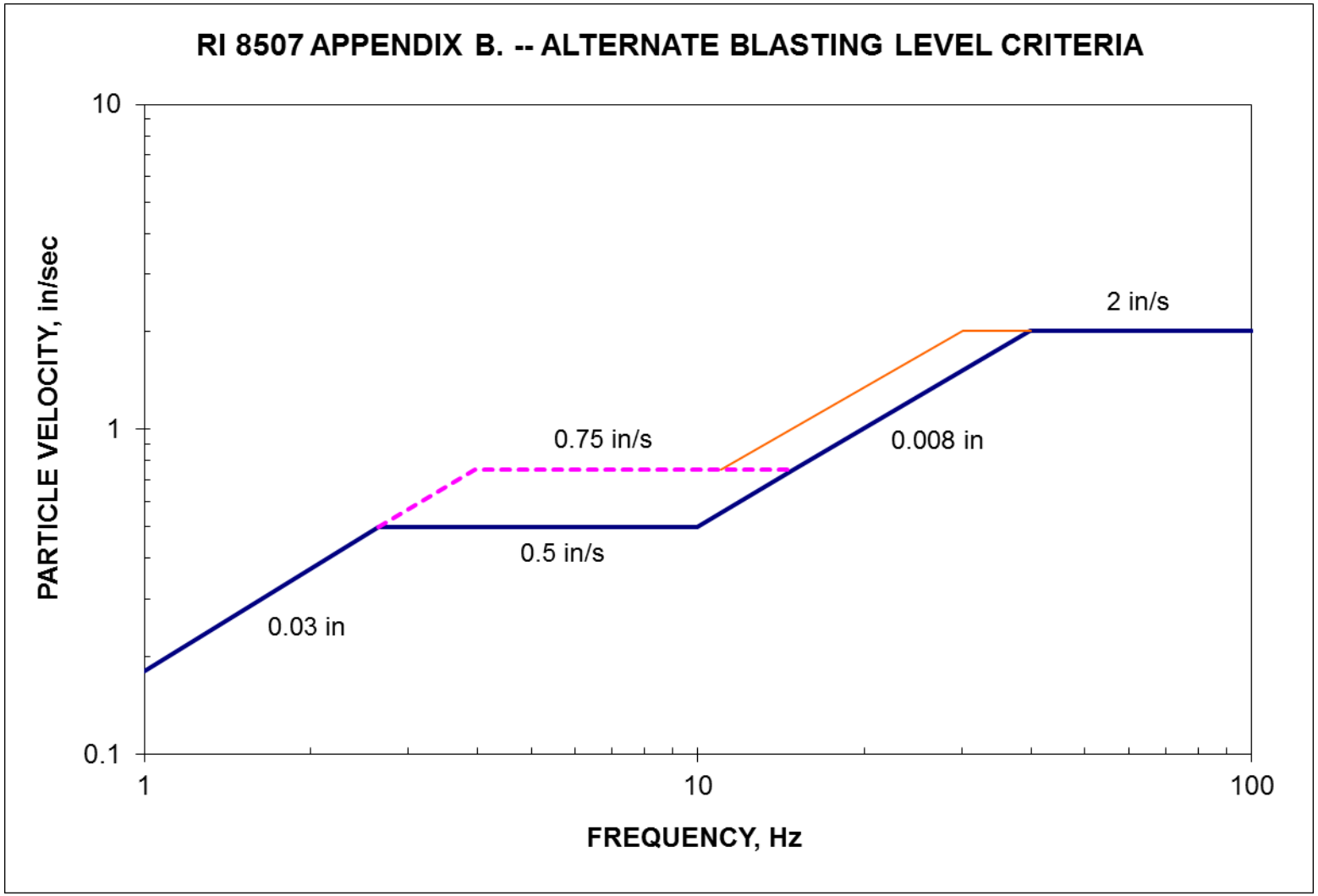
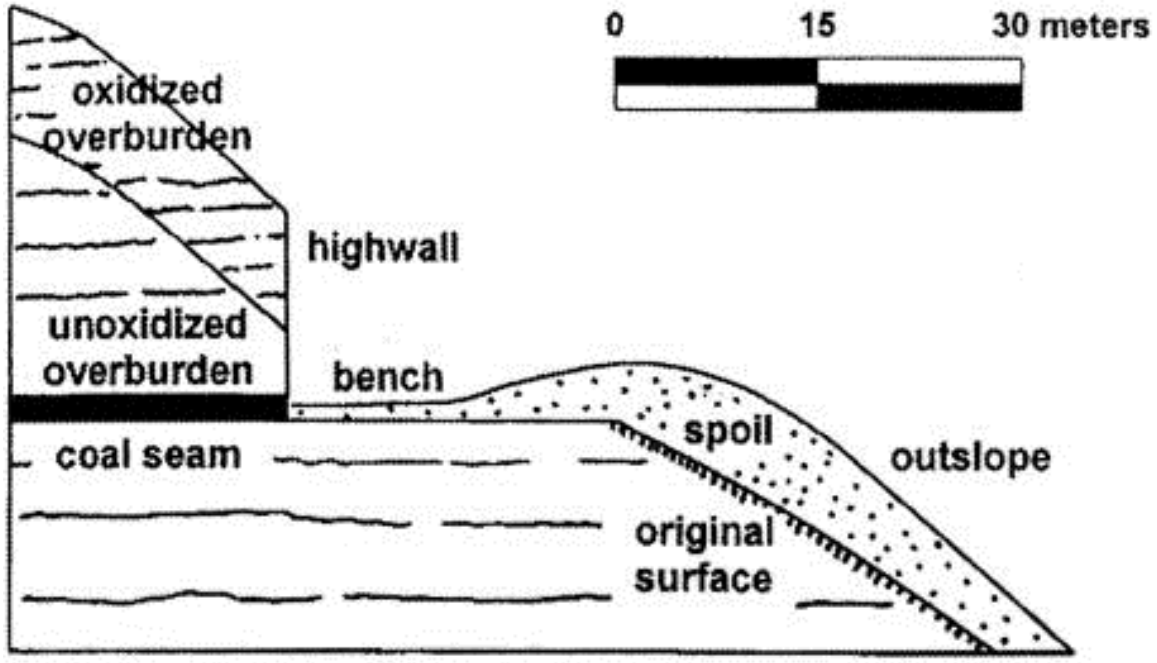
The Raising of “Z”

