imposed by individual regulatory authorities under § 816.64(a), as appropriate.

Section 816.65

As proposed, OSM has deleted previous § 816.65 and recodified its requirements as follows:

The requirements contained in previous § 816.65 (a) and (b), which set forth limitations on the hours and times of blasting, are adopted in amended form in § 816.64(a), which is discussed above. The requirements contained in previous § 816.65(c), pertaining to audible signals, are adopted in an amended form in § 816.66. OSM has deleted the requirement of periodic notification of meanings of warnings and all-clear signals. Those notifications are adequately provided through blasting signs and the blasting schedule.

Previous § 816.65(d), limiting access to blasting areas, has been rewritten and renumbered as new § 816.66(c), which is discussed below.

Previous § 816.65(e), governing airblast, has been adopted in amended form as § 816.67(b).

Previous § 816.65(f), pertaining to blasting within 1,000 feet of certain buildings and 500 feet of other facilities, was proposed to be incorporated in amended form in § 780.13(c). Instead it has been adopted in amended form as § 816.61(d), which is discussed above.

Previous § 816.65(g), governing flyrock, has been adopted as § 816.67(c), which is discussed below.

Previous § 816.65(h), containing a general performance standard requiring blasting to be conducted to prevent injury or damage, has been adopted as § 816.67(a), which is discussed below.

Requirements similar to those in previous § 816.65(i), which contained maximum peak-particle-velocities for blasting, have been adopted in amended form in § 816.67(d).

The requirements of previous § 816.65(j), identifying the circumstances where less stringent performance standards apply, have been adopted as § 816.67(e).

Previous § 816.65 (k) and (l), containing alternative means to determine peak-particle-velocities, have been modified and adopted as part of § 816.67(d).

Section 816.66. Use of explosives: Blasting signs, warnings, and access control. Section 816.66 contains provisions for blasting signs and warning procedures throughout the permit area. It also contains the physical access and control requirements to fulfill the notification provisions of § 515(b)(15)(A) and the public protection provisions of § 515(b)(15)(C) of the Act.

Section 816.66(a)

New § 816.66(a)(1) includes provisions from previous § 816.11(f)(1) and the proposed rule, and requires that the operator conspicuously place signs reading "Blasting Area" along the edge of any blasting area that comes within 100 feet of any public road right-of-way and at the point where any other road provides access to the blasting area. Notice along any road that provides access to a blasting area will ensure that anyone entering the blasting area is aware that blasting is taking place.

New § 816.66(a)(2) includes provisions from previous § 816.11(f)(2), and, at all entrances to the permit area from public roads or highways, requires signs which state "Warning! Explosives in Use." These signs must clearly list and describe the meaning of the audible blast warning and all-clear signals and explain the marking of blasting areas and charged holes.

In addition, all signs used to mark blasting areas must conform to the specification for signs and markers set out in § 816.11.

A State regulatory authority commenting on the proposal recommended that signs required under proposed § 816.66(a)(1) contain the warnings and explanations required for signs under proposed § 816.66(a)(2), because in some instances the signs referenced in § 816.66(a)(1) may be closer to the blasting site than those at entry points (referenced in § 816.66(a)(2)). OSM has not accepted this recommendation. The "Blasting Area" signs are intended to warn people of the limits of and to stay out of the area where blasting will take place. The more complete description of paragraph (a)(2) is intended to provide guidance to persons who may need to enter the permit area of precautions to follow when within the permit area.

Commenters objected to the 100-foot requirement and suggested that signs be required only when a public road right-of-way occurs within 50 feet of the blasting area, citing that more signs would be required than under the previous rules. OSM disagrees since the previous rules required signs on roads within 100 feet of the permit area but required signs at 50 feet when roads were actually within the permit area. OSM has adopted a consistent 100-foot distance in order to simplify the requirements.

A commenter suggested adding to § 816.66(a)(2) the phrase "awaiting firing" after "charged holes." OSM has accepted this suggestion, recognizing the need to clearly advise personnel entering the mine site of the precautions to be taken to prevent injury.

Section 816.66(b)

New § 816.66(b) requires the use of audible warning and all-clear signals of different pattern. It also requires notification of the meaning of the signals to those who work within the permit area and those who reside or regularly work within one-half mile of the permit area.

Several commenters objected to the term "different character" in proposed § 816.66(b) regarding the application of audible signals, assuming this meant different sounds, sounds with different tonal qualities. OSM recognizes this concern and has replaced "character" with "character or pattern" to allow use of the same instrument to make the sound in a different pattern to differentiate between "warning" and "all-clear."

Section 816.66(c)

New § 816.66(c) requires the controlled restriction of access to the blast area until hazards no longer exist and access can be safely resumed. Both livestock and persons are protected. Also it requires that no unusual hazards such as imminent slides or undetonated charges exist.

A commenter objected to the deletion of the first sentence of § 816.65(d) restricting access to areas subject to flyrock, when it was redesignated § 816.66(c). By including the phrase "within the blasting area" in § 816.66(c), OSM intends to encompass all areas where the hazards of flyrock are present. Therefore § 816.66(c) controls the same area where access was previously controlled under § 816.65(d).

Section 816.67. Use of explosives: Control of adverse effects.

Section 816.67(a)

OSM is adopting § 816.67(a) as proposed. The rule requires that blasting be conducted to prevent injury to persons, damage to public or private property outside the permit area, adverse impacts on any underground mine, and change in the course, channel, or availability of ground or surface waters outside the permit area. This provision, which is the successor to previous § 816.65(h), implements Section 515(b)(15)(C) of the Act.

Commenters objected to the requirement in proposed § 816.67(a) which requires blasting to be conducted in such a way as to prevent the "change in the course, channel, or availability of ground or surface waters outside the permit area." The commenters felt that it

would be impossible to distinguish between changes resulting from blasting and those resulting from other mine-related operations. The requirements of § 816.67(a) are adopted from Section 515(b)(15) of the Act which specifically requires that blasting be conducted in that manner. Furthermore, since OSM's permitting regulations at § 786.19(c) require the finding that damage will be prevented with respect to hydrology outside of the permit area resulting from mining, no blasting could be permitted which would result in material offsite hydrologic damage.

