May 7-10, 2017 Wigwam Resort Phoenix, AZ, USA

2017 HAULAGE & LOADING EXHIBITION AND CONFERENCE

Shovel-based Fragmentation Analysis of ROM to Improve Blast Planning

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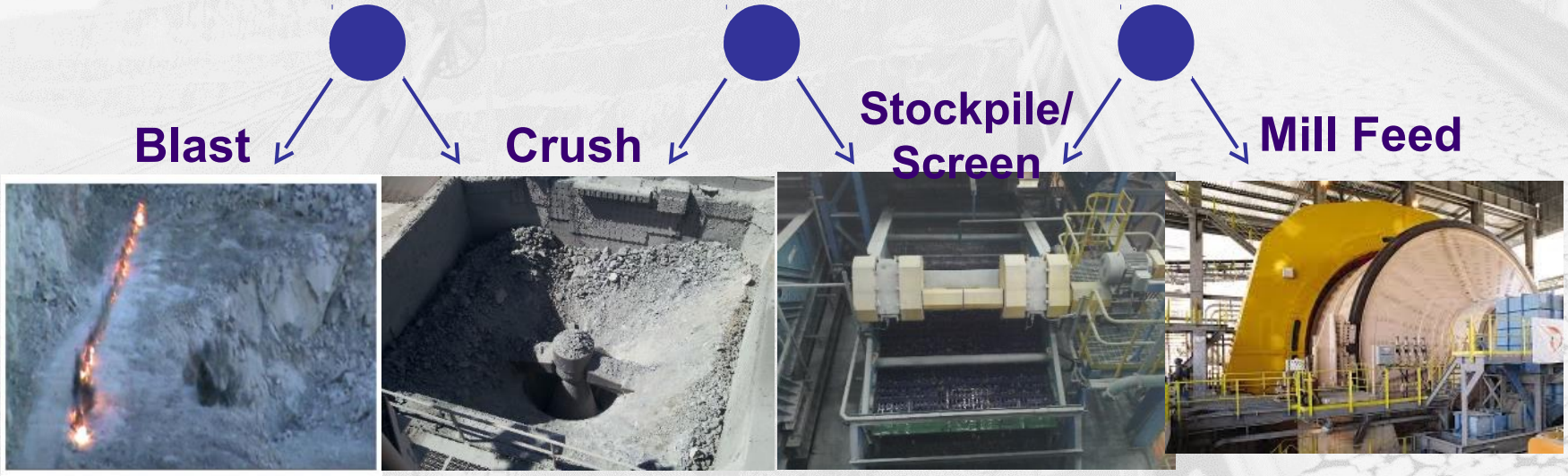
Topics of Discussion:

- Measure, Manage, Improve
- Mine site background and rock types
- Energy Factor (EF) by rock type
- Desired (PSD) Particle Size Distribution
- Mine blasting engineers use blast patterns in their short-range planning and downstream throughput.
- Shovel-based and conveyor belt PSD analysis system used

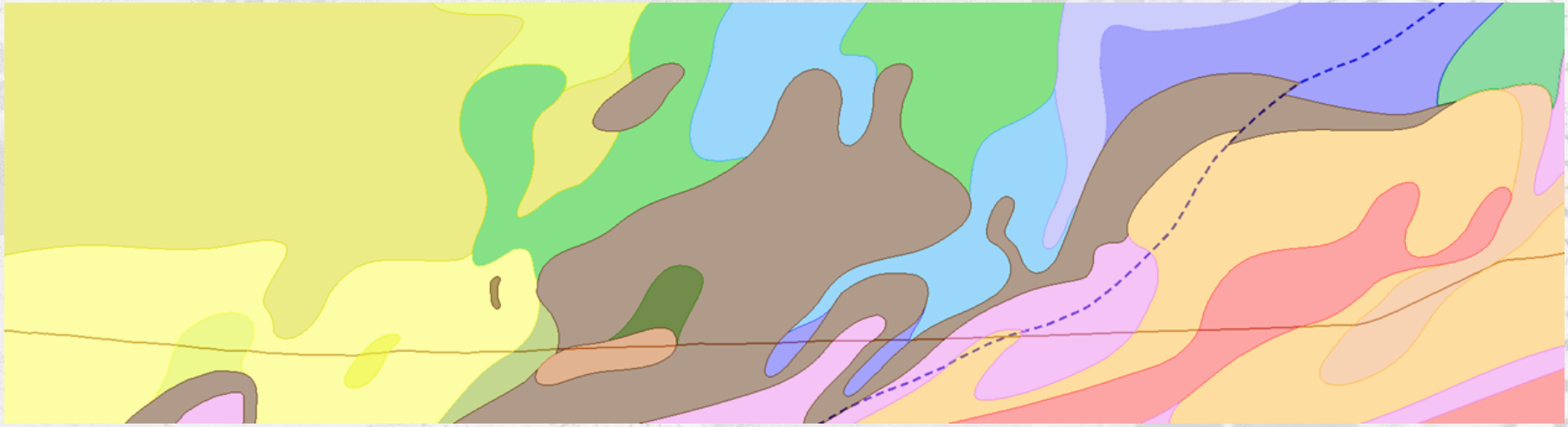
Measure, Manage, Improve



Maximize blasting, crushing, conveying and throughput effectiveness for your mine and mills.

