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APPENDIX 1

MATERIAL SPECIFICATION

Natural Rubber

Natural rubber was taken under the following specification

Mooney viscosity [ML(1+4) at 100 C]	80 +/-15
% Dirt content by mass (Max.)	0.05
% of Volatile material by mass (Max.)	0.8
% of Nitrogen by mass (Max.)	0.6
% of Ash by mass (Max.)	0.5
Initial Wallace Plasticity (Po) * Range (Min.)	30
Plastic Retention Index (PRL) (Min.)	70

Short Nylon fiber

Material is nylon 6. It was obtained from the approved supplier. The material was cut to approximately 6 mm. Specification of nylon material is as follows.

Breaking Strength – 1260D2 (Min.)	20.5 kg
Elongation at Break	+/-25
Twist Cable S	370 +/- 25 T/m
Twist Ply Z	375 +/- 25 T/m
Breaking Strength – 1890D2 (Min.)	30.5 kkg
Elongation at Break	+/-25
Twist Cable S	300 +/- 25 T/m
Twist Ply Z	305 +/- 25 T/m

1st Stage Chemicals

i. Carbon Black

Carbon black was taken from our approved supplier and it has the following specification:

DPB absorption (cm ³ /100g)	115-125
Loading adsorption number (mg/g)	85-89
Pour Density (Kg/m ³)	315-370
Fines Content (%)	10 max.
Ash (Max.) (%)	0.5

ii. Zinc Oxide

Zinc oxide used in the study was procured from approved supplier with the has following specification

% of Moisture (Max)	0.5
% of Pbo (Max)	0.15
% of Purity (Min)	99.5
% of Sieve Residue (max) 45 Micron (325 mesh)	0.25
% of Loss on Ignition (Max)	0.6

iii. Stearic Acid

Stearic Acid was obtained from approved supplier with the following specification:

Acid Value (mg,KOH/g)	190-215
Iodine Value (Max) (g,100g)	5
% of Fatty acid C18 (Min)	32

iv. 6PPD

6PPD was taken from approved supplier with the following specification:

% of Ash Content (max)	0.2
Melting point (min) °C	44
% of Active Ingredient (min)	97
% of Heat loss (max)	0.5

v. HS

% of Ash Content (Max.)	0.3
Softening point °C	83-93
% of Active ingredient (Min)	88

vi. OIL (Low PAHs Rubber Processing oil)

Kinematic viscosity @ 100° C	cSt	20-32
Aniline point °C		86-94
Density @ 15.0c	g/ml	0.930-0.950
Benzo (a) pyrene (BaP) (Max. ppm)		1
Sum 8 PAH's (Max. ppm)		10
Flash Point (Min.) °C		210

vii. RESORCINE 80 SBR

% of Resorcinol Content	77-81
Density (g/cm ³)	1.17-1.25

viii. SILICA

BET Surface Area (m ² / g)	160-195
% of Moisture	4 - 7
% of SiO ₂ , on anhydrous basis (Min.)	98
% of SiO ₂ (based on dry basis, 105 C for 1.5 hrs) (Min.)	93
% of Salt as Na ₂ SO ₄	< 1.5
% of 20 mesh sieve residue (Min.)	65
% of 80 mesh sieve residue (Min.)	75

2nd Stage Chemicals

i. SULPHUR

% of Sieve Residue (325mesh), (Max.)	10
% of Moisture (Max.)	0.5
% of Purity (Min.)	99.5

ii. TBBS

% of Purity (Min.)	95
% of Ash Content (Max.)	0.5
Melting point (Min.) °C	103
% of Loss of heating (Max.)	1
% of Free amine (Max.)	0.5

iii. PVI

% of Active ingredient content (Min)	95
% of Ash Content (Max.)	0.2
% Drying loss (Heat loss)	0.4
Melting point °C	88
% of Volatile matter (Max.)	0.5

iv. HMT

% of Hexamethylene tetramine	Min. 96
% Water content	Max. 0.5
% of Ash content	2.0 - 3.0
% of particles > 63 micro meter	Max. 1.0