How it fits in the regulatory world



Before 1977

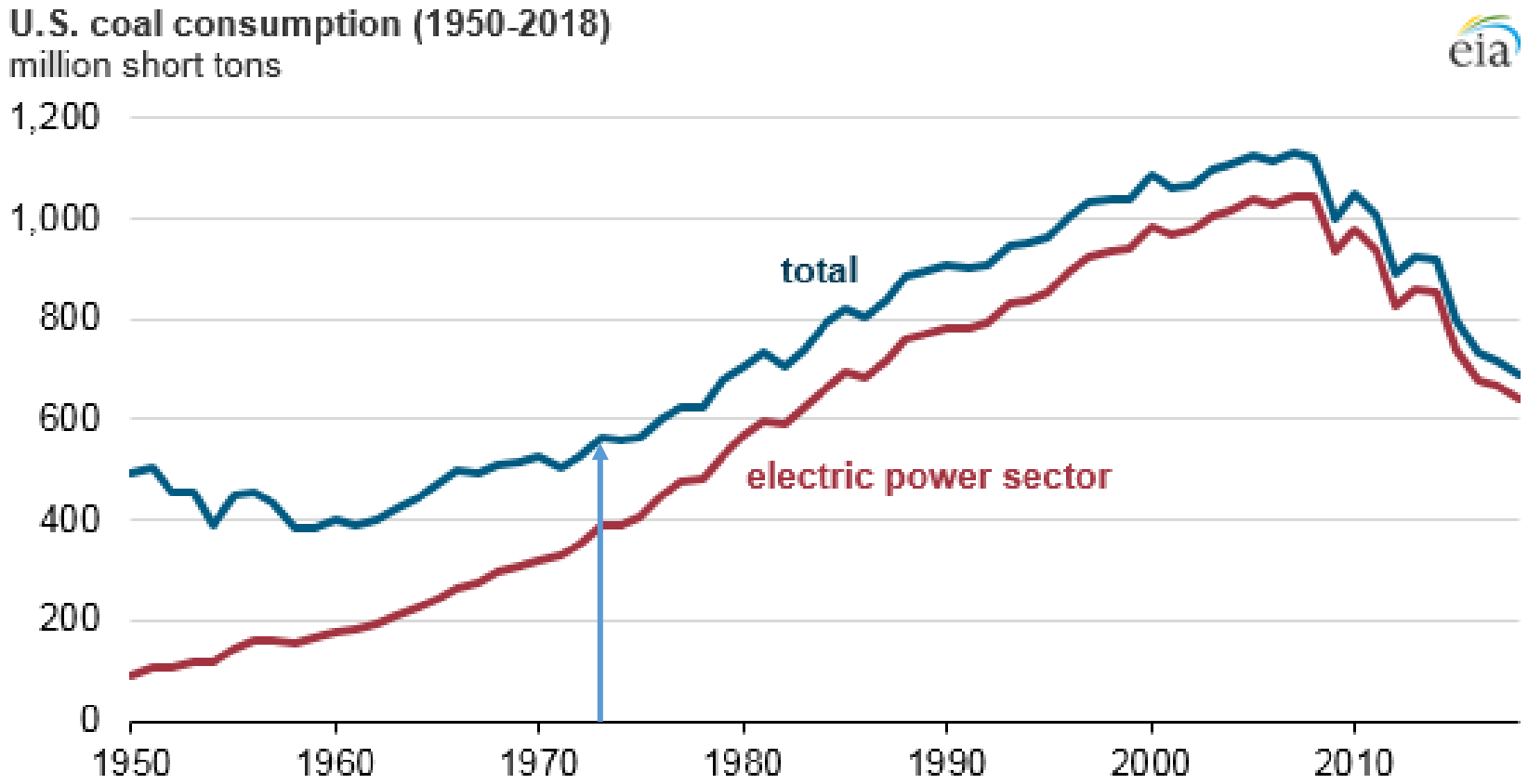
- No National standard on reclamation or blasting
- Shoot and shove common
- Some States with blasting rules – PA, KY
- 2.0 in/s reigning limit based on USBM Bulletin 656 (1971)
- Scaled Distance limit of 50 ft/lbs$^{1/2}$



Arab Oil Embargos – 1973, 1979

Industrial nations took steps to reduce their dependence on OPEC oil.

Electric utilities switched from oil to **coal**, natural gas, or nuclear power.



Surface Mining Control and Reclamation Act of 1977

- Shortly after the Arab Oil Embargo
- Congressional testimony that:
  - Productive lands are being lost
  - Blasting was significantly damaging property
- SMCRA - Coal Mining Only!
- Balance energy needs of US with reclamation
- Level the playing field for reclamation standards
- Blasting components
  - **Property protection**
  - **Blaster certifications**