Site Location Aerial View of Mine

Rock Types in Pit Walls



A series of interbedded skarns and altered silicious rocks with variable alteration and sulfide mineralogy

Rock Types

Marble

Massive garnet tactite

Green garnet tactite

Wollastonite Tactite

Rock Types

Quartzite

Diopside tactite

Siltstone

Siltstone with anhydrite

Rock Types

Argillite

Argillite

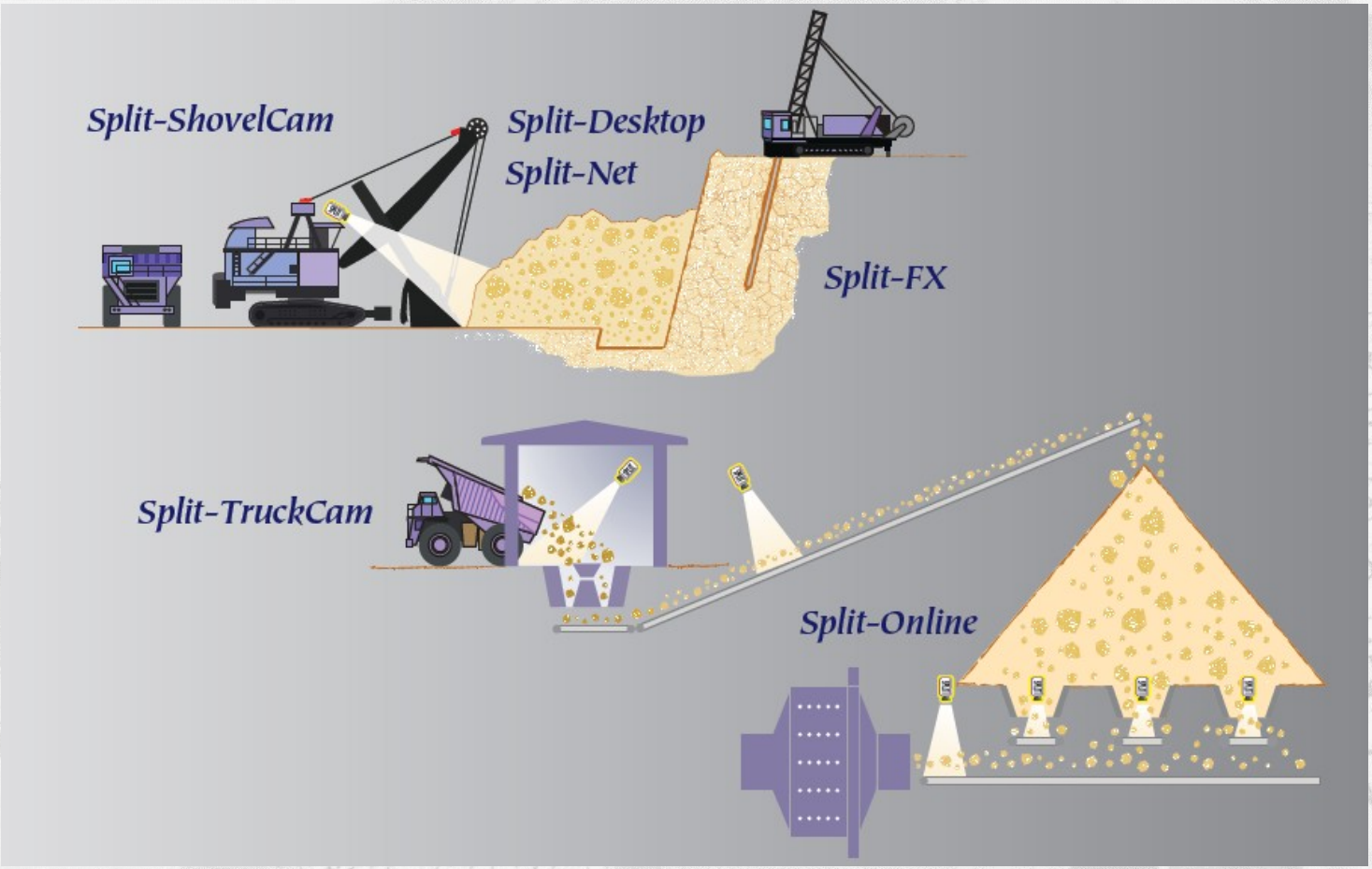
Quartz monzonite porphyry

Alluvium

Major Ore Types

Ore Typ		
Argillit		
Argillite Congl		

Measure and Manage Fragmentation from Muck Pile to Mill to Maximize Throughput and Profits



ROM Post-Blast Fragmentation

- Important feedback to mining and blasting, only place for feedforward information for downstream operations.

