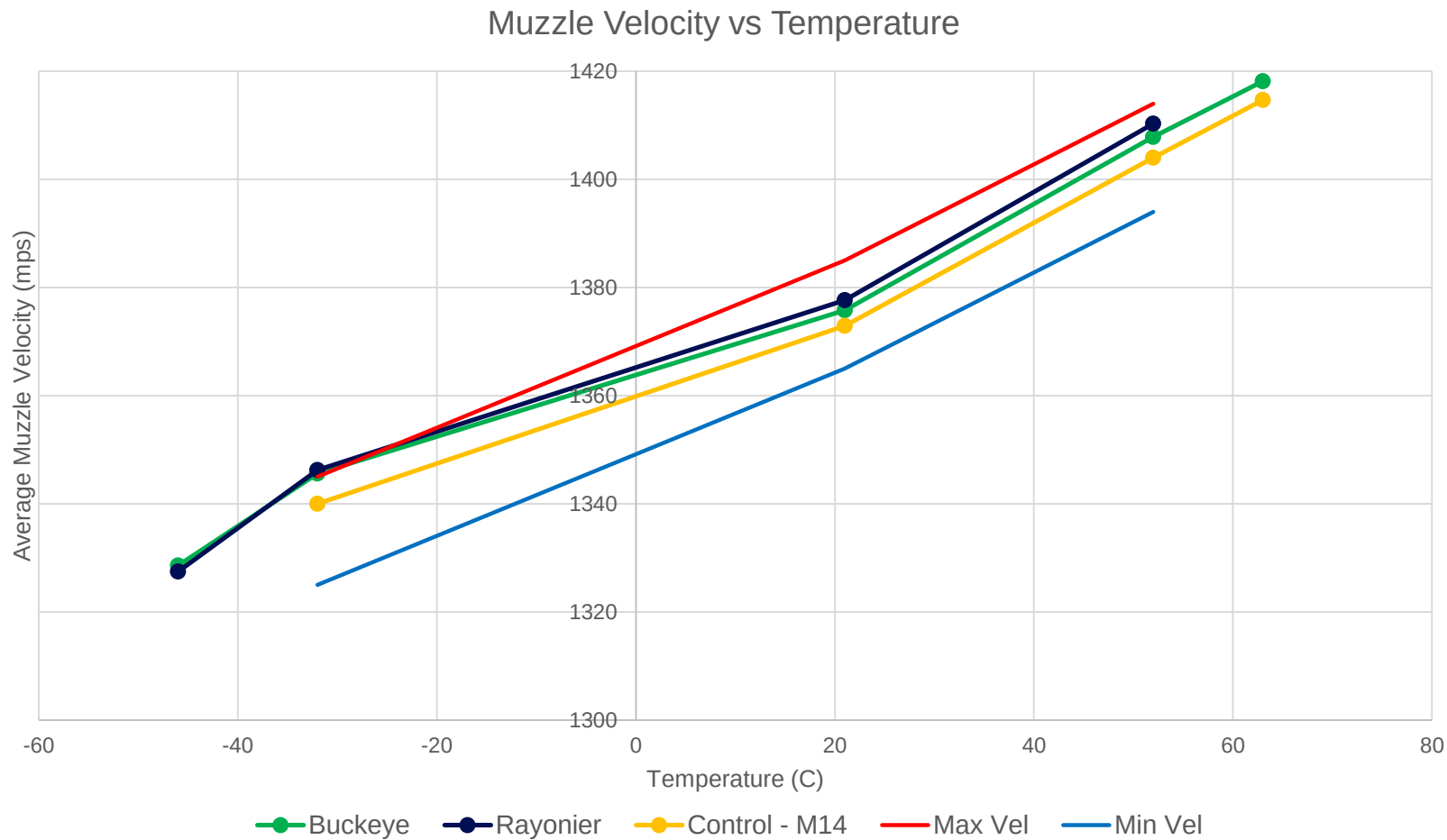
Muzzle velocities corrected with calibration rounds

Buckeye M1 Test conducted in 2014

Rayonier M1 Test conducted in 2016



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	Buckeye	Rayonier	Legacy
Charge Weight (kg)	6.93	7.02	7.10~7.30



