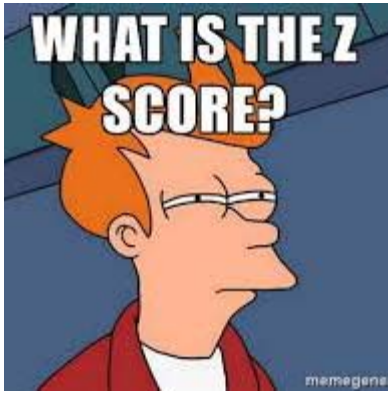
Using Magruder Data

More Than Just a Report Card!

- Z Scores, What You Can Do?
- Data Mining
- Z Control Charts (If there's time!)

magruder fertilizer
check sample program



Z Scores for the Magruder PT Program

Z is a Normalized measure of where you stand relative to the other participants in the scheme.

- Measured as the difference between your analysis (x_{LAB}) and the true analyte concentration (X_{AV}) described as:
  - **Assigned Value**
  - Robust Mean
  - True Value
  - Etc., etc., …
- And here's the twist; all divided by the robust SD (σ_{rob}) of the participants.
- The robust SD is the fit-for-purpose SD in our PT scheme.
- So, Z is essentially "how many ffp SDs are you away from the truth, as we know it?".

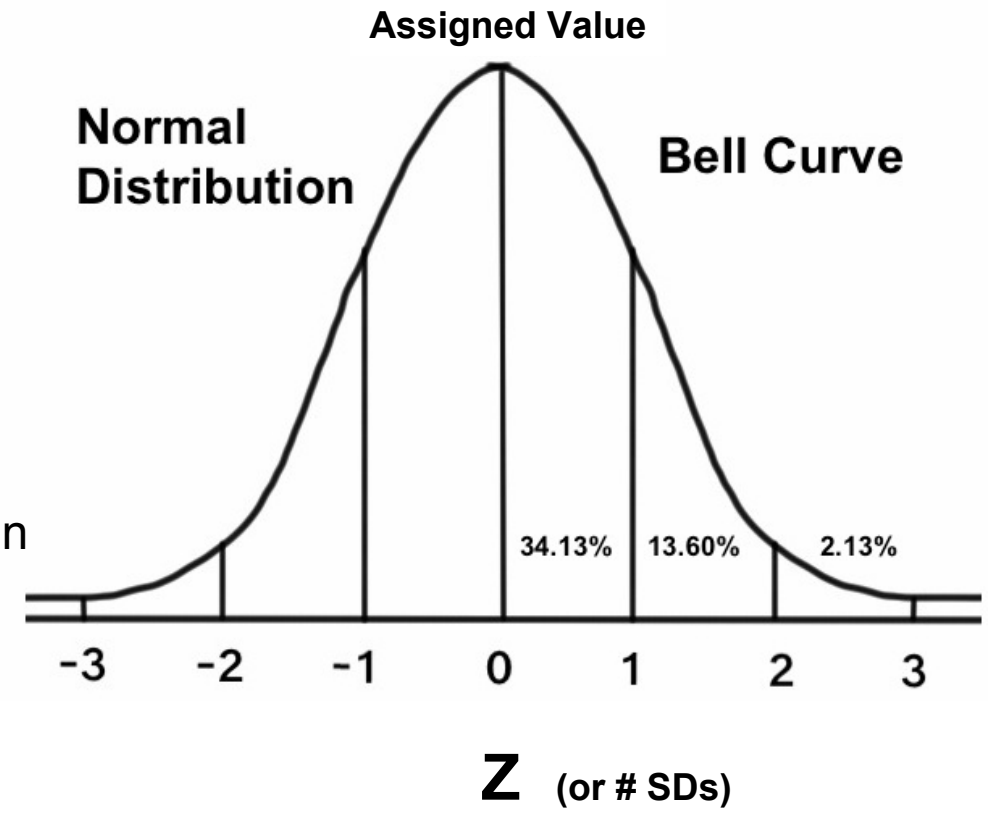
$$Z = \frac{x_{LAB} - X_{AV}}{\sigma_{rob}}$$

magruder fertilizer
check sample program

Z Scoring for Analytical Chemistry

We all remember the Bell Curve!

- The distribution of Analytical Chemistry results can be modeled with a Normal Bell Curve.
- How many SDs (or Zs) away from the Robust Mean is acceptable?
- As long as you are **within ± 3** SDs you pass or at least you "get away with it" – 99.7% capture!
- Beyond that you should try to start an investigation – some action is required – something is not quite right with the process!
- **Green is GOOD!**



magruder fertilizer
check sample program

Now, think about how much power σ has over your Z Score!

$$Z = \frac{x_{LAB} - X_{AV}}{\sigma}$$

If σ is equal to the robust SD (σ_{Rob}) ~ 95% Pass.

If σ is lower, Z is higher and many more fail!

If σ is higher, Z is lower and many more pass!

But, is the σ fit-for-your-purpose?

magruder fertilizer
check sample program

Fitness For Purpose (ffp) σ for Z Scores

- In the Magruder PT Program σ_{Rob} is the σ_{ffp}.
- However, you may have a client or a regulation or some other precision with which you must comply.
- In this case the Magruder σ_{ffp} may no longer be appropriate.
- Use an appropriate σ_{ffp} and adjust the equation to fit your need.

$$Z = \frac{x_{LAB} - X_{AV}}{\sigma_{ffp}}$$

magruder fertilizer
check sample program

Fitness For Purpose (ffp) σ for Z Scores

$$Z = \frac{x_{LAB} - X_{AV}}{\sigma_{ffp}}$$

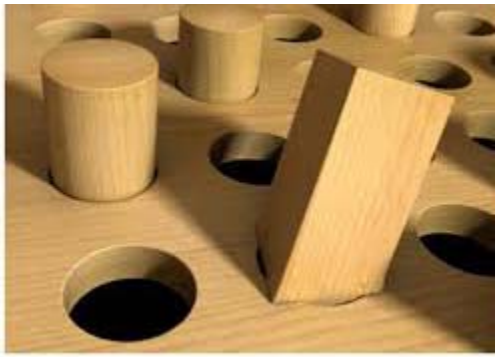
The %RSD (relative standard deviation) is a popular measure of precision.

$$\sigma_{ffp} = \frac{\%RSD}{100} \times X_{AV}$$

Example: For 3% RSD and X_{AV} = 15%

$$\sigma_{ffp} = \frac{3}{100} \times 15 = 0.45$$

magruder fertilizer
check sample program



Fitness For Purpose (ffp) σ for Z Scores

$$Z = \frac{x_{LAB} - X_{AV}}{\sigma_{ffp}}$$

The Horwitz %RSD is another popular measure of precision.

$$\sigma_{ffp} = \frac{2 \times C_{mf}^{-0.1505}}{100} \times X_{AV}$$

Where C_{mf} is the mass fraction concentration.

$$\text{Horwitz \%RSD} = 2 \times C_{mf}^{-0.1505}$$

Example: For X_{AV} = 15%: Mass fraction = 15 parts / 100 parts = 0.15

$$\sigma_{ffp} = \frac{2 \times 0.15_{mf}^{-0.1505}}{100} \times 15 = 1.33$$

magruder fertilizer
check sample program

Fitness For Purpose (ffp) σ for Z Scores

$$Z = \frac{x_{LAB} - X_{AV}}{\sigma_{ffp}}$$

Or, just a hard limit like no more than ±100 ppm.
A "designer" σ_{ffp} if you will!

$$\sigma_{ffp} = \frac{100}{3}$$

Example: $Sigma_{ffp}$ = 33.3: So within ± 3 Z captures 99.7% of values.

magruder fertilizer
check sample program

IA as a Fitness For Purpose Criteria

- Investigational Allowances (IA) can provide an industry standard ffp criteria.
- While this is not a Z Score, very simply:
  - ✓ Pass if: x_{LAB} is within $X_{AV} \pm IA_{AV}$ range.
  - ✓ Fail if: x_{LAB} is outside $X_{AV} \pm IA_{AV}$ range.
- This is now shown in reports and report cards as **IA Status**.

$$\textbf{IA Status} = \begin{cases} \textbf{Low} & \text{if } x_{LAB} < X_{AV} - IA_{AV} \\ \textbf{High} & \text{if } x_{LAB} > X_{AV} + IA_{AV} \\ \textbf{OK} & \text{Otherwise} \end{cases}$$

magruder fertilizer
check sample program

In Summary:

- Z Scores are an “Alert!” tool and are **NOT** diagnostic.
- Be aware of “fitness-for-purpose” criteria.
- What Z-Score suits your needs?
- Z is **NOT** about the people, it’s about the process!

Magruder Data Mining:

Where is the Mine?

