Today

• Overview of OSM
• Discuss blasting at coal mines
• Review recordkeeping requirements
• How might the records help you.
Coal Mining States

<table>
<thead>
<tr>
<th>State</th>
<th>2003 Production (Tons)</th>
<th>2002 Production (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1,071,753</td>
<td>1,094,283</td>
</tr>
<tr>
<td>WY</td>
<td>376,270</td>
<td>373,161</td>
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<tr>
<td>WV</td>
<td>139,711</td>
<td>150,078</td>
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<tr>
<td>KY</td>
<td>112,680</td>
<td>124,142</td>
</tr>
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</table>
OSM Responsibilities

- Balance Nation’s Energy Needs vs. Environmental Needs
- Fix Abandoned Mine Problems
  - Backfilling, Subsidence, Fires, Landslides, Water
- Regulate Active Mines – Surface effects
  - Reclamation/Land Productivity, Protect Water, Slope Stability, **Blasting Adverse Effects**
- Passes Responsibility to the States
  - OSM conducts oversight
  - Provides funding at 50%
Worker Safety? MSHA responsibility
Surface Mining Control and Reclamation Act of 1977 (SMCRA)

SECTION 515(b) General performance standards shall be applicable to all surface coal mining and reclamation operations and shall require the operation as a minimum to --

(15) insure that explosives are used only in accordance with existing State and Federal law and the regulations promulgated by the regulatory authority, which shall include provisions to -

(A) provide adequate advance written notice to local governments and residents who might be affected by the use of such explosives by publication of the planned blasting schedule in a newspaper of general circulation in the locality and by mailing a copy of the proposed blasting schedule to every resident living within one-half mile of the proposed blasting site and by providing daily notice to resident/occupiers in such areas prior to any blasting;
SMCRA

(B) maintain for a period of at least three years and make available for public inspection upon request a log detailing the location of the blasts, the pattern and depth of the drill holes, the amount of explosives used per hole, and the order and length of delays in the blasts;

(C) limit the type of explosives and detonating equipment, the size, the timing and frequency of blasts based upon the physical conditions of the site so as to prevent (i) injury to persons, (ii) damage to public and private property outside the permit area, (iii) adverse impacts on any underground mine, and (iv) change in the course, channel, or availability of ground or surface water outside the permit area;
SMCRA

(D) require that all blasting operations be conducted by trained and competent persons as certified by the regulatory authority;

(E) provide that upon the request of a resident or owner of a man-made dwelling or structure within one-half mile of any portion of the permitted area the applicant or permittee shall conduct a **pre-blasting survey** of such structures and submit the survey to the regulatory authority and a copy to the resident or owner making the request. The area of the survey shall be decided by the regulatory authority and shall include such provisions as the Secretary shall promulgate.
Use of Explosives Rules - 30 CFR

- Blast Plans (780.13)
- General requirements (816.61)
- Preblasting surveys (816.62)
- Blasting schedules (816.64)
- Blasting signs, warnings, and access control (816.66)
- Control of adverse effects (816.67)
- Records of blasting operations (816.68)
- Certification of blasters (850)
The Setting – Mine and People
Three Sciences

Blast

Flyrock

Air Vibrations or Airblast

Fumes

Ground Vibrations

Adverse Effects?

Structure
Blasting Basics

(a) $B = 15'$
Completely contained, only failure is pulverisation near the charge and radial tensile failure running out from it.

(b) $B = 12'$

(c) $B = 9'$
Surface and subsurface failure almost meet. There will be a shelf of unbroken rock between the two. Dom-ing or surface bulging.

(d) $B = 6'$
Full crater, burden completely broken out. Surface and subsurface failures run through to the surface.

(e) $B = 3'$
Full crater, lower volume than optimum fine fragmentation. Noise, flyrock, bowl shaped crater.

Assume Explosive = 40 lb. ANFO

Figure 7.17. Schematic of the Effect of Decreasing the Burden on Charges Fired in Rock.
Spatial Relationships

Complaint House,
550’

Compliance House,
450’

Complaint House 2,
1500’
Movie

“Dance of the Detonators”

• Multitude of blasts done safely
  • Construction
  • Quarries
  • Coal mining

• Anticipate the Adverse Effects
  • Flyrock
  • Ground Vibrations
  • Airblast
Blaster’s Focus
Geology Considerations
Unusual Geology
Dragline
Truck and Shovel
Bulldozer
Rotary Drills
Drill holes and Cuttings
Blast Hole Components
Bulk Loading
Bag Products – 50#
AN-Based Products

