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Coal Quality

CCI Coal Combustion Inc.
Understanding the business of coal

sponsor

PRB COAL USERS' GROUP

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Topics

Measuring Coal Properties
Rank and Combustion
Pulverizer Performance

Measuring Coal Quality

ASTM, ISO only produces average data

Power plants respond to swings in quality

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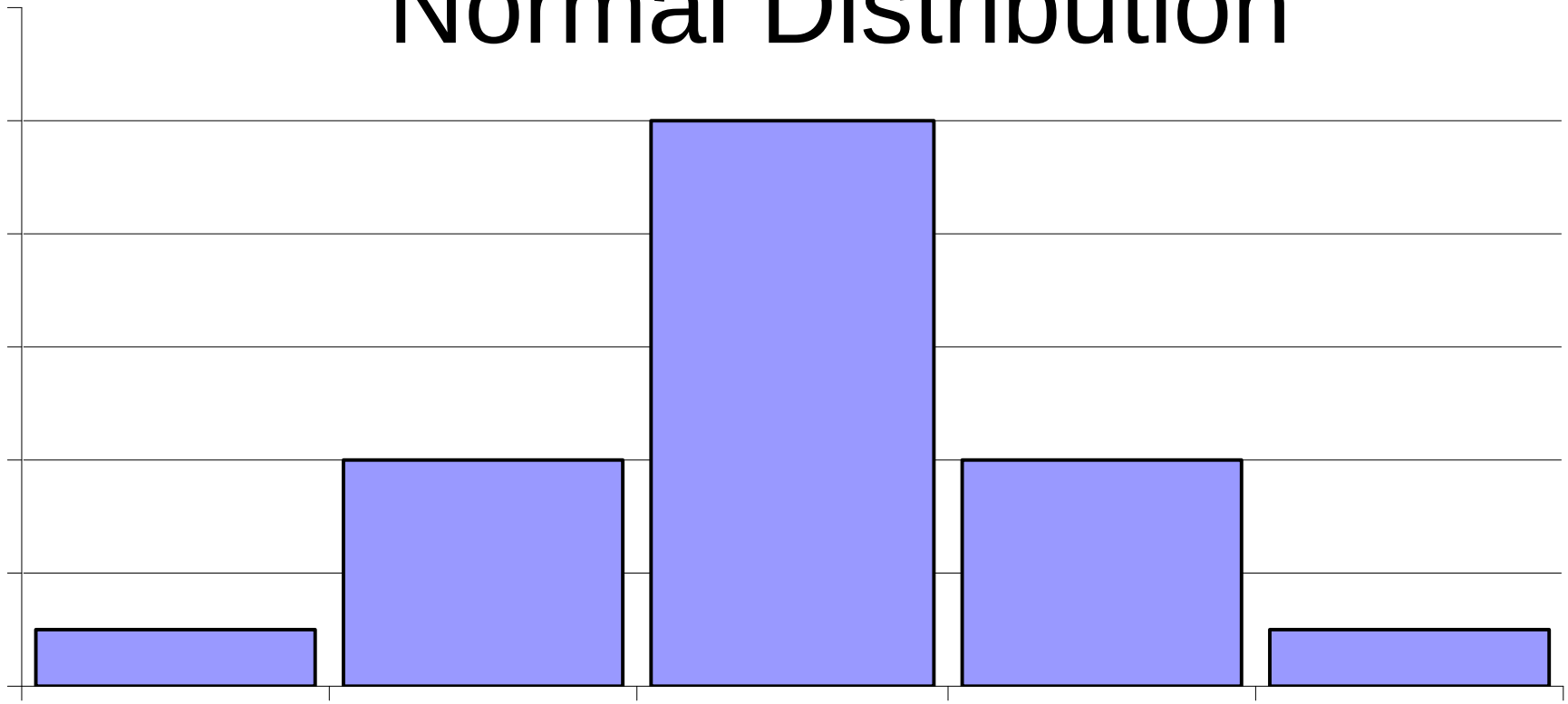
Normal Distribution