Section 816.67(b)

Airblast limits. OSM is adopting a slightly modified version of the airblast rule from that proposed in § 816.67(b). Airblast limits must be met at any dwelling, public building, school, church, or community or institutional building outside the permit area, with the exception of certain structures owned by the operator and covered by § 816.67(e). OSM has lowered the allowable airblast limit from that proposed for measuring systems with lower frequency limits below 6 Hz (hertz) from 130 to 129 dB (decibels). This has been done at the request of a commenter who indicated that the higher airblast limit was inconsistent with data published by the Bureau of Mines in RI8485 (Siskind and others, 1980).

In addition, OSM has retained separate airblast limits from previous § 816.65(e)(1) for c-weighted, slow response measuring systems and flat response measuring systems with a lower frequency limit of .1 Hz or lower. These peak limits are 105 dBC and 134 dB, respectively, and are consistent with BOM data. The c-weighted, slow response limit is the same as the previous rule and the .1 Hz or lower system limit than the previous rule. The use of of both of these measuring systems must be approved by the regulatory authority.

Several commenters suggested that airblast limits should not apply at locations where a structure is owned by an operator. It appears that there was some confusion as to the applicability of § 816.67(e). In its proposal OSM intended that Paragraph (e) apply to such structures for both airblast and ground vibration. In order to clarify the applicability of the exception in § 816.47(e), the phrase "except as provided in Paragraph (e) of this section" has been added to the end of the airblast standard in § 816.67(b)(1)(i).

A commenter suggested inclusion in § 816.67(b)(1)(ii) of specific rulemaking and public hearing procedures for reduction of the airblast standard. In its proposal OSM intended that the maximum allowable airblast standard applicable to a specific mine may be modified by the regulatory authority if OSM's permanent program limits appear to create excessive levels which may cause damage. To clarify its intent, OSM has revised § 816.67(b)(1)(ii) and inserted the phrase "for use in the vicinity of the specific blasting operation." Rulemaking procedures are not required for changes to the standards that are not of general applicability.

Another commenter believed that OSM's proposed language which included the word "may" and also the requirement "if necessary" gave the regulatory authority too much discretion to decline to reduce the maximum airblast limit, if it determined that a lower value is necessary to prevent damage. OSM believes that imposition of a lower value is properly within the discretion of the regulatory authority. However, should the regulatory authority determine a lower value to be necessary it must set a lower value. For this reason the final rule contains the language under which the regulatory authority determines whether or not imposition of a lower limit is necessary, and, if so, must reduce the limit.

Commenters objected to proposed § 816.67(b)(1)(iii) because it placed a burden on operators to evaluate "adverse atmospheric conditions." OSM agrees that there is no need to have such a specific requirement. Accordingly, proposed § 816.67(b)(1)(iii) has not been adopted. However, the requirement to meet applicable airblast standards is general and applies regardless of atmospheric conditions.

Airblast monitoring. A commenter on proposed § 816.67(b)(2)(i) suggested that airblast measurements should be required at the location and occurrence of every seismographic reading. In considering this provision, OSM recognizes the need for ensuring that airblast levels are met, but also believes that the location of seismographic monitoring, for instance, may not be the critical or appropriate location for airblast monitoring. Wind, temperature, and overcast weather can affect the maximum airblast location. Therefore, the final rule includes a general provision for periodic airblast monitoring by the operator in which the locations and the periods of such monitoring are left to the discretion of operators and the regulatory authority. A sentence has been added to the § 816.97(b)(2)(i) to emphasize that the regulatory authority may specify monitoring locations and determine which blasts have to be monitored.

A commenter was dissatisfied with the explanation in the preamble to § 816.67(b)(2) (47 FR 12766) concerning airblast monitoring "at or near the nearest structure." The issues raised are: (1) When is a notice of violation issued for exceeding airblast standards? and (2) where should monitoring be located? In response, OSM notes that airblast limits apply at any location where damage may occur (*i.e.*, the location of any structure, not necessarily the nearest). Therefore, a monitor located at any structure which records a value exceeding the maximum value for that frequency would record a violation. The location may not be the nearest structure because wind conditions may focus airblast away from near structures to those at greater distances from the blast. Although OSM is not requiring specific locations to be monitored, the operator is responsible to insure that such airblast monitoring does take place to assure compliance with airblast limits at all locations.

Section 816.67(b)(2)(ii) specifies the sensitivity of airblast monitoring equipment, requiring the upper end of the response range of the measuring system to have a flat frequency response of at least 200 Hz. A commenter objected to the provision in proposed § 816.67(b)(2)(iii) which would have allowed the regulatory authority to approve alternative measuring systems for airblast. As discussed in the preamble to the proposed rules (47 FR 12766), some suitable alternative monitoring systems exist, such as a 0.1 Hz- or a C-weighted instrument. As described above, OSM has inserted limits for these particular alternatives in the final that will provide equivalent levels of protection. Therefore proposed § 816.67(b)(2)(iii) is unnecessary and has not been adopted.

Section 816.67(c)—Flyrock. OSM has adopted § 816.67(c) approximately as proposed. The final rule is essentially the same as previous § 816.65(g). Flyrock includes material either travelling along the ground or in the air. It may not be cast more than one-half the distance to the nearest dwelling or other occupied structure nor beyond the area of regulated access. It may not be cast off the permit area.

