WipWare®

Sampling and Analysis Guide

Last Updated: June 29, 2021

WipWare Account Information

DATE ______________________

COMPANY ______________________

USERNAME ______________________

PASSWORD ______________________

Safeguard your account information, Notify WipWare MailFrag Services if you cannot login or your account security has been compromised.

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1.0 Introduction

Thank you for choosing WipWare's WipFrag/MailFrag Service; an economical and rapid method of collecting bulk material size and shape information.

This user's manual will cover:

- What is WipFrag/MailFrag Service?
- Developing a sampling strategy
- Collecting quality image samples
- Analyzing images using WipFrag
- How to submit MailFrag images
- Interpreting particle size data
- Frequently Asked Questions
- Pricing and service terms

1.1 Notice

The collection of image samples in today's productivity driven industrial environments can be challenging, however, there is no reason that it cannot be done safely.

Caution: Working near unconsolidated material can be dangerous as it may shift or settle without warning.

Warning: Observe site specific rules and regulations at all times.

1.2 Disclaimer

The information contained herein is based on experience and is believed to be accurate and up to date as of the date of its preparation. However, uses and conditions of use are not within the manufacturer's control and users should determine the suitability of such products and methods of use for their purposes. Neither the manufacturer nor the seller makes any warranty of any kind, express or implied, statutory or otherwise, except that the products described herein shall conform to the manufacturer's or seller's specifications. The manufacturer and the seller expressly disclaim all other warranties, INCLUDING, WITHOUT LIMITATION, WARRANTIES CONCERNING MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Under no circumstances shall the manufacturer or the seller be liable for indirect, special, consequential, or incidental damages including, without limitation, damages for lost or anticipated profits.

2.0 What is WipFrag / MailFrag Service?

WipWare's WipFrag software allows you to open and analyze your own images. WipWare's proprietary edge detection is used to render a polygon network around each particle to instantly generate fragmentation results.

WipWare's MailFrag Service allows you to send your images to us for analysis by our trained experts using WipFrag. We will analyze the images and send back the fragmentation results within 2 business days.

2.1 Outputs Received

WipFrag

Every analysis you perform is saved as an analysis file (ANA). You can also save the charts and merged results as PDF, PNG, or CSV. Using WipFrag, you can merge any number of results in any way you wish.

MailFrag Service

Analysis files can be submitted for MailFrag from within WipFrag 4. Our qualified technicians will perform the analysis and return the completed ANA to you via our built-in cloud synchronization.

2.2 WipFrag Process

Below is a simple overview of the WipFrag process:

1. Download WipFrag software.
2. Create/Log in to WipWare account (free of charge).
3. Open an image.
4. Set the scale.
5. Generate the edges.
6. Purchase/Use image analysis credits or annual subscription.
7. View the results.

2.3 MailFrag Process

Below is a simple overview of the MailFrag Service process:

1. Download WipFrag 4 software.
2. Create/Log in to WipWare account (free of charge).
3. Open an image.
4. Set the scale.
5. Purchase/Use image analysis credits
6. Submit image for analysis.
7. Allow up to 2 business days for results to be made available.
8. View results in WipFrag 4.

3.0 Developing a Sampling Strategy

It is critical to develop a good sampling strategy prior to undertaking any scientific study; failure to do so may compromise your project's validity. The purpose of developing a strategy is to create a set of systematic and unbiased rules that will be followed for the duration of the study, if these rules are properly developed you will avoid the frustration of an inconclusive study result.

Both WipFrag and MailFrag service are capable of analyzing any number of image samples; if you image each particle in the material, the analysis would be 100 percent representative. Since that is not practical for most applications we need to develop a method of systematically acquiring smaller samples that represent the characteristics of the material as a whole.

3.1 Sampling Methods

All sampling strategies should aim to control as many variables as possible; however, we sometimes need to make concessions at the expense of data quality. When selecting the sampling team personnel, special care must be taken to ensure availability to execute the sampling method you select (day/night/cross-shift/weekend etc…); ideally each of these "sample collectors" must also train and use the same equipment in the same way (same camera, lens, zoom, lighting, scale, perspective, exposure, resolution etc…) to achieve the best results.

When trying to determine which method is suitable you will need to ask yourself:

- What percentage of the material do I need to be statistically valid?
- What percentage of the material does each image sample contain?
- Are material characteristics expected to change throughout the sample?
- How important are the decisions you will be making based on the results?

There are many different ways to sample. It is often important to record the sampling methodology for future reference, possibly to defend the results; the balance between representativeness versus ease of sample collection must be determined.

Simple Random Sampling:

Simple random sampling involves the use of an eligible randomizer to generate the sampling parameters. This method is very good as long as it eliminates human bias.

EXAMPLE: rolling dice to determine how many samples will be taken each day and at what time.

Systematic Sampling:

Systematic sampling involves a strict time interval sampling regardless of circumstance. With reasonable frequency this method is typically superior to all other sampling methods as it is by definition systematic.

EXAMPLE: collecting one sample every X minutes.

Stratified Sampling:

If there are multiple versions of the material in similar volume then stratified sampling may be suitable. Stratified sampling involves taking equal number of random samples from each version of the material. This method is good if all versions of the material have similar volumetric proportions relative to the whole, otherwise it is a poor selection as it may overrepresent the smaller population and underrepresent the larger.

EXAMPLE: collecting a random but equal number of samples from each version of the material.

Probability Proportional to Size Sampling:

If there are multiple versions of the material in dissimilar volume then probability proportional to size sampling may be suitable. Probability proportional to size involves taking proportion corrected number of random samples from each version of the material. This method is good if the volumetric proportions can be accurately estimated; otherwise over/underestimation may occur.

EXAMPLE: collecting a random but proportion corrected number of samples from each version of the material.

Cluster Sampling:

Cluster sampling involves collecting multiple samples at specific time intervals. This method can be good if it is executed properly but has a significant probability of missing important material variation.

EXAMPLE: collecting X number of samples each day at X time.

Quota Sampling:

Quota sampling is considered non-probability sampling which involves the collection of a predetermined number of samples from select versions of the material. This method is generally not recommended for the purpose of material sampling because it is non-random and has a significant probability of missing important material variation.

EXAMPLE: collecting X number of samples from version A and Y number of samples from version B regardless of volumetric proportion.

Accidental Sampling:

Accidental, convenience or grab sampling is considered non-probability sampling which involves the collection of a sample whenever it is convenient. This is by far the most common and least desirable; it is non-random, non-systematic and has the highest probability of missing important material variation.

EXAMPLE: collecting a sample whenever it is convenient.

4.0 Collecting Quality Image Samples

The more you can establish standards and reduce variables the more consistent your images will be. *The better your images are, the better your results.*

Operators - The fewer personnel taking pictures the better, to avoid personal biases affecting sample procedure.