APPENDIX 2

Mixing cycle of Compounding trials

First Stage Mixing

Figure A 2.1: 0phr Fiber content

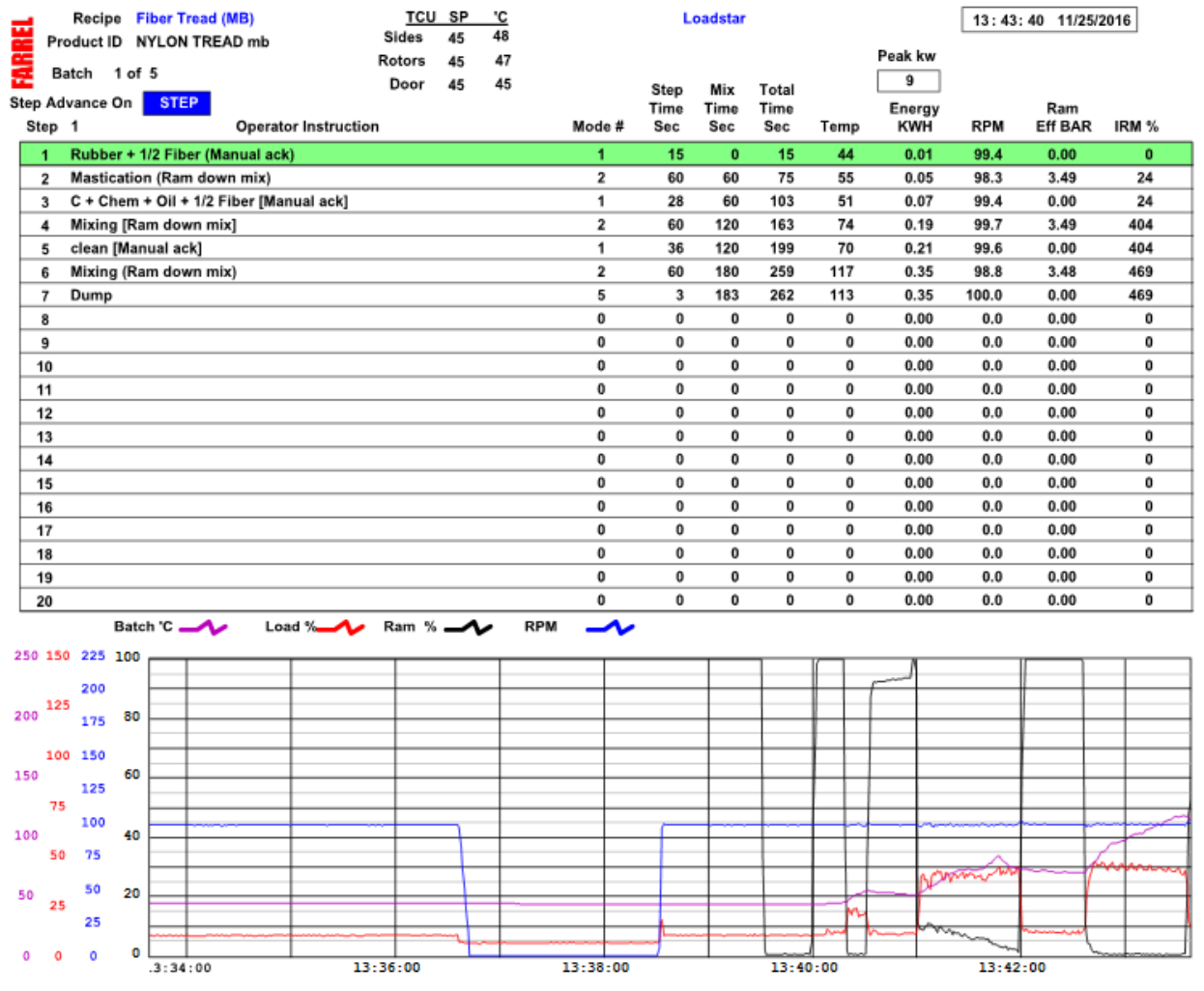


Figure A 2.2: 1 phr Fiber content

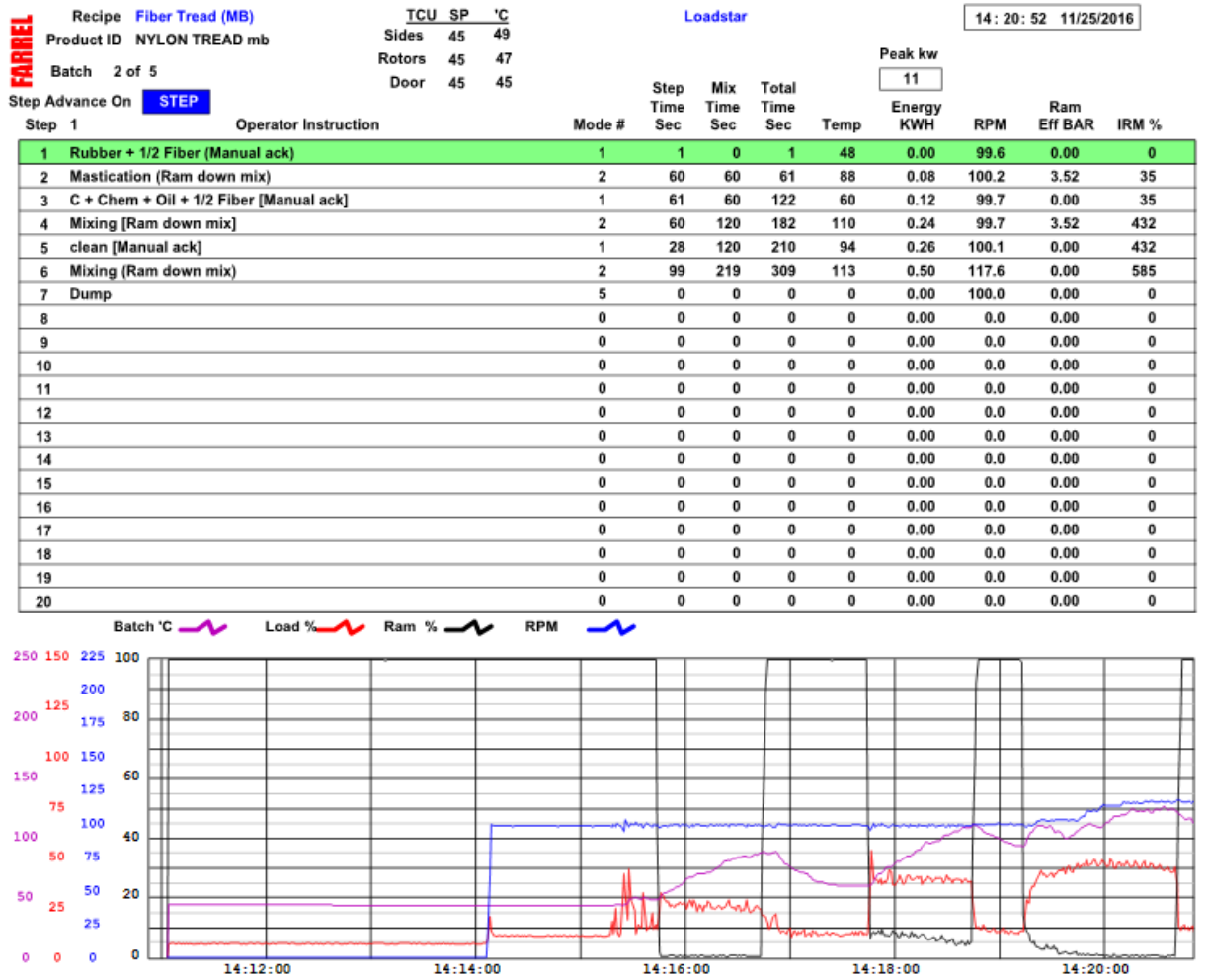


Figure A 2.3: 1.5 phr Fiber content

FABREL	Recipe	Fiber Tread (MB)	TCU	SP	°C	Loadstar				14:38:47 11/25/2016	
	Product ID	NYLON TREAD mb	Sides	45	47						
	Batch	3 of 5	Rotors	45	47						
			Door	45	45						
Step Advance On		STEP				Peak kw		12			
Step	1	Operator Instruction	Mode #	Step Time Sec	Mix Time Sec	Total Time Sec	Temp	Energy KWH	RPM	Ram Eff BAR	IRM %
1		Rubber + 1/2 Fiber (Manual ack)	1	53	0	53	54	0.04	100.5	0.00	0
2		Mastication (Ram down mix)	2	60	60	113	78	0.11	99.2	3.54	54
3		C + Chem + Oil + 1/2 Fiber [Manual ack]	1	54	60	167	58	0.15	100.1	0.00	54
4		Mixing [Ram down mix]	2	60	120	227	97	0.27	99.8	3.53	439
5		clean [Manual ack]	1	27	120	254	91	0.29	99.9	0.00	439
6		Mixing (Ram down mix)	2	60	180	314	119	0.44	123.6	3.51	607
7		Dump	5	3	183	317	114	0.44	100.4	0.00	607
8			0	0	0	0	0	0.00	0.0	0.00	0
9			0	0	0	0	0	0.00	0.0	0.00	0
10			0	0	0	0	0	0.00	0.0	0.00	0
11			0	0	0	0	0	0.00	0.0	0.00	0
12			0	0	0	0	0	0.00	0.0	0.00	0
13			0	0	0	0	0	0.00	0.0	0.00	0
14			0	0	0	0	0	0.00	0.0	0.00	0
15			0	0	0	0	0	0.00	0.0	0.00	0
16			0	0	0	0	0	0.00	0.0	0.00	0
17			0	0	0	0	0	0.00	0.0	0.00	0
18			0	0	0	0	0	0.00	0.0	0.00	0
19			0	0	0	0	0	0.00	0.0	0.00	0
20			0	0	0	0	0	0.00	0.0	0.00	0