Comments varied on the items to be included as flyrock. OSM, in review of these comments intends to include rock, mud, and debris as flyrock. It should be noted that flyrock is considered to be cast, projected, or thrown, not drifting smoke or dust particles of fragmented rock. Several commenters disagreed

with the provision limiting flyrock range to one-half the distance to the nearest inhabited structure. These commenters cited this restriction as contrary to other departmental requirements for maximum coal recovery. Others cited this provision as providing a degree of safety in excess of that required by the Act. OSM has opted to retain the provision for one-half the distance, but has limited its applicability to dwellings or other occupied structures. This places the burden on operators to provide appropriate design restraints when mining close to such dwellings or structures, such as additional stemming, burden, or mats to prevent flyrock. Section 522(e)(5) of the Act limits mining within 300 feet of occupied dwellings, subject to valid existing rights or unless a waiver is obtained from the owner. Such a waiver does not, however, waive the protection of § 816.67(c)(1) from flyrock or other adverse effects of blasting.

OSM has also chosen to retain the prohibition against casting flyrock beyond the permit boundary limit, rather than allowing operators to cast it on the land owned or leased by the operator.

Unless such land is permitted, access control is not provided, and public protection might be jeopardized.

A commenter suggested including public road rights-of-way in § 816.67(c)(1). OSM considered this addition, but rejected it because such areas will be protected according to either § 816.66(c)(2) or § 816.67(c)(3) which prevents flyrock from being cast outside the permit boundary or the area of control under § 816.66(c).

A commenter raised the question of defining the blasting site as the location from which flyrock distances are measured. OSM agrees with explosives industry terminology which generally refers to the limits of a blasting site as encompassing an area contained within the perimeter formed by the exterior charged holes. This differs from the area of regulated access (blasting area) referred to in § 816.66(a)(1) and § 816.66(c). The blasting area reflects the area where danger from flyrock exists for mine workers and persons potentially entering the mine site.

Commenters requested the phrase: "from the blasting site" be changed to "from its point of origin" in § 816.67(c) referring to the precise location of the flyrock. Determining the exact point of origin of flyrock is generally impossible after blasting has occurred, and therefore the language "from the blasting site" has been adopted as proposed.

Section 816.67(d)—Ground vibration. Section 515(b)(15)(C) of the Act requires the regulatory authority to establish limits on the use of explosives based on physical conditions of the site so as to prevent injury to persons and damage to public and private property outside the permit area. Ground vibration is among the most relevant factors which must be considered.

OSM has proposed three options for the control of ground vibration. The final rule governing ground vibration incorporates aspects of each of the three options proposed. The three options were: (1) A peak-particle-velocity for each permit based on site-specific data, (2) A variable ground-vibration limit based on distance to the nearest structure; and (3) A constant particle-velocity criterion of 1.0 inch per second at any structure outside the permit area. The discussion which follows first describes the rule that is adopted and then responds to specific comments on the various alternatives.

The rule adopted today sets limits on the allowable ground vibration (i.e., peak-particle-velocity) at certain types of protected structures to ensure the prevention of damage. These include dwellings, public buildings, schools, churches, or community of institutional buildings outside the permit area.

Peak-particle-velocities have been selected which reasonably assure that structures will be protected from damage. Blasts conducted close to structures where the frequency of ground vibration is generally highest will be allowed to have higher peak-particle-velocities. Further away, where potentially damage-causing lower frequencies would predominate, a lower peak-particle-velocity is mandated. For structures which are not buildings, the operator must submit a value for regulatory authority approval.

Three methods for ground-vibration limitation are provided in §§ 816.67(d)(2), (3) and (4) for the use of operators. These methods vary in their complexity and expense in application.

First, peak-particle-velocities are set for use with seismic monitoring. Section 816.67(d)(2)(i) provides specific numeric limits for ground vibration for use with general seismic monitoring and equivalent scaled-distance factors. These limits provide the protection to structures including residences, based on an analysis of the damage recorded by the RI8507 study (Siskind and others, 1980). The specific limits are described below, together with OSM's justification therefor.

Second, as an alternative provided under § 816.67(d)(3)(i), an operator may use a scaled-distance equation which determines charge-weights (the weight of explosives) based on the distance of the blast to the nearest structure. The equation is used to determine the allowable charge-weight per delay without mandatory seismic monitoring. Under § 816.67(d)(3)(ii) operators may, with regulatory authority approval, develop and use a modified scaled-distance equation.

Third, under § 816.67(d)(4) the operator is allowed to conform to maximum peak-particle-velocities that vary by frequency. In those situations an operator must use sophisticated seismic monitoring which records the frequency content of the ground vibrations. A detailed discussion of this paragraph is included below.

Under § 816.67(d)(5), the regulatory authority may reduce ground vibration levels on a site-specific basis if necessary to provide sufficient damage protection. Generally seismic monitoring is at the option of the operator; however, under § 816.67(d)(6) the regulatory authority may require it and specify locations for such monitoring.

Under § 816.67(e) the operator may exceed the prescribed ground-vibration levels at structures owned by the operator with the written waiver of any lessees.

In selecting particle-velocity limits, OSM has considered the differences between performance criteria, design standards, and the range of potential damage based on these parameters.

In controlling ground vibration, information such as geology, hydrology, seismic characteristics, distances to structures, and the amount of explosives must be evaluated. These factors, plus the level of fragmentation necessary, must be considered in setting the pattern of drill holes, selecting of explosives, and determining charge-weight. Design standards for ground vibration, such as burden, spacing, stemming, and subdrilling were not mandated by the previous rules and are not found in the final rule. Such design considerations are more appropriately applied by the certified blaster. The performance criteria to be met for ground vibration must be based on the ground-vibration levels predicted to cause damage. To stay within these levels, design parameters which are intended to keep ground vibration at or below the maximum allowable level must be used. Ground-vibration limits which protect homes and buildings from damage have been predicted from research studies. One Bureau of Mines study, RI8507 by Siskind and others (1980), provides a consolidation of such studies for the purpose of developing safe limits. The study recommended a 0.75 inch-per-second standard for dwellings with

gypsum-board interiors and 0.50 for plaster-on-lath interiors. These recommended limits have been highly criticized by operators, explosives users, explosives engineers, explosives manufacturers, and others as overly stringent. Some claim that these limits result from misinterpretation of the data. Also, portions of the RI8507 study have been cited for inaccurate data and damage findings, placing some question on the conclusions and recommendations of the study. A number of comments contained such criticism.