SMCRA - Blasting

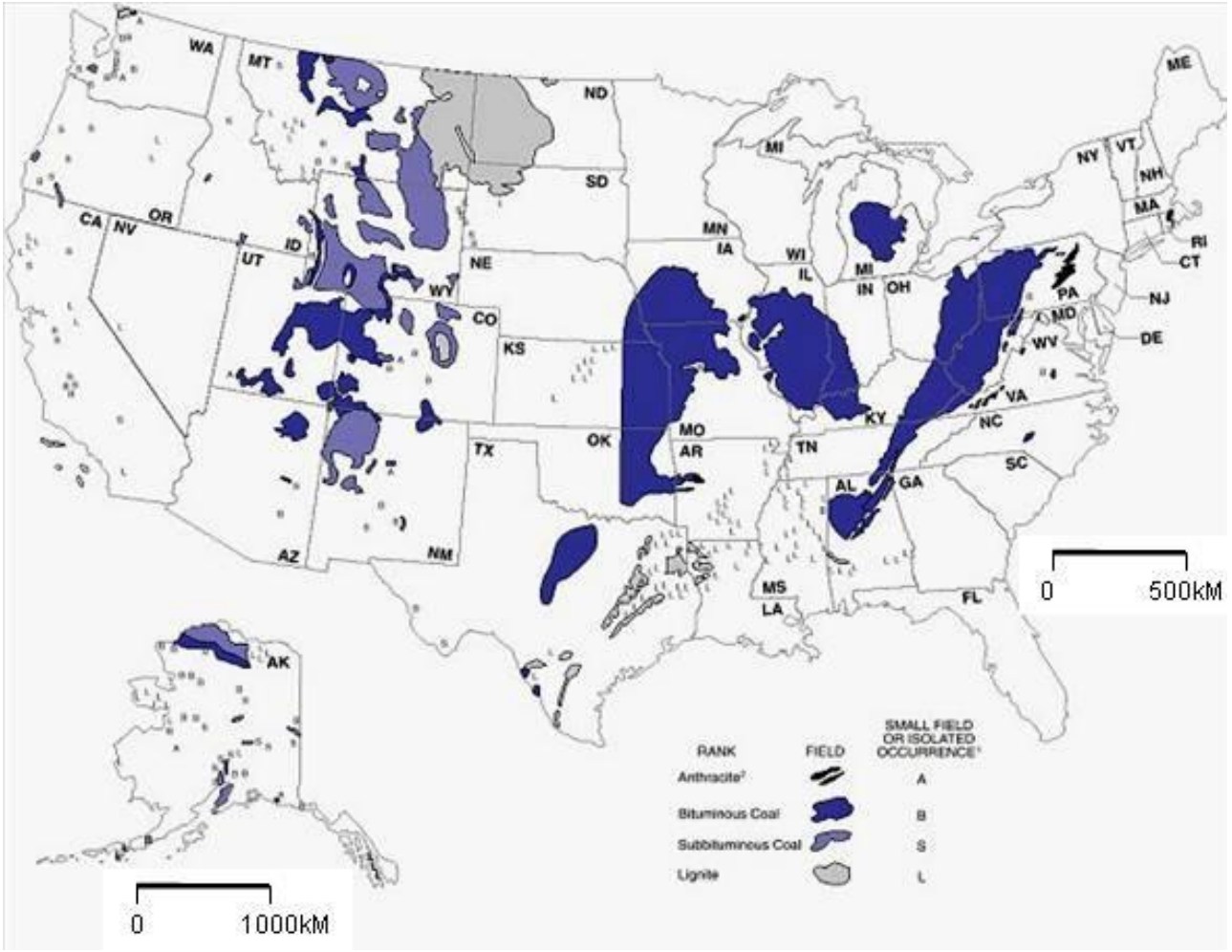
SECTION 515(b) General performance standards shall be **applicable to all surface coal mining and reclamation operations** and shall require the operation as a minimum to --

(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 -

(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;

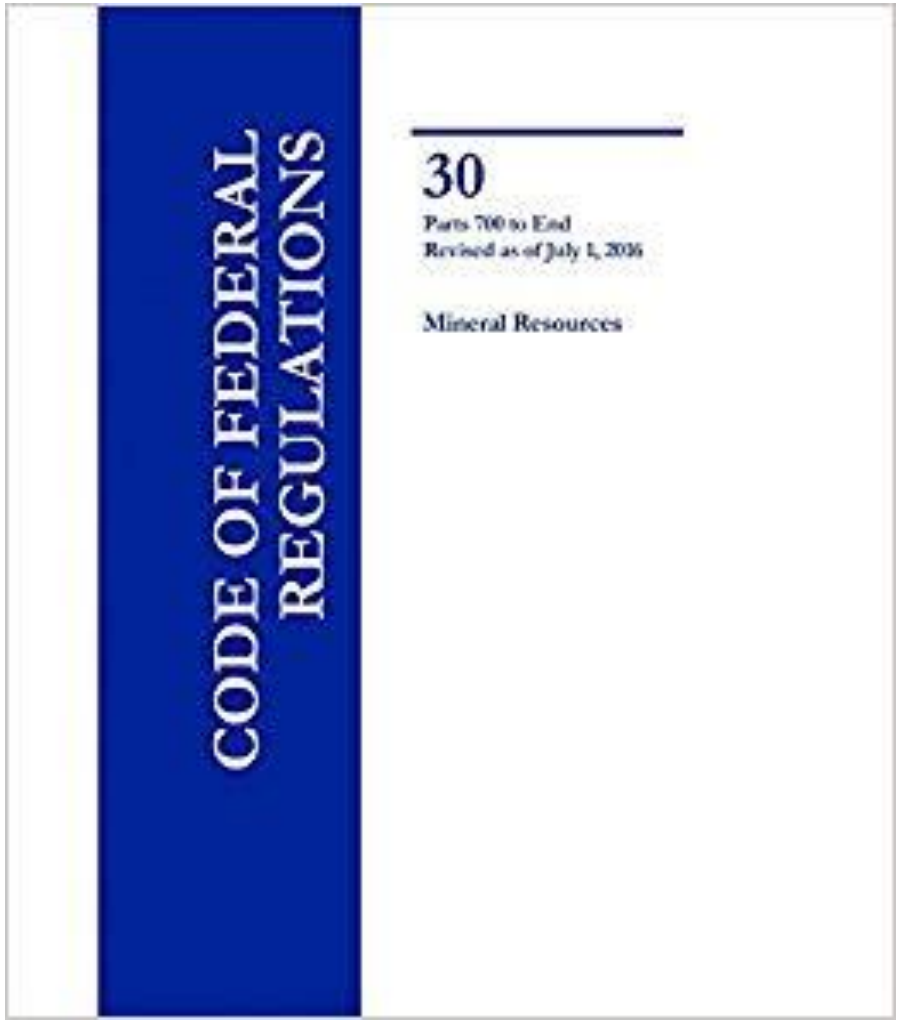
Federal rules considerations

- Apply nationally
- Administered locally by the states
- Scientific basis
- Equipment availability
- Economic Impact
- Attainability
- Provide a high probability of non-damage!