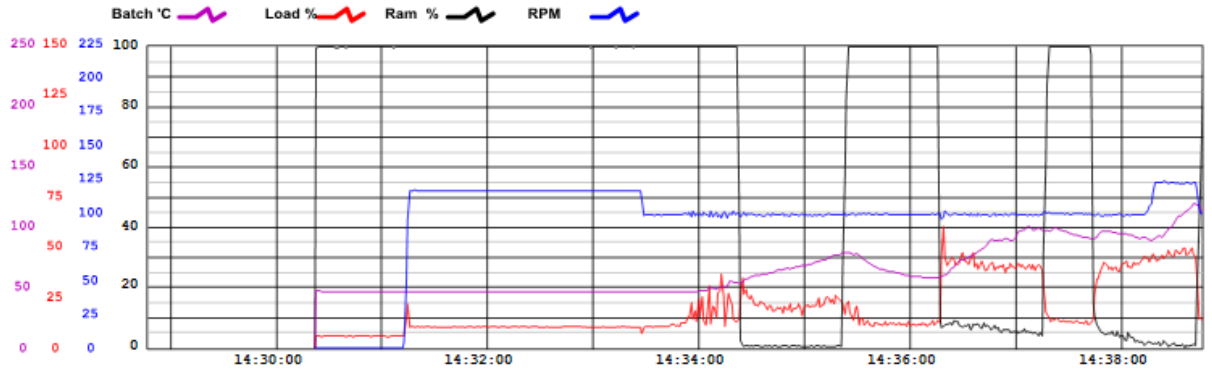


Figure A 2.4 : 2 phr Fiber content

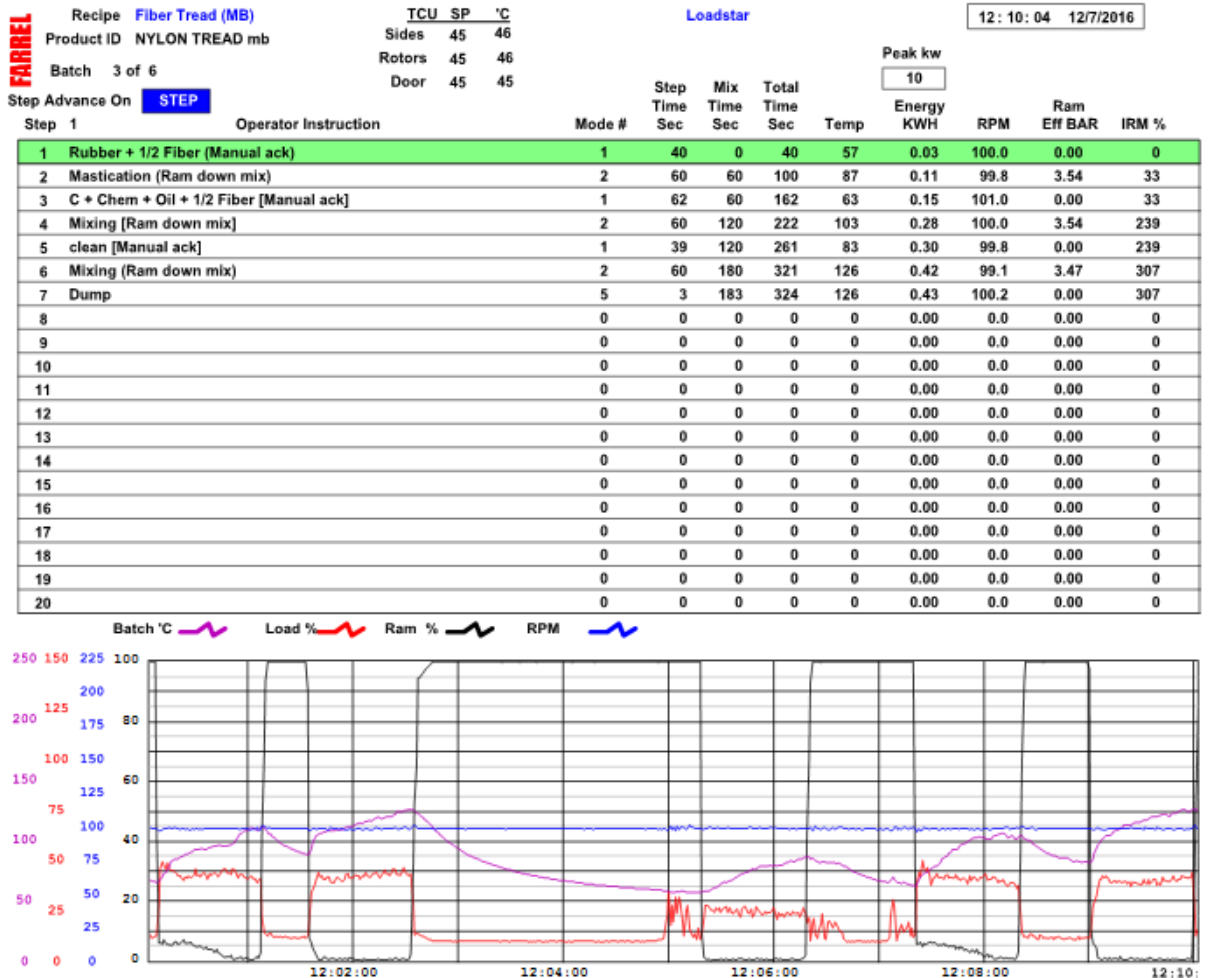


Figure A 2.5: 2.5 phr Fiber content

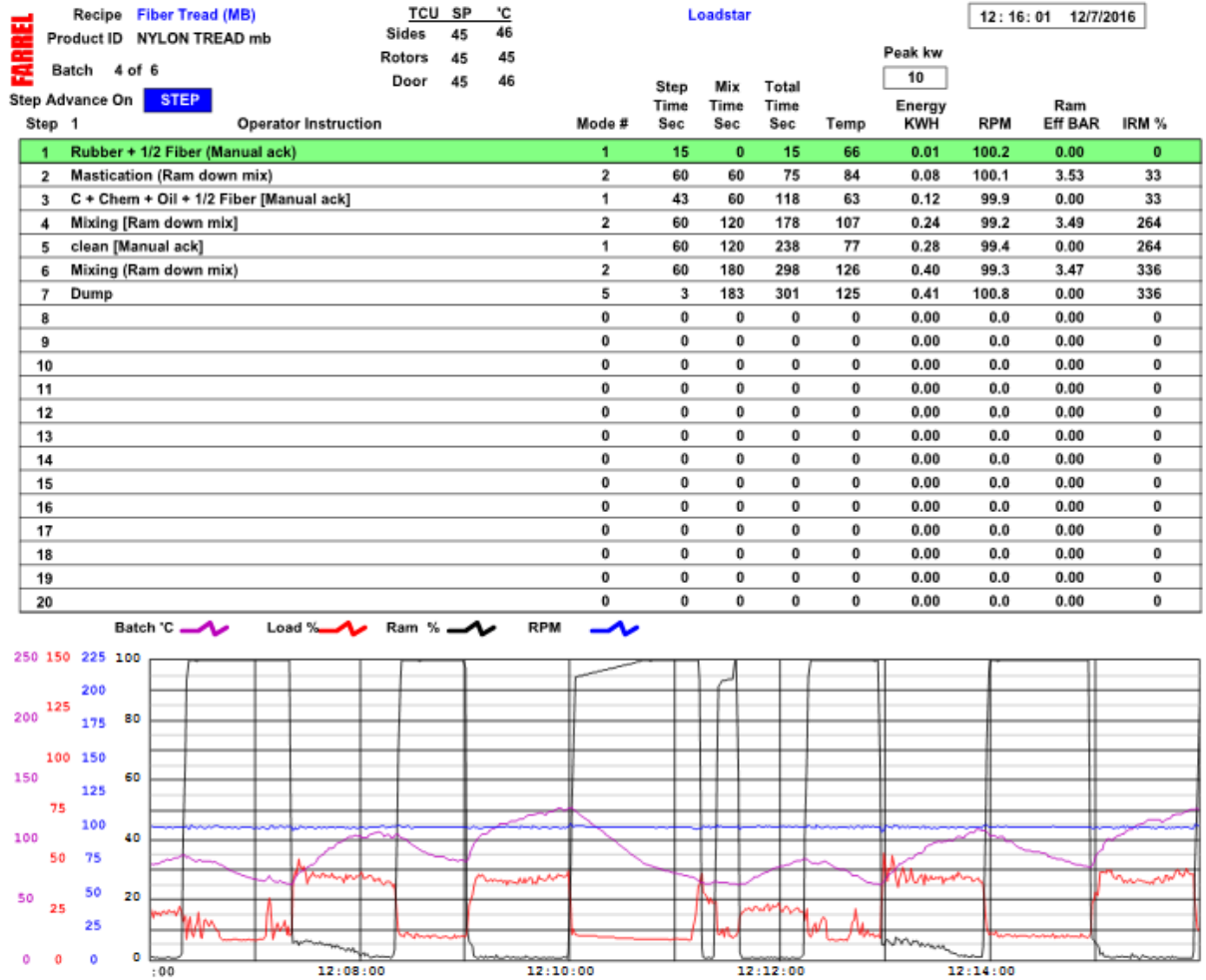


Figure A 2.6: 3 phr Fiber content

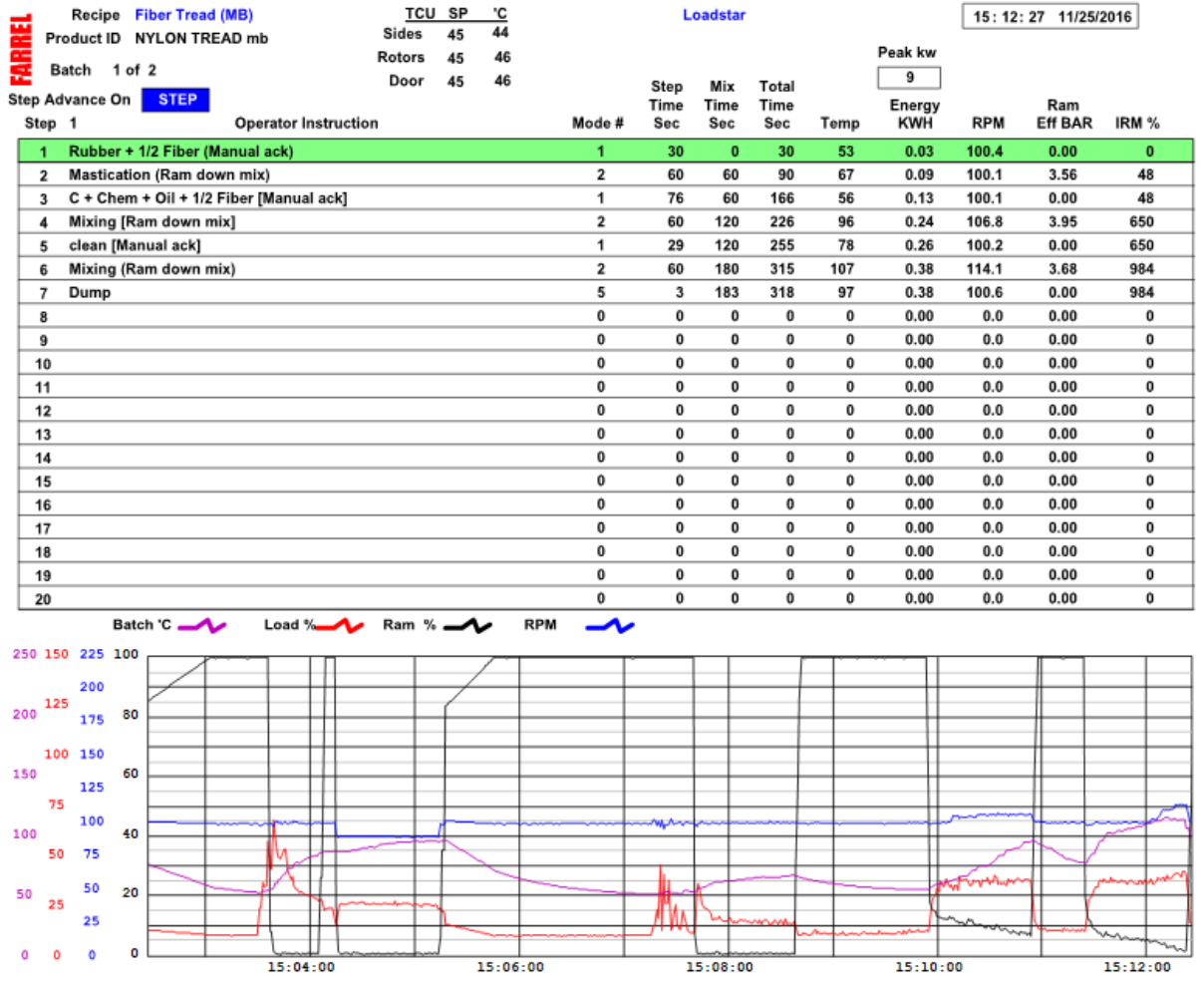
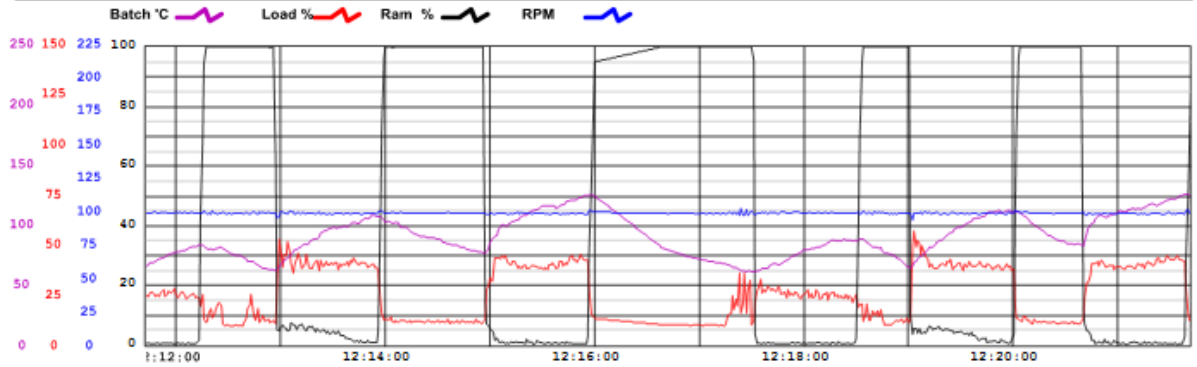


Figure A 2.7: 5 phr Fiber content

FARREL	Recipe	Fiber Tread (MB)	TCU	SP	°C	Loadstar					12: 21: 43 12/7/2016	
	Product ID	NYLON TREAD mb	Sides	45	46							
	Batch	5 of 6	Rotors	45	46							
	Door		45	45								
Step Advance On	STEP											
Step	1	Operator Instruction	Mode #	Step Time Sec	Mix Time Sec	Total Time Sec	Temp	Energy KWH	RPM	Ram Eff BAR	IRM %	Peak kw
1		Rubber + 1/2 Fiber (Manual ack)	1	23	0	23	62	0.02	100.0	0.00	0	12
2		Mastication (Ram down mix)	2	60	60	83	87	0.10	100.0	3.51	38	
3		C + Chem + Oil + 1/2 Fiber [Manual ack]	1	30	60	113	65	0.12	99.9	0.00	38	
4		Mixing [Ram down mix]	2	60	120	173	112	0.25	100.1	3.52	244	
5		clean [Manual ack]	1	38	120	211	84	0.27	99.6	0.00	244	
6		Mixing (Ram down mix)	2	60	180	271	126	0.39	99.2	3.47	324	
7		Dump	5	3	183	274	125	0.40	100.1	0.00	324	
8			0	0	0	0	0	0.00	0.0	0.00	0	
9			0	0	0	0	0	0.00	0.0	0.00	0	
10			0	0	0	0	0	0.00	0.0	0.00	0	
11			0	0	0	0	0	0.00	0.0	0.00	0	
12			0	0	0	0	0	0.00	0.0	0.00	0	
13			0	0	0	0	0	0.00	0.0	0.00	0	
14			0	0	0	0	0	0.00	0.0	0.00	0	
15			0	0	0	0	0	0.00	0.0	0.00	0	
16			0	0	0	0	0	0.00	0.0	0.00	0	
17			0	0	0	0	0	0.00	0.0	0.00	0	
18			0	0	0	0	0	0.00	0.0	0.00	0	
19			0	0	0	0	0	0.00	0.0	0.00	0	
20			0	0	0	0	0	0.00	0.0	0.00	0	



Second Stage Mixing

Figure A 2.8: 0 phr Fiber content

Recipe 2-tr-385
 Product ID prageeth
 Batch 2 of 5

TCU SP °C
 Sides 45 50
 Rotors 45 49
 Door 40 43

Loadstar

15: 58: 01 11/29/2016

Peak kw
 11

Step Advance On **STEP**

Step	Operator Instruction	Mode #	Step Time Sec	Mix Time Sec	Total Time Sec	Temp	Energy KWH	RPM	Ram Eff BAR	IRM %
1	manual ack (mb)	1	49	0	49	79	0.07	99.3	0.00	0
2	RAM DOWN MIXING	2	30	30	79	101	0.13	99.9	3.55	27
3	MANUAL ACK (CHEM)	1	17	30	96	102	0.15	99.9	0.00	27
4	RAM DOWN MIXING	2	60	90	156	111	0.24	94.6	3.54	81
5	DUMP	6	3	93	159	110	0.24	99.7	3.50	81
6		0	0	0	0	0	0.00	0.0	0.00	0
7		0	0	0	0	0	0.00	0.0	0.00	0
8		0	0	0	0	0	0.00	0.0	0.00	0
9		0	0	0	0	0	0.00	0.0	0.00	0
10		0	0	0	0	0	0.00	0.0	0.00	0
11		0	0	0	0	0	0.00	0.0	0.00	0
12		0	0	0	0	0	0.00	0.0	0.00	0
13		0	0	0	0	0	0.00	0.0	0.00	0
14		0	0	0	0	0	0.00	0.0	0.00	0
15		0	0	0	0	0	0.00	0.0	0.00	0
16		0	0	0	0	0	0.00	0.0	0.00	0
17		0	0	0	0	0	0.00	0.0	0.00	0
18		0	0	0	0	0	0.00	0.0	0.00	0
19		0	0	0	0	0	0.00	0.0	0.00	0
20		0	0	0	0	0	0.00	0.0	0.00	0