OSM considers RI8507 as the most up-to-date consolidation of research data for evaluation of blast-induced damage, but agrees that the interpretation of the data raises some questions. OSM utilizes the study's data base to support the regulatory limits on blasting, but does not accept the study's recommended standards. From the data on page 16 of RI8507, OSM concludes that design indicators, relating design to performance levels such as the weight of explosives per delay, do not consistently produce absolutely predictable uniform levels of performance. Thus a blast using a specific charge-weight of explosives may result in a range of particle-velocities, and repeated blasts at that charge-weight may result in somewhat different ranges. Use of scaled-distance factors as design guides produces ranges of results as depicted on Figure 11 of RI8507. (For example, the range of expected particle-velocities for different mining blasts for a scaled-distance of 100 is from 0.015 to 0.20 inch per second, a factor of 1,333 percent.) Therefore, an operator attempting to meet a 1.0-inch-per-second standard would not design for a blast with a peak particle velocity of 1.0 inch per second, but rather would design for a blast with an expected range of peak particle velocities not to exceed 1.0 inch per second. The design range for a 1.0-inch-per-second limit from Figure 11 is 0.15 to 1.0 inch per second with a scaled-distance of 30. A scaled-distance of 55 results in a range of lower values. When monitored with seismographs, this approach will require careful application of design criteria to fall within the maximum limit. Without seismic monitoring, conservative safety factors must be applied to assure compatible performance for regulatory compliance.

Because OSM believes operators must design to achieve lower levels than the maximum permissible, setting a 1.0-inch-per-second performance level is believed by OSM to result in actual readings in the range 0.30 to 0.70 inch per second. This range is consistent with the recommendations in RI8507 (Siskind and others, 1980). OSM believes that a 1.0-inch-per-second peak-particle-velocity will prevent the occurrence of threshold damage and has set such a standard in § 816.67(d)(2)(i) for distances of 301 to 5,000 feet from the blasting site to the nearest building.

Several commenters objected to the use of the RI8507 study. The report incorporates and consolidates field data and laboratory experiments conducted in the definition of damage produced by blast vibrations. In addition to the conclusions reached, which have been the subject of much dispute, it has several chapters dealing with the fundamentals of ground vibration and airblast, including ground-vibration propagation with scaled-distance, response-spectra analysis applications, interior considerations such as amplification; and a chapter on failure characteristics of materials which relates damage potential to the inability of materials to undergo deformation and withstand stress or strain.

Commenters' concerns focused on the adequacy of the new structures and data observed, the relevance of the old study data, and the definition of the terms "threshold," "minor," and "major" damage. In developing these rules, OSM has relied upon the new data in RI8507 which was collected on actual structures in a controlled manner using highly complex and sensitive monitoring equipment. OSM followed the suggestion of commenters and used such data as a basis for its regulatory actions.

In review of damage data in the RI8507 study in Figure 46 on page 51, as related to the readings in Table 1 on page 10 of that report, OSM finds that threshold damage did not occur until considerably higher levels than the report's conclusions indicate. For instance, "structure 51" incurred damage from all recorded blasts except one at 0.5 inch per second. Threshold damage ranged from levels of 1.04 to 7.25 inches per second, but the damage which was observed at 1.04 inches per second immediately followed six higher recordings in the following order: 1.16, 1.22, 2.84, 1.24, 1.86, and 10.21 inches per second. OSM believes that if the structure had not been weakened by the six successive stronger blasts, a vibration of 1.04 inches per second may not have damaged it. "Structure 27" recorded damage at the lowest reading of the new data in RI8507 (0.72 inch per second). This value followed blasts at the following levels: 1.38, 1.89, 1.91, 2.33, 3.73, 5.31, 2.34, and 1.22 inches per second. Of these, only blasts with ground vibrations recorded at 1.91 and 5.31 inches per second were attributed with threshold damage. Numerous blasts with considerably higher values did not result in damage.

The data below taken from Report RI8507 demonstrate that the range of threshold damage occurred at 0.75 to 2.0 inches per second, with the majority of damage points concentrated between 1.0 and 2.5 inches per second, whereas, no nondamage points were observed above 2.0 inches per second. Of the structures presented as new damage points on Figure 46 of RI8507, the following data are evaluated:

Structure No.	Material type	Number of observations		Number of damage points	
		<1.0[1]	>1.0[1]	<1.0[1]	>1.0[1]
19	Plaster/lath.	29	16	1	5
20	Gypsum board.	13	2	2	1
27	Plaster/lath.	1	9	1	2
51	Plaster/lath/brick.	1	11	0	[2]13
58	Gypsum board/brick.	1	5	0	5
61	Gypsum board/plaster.	1	1	1	1
Total		46	44	4	27

[1] Inch per second.
[2] Questionable data plotting.

Based on the above table, 91 percent of blasts observed below 1.0 inch per second did not cause damage. Of the 4 blasts observed below 1.0 inch per second that caused damage, one at 0.72 inch per second followed two blast observations greater than 1.0 inch per second (2.34 and 1.22) which did not result in damage. Therefore, the 0.72 value is questionable as the actual damage-producing blast. Another damage value of 0.79 followed a nondamage value of 1.10 inches per second.

Therefore, OSM considers the 1.0-inch-per-second standard adopted in § 816.67(d)(2)(i) for the range of 300 to 5,000 feet to provide a degree of protection consistent with the Act, because (1) The range of threshold damage appears to occur at levels above 1.0 inch per second; (2) the range of recordings in field blasts designed to meet a maximum limit of 1.0 inch per second will infrequently reach 1.0 inch per second with expected results in the range from 0.30 to 0.90 inch per second; and (3) the ground-vibration criteria coupled with other limitations on adverse effects from blasting will tend to require design considerations which lead to cumulative protection (*i.e.*,

separate constraints on flyrock and airblast will limit charge-weight, dimensions, and explosive characteristics).

