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TECHNICAL MEMORANDUM No. 4
BLASTING MITIGATION PLAN (BMP) FOR LAS VIRGENES 5MG TANK PROJECT

Attention: Thomas Blake, C.E.G.
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Introduction and Scope

The primary purposes of this technical memorandum are to:

1) Finalize Blasting Specifications for the District's 1235-Ft Backbone Improvements 5 MG Reservoir Project.
2) Include expanded blasting specifications for trench excavations.
3) Prepare a map showing locations where blasting is allowed.
4) Provide a summary review of controlling methods that will be incorporated into the project design and construction to mitigate impacts.
5) Provide guidelines for qualifications of key blasting personnel (in specifications).

A comprehensive review of blast-induced effects and control measures regarding this project is provided in a report and enclosures prepared by the author in May 2011. That information is not repeated in this memorandum.

Allowable Blasting Zones

For this work, very hard rock must be excavated at the water tank site and in trenches needed to build associated pipelines that will transfer water to and from the treatment plant.

Locations where use of controlled blasting methods should be allowed to excavate rock at the tank site and for trenches needed for associated pipes are shown in Figure 1.

It is understood that the Las Virgenes Municipal Water District (LVMWD) wishes to minimize overall impacts of the construction work to the community. Moreover, blasting must be limited to zones where effects can be controlled to assure there are no impacts to the stability of embankment fill areas of the existing dam and the District's buildings.

Measures that will be applied to minimize impacts to the community and assure protection of the dam are summarized in following sections. These controls and limitations are also included finalized blasting specifications in Attachment 1.

Protecting the Dam from Blast Impacts

In a draft position paper prepared by Gregg Scott (2008) of the US Bureau of Reclamation (2008), a vibration limit of 4.0 in/s is recommended as vibration limit for embankment dams. This proven safe limit was included in the original draft blasting. The author has used this limit in specifications at a dozen or so civil construction projects and all blasting occurred without incident. However, California Division of Safety of Dams (DSOD) has indicated the vibration limit should be lowered to 2.0 in/s.

In response to CA-DSOD's ruling, the specified vibration limit at the Dam has been changed to 2.0 in/s. The most current draft blasting specifications are included in Attachment I.

For this work, with a 2.0 in/s PPV limit at the Dam, the cost of blasting will increase and the Contractor may opt to use other methods for the pipe trench excavations located near the Dam. Other methods including mechanical ripping or the use of expansive chemical grout might be used in these transition areas. Cement-based chemical grouts solidify after placement in drilled holes. Grout will not migrate in the ground and cause any environmental problems.

For practical purposes, in order to comply with the 2.0 in/s peak particle velocity limit, blasting in ground located within 20 or so feet of the dam embankment areas will likely not be possible because the weight of charges would be less than 1.0 pound.

Blasting near the District's Facilities Building

As shown in Figure 1, blasting is not restricted for excavating trenches that may be located near the District's Facilities Building. If hard rock is located in those trench areas, blasting can be done safely to meet the 2.0 in/s PPV limit prescribed for the building. A few years ago a similar pipe trench was safely blasted in hard granite located within 20 feet of the San Juan Water District's Maintenance Building in Folsom, CA. The author oversaw this work.

For all blasting, a provision in the blasting specifications requires a minimum scaled distance of 21 for the District's Facilities Building. Note that units of scaled distance derived from spatial relationships based on principles of dimension similitude are $ft/lb^{1/2}$. Since these units are not meaningful to blasters it is standard practice to not include them in specifications. A technical module regarding vibration scaling relationships that explains how distance is normalized by dividing it by the square root of the charge-per-delay is provided in Attachment III.

The minimum scaled distance value, which all blasters are taught to use, will automatically reduce charge weights as blasts become closer to the structure of concern. The relationship between scaled distance, distance and charge-weight-per-delay is shown in Equation 1.

$$W = \left( \frac{D}{D_s} \right)^2 \qquad \text{Equation 1}$$

Where: D = Distance (ft)
W = Maximum Charge-weight-per-delay (lb)
$D_s$ = Scaled Distance (ft/lb$^{1/2}$)

For instance if a blast is 20 feet from the Facilities Building, the maximum charge-per-delay would be 0.9 pounds [$(20 / 21)^2$]. If the distance reduces to 15 feet the charge drops significantly to 0.5 pounds [$(15 / 21)^2$]. These are very small charges and blasting closer than 15 feet is not practical.

