Milling Analysis Tools Pre-Conference Workshop October 5, 2019

10th Annual Southeast Asia Region Conference & Expo
Intercontinental Jakarta Pondok Indah Hotel
Jakarta, Indonesia

Workshop Presenter

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IAOM Staff Introduction

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Agenda–Part I

Time	Topic/Activity
09:00– 09:15	Introduction and Agenda Review
09:15–10:00	Step Chart Development and Analysis
10:00–10:15	Morning Break
10:15–11:15	Weigh-Off Data Collection and Analysis
11:15–12:30	Granulation Curve Development and Analysis

Agenda–Part II

12:30–13:30	Lunch Break
13:30–14:15	Milling Loss Calculations
14:15—15:45	Laboratory Milling
15:45–15:00	Wrap-up Workshop Concludes

After today you should be able to ....

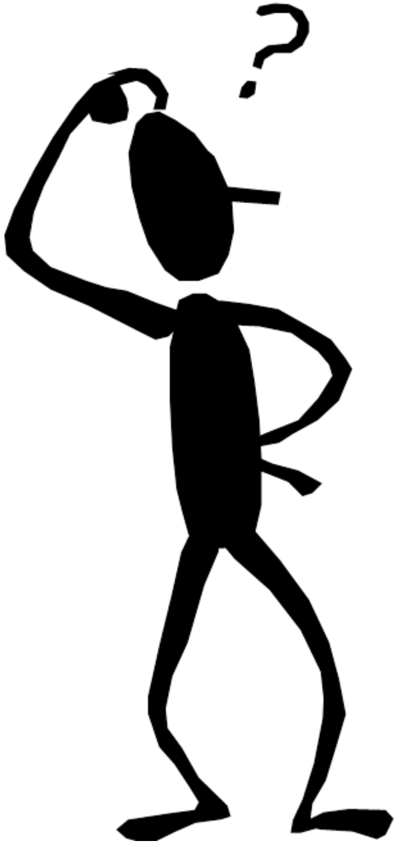
- Develop and utilize step chart information
- Evaluate weigh-off data to aid in analysis and problem identification
- Properly develop and analyze granulation curves

After today you should be able to ....

- Consider milling loss calculations and need for process data to control loss
- Understand potential value of laboratory milling in wheat evaluation

Informal

- Ask questions
- Share Experiences
- Contact me any time



Courtesy Request

Please put your phones on beep and limit conversation till you are outside the meeting room

Serving You!!!

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Step Chart Development and Analysis

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Step Chart Development

- A step chart as a method of tabulating the flow rate, percentage of total stock, and the quality of stock going TO (destination) and FROM (origin) each operation in a mill flow for the purpose of analyzing load and quality balance throughout the entire mill.

Step Chart Purpose

- Properly developed the step chart provides the sequence to be followed for a weigh-off and sampling to ensure product flow rates and qualities are measured without having been disturbed or put out of balance by previous disruptions of material flow or machine performance.

Use of Step Chart Information

- Estimate loads in the mill
- Evaluate equipment utilization
- Identifying material handling requirements

Starting Point

	Stock Destination													
		1B	2B	3B	4B	1C	2C	3C	4C	5C	R1	R2	R3	6C
Stock Origin	1B		X			X		X			X			
	2B			X		X		X			X			
	3B				X	X		X			X			
	4B								X				X	
	1C						X					X		
	2C							X					X	
	3C								X				X	
	4C									X				
	5C													X
	R1					X	X					X		
	R2								X				X	
	R3													X
	6C													

Insert Rows and Columns

Insert column to the right of the same product stream

Insert a row above the desired product stream

Stock Destination

Stock Origin	1B	2B	3B		4B	1C	2C	3C	4C	5C	R1	R2	R3	6M
1B		X				X		X			X			
2B			X			X		X			X			
3B					X	X		X			X			
4B									X				X	
1C							X					X		
2C								X					X	
3C									X				X	
4C										X				
5C														X
R1						X	X					X		
R2									X				X	
R3														X
6C														

Move Rows and Columns

Moved Column

Move the entire column into the blank space

Stock Destination

Stock Origin

	1B	2B	3B	R1	4B	1C	2C	3C	4C	5C		R1	R2	6C
1B		X		X		X		X						
2B			X	X		X		X						
3B				X	X	X		X						
R1						X	X					X		
4B									X				X	
1C							X					X		
2C								X					X	
3C									X				X	
4C										X				
5C														X
R1									X				X	
R2														X
6C														

Moved Row

Move the entire row into the blank space

Delete Blank Rows and Columns

- After the move is completed the newly created blank rows and columns are deleted and the process of identifying additional moves to ensure all destinations stocks are shown below origin stocks as required in the definition.

Draw Stair Step

Stock Destination

Stock Origin

	1B	2B	3B	R1	1C	2C	4B	3C	R2	4C	5C	R3	6C
1B		X		X	X			X					
2B			X	X	X			X					
3B				X	X		X	X					
R1					X	X			X				
1C						X			X				
2C								X				X	
4B										X		X	
3C										X		X	
R2										X		X	
4C											X		
5C													X
R3													X
6C													

Alternative Solutions!

Stock Destination

Stock Origin	1B	2B	3B	R1	1C	4B	2C	3C	R2	4C	5C	R3	6C
1B		X		X	X			X					
2B			X	X	X			X					
3B				X	X	X		X					
R1					X		X		X				
1C							X		X				
4B										X		X	
2C								X				X	
3C										X		X	
R2										X		X	
4C											X		
5C													X
R3													X
6C													

Ring-around

- Sometimes it is impossible to establish a diagonal, stair stepped line
- A ring-around occurs when product from a system finds its way back into the same system directly or through another system.
- A ring-around is best avoided but may be needed in order to maintain equipment functionality

Step Chart Analysis

- Additional columns for flour grades and by-products may be added

- The sum of each process column should be equal to the sum of the corresponding process row.

- The mass flow in and out of a system should be reasonably close perhaps 5% or less difference.

	B1/B2	DB1/B2	P1	P2	DD1	D1	R1C	P3	P4	P7	R1M	R1F	C1	B3C	B3F	DB3	C1A	P6	C1B	P5	C2	R2A	R2B	C3	B4C	BR1	VIBRO1	R3	B4F	DB4	5BC	BR2	DF	BR3	VIBRO 2	VIBRO 3	5BF	C4	Br4	C5	C6	R4	C7	C8	F-1	F-2	F-3	F-4	Germ	Coarse Bran	Fine Bran	Pollard	From
B1/B2		X	X	X										X	X																															X	X,X						
DB1/B2					X			X																																						X	X,X						
P1						X	X								X																																						
P2							X				X				X							X																															
DD1									X										X																											X							
D1										X							X											X																		X							
R1C										X		X																X																	X								
P3											X	X										X						X																									
P4												X					X					X						X																									
P7												X										X						X, X														X											
R1M													X				X						X																						X,X								
R1F													X				X						X																						X,X								
C1																	X		X																										X,X								
B3C																X									X			X	X																	X	X						
B3F																X									X			X	X																	X	X						
DB3																		X		X	X																										X,X,X						
C1A																			X																										X								
P6																			X		X							X														X											
C1B																					X		X																							X							
P5																						X						X														X											
C2																								X				X																		X,X							
R2A																								X				X																	X								
R2B																												X										X								X							
C3																												X										X-VA								X							
B4C																										X																											
BR 1																											X				X																						
VIBRO 1																													X-S																			X					
R3																													X											X		X X					X		X-V	X-V			
B4F																														X		X										X					X	X					
DB4																																X-VA						X, X-VA									X						
5BC																																		X																			
BR 2																																			X		X																
DF																																				X	X																
BR 3																																				X											X			X			
VIBRO 2																																					X-S											X					
VIBRO 3																																					X-S											X					
5BF																																							X									X,X					
C4																																								X		X				X,X							
BR4																																									XS										X		
C5																																									X		X			X							
C6																																											X					X			X-V	X-V	
R4																																											X					X	X-V	X-V	X		
C7																																												X				X			X-V	X-V	
C8																																																X				X	
To																																																					

Weigh-Off Data and Analysis

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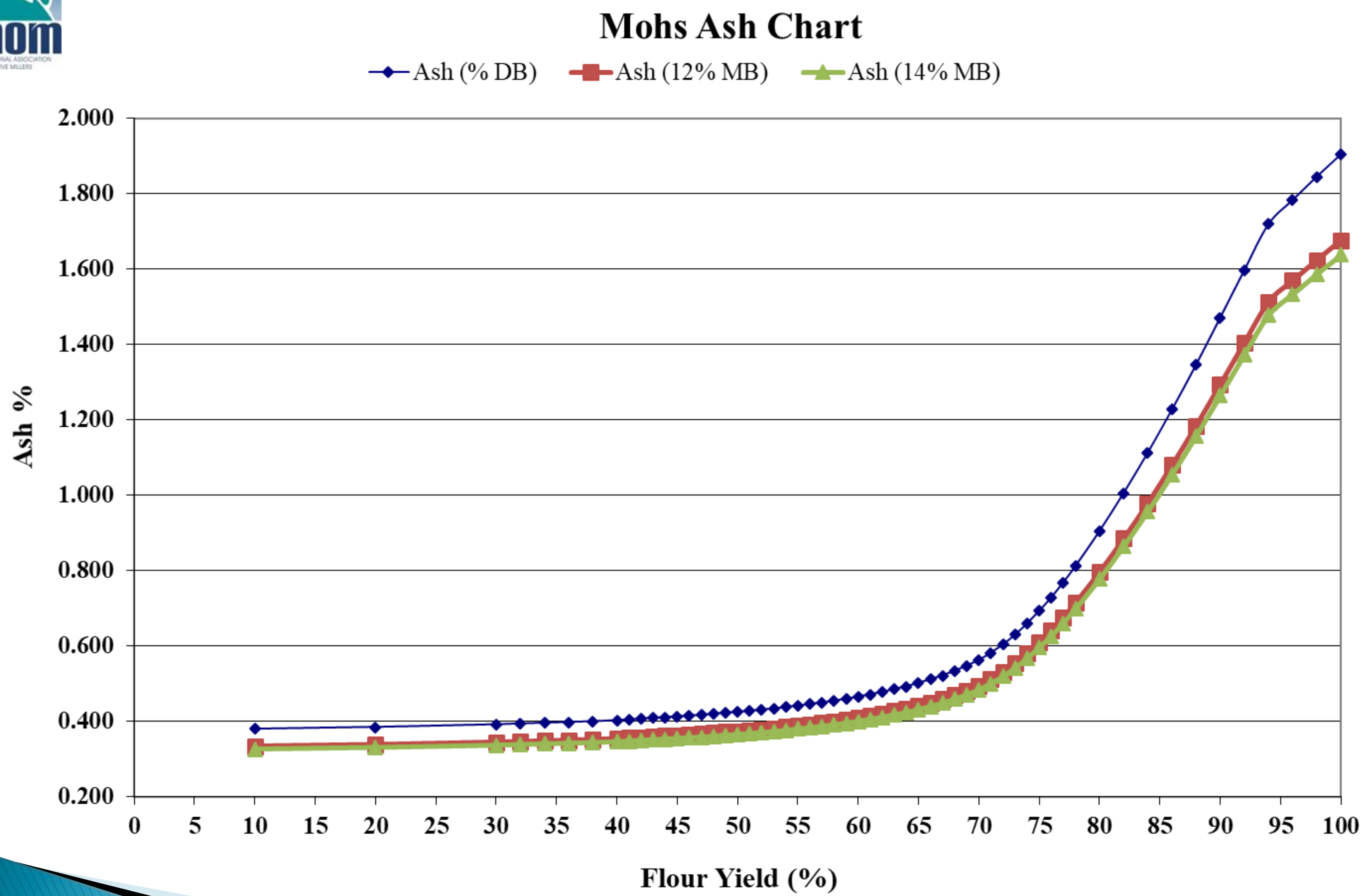
Cumulative Ash Curve

- Graph showing how flour ash increases when starting from the lowest ash individual flour in a mill and progressively adding the rest of the individual flours to previous mix in order of their ascending ash contents.

- Used for evaluating mill performance and those varietal differences of grains that effect milling.



Mohs Ash Chart
Ash (% DB)
Ash (12% MB)
Ash (14% MB)
2.000
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
Ash %
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Flour Yield (%)

Flour Collection Layout

Mill-A HRW

Stream spouted to flour screw conveyor

S.C.