Excel Data Downloads 2017
2017 Cumulative Analyte Data Report
2017 Cumulative Analyte Summary Report
2017 Cumulative Method Data Report
2017 Cumulative Method Summary Report
2017 Cumulative Method Precision Report

We'll look at these 3 Method reports

magruder fertilizer
check sample program

Data Mining in the 2017
"Cumulative Method Summary Report"

Let's look at the New IA Ratio metric:

$$\text{IA Ratio} = \frac{\text{Robust \%RSD}}{\text{IA \%RSD}}$$

- Both %RSD's represent ~68% of data.
- This factor should be less than 1.
- Lower implies more precision relative to IA.
- Values <= 1 will appear in **Green**.
- Values > 1 may appear in **Green**, **Orange** ,then **Red** if Significant (f).
- **Grey** is applied where the number of labs is < 6.

magruder fertilizer
check sample program

Data Mining in the "Cumulative Method Summary Report".

Two Potassium Methods.

Sample Number	Sample Name	# Labs	Assigned Value (%)	IA at Method Value	Robust sd	Robust % RSD	Method IA Ratio
Soluble Potassium as K_2O, STPB Oxalate							
170611	Grade 2-15-15 w/PO3	10	17.79	1.003	0.571	3.21%	**1.33**
170811*	Grade 21-0-5	10	**5.20**	0.438	0.199	3.83%	**1.06**
170711	Grade 7-25-40	9	40.48	1.545	0.423	1.04%	**0.64**
171211	Grade 5-15-30	9	30.44	1.401	0.403	1.32%	**0.67**
Soluble Potassium as K_2O, AA (Oxalate)							
170611	Grade 2-15-15 w/PO3	8	17.53	0.994	1.98	11.29%	**4.64**
170411*	Grade 15-15-15 + Micros	7	**2.47**	0.410	0.372	15.02%	**2.11**
170711	Grade 7-25-40	7	40.22	1.542	1.70	4.22%	**2.56**
171211	Grade 5-15-30	6	30.79	1.410	1.68	5.45%	**2.77**

magruder fertilizer
check sample program

Data Mining in the "Cumulative Method Summary Report".

Acid Soluble Boron (165) – All 2017 methods

Samples	# Labs	Assigned Value (%)	IA at Method Value	Robust SD	Robust % RSD	Method IA Ratio
Grade 5-15-30	19	0.255	0.041	0.032	12.5%	1.80
Grade 15-15-15 + Micros	18	0.292	0.047	0.039	13.2%	1.92
Grade 15-15-15 + Micros	13	0.274	0.044	0.038	13.9%	2.01
Grade 5-15-30	11	0.234	0.038	0.019	8.2%	1.18
Grade 5-15-30	11	0.248	0.040	0.026	10.4%	1.50
Grade 18-46-0 DAP	7	0.012	0.005	0.007	55.2%	3.30
Grade 15-15-15 + Micros	6	0.247	0.040	0.064	26.1%	3.75
MAP plus S, 12-40-0	6	0.008	0.004	0.007	94.6%	4.16
MAP plus S, 12-40-0	5	56.0	1.0	78.0	139.3%	181.74
Grade 16-1-0	5	0.007	0.004	0.010	145.9%	5.93
Grade 21-0-5	5	0.003	0.003	0.003	105.9%	2.11

IA Ratio a little dodgy at the participation low end (< 6).

magruder fertilizer
check sample program

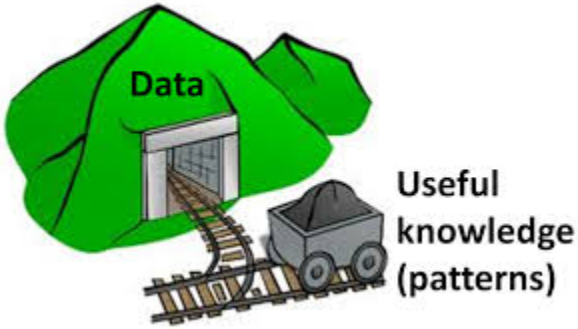
Acid Soluble Boron (165) – All 2017 methods

Sample Number	Sample Name	Method Code	# Labs	Assigned Value (%)	IA at Method Value	Robust sd	Robust % RSD	Method IA Ratio
171211	Grade 5-15-30	**165.99**	19	**0.255**	0.041	0.032	**12.5%**	**1.80**
170411	Grade 15-15-15 + Micros	**165.99**	18	**0.292**	0.047	0.039	**13.2%**	**1.92**
170411	Grade 15-15-15 + Micros	**165.30**	13	**0.274**	0.044	0.038	**13.9%**	**2.01**
171211	Grade 5-15-30	**165.00**	11	**0.234**	0.038	0.019	**8.2%**	**1.18**
171211	Grade 5-15-30	**165.30**	11	**0.248**	0.040	0.026	**10.4%**	**1.50**
170111	Grade 18-46-0 DAP	**165.99**	7	**0.012**	0.005	0.007	**55.2%**	**3.30**
170411	Grade 15-15-15 + Micros	**165.00**	6	**0.247**	0.040	0.064	**26.1%**	**3.75**
170911	MAP plus S, 12-40-0	**165.99**	6	**0.008**	0.004	0.007	**94.6%**	**4.16**

Does the IA for Boron adequately reflect the analytical dispersion?

Might need to reevaluate IA for Boron!

magruder fertilizer
check sample program



Data Mining the "Cumulative Method Precision" report.

Precision:

- Essentially estimating and separating out **Intra Lab** dispersion from **Inter Lab** dispersion. This is "**Within**" and "**Between**" lab precision respectively.
- Precision within (S_r) and between (S_R) labs is calculated according to **ISO 5725-2** concepts. These are not robust procedures!
- Reproducibility (S_R) can form the basis for better estimates of IA values.
- Repeatability (S_r) is highly indicative of method robustness.
- Horwitz describes the S_R/S_r ratio as usually between 2 and 4 (skewed → 2).

magruder fertilizer
check sample program

"Cumulative Method Precision Report"

This looks like what you see in your lab.

This is what you don't usually see.

The Ratio: from Horwitz ~ 2 to 4

Acid Soluble Boron , 2 Methods & Other*

Sample Name Analyte Code: 165	# Labs	Mean	Between Labs %RSD	Repeatability %rsd	Reproducibility %RSD	sR/sr
Grade 5-15-30	9	0.24	6.4%	**4.4%**	**7.8%**	1.8
Grade 15-15-15 + Micros	11	0.28	11.6%	**3.0%**	**12.0%**	4.0
Grade 5-15-30	10	0.25	9.9%	**2.2%**	**10.2%**	4.6
Grade 15-15-15 + Micros*	16	0.28	15.4%	**2.5%**	**15.6%**	6.2
Grade 5-15-30*	17	0.25	9.5%	**4.4%**	**10.5%**	2.4
		Weighted Mean		**3.41%**	**12.35%**	**3.6**

In general there is more variance between labs than within labs.

magruder fertilizer
check sample program

This looks like what you see in your lab.

This is what you don't usually see.

Some High Ratios!

"Cumulative Method Precision Report"

Total Nitrogen, Combustion (18%)

Sample Name Method Code: 010.06	# Labs	Mean	Between Labs %RSD	Repeatability %rsd	Reproducibility %RSD	sR/sr
Grade 18-46-0 DAP	49	18.3	1.5%	**0.5%**	**1.6%**	3.2
Grade 27-0-0	50	26.6	3.5%	**0.6%**	**3.6%**	5.7
Grade 28-0-0 Liquid SR	56	28.4	1.0%	**0.5%**	**1.1%**	2.3
Grade 15-15-15 + Micros	56	20.1	1.4%	**0.6%**	**1.5%**	2.8
Grade 16-1-0	54	16.9	0.9%	**0.5%**	**1.0%**	2.1
Grade 2-15-15 w/PO_3	53	2.1	9.0%	**1.7%**	**9.2%**	5.5
Grade 7-25-40	52	6.6	12.5%	**1.5%**	**12.6%**	8.4
Grade 21-0-5	54	21.1	1.4%	**0.7%**	**1.5%**	2.3
MAP plus S, 12-40-0	54	12.5	1.4%	**0.8%**	**1.6%**	2.0
Grade 12-0-0-26S	50	12.1	2.0%	**0.7%**	**2.2%**	3.0
Grade 5-15-30	49	5.2	2.2%	**1.2%**	**2.5%**	2.1
		Weighted Mean		**0.7%**	**2.85%**	**4.09**

magruder fertilizer
check sample program

"Cumulative Method Data Report" aka "All Tests" reports.

Data Mining in the New IA
Cumulative Method Data Report.