Several commenters compared the recommended levels in the RI8507 study (Siskind and others, 1980) to the values OSM proposed in Option I for structure type and frequency.

As can be seen from the following comparison, the recommended peak-particle-velocities of the study are lower than those in OSM's proposal.

Structure type	RI8507 recommended at 40 Hz (in/sec)	OSM rule at 10 Hz (in/sec)
2	0.50	0.75
3	0.75	1.00

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 interiors, reinforced concrete or concrete masonry unit foundations, and other wood-frame and wood-clad structure.

In response to these commenters, OSM recognizes the need for blasting levels which prevent damage. However, in review of the data contained in Figure 46 of RI8507, OSM observes that the lowest damage value associated with blasts affecting plaster-on-lath interiors was 0.72 inch per second on "structure 27," and the lowest value affecting gysum-board interiors was about 0.79 inch per second on "structure 20." Structures such as "51" (plaster/lath/brick), "19" (plaster/lath), and "58" (gypsum board/brick) showed the occurrence of threshold damage at blasts ranging from 0.85 to 5.75 inch per second with the majority of points between 1.0 and 3.0 inches per second.

Imposing a ground-vibration level of 0.5 inch per second for such structures would protect these structures, but OSM believes this level is overly conservative. A value of 0.75 inch per second would also have provided protection. OSM believes that if a blast is designed to avoid exceeding the limit, the design level will have to be far less than the maximum, because predictability of the maximum particle velocity is difficult unless a conservative scaled-distance equation is applied. OSM expects that blast designers would have to use design criteria of 0.3 to 0.5 inch per second to meet a 0.75-inch-per-second performance standard. Under a 1.0-inch-per-second standard, only rarely are values expected actually to reach the maximum levels. Actual recorded vibration levels are expected to range from 0.30 to 0.90 inch per second. The setting of particle velocity limits, rather than specifying design parameters for different types of structures ensures protection and allows the blaster reasonable latitude in conducting the shot. Such practices ensure protection consistent with the parameters of the RI8507 study (Siskind and others, 1980) without penalizing the operator by restrictive performance levels. The possibility of every blast reaching a constant 1.0-inch-per-second level is small. Furthermore, an occasional blast which reaches that level does not present a high degree of damage potential. Additionally, if blasting levels do consistently reach the prescribed standard and the regulatory authority considers this a potentially damaging level, it is authorized in §816.67(d)(3)(ii) to reduce the allowable maximum standard to a lower value.

One commenter agreed that the concepts applied by OSM were valid, but disagreed with the specific values proposed and the claimed oversimplification of the ground-vibration issue. The commenter recommended a constant 1.0-inch-per-second standard be mandated in the final rule. OSM, in developing the final rule, has incorporated suggestions from various commenters and under § 816.67(d)(2)(i) has applied a constant 1.0-inch-per-second value over a normal operating range of 300 to 5,000 feet, recognizing the occurrence of high frequency close to structures and low frequencies which would exist if the vibration intensity carried beyond 5,000 feet. This does not preclude low frequency from occurring in close-in blasts or high frequency from occurring at distances greater than 5,000 feet. However, based on the data found in RI8507, a constant 1.0-inch-per-second standard would have prevented at least 85 percent of the damage points, and it is noted that 15 observations produced no damage above the 1.0-inch-per-second particle-velocity level.

In § 816.67(d)(20)(i), ground-vibration limits within 300 feet and beyond 5,000 feet are different from the 1.0-inch-per-second standard. Based on the predominant occurrence of high frequency vibration near the blasting site, OSM allows a 25-percent higher particle-velocity limit within 300 feet of a blasting site. The higher level would only be allowed for residences within 300 feet after owner approval and when prior blast designs must also be submitted to the regulatory authority. The additional constraints when blasting within 300 feet, as well as the probability of higher frequencies, justify the increase to 1.25 inches per second.

Conversely, at distances beyond 5,000 feet, levels at 0.75 inch per second must be observed with due regard to the potential for potentially damaging low frequency vibrations.

Commenters called OSM's attention to the study conducted at the Wright Mine in Warrick County, Ind., by Braile and others (1982). This study only dealt with the propagation of ground-vibration waves: data was observed for the site-specific geology and geologic type but no analysis of damage was conducted. The conclusions support the limits on blasting which produces low frequency ground vibrations and long duration surface waves, because such occurrences raise damage potential as well as result in annoyance to residents. The study concludes that vibrations at 5,000 feet could be perceptible and disturbing to persons inside a structure. However, the study does not indicate a damage threshold for these low frequency waves. Other studies suggest that the results achieved by the peak-particle-velocity standards prescribed today will prevent damage from low frequency blasts. Because OSM is statutorily charged only to prevent damage to structures and injury to persons, OSM has based blast limits on avoidance of physical injury or damage rather than annoyance.

Many commenters suggested that OSM consolidate proposed Options 1 and 3, while others supported variable peak particle velocity as a function both of frequency and distance from the blasting site. Several commenters recommended proposed Option 1 because it (1) Considered levels of protection by structure type as well as frequency and (2) allowed a 2.0-inch-per-second maximum peak particle velocity under some site-specific conditions, whereas Options 2 and 3 apply generally conservative limits and equations. Based on these comments, OSM has adopted a variant of Option 1 in the form of Figure 1 as an alternative method of determining peak particle velocity. This provision, § 816.67(d)(4), provides a site-specific approach to blasting restrictions based on carefully monitored frequency of the blast and provides adequate flexibility for State program adaption. The derivation of the values used in this alternative is described below.