Quality Parameter

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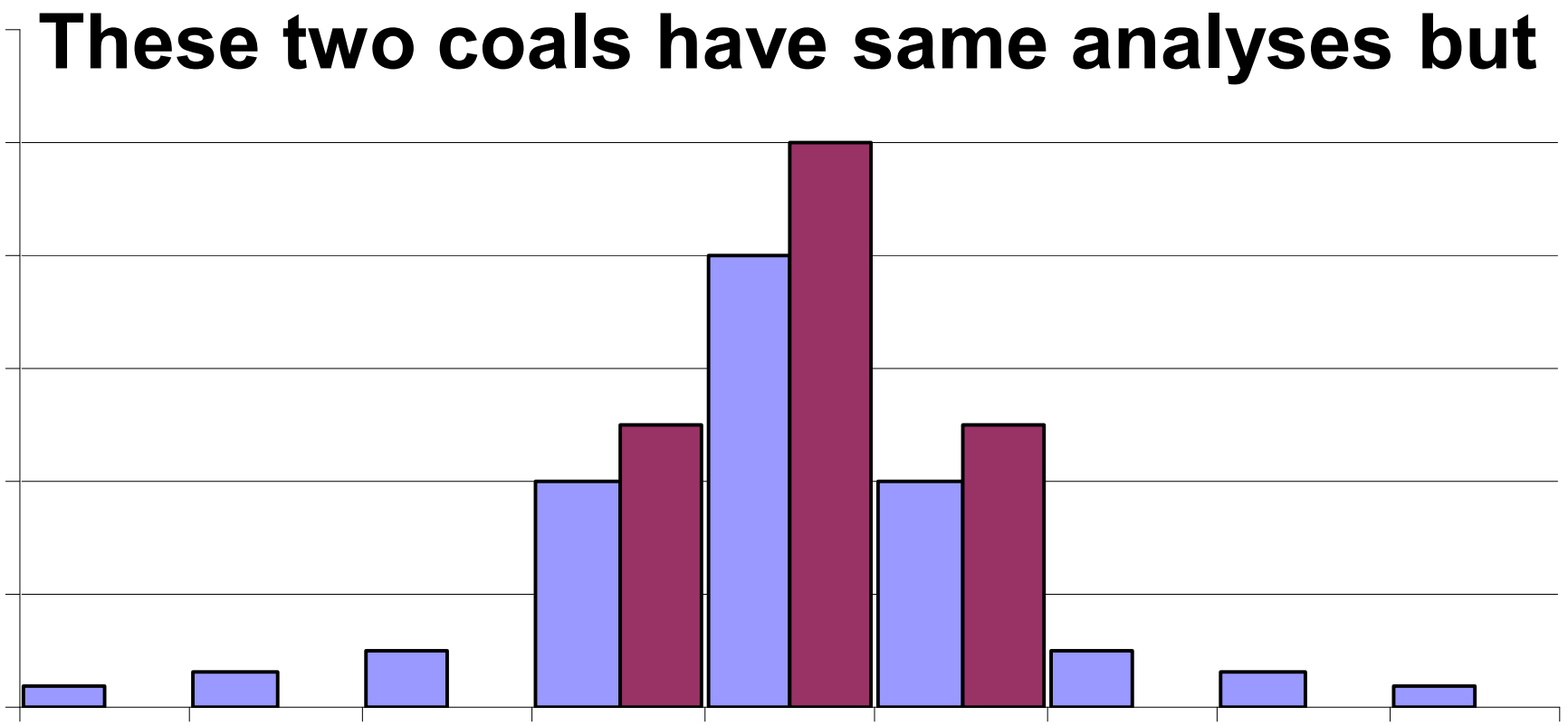
Small and Large Variability



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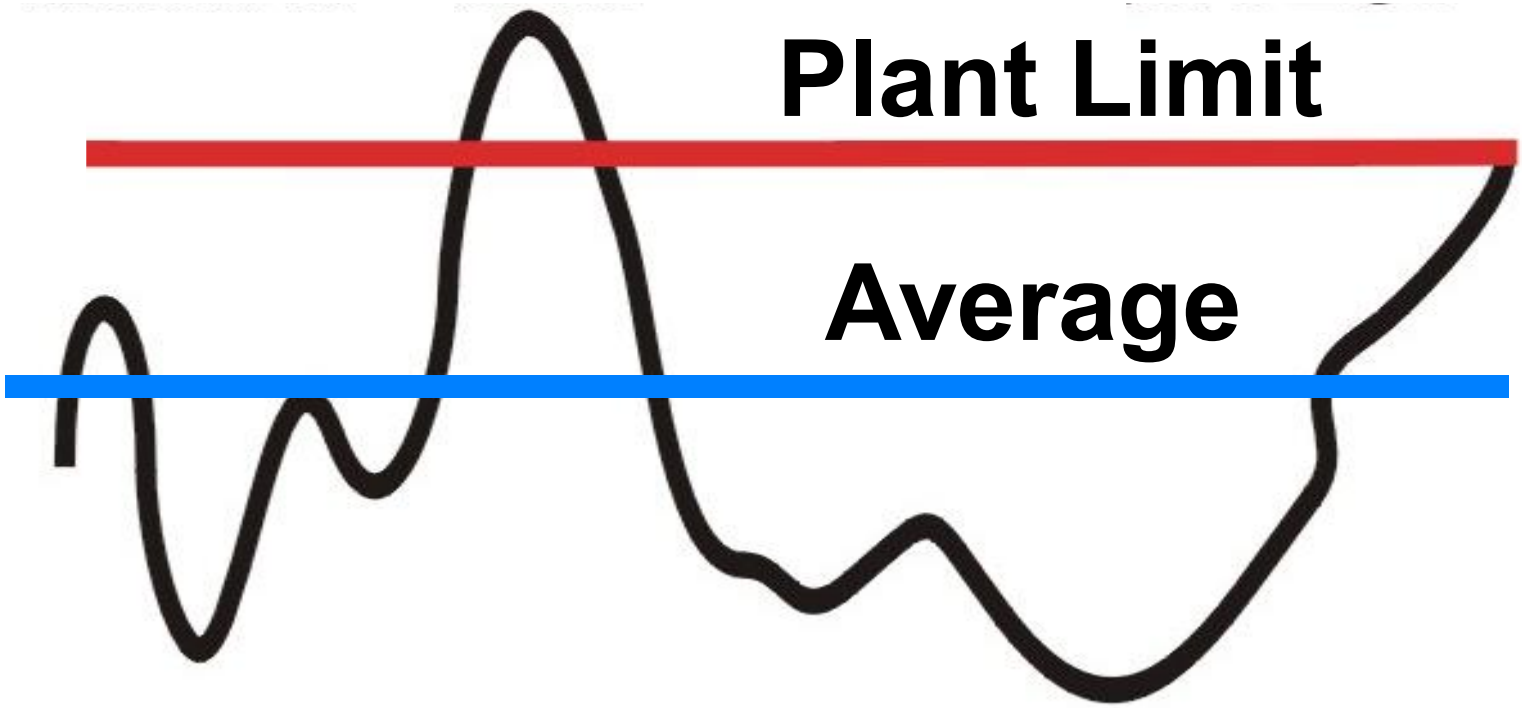