A look at Total Sulfur Method 148.01
"Total Sulfur, Gravimetric - sulfate and elemental"

How the new IA metric "Method IA Status" (fixed dispersion) compares with Z Scores (variable dispersion).

$$\textbf{IA Status} = \begin{cases} \textbf{Low} & \text{if } x_{LAB} < X_{AV} - IA_{AV} \\ \textbf{High} & \text{if } x_{LAB} > X_{AV} + IA_{AV} \\ \textbf{OK} & \text{Otherwise} \end{cases}$$

$$Z = \frac{x_{LAB} - X_{AV}}{\sigma_{rob}}$$

Method Code	Analyte and Method (Units)	Lab Code	Lab Data		Method Values			# Tests	Magruder CS Z Score	Method IA Status	Flag
			Value	Range	Rob Mean	Rob SD	R-bar				
171111 Grade 12-0-0-26S										**IA = 1**	
148.01	Total Sulfur, Gravimetric - sulfate and	0500	**25.3**	0.0000	**26.4**	**0.56**	0.1699	12	**-1.95**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0534	**25.6**	0.2800	**26.4**	**0.56**	0.1699	12	**-1.43**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0040	**26.1**	0.1000	**26.4**	**0.56**	0.1699	12	**-0.60**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0231	**26.1**	0.0000	**26.4**	**0.56**	0.1699	12	**-0.51**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0513	**26.2**	0.1300	**26.4**	**0.56**	0.1699	12	**-0.37**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0157	**26.5**	0.1000	**26.4**	**0.56**	0.1699	12	**0.12**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0029	**26.5**	0.1700	**26.4**	**0.56**	0.1699	12	**0.29**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0485	**26.7**	0.0628	**26.4**	**0.56**	0.1699	12	**0.59**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0105	**26.8**	0.5200	**26.4**	**0.56**	0.1699	12	**0.68**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0114	**26.8**	0.4000	**26.4**	**0.56**	0.1699	12	**0.70**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0095	**26.9**	0.1200	**26.4**	**0.56**	0.1699	12	**0.84**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0476	**27.0**	0.1556	**26.4**	**0.56**	0.1699	12	**1.18**	**OK**	0
~~148.01~~	~~Total Sulfur, Gravimetric - sulfate and~~	~~0230~~	~~**25.6**~~	~~2.500~~	~~**26.4**~~	~~**0.56**~~	~~0.1699~~	~~12~~	~~**-1.50**~~	~~**OK**~~	~~1~~
~~148.01~~	~~Total Sulfur, Gravimetric - sulfate and~~	~~0530~~	~~**2.6**~~	~~0.0000~~	~~**26.4**~~	~~**0.56**~~	~~0.1699~~	~~12~~	~~**-42.83**~~	~~**Low**~~	~~2~~
171211 Grade 5-15-30										**IA = 0.46**	
148.01	Total Sulfur, Gravimetric - sulfate and	0513	**4.1**	0.0900	**5.2**	**1.07**	0.1293	9	**-0.93**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0476	**4.1**	0.0641	**5.2**	**1.07**	0.1293	9	**-0.92**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0324	**4.3**	0.2900	**5.2**	**1.07**	0.1293	9	**-0.78**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0444	**4.5**	0.1500	**5.2**	**1.07**	0.1293	9	**-0.56**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0405	**5.1**	0.1400	**5.2**	**1.07**	0.1293	9	**-0.07**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0055	**6.0**	0.0700	**5.2**	**1.07**	0.1293	9	**0.71**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0534	**6.1**	0.1100	**5.2**	**1.07**	0.1293	9	**0.77**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0040	**6.1**	0.2000	**5.2**	**1.07**	0.1293	9	**0.80**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0157	**6.3**	0.0500	**5.2**	**1.07**	0.1293	9	**0.97**	**High**	0
~~148.01~~	~~Total Sulfur, Gravimetric - sulfate and~~	~~0114~~	~~**4.7**~~	~~0.7800~~	~~**5.2**~~	~~**1.07**~~	~~0.1293~~	~~9~~	~~**-0.44**~~	~~**Low**~~	~~1~~

Method Code	Analyte and Method (Units)	Lab Code	Lab Data		Method Values			# Tests	Magruder CS Z Score	Method IA Status	Flag
			Value	Range	Rob Mean	Rob SD	R-bar				
170411 Grade 15-15-15 + Micros										**IA = 0.41**	
148.01	Total Sulfur, Gravimetric - sulfate and	0513	**2.4**	0.0100	**4.2**	**1.14**	0.0852	14	**-1.64**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0457	**2.6**	0.0700	**4.2**	**1.14**	0.0852	14	**-1.42**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0073	**3.4**	0.1100	**4.2**	**1.14**	0.0852	14	**-0.71**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0177	**3.5**	0.0222	**4.2**	**1.14**	0.0852	14	**-0.63**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0510	**3.5**	0.0004	**4.2**	**1.14**	0.0852	14	**-0.61**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0029	**3.7**	0.0100	**4.2**	**1.14**	0.0852	14	**-0.45**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0230	**4.7**	0.2300	**4.2**	**1.14**	0.0852	14	**0.42**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0105	**4.8**	0.1100	**4.2**	**1.14**	0.0852	14	**0.50**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0157	**4.8**	0.1500	**4.2**	**1.14**	0.0852	14	**0.50**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0324	**4.9**	0.0500	**4.2**	**1.14**	0.0852	14	**0.54**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0485	**4.9**	0.0700	**4.2**	**1.14**	0.0852	14	**0.57**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0055	**4.9**	0.1200	**4.2**	**1.14**	0.0852	14	**0.61**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0114	**5.0**	0.1000	**4.2**	**1.14**	0.0852	14	**0.66**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0231	**9.7**	0.1400	**4.2**	**1.14**	0.0852	14	**4.79**	**High**	0
170811 Grade 21-0-5										**IA = 0.47**	
148.01	Total Sulfur, Gravimetric - sulfate and	0230	**5.2**	0.1800	**5.4**	**0.19**	0.0913	11	**-1.11**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0105	**5.3**	0.0200	**5.4**	**0.19**	0.0913	11	**-0.75**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0444	**5.3**	0.3000	**5.4**	**0.19**	0.0913	11	**-0.75**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0040	**5.3**	0.0000	**5.4**	**0.19**	0.0913	11	**-0.49**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0029	**5.3**	0.1000	**5.4**	**0.19**	0.0913	11	**-0.44**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0500	**5.3**	0.0800	**5.4**	**0.19**	0.0913	11	**-0.28**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0055	**5.4**	0.0100	**5.4**	**0.19**	0.0913	11	**-0.05**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0102	**5.4**	0.1143	**5.4**	**0.19**	0.0913	11	**0.28**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0157	**5.5**	0.0800	**5.4**	**0.19**	0.0913	11	**0.59**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0073	**8.1**	0.0200	**5.4**	**0.19**	0.0913	11	**13.90**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0534	**8.6**	0.1000	**5.4**	**0.19**	0.0913	11	**16.41**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0324	**5.2**	0.5200	**5.4**	**0.19**	0.0913	11	**-1.05**	**OK**	1
148.01	Total Sulfur, Gravimetric - sulfate and	0485	**0.0**	0.0000	**5.4**	**0.19**	0.0913	11			4

Method Code	Analyte and Method (Units)	Lab Code	Lab Data		Method Values			# Tests	Magruder CS Z Score	Method IA Status	Flag
			Value	Range	Rob Mean	Rob SD	R-bar				
170911	**MAP plus S, 12-40-0**									**IA = 0.56**	
148.01	Total Sulfur, Gravimetric - sulfate and	0534	**6.5**	0.0400	**7.2**	**0.15**	0.0771	17	**-4.50**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0444	**7.0**	0.1200	**7.2**	**0.15**	0.0771	17	**-1.39**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0230	**7.1**	0.0100	**7.2**	**0.15**	0.0771	17	**-0.91**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0231	**7.1**	0.0500	**7.2**	**0.15**	0.0771	17	**-0.84**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0481	**7.1**	0.0100	**7.2**	**0.15**	0.0771	17	**-0.65**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0105	**7.2**	0.0100	**7.2**	**0.15**	0.0771	17	**-0.32**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0371	**7.2**	0.3200	**7.2**	**0.15**	0.0771	17	**-0.29**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0073	**7.2**	0.0300	**7.2**	**0.15**	0.0771	17	**-0.26**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0485	**7.2**	0.2107	**7.2**	**0.15**	0.0771	17	**0.06**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0029	**7.2**	0.0700	**7.2**	**0.15**	0.0771	17	**0.20**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0040	**7.3**	0.1000	**7.2**	**0.15**	0.0771	17	**0.23**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0513	**7.3**	0.0500	**7.2**	**0.15**	0.0771	17	**0.39**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0055	**7.3**	0.0700	**7.2**	**0.15**	0.0771	17	**0.84**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0324	**7.4**	0.1900	**7.2**	**0.15**	0.0771	17	**0.91**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0500	**7.4**	0.0200	**7.2**	**0.15**	0.0771	17	**0.94**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0157	**7.4**	0.0000	**7.2**	**0.15**	0.0771	17	**1.14**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0102	**7.4**	0.0100	**7.2**	**0.15**	0.0771	17	**1.45**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0114	**7.5**	0.6300	**7.2**	**0.15**	0.0771	17	**2.07**	**OK**	1
161211	**MAP plus S**									**IA = 0.63**	
148.01	Total Sulfur, Gravimetric - sulfate and	0444	**4.8**	0.0100	**8.5**	**2.27**	0.1904	12	**-1.60**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0324	**5.1**	0.0000	**8.5**	**2.27**	0.1904	12	**-1.49**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0230	**5.5**	0.5600	**8.5**	**2.27**	0.1904	12	**-1.34**	**Low**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0055	**8.7**	0.0500	**8.5**	**2.27**	0.1904	12	**0.10**	**OK**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0073	**9.3**	0.3700	**8.5**	**2.27**	0.1904	12	**0.37**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0157	**9.5**	0.1600	**8.5**	**2.27**	0.1904	12	**0.46**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0028	**9.5**	0.4000	**8.5**	**2.27**	0.1904	12	**0.47**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0231	**9.6**	0.0100	**8.5**	**2.27**	0.1904	12	**0.50**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0105	**9.7**	0.1000	**8.5**	**2.27**	0.1904	12	**0.54**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0037	**9.7**	0.4950	**8.5**	**2.27**	0.1904	12	**0.56**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0029	**9.9**	0.0400	**8.5**	**2.27**	0.1904	12	**0.63**	**High**	0
148.01	Total Sulfur, Gravimetric - sulfate and	0485	**10.0**	0.0900	**8.5**	**2.27**	0.1904	12	**0.69**	**High**	0