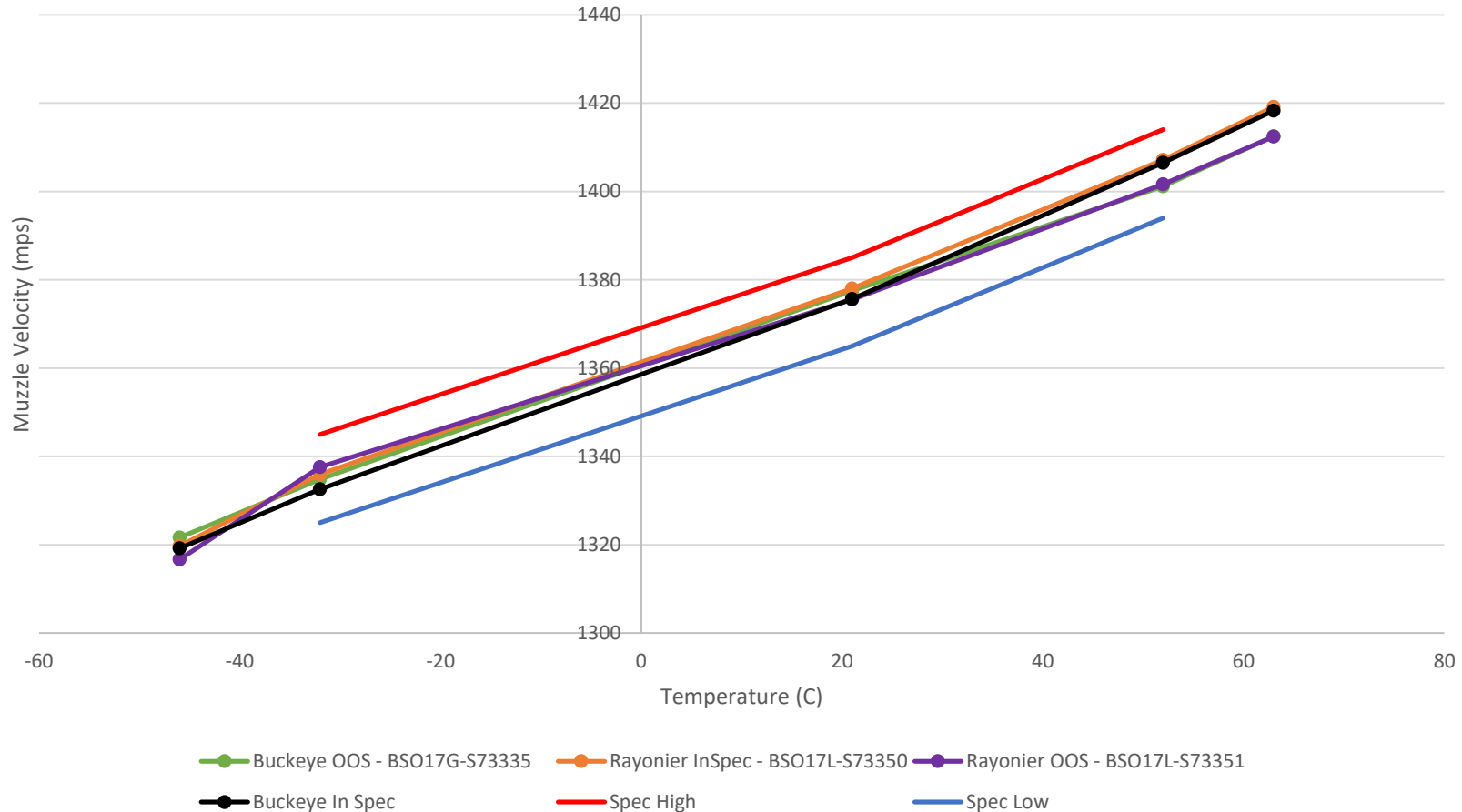
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2018 KRAFT RPD596 PROPELLANTS MUZZLE VELOCITIES VS TEMPERATURE



2018 Kraft RPD596 Propellants - Muzzle Velocity vs Temperature



	Buckeye In Spec	Buckeye OoS	Rayonier In Spec	Rayonier OoS	Legacy
Charge Weight (kg)	7.11	7.13	7.28	7.16	7.10~7.30