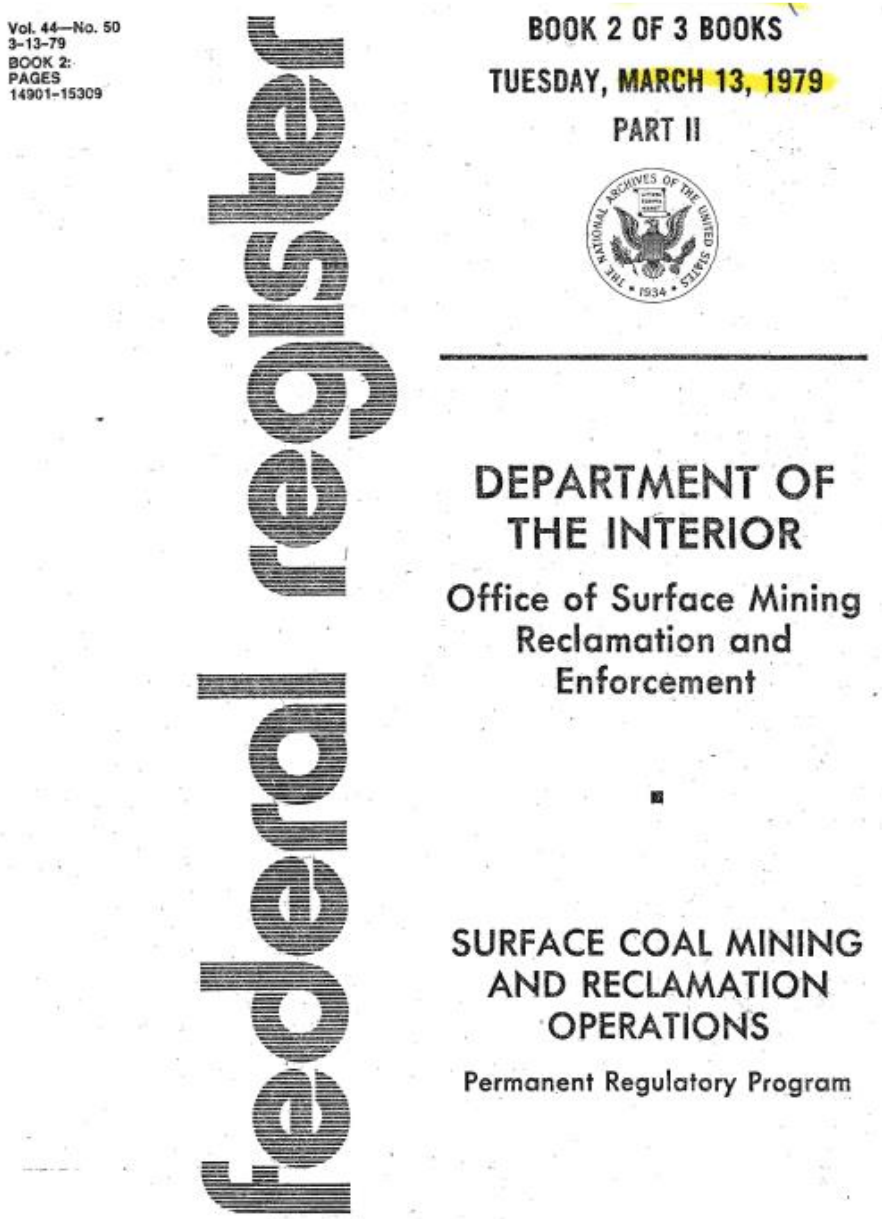
30 Code of Federal Regulations (CFR) Mineral Resources

- 1977 - Interim rules
- 1979 - First iteration permanent rules
- 1980 - Overturned rules by US Court of Appeal, DC
- 1983 - Second iteration permanent rules
- 1993 – Zell Petition
- 2019 - Same Rules to date



1977 Interim Rules

- No blasting within 1000 feet of a dwelling or public building, school, church, or commercial or institutional structure
- PPV less than 1.0 in/s
- Lower level based on:
  - Population density or land use
  - Age or type of structures
  - Geology or Hydrology of the area
  - Frequency of blasts
- Scaled Distance of 60, $W = (D/60)^2$
- Based on discussions with USBM personnel