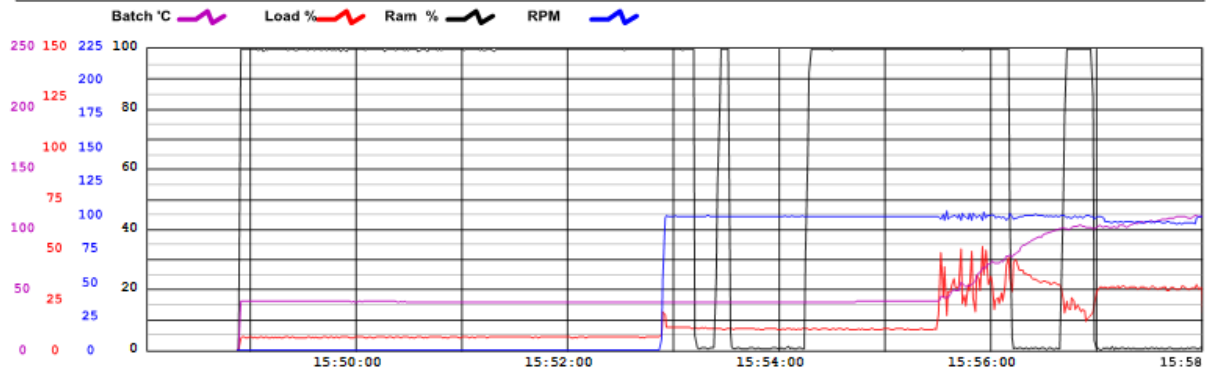


Figure A 2.9: 1 phr Fiber content

Recipe 2-LS345		TCU SP °C		Loadstar		14:10:41 12/8/2016				
Product ID Prageeth		Sides	40	42						
Batch 5 of 6		Rotors	40	42						
Door		40	40							
Step Advance On STEP				Peak kw		9				
Step	Operator Instruction	Mode #	Step Time Sec	Mix Time Sec	Total Time Sec	Temp	Energy KWH	RPM	Ram Eff BAR	IRM %
1	manual ack (MB)	1	101	0	101	94	0.13	100.9	0.00	0
2	Ram down mix	2	30	30	131	115	0.19	100.3	4.22	17
3	manual ack [chemical]	1	19	30	150	112	0.21	99.4	0.00	17
4	Ram down mix	2	60	90	210	117	0.30	89.5	4.22	54
5	Dump	5	3	93	213	117	0.31	99.6	0.00	54
6		0	0	0	0	0	0.00	100.0	0.00	0
7		0	0	0	0	0	0.00	0.0	0.00	0
8		0	0	0	0	0	0.00	0.0	0.00	0
9		0	0	0	0	0	0.00	0.0	0.00	0
10		0	0	0	0	0	0.00	0.0	0.00	0
11		0	0	0	0	0	0.00	0.0	0.00	0
12		0	0	0	0	0	0.00	0.0	0.00	0
13		0	0	0	0	0	0.00	0.0	0.00	0
14		0	0	0	0	0	0.00	0.0	0.00	0
15		0	0	0	0	0	0.00	0.0	0.00	0
16		0	0	0	0	0	0.00	0.0	0.00	0
17		0	0	0	0	0	0.00	0.0	0.00	0
18		0	0	0	0	0	0.00	0.0	0.00	0
19		0	0	0	0	0	0.00	0.0	0.00	0
20		0	0	0	0	0	0.00	0.0	0.00	0

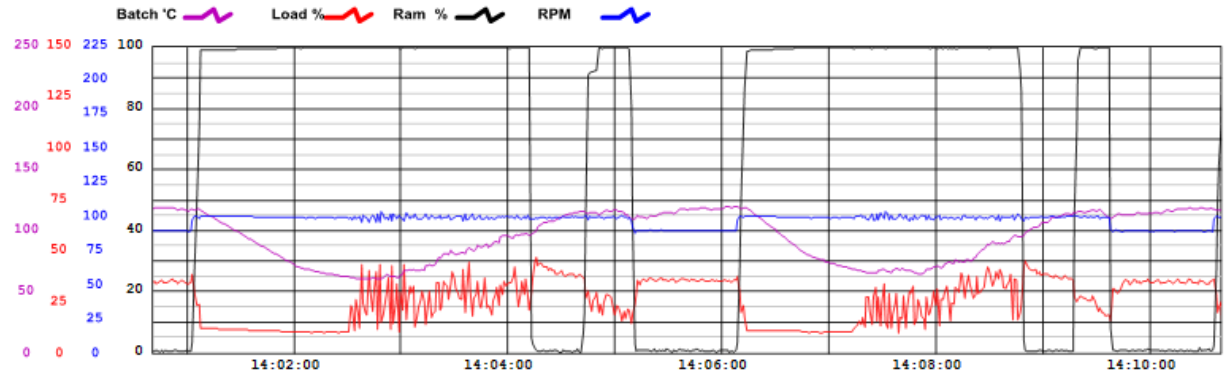


Figure A 2,10: 1.5 phr Fiber content

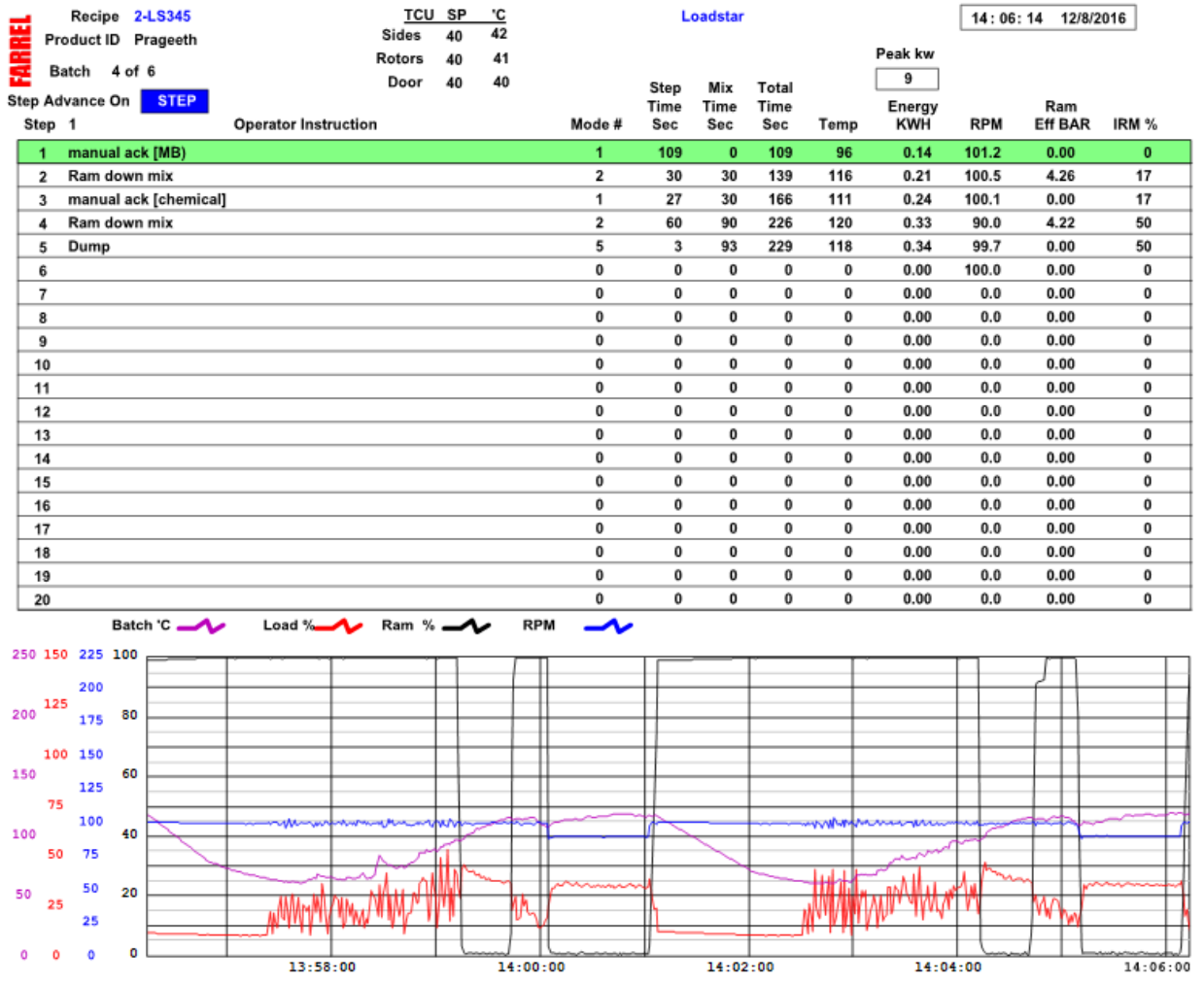


Figure A 2.11: 2 phr Fiber content

FARREL	Recipe	2-LS345	TCU SP °C		Loadstar		14:01:08 12/8/2016				
	Product ID	Prageeth	Sides	40	42						
	Batch	3 of 6	Rotors	40	41						
	Door	40	41								
Step Advance On	STEP										
Step	1	Operator Instruction	Mode #	Step Time Sec	Mix Time Sec	Total Time Sec	Temp	Energy KWH	RPM	Ram Eff BAR	IRM %
1	manual ack [MB]		1	121	0	121	97	0.14	100.4	0.00	0
2	Ram down mix		2	30	30	151	116	0.20	99.7	4.25	21
3	manual ack [chemical]		1	21	30	172	108	0.23	99.8	0.00	21
4	Ram down mix		2	60	90	232	117	0.32	89.4	4.20	70
5	Dump		5	3	93	235	118	0.33	99.9	0.00	70
6			0	0	0	0	0	0.00	100.0	0.00	0
7			0	0	0	0	0	0.00	0.0	0.00	0
8			0	0	0	0	0	0.00	0.0	0.00	0
9			0	0	0	0	0	0.00	0.0	0.00	0
10			0	0	0	0	0	0.00	0.0	0.00	0
11			0	0	0	0	0	0.00	0.0	0.00	0
12			0	0	0	0	0	0.00	0.0	0.00	0
13			0	0	0	0	0	0.00	0.0	0.00	0
14			0	0	0	0	0	0.00	0.0	0.00	0
15			0	0	0	0	0	0.00	0.0	0.00	0
16			0	0	0	0	0	0.00	0.0	0.00	0
17			0	0	0	0	0	0.00	0.0	0.00	0
18			0	0	0	0	0	0.00	0.0	0.00	0
19			0	0	0	0	0	0.00	0.0	0.00	0
20			0	0	0	0	0	0.00	0.0	0.00	0