An operator-commenter preferred proposed Option 1 because it allowed limits to be set based on site-specific conditions. Other commenters objected to Option 1 because it contained values believed to be too permissive and would

be difficult to implement due to the variety of structure types, frequency verification, and monitoring constraints. The commenters also felt that levels for Type 4 structures would be too restrictive. OSM believes that the final rule reflects the positive aspects of Option 1, flexibility and site-specific levels, but only places the requirement of stringent monitoring and data development on those choosing to undertake such a sophisticated approach. OSM has decided not to adopt different standards for different types of structures because such a rule would be unnecessarily complex, would require an extensive analysis of structures surrounding the blasting site and would be difficult to enforce.

Some commenters expressed support for the Option 1 standards, because it appeared to be the only limit restricting ground vibration at the location of utilities (buried pipes, etc.). OSM did not intend that Option 1 be the only protection for pipelines, underground mines, water towers, impoundments, and tunnels, but recognizes that these structures are less susceptible to damage than buildings and residences. Therefore, OSM has included a provision under § 816.67(d)(1) to limit ground vibration at such structures as determined by the regulatory authority. Currently, the Mine Safety and Health Administration requires levels less than or equal to 2.0 inches per second for underground mines.

Some commenters preferred Option 3, but suggested a modification to allow values greater than 1.0 inch per second in areas specifically approved by the regulatory authority. In the new rule being adopted, OSM has incorporated two provisions allowing such values. First, at distances less than 300 feet an upper limit of 1.25 inches per second has been established in § 816.67(d)(2)(i) because of the frequency considerations; however, as noted throughout the comments, lack of substantiating data precludes incorporating limits in excess of 1.0 inch per second as proposed in Option 2 for distances between 300 and 3000 feet. Second, the use of alternative blasting criteria under § 816.67(d)(4), the limits of which are specified in Figure 1, will allow values up to 2.0 inches per second if site conditions warrant for blast frequencies in excess of 30Hz.

A commenter suggested that the only acceptable safe blasting criteria would be a variable limit with frequency similar to proposed Figure 1, or the use of response-spectra analysis requiring investigation of the natural frequency of the structure to be protected and relating this information to the blast vibration frequencies. OSM acknowledges that response-spectra analysis as used in the RI8507 study (Siskind and others, 1980) and by vibration consultants provides a unique solution because it sets allowable limits accurately by predicting the range of potential damage. However, OSM believes that a much more general standard must be authorized for application at coal mines where 200 to 1,000 houses may be involved. OSM does not want to discourage the use of response-spectra analysis, especially where a regulatory authority determines that a lower standard should apply. This technique if applied on a case-by-case basis might prove to be the best substantiation of the actual damage range. In order to allow such technique and to provide operators the option to increase particle velocities above the maximum limits set for general compliance, OSM has included in § 816.67(d)(4) an alternative method using Figure 1. Using this option requires monitoring of particle velocity at the frequency levels, which may be augmented by response spectra for confirmation of the structure's interaction with the monitored wave forms. In using this alternative, the seismographic record will provide evidence of regulatory compliance, as well as evidence of damage potential for information of nearby homeowners.

A commenter, objecting to all options presented in the proposed rules, cited difficulty in the application of proposed Option 1, disputed the assumption that frequency decreases linearly with distance from the blasting site as found in proposed Option 2, and did not like the inclusion of the alternative blasting criteria under proposed Option 3.

Commenters also believed that proposed Option 3 ignored structural response, claiming that single value limits are an oversimplification of blasting effects and misleading to further study.

As described above, the new rule combined the three options; it allows the application of three levels of ground-vibration control: (1) Seismic monitoring of peak particle velocity, (2) use of a scaled-distance equation without monitoring, and (3) complex monitoring of velocity at associated frequencies. Each allows a somewhat different approach to control of blasts, but each provides equivalent levels of damage prevention.

Several commenters suggested adding the use of vector-sum seismographs to the peak-particle-velocity component concept of § 816.67(d)(1)(i). OSM recognizes that some monitoring equipment records vector sum and that requiring component seismographs may be expensive for the operator. To avoid this unnecessary burden, OSM has allowed, but does not require, the use of vector-sum units. The Bureau of Mines has concluded that component velocity is the best indicator of damage potential and thus recommends limits and readings be in component format. The values listed for acceptable vector sum limits are identical for component limits, ensuring conservative results when using a vector-sum instrument. OSM recognizes that this will produce conservative monitoring standards, but a general conversion of component to vector-sum equivalent is not available.

Commenters were concerned that OSM's 1.0-inch-per-second standard would not provide adequate protection of sensitive structures. OSM believes that the limit of 1.0-inch per second over the range from 300 to 5,000 feet does set a limit which considers structural response. Setting a universally applied limit assumes that structures to be protected have natural frequencies in the range of 10–20 Hz (hertz). At frequencies between 10 and 20 Hz the safe vibration level recommended in RI8507 ranges between 0.75 and 1.40 inches per second. As indicated in OSM's evaluation of data from RI8507, the range of threshold damage appears to begin at levels greater than 1.0 inch per second. Therefore, a 1.0-inch-per-second standard provides protection within this range over the broad range of distances.

A commenter objected to the prohibition placed on mining within 300 feet of a dwelling without owner approval and within 300 feet of public buildings. The commenter felt that such limitations were inappropriate and could interfere with maximum coal recovery. Section 522 of the Act prohibits any mining operations within 300 feet of public buildings or dwellings (without owner consent) subject to valid existing rights. Rules governing these areas are set forth at 30 CFR Parts 761 and 769. It would be duplicative to restate them in conjunction with the blasting rules. Accordingly, the proposed language in § 816.67(d) has not been adopted.

Section 816.67(d)(1) sets levels for structures other than buildings. This new rule places the burden of setting particle-velocity limits for these structures on the operator and the regulatory authority. Operators would propose standards for structures, and the regulatory authority would approve or modify them.