No.	1	2	3	4	5	6	7	8	9	10
F4										
F3	**1**	2	**3**	4	5	6	7	8	9	10
F1	1	2	3	4	5	6	7	**8**	9	**10**
F2	1	**2**	3	**4**	**5**	**6**	**7**	8	**9**	10
Name	B3A	B1B2A	B1B2B	B3B	2DB1B2	B1B2C	1DB1B2	1R1f	1DB1B2	1R1m
Grade	3	2	3	2	2	2	2	1	2	1

No.	11	12	13	14	15	16	17	18
F4								
F3	1	2	3	4	5	6	7	8
F1	1	2	**3**	**4**	5	6	7	**8**
F2	1	2	3	4	**5**	6	**7**	8
Name	2R1fψ	2R1mψ	1R1m	1R1f	DD1	2R1cψ	D1	1R1c
Grade			1	1	2		2	1

No.	19	20	21	22	23	24	25	26	27	28	29	30
F4												
F3	1	**2**	3	**4**	**5**	6	7	8	9	**10**	11	**12**
F1	**1**	2	3	4	5	6	**7**	**8**	9	10	11	12
F2	1	2	**3**	4	5	6	7	8	9	10	**11**	12
Name	C1	1DB3	R2a	2DB3	1DB3	2C1bψ	1C1a	1C1b	2C1aψ	R3	R2b	DB4
Grade	1	3	2	3	3		1	1		3	2	3

No.	31	32	33	34	35	36	37	38	39	40
F4						1	**2**	**3**	**4**	5
F3	1	2	3	4	5	**6**	7	8	9	10
F1	**1**	2	3	**4**	**5**	6	7	8	9	10
F2	1	2	3	4	5	6	7	8	9	**10**
Name	1C2	2C2ψ	2C3ψ	1C2	1C3	1B4f	Df	2B4f	R4	2C4
Grade	1			1	1	3	4	4	4	2

No.	41	42	43	44	45	46	47	48	49	50	51	52
F4	**1**	2	**3**	**4**	**5**	**6**	7	8	9	10	11	**12**
F3	1	2	3	4	5	6	7	**8**	**9**	**10**	**11**	12
F1	1	2	3	4	5	6	7	8	9	10	11	12
F2	1	**2**	3	4	5	6	**7**	8	9	10	11	12
Name	2B5f	1C4	1B5f	1C8	C7	C6	C5	2C8ψ	V2	V1a	V3	V1b
Grade	4	2	4	4	4	4	2	3	3	3	3	4

Collecting the Data

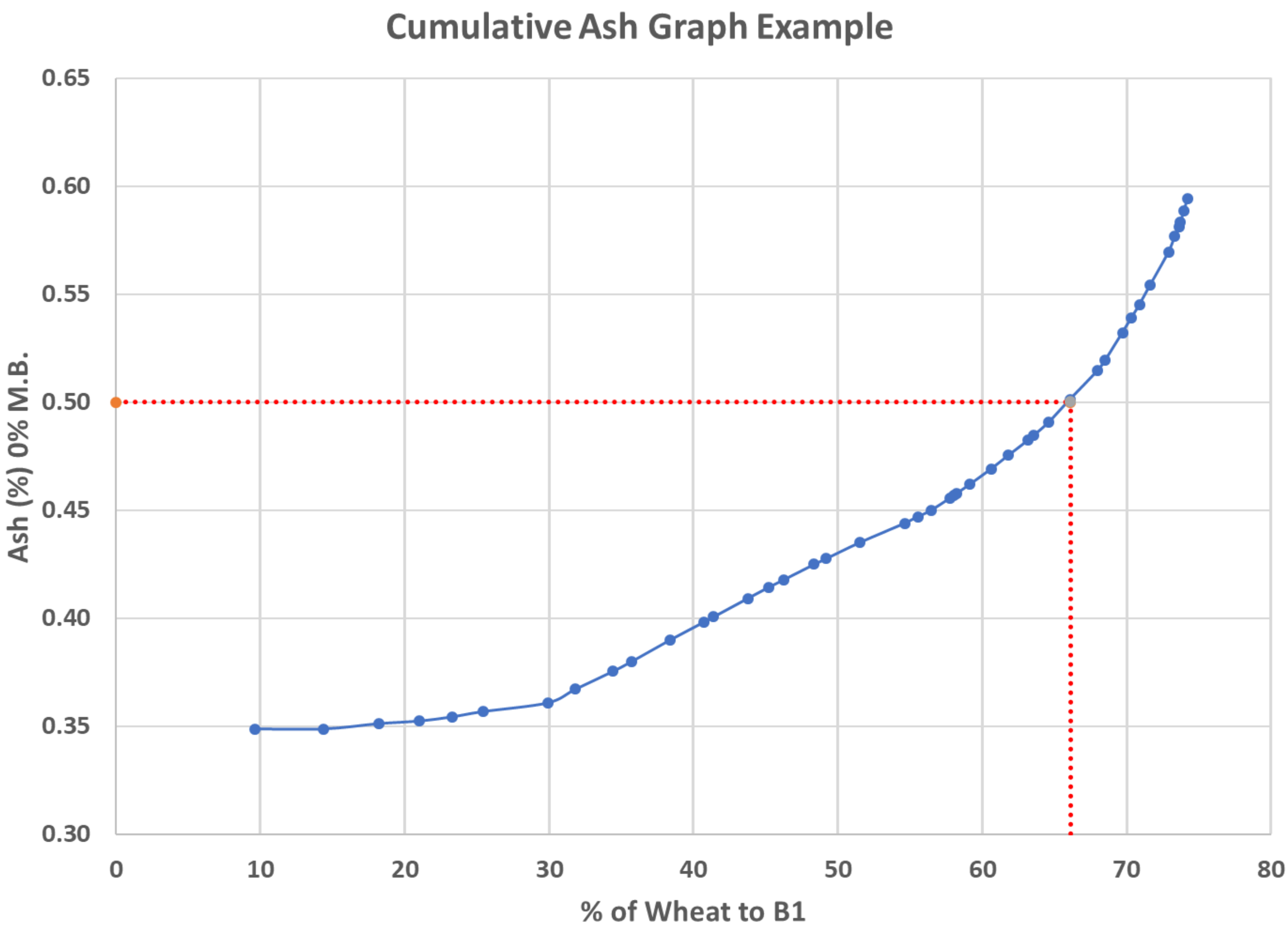
- Mill must be operating in a steady state
- Uniformly conditioned homogeneous wheat
- Confirm minimal automated control changes
- Sample downstream and move upstream
- Flour stream collection independent
- Practice and repeat weigh-off procedure
- Sample at least 15 seconds or longer
- Converted weight to a uniform time period for example Kg/min or Kg/hr.

Example of Weigh-Off Data

Stream	ASH (0% M.B.)	Kg/hr	System Average		Deviation from Average (%)	
			ASH (0% M.B.)	Kg/hr	ASH (0% M.B.)	Kg/hr
B1B2A	0.641	146	0.676	142	-5	3
B1B2B	0.747	137			11	-3
B1B2C	0.639	142			-5	0
C1A	0.359	450	0.441	440	-19	2
C1B	0.524	430			19	-2
C2A	0.560	374	0.571	352	-2	6
C2B	0.582	330			2	-6
R1FA	0.386	712	0.369	1115	5	-36
R1FB	0.351	1518			-5	36
R1MA	0.376	359	0.364	556	3	-35
R1MB	0.353	753			-3	35
B3A	0.803	192	0.809	203	-1	-5
B3B	0.814	214			1	5
R2A	0.464	301	0.532	337	-13	-11
R2B	0.600	373			13	11

Cumulative Ash Calculation Example

Stream	Q	ΣQ	A	Q*A	ΣQ*A	ΣQ*A/ ΣQ
C2	18.43	18.43	0.376	6.922	6.922	0.376
C1	38.77	57.2	0.406	15.733	22.655	0.396
C3	8.19	65.39	0.441	3.609	26.265	0.402
R1	7.18	72.57	0.441	3.164	29.429	0.406
R2	1.1	73.67	0.501	0.551	29.980	0.407
C4	5.03	78.7	0.508	2.556	32.536	0.413
4B	3.69	82.38	0.566	2.090	34.626	0.420
3B	2.54	84.92	0.603	1.533	36.159	0.426
2B	4.07	88.99	0.669	2.721	38.880	0.437
C5	4.36	93.35	0.722	3.148	42.028	0.450
R3	1.68	95.02	0.740	1.242	43.271	0.455
B5	1.1	96.12	0.773	0.851	44.121	0.459
1B	3.88	100	0.812	3.149	47.270	0.473
Total	100					


Cumulative Ash Graph Example
Ash (%) 0% M.B.
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0
10
20
30
40
50
60
70
80
% of Wheat to B1

Granulation Curve Development and Analysis

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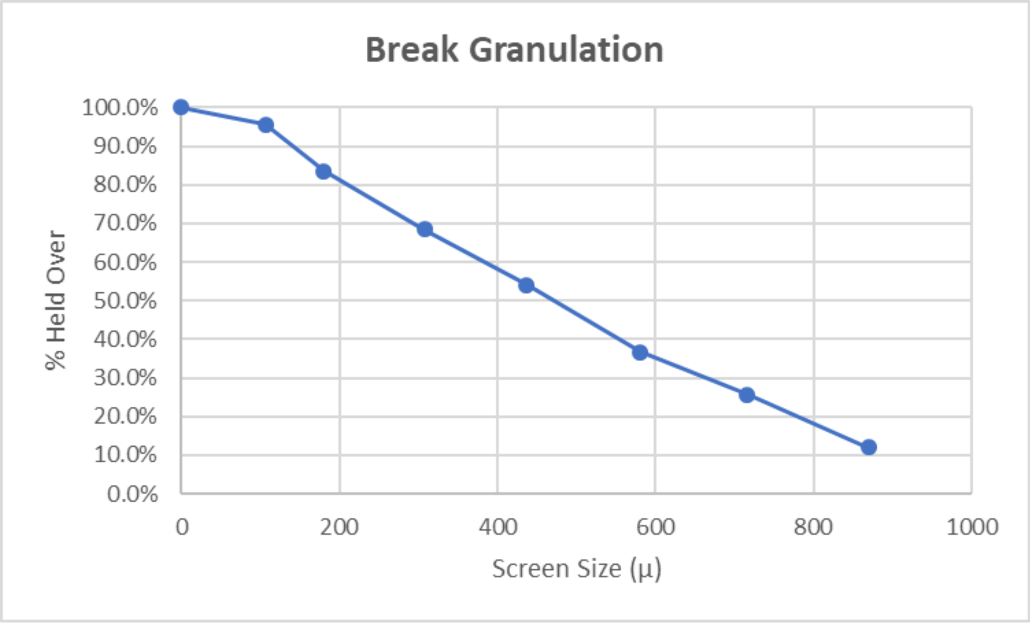
Granulation Curve Definition

- A granulation curve or profile curve is a graphic representation of the measured percentage of material cumulative held over a given size screen opening.



Category and factors influencing granulation profile

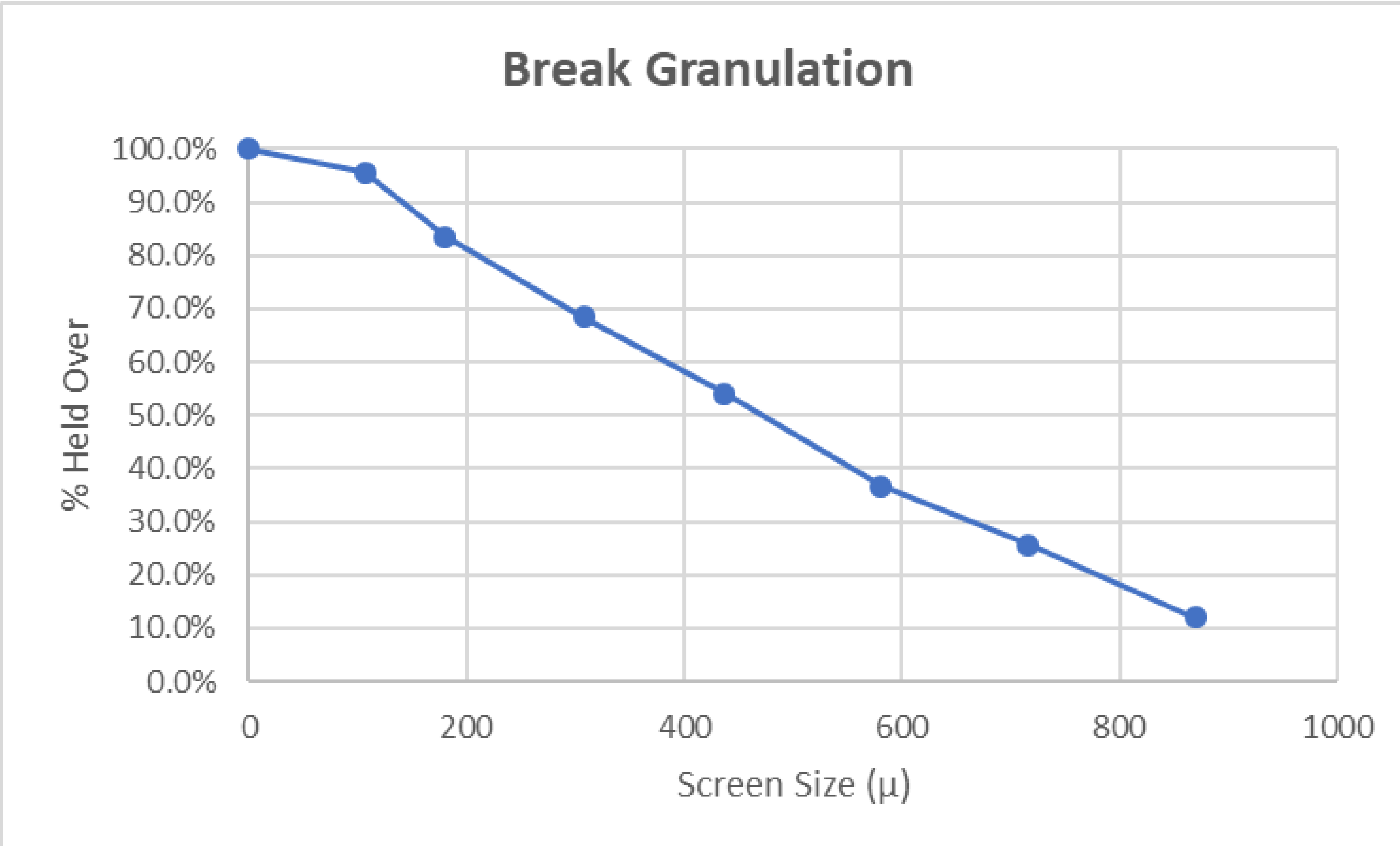
Category	Factors
Mother Nature	Temperature, Relative Humidity
Mankind	Improper Water Setting during Tempering, Improper Roll Corrugation, Selection/Installation
Material	Kennel Size, Kernel Hardness, Wheat Variety
Measurement	Scale Weights, Screen Identification, Sifting Time
Machines	Roll Wear, Belt Slip, Roll Setting
Method	Sampling Collection, Screen Selection, Calculation