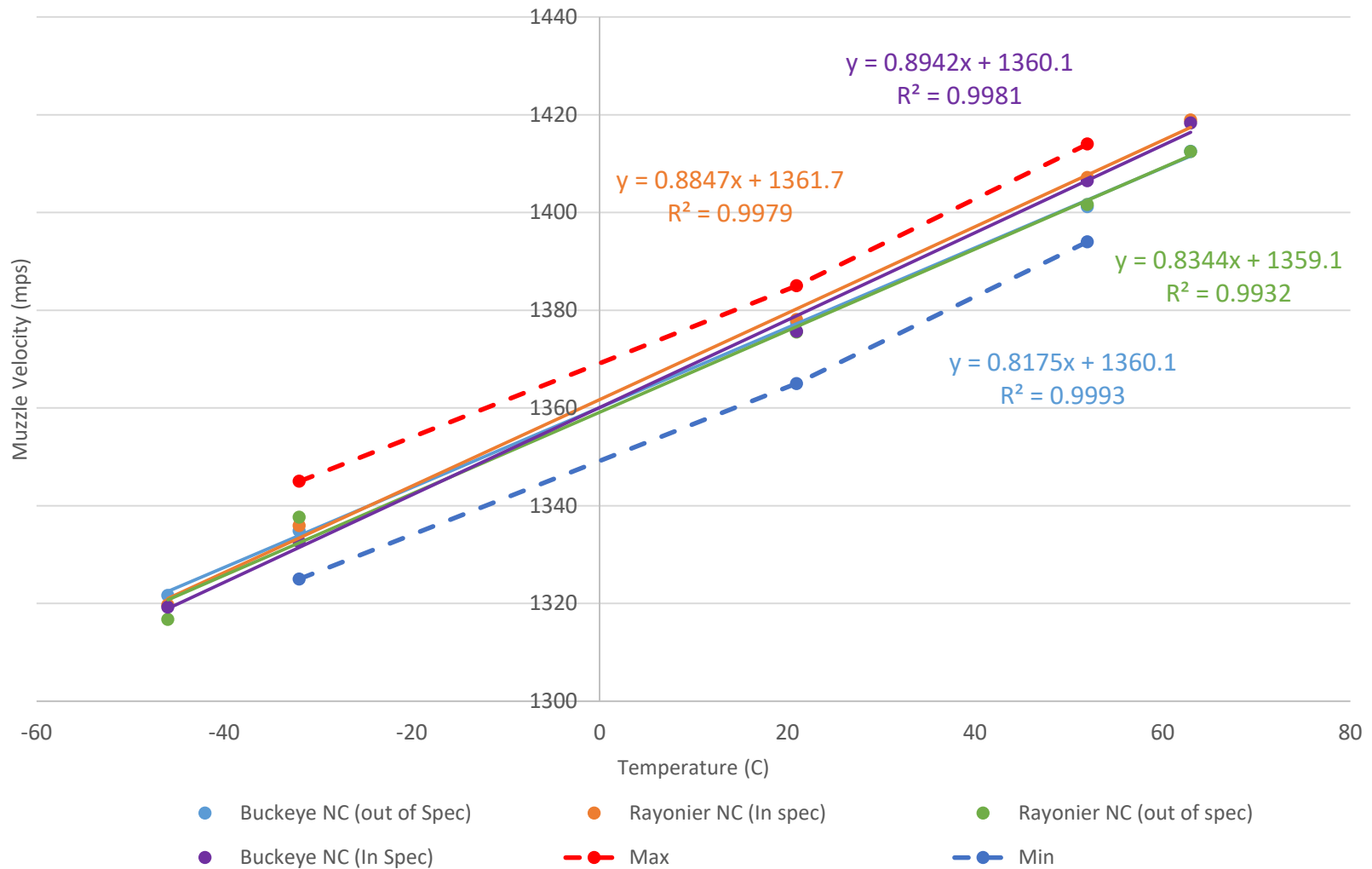


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FORMULATION EFFECTS ON TEMPERATURE SENSITIVITY



2018 Kraft RPD596 Propellants - Muzzle Velocity vs Temperature

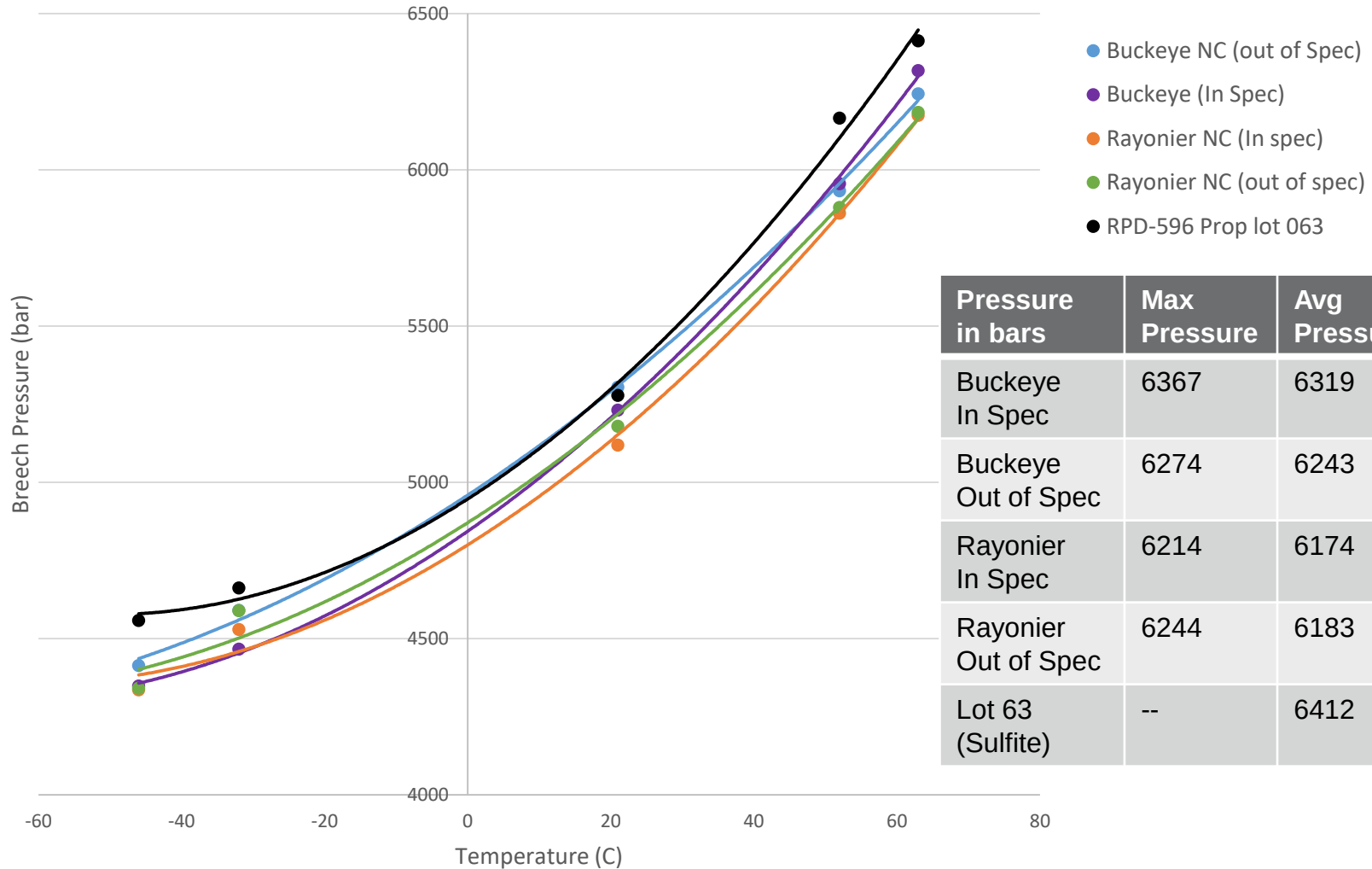




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2018 Kraft Propellants - Breech Pressure vs Temperature





- Kraft cellulose can be used to support production of military grade NC and propellants
- Kraft M1 and RPD596 propellants passed all required safety testing and long term stability tests
- As compared to legacy configurations, Kraft propellants tend to have higher burn rates/lower charge weights
- Although drop-in replacement is possible, optimization may need to be considered