> "Some photographers will be drawn to the largest particles; others will select areas of uniform distribution," wrote Norbert Maerz in 'Image Sampling Techniques and Requirements for Automated Image Analysis of Rock Fragmentation' (1996).

Equipment - Use the same camera and lens where feasible.

Physical Setup - Camera position, camera height, and camera-to-subject distance should be standardized as much as possible.

Lighting - Use consistent lighting: Lighting geometry, light to subject distance, light height, lighting angle (relative to camera position) and lighting orientation (aiming).

Camera Settings – Try to standardize Aperture, Shutter, ISO, White Balance, Capture size & quality.

Sample Selection - Work in a systematic manner to capture statistically representative samples. Large drifts, or those containing primarily small particles, should be photographed in grid-like segments.

5.0 Equipment

5.1 Camera

Point & Shoot

Compact digital cameras can yield good images above ground in good lighting. Because the small image sensors in these cameras are inefficient at gathering photons in low-light situations, their performance drops off dramatically in the conditions common to underground photography. As ISO sensitivity is increased to compensate for low-light levels, the signal-to-noise ratio rises significantly, limiting the usefulness of the resulting images for photographic fragmentation analysis.

D-SLR

D-SLR cameras, with their larger sensors, are far more efficient at gathering photons in low-light situations, making them better suited to underground photography.

Cameras with 18 megapixel and even higher resolution sensors are common now, but the full-resolution files these cameras produce are far in excess of what is required for fragmentation photoanalysis. Choosing a smaller capture size will result in smaller files that analyze much faster.

2.5 MP capture – 1900 x 1300 pixels – 7MB file size

5MP capture – 2500 x 1800 pixels – 12.9MB file size

18MP capture – 5100 x 3500 pixels – 51.1MB file size

5.2 Lens

Understand that with many D-SLR cameras, the image sensor is smaller than traditional 35mm film, meaning that a 'crop factor' must be taken into account when discussing lenses. Typically, this crop factor is between 1.3x and 2x (consult your camera documentation to determine the factor for your particular camera body). The crop factor increases the *effective focal length* of all your lenses. For example, a 35mm lens on a body with a crop factor of 1.6 (typical of most non-pro Canon D-SLRs), would effectively become a 56mm lens (35 x 1.6 = 56).

Crop factors –
Canon Professional bodies – 1x to 1.3x
Canon Consumer bodies – 1.6x
Nikon Professional bodies – 1x to 1.5x
Nikon Consumer bodies – 1.5x
Olympus bodies – 2x
Pentax bodies – 1.5x

Avoid <u>effective</u> focal lengths smaller than 40mm for fragmentation analysis purposes. Effective focal lengths of 40mm-135mm are best.

Try to standardize camera-to-subject distance and focal length for more consistent results.

5.3 Filter

In the hostile conditions often encountered while capturing images for fragmentation analysis, it's a good idea to protect the front element of your lens from dust, moisture, scratches.

Use high-quality clear protective filters such as: B&W MRC (Multi-Resistant Coating), Hoya Pro 1 HMC (Hoya Multi-Coating), or Nikon NC (Neutral Colour).

Protective filters should be removed if shooting through glass or shooting a backlit scene to avoid loss of contrast and/or flare.

5.4 Tripod or Support

Using a tripod helps ensure sharp, consistent images and helps improve composition and framing. Tripods also permit the use of shutter speeds that might result in camera shake if hand-held, as well as permit the use of small aperture settings to increase depth-of-field.

5.5 Lighting

A pair of standard work lights on tall stands is a low-cost, readily available solution.

6.0 Camera Configuration & Settings

6.1 File Format

JPEG: The JPEG file format produces compressed files that occupy minimal disc space. Care needs to be taken to avoid overcompression, both in-camera and during post-processing. Avoid making changes and saving a JPEG file multiple times. With each 'save' operation, the file is recompressed and detail can suffer.

6.2 Capture Size

Set capture size in camera rather than downsize using image processing software (Photoshop, etc.). Less than 1.5MP provides insufficient detail – especially dependent on coverage area and material sizes. More than 5.0MP is excessive (slows software) and may require resampling, which if not done correctly can introduce artifacts.

6.3 Capture Quality

This refers to the compression setting that is used when creating JPEG files in-camera. Use the least amount of compression possible with your camera. Manufacturers use varying terminology to describe this feature such as; Good/Better/<u>Best</u>, or Normal/Fine/<u>Superfine</u>, or <u>Smooth</u>/Stepped. In each case the underlined term is the preferred setting to use.

6.4 White Balance

Not overly critical for this application. Auto White Balance can be used, or if using halogen work lamps, set white balance to Tungsten (Incandescent).

6.5 Focal Length

Choice of focal length can affect analysis results. Wide-angle lenses with effective focal lengths below 35mm should not be used due to perspective error; foreshortening between foreground and background will skew results. Corner and edge distortion inherent to wide angle optics will produce sizing inaccuracies. Using wide-angle optics also complicates light placement.

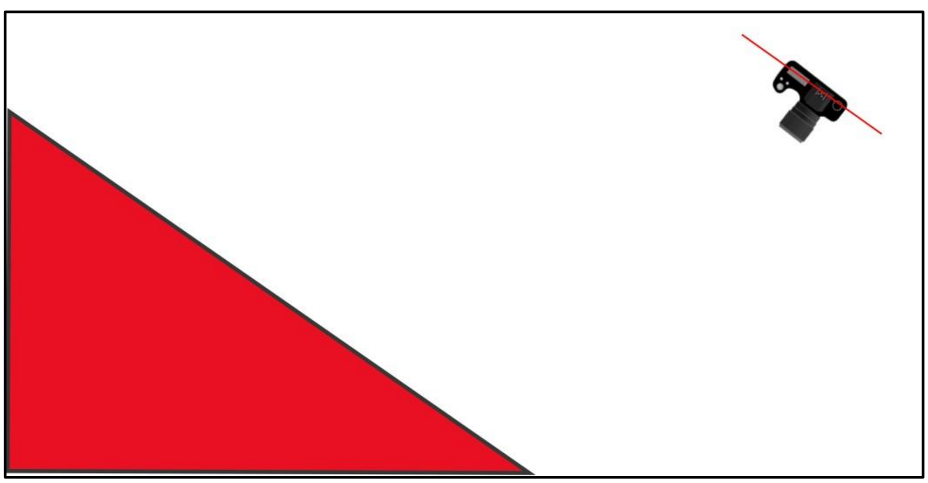
For muck piles, use the longest focal length that is practical in any given situation. Placing the camera further away from the pile and zooming in to fill the viewfinder with muck will yield the best results.

Below is a comparison of identically sized coffee mugs shot with telephoto (Figure 3-1) and wide-angle (Figure 3-2) to illustrate perspective distortion.

Figure 3-1: Telephoto

Figure 3-2: Wide-Angle

6.6 Point of View (Camera location)



If possible, elevate the camera position and orient the camera back parallel to the face of the muck pile. This approach will yield the best perspective on the pile and result in images that are more representative of the actual material being analyzed.