ANFO

Emulsion Matrix

Augured Blends

Pumpable Blends
Primer = Booster + Detonator
Decked Holes

- **Collar Stemming**
  Inert material from top of uppermost explosive charge to the surface

- **Interdecking**
  Inert material between explosives charges

- **Backfilling**
  Inert material between explosives charge and the coal
Holes are designed to focus energy laterally.
Blast Hole Parameters

- $B = \text{BURDEN (ft)}$
- $S = \text{SPACING (ft)}$
- $T = \text{STEMMING (ft)}$
- $H = \text{HOLE DEPTH (ft)}$
- $T_d = \text{DECKING (ft)}$
- $J = \text{SUB DRILL *(ft)}$
- $F = \text{BACKFILL (ft)}$

*Not used when shot directly above coal*
BLAST DESIGN

RULES OF THUMB

PEAK PARTICLE VELOCITY (PPV) = 438 X (SD)^0.5

(Greater than 55)

(MAXIMUM EXPECTED)

GIVEN DISTANCE (SD) = Distance to structure divided by square root of the charge weight.

POWDER FACTOR (PF) = Powder per hole divided by rock volume per hole.

PD(holes) = CW(holes) X D(holes) X S(holes) X H(holes) / 27

CHARGE WEIGHT (CW) = Powder column times the loading density.

LD(holes) = 0.3405 X density(grams/cm^3) X d(holes)^3

POWDER COLUMN (PC) = Hole depth minus stemming.

PC(holes) = H(holes) - T(holes)

LOADING DENSITY (LD) = 0.3405 times the explosive density times the hole diameter squared.

STEMMING (T) = 0.5 to 1.0 times the burden.

T(holes) = 0.5 X B(holes) to 1.0 X B(holes)

BURDEN (B) = 2 to 3 times the diameter.

B(holes) = 2 X d(holes) to 3 X d(holes)

SPACING (S) = 1 to 2 times the burden.

S(holes) = 1 X B(holes) to 2 X B(holes)

HOLE DIAMETER (d) = Hole depth (T) divided by 5 to 10.

d(holes) = H(holes) / 5 to H(holes) / 10

(Typically 2.5 x d)

(Typically 0.7 x B)

(Usually not an option)
Drill Patterns
and
Initiation Sequence
Drilling Layout

Staggered

Rectangular

Square
Blast Design Patterns

4 ROWS WITH 5 HOLES

BLASTING AGENT

STEMMING

PRIMER
(DETONATOR AND BOOSTER)

BURDEN

HIGHWALL

SPACING

BLASTHOLE
BLASTMASTER® T&D (Trunkline & Delay)
7 HOLES/ROW, ∞ NUMBER OF ROWS
59 MS HOLE-HOLE, 17 MS ROW-ROW
ONE HOLE/DELAY

Connecting Holes

NOTE: IN HOLE DELAY 500 MS
Electric Distribution Network

Electric Caps
NON-EL Distribution Network

DETONATING CORD
PETN – 6 to 50 grains per foot
NON-EL Distribution Network

SHOCKTUBE
Lead-in Line
Blasting Machines
Detonation
Surface and Downhole Delays
Conventional Blast
Cast Blast
Parting Blast
Coal Blast
Example... Good or bad?
Adverse Effects

FLYROCK
GROUND VIBRATION
AIRBLAST
Flyrock

- Beyond the permit area
- Beyond the blast area
- $> \frac{1}{2}$ the distance to a house
Flyrock Injury
Flyrock Property Damage
Vibrations – Ground and Air
Blasting Seismographs
** SAFEGUARD SEISMIC UNIT 2000DK **

DATE: 09/12/95 TIME: 15:18:06  
Event: 009 Recording Time: 10  
SN: 2243  

Event: 009 Recording Time: 10  
Summary

<table>
<thead>
<tr>
<th></th>
<th>L</th>
<th>T</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPV (in/sec)</td>
<td>0.10</td>
<td>0.14</td>
<td>0.07</td>
</tr>
<tr>
<td>PD (in x.001)</td>
<td>2.39</td>
<td>2.97</td>
<td>1.38</td>
</tr>
<tr>
<td>PPA (g)</td>
<td>0.02</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>FREQ (Hz)</td>
<td>8.0</td>
<td>7.6</td>
<td>16.6</td>
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<tr>
<td>RESULTANT PPV (in/sec):</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEAK AIR PRESSURE: (dB)</td>
<td>114</td>
<td></td>
<td></td>
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<tr>
<td>(psi)</td>
<td>0.00145</td>
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</tr>
</tbody>
</table>

** VELOCITY WAVEFORM GRAPH SCALE **

TIME = 100 MSEC PER MARK  
SEISMIC = +/- .64 IN/SEC  
SOUND = +/- 0.00232 PSI  

SHAKETABLE CALIBRATED: 06/20/95

By GeoSonics, Inc.