Blasting

- Blasting is conducted 5 days a week M-F and as needed on weekends.
- Average pattern size is 75-90 holes
- 2,538 tons/hole average
- Target ROM P80 is 6-9-inches

Spacing:

Staggered – Equilateral

30’ x 35’ softer material or waste

20’ x 25’ or 25’ x 30’ harder material

Stemming:

- North Mill Ore & South Mill Ore:
  - 18’-24’ stemming
  - Goal is generate fines to maximize throughput and for the SAG mill to generate coarse oversize in the stem zone for “grinding media.”
  - Different philosophy – usually to enhance throughput is maximize fragmentation.

Energy Factor:

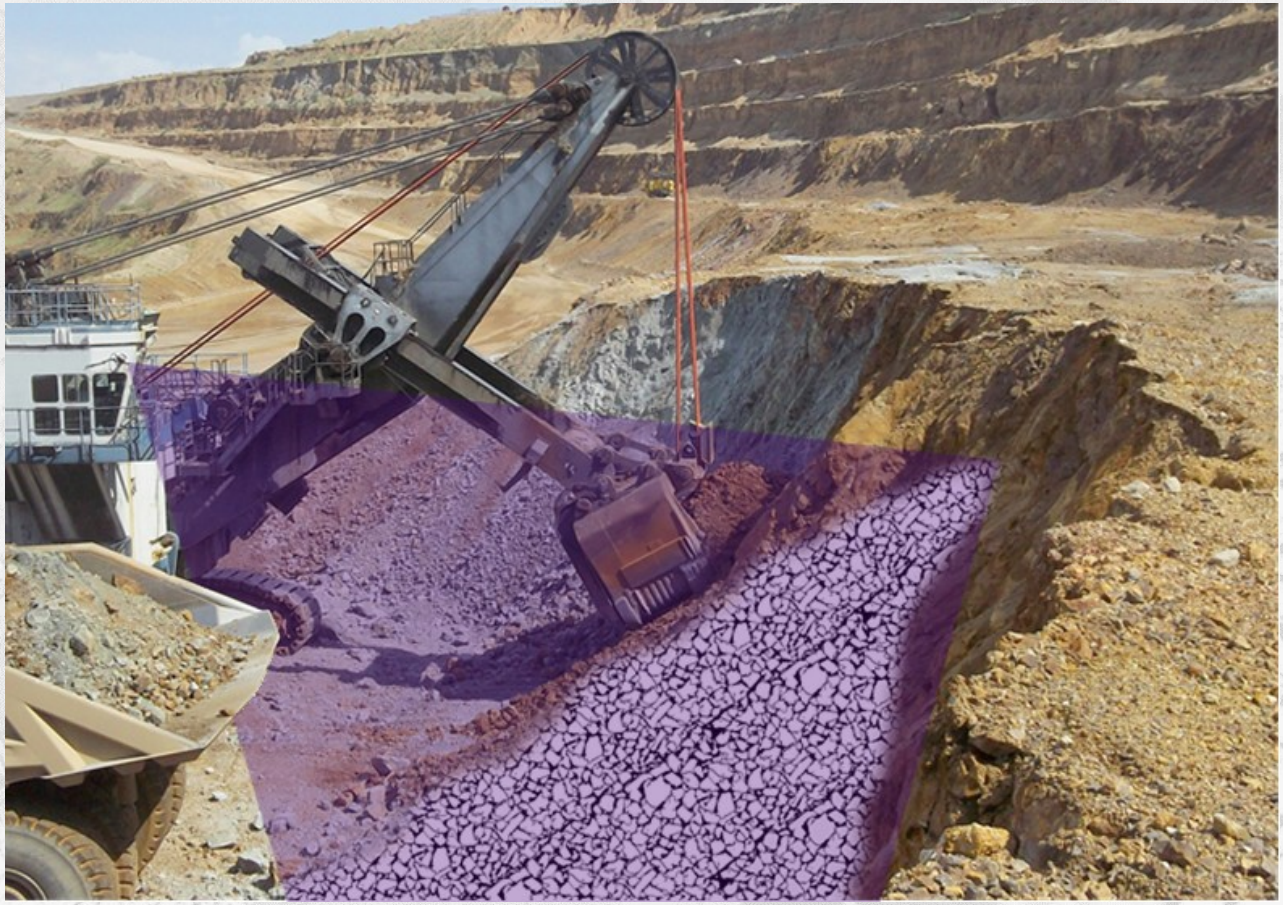
Explosive energy used to break the rocks, measured in kCal/ton.