Does this coal met spec?

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Coal Quality verse Coal Specifications?

Coal Specifications are the coal qualities a plant or process would like to have. These are generally specific.

Coal Quality is the measurement of the properties of a coal product. These are not specific.

Coal quality values or numbers are determined by laboratory analyses of a small sample of the coal being traded. It is different in many ways from other types of numbers used in coal commerce because not only does the quality of a coal vary considerable, so can the methods used to test the quality.

Contrast

$20.00 per ton verse somewhere between $19 and $21

Payment due by 12:00 pm June 1, 2006 verse guaranteed to be after May.

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Why is this?

Geology ï Fossilized swamps and rain forests
Mining ï Rocks, Water, and Coal too
Sampling ï Good, Bad, and Ugly
Sample preparation and other games
Laboratory Analyses and number generators

Auditing and Trusting the values

Coal Swamps and Rain Forest

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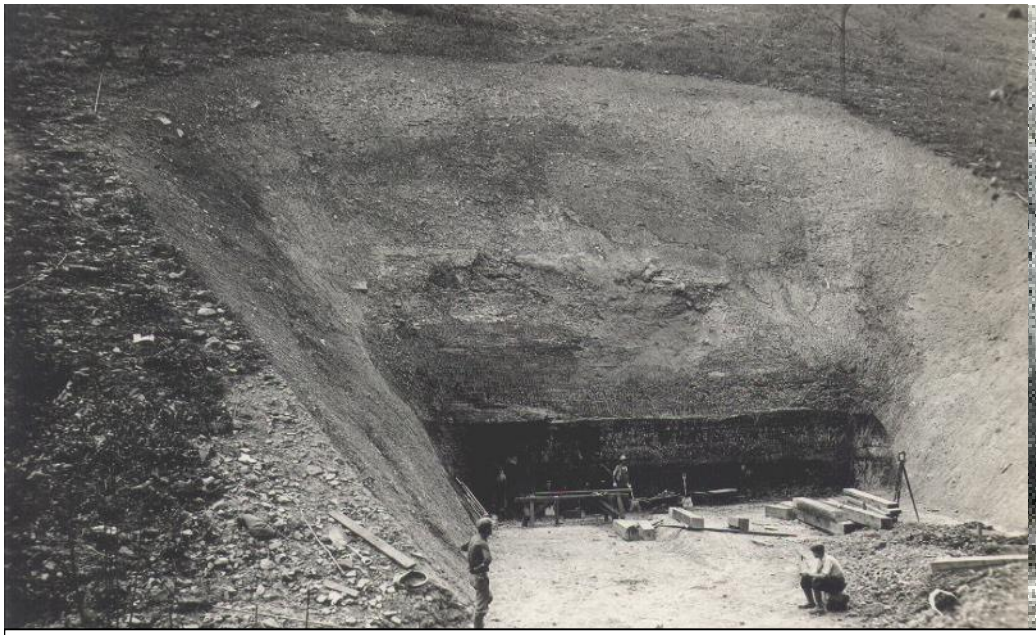

This is where coal comes from.

What is ASTM, ISO?

- Provides Standards and Guidelines to minimize errors in testing.
- Not a Certifying Organization
- Does not address Btu/lb differences between the same coal sampled twice, only dry ash. (Dry ash will be within 10% of actual dry ash 19/20 times if good ASTM sampling is used.)
- Does not address variability within shipment.