Use of Granulation Curve

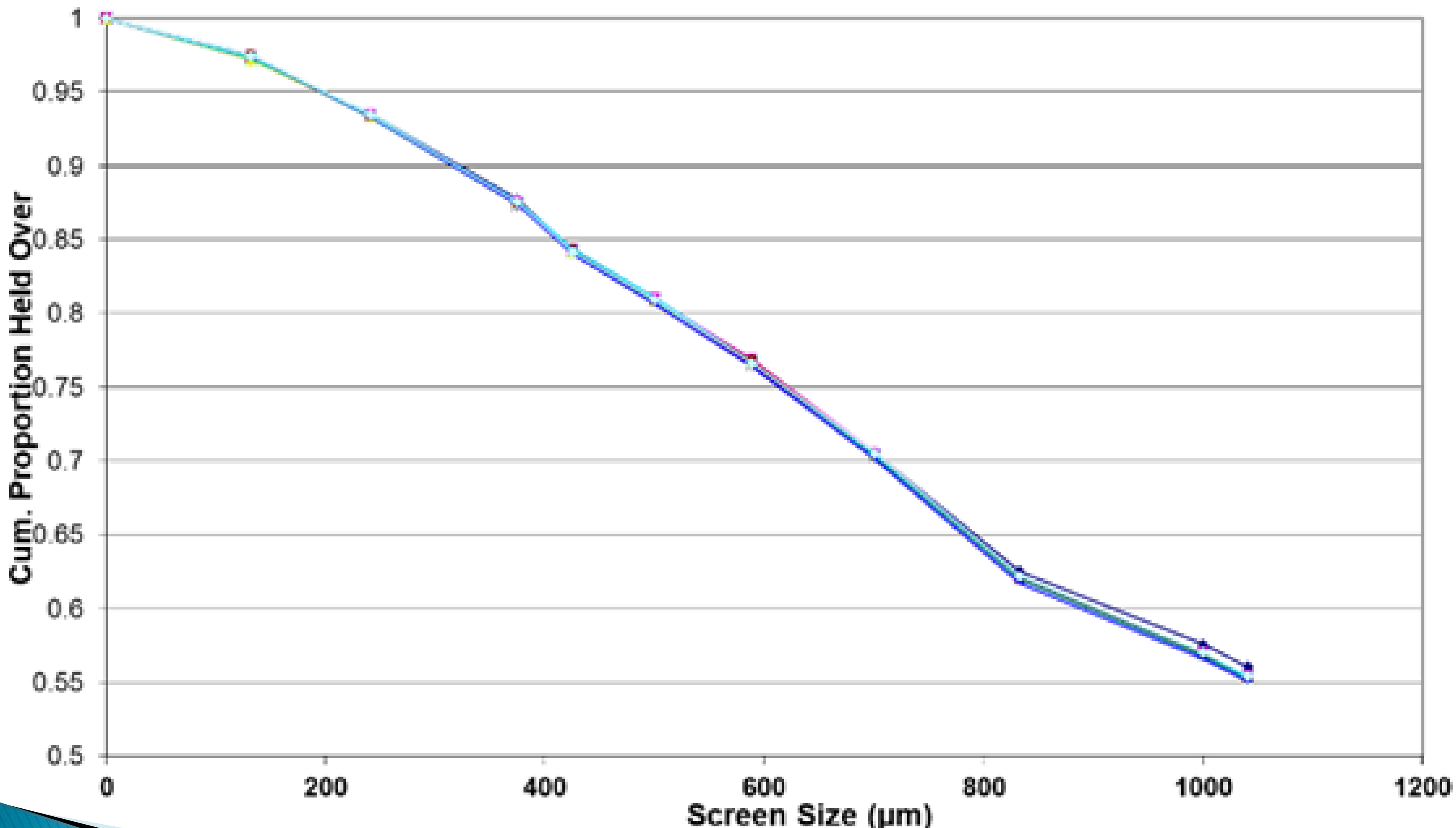
- Estimate expected loads
- Evaluate roll wear
- Evaluate sifter efficiency
- Estimate loading changes

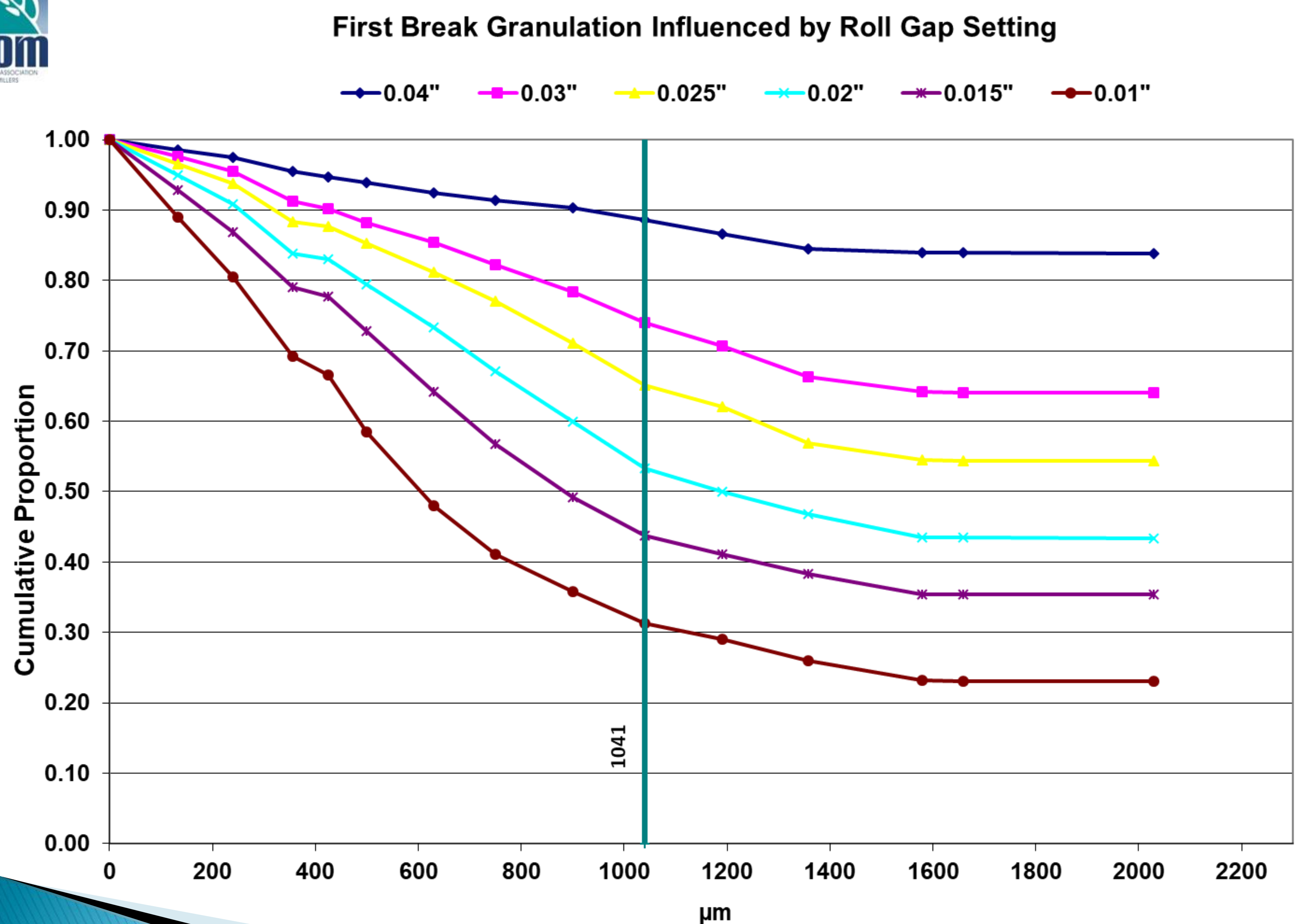
Granulation Curve Calculations

Screen	Microns	Grams	%	∑%	
24 SS	869	59	12.0%	12.0%	
28 SS	716	67	13.6%	25.7%	
34 SS	581	54	10.9%	36.6%	
46 SS	437	86	17.5%	54.1%	
62 SS	308	71	14.4%	68.5%	
94 SS	180	74	15.1%	83.6%	
165 SS	107	59	12.0%	95.6%	
Pan	0	22	4.4%	100.0%	
		490	100.0%		
Initial sample was 500 grams, therefore recovery is 98%					

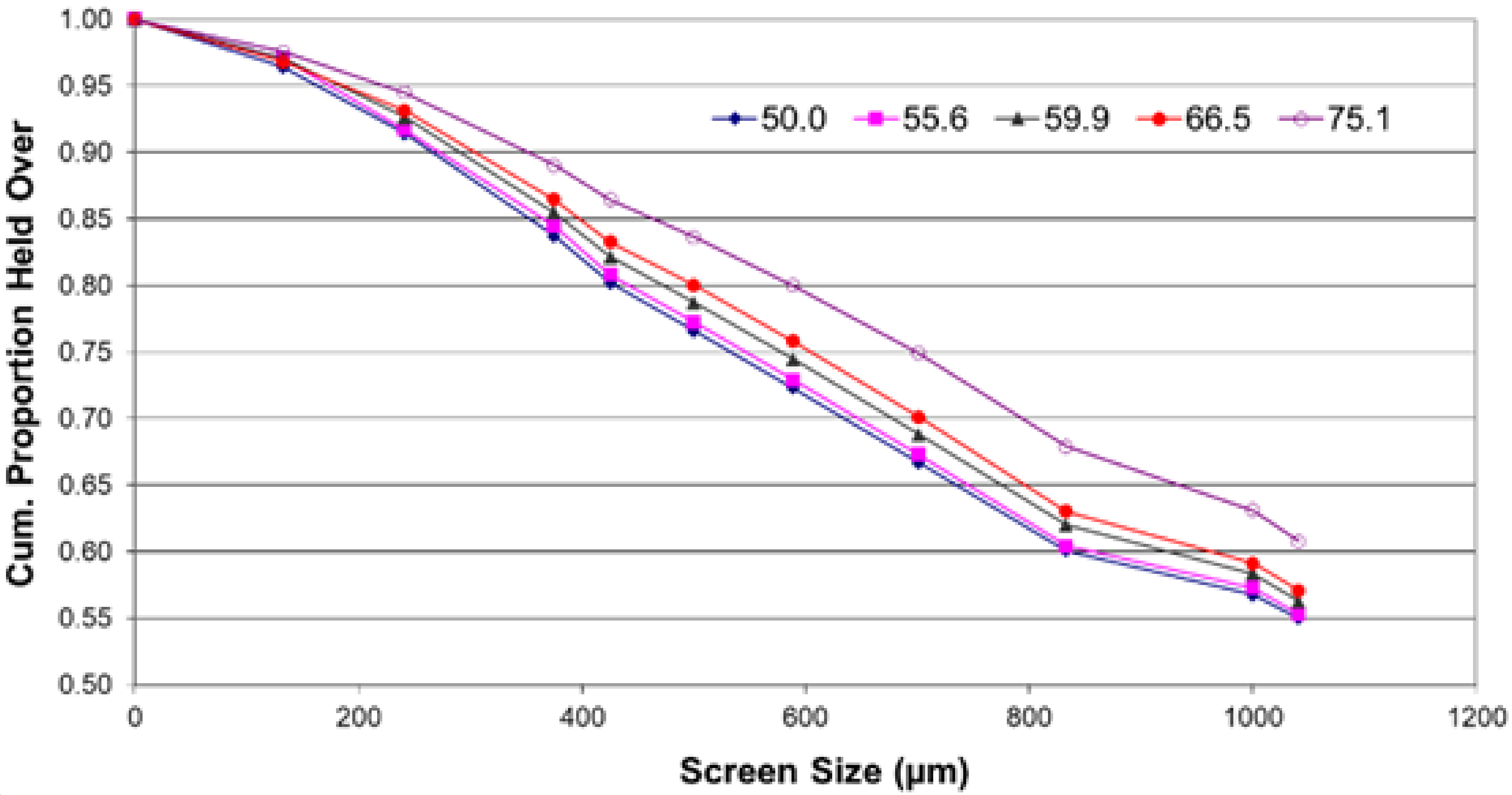

Break Granulation
% Held Over
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
0
200
400
600
800
1000
Screen Size (µ)