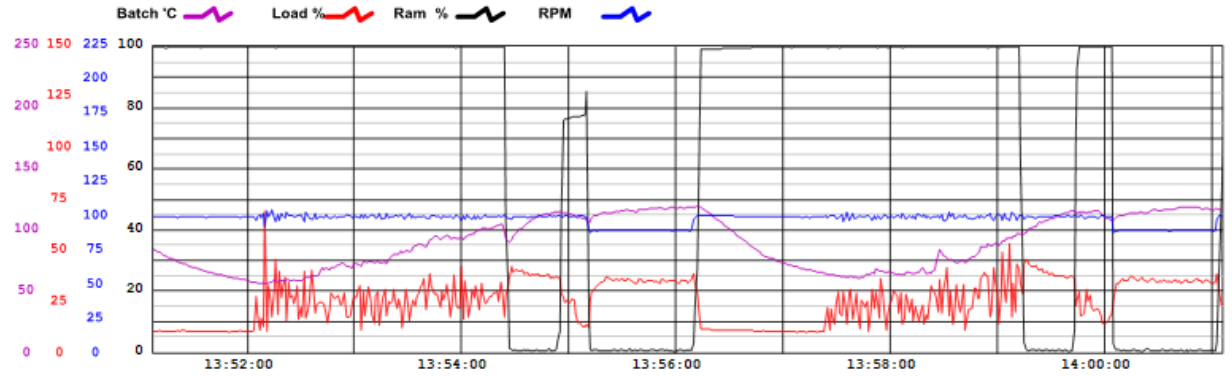


Figure A 2.12: 3 phr Fiber content

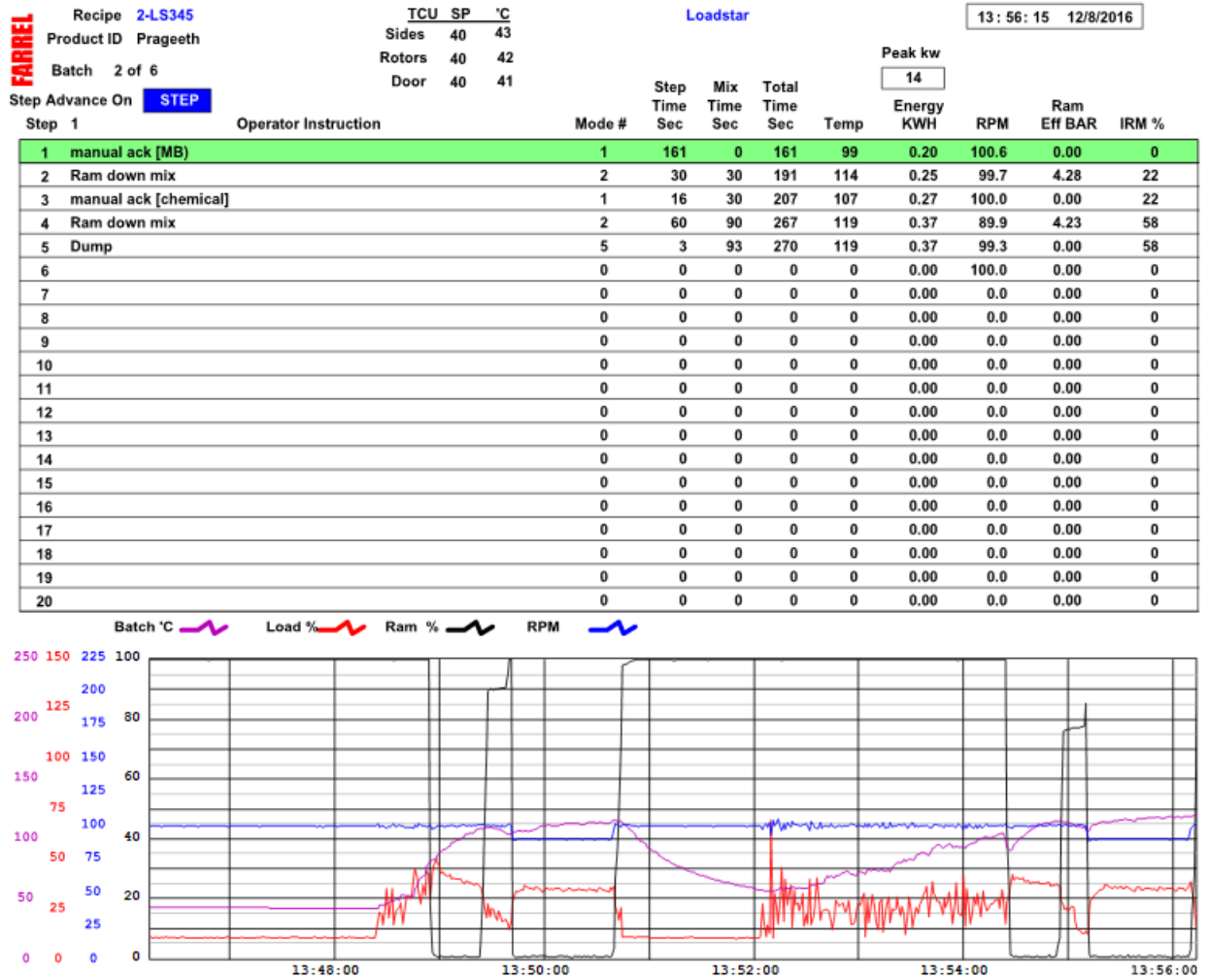


Figure A 2.13: 10 phr Fiber content

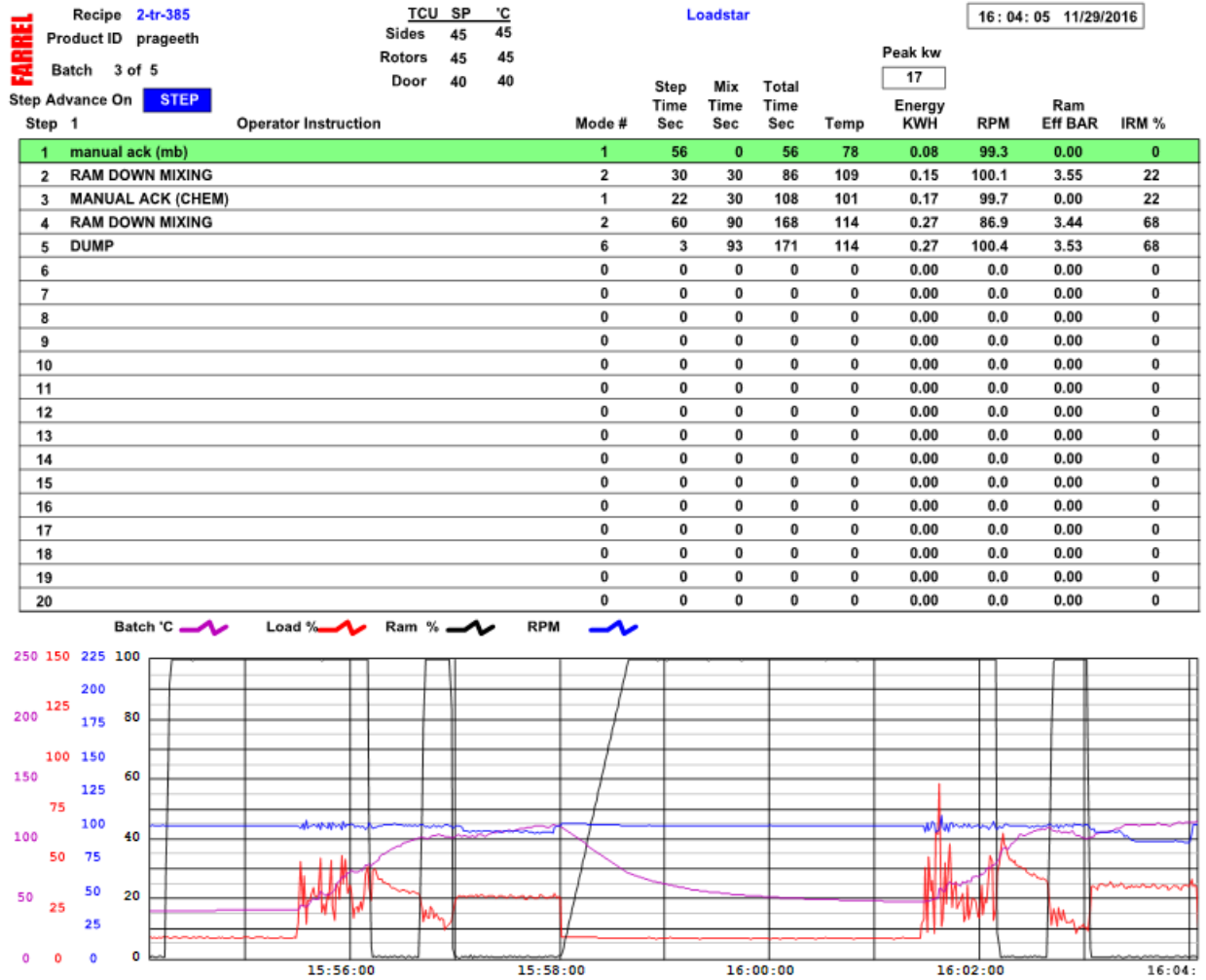


Figure A 2.14: 15 phr Fiber content

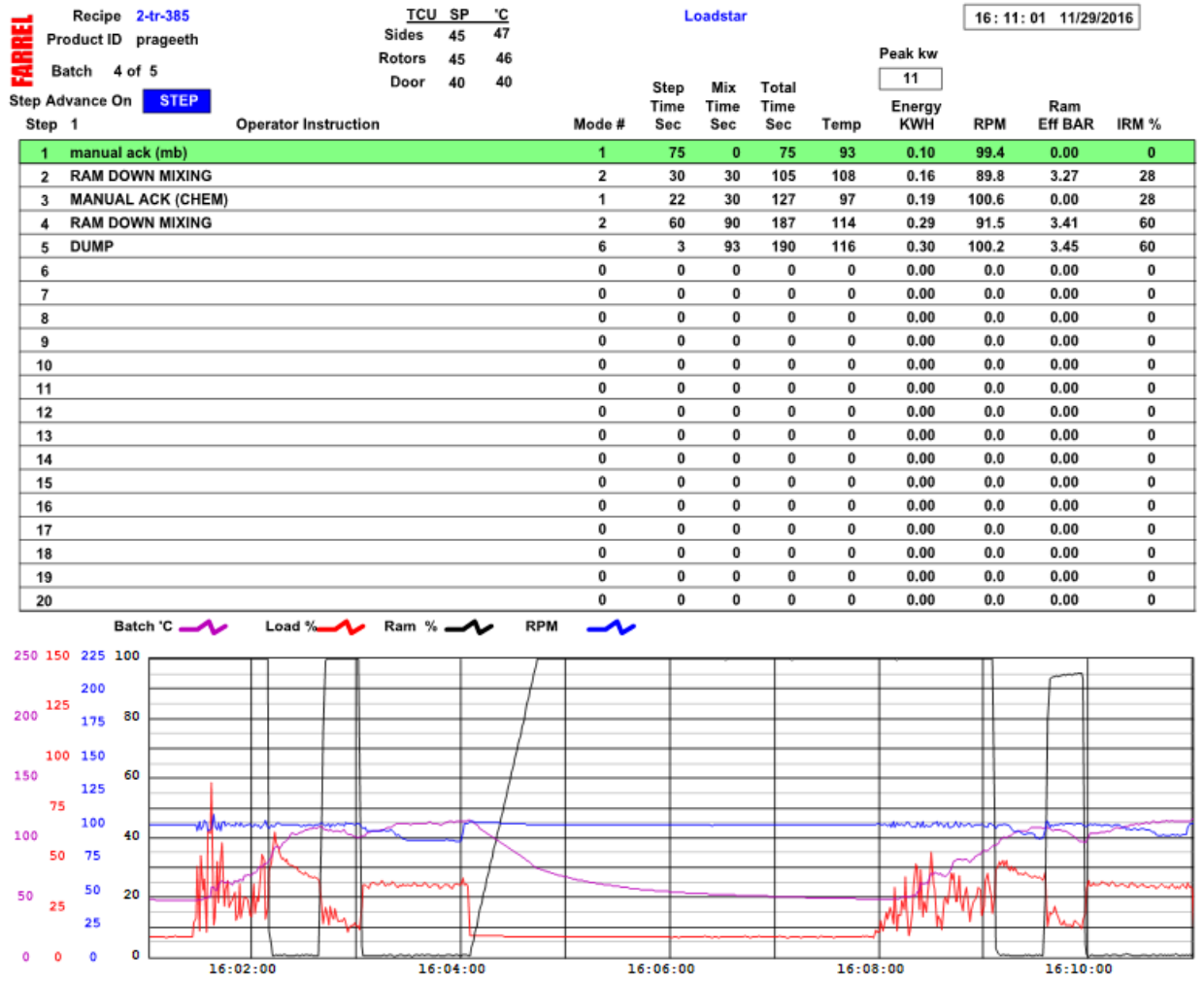
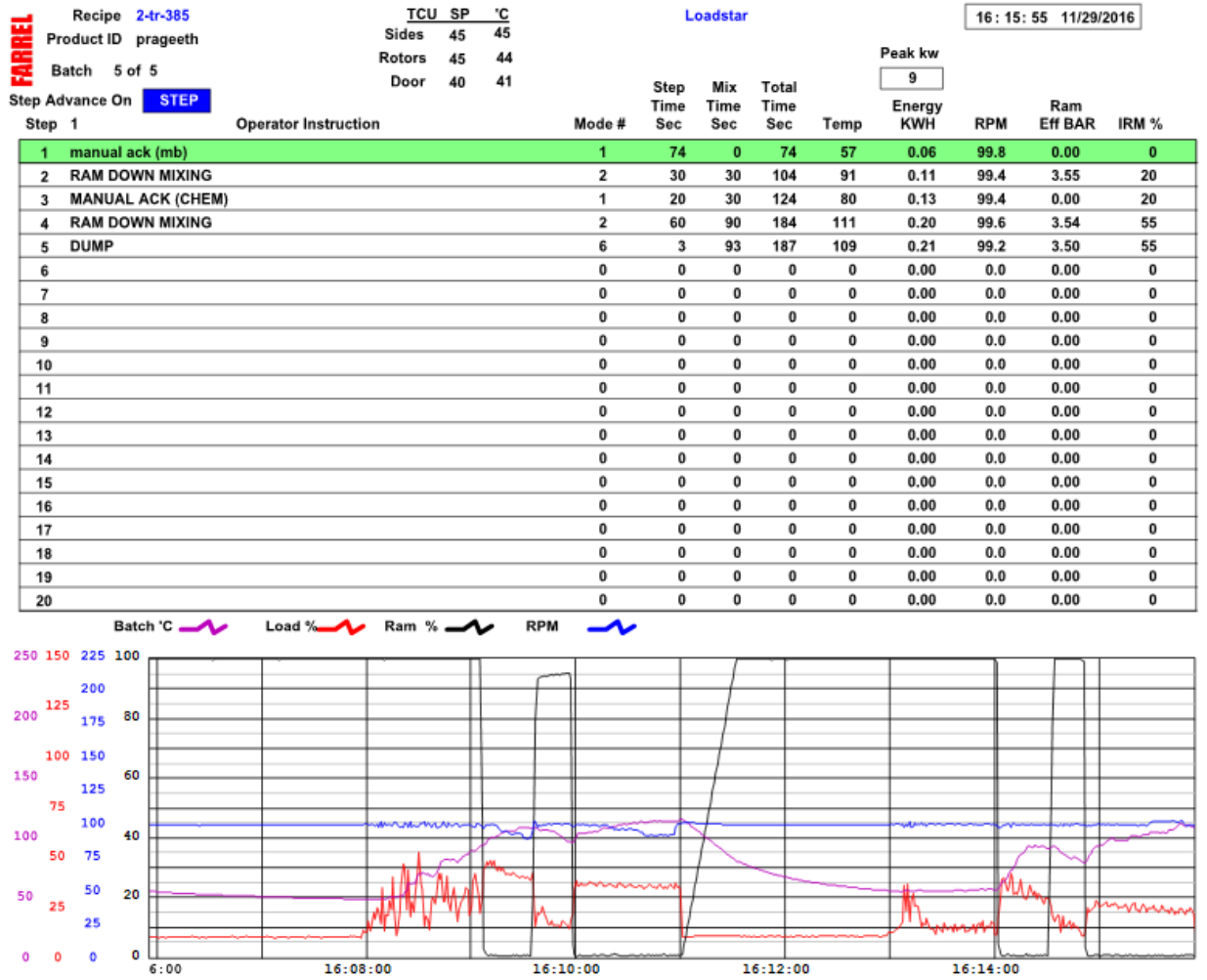