magruder fertilizer
check sample program

"Cumulative Method Data Report" aka "All Tests" reports.

We have just seen the lab results from 6 samples for one Method.
"Total Sulfur, Gravimetric - sulfate and elemental"

Clearly, **IA Status** predicts a different outcome than **Z Score**, for only some Samples.

It is important to recognize:

- **IA Status** is derived from a fixed dispersion (IA) set by the fertilizer regulators.
- **Z Scores** are derived from variable dispersion (σ_{Rob}) set by participants in that round.

Data Mining in the Cumulative Reports

Much can be learned from just sorting the data:

- Using the Excel Data Downloads available on the Magruder Website (easily sortable!).
- Sort these 2017 reports by Method Code:
  - Cumulative Method **Summary** Report
  - Cumulative Method **Precision** Report
  - Cumulative Method **Data** Report
- These files are the annual collection of information contained in sample reports you get every month on the DRW, which are:
  - Method All Tests Report
  - Individual Method Performance Summary
- After sorting scroll down and look for methods of interest! (Hint: colors can really help!).
- Cumulative Analyte Reports are also available (no precision!).

GET CREATIVE!

“There is a wealth of information out there just dying to spill it’s guts!”

magruder fertilizer
check sample program

To Sum Up:

- **We have talked about Z Scores – a simple calculation.** $Z = \frac{x_{LAB} - X_{AV}}{\sigma_{ffp}}$
  - Described fit-for-purpose sigmas.
  - Discussed calculating your own ffp sigma.

  - All the hard work is provided by Magruder as X_{AV} (Assigned Value).
- **We have talked about Magruder Data Mining.**
  - There are 5 Cumulative Excel data files produced for each year.
  - The story here is “just sort to see”!
- **We briefly touched upon the new IA metrics.**
  - IA Ratio: Robust %RSD / IA %RSD
  - IA Status: Relative to $X_{AV} \pm IA_{AV}$

Magruder

Control Charts

An Excel file you can download from the website.

Magruder Check Sample: Z Control Charts

Enter Lab # Below

0000

Get Current Data

First check the Sample list below to make sure you have downloaded the latest version from the website. The last Sample in the list should reflect the most current Sample for which reports have been released.

Now enter your Lab Number. When you hit the enter key your Lab Number will convert to the standard 4 character format (leading 0's).

Finally click the [Get Current Data] button and you will be switched to the Control Charts sheet. These control charts show Z-scores for the last 16 Magruder Check Samples by Analyte and Method submitted by you.

When in the Control Charts sheet you can scroll sequentially through your Methods by tapping the [Tap To Scroll Through Charts] button or select the method of interest directly in the scroll box. If you wish you can print this page using the Excel Print Preview and Print icons.

When you return to this sheet samples for which you submitted data will be marked with an astrix. To return just click on the "StartUp" tab below.

16 Samples in This Version

Number	Name
*161011	MOP
*161111	Grade 32-0-10
*161211	MAP plus S
*170111	Grade 18-46-0 DAP
*170211	Grade 27-0-0
*170311	Grade 28-0-0 Liquid SR
*170411	Grade 15-15-15 + Micros
*170511	Grade 16-1-0
*170611	Grade 2-15-15 w/PO3
*170711	Grade 7-25-40
*170811	Grade 21-0-5
*170911	MAP plus S, 12-40-0
*171011	Epsom Salts
*171012	TSP, 0-45-0
*171111	Grade 12-0-0-26S
*171211	Grade 5-15-30

THIS IS AN EXCEL FILE!

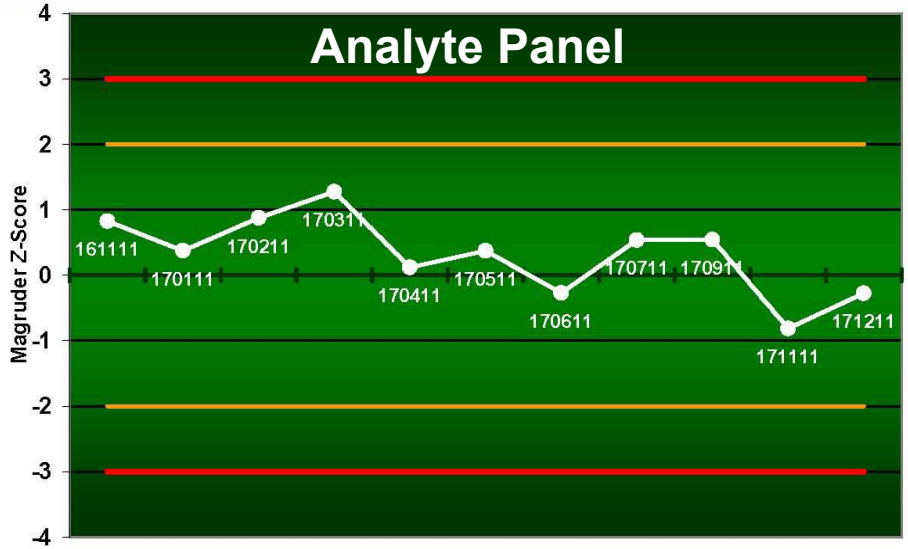
- On left - the opening sheet.
- Check the list for latest sample.
- Enter your lab number.
- Click “Get Current Data” button
- On return to this sheet, stars will appear on sample numbers you submitted.

magruder fertilizer
check sample program
STRIVING FOR EXCELLENCE IN ANALYSIS

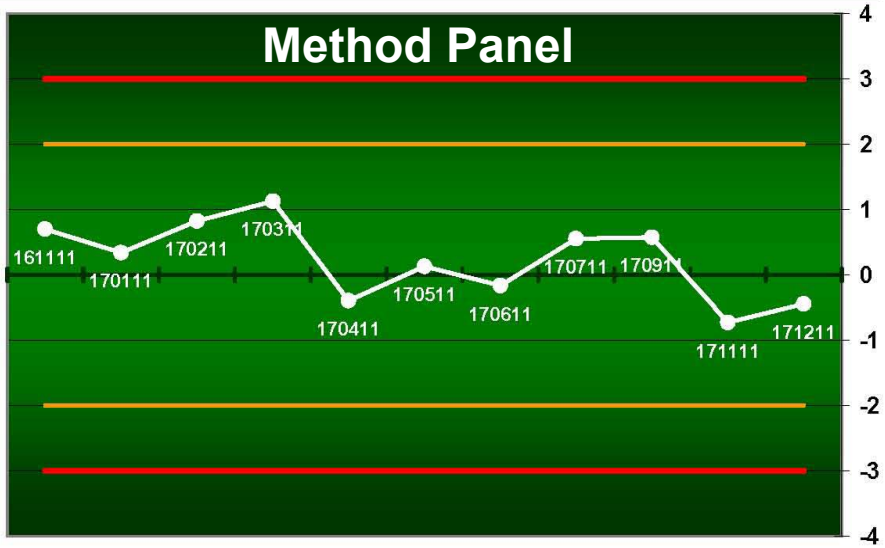
Magruder Check Sample Z Control Charts For Lab 0000

Analyte Code 010 | Chart 4 of 37 | Method Code 010.60

Total Nitrogen (%)



Total Nitrogen, Combustion (%)