THANKS/Q&A

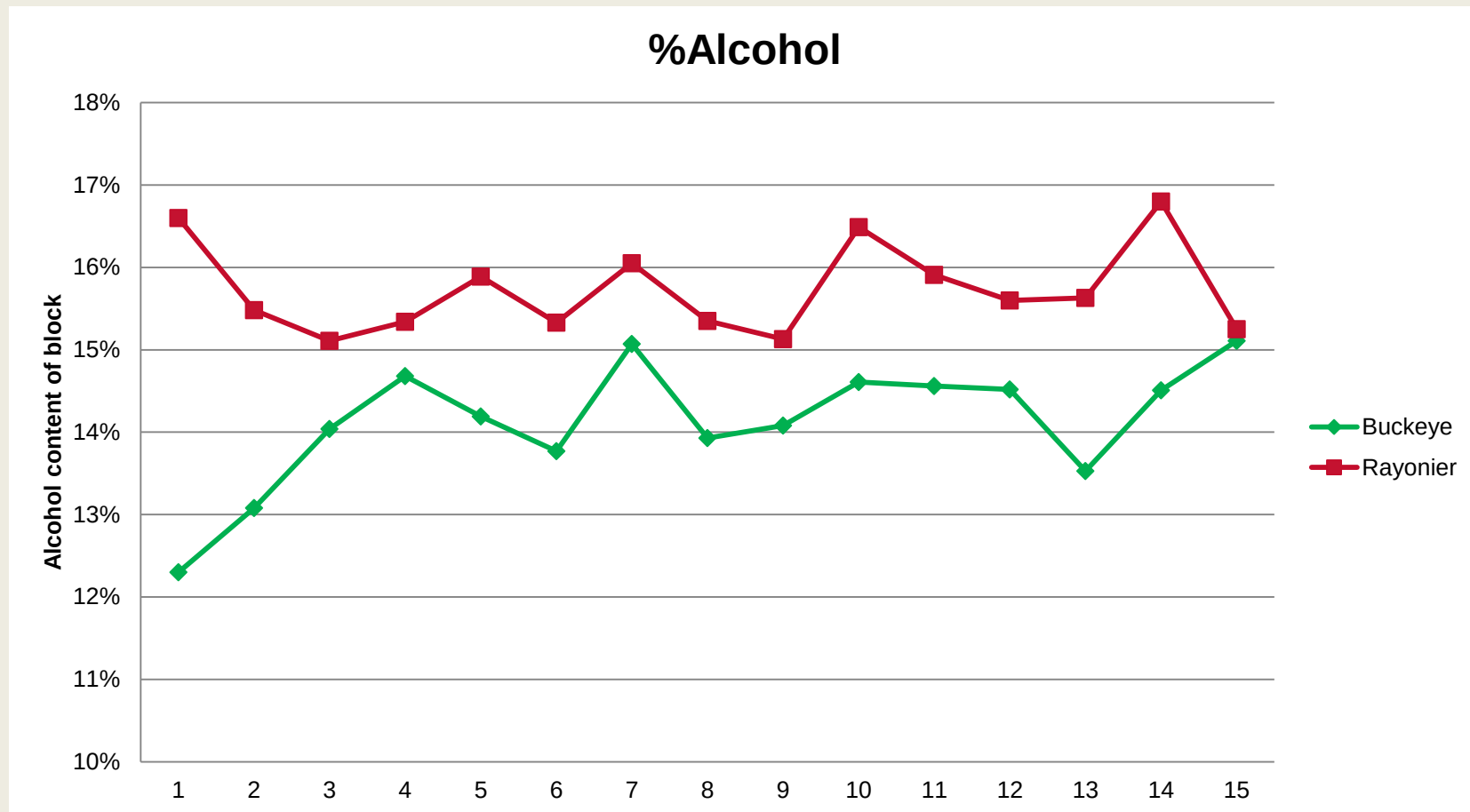




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Back Up Slides



Based on historical data, %Alcohol per NC