From ASTM Standards

- Designed for 1000 ton lots
- Sampling only addresses dry ash

to be within +/- 10% of actual values

What about Moisture

@ 25% moisture

CV 5000 +/- 167

+/- 3% of value or money

Coal Sampling & Analyses

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1 / 20,000,000,000

Terms

Proximate means Approximate

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Proximate

Moisture
Ash
Volatile - important to smoke

Fixed Carbon (by Difference)

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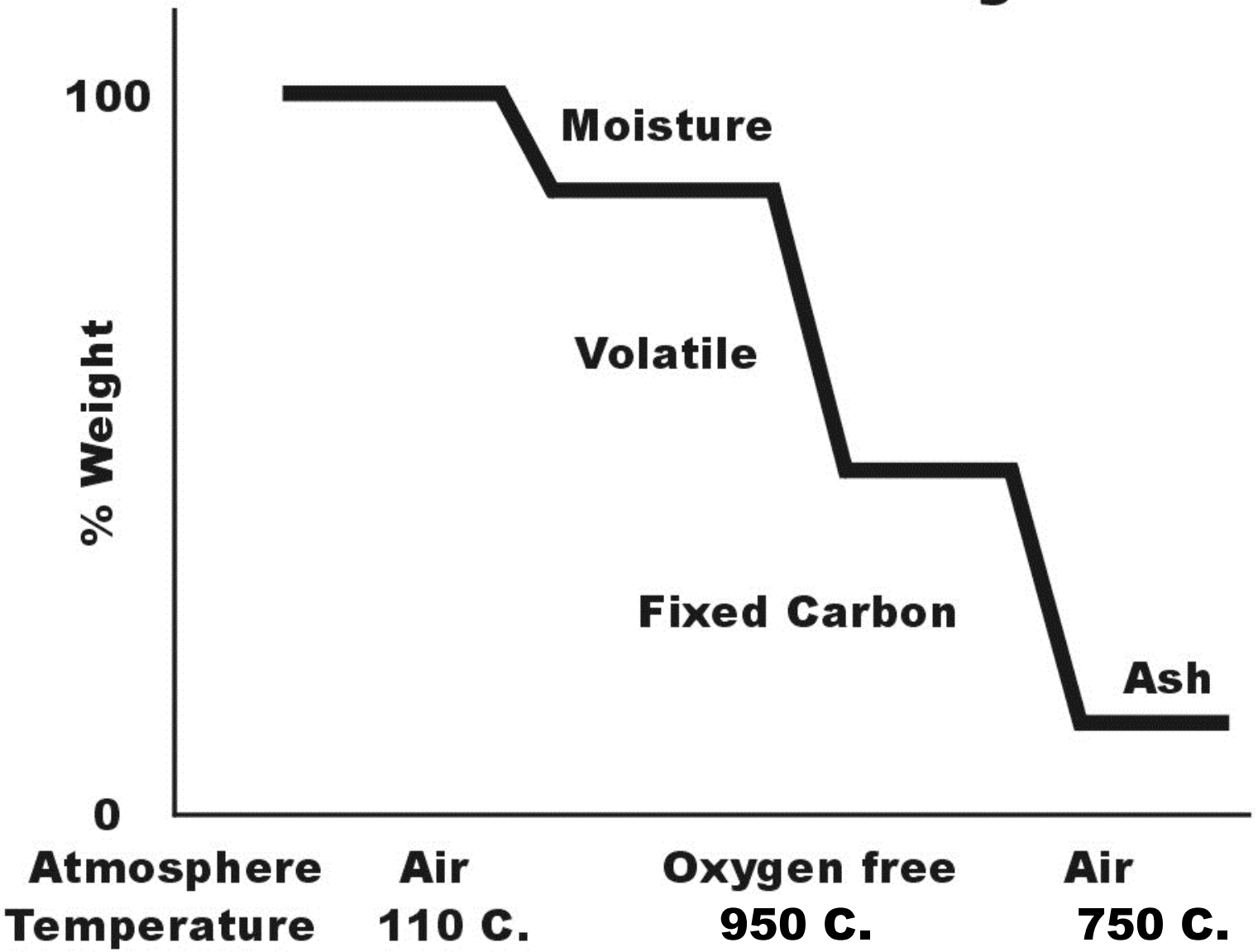
Denbigh - 1863 Blockade runner fueled with low volatile
Did captain use ap**proximate** test?

Proximate Analyses



Short Prox

Moisture – total moisture in sample

Ash – inorganic rock like material remaining after complete combustion

Sulfur – total sulfur in sample including organic, pyritic, and sulfate

Heating Value – higher heating value (HHV) of coal expressed as Btu/lb, Kcal/Kg, or MJ/Kg
Generally is the amount of energy needed to raise mass of water one degree

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Ultimate

Moisture, Ash, Sulfur – as described

Carbon – total elemental carbon

Hydrogen – total elemental hydrogen not included in moisture, (fuel hydrogen)

Nitrogen – total elemental nitrogen

Oxygen (by difference) – remaining major element calculated by summing moisture, ash and elements listed above and subtracting from 100

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Terms

As Received

Air Dry Basis or As determined

ADB – Totally useless (lab sample)

Dry Basis, DB

Moisture Ash Free, MAF

Moisture Mineral Matter Free, MMMF

Dry Ash Free, DAF

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We understand the concept of buying CV because

Boilers want heat.