Box 779, Warrendale, PA 15095 U.S.A.
TEL: 412.934.2900 FAX: 412.934.2999
## Ground Vibrations

<table>
<thead>
<tr>
<th>Distance</th>
<th>SD</th>
<th>PPV</th>
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<tbody>
<tr>
<td>&lt; 301</td>
<td>50</td>
<td>1.25</td>
</tr>
<tr>
<td>301 – 5000</td>
<td>55</td>
<td>1.00</td>
</tr>
<tr>
<td>&gt; 5000</td>
<td>65</td>
<td>0.75</td>
</tr>
</tbody>
</table>
Airblast – Pressure Wave
Airblast

2 Hz microphone 133 dB

All seismographs manufactured today have 2 Hz lower frequency response range.
Structure Response

- Structure distortions are caused both by ground and air vibrations
- Fall into two categories
  - whole structure
  - mid-wall
Whole structure shear distortions cause wall strains that may lead to wall cracking.
Mid-wall response

Move like a drum and result in rattling (noise) of loose objects on, or resting against walls.

Motions do not result in wall cracking. But the noise can startle occupants, promoting the perception of structure damage.
What is the worst case scenario of response?

When the frequency of the ground or air pulse is close to the natural or fundamental frequency of the structure

- the structure will temporarily resonate at the fundamental mode

- the time duration of structure shaking may be far longer than that of the ground

- structures may exhibit an amplification of the ground excitations
When the house shakes, owners are Annoyed or Fear Damage
What are the Most Important Parameters in Evaluating the Adverse Effects?

- Location of the blast
- Location of the compliance house
- Distance between the two
- Charge weight per delay
- Confinement
- Type of blast
## Coal Mine Blasting Records

### Austin Powder Company Blast Report

**Date:**

<table>
<thead>
<tr>
<th>Shot No.</th>
<th>Time of Blast</th>
<th>Location</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

**Company (Permittee):**

**Permit No.:**

**Weather:**

- [ ] Cloudy
- [ ] Clear

**Type of Terrain:**

- [ ] Hilly
- [ ] Flat

**Who Direction:** (Circle One)

- [ ] N
- [ ] NE
- [ ] E
- [ ] SE
- [ ] S
- [ ] SW
- [ ] W
- [ ] NW

**Velocity ± MPH:**

**Temperature (°F):**

**Nearest Protected Structure:**

**Name of Structure and/or Type:**

**Distance (ft):**

**Direction and Bearing:** (In Ohio, direction must be stated in degrees)

**Or Compass Point (Cps):**

- [ ] N
- [ ] NE
- [ ] E
- [ ] SE
- [ ] S
- [ ] SW
- [ ] W
- [ ] NW

**Method Used:**

- [ ] Measured
- [ ] Ohio Map
- [ ] Topo Map
- [ ] Other

**Type of Material Blasted:**

**Hole Diameter:**

**Ave. Depth of Water:**

**N. O. Holes:**

**No. of Rows:**

**Burden:**

**Spacing:**

**Face Height:**

**Pack Fill Depth:**

**Sub-Drilling:**

**Length of stemming:**

**Type of stemming:**

**Were Blasting Mats Used:**

- [ ] Yes
- [ ] No

**If Yes, Type Used:**

**Explosives:**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Total Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

**Type of Primer:**

**Total Weight of Explosives (Include Primers):**

**Type of Initiation System:**

- [ ] Electric
- [ ] Non Electric

**Delay Detonators Used (Type):**

**Initiation Method:**

- [ ] Sequential M/C/1/NF Setting
- [ ] C/D-40c
- [ ] C/D-40x
- [ ] Other (Name: )

**Circle Scale Distance Used:**

- W = (D/50)
- W = (D/60)
- W = (D/70)
- Other (Name: )

**Legal Weight of Explosives Per Delay:**

**Check Your State & Local Regulations for Proper Scale Distance:**

**Weight of Explosives Per Row:**

**Max. No. of Holes Within AM Period:**

**Max. Wt. of Explosives Within AM Period:**

**Actual Wt.:**

**Total No. of Tons Produced:**

**Total Cubic Yards Produced:**

**Total Powder Factor:**

- [ ] 1 Tons
- [ ] 1 Cubic Yard
- [ ] 1 Tons/Cubic Yard

**Check Here: If blast occurred at a time other than the scheduled time explain why in the comment section:**

**Check Here: If a misfire occurred, if misfire occurred explain procedure used to eliminate the hazard please use comment section:**