First Break Granulation Curves
(Ten Replications)

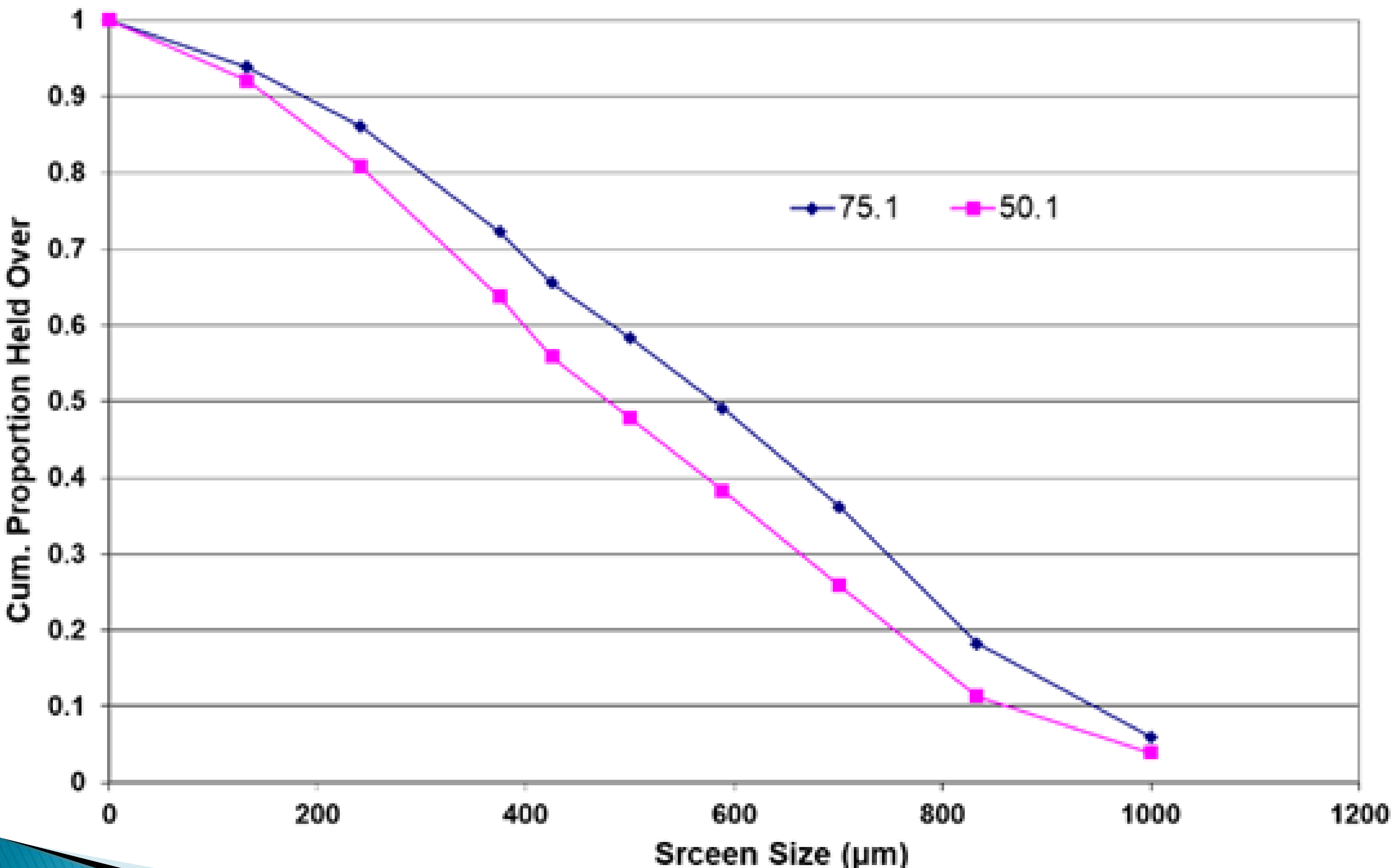



First Break Granulation Influenced by Roll Gap Setting
0.04"
0.03"
0.025"
0.02"
0.015"
0.01"
Cumulative Proportion
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
µm
1041

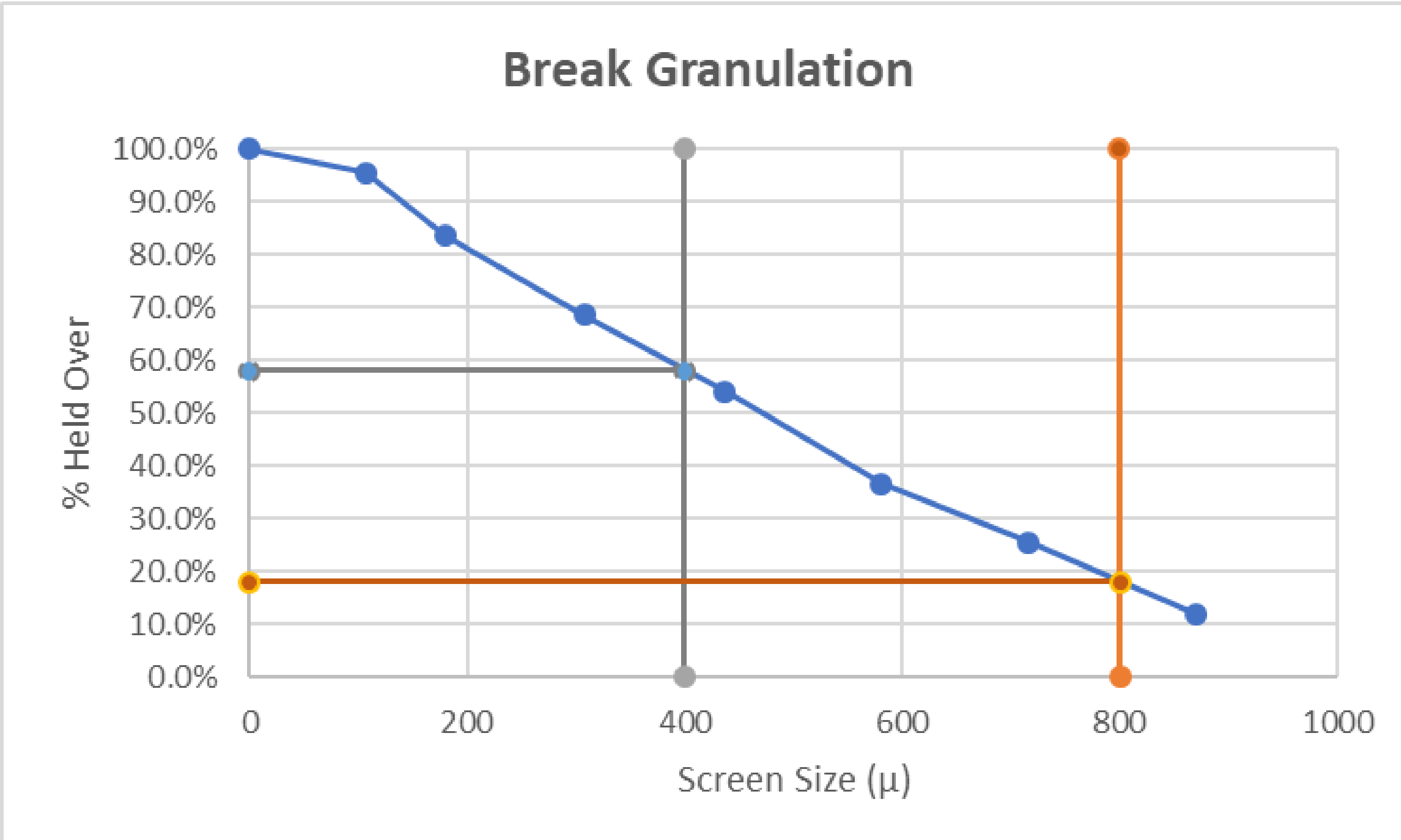
Influence of Average Kernel Hardness on First Break Granulation



Influence of Average Kernel Hardness on Sizings Granulation



Graphical Interpolation



Mathematical Interpolation

- Pick your origin or reference
- Determine slope
- Calculate change to alternative screen
- Follow the line

Milling Loss Calculations

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Measure	Consider Using to Separate Moisture Gain/Loss From Dry Matter Gain/Loss	Scales/Count	Raw Wheat Inventory		Cleaning Operations	Tempering Operations	Milling Operations	Four Packaging	Feed Packaging	Warehouse
		Invoice-Load Out	Invoice Vs. Unloading Variance							
Moisture	Dry Matter	Unloading		Inventory Variance						
Moisture	Dry Matter	Raw Wheat			Cleaning Losses	Cleaning and Tempering System Material Balance				
Moisture	Dry Matter	Screening								
Moisture	Dry Matter	Clean Dry Wheat								
Moisture	Dry Matter	Tempered Wheat					Milling Yield Balance and Losses			
Moisture	Dry Matter	Feed							Feed Transfer Loss/Gain & Overpack	
Moisture	Dry Matter	Flour						Flour Transfer Loss/Gain & Overpack		
Moisture	Dry Matter	Packaging								
Check Weights										Order-Billing Damage Trash Damage to Feed Reclaim Variance
		Warehousing								

	SCALE MONITORING	2-May-19	3-May-19	4-May-19	5-May-19	6-May-19	7-May-19	8-May-19	
48	Intake records (Mill)	368.823	204.736	219.767	208.456	-	219.356	239.826	512
49									
50									
51	Plan Milling(Hrs)	15.020	21.750	15.440	15.670	6.620	6.840	24.000	[illegible]
52	Actual Milled(Hrs)	14.680	20.400	14.440	15.390	6.610	6.600	22.480	[illegible]
53	1BK wheat (MT)	228.160	318.258	215.265	231.981	102.676	104.753	358.754	[illegible]
56	Flour (MT)	174.373	241.458	162.571	175.992	78.014	78.047	269.236	[illegible]
57	By-product(MT)	47.102	64.305	44.890	48.047	21.781	21.946	76.859	[illegible]
58	Total Product(FL+Byproduct)	221.48	305.76	207.46	224.04	99.80	99.99	346.10	[illegible]
59	Total product percentage	97.07	96.07	96.37	96.58	97.19	95.46	96.47	[illegible]
60	Total Break Down	0.34	1.35	1.00	0.28	0.01	0.24	1.52	[illegible]
72	Speed	15.54	15.60	14.91	15.07	15.53	15.87	15.96	[illegible]

MILL A | MILL B | INTAKE RECORDS | POLLARD MILL B | Flour in Pollard Mill A

Ready

	1	2	3	4	5	6	7	
Plan hrs	15.02	21.75	15.44	15.67	6.62	6.84	24	
Actual hrs	14.68	20.4	14.44	15.39	6.61	6.6	22.48	
1BK MT	228.16	318.258	215.265	231.981	102.676	104.753	358.754	
Fl MT	174.373	241.458	162.571	175.992	78.014	78.047	269.236	
Fd MT	47.102	64.304	44.89	48.047	21.781	21.946	76.859	
Total Product MT	221.475	305.762	207.461	224.039	99.795	99.993	346.095	**Avg.**
TP %	97.07%	96.07%	96.37%	96.58%	97.19%	95.46%	96.47%	96.5%
Break Down hrs	0.34	1.35	1	0.28	0.01	0.24	1.52	**Avg.**
Speed	15.54	15.60	14.91	15.07	15.53	15.87	15.96	15.50
JAG Actual Hours	14.68	20.4	14.44	15.39	6.61	6.6	22.48	**Avg.**
JAG Speed MT/hr	15.54	15.60	14.91	15.07	15.53	15.87	15.96	15.50

	1	2	3	4	5	6	7	
DM Wheat	191.6544	267.3367	180.8226	194.864	86.24784	87.99252	301.3534	
DM Fl	149.612	207.171	139.4859	151.0011	66.93601	66.96433	231.0045	
DM FD	40.60192	55.43005	38.69518	41.41651	18.77522	18.91745	66.25246	
Total DM	190.214	262.601	178.1811	192.4177	85.71123	85.88178	297.2569	**Avg.**
Recovered DM	99.2%	98.2%	98.5%	98.7%	99.4%	97.6%	98.6%	15.50
DMLoss	0.75%	1.77%	1.46%	1.26%	0.62%	2.40%	1.36%	1.4%
DM MT Lost?	1.440	4.736	2.642	2.446	0.537	2.111	4.096	
Shake Down Time? Min	5.577	18.334	10.226	9.471	2.077	8.172	15.859	