<u>It is calculated using</u>:

Hole spacing (burden and spacing)
Hole diameter
Number of holes
Density of blasting product
Tonnage factor of rock types

Split-ShovelCam®

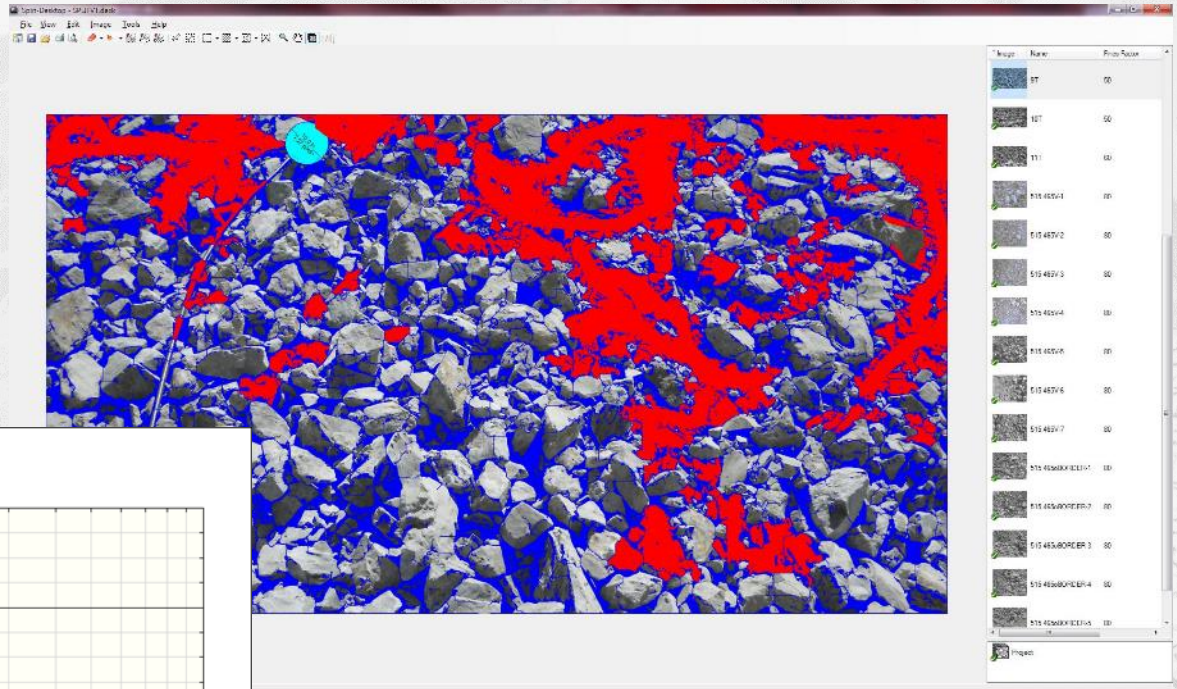
- Real-time post blast fragmentation measurement.
- Monitor your muck pile PSD and optimize blast design for mine to mill.
- Where do you measure your fragmentation?