**Seismograph Data:**

**Date of Seismograph:**

**Time of Seismograph Reading:**

- [ ] AM
- [ ] PM

**Type of Instrument:**

**Sensitivity:**

**Calibration Signal or Date of Calibration:**

**Location:**

**Distance from Blast Location:**

- [ ] N
- [ ] NE
- [ ] E
- [ ] SE
- [ ] S
- [ ] SW
- [ ] W
- [ ] NW

**Seismic Data:**

**Digital Readout:**

- [ ] Yes
- [ ] No

**Name of Person Taking Seismic Reading:**

**Name of Person or Firm Analyzing Record:**

**Form 234-4 Rev: 11-69**

**Attach Seismic Record if Available**
Blaster and Crew

Blaster Certification
30 CFR 850 - States have counterparts
  – Experience
  – Training
  – Testing

Responsible Party or Employee Possessor?

Blasting Crew
30 CFR 816.61 General requirements.
(ii) Give direction and on-the-job training to persons who are not certified and who are assigned to the blasting crew or assist in the use of explosives.
Why Blasting Records?

- Regulatory requirement
- Post blast assessment - analyzing problems
- Liability protection - Documentation or Evidence of the actual blast … “Eye-Witness Testimony”
**General**

<table>
<thead>
<tr>
<th>Permit #</th>
<th>Operator</th>
<th>Date</th>
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<thead>
<tr>
<th>Permittee</th>
<th>Operator</th>
<th>Time (hrs)</th>
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<tr>
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<table>
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<tr>
<th>Blaster</th>
<th>Signature</th>
<th>Cert.</th>
<th>Exact Location (GPS)</th>
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<thead>
<tr>
<th>Weather / Sky Coverage</th>
<th>Temp F</th>
<th>Wind speed / direction</th>
<th>Coal seam</th>
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<tr>
<th>Protected Structures</th>
<th>Name</th>
<th>Distance (ft)</th>
<th>Azimuth</th>
<th>Scale Distance</th>
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<tr>
<th>Utility / other feature</th>
<th>Name</th>
<th>Distance (ft)</th>
<th>Azimuth</th>
<th>Scale Distance</th>
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<tr>
<th>Material blasted (%)</th>
<th>Sandstone</th>
<th>Shale</th>
<th>Limestone</th>
<th>Other</th>
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<tr>
<th>Blast Type</th>
<th>Breakdown</th>
<th>Presplit</th>
<th>Cast</th>
<th>Production</th>
<th>Other</th>
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<thead>
<tr>
<th>Diameter</th>
<th>Burden</th>
<th>Spacing</th>
<th>Cubic yards blasted</th>
<th>Average PF</th>
<th>Highest PF</th>
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<thead>
<tr>
<th>Hole depth (ft)</th>
<th># holes</th>
<th>Stemming (ft)</th>
<th>Type</th>
<th>Interdeck (ft)</th>
<th>Backfill (ft)</th>
<th>Total feet</th>
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<th># holes</th>
<th>Stemming (ft)</th>
<th>Type</th>
<th>Interdeck (ft)</th>
<th>Backfill (ft)</th>
<th>Total feet</th>
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<tr>
<th>Explosives</th>
<th>ANFO</th>
<th>Emulsion</th>
<th>Blend</th>
<th>Boosters</th>
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<th>Density</th>
<th>Density</th>
<th>Density</th>
<th># used</th>
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<th>Manufacturer</th>
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<thead>
<tr>
<th>Delay</th>
<th>Quantity</th>
<th>Delay</th>
<th>Quantity</th>
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<thead>
<tr>
<th>Electric</th>
<th>Delay</th>
<th>Quantity</th>
<th>Detcord (ft)</th>
<th>Blasting Machine/Initiation Method</th>
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<thead>
<tr>
<th>Series</th>
<th>Yes / No</th>
<th>Parallel</th>
<th>No. circuits</th>
<th>Other</th>
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<table>
<thead>
<tr>
<th>Seismograph Model</th>
<th>Location</th>
<th>Distance (ft)</th>
<th>PPV (in/s)</th>
<th>L</th>
<th>T</th>
<th>V</th>
</tr>
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<tbody>
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<thead>
<tr>
<th>Operator</th>
<th>Trigger levels (PPV/dB)</th>
<th>Air (dB)</th>
<th>Frequency</th>
<th>L</th>
<th>T</th>
<th>V</th>
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<table>
<thead>
<tr>
<th>Analyst</th>
<th>Blasting crew</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Comments:</th>
<th>Mats or other protection used or reasons and conditions for an unscheduled blast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
Sketch the blast pattern and illustrate the surface and down hole delays. **Include the amount of explosives in each hole**.
30 CFR Sec. 816.68
Use of Explosives: Records of Blasting Operations.
• The operator shall retain a record of all blasts for at least **3 years**.