Various commenters made recommendations regarding scaled-distance equations, a variant of which was proposed for all three options. Some commenters agreed with the correlation values proposed (e.g., $Ds=55$ correlating to 1.0 inch per second) while others believed that $Ds=60$ should be used to correspond to 1.0 inch per second, stating that it would better meet the requirements of the Act. Another commenter objected to the use of scaled distance as a safe blasting criterion. That commenter presented information attempting to refute the accuracy of scaled distance as a predictor at any specific value. OSM based the correlation values proposed (47 FR 12768) on the blast data contained on pages 10–17 of the RI8507 study and believes use of scaled distance will prevent damage in more than 99 percent of blasts as described below.

The use of the scaled-distance equations of § 816.67(d)(3) provides an operator with the option of not monitoring every blast to ensure compliance with the specified maximum ground-vibration level. Siskind and others (1980) in the RI8507 study collected and consolidated blast vibration data from blasting at various distances and blasting parameters. When displayed and analyzed, these data provide a line representing the mean occurrence of a specific particle velocity for a specified scaled-distance level. The equation adopted in § 816.67(d)(3) divides distance from the blast to the structure to be protected by a scaled-distance factor to yield the square root of the total charge weight of explosives which may be detonated in any 8-millisecond period: $(D/Ds)=/W$, where D=the distance from the blast to the structure to be protected, Ds=the scaled-distance factor, and W=the charge weight of explosives.

The values of ground vibration measured at location D from the blast reflect the actual measured ground vibration. Mean curves were developed as part of the RI 8507 study based on the actual ground vibrations measured. (See p. 14 of the RI 8507 study.) The mean portrayed thereon reflects an averaging of values above and below the curve at any scaled-distance factor. The curve representing a 95-percent-confidence level for specific vibration levels is obtained statistically, resulting in a similar curve two standard deviations above the mean. This results in a level providing 95-percent confidence that actual monitoring will fall at or below the predicted ground vibration. OSM has selected scaled-distance factors taken from the standard deviation curve. Coupled with the remote possibility of damage at the predicted level, these factors will afford a degree of protection in excess of 99 percent for the structure to be protected.

Some commenters felt that the proposed scaled distance of 70 in Option 1 was too conservative. Under the final rule, the maximum scaled-distance factor will be 65. Under the tables in new §§ 816.67(d)(2)(i) and 817.67(d)(2)(i), the scaled distance of 65 is applied only when the distance to the nearest building is greater than 5,000 feet. This will allow the use of a maximum of 5,900 pounds of explosives per 8-millisecond delay period at a distance of 5,000 feet. OSM does not believe this limit will constrain an operator unduly since explosive technology has developed delay blasting techniques available to conduct large blasts using this amount per delay. The scaled-distance denominator of 65 corresponds to a 0.75-inch-per-second peak particle velocity. In setting this peak particle velocity, OSM recognizes the need for lower ground vibration at locations of lower frequency. After traveling 5,000 feet, the intensity of a seismic wave should dissipate below the 0.75 peak-particle-velocity level; thus the standard should rarely be exceeded.

Some commenters contended that the proposed equation $W=D^{1.5}/90$ in Option 2 was too conservative for the large areas blasted in the West. OSM has not adopted that optional equation because it was too stringent at long distances and not stringent enough when structures were within 500 feet. Therefore, its applicability would have been limited to the distances between 1,000 and 3,000 feet, whereas the scaled-distance equation adopted in this new rule, using $Ds=55$, can be applied at distances between 300 and 5,000 feet.

OSM believes that the 55 level for Ds over the 300 to 5,000 foot range provides sufficient protection; as described earlier, a 1.0 inch-per-second level reflects an appropriate standard to provide damage protection.

Section 816.67(d)(3)(ii) allows the operator flexibility in modifying the scaled-distance factor Ds to allow for higher or lower scaling factors. The provision requires that after the operator correlates the mean occurrence of particle velocity with scaled distance, the modified value for the scaled-distance factor Ds must reflect a point that is two standard deviations above the mean regression curve. This correlation value provides a 95-percent-confidence level that the maximum allowable particle velocity will not be exceeded. A technical guidance document will be made available by OSM demonstrating the application of the modified equation and its derivation.

One commenter suggested that a lower limit be established on modified scaled-distance below which the regulatory authority would not set a standard. OSM has not accepted the suggestion. OSM believes that a 1.0-inch-per-second standard over the normal working distances provides adequate protection in general blasting practice, but recognizes that structure condition, geology, and vibration frequency affect damage potential and are site specific. The Act requires site-specific limits for use of explosives, and values as low as 0.5 inch per second may be necessary. The setting of a lower value is more appropriately left to the discretion of the regulatory authority at the time of evaluating the site-specific conditions.

Certain site-specific conditions warrant higher bore hole loadings per delay, but protection of people and property must be assured. Other site-specific conditions may warrant reduction of allowable peak particle velocity and the lowering of the weight of explosives per delay (i.e., higher scaled-distance factors). The provisions of § 816.67(d)(5)(ii) require the regulatory authority to take action if necessary to provide damage protection. Critical factors in assessing damage probability include distance to the nearest structure and charge weight.

A commenter objected to the proposed term "in the vicinity of the mine" with respect to proposed § 816.67(d)(3)(iii) which would have required regulatory authorities, upon requests from owners and residents, to evaluate the maximum allowable ground-vibration standard. The same commenter felt that "vicinity" could mean 100 feet or 100 miles. The commenter suggested that such requests be limited to structures within one-half mile of the permit area. OSM believes that the proposed provision is unnecessary. Upon request from a resident, or for any other reason, the regulatory authority may require seismic monitoring of blasts and may reduce ground vibration limits if conditions warrant. Thus, the regulatory authority has ample authority to protect those in the vicinity of the blasting.