Figure A 2.15: 20 phr Fiber content



APPENDIX 3

MINITAB RESULT SHEET

Figure A 3.1: Tensile test Results (Longitudinal or parallel to fiber oriented direction)

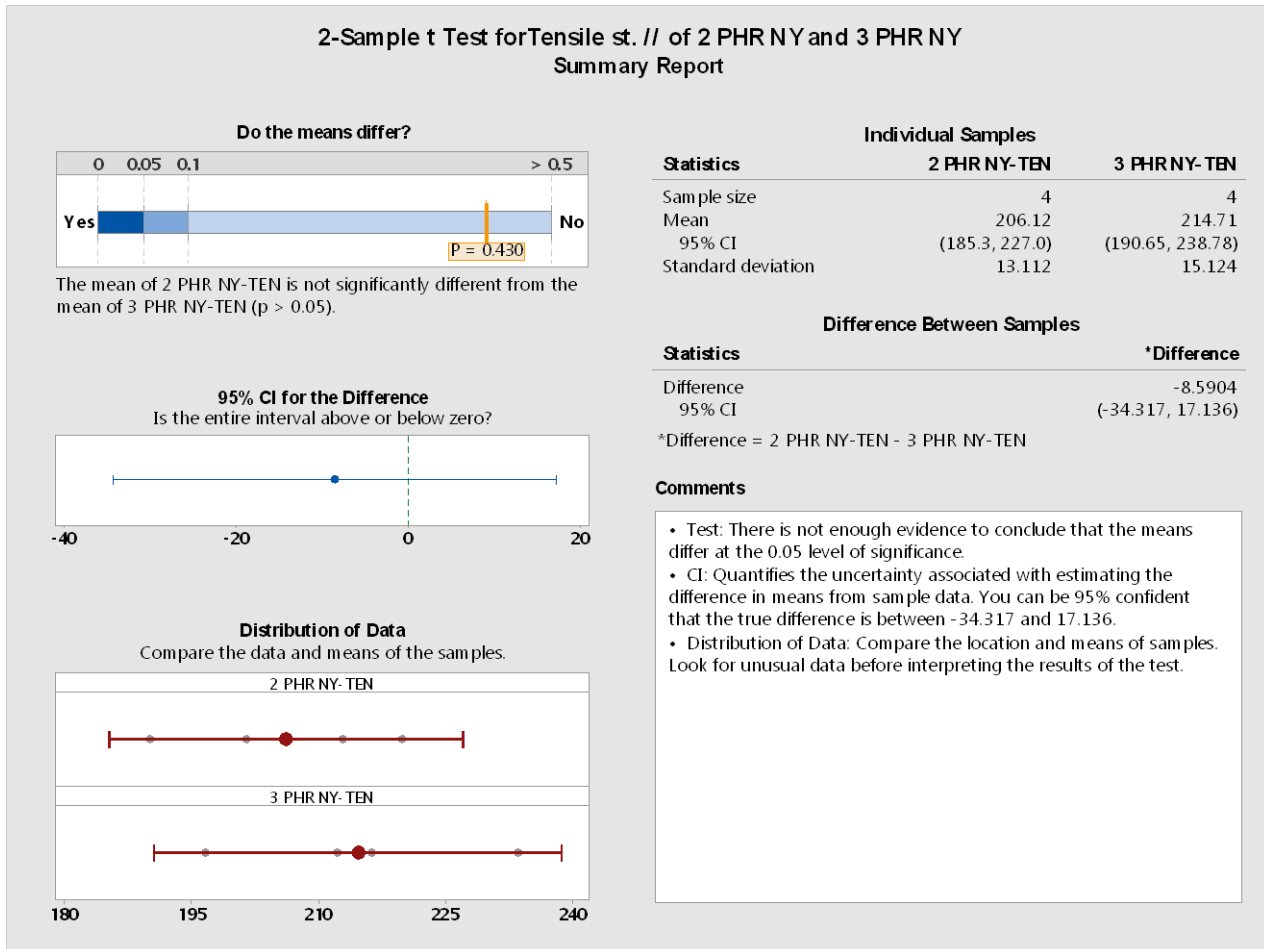


Figure A 3.2: Tensile test Results (Transvers or perpendicular to fiber oriented direction)