Tap To Scroll Through Charts

Analyte Code and Name						Method Code and Name							
010 Total Nitrogen (%)						010.60 Total Nitrogen, Combustion (%)							
Number of Samples	11		Analyte Values		Your				Lab Data		Threshold	Method Values	
Sample Name & Code	Z	# Labs	Rob Mean	Rob SD	Method	Code	Z	# Labs	Value	Range	% RSD	Rob Mean	Rob SD
Grade 32-0-10 161111	0.83	75	32.34	0.3510	010.60	161111	0.70	55	32.64	0.0300	0%	32.44	0.2845
Grade 18-46-0 DAP 170111	0.37	67	18.29	0.2678	010.60	170111	0.34	54	18.39	0.0570	0%	18.29	0.2722
Grade 27-0-0 170211	0.88	67	26.59	0.8404	010.60	170211	0.82	55	27.33	0.0200	2%	26.52	0.9822
Grade 28-0-0 Liquid 170311	1.28	76	28.31	0.3561	010.60	170311	1.13	57	28.76	0.0600	1%	28.39	0.3240
Grade 15-15-15 + Mi 170411	0.12	81	19.95	0.4052	010.60	170411	-0.40	58	19.99	0.0640	0%	20.10	0.2578
Grade 16-1-0 170511	0.37	78	16.88	0.2172	010.60	170511	0.13	56	16.96	0.0200	0%	16.94	0.1643
Grade 2-15-15 w/PO 170611	-0.27	80	2.094	0.1521	010.60	170611	-0.16	56	2.053	0.0680	1%	2.082	0.1762
Grade 7-25-40 170711	0.54	67	6.770	0.5281	010.60	170711	0.55	55	7.054	0.0474	2%	6.749	0.5527
/AP plus S, 12-40-0 170911	0.54	73	12.46	0.2121	010.60	170911	0.57	57	12.57	0.0760	0%	12.46	0.2012
ade 12-0-0-26S 171111	-0.82	69	12.12	0.2238	010.60	171111	-0.73	53	11.94	0.1800	1%	12.11	0.2301
de 5-15-30 171211	-0.28	67	5.140	0.1444	010.60	171211	-0.45	52	5.100	0.0600	1%	160	0.1335

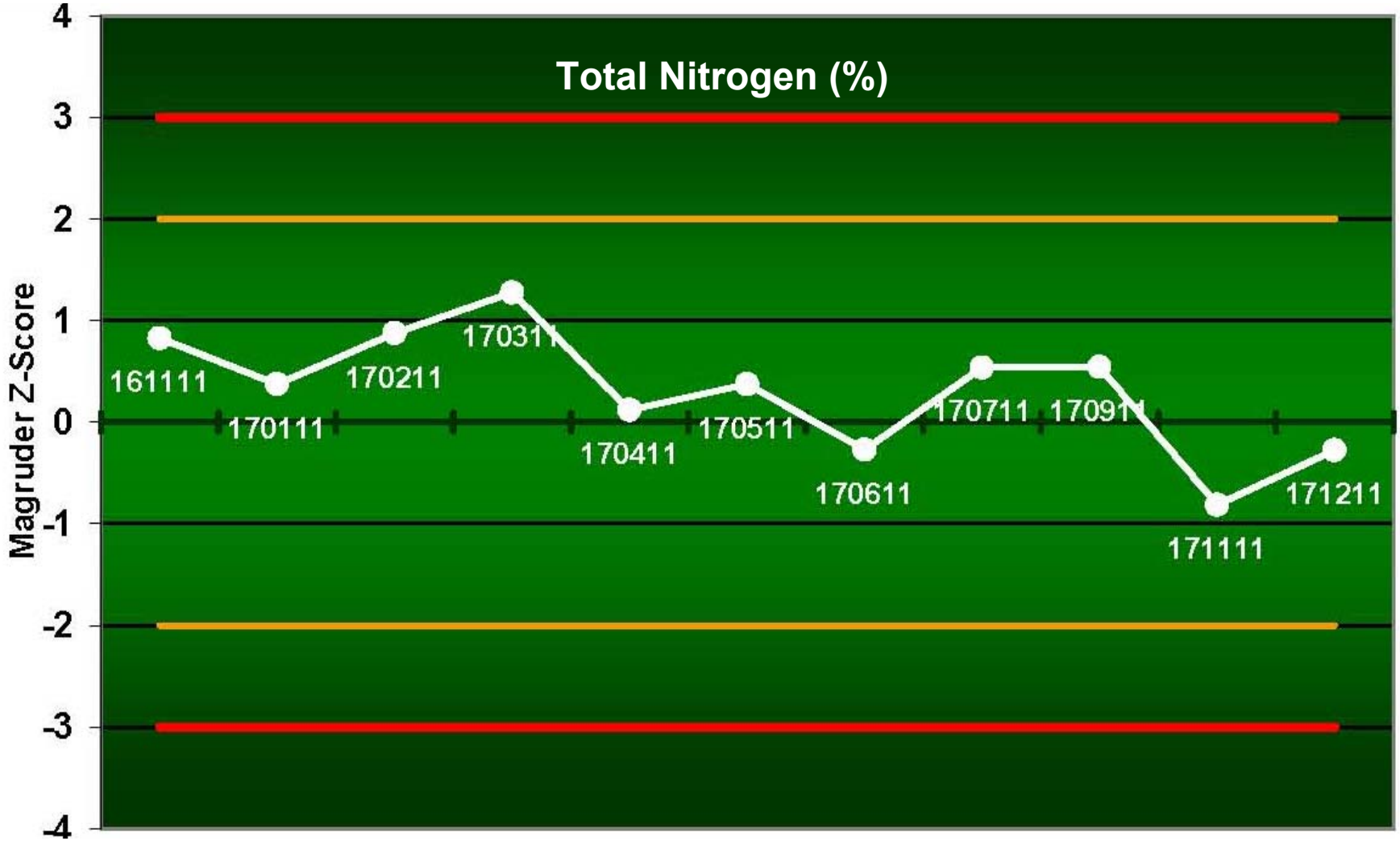
001.10
003.10
010.1
010.6
020.1
020.40
041.10
041.11
041.60
041.99
050.60
050.62
050.99
060.00
101.00
101.03
121.00
121.03

Select Your Method

Look for IA Status in Future.

magruder fertilizer
check sample program

Analyte Chart (independent of method)