As mentioned above, § 816.67(d)(4) presents a third optional ground-vibration standard. This is based on the standard proposed as Figure 1 in Option 3 in the proposed rule. It requires more stringent monitoring than the normal peak particle velocity and allows more flexibility to operators to use greater

charge weights. The limits are set forth in a graphic distribution of maximum allowable particle velocity versus blast vibration frequency. These are shown in a new Figure 1 to be included as part of the rule. Commenters requested that the limits of proposed Figure 1 be revised. Several commenters wanted this criterion to be the only one to apply to regulation of ground vibration. Others objected to the use of the criterion altogether and suggested its deletion. OSM has included the criterion as an alternative to allow flexibility by operators and regulatory authorities if they wish to conduct the more extensive monitoring required. The alternative blasting criterion (new Figure 1) differs slightly from that proposed. One commenter suggested retention of the proposed curve above 20 Hz, but a limit of 1.0 inch per second for the portion of the curve below 20 Hz. Another commenter provided a rationale for adjusting the cutoff point for the 2.0-inch-per-second standard from 40 Hz to 30 Hz, since the interaction with an amplification of natural frequencies of residential structures primarily occurs in the 5 to 20 Hz range. The suggestion to rely on a constant 1.0-inch-per-second limit up to 20 Hz has been rejected because it fails to acknowledge the impact of predominant low-level blast vibration frequency within the range of 5 to 10 Hz.

In determining the values in Figure 1, OSM has adopted the Bureau of Mines proposal cited in Appendix B of RI8507 (Siskind and others, 1980). For frequencies up to 4 Hz, a constant maximum amplitude of 0.030 inch will be allowed. (Under this standard, amplitude is related to particle velocity through the use of the equation $V=2\pi fA$, where V is the particle velocity, f is the frequency, and A is the amplitude.) Over this frequency range the maximum allowable particle velocity increases from 0.19 inch per second to 0.75 inch per second. At frequencies of 4 through 11 Hz a constant allowable particle velocity of 0.75 inch per second is set.

The level over the range 4 to 11 Hz was set at 0.75 inch per second rather than 1.0 inch per second to acknowledge the need to reduce particle velocity at low frequencies. Over the frequency range of 11 through 30 Hz, a constant amplitude of 0.0107 inch is allowed. This correlates to maximum particle velocities of 0.75 inch per second to 2.0 inch per second. Above 30 Hz, a constant peak particle velocity of 2.0 inches per second will be allowed.

A commenter cited concern with varying threshold levels on the basis of structure type and vibration frequency and allowing a maximum level of 2.0 inches per second. These commenters felt that proposed Option 1 would be the most beneficial in regulating the industry. OSM does not believe that a general limit of 2.0 inches per second provides adequate protection. In the previous rules, a peak particle velocity of 2.0 inches per second was allowed in some instances only when applying stringent monitoring techniques. In the final rule, the particle-velocity standard sought by the commenter is allowed under § 816.67(d)(4) at frequencies above 30 Hz, but only under well-monitored and controlled conditions that require seismic monitoring using equipment recording both particle-velocity data and vibration frequency levels to assure continuous compliance.

A commenter raised the problem of determining predominant frequency in applying proposed Option 1 dealing with the structure tables. This problem also exists in implementing the alternative blasting criteria of Figure 1. Therefore, a provision has been added to § 816.67(d)(4) to require approval of the method to be used in evaluating and ultimately establishing the predominant frequency at which vibration levels occur.

A commenter felt that the proposed alternative blasting criterion of Figure 1 was overly stringent and too expensive for most operators. They also were concerned about the possibility of rendering existing monitoring equipment obsolete by this rule. OSM has included new Figure 1 in the final rule for optional application. Some operators may find the economic outlay beneficial to production and the protection of nearby structures; those who do not need not use this alternative method of determining maximum ground vibration. Other provisions of the rules allow conventional monitoring and use of equations without monitoring.

Commenters requested clarification as to what was required to evaluate blast vibration frequency. They wanted to know whether visual inspection of seismographic records was adequate or whether electronic anlaysis of frequency would be required. Under § 816.67(d)(4), which requires regulatory authority approval of the method of analysis of the predominant frequency contained in the blasting records, visual inspection may be adequate if traces are distinct and only a few frequencies are contained in the wave-form. However, seismographic consultants have found that various waves with multiple frequencies typically are contained in the blasting record. In those cases, electronic analysis is necessary to separate the wave traces and analyze each intensity and frequency. OSM does not intend to mandate electronic analysis; rather the determination of what type of analysis is appropriate should be made by the regulatory authority.

Commenters did not believe that frequency analysis, which requires sophisticated equipment, should be required in all cases. Except when the criteria of § 816.67(d)(4) are used, the final rule leaves frequency analysis to the discretion of the regulatory authority. OSM recognizes its value as an indicator of vibration damage probability, but also recognizes the complexity and expense in its application, as well as the uncertainties in determining specific frequency levels.

Commenters referred to human annoyance from blast vibrations. Human response has been addressed by the RI8507 study (Siskind and others, 1980) and other researchers in the ground-vibration field. OSM concludes that the limits on airblast provide the most appropriate basis for minimizing disturbance to nearby residents. In addition, there does not appear to be a standardized correlation between ground vibration levels and degrees of annoyance, apart from injury and damage. OSM believes that through an effective public relations program and communication with nearby residents much anxiety over annoyance can be mitigated.

A commenter complained that OSM had not satisfied its obligations under the Administrative Procedure Act (APA) by indicating a preferred course of action. The APA requires that an agency publish an explanation of its proposed action sufficient to allow for meaningful comments. Due to the complexity of these issues OSM devised several regulatory approaches and has explained each of them with sufficient specificity to attract the numerous comments it has received. A decision on which option to adopt was not made until after evaluation of all the comments received. This new rule adopted by OSM falls well within the range of the alternatives proposed.

Section 816.67(e)

New § 816.67(e) excludes from ground vibration and airblast limits structures owned by the operator and those owned by the operator and leased to others if waivers are obtained from the lessees. Commenters requested that the exclusion for structures owned by the operator and leased to others apply to all options. This was the intent of the proposed rule, but was misinterpreted