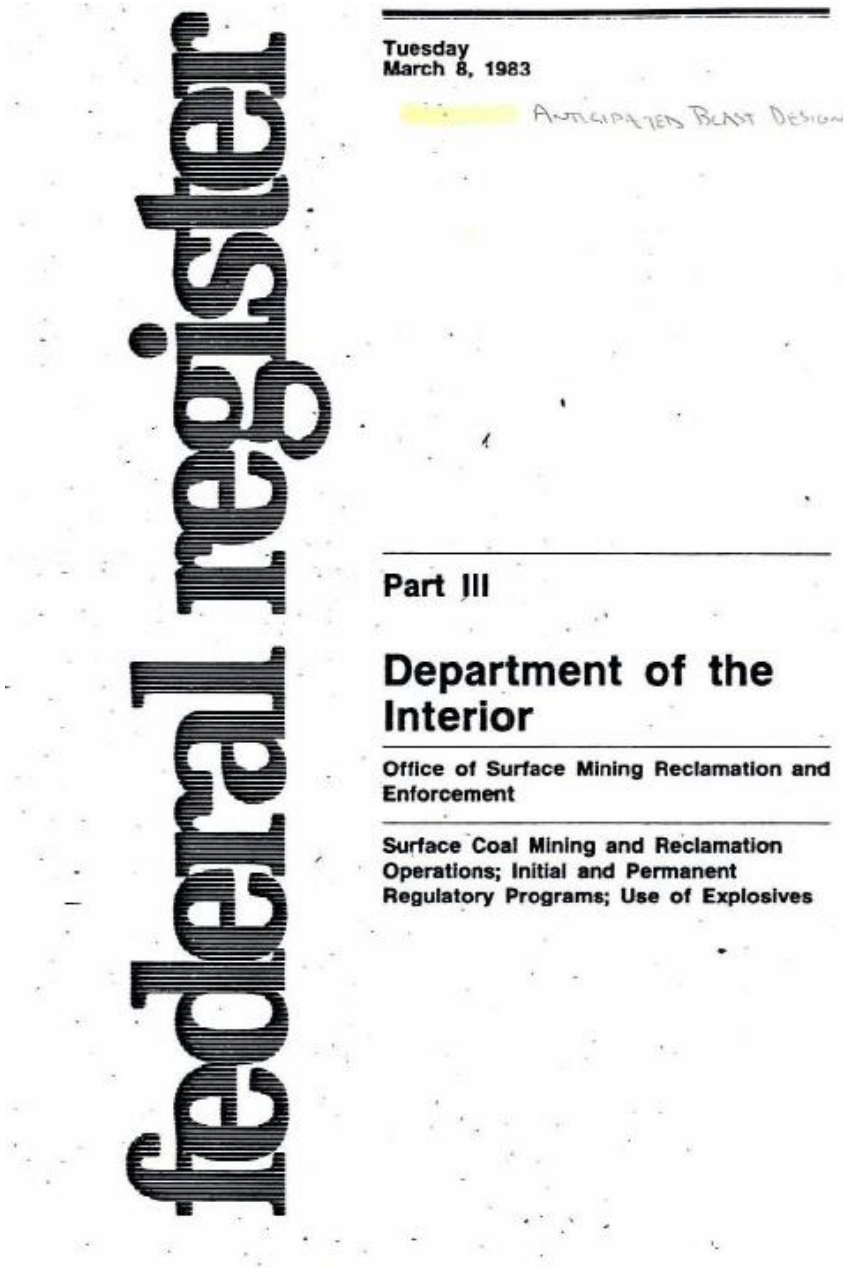


1980 – US Court of Appeals, DC

- Overturned the interim rules
- Blasting prohibition at 1000 feet not granted by Congress, only 300 feet
- PPV = 2.0 in/s is justifiable in USBM 656
- The regulation of 1.0 in/s is without support in the record and therefore arbitrary and capricious
- OSM decided to revisit the permanent 1979 rules too because they were nearly identical.

1983 Permanent Rules
30 CFR 816.67
Use of Explosives:
Control of the Adverse Effects

- Anticipated Blast Designs required within 1000 feet
- Ground vibration limits based on USBM RI 8507, 1980
  - Frequency / Particle velocity dependent
  - Considered vibration limits based on structure type.



30 CFR 816.67 Proposal Option 1

Peak-particle-velocity (inch/second)	*Ds* (scaled-distance factor)
2.00	35
1.60	40
1.35	45
1.15	50
1.00	55
0.70	70
0.50	90

Type of structure [a]	Maximum peak-particle-velocity in inch/second allowable with seismic monitoring at indicated hertz value		
	<10 Hz	10 to 40 Hz	>40Hz
1	0.50	0.50	0.50
2	0.75	1.0	2.0
3	1.0	1.5	2.0
4	2.0	2.0	2.0
5 [b]			

[a] 1. Sensitive or protected structures such as historic buildings, monuments, and residences with construction elements such as plaster interiors and rough stone foundation walls.

2. Older homes more than 20 years old with construction elements such as plaster-on-lath interiors and deteriorated or rigid, easily fractured construction materials.

3. Modern homes less than 20 years old with gypsum-board interior, reinforced concrete or concrete-masonry-unit foundations, and other wood-frame and wood-clad structure.

4. Structures with safety considerations such as water towers, impoundments, tunnels, pipelines, towers, and underground mines.

5. Buildings or structures designed to resist dynamic loads such as earthquake, wind, traffic, etc.

[b] Maximum; peak-particle-velocity to be determined by a qualified registered professional engineer.

30 CFR 816.67 Proposal Option 2

$CW = D^{1.5} / 90$

Distance to structure from blast site (feet)	Maximum ground-vibration limit allowable with seismic monitoring (inch/second) [1]
0–300 [2]	1.60
301–500	1.35
501–1,000	1.20
1,001–3,000	1.00
3,001–5,000	0.90
beyond 5,001	0.75

[1] Ground vibration recorded as the peak-particle-velocity. Particle velocity shall be recorded in three mutually perpendicular directions. The peak-particle-velocity shall be the largest of any of the three measurements.

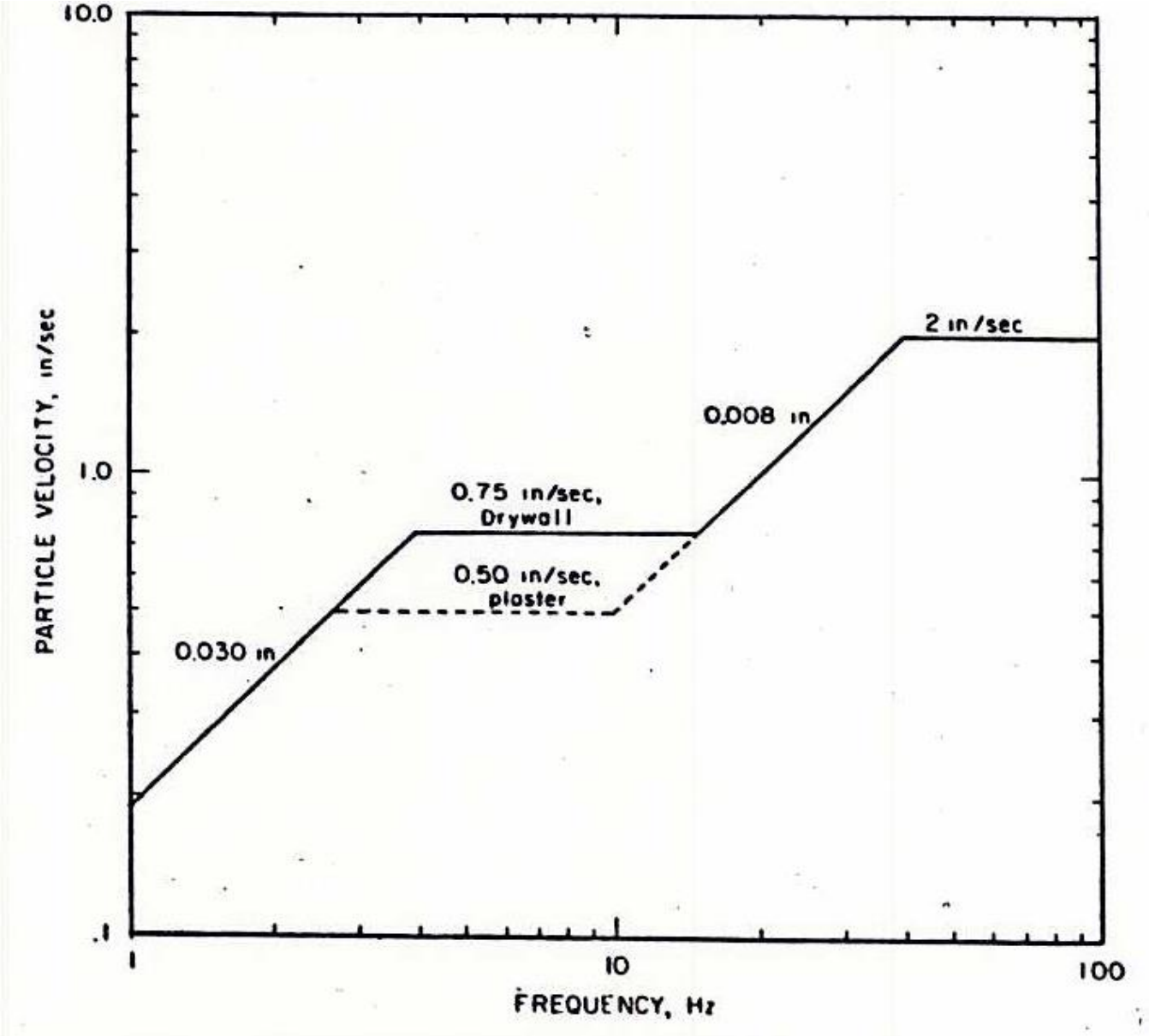
[2] Subject to owner approval for dwellings; no mining may occur within 300 feet of public buildings.