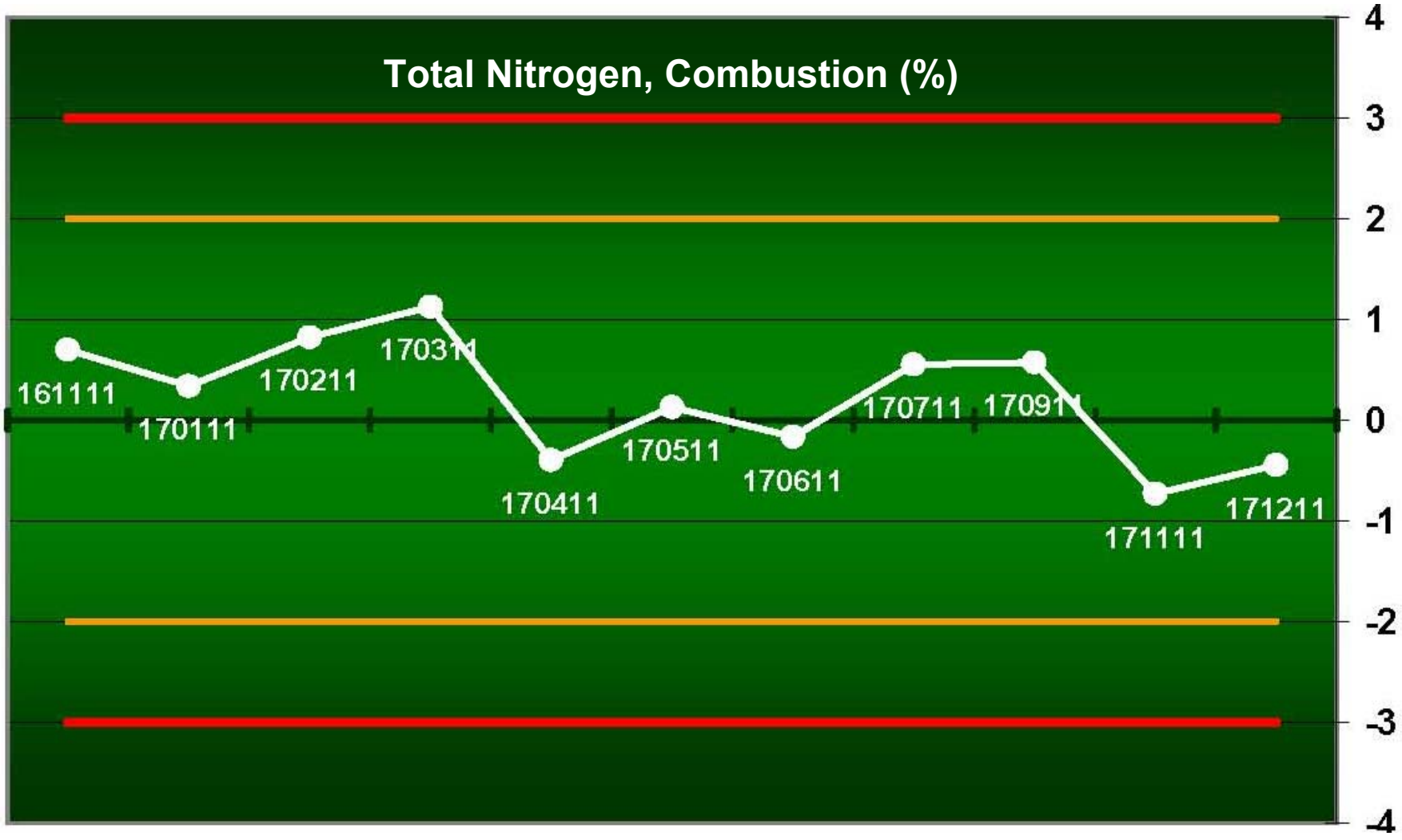


magruder fertilizer
check sample program

	Analyte Code and Name					
	010 Total Nitrogen (%)					
Number of Samples		11		Analyte Values		Your
Sample Name & Code		Z	# Labs	Rob Mean	Rob SD	Method
Grade 32-0-10	161111	0.83	75	32.34	0.3510	010.60
Grade 18-46-0 DAP	170111	0.37	67	18.29	0.2678	010.60
Grade 27-0-0	170211	0.88	67	26.59	0.8404	010.60
Grade 28-0-0 Liquid	170311	1.28	76	28.31	0.3561	010.60
Grade 15-15-15 + Mi	170411	0.12	81	19.95	0.4052	010.60
Grade 16-1-0	170511	0.37	78	16.88	0.2172	010.60
Grade 2-15-15 w/PO	170611	-0.27	80	2.094	0.1521	010.60
Grade 7-25-40	170711	0.54	67	6.770	0.5281	010.60
MAP plus S, 12-40-0	170911	0.54	73	12.46	0.2121	010.60
Grade 12-0-0-26S	171111	-0.82	69	12.12	0.2238	010.60
Grade 5-15-30	171211	-0.28	67	5.140	0.1444	010.60

magruder fertilizer
check sample program

Your Method Chart



magruder fertilizer
check sample program

Method Code and Name							
010.60 Total Nitrogen, Combustion (%)							
			Lab Data		Threshold	Method Values	
Code	Z	# Labs	Value	Range	% D	Rob Mean	Rob SD
161111	0.70	55	32.64	0.0300		32.44	0.2845
170111	0.34	54	18.39	0.0570		18.29	0.2722
170211	0.82	55	27.33	0.0200		26.52	0.9822
170311	1.13	57	28.76	0.0600		28.39	0.3240
170411	-0.40	58	19.99	0.0640		20.10	0.2578
170511	0.13	56	16.96	0.0200		16.94	0.1643
170611	-0.16	56	2.053	0.0680		2.082	0.1762
170711	0.55	55	7.054	0.0474		6.749	0.5527
170911	0.57	57	12.57	0.0760		12.46	0.2012
171111	-0.73	53	11.94	0.1800		12.11	0.2301
171211	-0.45	52	5.100	0.0600		5.160	0.1335

IA Status here in Future

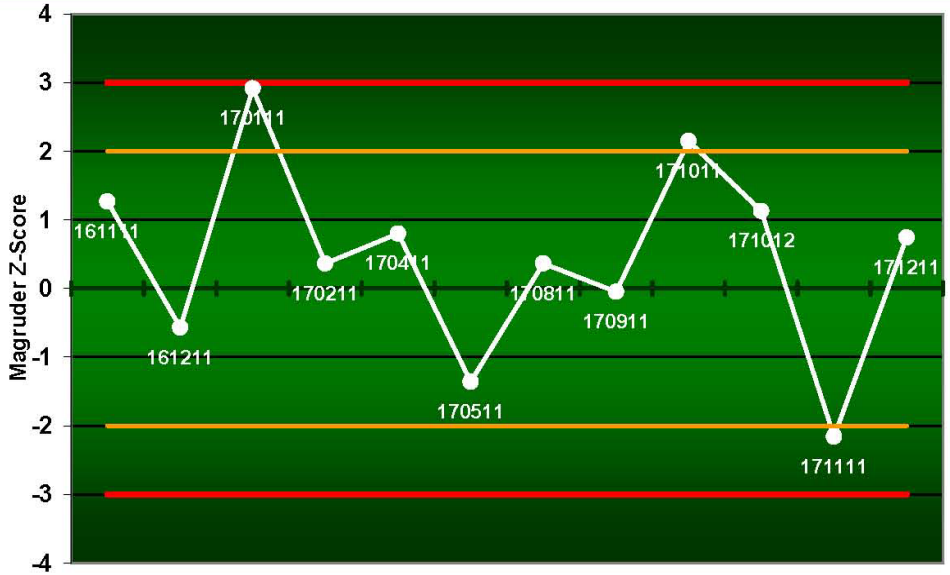
You could calculate your own Z Scores!

magruder fertilizer
check sample program
STRIVING FOR EXCELLENCE IN ANALYSIS

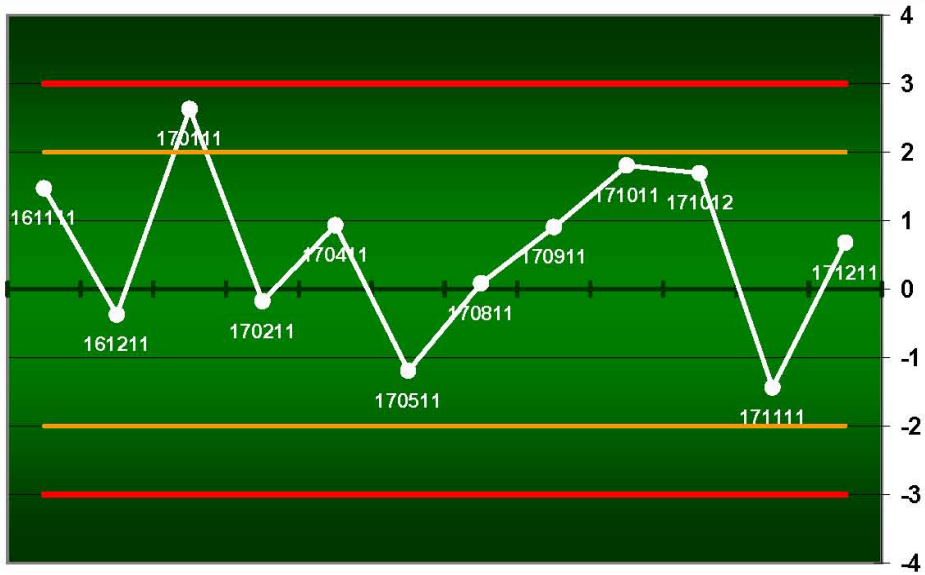
Magruder Check Sample Z Control Charts For Lab 0000

Analyte Code 148 | Chart 6 of 11 | Method Code 148.07

Total Sulfur (%)



Total Sulfur, ICP, test portion as in 2006.03... (%)



	Analyte Code and Name						Method Code and Name							
	148 Total Sulfur (%)						148.07 Total Sulfur, ICP, test portion as in 2006.03... (%)							
Number of Samples		12		Analyte Values		Your				Lab Data		Threshold	Method Values	
Sample Name & Code		Z	# Labs	Rob Mean	Rob SD	Method	Code	Z	# Labs	Value	Range	%RSD	Rob Mean	Rob SD
Grade 32-0-10	161111	1.27	9	7.116	0.3816	148.07	161111	1.47	5	7.640	0.1000	4%	7.024	0.4191
MAP plus S	161211	-0.57	40	9.492	0.9896	148.07	161211	-0.37	11	8.930	1.300	2%	9.344	1.106
Grade 18-46-0 DAP	170111	2.92	10	2.192	0.0840	148.07	170111	2.63	6	2.455	0.1100	6%	2.195	0.0882
Grade 27-0-0	170211	0.36	7	0.2078	0.0552	148.07	170211	-0.18	4	0.2300	0.0040	2%	0.2406	0.0594
Grade 15-15-15 + Mi	170411	0.80	45	4.574	0.4957	148.07	170411	0.93	12	4.970	0.0400	3%	4.712	0.2768
Grade 16-1-0	170511	-1.36	41	19.12	0.7888	148.07	170511	-1.20	11	18.05*	3.500	3%	19.03	0.8235
Grade 21-0-5	170811	0.36	44	5.343	0.2401	148.07	170811	0.08	12	5.430	0.4200	0%	5.409	0.2556
MAP plus S, 12-40-0	170911	-0.05	47	7.023	0.3618	148.07	170911	0.90	12	7.005	0.1700	2%	6.774	0.2565
Epsom Salts	171011	2.15	51	13.19	0.5648	148.07	171011	1.81	13	14.40	0.6000	4%	13.22	0.6545
TSP, 0-45-0	171012	1.13	8	1.117	0.0916	148.07	171012	1.69	5	1.230	0.0000	5%	1.115	0.0676
Grade 12-0-0-26S	171111	-2.16	38	26.40	0.8319	148.07	171111	-1.44	12	24.60*	2.800	4%	26.62	1.406
Grade 5-15-30	171211	0.74	37	5.467	0.8675	148.07	171211	0.68	11	6.110	0.1800	8%	5.275	1.154