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We understand the concept of buying Kcal by pricing fuels In:

$/MKcal = ($/ton) /(Kcal/Kg/1,000)

Example:

$40/ton coal 6700Kcal/Kg

$/MKcal = (40)/(6700/1,000)

$/MKcal = (40)/(6.7)

$/MKcal = 40/6.7 = $5.97 $/MKcal

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Lets look at all boiler related coal qualities on a heat basis; lets put all percentages on a per million Kcal basis

LOADING LEVELS

Coal Reactivity

Volatile

Fuel Ratio, FC/Vol

MAF Oxygen

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Coal Reactivity

Volatile
Oxygen
per million Kcals

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Volatiles

	Hi Qual. Bit.	Sub-Bit
Volatile%	**34**	**34**
KCal/KG	**6,950**	**4,750**
FC/Vol	**1.5**	**1.0**
Kg Vol/MKcal	**49**	**72**

72/49 = 1.47 or LCV = 47% more vol

Spontaneous Combustion

Has been shown by

US Bureau of Mines to relate to

MAF OXYGEN CONTENT

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Spontaneous Combustion

High Oxygen Sub- Bituminous Coals come with their own air

Self Heating Temp C.

=140-6.6(MAF Ox)

Self Heating Potential

Bituminous A, B = Low

Bituminous C = Medium

Sub Bituminous = High

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NOX

Air verse Fuel

Air is 79% N_2

N_2 is happy being N_2

Hard to burn N_2

Air verse Fuel

Coal is 0.5-2.0% N

N is not N_2

C-N=C

Air verse Fuel

Most Fuel Nitrogen forms NO_X

Air verse Fuel

Temperature
and O2 burns
Air Nitrogen

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Formation

Lower Oxygen
Lower Flame Temp
Lower Fuel Nitrogen
Increase Reactivity

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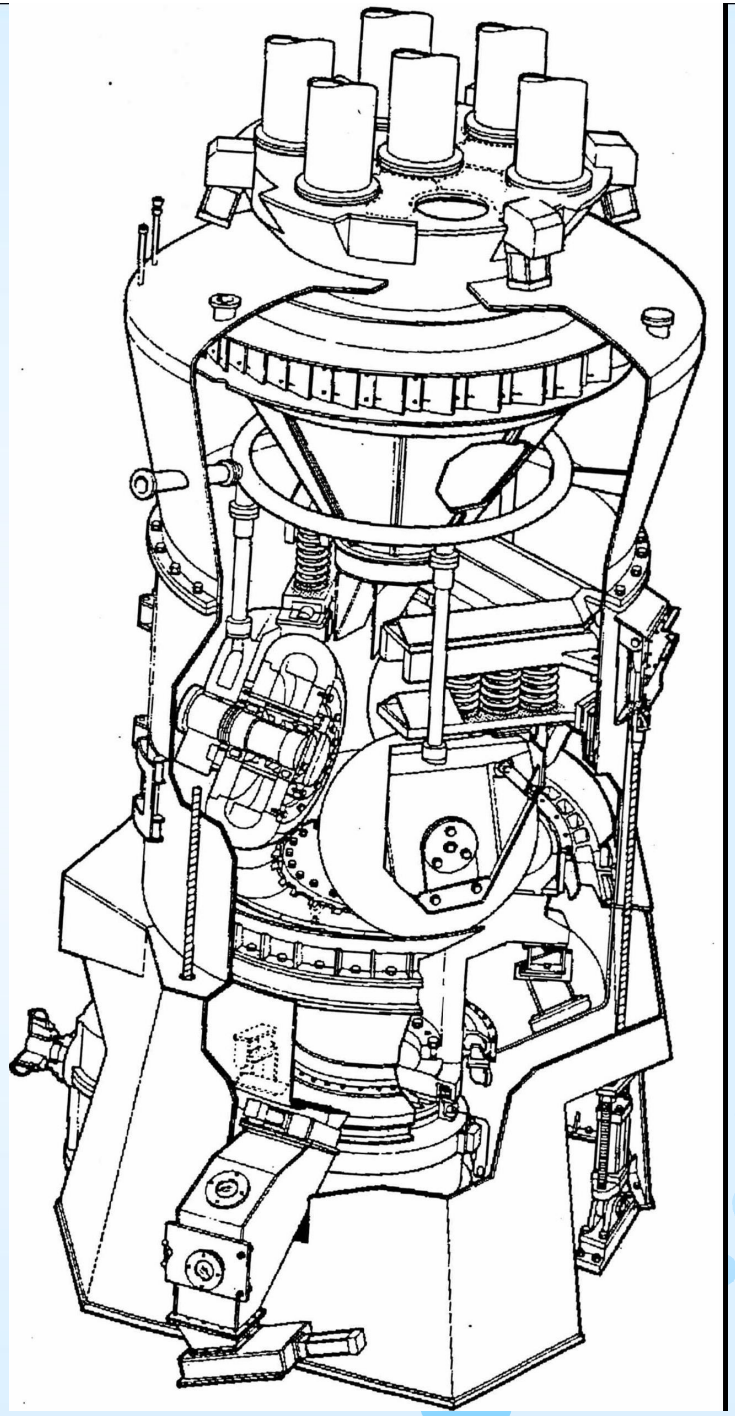
Consider Nitrogen/oxygen ratio