	1	2	3	4	5	6	7	**Average**	
Wheat	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	B1 %	TP%
Flour	76.4%	75.9%	75.5%	75.9%	76.0%	74.5%	75.0%	75.6%	78.4%
Feed	20.6%	20.2%	20.9%	20.7%	21.2%	21.0%	21.4%	20.9%	21.6%
	97.1%	96.1%	96.4%	96.6%	97.2%	95.5%	96.5%	96.5%	100.0%
								Avg.	
Moisture Loss Calc	2.30%	2.44%	2.40%	2.37%	2.28%	2.53%	2.39%	2.4%	
Calc. Moist and DM Loss	3.05%	4.21%	3.86%	3.62%	2.91%	4.93%	3.75%		
Calculated	96.95%	95.79%	96.14%	96.38%	97.09%	95.07%	96.25%		
Overall Reported	97.07%	96.07%	96.37%	96.58%	97.19%	95.46%	96.47%		
Difference	0.12%	0.28%	0.23%	0.20%	0.10%	0.38%	0.22%		

Product	MT	Moisture
1BK Wheat	228.16	16.0%
Flour	174.373	14.2%
Feed	47.102	13.8%

Water Mass Calculation

Formula	Water (MT)
Weight X Moisture %	36.51
Weight X Moisture %	24.76
Weight X Moisture %	6.50
Example	228.16 X .16=36.51

Dry Matter Mass Calculation

Formula	Dry Mater (MT)
Product Weight-Water Weight	191.65
Product Weight-Water Weight	149.61
Product Weight-Water Weight	40.60
Example	228.16-36.51=191.65

Total Mass Loss

Formula	Total (MT)
Weight Out-Weight In	-6.69
Example (174.373+47.102)-228.16=-6.69	

Water Mass Loss

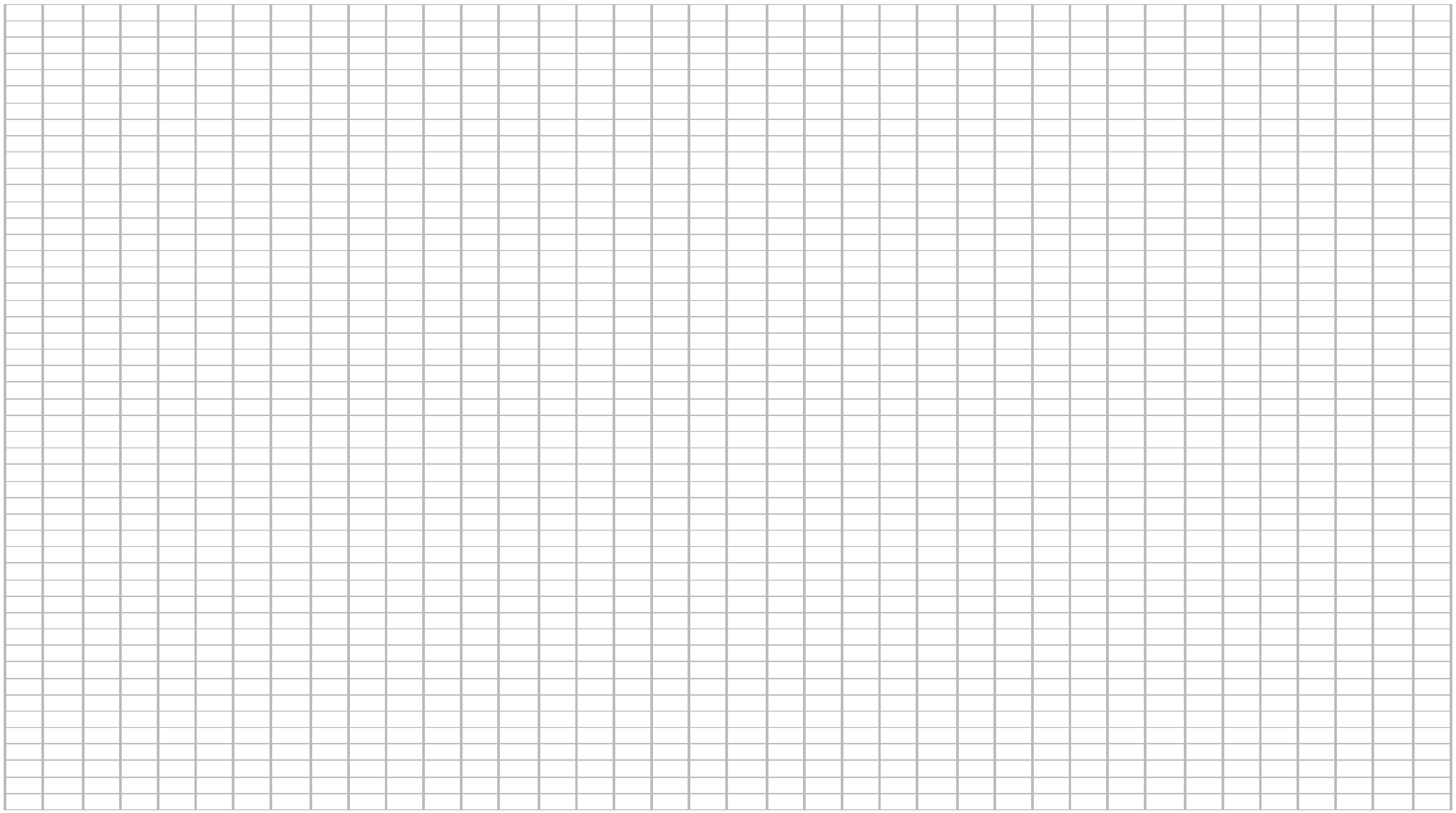
Formula	Water (MT)
Water In-Water Out	5.24
Example	36.51-24.76-6.50=5.24

Dry Matter Mass Loss

Formula	Dry Mater (MT)
Dry Matter In-Dry Matter Out	1.44
Example	191.65 - 149.61-40.6=1.44

% Moisture Loss	(%)
% of B1	2.30%
Example (5.24/228.16)*100=2.30	

% Dry Matter Loss	(%)
% of B1	0.63%
Example (5.24/228.16)*100=2.30	



Laboratory Milling: Challenges in Wheat Crop Evaluation

Pre-Conference Workshop
October 5, 2019

10th Annual Southeast Asia Region Conference & Expo
Intercontinental Jakarta Pondok Indah Hotel
Jakarta, Indonesia

Laboratory Milling Provides Opportunity To….

- Evaluate milling properties and characteristics of grain
- Produce material for further testing
- Predict large scale performance

Evaluation Set-Up

- Sample selection
- Sampling
- Grain tests
- Grain preparation
- Prepare mill

Experimental Mills

- Brabender Quadrumat Jr.
- Brabender Quadrumat Sr.
- Chopin Laboratory Mill
- Buhler Experimental MLU 202
- Ross or Allis Experimental Mill
- Miag Multomat Experimental Mill
- Pilot Mills
- Commercial Mill

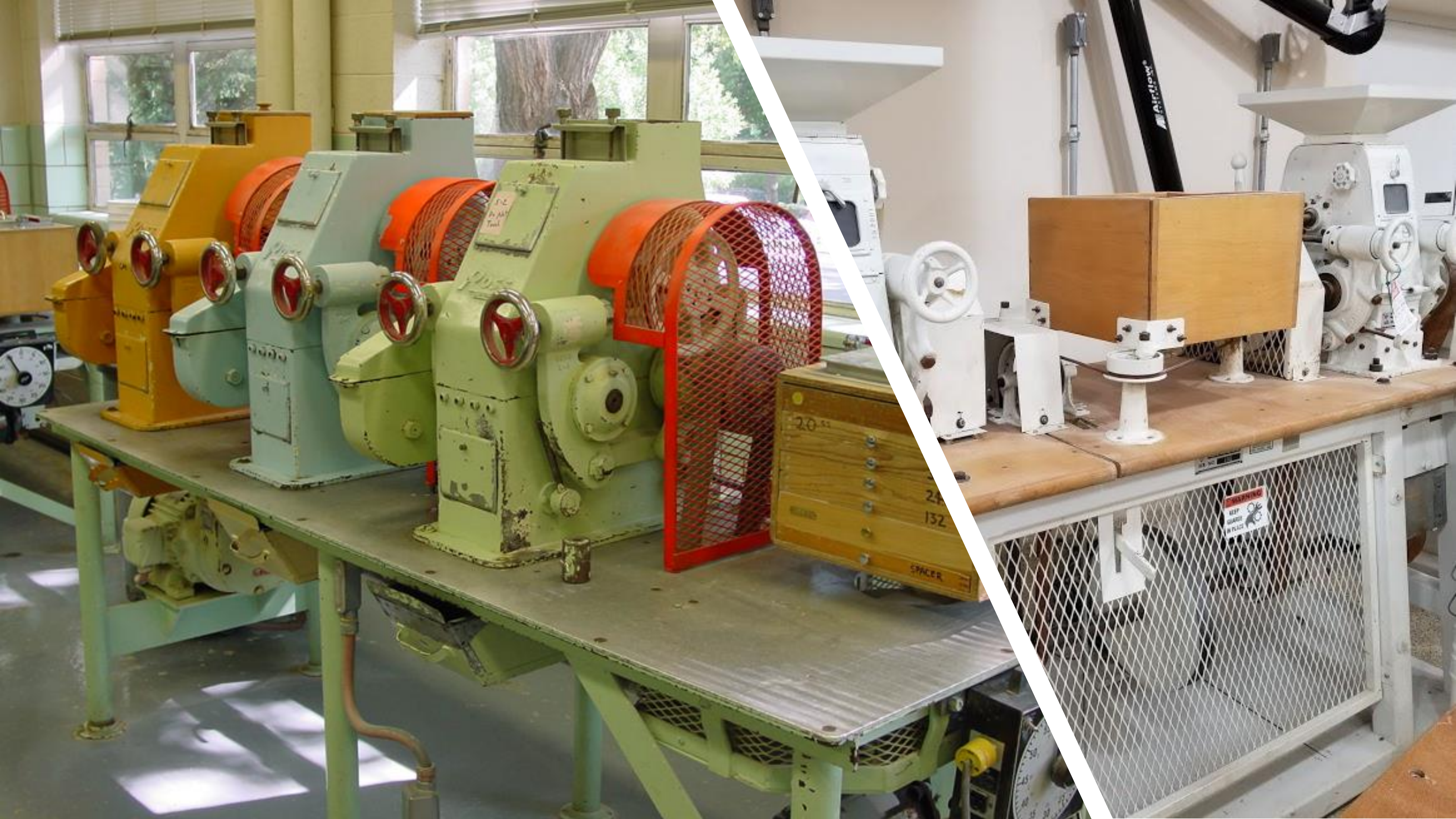
AACC International Approved Methods- Section 26 Experimental Milling

26-10.02 Experimental Milling: Introduction, Equipment, Sample Preparation, and Tempering
26-21.02 Experimental Milling—Bühler Method for Hard Wheat
26-22.01 Experimental Milling—Batch Method for Hard Wheat
26-30.02 Experimental Milling—Bühler Method for Soft Wheat Short-Extraction Flour
26-31.01 Experimental Milling—Bühler Method for Soft Wheat Straight-Grade Flour
26-32.01 Experimental Milling—Batch Method for Soft Wheat
26-41.01 Experimental Milling—Bühler Method for Durum Wheat
26-42.01 Experimental Milling—Batch Method for Durum Wheat
26-50.01 Brabender Quadrumat Jr. (Quadruplex) Method
26-70.01 Chopin CD1 Laboratory Mill Method
26-95.01 Experimental Milling: Temper Table