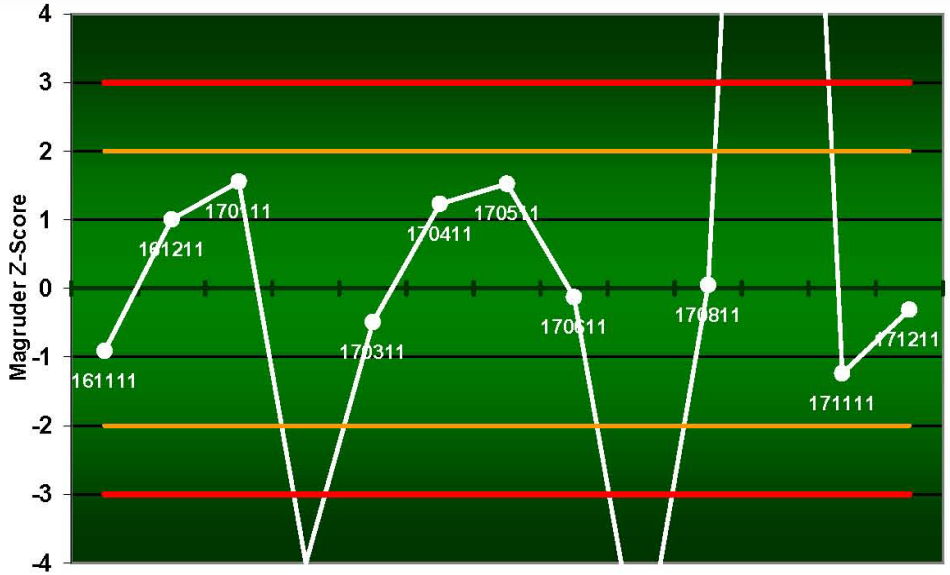
A slightly more erratic process, but still in control!

magruder fertilizer
check sample program
STRIVING FOR EXCELLENCE IN ANALYSIS

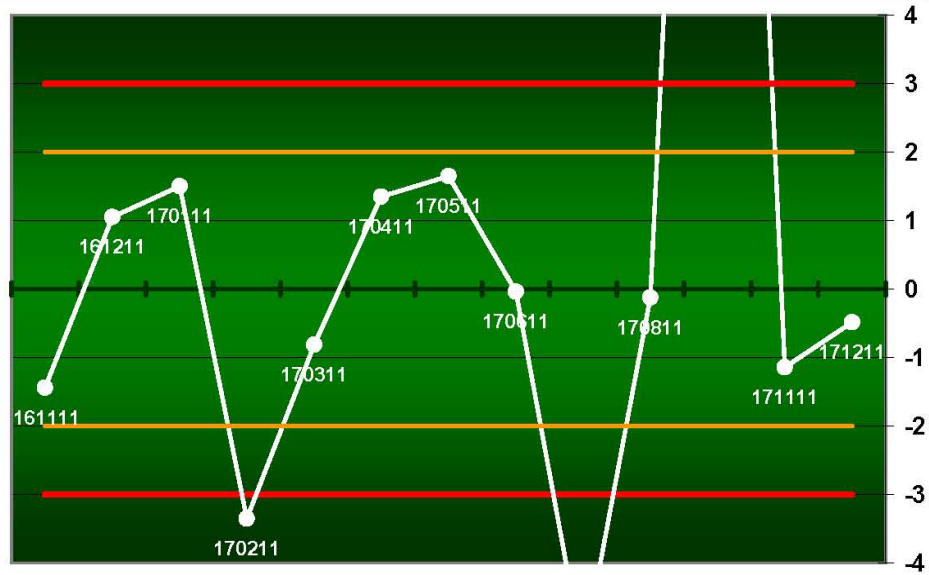
Magruder Check Sample Z Control Charts For Lab 0000

Analyte Code 010 | Chart 1 of 11 | Method Code 010.60

Total Nitrogen (%)



Total Nitrogen, Combustion (%)



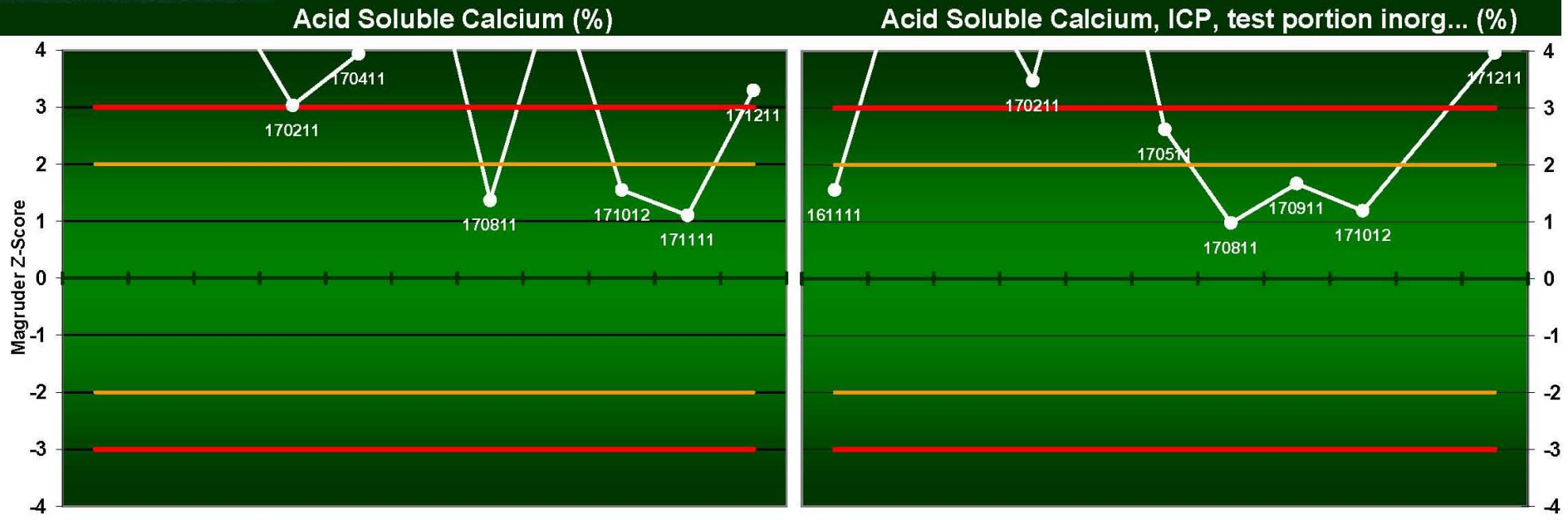
	Analyte Code and Name						Method Code and Name							
	010 Total Nitrogen (%)						010.60 Total Nitrogen, Combustion (%)							
Number of Samples	13			Analyte Values		Your				Lab Data		Threshold	Method Values	
Sample Name & Code		Z	# Labs	Rob Mean	Rob SD	Method	Code	Z	# Labs	Value	Range	%RSD	Rob Mean	Rob SD
Grade 32-0-10	161111	-0.91	75	32.34	0.3510	010.60	161111	-1.45	55	32.03	0.0300	1%	32.44	0.2845
MAP plus S	161211	1.00	72	12.06	0.2047	010.60	161211	1.05	57	12.27	0.0100	1%	12.07	0.1876
Grade 18-46-0 DAP	170111	1.56	67	18.29	0.2678	010.60	170111	1.50	54	18.70	0.1250	1%	18.29	0.2722
Grade 27-0-0	170211	-4.01	67	26.59	0.8404	010.60	170211	-3.36	55	23.23*	0.0700	6%	26.52	0.9822
Grade 28-0-0 Liquid	170311	-0.49	76	28.31	0.3561	010.60	170311	-0.82	57	28.13	0.0600	0%	28.39	0.3240
Grade 15-15-15 + Mi	170411	1.23	81	19.95	0.4052	010.60	170411	1.35	58	20.45	0.0300	1%	20.10	0.2578
Grade 16-1-0	170511	1.53	78	16.88	0.2172	010.60	170511	1.65	56	17.21	0.0200	1%	16.94	0.1643
Grade 2-15-15 w/PO	170611	-0.13	80	2.094	0.1521	010.60	170611	-0.04	56	2.075	0.0300	0%	2.082	0.1762
Grade 7-25-40	170711	-5.63	67	6.770	0.5281	010.60	170711	-5.34	55	3.795*	0.0100	22%	6.749	0.5527
Grade 21-0-5	170811	0.05	82	21.05	0.3075	010.60	170811	-0.13	56	21.06	0.0400	0%	21.10	0.2994
MAP plus S, 12-40-0	170911	19.53	73	12.46	0.2121	010.60	170911	20.58	57	16.60	0.4000	17%	12.46	0.2012
Grade 12-0-0-26S	171111	-1.24	69	12.12	0.2238	010.60	171111	-1.15	53	11.85	0.0500	1%	12.11	0.2301
Grade 5-15-30	171211	-0.31	67	5.140	0.1444	010.60	171211	-0.48	52	5.095	0.0300	1%	5.160	0.1335