30 CFR 816.67 Proposal Option 3

PPV < 1.0 in/s

Or

CW = $(D/55)^2$



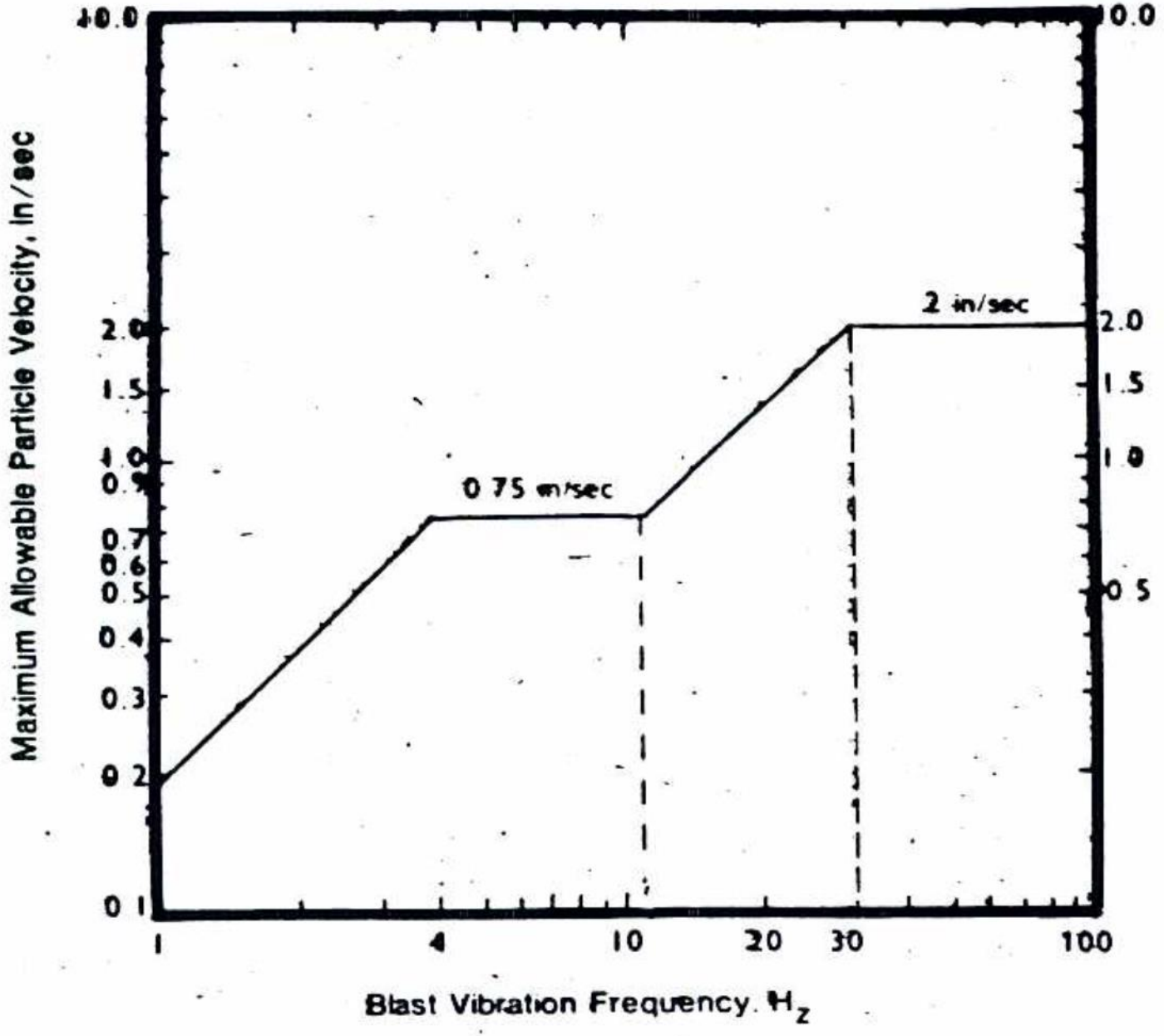
30 CFR 816.67 Final

Distance (D), from the blasting site, in feet	Maximum allowable peak particle velocity (Vmax) for ground vibration, in inches/second [1]	Scaled-distance factor to be applied without seismic monitoring [2]
0 to 300	1.25	50
301 to 5,000	1.00	55
5,001 and beyond	0.75	65

[1] Ground vibration shall be measured as the particle velocity. Particle velocity shall be recorded in three mutually perpendicular directions. The maximum allowable peak particle velocity shall apply to each of the three measurements.

[2] Applicable to the scaled-distance equation of Paragraph (d)(3)(i) of this section.