Minimizing Blasting Impacts to the Community

Best possible practices must be applied to control movement of blasted rock, limit vibration and noise, and suppress dust. Provisions intended to assure these controls are included in the attached blasting specifications. These controlling practices and limitations will include:

1) All blasts will be covered with heavy blast mats to assure no blasted material leaves immediate blast areas.
2) Blast areas will be wetted by sprayed water before blasting to minimize airborne dust.
3) Intensity of ground vibration at offsite residential property shall be limited to 0.5 in/s, which is the lowest level in the recommended safe range (RI 8507).
4) Intensity of blast-induced noise is limited to 0.01295 psi (133 dBL).

Other specific controls such as the use of best stemming material to confine charges and scaled distance rules that will assure vibration control are included in the blasting specifications.

References

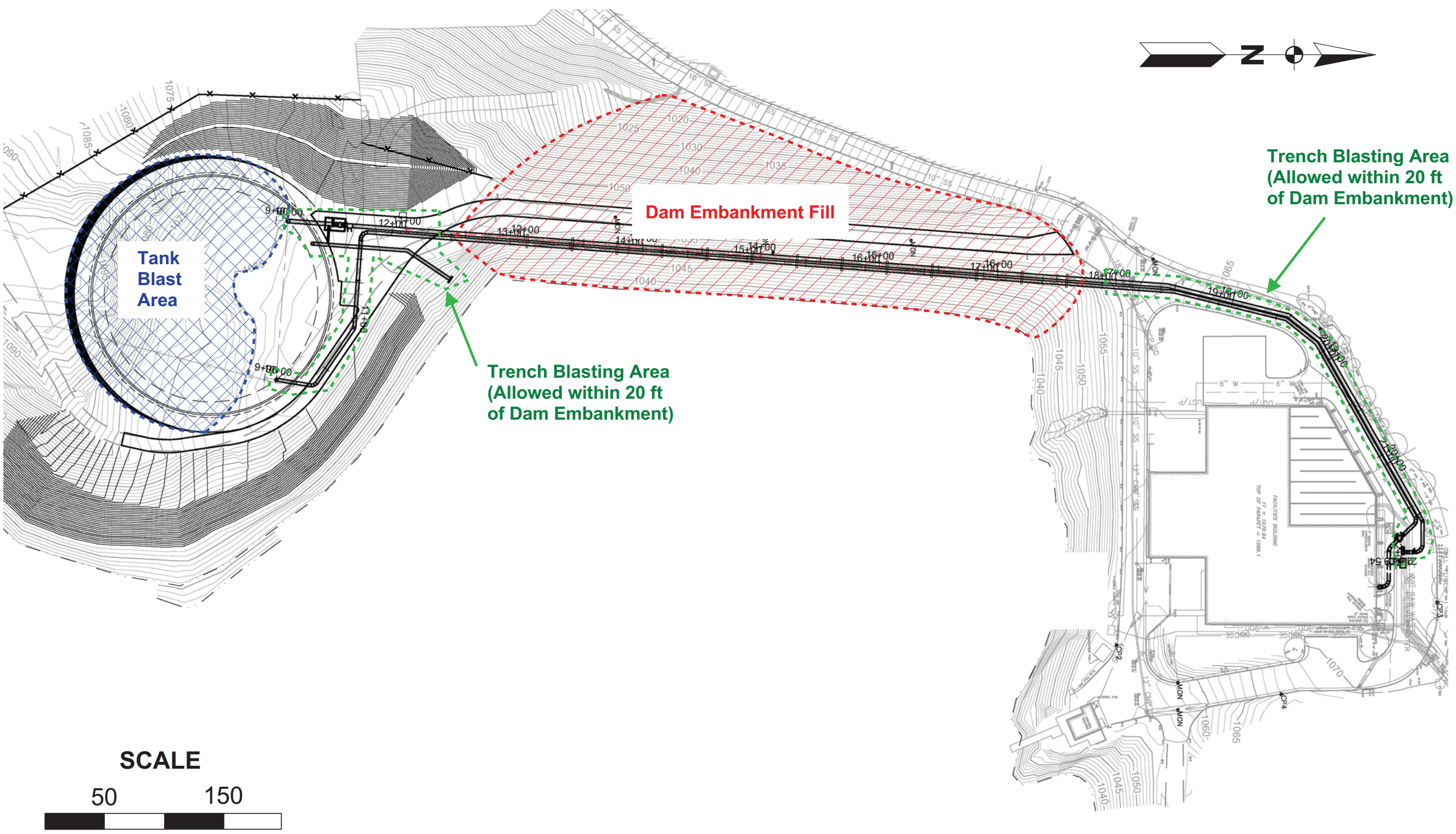
Scott, G.A., (2008). U.S Bureau of Mines, Draft Position Paper Construction Blasting Vibration Limits. April, 2008.