This visual certainly indicates sporadic problems!

magruder fertilizer
check sample program
STRIVING FOR EXCELLENCE IN ANALYSIS

Magruder Check Sample Z Control Charts For Lab 0000

Analyte Code 101 | Chart 4 of 11 | Method Code 101.30



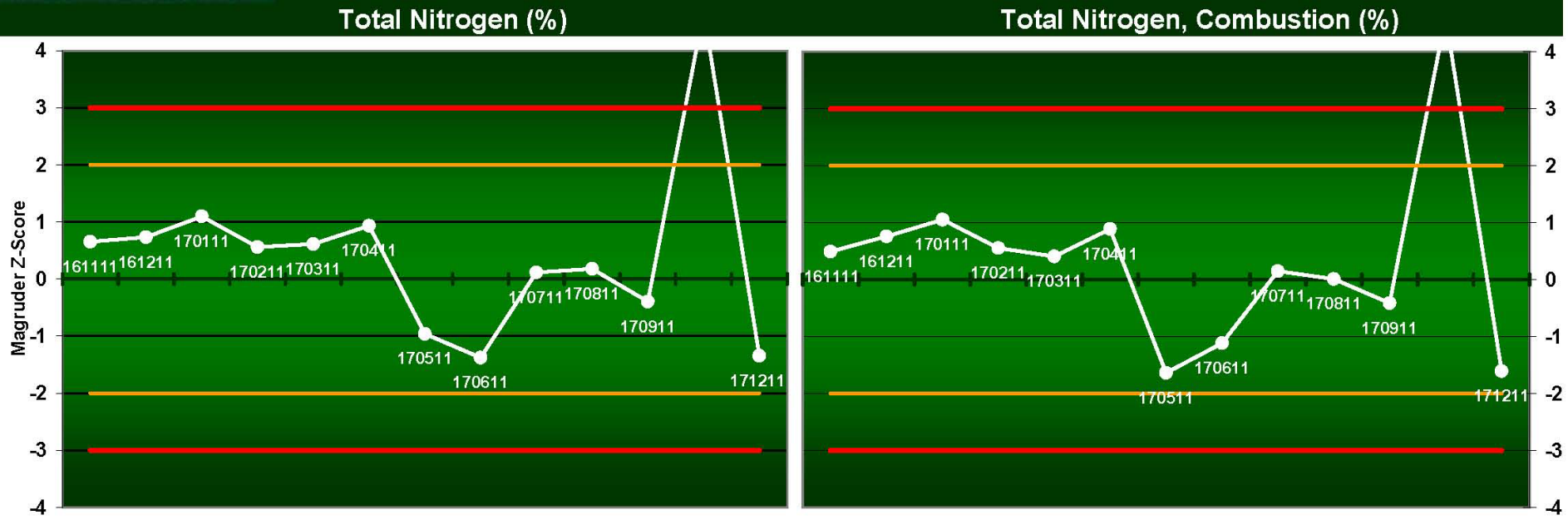
	Analyte Code and Name						Method Code and Name							
	101 Acid Soluble Calcium (%)						101.30 Acid Soluble Calcium, ICP, test portion inorg... (%)							
Number of Samples		11		Analyte Values		Your				Lab Data		Threshold	Method Values	
Sample Name & Code		Z	# Labs	Rob Mean	Rob SD	Method	Code	Z	# Labs	Value	Range	% RSD	Rob Mean	Rob SD
Grade 32-0-10	161111	43.66	12	0.0944	0.0080	101.30	161111	1.56	5	0.4445	0.0190	84%	0.1654	0.1562
MAP plus S	161211	7.85	14	0.2201	0.0532	101.30	161211	5.48	6	0.6375	0.0910	93%	0.2236	0.0673
Grade 18-46-0 DAP	170111	4.95	14	0.2803	0.0538	101.30	170111	5.62	8	0.5465	0.0230	49%	0.2749	0.0442
Grade 27-0-0	170211	3.03	56	4.502	0.2419	101.30	170211	3.48	21	5.235	0.1100	8%	4.496	0.2124
Grade 15-15-15 + Mi	170411	3.93	23	0.3360	0.0534	101.30	170411	7.84	8	0.5460	0.0420	27%	0.3553	0.0222
Grade 16-1-0	170511	6.21	17	0.4945	0.0407	101.30	170511	2.62	6	0.7470	0.0880	22%	0.5162	0.0784
Grade 21-0-5	170811	1.37	17	6.730	0.4868	101.30	170811	0.98	7	7.395	0.0300	5%	6.783	0.5655
MAP plus S, 12-40-0	170911	5.28	16	0.4252	0.0358	101.30	170911	1.67	8	0.6140	0.0360	17%	0.4607	0.0840
TSP, 0-45-0	171012	1.55	62	13.48	0.7251	101.30	171012	1.19	25	14.60	0.2000	4%	13.48	0.9366
Grade 12-0-0-26S	171111	1.10	3	0.0738	0.0764	101.30	171111		2	0.1580	0.0340			
Grade 5-15-30	171211	3.29	44	0.3850	0.0656	101.30	171211	3.97	15	0.6010	0.0020	31%	0.3700	0.0582

Time to start thinking about a possible Method Bias!

magruder fertilizer
check sample program
STRIVING FOR EXCELLENCE IN ANALYSIS

Magruder Check Sample Z Control Charts For Lab 0000

Analyte Code 010 | Chart 1 of 19 | Method Code 010.60



	Analyte Code and Name						Method Code and Name							
	010 Total Nitrogen (%)						010.60 Total Nitrogen, Combustion (%)							
Number of Samples	13			Analyte Values		Your				Lab Data		Threshold	Method Values	
Sample Name & Code		Z	# Labs	Rob Mean	Rob SD	Method	Code	Z	# Labs	Value	Range	%RSD	Rob Mean	Rob SD
Grade 32-0-10	161111	0.66	75	32.34	0.3510	010.60	161111	0.49	55	32.58	0.1100	0%	32.44	0.2845
MAP plus S	161211	0.73	72	12.06	0.2047	010.60	161211	0.76	57	12.21	0.0200	1%	12.07	0.1876
Grade 18-46-0 DAP	170111	1.10	67	18.29	0.2678	010.60	170111	1.05	54	18.58	0.0200	1%	18.29	0.2722
Grade 27-0-0	170211	0.56	67	26.59	0.8404	010.60	170211	0.55	55	27.06	0.1480	1%	26.52	0.9822
Grade 28-0-0 Liquid	170311	0.62	76	28.31	0.3561	010.60	170311	0.40	57	28.53	0.3700	0%	28.39	0.3240
Grade 15-15-15 + Mi	170411	0.93	81	19.95	0.4052	010.60	170411	0.89	58	20.33	0.1100	1%	20.10	0.2578
Grade 16-1-0	170511	-0.96	78	16.88	0.2172	010.60	170511	-1.64	56	16.67	0.0400	1%	16.94	0.1643
Grade 2-15-15 w/PO	170611	-1.38	80	2.094	0.1521	010.60	170611	-1.12	56	1.885	0.0700	5%	2.082	0.1762
Grade 7-25-40	170711	0.11	67	6.770	0.5281	010.60	170711	0.15	55	6.830	0.1000	1%	6.749	0.5527
Grade 21-0-5	170811	0.18	82	21.05	0.3075	010.60	170811	0.01	56	21.10	0.3600	0%	21.10	0.2994
MAP plus S, 12-40-0	170911	-0.40	73	12.46	0.2121	010.60	170911	-0.41	57	12.38	0.0300	0%	12.46	0.2012
Grade 12-0-0-26S	171111	4.68	69	12.12	0.2238	010.60	171111	4.61	53	13.17	0.0000	4%	12.11	0.2301
Grade 5-15-30	171211	-1.35	67	5.140	0.1444	010.60	171211	-1.61	52	4.945	0.1100	2%	5.160	0.1335

So, when this happens, don't get too worried!

magruder fertilizer
check sample program

Summary:

- These “Control” charts provide a quick process visual over time.
- They are not strictly control charts but more like Z tracking charts.
  - Each sample is different (somewhat handled by Z normalization!).
  - But remember, each Z is derived from a different dispersion σ_{Rob}.
- **But useful nonetheless!**
- The Control charts are easily accessible from the Website.
- Each Lab can and should visually track Z Scores over time.
- All the critical data is provided for both Analyte and Method Z Scores.