6.7 Composition

Fill your viewfinder with rock particles and avoid capturing surrounding areas such as tunnel roof, floor or walls underground, or areas of sky in outdoor images.

Below is an example of a composition that is too loose, which includes irrelevant areas (Figure 3-3) and one where the photographer has filled the viewfinder entirely with relevant material (Figure 3-4).

Figure 3-3: Wasted Area

Figure 3-4: Filled Area

6.8 Exposure Mode & Settings

Correct exposure yields an image that is not too light, not too dark. Three variables are Shutter Speed, Aperture, and ISO.

Shutter Speed

If not using a tripod or other support, you need a shutter speed fast enough to avoid camera shake. The hand-holding threshold will vary depending on effective focal length setting of lens. To determine the hand-holding threshold in any given situation:

1. Determine effective focal length: Multiply focal length (as indicated on lens barrel) by your camera's crop factor, typically 1X to 2X depending on camera model.
2. Create a fraction using the effective focal length as the denominator.
3. The shutter speed closest to this fraction is the hand-holding threshold for this situation.
4. Do not use shutter speeds slower than the result of Step 3.

EXAMPLE: lens set to 50mm on a 1.5X body…

1. *50mm X 1.5 = 75mm (Effective Focal Length)*
2. *1/75*
3. *Set shutter speed to 1/80 sec or faster.*

NOTE: *Some lenses are available featuring Vibration Reduction or Image Stabilization. These lenses can extend the hand-holding threshold by varying amounts. You should conduct tests to determine how this feature performs in specific applications with your equipment before deviating from the above formula.*

Below illustrates the comparison between a sharply-focused image (Figure 3-5) with one suffering from directional unsharpness caused by camera movement during exposure (Figure 3-6).

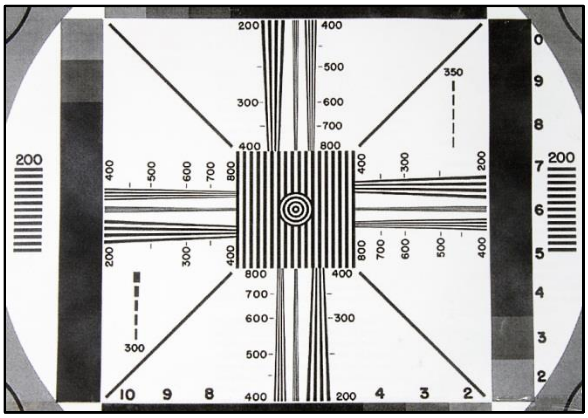


Figure 3-5: Sharply Focused

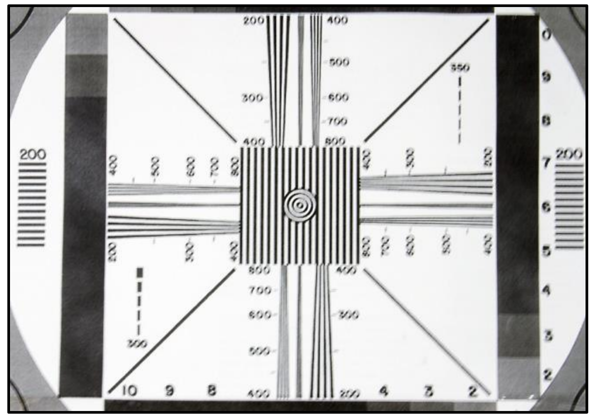


Figure 3-6: Motion Blurred

Aperture

You need to use an aperture setting that ensures adequate depth-of-field. This will vary depending on camera-to-subject distance, focal length setting and depth of material to be photographed.

Setting will typically be f8 or smaller (f11, f16 etc.). Aperture settings larger than f5.6 (f4, f2.8 etc.) may not provide sufficient depth-of-field to hold all particles in sharp focus.

Use Aperture Priority mode and set aperture to f8. Make note of the shutter speed the camera chooses and determine if it is fast enough to prevent camera shake. If not, you need to use camera support or adjust ISO upwards.

Images below illustrate the effect of the aperture setting on depth-of-field, where a wide aperture setting of f3.5 allows only the point-of-focus to remain sharp (Figure 3-7), while a small aperture setting of f11 produces a deeper field of sharp focus (Figure 3-8).

Figure 3-7: Wide Aperture (f3.5)

Figure 3-8: Small Aperture (f11)

ISO

You should use the lowest ISO setting that is adequate in any given situation. Noise increases with higher ISO settings. If, after setting the aperture, your shutter speed is too slow to hand-hold, adjust ISO setting upwards until shutter speed meets or exceeds the hand-holding threshold. If ISO cannot be raised high enough to permit a safe hand-holding shutter speed, you must use camera support (tripod, etc.).

Below is an image shot with a low ISO setting of 100 (Figure 3-9) and one shot with a very high ISO setting of 12,800 (Figure 3-10). Note the appearance of grain-like noise throughout the image with the high ISO setting (Figure 3-10).

Figure 3-9: Low ISO (100)

Figure 3-10: Very High ISO (12,800)

7.0 Lighting

7.1 Considerations

There are three primary considerations for lighting – Intensity, Uniformity and Contrast.

Intensity

Intensity is important only if hand-holding the camera. Intensity must be sufficient to permit a fast enough shutter speed to overcome camera movement during exposure which will cause loss of sharpness. Using a tripod is one of the best ways to improve both capture sharpness and ensure segmented coverage of a large pile.

Uniformity

If a large area is lit with a single light there will be a falloff of intensity towards the edges compared to the center. Falloff can also occur between the front and back of a muckpile. If exposure is based on the intensity of illumination in the center/front of the field (as it should), material at the edges/back may be underexposed, hampering analysis.

The farther a light source is located from the subject, the more even its illumination will be. When lights are used in close proximity to the material, intensity may vary considerably, with objects farther from the light source receiving significantly less illumination.

Images below illustrate the comparison between an image where light falls with even intensity on both rocks and the background (Figure 4-1) and an image where the light source is moved closer to the subject (Figure 4-2), causing objects located at varying distances from the source to receive significantly different intensities of illumination.

Figure 4-1: Distant Light Source

Figure 4-2: Near Light Source

Contrast

Photographic fragmentation analysis is dependent on contrast between rock particles and the shadows between the particles. If contrast is too high, surface texture of individual particles may result in the software interpreting them as multiple smaller blocks. If contrast is too low, shadows between blocks may be absent and the software may misinterpret small particles as larger single blocks.

Excessively high contrast is common when using artificial light underground or low-angled sunlight above ground. Avoid use of on-axis artificial light which tends to throw shadows behind the particles creating low contrast conditions. Similarly, when working above ground, heavily overcast skies can produce low contrast images.