Revey, G. F. (2011). Similitude Relationships for Blast-Induced Vibration, Overpressure and Strain Prediction and Control

Respectfully submitted,

Gordon Revey

**Figure 1 -- LAS VIRGENES MUNICIPAL WATER DISTRICT 5 MG RESERVOIR PROJECT - ALLOWABLE BLAST AREA MAP**



# ATTACHMENT I

# DRAFT BLASTING SPECIFICATIONS
# FOR LAS VIRGENES 5MG TANK PROJECT

# SECTION XXXXX
# BLASTING

## PART 1 GENERAL

### 1.1 WORK INCLUDES

A. Rock blasting necessary for miscellaneous facilities, including: tanks, pipe and utility trenches, miscellaneous structure foundations, site drainage and permanent access roads.

### 1.2 REFERENCES

A. The Contractor shall comply with the applicable rules, regulations and standards established by the Regulatory Agencies, codes and professional societies listed herein, including rules and regulations for storage, transportation, and use of explosives. These rules and standards include but are not limited to the following:

1. The Federal Occupational Safety and Health Act of 1970 and the Construction Safety Act of 1969, as amended.
2. OSHA of 1970, 29 U.S.C., Section 651 et seq., including safety and health regulations for construction.
3. CFR 27, U.S. Department of Justice, Alcohol, Tobacco, Firearms and Explosives Division (ATF). 27 CFR Part 555, Implementation of the Safe Explosives Act, Title XI, Subtitle C of Public Law 107-296; Interim Final Rule.
4. Organized Crime Control Act of 1970, Title XI, Public Law 91-452, approved October 15, 1970, as amended.
5. CFR 49, Parts 100-177 (DOT RSPA); 301-399 (DOT FHA).
6. California Code of Regulations (CCR)
   a. Title 8, Chapter 4, Subchapter 20, Tunnel Safety Orders
   b. Title 8, General Industry Safety Orders, Subchapter 7, Group 18. Explosives and Pyrotechnics
7. Non-regulating Industry Support Organizations
   a. Vibration Subcommittee of the International Society of Explosive Engineers (ISEE), blast monitoring equipment operation standards (1999 or later version if available).
   b. IME (Institute of Makers of Explosives) Safety Library Publications (SLPs).

1.3 DEFINITIONS

1. Air-overpressure – absolute value of increases or reductions to atmospheric pressure measured with a 2-Hz flat-response microphone and expressed in decibels or psi.

2. Blaster-in-Charge or Blasting Supervisor - The single designated and licensed person with complete responsibility and total authority over all decisions involving safe handling, use and on-site security of explosives.

3. Charge-per-Delay - For vibration control, any charges firing within any 8-millisecond time period are considered to have a cumulative effect on vibration and air-overpressure effects. Therefore, the maximum charge-per-delay (W) is the sum of the weight of all charges firing within any 8-millisecond time period. For example, if two 100-lb. Charges fire at 100 ms and one 115-lb charge fires at 105 ms, the maximum charge per delay would be 315 lbs.