Junior
Senior


CHOPIN


BÜHLER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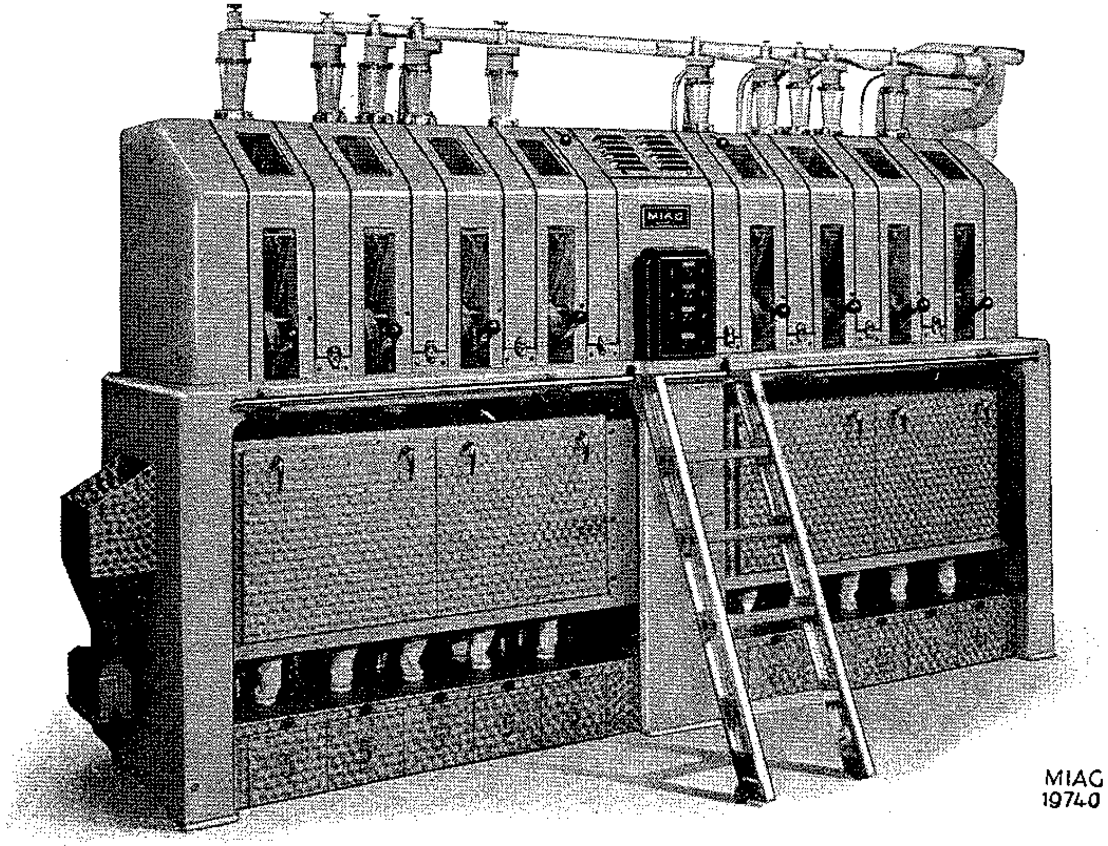
132
WARNING
KEEP GUARDS IN PLACE



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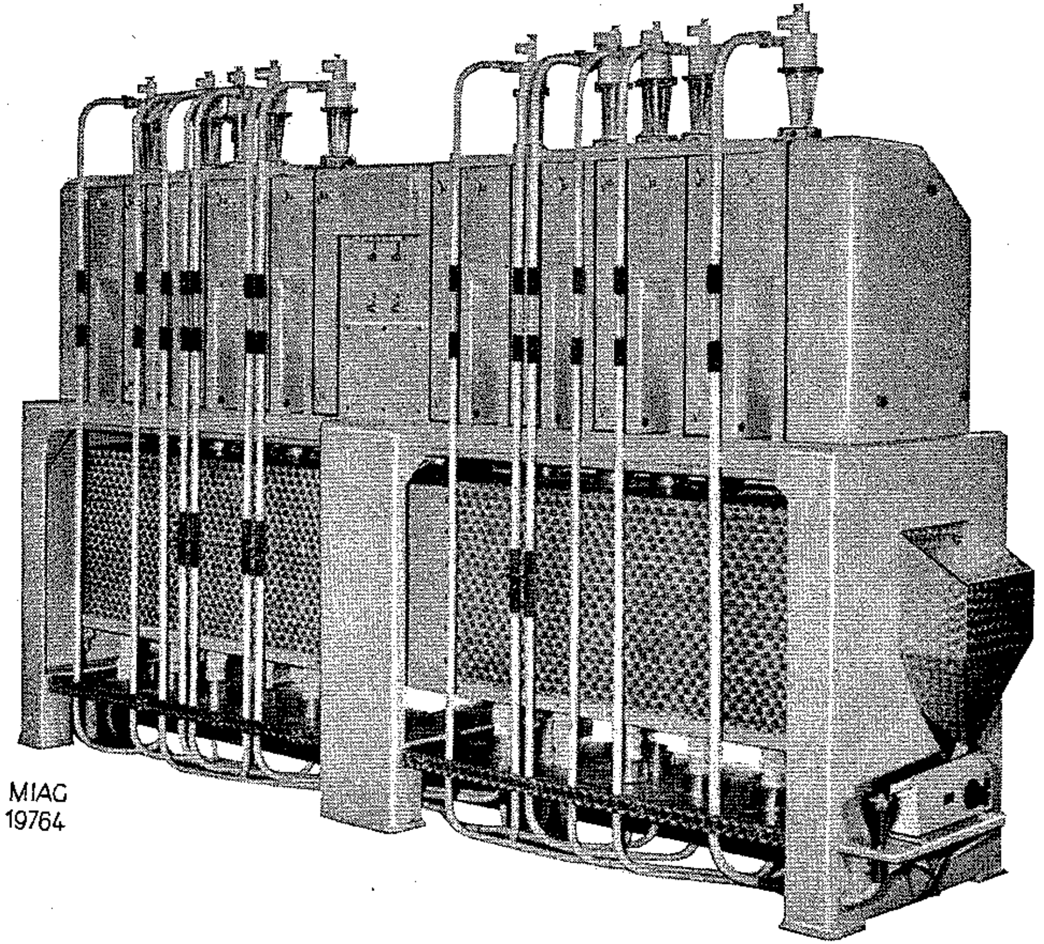

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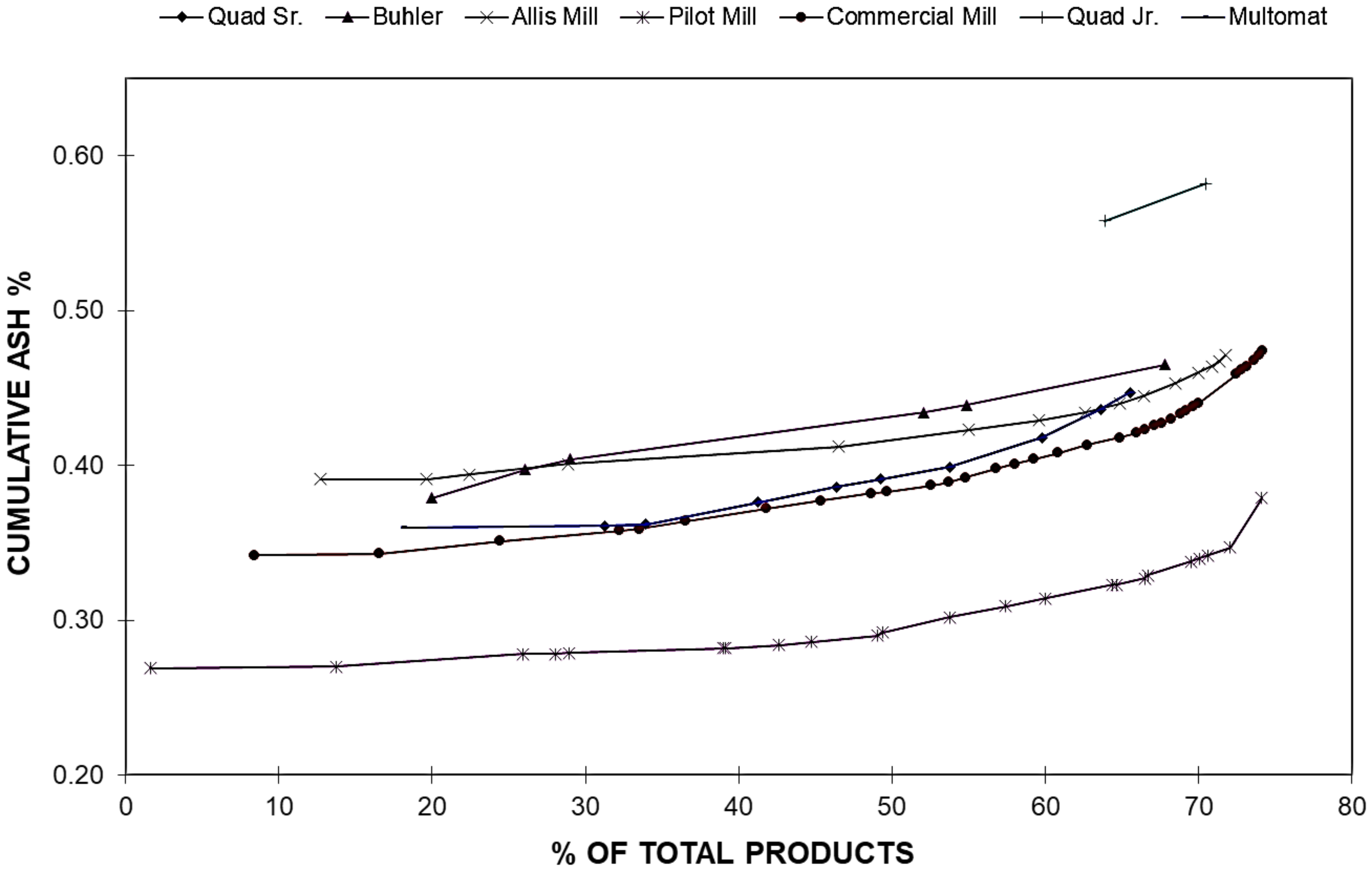
Cumulative Ash Curves For Experimental Mills



Dinesh Mehrotra, 1963. Predicting Commercial Milling Results by Experimental Means, Master’s Thesis, Kansas State University

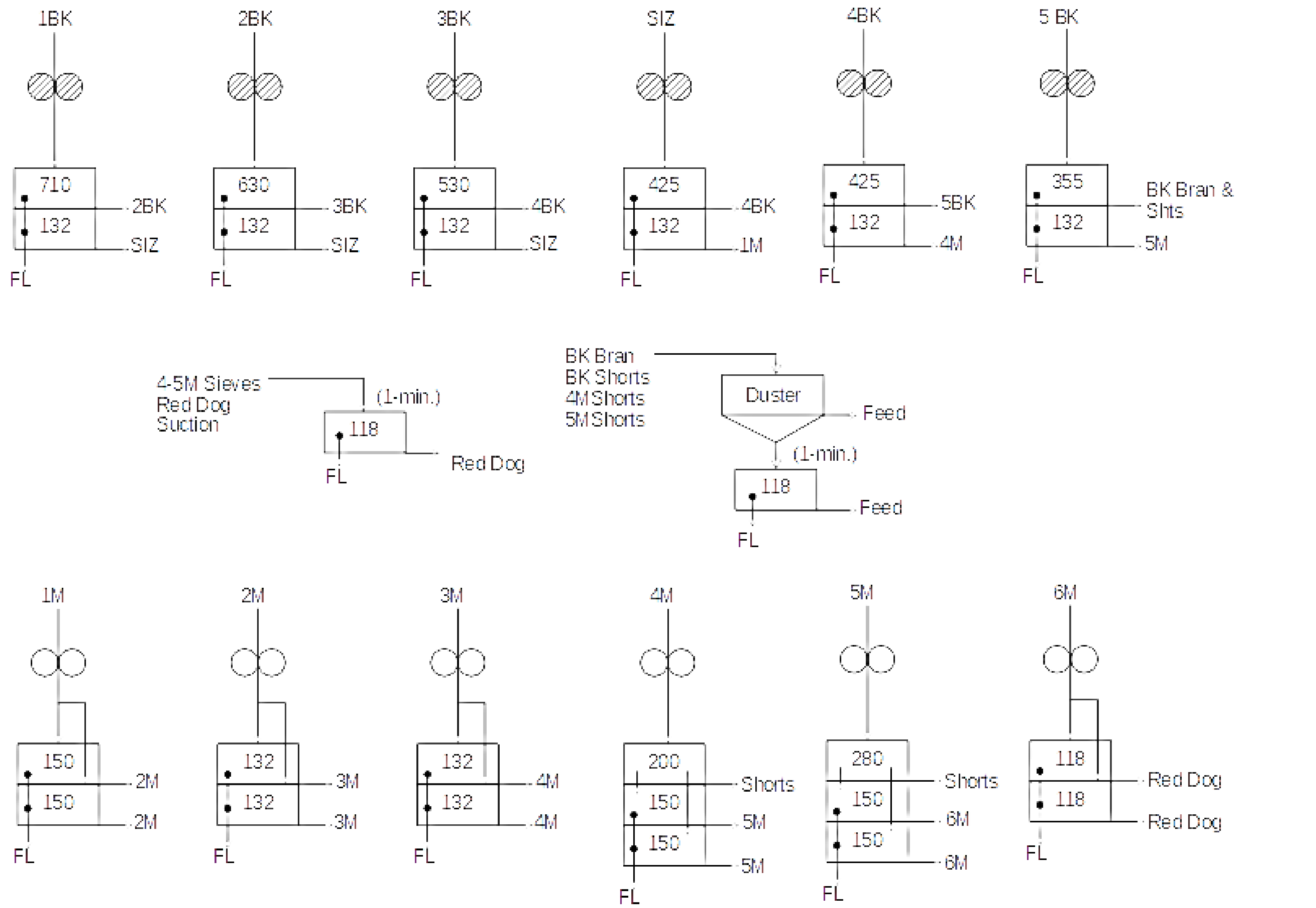
Laboratory Mill Grinding and Sifting Operations

	Flours				
	Break	Reduction	Feed	Adjust	Adjustment Mode
Quad. Jr.	1	1 or 2	1	No	Manual non-operating
Quad. Sr.	1	1	1	No	Manual non-operating
Chopin	1	1	2	No	Pre-set
Bühler	3	3	2	Yes	Linked 3 Operations (L and R)
Ross/Allis	5	8	4	Yes	Independent (L and R)
Miag	3	5	4 or 5	Yes	Independent (In/out)
Bühler Tandem	5	7	5	Yes	Linked 3 Operations (L and R)

Laboratory Vs. Commercial Mill

- Yields (65-71%) and Commercial Mill Yields (74-78%)
- Coarse and fine systems
- Gradual corrugation selection for breaks
- Impact Grinding
- Purifiers
- Bran and Shorts Dusters
- Enclosed system

Tandem Mill- Bühler



Martin, D.G., and Dexter, J.E. 1991. A Tandem Buhler Laboratory Mill: Its Development and Versatility. AOM Bull. April: 5855-5864.