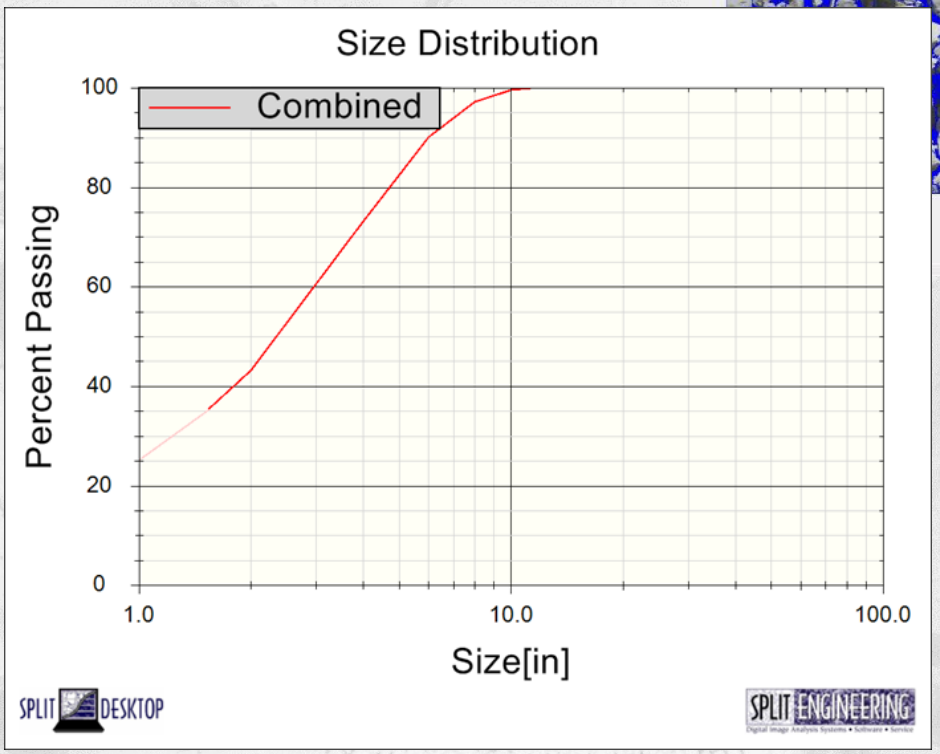


Mission's - Measure, Manage, Improve

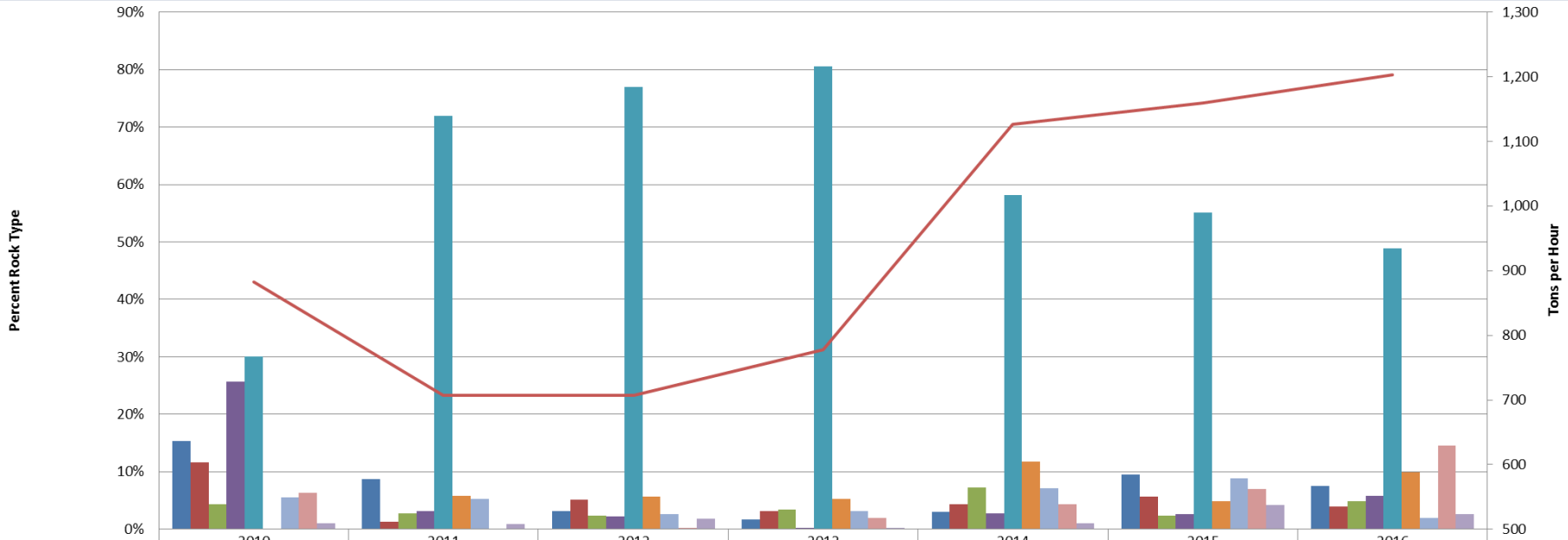
P80 Goal: 6-9 inches

P80 = 80% passing particle size of a square screen measured in inches.