Pulverizers

Coal Flow
Air Flow
Coal Pipe Velocity
Outlet Temperature
Coal Fineness
Reject Material



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Pulverizers Dry and Grind

More Moisture
- Lower Outlet Temp

Lower Kg/Kcal
- Higher Tonnage Rate
- Higher PA Flow

Moisture sensitive

only three values

High, Medium, Low

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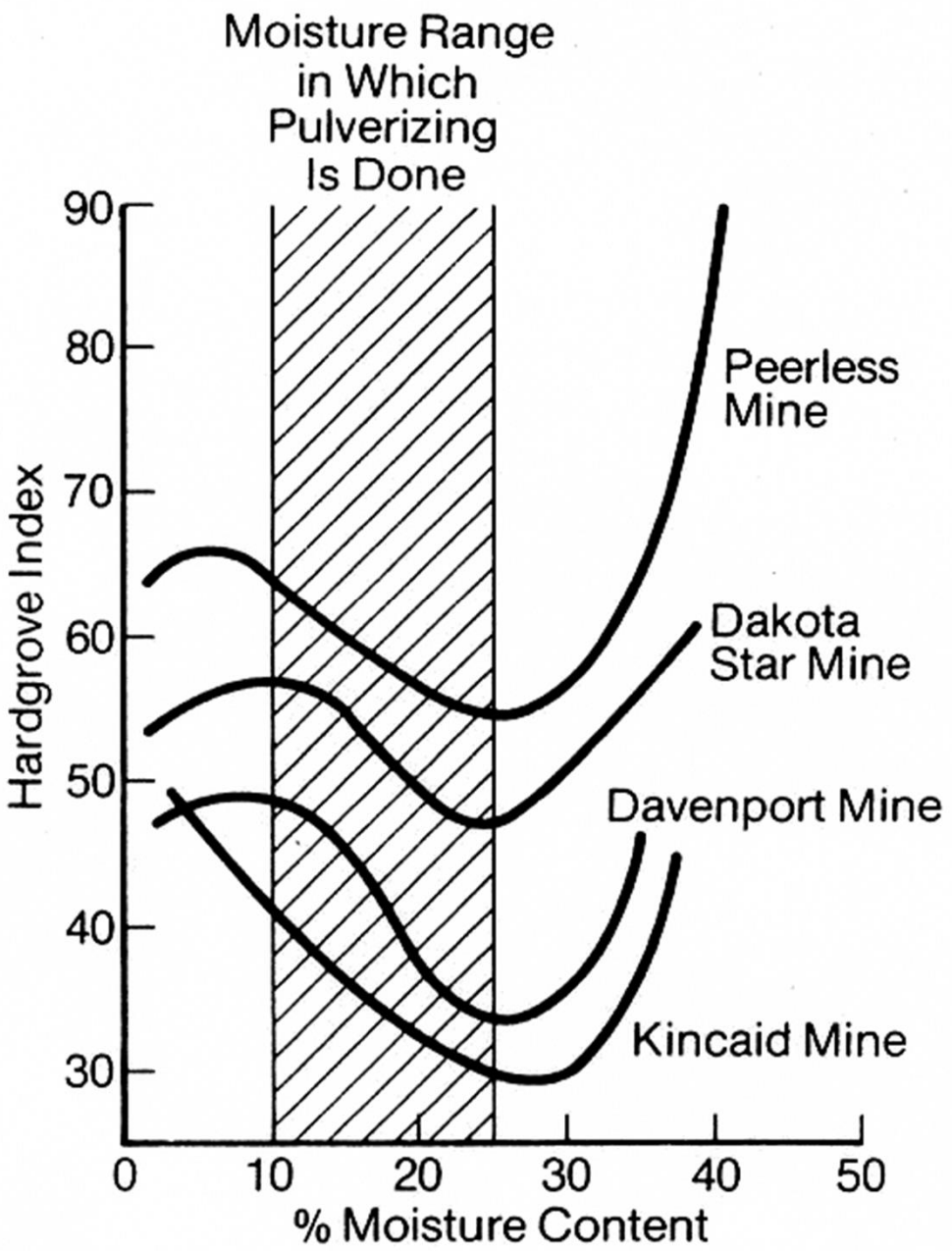
Why High Medium and Low work