block is 20%-23% using sulfite NC

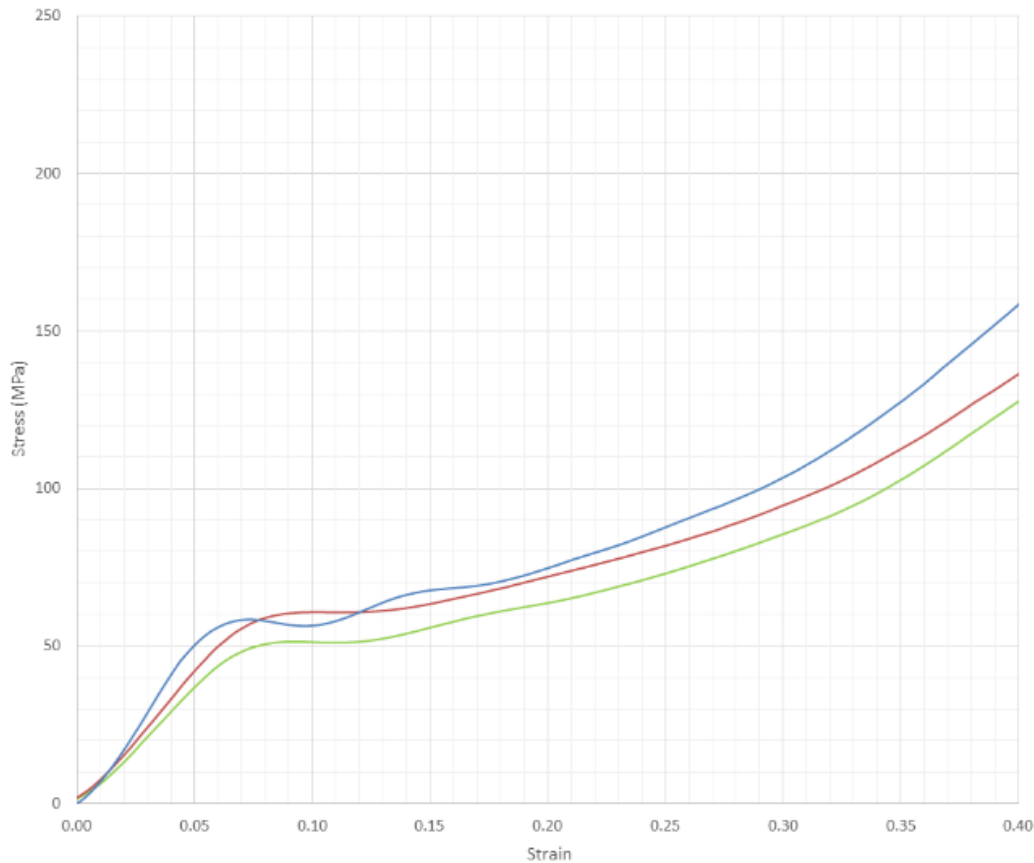


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MECHANICAL PROPERTIES TEST @ 63°C