USDA/ARS
Tandem Mill
August 20, 2018
JAG

2018 Results

Control Sample Milling	Flour T. P. %	Recovery %	Fl. Wheat %
Average	76.5	97.5	74.5
Std. Dev.	0.6	1.0	0.5
Max.	78.0	99.5	75.3
Min.	75.7	95.5	73.6
Range	2.3	4.0	1.7
CV%	0.84%	1.03%	0.70%

Survey Sample Milling	Flour T. P. %	Recovery %	Fl. Wheat %
Avg	75.2	96.5	72.6
Std. Dev.	1.1	1.5	1.2
Max.	78.5	100.8	76.5
Min.	73.4	93.0	69.9
Range	5.1	7.8	6.6
CV %	1.5%	1.5%	1.7%

2018 Control vs. Survey

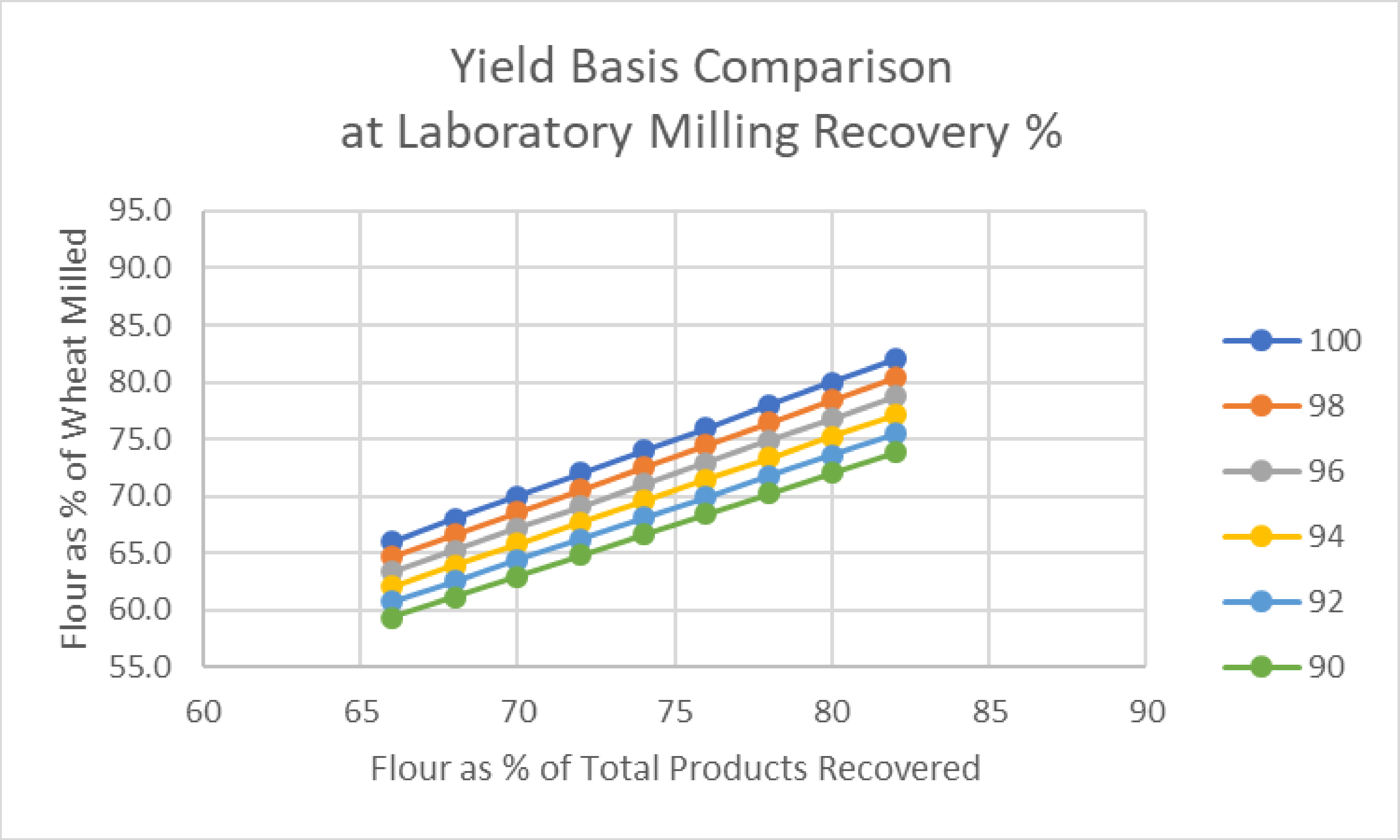
	Control N=22					Survey N=89				
	Average	Std. Dev.	Min.	Max.	Range	Average	Std. Dev.	Min.	Max.	Range
1BK	3.07%	0.37%	2.21%	4.01%	1.80%	1.99%	0.43%	1.06%	3.12%	2.06%
2BK	3.23%	1.13%	1.87%	5.55%	3.68%	2.61%	0.99%	0.68%	5.21%	4.53%
3BK	1.67%	0.42%	1.03%	2.34%	1.31%	1.40%	0.34%	0.67%	2.14%	1.48%
SIZ	19.03%	2.06%	15.61%	23.34%	7.73%	15.03%	2.37%	11.46%	19.92%	8.47%
4BK	1.58%	1.13%	0.85%	6.41%	5.56%	1.21%	0.89%	0.68%	7.43%	6.74%
5BK	0.84%	0.17%	0.65%	1.40%	0.76%	0.72%	0.12%	0.44%	1.22%	0.78%
1M	29.43%	2.71%	24.79%	32.63%	7.84%	27.55%	2.33%	19.71%	32.52%	12.81%
2M	8.21%	0.82%	6.50%	10.23%	3.73%	10.39%	1.19%	7.45%	13.76%	6.30%
3M	3.53%	0.51%	2.56%	4.76%	2.20%	4.93%	1.03%	2.14%	7.71%	5.56%
4M	4.91%	1.83%	1.10%	7.26%	6.16%	5.88%	1.89%	1.04%	10.33%	9.28%
5M	1.32%	0.37%	0.73%	2.02%	1.29%	1.71%	0.49%	0.53%	2.61%	2.08%
6M	1.78%	0.51%	0.49%	2.79%	2.30%	1.91%	0.53%	0.25%	3.53%	3.28%
Bran & BK SHT (BBS)	14.70%	1.08%	12.89%	16.85%	3.96%	15.93%	1.10%	13.86%	18.69%	4.83%
Red Dog	0.93%	0.50%	0.40%	2.52%	2.12%	0.88%	0.31%	0.37%	2.56%	2.19%
4MS (4M SHTS)	1.33%	0.50%	0.54%	2.41%	1.87%	1.81%	0.49%	0.37%	3.03%	2.66%
5MS (5M SHTS)	1.04%	0.47%	0.52%	2.67%	2.15%	1.32%	0.45%	0.17%	2.55%	2.38%

Reporting Basis Comparison

	% of Total Products								
% Recovery	82	80	78	76	74	72	70	68	66
100	82.0	80.0	78.0	76.0	74.0	72.0	70.0	68.0	66.0
98	80.4	78.4	76.4	74.5	72.5	70.6	68.6	66.6	64.7
96	78.7	76.8	74.9	73.0	71.0	69.1	67.2	65.3	63.4
94	77.1	75.2	73.3	71.4	69.6	67.7	65.8	63.9	62.0
92	75.4	73.6	71.8	69.9	68.1	66.2	64.4	62.6	60.7
90	73.8	72.0	70.2	68.4	66.6	64.8	63.0	61.2	59.4
Range	8.2	8.0	7.8	7.6	7.4	7.2	7.0	6.8	6.6

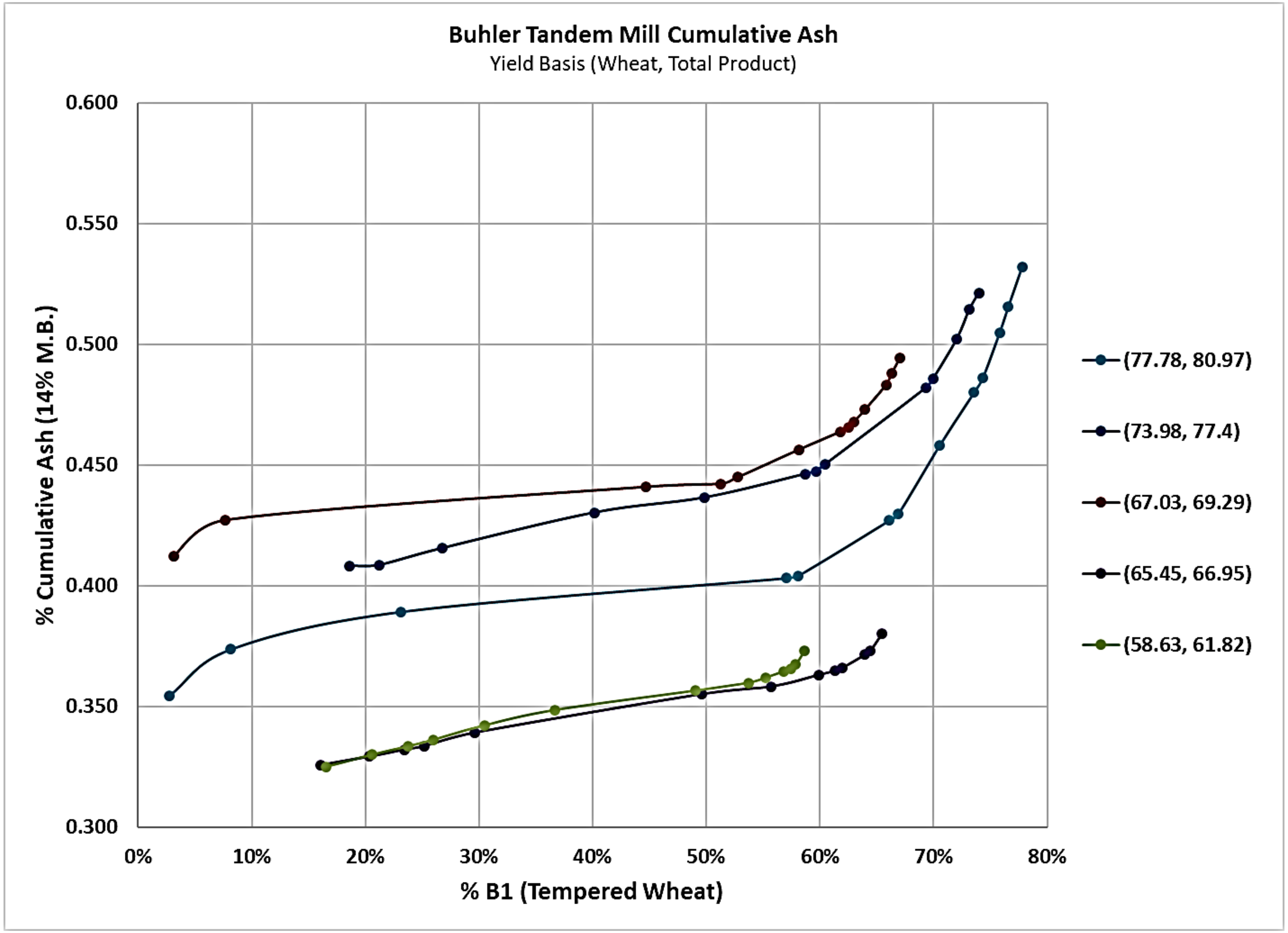
Covert Flour Yield % Basis Total Products to Flour Yield % Basis Wheat

	Input		**Output**
Flour as % Total Products	78	Flour as % Wheat	74.9
Lab Milling Recovery %	96		


Yield Basis Comparison
at Laboratory Milling Recovery %
Flour as % of Wheat Milled
95.0
90.0
85.0
80.0
75.0
70.0
65.0
60.0
55.0
60
65
70
75
80
85
90
Flour as % of Total Products Recovered
100
98
96
94
92
90