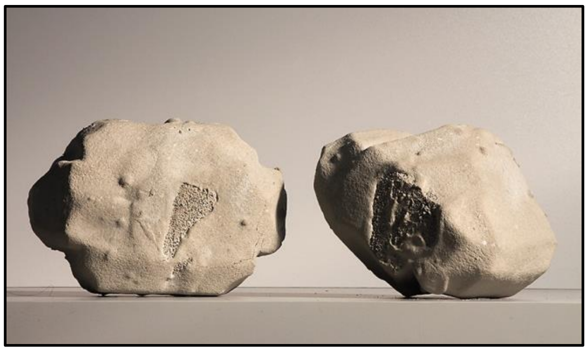


Figure 4-3: High Contrast

Figure 4-4: Low Contrast

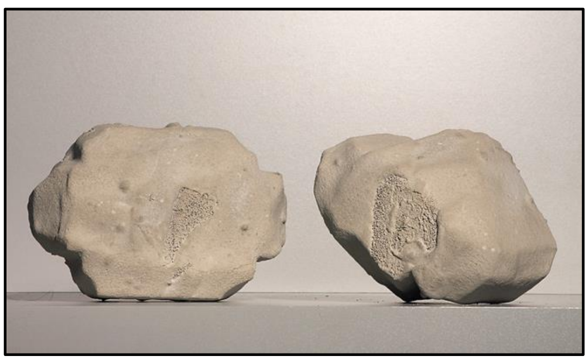


Figure 4-5: Normal Contrast

7.2 Shadows

Lighting is arguably one of the most important factors for photographs destined for fragmentation analysis software. Lighting determines shadow formation. In an ideal image, particles are clearly delineated by soft shadows.

If shadows are too strong (dark), analysis suffers. This is typical of images taken with a single off-camera light. Shadows will fall to one side of the material, and in the absence of fill light may be dark enough to obscure material or may be mistaken for particles.

If shadows are absent, analysis suffers. This is typical of on-axis light such as the camera’s built-in flash, where the shadows fall behind the material and are hidden from view.

7.3 Lighting Gear

The light source that many new users attempt to employ is on-camera flash, whether the camera's built-in flash or a hot-shoe mounted accessory flash. Unfortunately, when the light is coming from the camera position, the shadows are cast BEHIND the subject. Form and texture are obscured. Think in terms of the difference between an on-camera flash lit picture of a friend and a professionally-lit portrait. In the first example, there are no shadows and the subject looks 'flat', while in the second, controlled shadows bring three-dimensional modeling to the face.

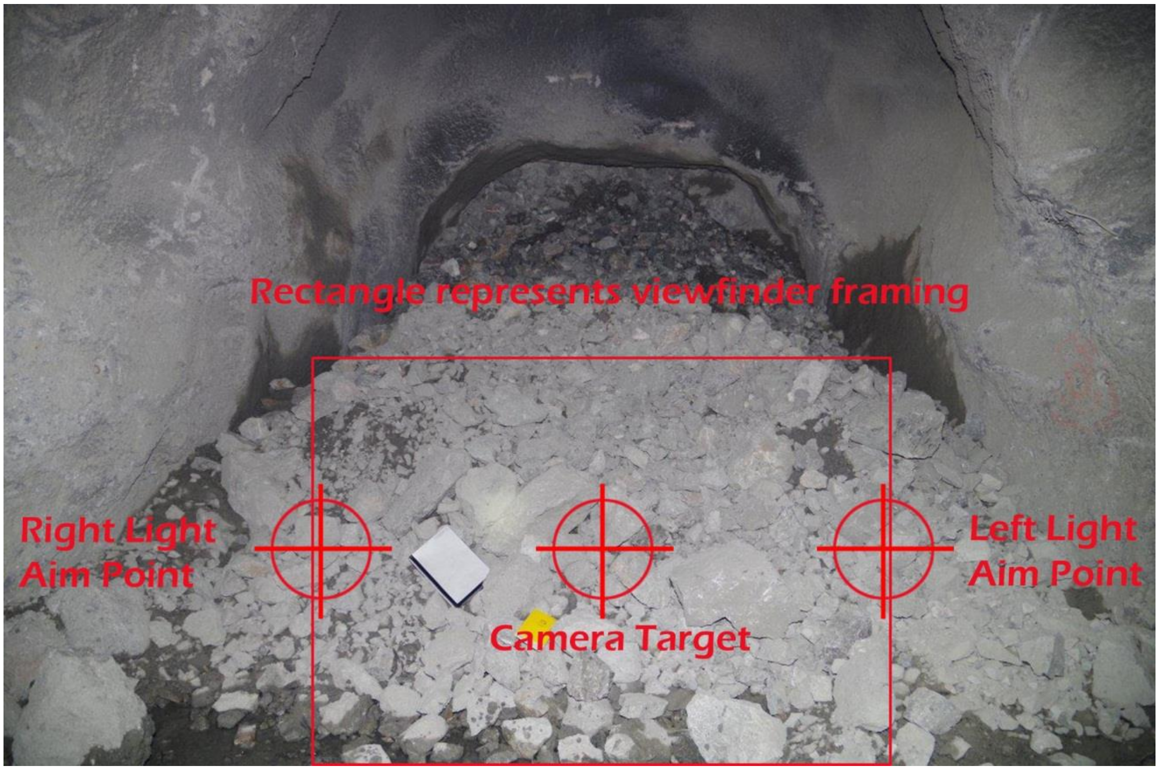
Ideal lighting is difficult to achieve underground without use of supplementary lights.

A pair of 500W or greater single-head halogen work lights on stands is inexpensive, portable and effective. Look for units with support stands that go as high as possible. The more common dual-head units can produce multiple shadows that may affect analysis. Remove the protective cage as it will affect even illumination.