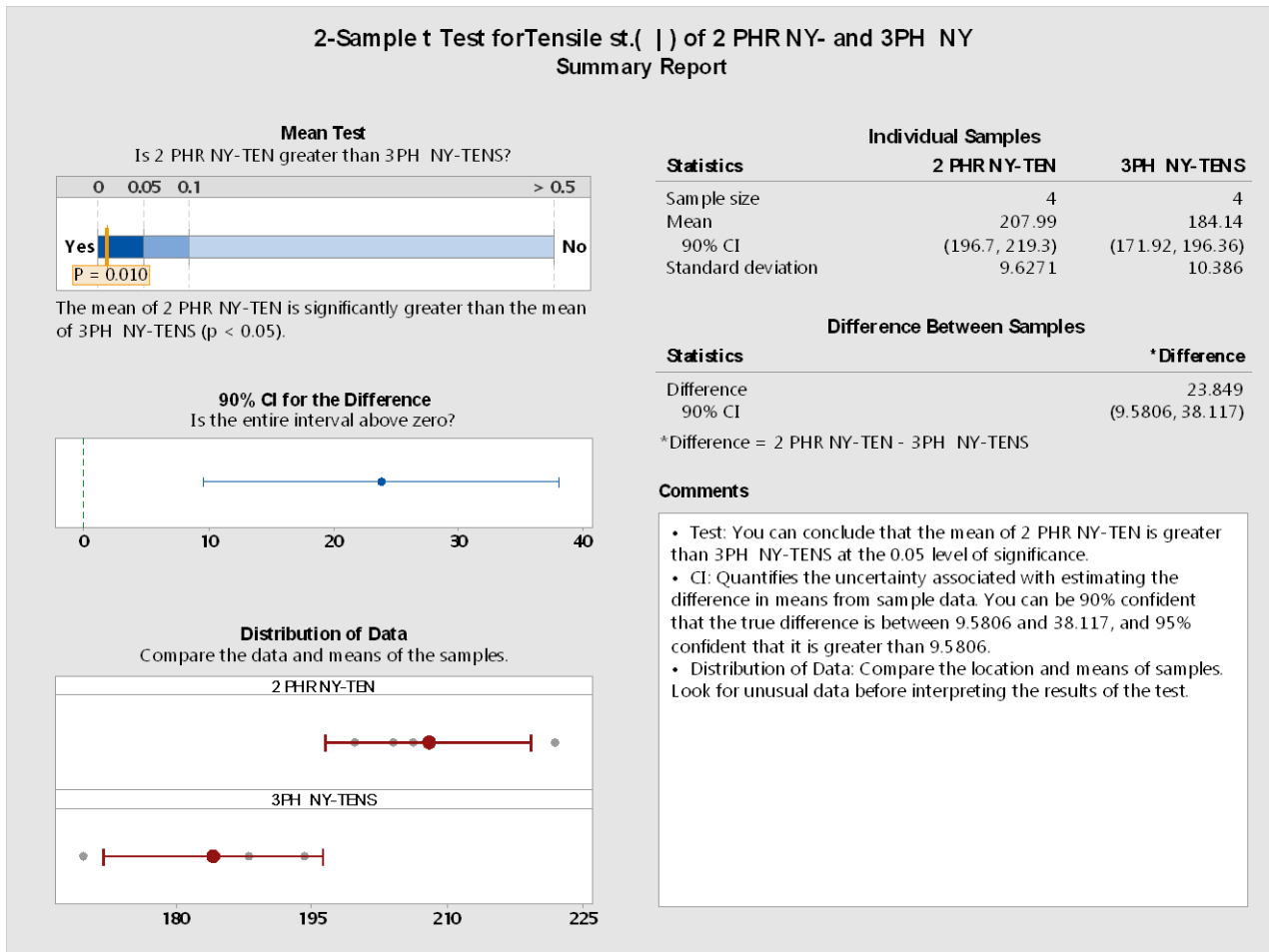


Figure A 3.3: Tearing test Results (Longitudinal or parallel to fiber oriented direction)

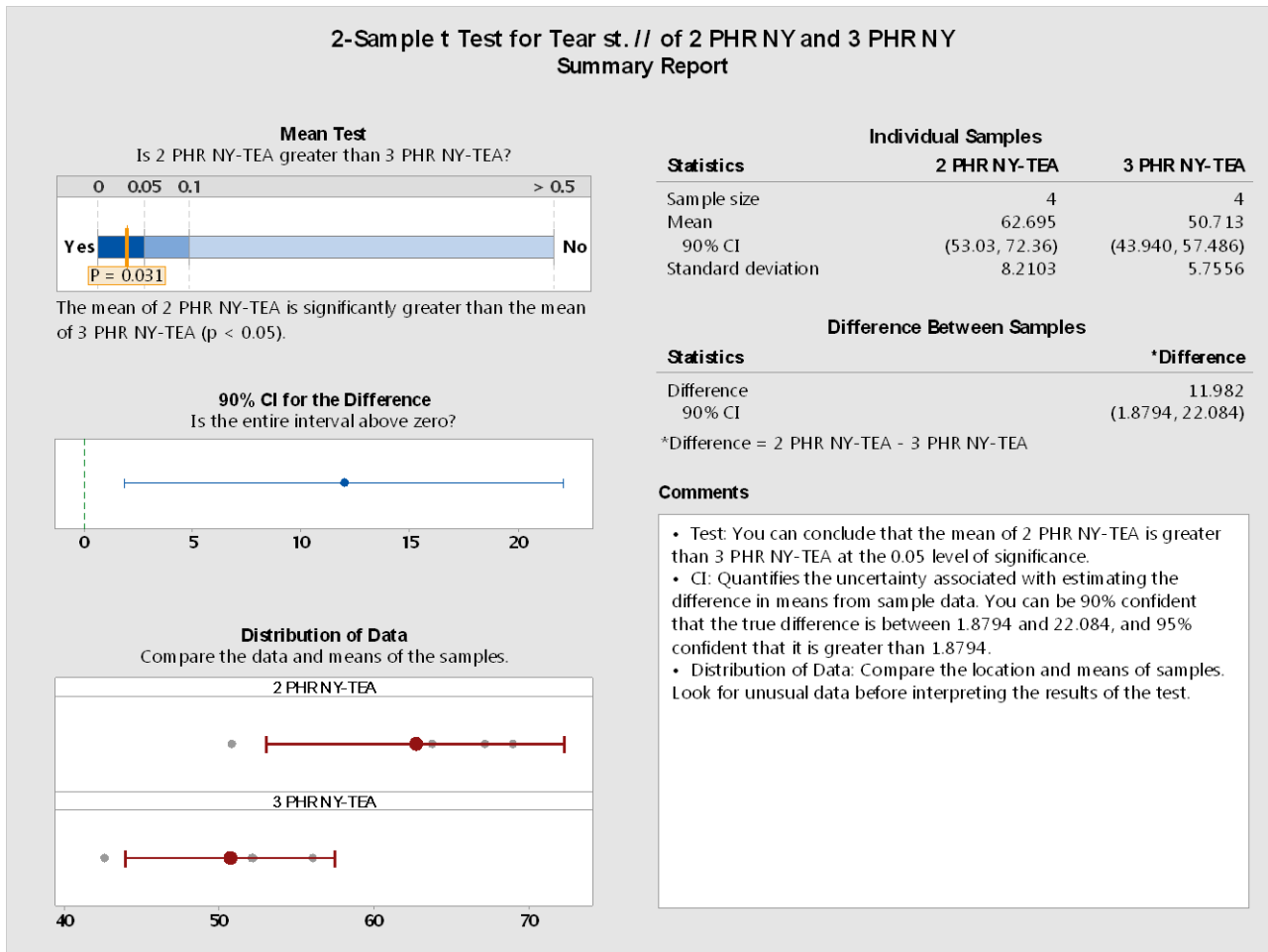


Figure A 3.4: Tearing test Results (Transvers or perpendicular to fiber oriented direction)

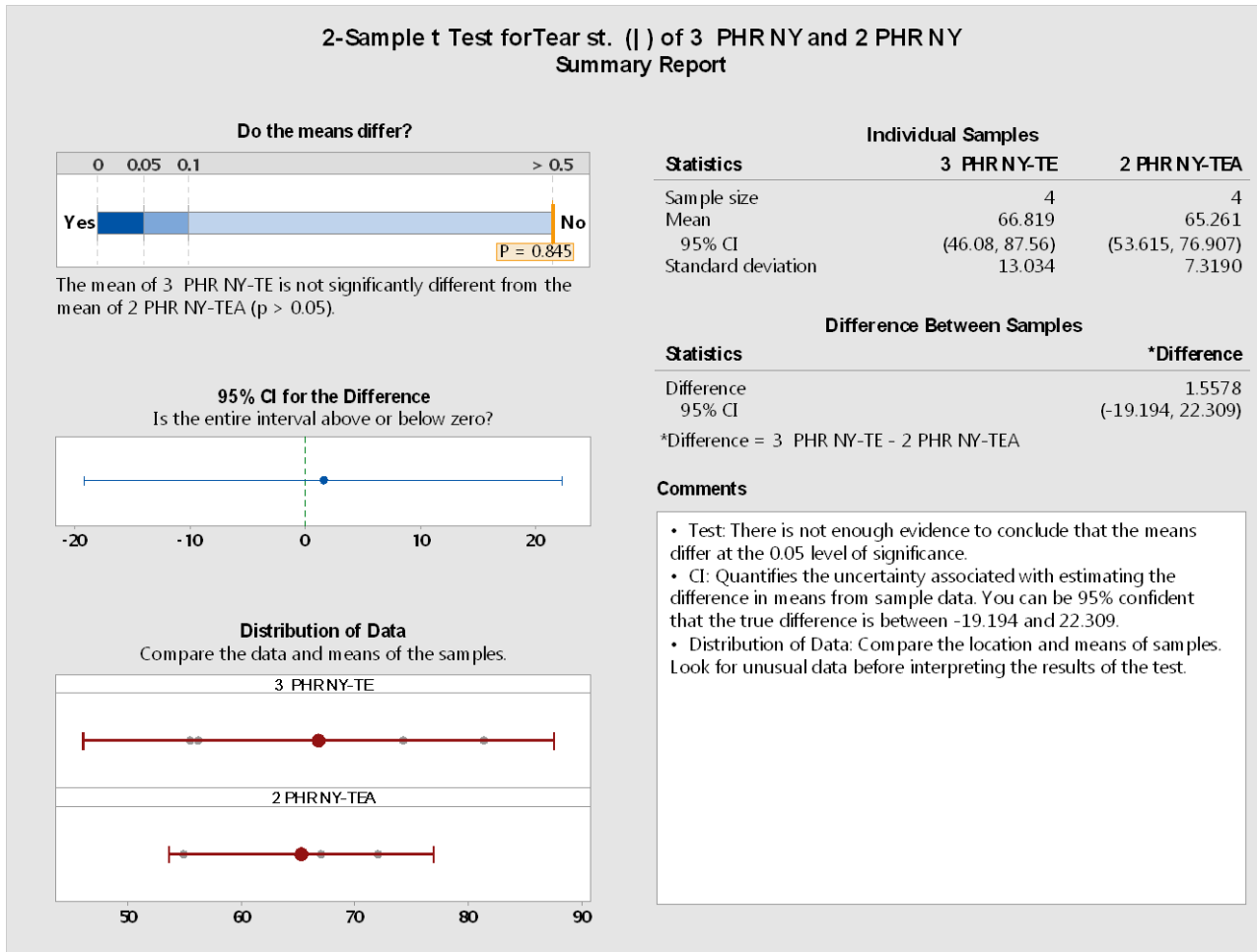


Figure A 3.5: Cut & Chip test Results (Average Weight loss)