Yield Study

Wheat Data	Unit and Basis		Everest	1863
Moisture	% as-is		10.44	10.57
Ash	(%) 14% moisture basis		1.719	1.308
Protein	(%) 14% moisture basis		12.07	10.70
Single Kernel Data	Hardness Index	Average	66.49	49.34
		St. Dev.	18.24	16.91
	Moisture (%)	Average	9.39	9.78
		St. Dev.	0.88	0.60
	Weight (mg)	Average	33.26	28.69
		St. Dev.	8.12	6.21
	Size (mm)	Average	2.73	2.57
		St. Dev.	0.30	0.27
	Classification		Hard	Mixed



Buhler Tandem Mill Cumulative Ash
Yield Basis (Wheat, Total Product)
0.600
0.550
0.500
0.450
0.400
0.350
0.300
% Cumulative Ash (14% M.B.)
0%
10%
20%
30%
40%
50%
60%
70%
80%
% B1 (Tempered Wheat)
(77.78, 80.97)
(73.98, 77.4)
(67.03, 69.29)
(65.45, 66.95)
(58.63, 61.82)

Yield Profile Changes

Milling Data	Unit and Basis	Target Flour Extraction % 80	75	70	65	60
Flour Yield	(%) basis wheat milled	78.1%	74.0%	67.0%	65.5%	58.6%
Recovered Products	(%) basis wheat milled	96.4%	95.6%	96.7%	97.8%	96.4%
Flour Yield	(%) total products recovered	81.1%	77.4%	69.3%	67.0%	60.8%

Yield Profile Changes

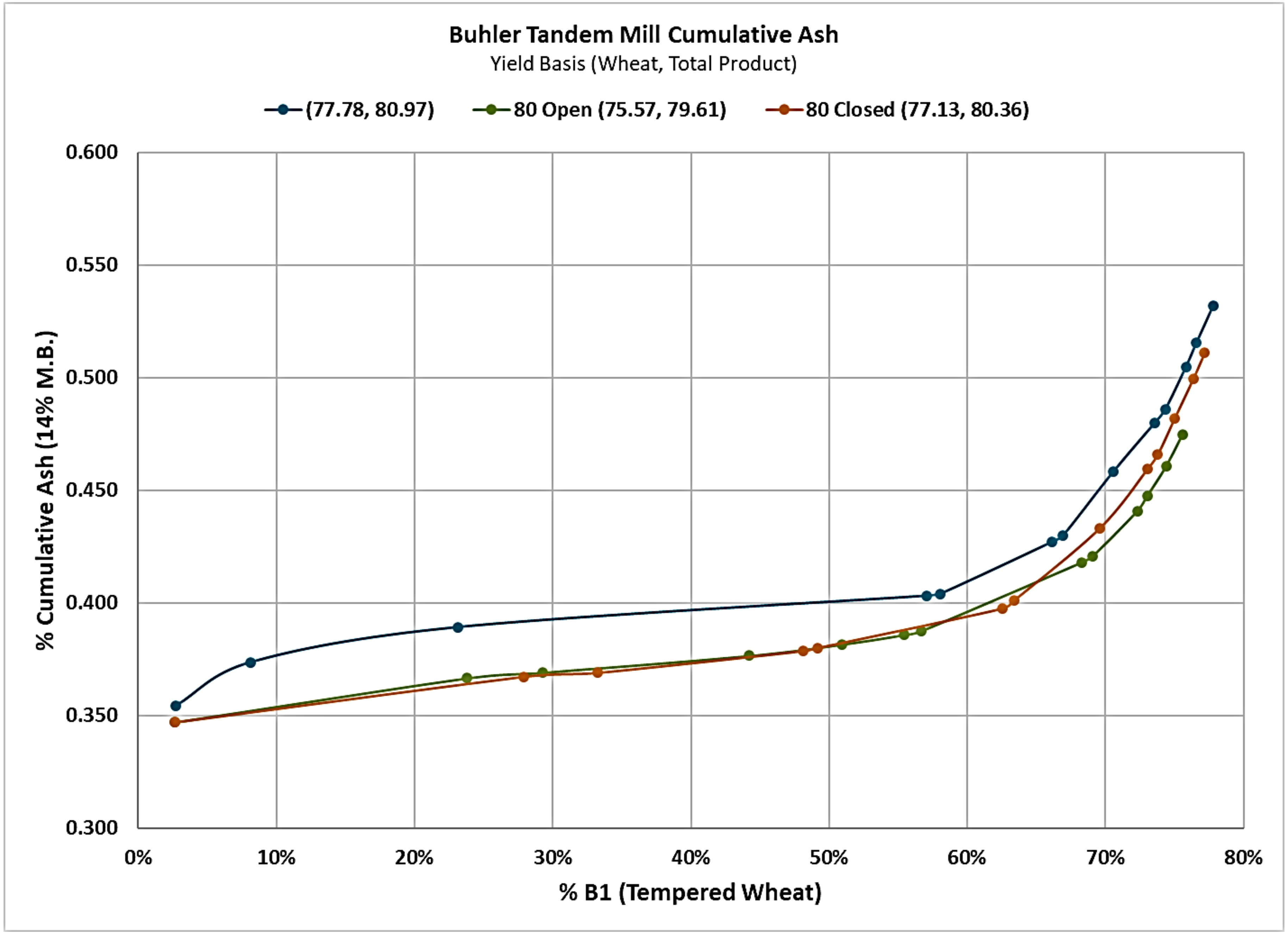
Flour Data	Unit and Basis	Target Flour Extraction % 80	75	70	65	60
NIR-Mill	Moisture (%) as-is	14.13	14.06	13.81	13.86	13.95
	Ash (%) 14% moisture basis	0.530	0.458	0.412	0.377	0.371
	Protein (%) 14% moisture basis	10.56	10.35	9.84	9.82	9.79
Thermogravimetric Analyzer (TGA)	Moisture (%) as-is	13.74	13.72	13.44	13.50	13.59
	Ash 14 % moisture basis	0.657	0.576	0.518	0.448	0.437
	Protein (%) 14% moisture basis	10.45	10.19	9.70	9.56	9.50
NIR-Lab	Moisture (%) as-is	13.97	14.01	13.73	13.78	13.85
	Ash (%) 14 % moisture basis	0.541	0.459	0.425	0.387	0.379
	Protein (%) 14% moisture basis	10.49	10.26	9.79	9.78	9.73
Ash (Furnace)	Ash (%) 14% moisture basis	0.609	0.466	0.416	0.387	0.379
Starch Damage	Iodine Absorption (%)	96.62	95.24	96.31	95.31	93.58
SD Matic	AACC76-31 (%)	6.77	5.70	6.51	5.75	4.55
	Farrand Units	48.1	34.5	44.8	35.3	21.8

Yield Profile Changes

Dough Data	Unit and Basis	Target Flour Extraction % 80	75	70	65	60
Mixograph	Mix Absorption (%) as-is)	61.1	60.5	60.0	60.0	59.8
	Flour Absorption (%) as-is	61.1	60.5	59.7	59.7	59.7
	Mix Time (min)	4.0	4.1	4.2	4.2	4.3
	Mix Tolerance (min)	2.0	2.0	2.7	1.7	1.0
Alveograph	P (mm) tenacity	89.7	73.7	94.3	76.3	71.7
	L (mm) extensibility	73.3	85.3	71.7	75.3	77.3
	G (mm) swelling index	19.1	20.6	18.8	19.3	19.6
	W (10^{-4}J) baking strength	222.7	219.3	242.7	206.3	198.7
	P/L (ratio) configuration ratio	1.2	0.9	1.3	1.0	0.9
	Ie (%) elasticity index	51.9	57.3	55.4	55.9	56.4
Farinograph	Absorption (%) as-is	58.7	56.6	58.7	56.2	55.3
	Absorption (%) 14% moisture basis	58.7	56.6	58.4	56.0	55.1
	Development (min)	5.6	6.0	5.0	5.7	6.6
	Stability (min)	9.5	10.5	12.6	11.2	12.4
	Tolerance Index	31.0	29.0	11.0	23.7	26.3
	Breakdown (min)	10.6	11.2	13.5	11.6	12.6
	Quality Number	106.7	111.7	135.0	116.3	126.3

Yield Profile Changes

Baking Data	Unit and Basis	Target Flour Extraction % 80	75	70	65	60
Test Bake	Flour Absorption (%) as-is	62.0	60.7	62.0	60.9	60.2
	Flour Absorption (%) 14 % moisture basis	62.0	60.7	61.7	60.6	60.0
	Bake Mixing Tolerance Index	4.2	4.5	4.7	4.4	4.5
	Crumb Score	2.8	3.2	3.5	3.2	3.2
	Loaf Volume (cc)	895.0	858.3	845.0	861.7	871.7
	Dough Weight (gms)	171.7	170.3	171.6	170.2	170.5
	Proof Height (cm)	7.2	7.2	7.2	7.0	6.9
	Loaf Weight (gms)	150.5	147.6	150.2	148.9	149.4
	Color	Dark Yellow	Yellow	Slight Yellow	Yellow	Yellow



Buhler Tandem Mill Cumulative Ash
Yield Basis (Wheat, Total Product)
(77.78, 80.97)
80 Open (75.57, 79.61)
80 Closed (77.13, 80.36)
% Cumulative Ash (14% M.B.)
0.600
0.550
0.500
0.450
0.400
0.350
0.300
0%
10%
20%
30%
40%
50%
60%
70%
80%
% B1 (Tempered Wheat)

Primary Reduction Changes

		Target Flour Extraction %		
Milling Data	**Unit and Basis**	**Open**	**Closed**	**Std.**
Flour Yield	(%) basis wheat milled	75.57%	77.18%	77.78%
Recovered Products	(%) basis wheat milled	94.93%	96.05%	96.05%
Flour Yield	(%) total products recovered	79.61%	80.36%	80.97%

Primary Reduction Changes

Flour Data	Unit and Basis	Grinding Method		
		Open	Closed	Standard
NIR-Mill	Moisture (%) as-is	13.89	14.13	13.97
	Ash (%) 14% moisture basis	0.497	0.526	0.541
	Protein (%) 14% moisture basis	10.54	10.52	10.49
Thermogravimetric Analyzer (TGA)	Moisture (%) as-is	13.69	13.92	13.74
	Ash 14 % moisture basis	0.585	0.633	0.657
	Protein (%) 14% moisture basis	10.25	10.36	10.45
NIR-Lab	Moisture (%) as-is	13.89	14.13	13.97
	Ash (%) 14 % moisture basis	0.497	0.526	0.541
	Protein (%) 14% moisture basis	10.54	10.52	10.49
Ash (Furnace)	Ash (%) 14% moisture basis	0.523	0.580	0.610
Starch Damage SD Matic	Iodine Absorption (%)	95.74	96.12	96.62
	AACC76-31 (%)	6.08	6.36	6.77
	Farrand Units	39.24	42.87	48.11

Primary Reduction Changes

Dough Data	Unit and Basis	Grinding Method Open	Closed	Standard
Mixograph	Mix Absorption (%) as-is)	61.1	60.8	61.1
	Flour Absorption (%) as-is	61.0	61.0	61.1
	Mix Time (min)	4.0	4.1	4.0
	Mix Tolerance (min)	1.0	1.0	2.0
Alveograph	P (mm) tenacity	79.0	85.0	89.7
	L (mm) extensibility	85.0	76.0	73.3
	G (mm) swelling index	20.5	19.4	19.1
	W (10^{-4}J) baking strength	229.0	223.0	222.7
	P/L (ratio) configuration ratio	0.9	1.1	1.2
	Ie (%) elasticity index	56.0	53.8	51.9
Farinograph	Absorption (%) as-is	61.0	58.5	58.7
	Absorption (%) 14% moisture basi	60.9	58.6	58.7
	Development (min)	7.5	5.2	5.6
	Stability (min)	10.6	9.5	9.5
	Tolerance Index	36.0	28.0	31.0
	Breakdown (min)	11.8	10.6	10.6
	Quality Number	118.0	106.3	105.7

Primary Reduction Changes

		Grinding Method		
Baking Data	**Unit and Basis**	**Open**	**Closed**	**Standard**
Test Bake	Flour Absorption (%) as-is	62.7	62.4	62.0
	Flour Absorption (%) 14 % moistur	62.6	62.5	62.0
	Bake Mixing Tolerance Index	4.5	4.3	4.2
	Crumb Score	3.0	2.8	2.8
	Loaf Volume (cc)	910.0	878.3	895.0
	Dough Weight (gms)	172.8	172.4	171.7
	Proof Height (cm)	7.4	7.2	7.2
	Loaf Weight (gms)	152.4	151.6	150.5
	Color	Yellow	Dark Yellow	Dark Yellow

Acknowledgements

- Plains Grain Incorporated-Mark Hodges-Executive Director
- USDA/ARS/CGAHR-Grain Quality & Structural Research Unit-Dr. Brad Seabourn-Supervisory Research Food Technologist

- Kansas Wheat Commission-Justin Gilpin-CEO