4. Controlled Blasting – Excavation of rock using explosives, wherein the blast is carefully designed and controlled to provide a distribution of charge and confining stemming that will excavate the rock to the required limits but minimize overbreak, control rock movement, and assure that intensities of blast-induced vibration and air-overpressure do not exceed regulated or specified limits.

5. Delay-Decked-Charge – Multiple charges with differing firing times placed within a single blasthole that are separated by inert stemming material.

6. Line Drilling - A method of overbreak control in which a series of very closely spaced holes is drilled at the perimeter of the excavation. These holes are not loaded with explosives.

7. Occupied Building - Structure on or off construction limits that is occupied by humans or livestock.

8. Over-excavation – Excavation beyond the neat lines shown on the Drawings.

9. Peak Particle Velocity - Peak Particle Velocity (PPV): The maximum of the three ground vibration velocities measured in the vertical, longitudinal and transverse directions. PPV measurement units are expressed in inches per second (ips).

10. Pre-splitting - A drilling and blasting technique wherein small diameter holes are drilled on close-spacing along the neat excavation lines. The charges are small in diameter, specially prepared for pre-splitting, and are detonated ahead of the main production charges. This technique requires free relief of the perimeter and may require advance excavation of the production area to provide that relief.

11. Primary Initiation - The method used to initiate a blast(s) from a remote and safe location. Primary initiation systems use shock-tubes or electrical current to convey firing energy from the point of initiation to blast locations.

12. Production Holes - Blast holes in the main body of the rock mass being removed by drilling and blasting.

13. Prohibited Persons - Persons prohibited from handling or possessing explosive materials as defined by the seven categories described in Section 555.11 of 27 CFR (ATF Rules).

14. Scaled Distance: A calculated value describing relative vibration energy based on distance and charge-per-delay. For ground vibration control and prediction purposes, Scaled Distance (Ds) is obtained by dividing the distance of concern (D) by the square root of the charge-per-delay (W); so Ds = D/W1/2 or when a minimum defined scaled distance is defined to limit charge weight, W = (D/Ds)2. For example, if a blast is designed to meet a minimum scaled distance of 60, the maximum charge-per-delay for a blast located 600 feet from the structure of concern would be (600/60)2, or 100 pounds.

15. Seismograph – An instrument used to record the intensity and frequency of ground vibrations measured with three mutually perpendicular geophones and a linear-scale microphone that measures air-overpressure.

## 1.4 SUBMITTALS

A. Administrative

1. Blasting Licenses and Permits:
   a. Copy of CalOSHA Blasting Licenses with Construction and Non-electric initiation system endorsements for all proposed blasters-in-charge.
   b. Copies of all blasting permits required by Los Angeles County.
   c. Copy of Blasting CONTRACTOR's federal ATF License.

2. Conceptual Blasting Plan. Submit at least 30 days prior to start of blasting:

   a. General blasting methods that are expected to be used for rock excavation.
   b. Description of blasting techniques as well as techniques to control noise, blasting vibrations, air-overpressures, and fly rock. Include detailed specifications of blasting mats and how they will be safely placed to cover all blasts as required Part 3.1.D.
   c. Procedures to monitor blast-induced vibrations and air-overpressures at adjacent foundation areas, existing or previously completed structures, and other existing facilities.
   d. Name and qualifications of the person(s) responsible for monitoring and reporting blast vibrations.

e. Detailed description of clearing, guarding and warning signals that will be applied to assure that no persons or visible wildlife will be in areas where any harm could be caused by blasting operations.
f. Provide a general sequence and schedule of planned blasting work including lift heights, the general sequence of drilling, blasting, and excavating.
g. Include details of a test blast using no more than 60% of the maximum expected charge-per-delay.