• Upon request, copies of these records shall be made available to the regulatory authority and to the public for inspection.

• Such records shall contain the following data:

  (a) Name of the operator conducting the blast.
  (b) **Location**, date, and time of the blast.
  (c) Name, signature, and certification number of the blaster conducting the blast.
Exact Location

- Locate the blasting pattern within the permit boundary
- Global Positioning System
  - Lat-Long, Decimal seconds
  - UTM
- Distance and Azimuth or Bearing
- Grid maps
- Project station
- Garmin GPS and TopoFusion
(d) **Identification, direction and distance**, in feet, from the nearest blast hole to the nearest dwelling, public building, school, church, community or institutional building outside the permit area, except those described in Section 816.67(e).

(e) Weather conditions, including those which may cause possible adverse blasting effects.

(f) Type of material blasted.
Identify Protected Structure

Use the correct structure

- Street Address
- Full name of occupant
- House number from permit or project maps
Distance and Direction

- Distance from the closest blast hole
- Cardinal directions are too general
- Azimuth to the structure from the blast site is preferred
  Eg. 1500 feet 160 degrees
Blast Details

(g) Sketches of the blast pattern including number of holes, burden, spacing, decks, and delay pattern.
(h) Diameter and depth of holes.
(i) Types of explosives used.
(j) Total weight of explosives used per hole.
(k) The maximum weight of explosives detonated in an 8-millisecond period.
(l) Initiation system.
(m) Type and length of stemming.
(n) Mats or other protections used.
Sketches of Blast Pattern

<table>
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<tr>
<th>Depth</th>
<th>Delay</th>
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<td>125</td>
<td>200</td>
<td>225</td>
</tr>
</tbody>
</table>

Shot Rock
Explosives used per Hole

\[ LD = 0.34 \times (d^2 \times \rho) = 0.34 \times (6.75^2) \times 0.92 = 14.6 \text{ lb/ft} \]

\[ CW = 14' \times 14.6 = 205.16 \]
Initiation System

Electric
- Cap numbers
- Sequential Blasting Machine settings

Nonelectric
- Surface MS times
- Downhole MS times
(o) Seismographic and airblast records, if required, which shall include--
(1) Type of instrument, sensitivity, and calibration signal or certification of annual calibration;
(2) Exact location of instrument and the date, time, and distance from the blast;
(3) Name of the person and firm taking the reading;
(4) Name of the person and firm analyzing the seismographic record; and
(5) The vibration and/or airblast level recorded.
Blasting Seismographs

- Seismograph location
  - Address or map ID #
- Name of seismo operator
  - Full name
- Highest PPV and dB
  - Record the highest trace PPV
  - Record dB level
  - Attach wave form printout
(p) Reasons and conditions for each unscheduled blast.

List any remarkable event

- Flyrock
- Cutoffs or Misfires
- Cracked rock strata
- Holes left unloaded
- Site security issues
OSM Requires Blast Records

Each mine must maintain for a period of at least three years and make available for public inspection upon request a log detailing the location of the blasts, the pattern and depth of the drill holes, the amount of explosives used per hole, and the order and length of delay in the blasts;

ATF is a member of the public!!
Useful Blast Log Items to ATF

• Number of holes
• Initiation System
• Amount of explosives per hole
  – Main charge (ANFO, Emulsion)
  – Boosters (High Explosives)
  – Detonators (Down Hole Detonators)
• Delay sequence (Surface Detonators)
OSM Resources

• National Technical Training Program (NTTP)
  – Blasting and Inspection
  – Advanced Blasting: Investigation and Analysis of Adverse Effects

• Technical Innovation and Professional Services (TIPS) www.tips.osmre.gov
  – Blast Log Evaluation Program (BLEP)

• Appalachian Region Blasting Web Page
  – www.ARblast.osmre.gov
OSM Contacts

• Appalachian Region – Pittsburgh, PA
  – Ken Eltschlager, Mining/Explosives Engineer
  – keltschlager@osmre.gov or (412) 937-2169

• Mid-Continent Region - St. Louis, MO
  – David Best, Civil Engineer
  – dbest@osmre.gov or (618) 463-6463 x123

• Western Region – Denver, CO
  – Mike Rosenthal, Mining Engineer
  – mrosenthal@osmre.gov or (303) 844-1400 x1453