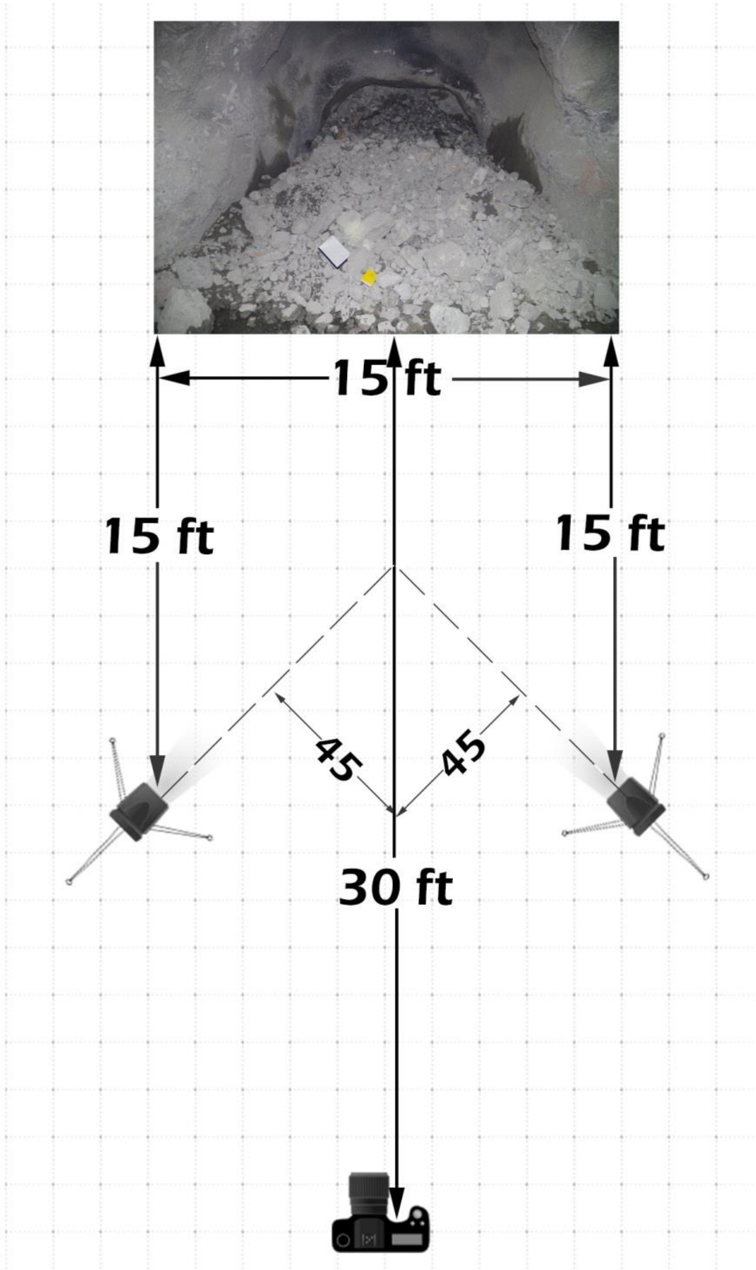
If low-power lights are used or powerful lights are used at considerable distance, the resulting shutter speeds may require camera support.

Long-life, energy-efficient LED work lights are available but tend to be more expensive to purchase.

7.4 Light Placement



- Position lights equal distances to left and right of camera position and as far apart as possible.
- Position lights as high as possible.
- Aim light on right towards left edge of drift (approx. 45 degrees from lens axis).
- Aim light on left towards right edge of drift (approx. 45 degrees from lens axis).
- Crossing the lights in this manner will produce the most even illumination, reducing 'hot-spots'.
- If lighting angle is less than 15 degrees from lens axis, shadow formation will be less than ideal.
- If lights are positioned too close to the muckpile, the resulting fall-off in intensity will mean that particles near the back of the pile receive significantly less illumination than the front of the pile. As light-to-subject distance increases falloff is reduced.



Lighting Placement Diagram

For example, let's say you want to capture a 15-foot wide drift in a single image. If you're using a D-SLR with a crop factor of 1.6 and a lens set to 35mm (effectively 56mm), the camera would need to be positioned approx. 30 feet from the front of the drift in order to fit the drift in the frame from edge-to-edge.

In this scenario your lights should be no closer than 15 feet from the front of the drift (45-degrees). Farther is better. Even with lights placed at 15ft, the back of the pile will receive one f-stop less light than the front. By metering the center of the drift, acceptable images should be obtained. With lights placed at 30 feet (15-degrees), there would be no difference whatsoever in brightness between front and back of the drift. Intensity will be reduced however, producing less light on the muckpile and requiring longer shutter speeds.

Special Considerations

Wet (reflective) material – specular highlight formation may affect analysis accuracy. Diffusing the light will produce larger, more even highlights. Complete elimination of specular highlights on reflective material requires use of polarized lighting sources in combination with a polarizing filter on the camera lens and is likely too complex for most users.