RPD-596 Uniaxial Compression SR=200 T=63



- Lot 191 - Baseline
- Lot 245 - Experimental
- Lot 246 - Experimental

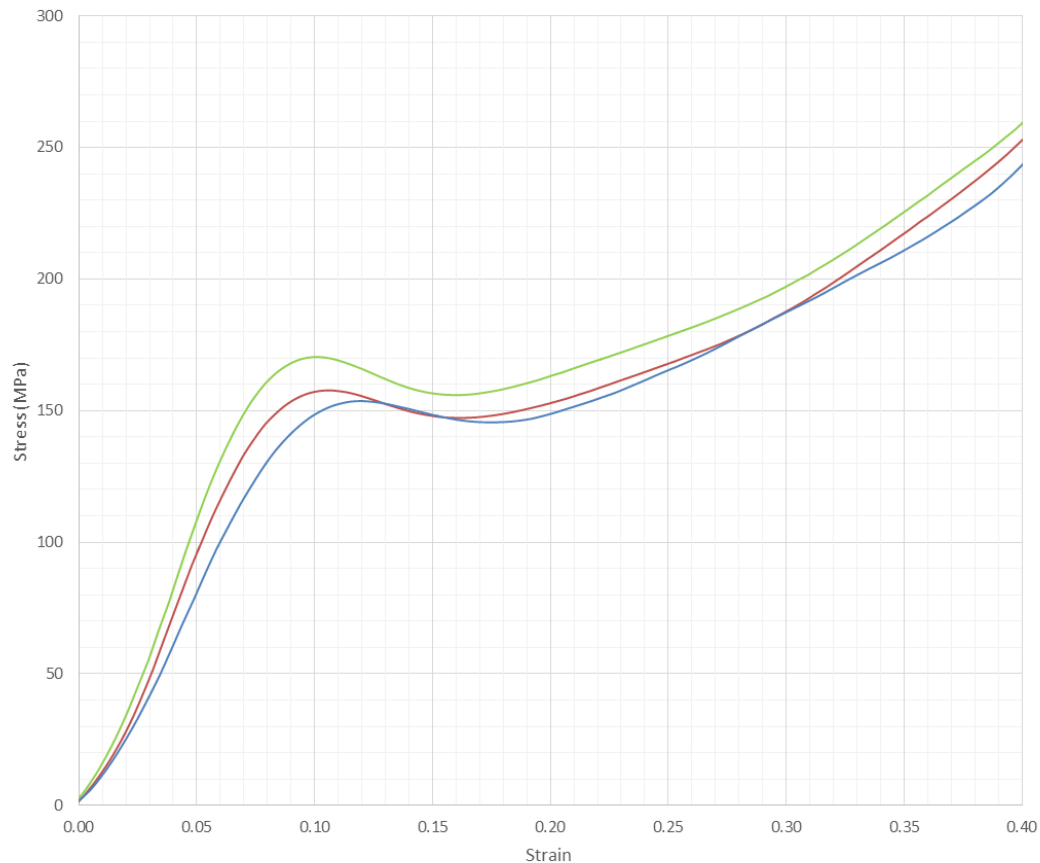


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MECHANICAL PROPERTIES TEST @ 23°C



RPD-596 Uniaxial Compression SR=200/s T=23



- Lot 191 - Baseline
- Lot 245 - Experimental
- Lot 246 - Experimental



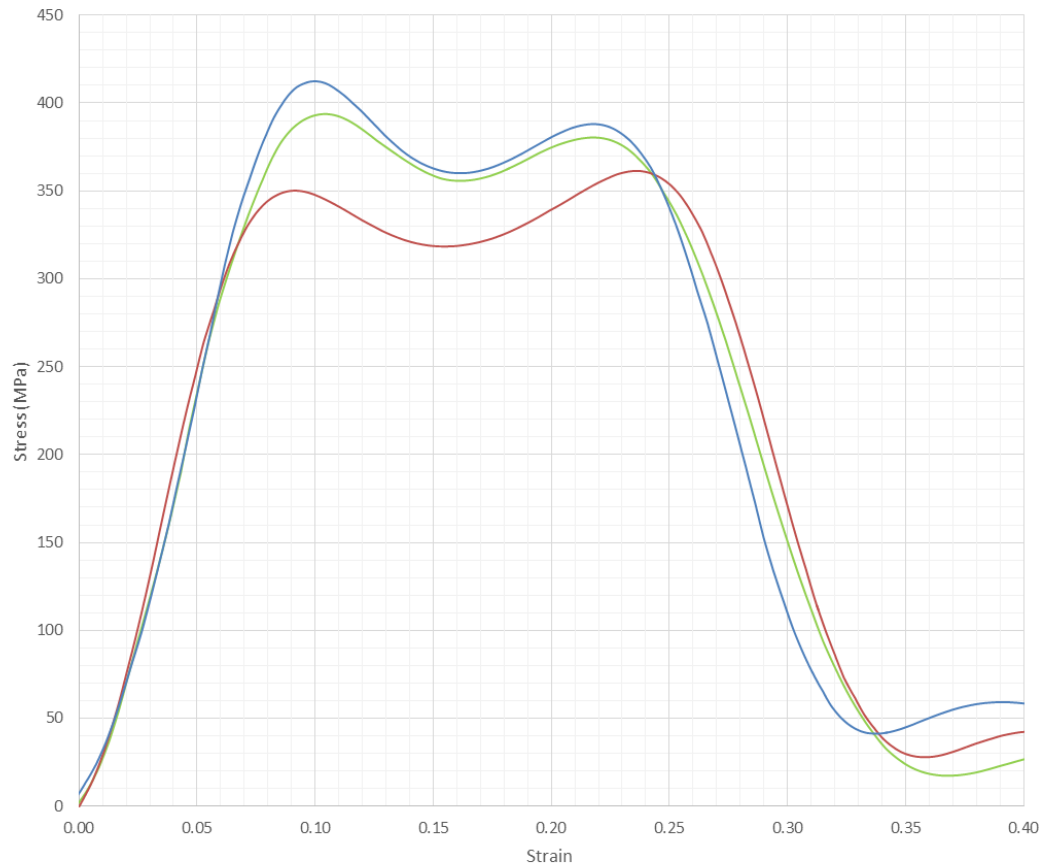


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MECHANICAL PROPERTIES TEST @ -32°C



RPD-596 Uniaxial Compression SR=200/s T=-32



- Lot 191 - Baseline
- Lot 245 - Experimental
- Lot 246 - Experimental