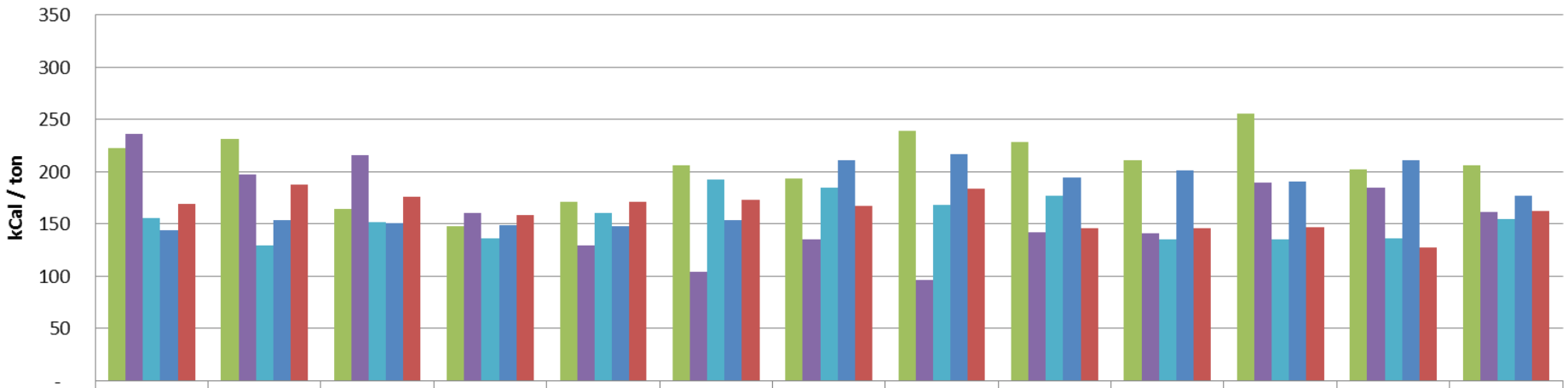
Asarco - Mission South Mill Rock Types



	2010	2011	2012	2013	2014	2015	2016
Garnet Tactite	15.3%	8.7%	3.1%	1.7%	3.0%	9.5%	7.6%
Diopside Tactite	11.6%	1.3%	5.1%	3.2%	4.3%	5.7%	3.9%
Quartzite	4.4%	2.7%	2.3%	3.4%	7.2%	2.3%	4.8%
Qtz Monz Porph	25.7%	3.1%	2.2%	0.3%	2.8%	2.6%	5.8%
Argillite	30.0%	71.9%	77.0%	80.6%	58.2%	55.1%	48.9%
Arkose	0.0%	5.8%	5.7%	5.3%	11.8%	4.8%	9.9%
Marble	5.6%	5.3%	2.6%	3.1%	7.1%	8.8%	1.9%
Siltstone	6.4%	0.1%	0.2%	1.9%	4.3%	7.0%	14.6%
Epidote Tactite	1.0%	0.9%	1.8%	0.3%	1.1%	4.2%	2.6%
TPH	883	707	707	778	1,126	1,159	1,203

The change in the rock type blend (lower BWI / hard ore) and the expansion of the mill resulted in a tons per hour increase over the last 3 years.

Asarco - Mission South Mill Energy Factor



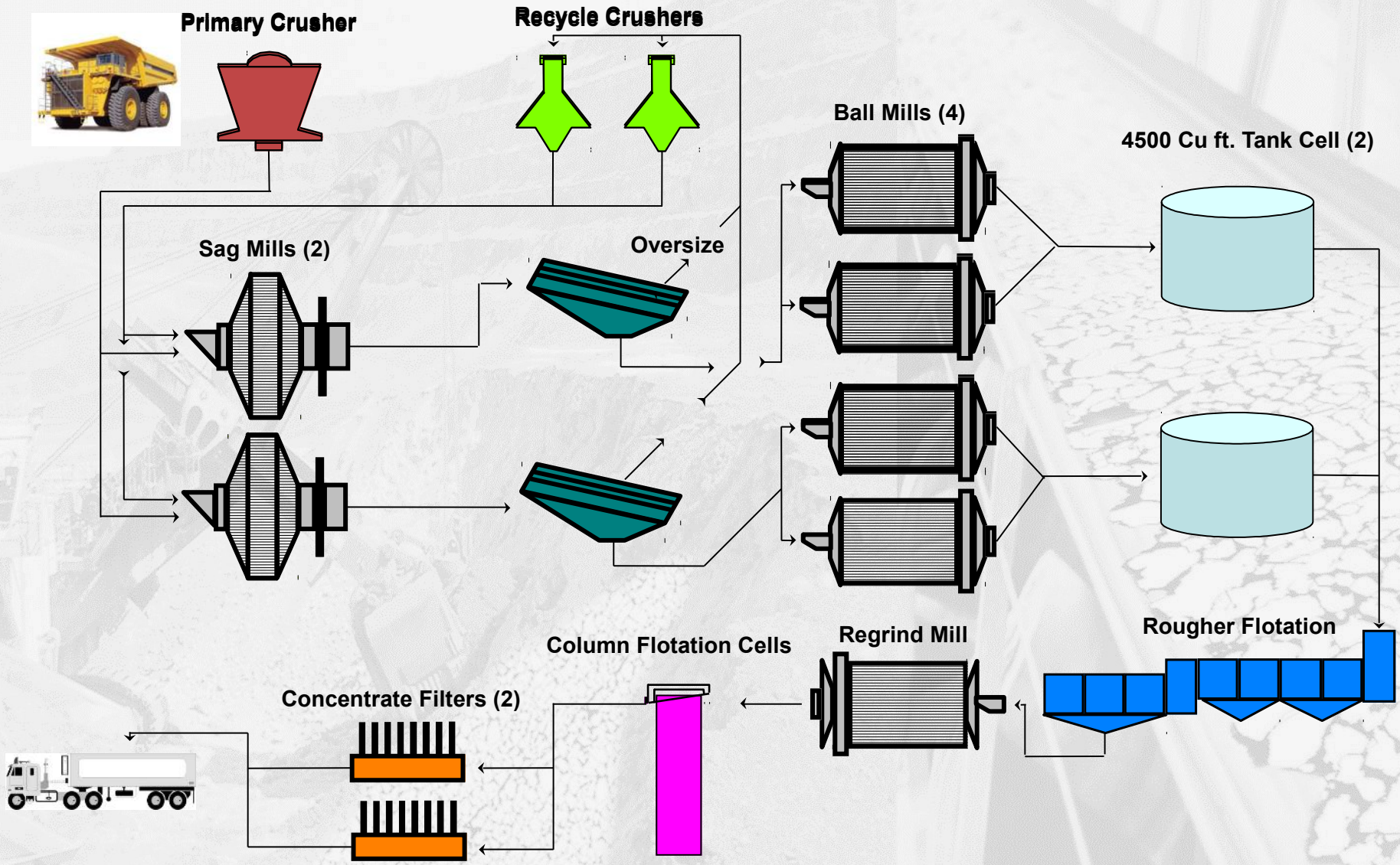
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YTD
2012	222	232	164	148	172	207	193	239	228	211	256	202	206
2013	237	197	216	161	130	104	136	97	142	141	189	185	161
2014	156	129	152	136	160	192	185	169	177	135	135	136	155
2015	144	154	151	149	148	154	211	217	194	201	190	211	177
2016	169	188	176	159	171	173	167	184	146	146	147	128	163