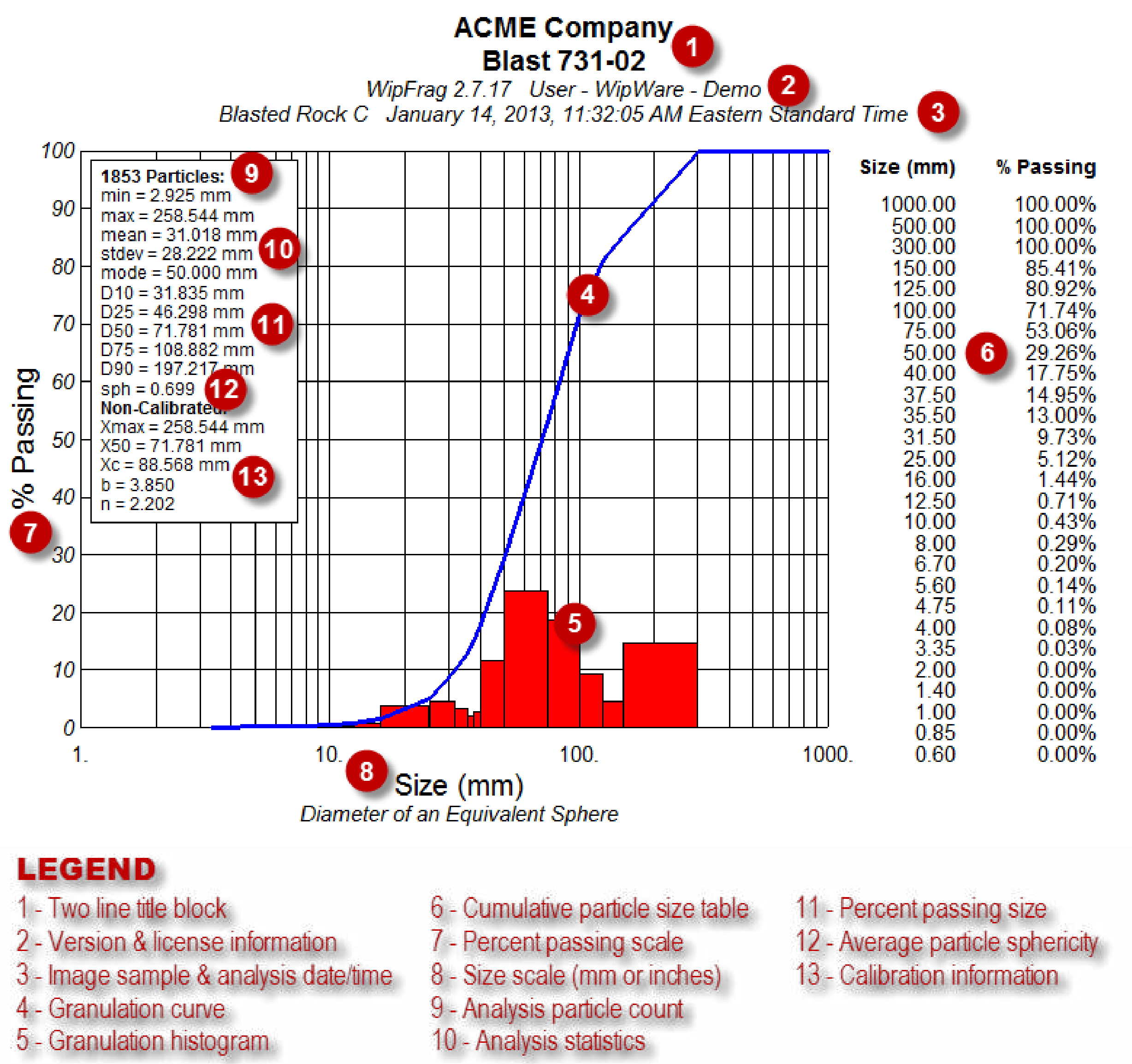
8.0 Interpreting Particle Size Data

The particle size distribution (PSD) of material is critical in understanding its physical and chemical properties. It affects the strength and load-bearing properties of rocks and soils. It affects the reactivity of solids participating in chemical reactions, is necessary to determine material density, and needs to be tightly controlled in many industrial applications.

8.1 Particle Size Distribution Types

Particle Size Distributions are typically expressed in one of four ways:

- Cumulative percent passing curve
- Cumulative percent retained curve
- Data Table
- Histogram



Three of these are usually represented in log-normal graphical plots since the size distribution range will often traverse many orders of magnitude between the smallest and largest particle which would be difficult to illustrate in normal graphical space. Generally there is a preference by discipline, e.g. Metallurgists generally prefer the cumulative percent passing curves as it may be easier to find typical KPI values that are critical to the process, such as D80 (Diameter of 80% of the material), whereas blast designers generally prefer the histogram because it is easier to see non-standard particle size distributions which can be indicative of a blasting malfunction.

8.2 Particle Size Distribution Parameters

There are many parameters that can be used to describe points in a PSD; these include Min/Max/Mean/Median/Mode Particle Size, any number of 0-100% Passing or up to 27 user definable size fractions. Access to this data is made simple via CSV files that any spreadsheet application can open, if you have not already captured the real time particle size telemetry into a plant/process historian. Below is an example of the CSV contents.

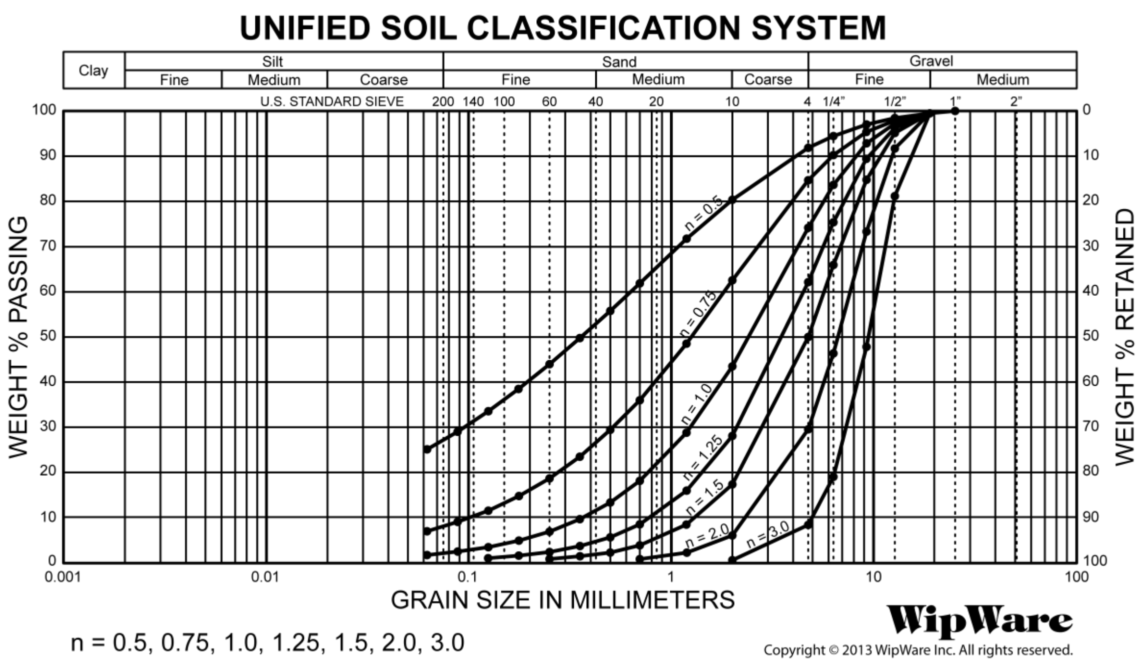
	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Year	Month	Day	Hour	Minute	Second	D1	D5	D10	D20	D25	D30	
2	2013	2	18	22	49	5	8.10E+00	1.34E+01	1.73E+[illegible]	[illegible]35E+01	2.65E+01	2.94E+01	
3	2013	2	18	22	49	45	7.21E+00	1.28E+01	1.65E+01	2.28E+01	2.59E+01	2.87E+01	
4	2013	2	18	22	50	10	1.21E+01	2.03E+01	2.70E+01	3.58E+01	3.98E+01	4.42E+01	
5					CONTINUE								
6		D50	D70	D75	D80	D90	D95	D99	Xc	n	b	Xmax	
7		4.09E+01	6.29E+01	7.06E+01	8.02E+01	1.28E+02	1.48E+02	2.67E+02	5.24E+01	1.87E+[illegible]	[illegible]97E+00	1.68E+02	
8		4.09E+01	6.24E+01	6.89E+01	7.63E+01	1.27E+02	1.46E+02	2.63E+02	5.35E+01	1.81E+00	4.00E+00	1.79E+02	
9		6.24E+01	8.92E+01	1.00E+02	1.26E+02	2.07E+02	2.54E+02	2.91E+02	7.47E+01	2.13E+00	3.75E+00	2.44E+02	
10					CONTINUE								
11		0.6 mm	0.85 mm	1 mm	1.4 mm	2 mm	3.35 mm	4 mm	4.75 mm	5.6 mm	6.7 mm	8 mm	
12		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-[illegible]	[illegible]00E-01	2.83E-01	3.96E-01	6.30E-01	9.51E-01	
13		0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.07E-02	1.69E-01	2.61E-01	3.61E-01	5.00E-01	8.00E-01	1.32E+00	
14		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.93E-02	9.93E-02	1.23E-01	2.19E-01	2.54E-01	4.07E-01	
15					CONTINUE								
16		10 mm	12.5 mm	16 mm	25 mm	31.5 mm	35.5 mm	37.5 mm	40 mm	50 mm	75 mm	100 mm	
17		1.93E+00	3.95E+00	7.91E+00	2.24E+01	3.36E+01	4.26E+01	4.55E+01	4.89E+01	6.17E+01	7.78E+01	8.83E+01	
18		2.47E+00	4.55E+00	9.13E+00	2.34E+01	3.50E+01	4.19E+01	4.59E+01	4.90E+01	6.05E+01	7.97E+01	8.65E+01	
19		5.46E-01	1.09E+00	2.29E+00	7.93E+00	1.46E+01	1.96E+01	2.26E+01	2.52E+01	3.66E+01	6.35E+01	7.50E+01	
20					CONTINUE								
21		125 mm	150 mm	300 mm	500 mm	1000 mm	Min	Max	Mean	Mode	Stdev	Sphericity	
22		8.94E+01	9.55E+01	1.00E+02	1.00E+02	1.00E+02	2.11E+00	1.68E+02	[illegible]	5.00E+01	1.63E+01	[illegible]	
23		8.94E+01	9.60E+01	1.00E+02	1.00E+02	1.00E+02	1.77E+00	1.79E+02	1.6[illegible]E+01	5.00E+01	1.58E+01	7.0[illegible]E-01	
24		7.99E+01	8.39E+01	1.00E+02	1.00E+02	1.00E+02	3.02E+00	2.44E+02	2.62E+01	5.00E+01	2.46E+01	6.98E-01	
25					CONTINUE								
26		Particles	Image		frag								
27		[illegible]	Blasted Rock A		[illegible]asted Rock A.frag								
28		[illegible]	Blasted Rock B		Blasted Rock B.frag								
29		1841	Blasted Rock C		Blasted Rock C.frag								
30													
31													