PPV = 438 $SD^{1.52}$

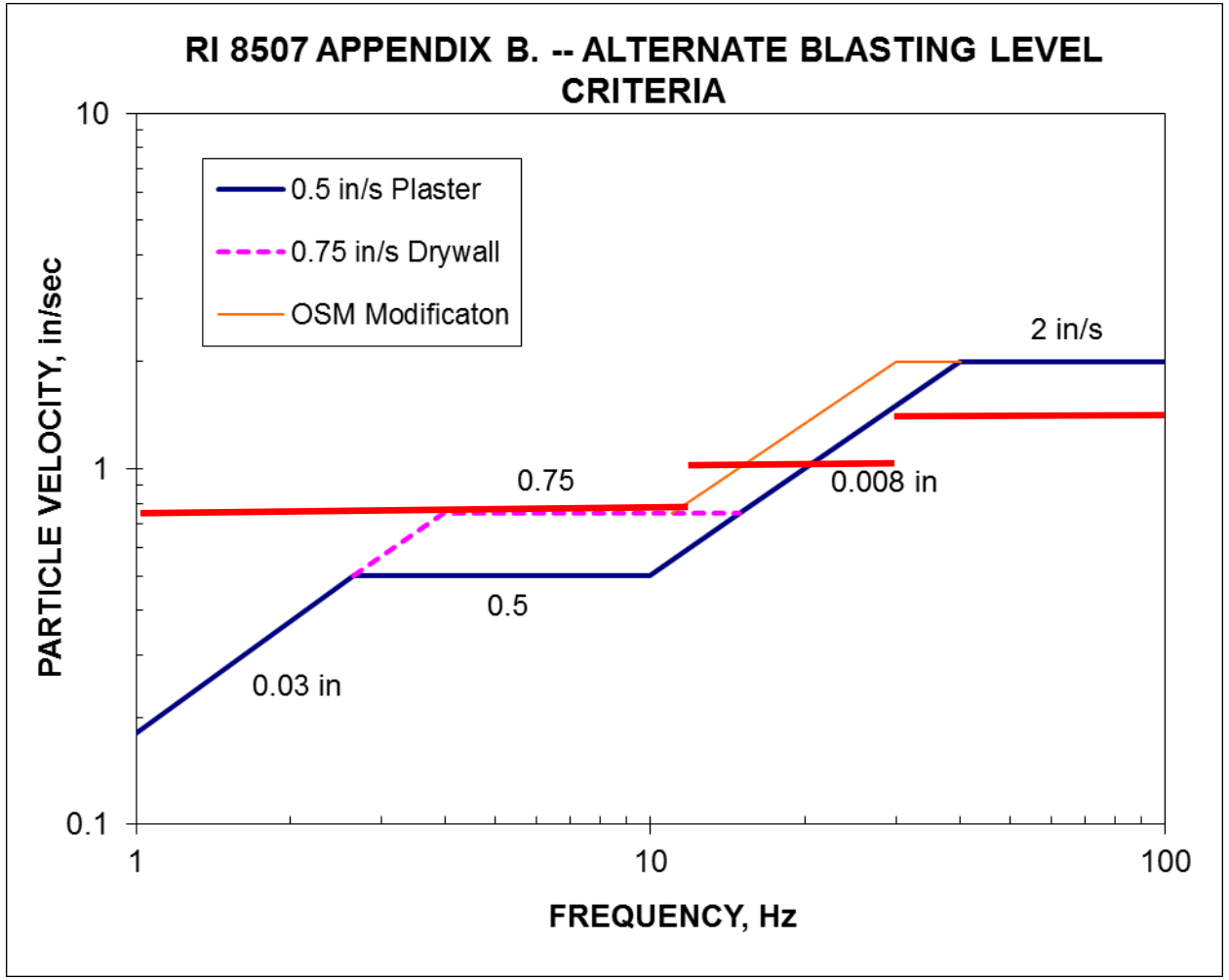


OSMRE Ground Vibration Limits

Distance	**SD_2**	**PPV**
0 - 300	50	1.25
301 – 5000	55	1.00
5001 and beyond	65	0.75

- dwelling, public building, school, church, or community or institutional building
- *Regulatory Authority is responsible to lower the limit if necessary to ensure damage prevention.*
- Set limits on “other structures”