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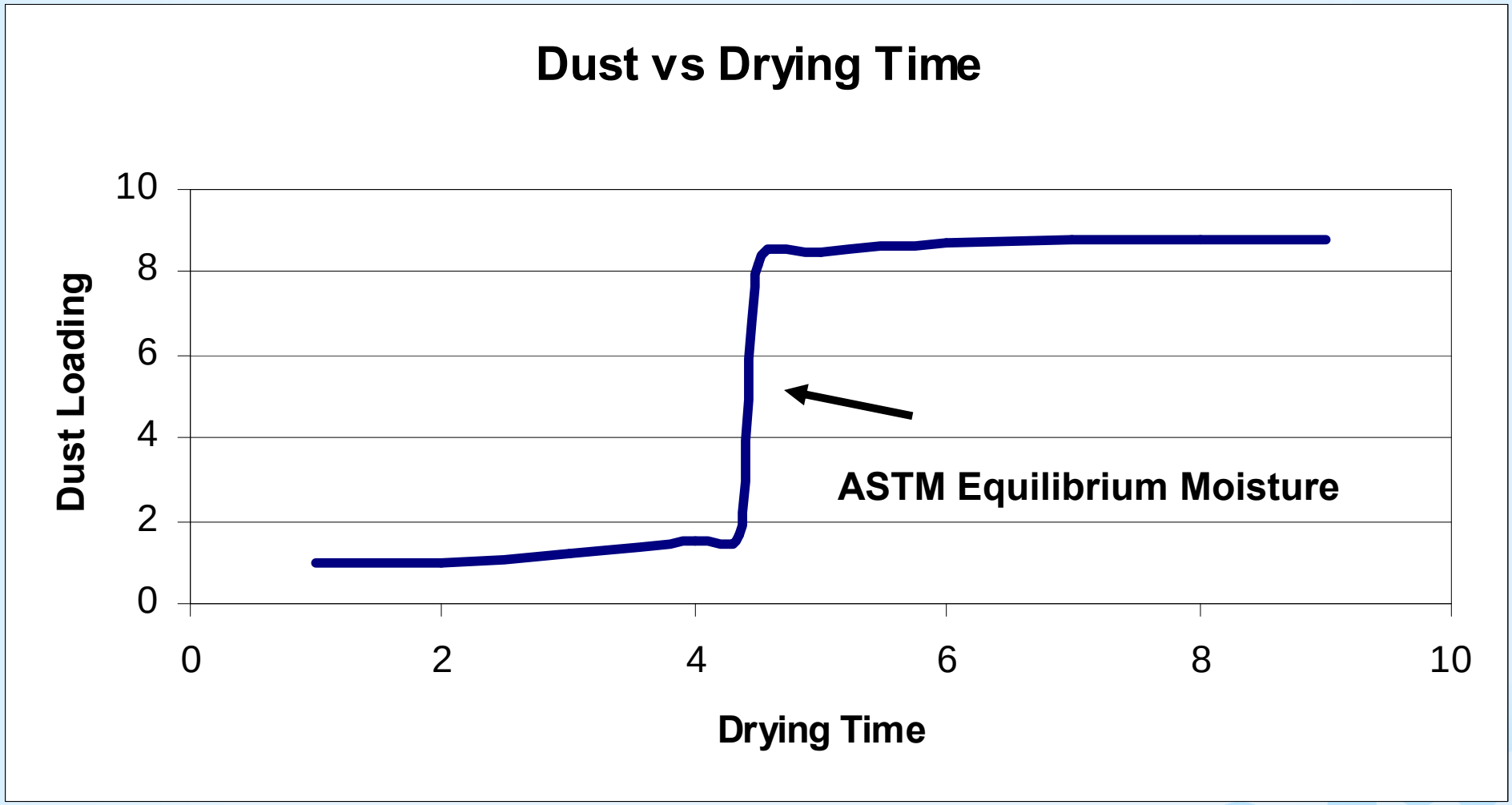