Year	Ave EF	% Change
2012	206	
2013	161	-21.8%
2014	155	-3.7%
2015	176	+13.8%
2016	163	-8.0%

Much work went into identifying the explosive energy for optimal mill throughput, seems that ~164 Kcal/ton

Asarco - Mission South Mill

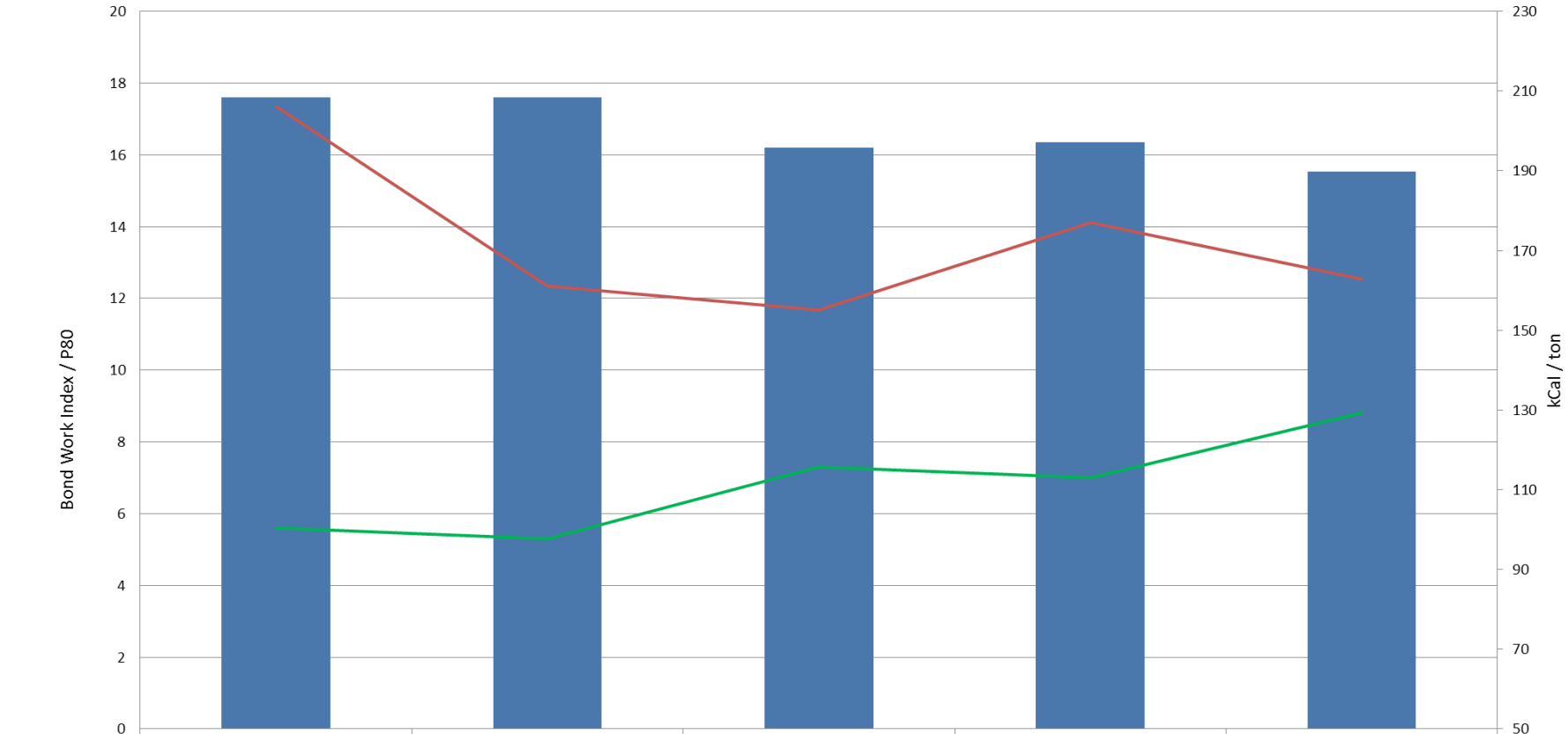
South Mill Flow Sheet



Split-Online® Automated Particle Size Analysis

Split-Online system provides real-time analysis data for operators to maximize effectiveness of crushing, conveying and screening by measuring particle size distribution, shape and color to improve key product yield, operating efficiency and product quality.

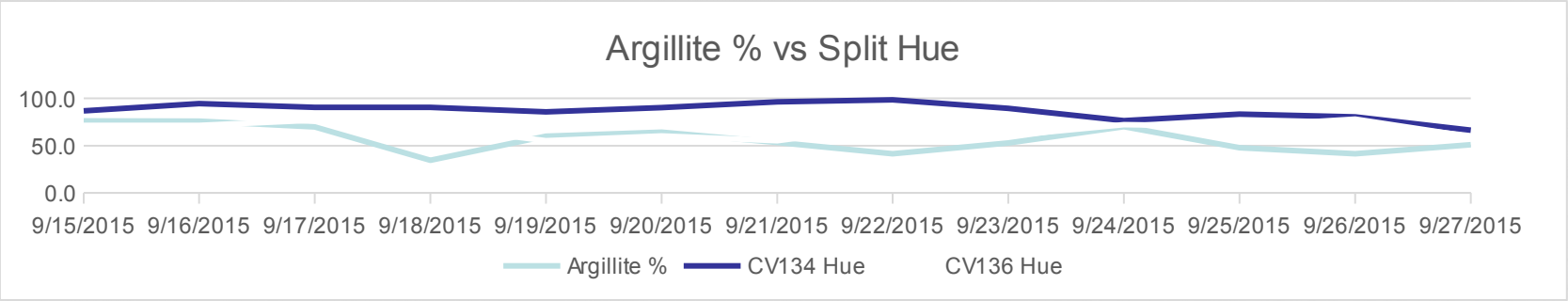
South Mill BWI vs EF and P80

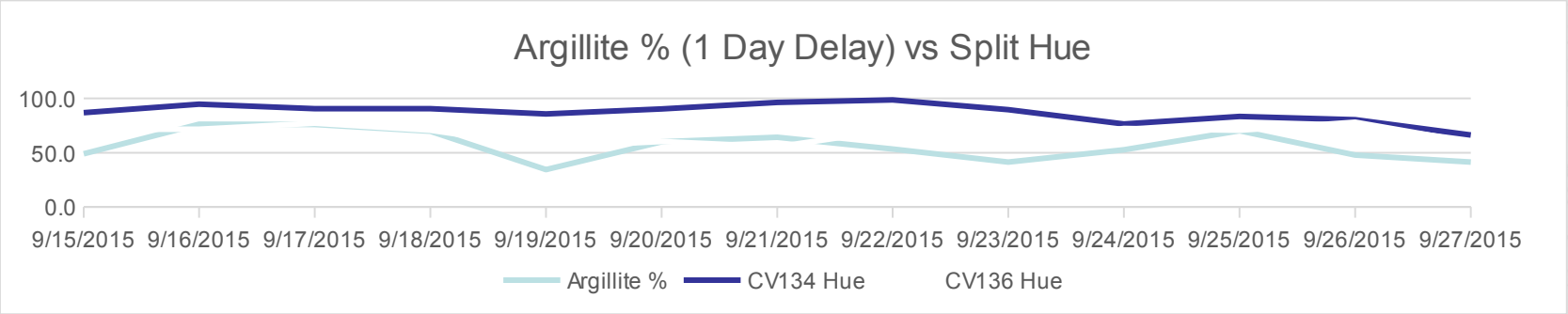


	2012	2013	2014	2015	2016
BWI	17.6	17.6	16.2	16.4	15.5
P80	5.6	5.3	7.3	7.0	8.8
Energy Factor	206.0	161.0	155.0	177.0	162.8

As the energy factor decreases, the rock size increases.

Color HSL Tracking with Image Analysis





Using color analysis in the Split-Online system we are able to correlate ore types to mill feed and throughput. Tracking the material PSD and color from Mine to Mill.

SPLIT ENGINEERING
Digital Image Analysis Systems • Software • Service

Thank You!
Questions?

Experience in the Mining Industry!

Split Engineering is the world leader in providing proven digital image technology to calculate the size distributions of fragmented rock. Established in 1997, with more than 160 Split-Online systems, 645 camera installations at over 119 different client sites worldwide in the base and precious metal mining and aggregate industries.