3. Blasting Safety Plan

a. A complete description of the clearing and guarding procedures that will be employed to ensure personnel, staff, visitors, and all other persons are at safe locations during blasting. This information shall include details regarding visible warning signs or flags, audible warning signals, method of determining blast area zones, access blocking methods, guard placement and guard release procedures, primary initiation method, and the system by which the blaster-in-charge will communicate with site security guards.

b. Detailed description of how explosives will be safely transported and used at the various work sites. Plans shall explain how day-storage boxes and explosive transport vehicles will satisfy all applicable regulations. This plan shall also indicate how explosives will be inventoried, secured and guarded to prevent theft or unauthorized use of explosives.

c. Include Material Safety Data Sheets (MSDS) and specific details about hazard communication programs for employees.

d. Equipment that will be used to monitor the approach of lightning storms and in the event of such, evacuation and site safety security plans.

e. Contingency plans for handling of misfires caused by cut-offs or other causes.

f. Fire prevention plan details, including smoking policies, procedures and limitations for work involving any open flames or sparks, description and location of all fire-fighting equipment, and fire-fighting and evacuation plans. Also include plans for removing weeds or dried brush adjacent to blast areas.

g. Initial and ongoing blasting and fire safety training programs.

h. Description of the personal protective equipment that will be used by the Contractor's personnel, including but not limited to, safety glasses, hard-toe footwear, hard hats and gloves.

i. Obtain copies of all applicable codes, regulations and ordinances, keep a copy in project files at all times, and provide LVMWD’s Representative with a copy. The Contractor's Safety Representative shall ensure that ongoing blasting work complies with all applicable regulations.

4. Qualifications:

   a. Submit names of all proposed Blasters-in-Charge and include experience summaries documenting they have a minimum of 10 years of construction blasting experience at projects with similar blasting conditions. Include references for each proposed Blaster-in-Charge from representatives of at least three owners at projects of a similar nature.

   b. Submit qualifications of proposed Blasting Consultant in conformance with Part 1.5.B.

   c. Submit qualifications of proposed Property Condition Survey Professional in conformance with Part 1.5.C.

5. At least 20 days before surveys are done, submit name and qualifications of the independent Professional or firm proposed to conduct pre-blast condition survey(s), including a list of references.

6. Blast Monitoring Equipment – Details of instrumentation to be used to monitor vibrations and air-overpressure levels complete with performance specifications and user’s manuals supplied by the manufacturer. Also submit copies of calibration certificates from the equipment maker certifying that microphones, geophones and all recording equipment has been calibrated within 12 months of the time it will be used.

7. Submit three copies of all pre-blasting reports including photographs and video in DVD format to LVMWD’S Representative at least 10 calendar days before any blasting occurs. The surveys shall be repeated at the conclusion of blasting, and three copies of the post-blasting reports shall be delivered to LVMWD’S Representative seven calendar days after completion of all basting activities.

B. Individual Blasting Plans and Records:

1. Submit Individual Shot Plans at least 48 hours prior to the proposed time of each blast. The review of blasting plans by the Engineer shall not relieve the Contractor of responsibility to assure that all work is done safely and without damage to adjacent structures. Plans shall include:

   a. Sketches showing number, location, diameter, depth, inclination of drill holes.
   b. Sketches showing amount, type and distribution of explosive per hole; and type and quantity of stemming used to confine all blast charges.
   c. Pounds of explosive per square foot for wall-control blasting.
   d. Powder factor (lb/yd$^3$) for production blasting.
   e. Delay timing pattern showing initiation hookup and firing times for all separate charges.

f. Maximum charge-per-delay, distance to nearest structures of concern, including scaled distances and calculations of maximum expected peak particle velocity.
g. Scaled drawings showing the location of the blast with respect to structures of concern and final slopes, lines, and grades.
h. Location of seismographs that will be deployed to monitor blast-induced ground motion and air-overpressure
i. A description of blast covering and ground wetting methods.
j. Proposed date and time of blast.

2. Blast Monitoring Records: Submit the following within 24 hours after all blasts:

a. A copy of the instrument-software generated blast monitoring report at each instrument location that includes measured peak particle velocity in inches per second, peak air-overpressure in linear-scale decibels and vibration and air-overpressure event plots, date and time of event recording, and date the instrument was last calibrated.
b. Scaled map showing the locations of all blast monitoring instruments.