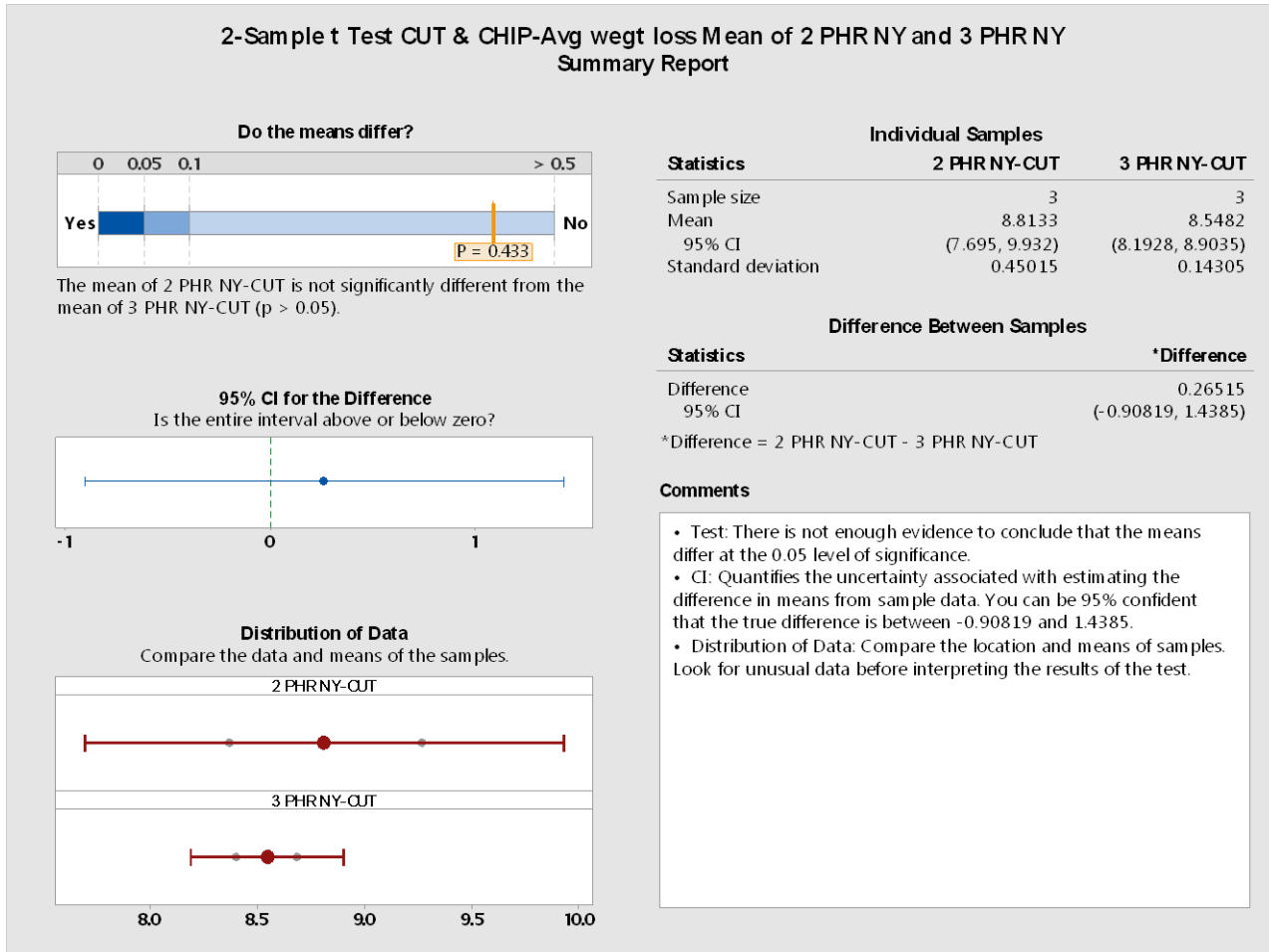


Figure A 3.6: Cut & Chip test Results (Average Diameter loss)

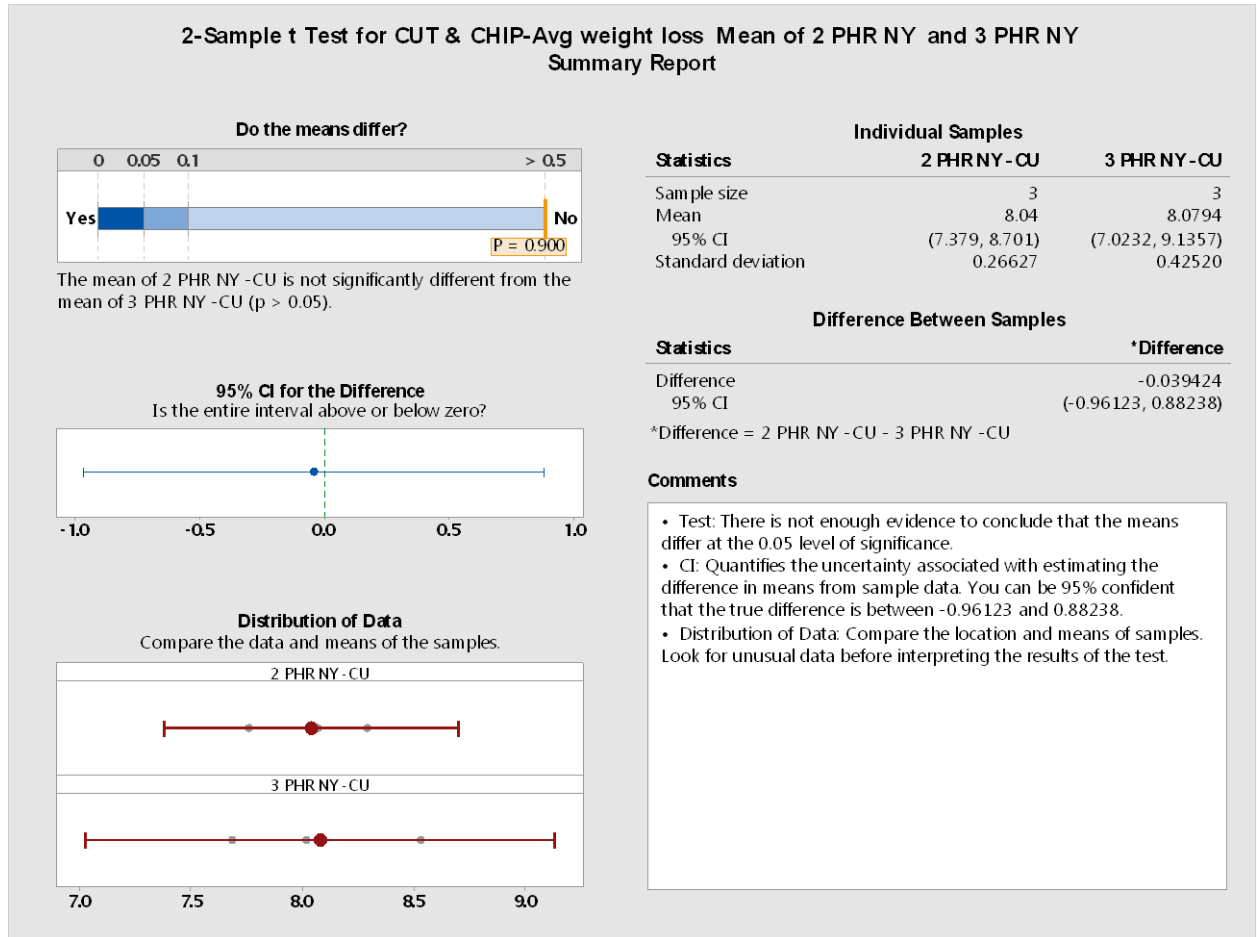


Figure A 3.7: Abrasion test Results

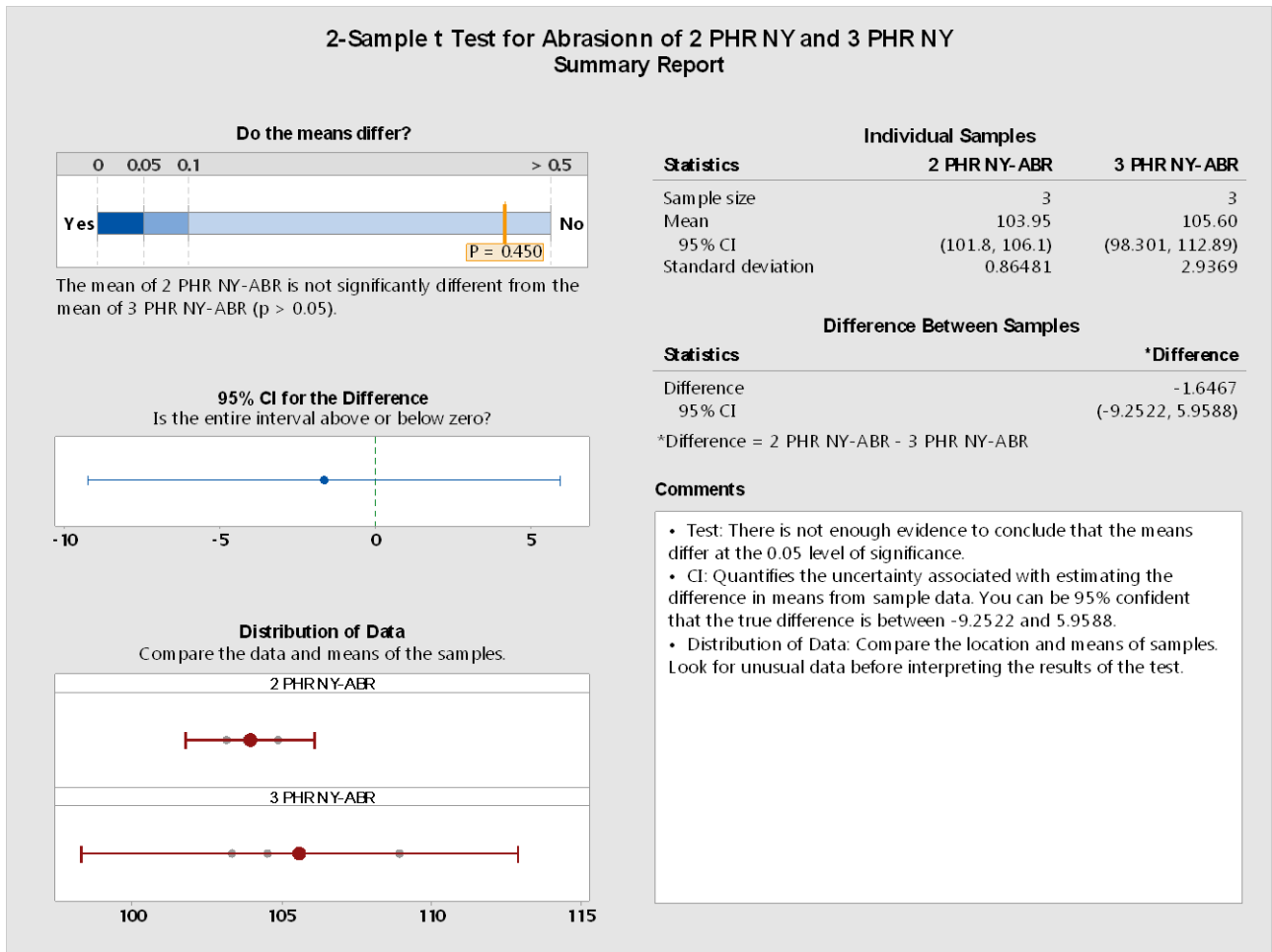


Figure A 3.8: Compression test Results