LEGEND

1 - Analysis time (year, month, day, hour, minute, second)
2 - Percent passing size (D1, D5, D10, D20, D25, D30, D50, D70, D75, D80, D90, D95, D99)
3 - Calibration information (Xc, n, b, Xmax)
4 - Cumulative particle size data (ISO, Standard or 27 user defineable size classes)
5 - Analysis statistics (minimum, maximum, mean, standard deviation)
6 - Average particle sphericity
7 - Analysis particle count
8 - Image sample name and output file name

8.3 Particle Size Distribution Formulas

Most PSD’s can also be described using a formula of best fit. For this purpose, there are dozens of models, however, WipWare currently supports two; Rossin Rammler and the Swebrec methods. Rossin Rammler is based on two parameters, Xc and n, each of which could be used as a KPI. For example, Xc is known as the characteristic size of the distribution and is more specifically D63.2 (63.2% of the material is X size or less) which is a very useful and versatile number to work with. The n value is a measure of uniformity. For example, marbles that have very little variation in size will have a very high n value such as 10+ whereas ultra-wide particle size distributions, such as blast results, can yield particles the size of cars down to dust and will have a much smaller uniformity of < 0.75.

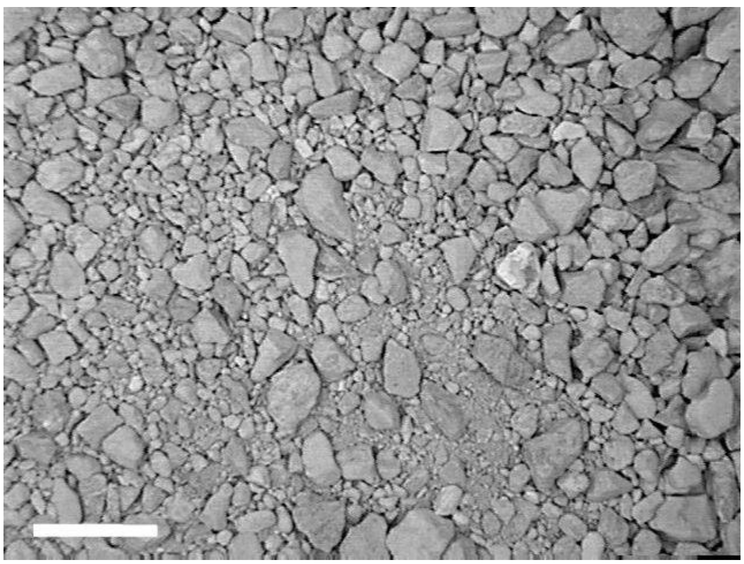


n=3.0
Characterized by a very uniform size distribution, where the smallest common visible block is about 1/3 the size of the largest common block.

(Scale = 1”)

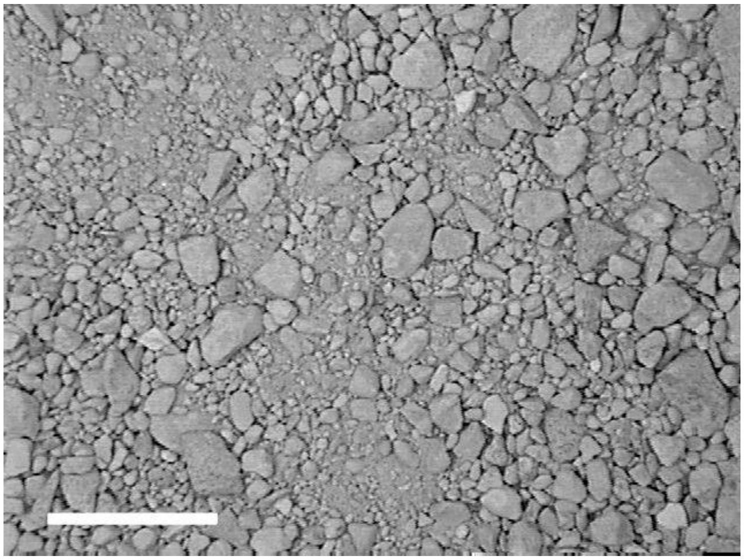
n=2.0
Characterized by a fairly uniform size distribution, where the smallest common visible block is about 1/5 the size of the largest common block. The ratio of the number of largest common blocks to smallest common blocks is about 20:1.

(Scale = 1”)



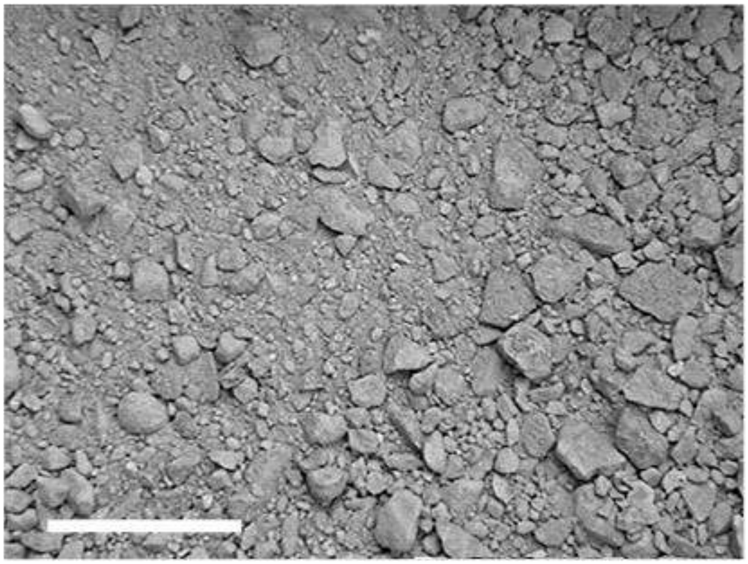
n=1.5
Characterized by a moderately poorly uniform size distribution, where the smallest visible common block is about 1/8 the size of the largest common block. The ratio of the number of the largest common blocks to smallest common blocks is about 8:1. Small areas of particles that are too small to be resolved cover about 5% of the image.