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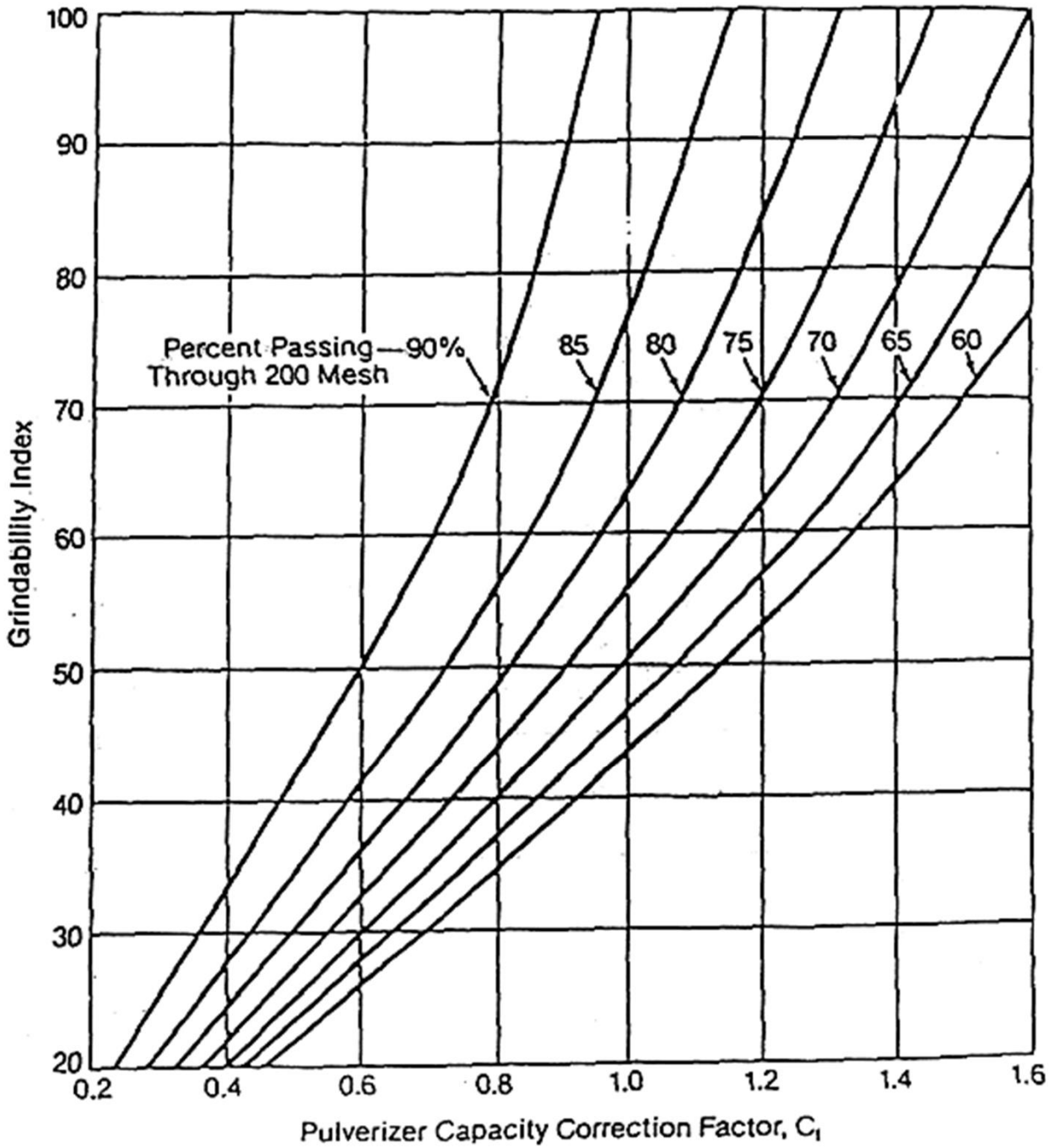
KEMA Research

Mill Capacity And HGI



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Pulverizer Capacity

~~HGI~~

CV

Moisture

Inlet Coal Size

Pulverized Coal Size

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What About Abrasion?

HGI does not Measure Abrasion.

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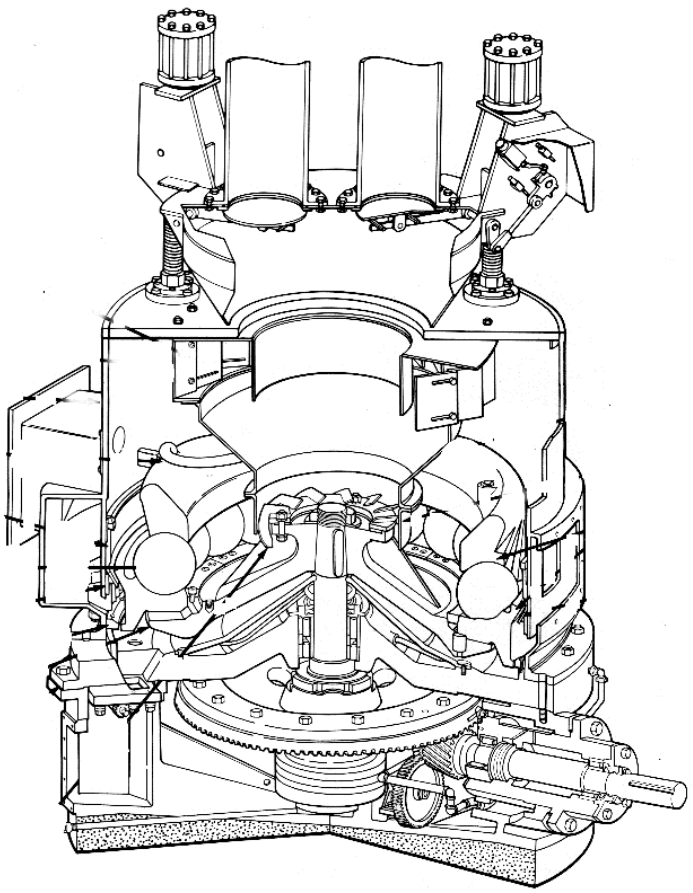
Ash Wears Them Out

Impacts load
High Maintenance
Performance Testing

“Most miners I know will sell you rocks at the price of coal.”



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Raask Quartz

%Quartz ~ SiO_2–1.5x Al_2O_3

% Quartz X Kg ash/MKcal =

Kg Quartz per Million Kcals

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Sizing

Set for Coal type
Set for Slag control

May be opposite directions

LOI

Loss on Ignition

Represents unburnt Carbon

Fluid Bed needs C%

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Coal Size
Excess Air
Amount of Ash

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Excess Air impacts NOx is it balanced?

$$\frac{1.5 + 3.5}{2} \neq 2.5$$

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Amount of Ash

more ash =
lower LOI
but not better
combustion

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Thank you!

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