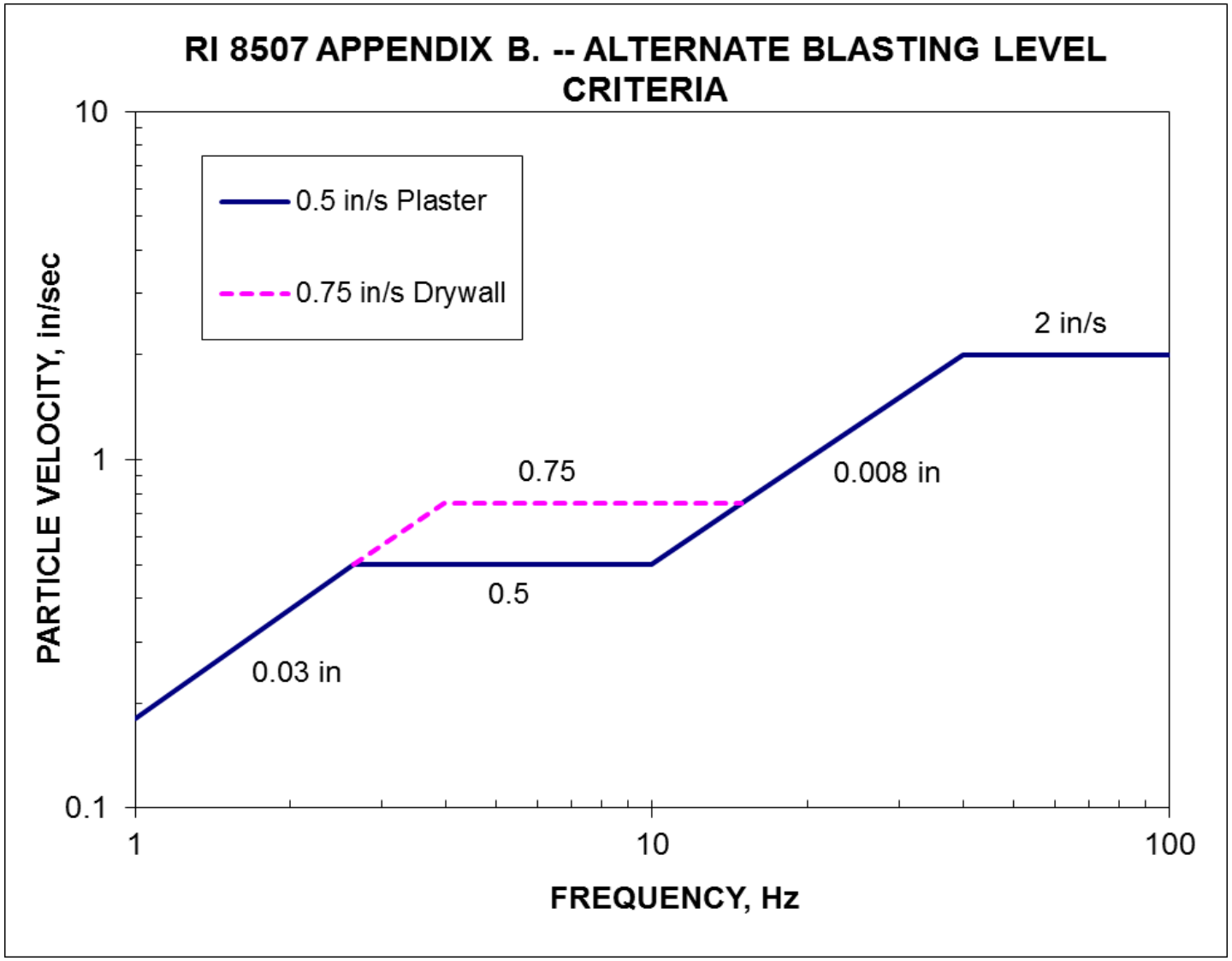
Comparison of Compliance Methods



Ground Vibration Limits

- OSM – First agency to adopt, with modification, USBM RI 8507
- Coal mining states quickly followed “for coal”
- Many kept 2.0 in/s criterion for all other blasting
- IME adopted
- NFPA adopted
- But because of litigation the “original Z” curve crept back into view
- ISEE initiative resulted in changes to NFPA and IME

ISEE, IME, NFPA Ground Vibration Limits 2019



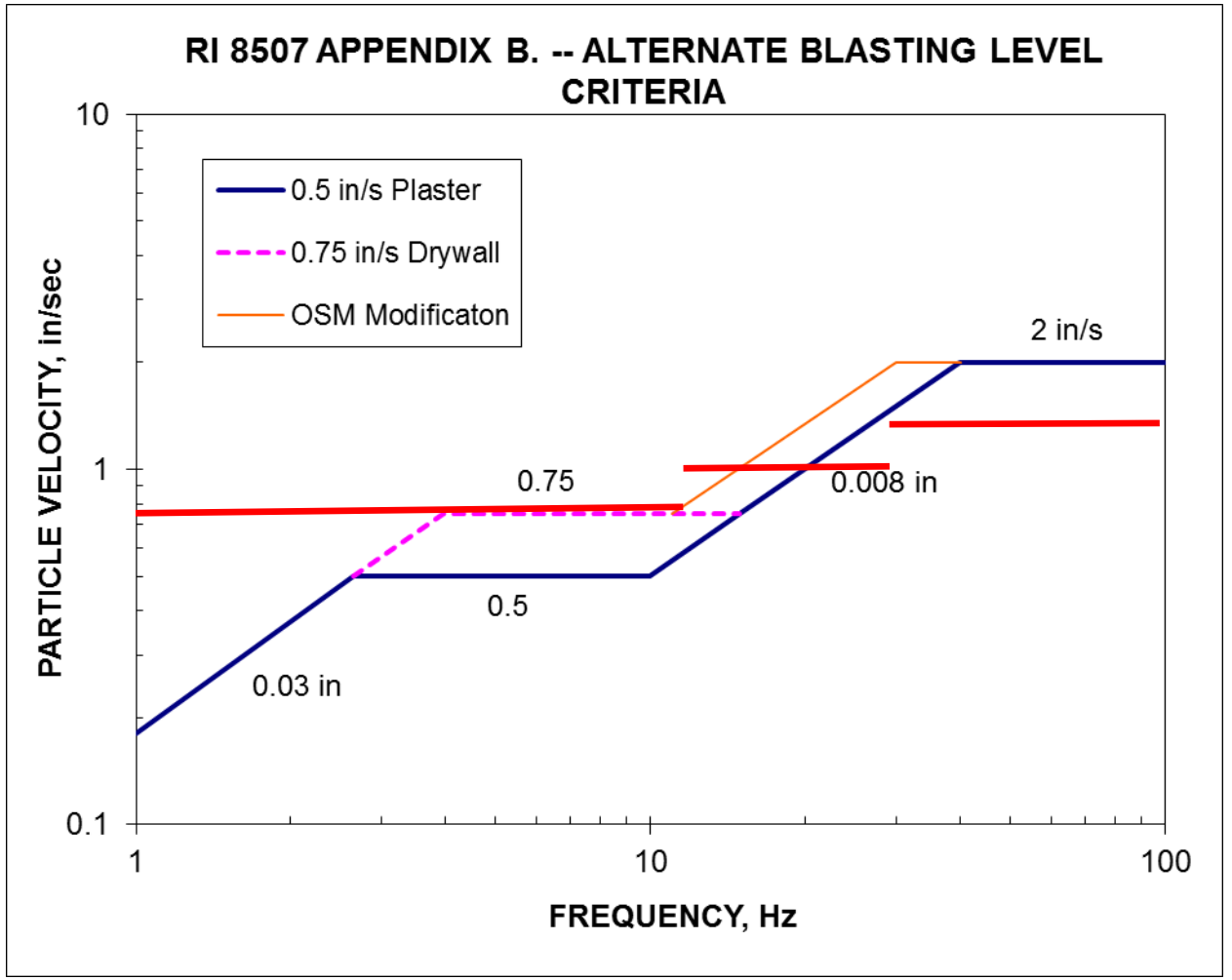
ISEE, IME, NFPA Ground Vibration Limits 2019

Distance	**SD_2**
0 - 300	50
301 – 1000	55
1001 and beyond	65
Some States	90

“Z” is alive and well

- 40 years after RI 8507 the standard is still valid
- Provides for a high probability of non-damage
- Used in all legal cases alleging damage
- Adopted by the professional societies
- Easily used with current blasting seismographs
- Many states have adopted “Z” for compliance
- What is important?
  - **PPV**
  - **Frequency**
  - **Structure type**

Questions?


RI 8507 APPENDIX B. -- ALTERNATE BLASTING LEVEL CRITERIA
PARTICLE VELOCITY, in/sec
10
1
0.1
1
10
100
FREQUENCY, Hz
0.5 in/s Plaster
0.75 in/s Drywall
OSM Modificaton
2 in/s
0.75
0.008 in
0.5
0.03 in