(Scale = 1”)



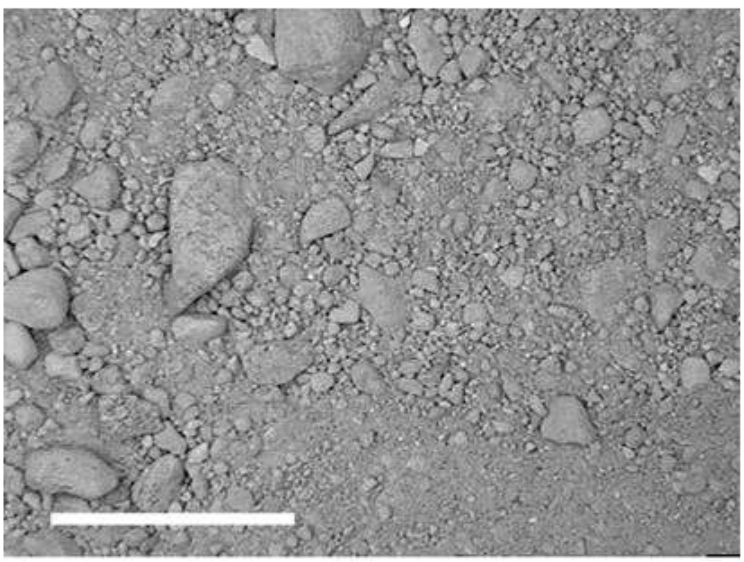
n=1.25
Characterized by a poorly uniform size distribution, where the smallest common visible block is about 1/12 the size of the largest common block. The ratio of the number of largest common blocks to smallest common blocks is about 2:1. Areas of particles that are too small to be resolved cover about 15% of the image.

(Scale = 1”)



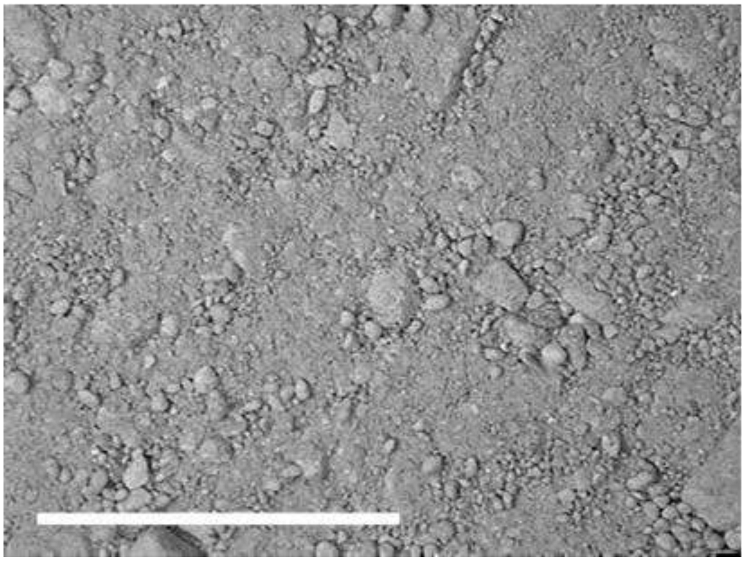
n=1.0
Characterized by a moderately well graded size distribution, where the smallest common visible block is about 1/16 the size of the largest common block. The ratio of the number of largest common blocks to smallest common blocks is about 1:2. Areas of particles that are too small to be resolved cover about 30% of the image.

(Scale = 1")



n=0.75
Characterized by a well graded size distribution, where the smallest common visible block is about 1/18 the size of the largest common block. The ratio of largest common blocks to smallest common blocks is about 1:8. Areas of particles that are too small to be resolved cover about 40% of the image.

(Scale = 1")



n=0.5
Characterized by a very well graded size distribution, where the smallest common visible block is about 1/20 the size of the largest common block. The ratio of largest common blocks to smallest common visible blocks is about 1:15. Areas of particles that are too small to be resolved cover over 50% of the image.

(Scale = 1”)

8.4 Study Planning and Execution

When undertaking a formal study it is important to first understand the data, how it is collected and what it represents. Once suitable KPI's are determined, a suitable base line must be established prior to inducing changes to the process; this helps avoid misinterpreting relative change for noise. Moving forward, strict adherence to the pre-established systematic sampling methodology is critical; this minimizes the possibility of your study becoming invalid or inconclusive.

If you require assistance establishing a study strategy or interpreting the resulting data WipWare can connect you with approved consultants, specialists and even third party software to assist with continuous improvement efforts. Contact WipWare Technical Services for details.

Publishing a technical paper? We are interested in technical papers that apply WipWare technology; if you are currently planning, working on or have already published a technical paper that involves our systems particle size/shape telemetry we would like to hear about it. A reward for best paper is awarded annually!

9.0 Frequently Asked Questions

This section of the guide answers the three most common questions new users have when starting a study using WipFrag or a MailFrag Service campaign.

9.1 Are high resolution image samples better?

Large and small image samples each have their benefits and disadvantages. WipWare recommends taking 1.2 to 5.0 MegaPixel image samples depending on the particle sizes being analyzed. To help decide what resolution is best for your application take note of the following:

- Higher resolution images are large, sometimes difficult to handle files that are less effective at detecting oversize and more effective at detecting fines
- Lower resolution images are small, usually easy to handle files that are more effective at detecting oversize and less effective at detecting fines
- If you cannot outline the particles of interest visually, neither can our technology
- It is always possible to reduce the image resolution

9.2 What is a suitable scale device?

Every image to be analyzed must include a scale device in the image sample. When selecting a suitable scale device, it is important that all of the following points are checked:

- Scale device should contrast well against the material being analyzed
- Scale device should be at least 1/10th of the image sample width (more is better)
- Scale device must be dimensionally stable (avoid inflatable objects)
- Scale device must be placed perpendicular to the camera view
- If acquiring image samples perpendicular to the material surface is not possible, multiple scale devices may be necessary for tilt correction

9.3 How many image samples should I take?

The short answer to this question is as many as possible; the practical answer to this question is different for each user and better determined by your goal. The questions you need to ask yourself are:

- What percentage of the material do I need to be statistically valid?
- What percentage of the material does each image sample contain?
- How important are the decisions you will be making based on the results?