3. Blast Reports: Submit the following within 24 hours after all blasts:

a. Submit blast report showing actual charge delay timing details showing surface and in-hole firing times of all initiators, summaries of all explosives and initiators used, maximum charge-per-delay, hole diameters, spacing, depths, burden, and hole charging and stemming configuration of typical holes. Also include all information required by State of California CalOSHA regulations.

C. Approval by LVMWD'S Representative of the Conceptual Blasting Plan and Individual Shot Plans proposed by CONTRACTOR will only be with respect to the basic principles and methods that CONTRACTOR intends to employ. Approval by LVMWD'S Representative does not relieve CONTRACTOR of sole responsibility and liability for the safety of persons and property.

## 1.5 QUALITY CONTROL

A. All Blasters-in-charge shall be properly licensed and have a minimum of ten years of construction blasting experience at projects with similar scope and complexity.

B. Retain the services of an experienced blasting consultant with at least 10 years experience in developing and overseeing successful close-in blasting work for similar construction projects. All blasting plans, test blasting plans and revisions shall be prepared by or reviewed by and covered with a signed review letter by the blasting consultant. The blasting consultant will not be required to sign the individual blast plans provided they are signed by an on-site licensed blaster. The Blasting Consultant must not be an employee of any Contractors or associated companies of Contractors involved in the work.

C. The independent professional performing the pre-blast condition surveys shall have at least 5 years of documented experience in performing surveys of structures at dams and other heavy civil structures. The survey professional must also be a completely independent third party who is not be an employee of the Contractor, associated companies, or any suppliers to the work.

D. Images of all blasts shall be recorded with a digital video camera. If the camera is within the zone that may be affected by the blast, as defined by the Blaster-in-Charge, the camera must be started before the blast area is cleared and run without being attended by personnel. Copies of blast video files shall be submitted to the Engineer within 24 hours and before any subsequent blasting work occurs.

1.6 BLASTING SAFETY AND EXPLOSIVES SECURITY

A. Comply with all applicable federal, state and local regulations.

B. Protect the safety of all persons and wildlife; and protect all property during blasting operations.

C. Explosives Security: The responsible CONTRACTOR holding the ATF license for this work shall ensure the security of explosive materials at all times when explosive materials are used or kept on the project site and the CONTRACTOR shall ensure that:

1. All persons that handle explosive materials, have control over them, or access to them, must not be prohibited persons, as defined in Section 555.11 of 27 CFR (ATF Rules).

2. All blasting work and explosive handling activities are done under the direct supervision of a properly licensed Blaster-in-Charge.

3. When explosives are delivered to the work sites, they must not be unloaded from delivery vehicles until a responsible blaster-in-charge has signed the delivery paperwork and assumes full authority and responsibility for the security of the explosive materials. Unused explosive materials must be similarly signed over to a properly licensed driver with a Commercial Drivers License with a Hazmat endorsement before explosive materials are loaded onto a fully-DOT-compliant vehicle for removal from the site.

4. The CONTRACTOR shall maintain copies of ATF Employee Possessor questionnaire forms (OMB No. 1140-0072) or documentation of ATF clearance on the CONTRACTOR's ATF license for all employees who will possess, handle or have access or control over explosives for this work as defined in 27 CFR Part 555. This documentation must be available upon request by the appropriate authorities or LVMWD'S Representative. CONTRACTOR and subcontractor employees, without submitted evidence of satisfactory ATF clearance, must not handle, control or have access to explosive materials.

1.7 EXPLOSIVE STORAGE

A. No explosives shall be stored overnight on site.

1.8 PRE-BLAST CONDITION SURVEY

A. Prior to any blasting, perform a pre-blast survey of the conditions of the Las Virgenes Dam and any other facilities designated by LVMWD's Representative. The pre-blast survey shall include a photographic record of all visible and accessible facilities within 1,000 feet of the blast area.

B. Survey the interior and exterior conditions of all residential property and associated structures located within 1,000 feet of blasting areas. If owner's refuse surveys, provide copies of certified-mail letters documenting attempts to provide the survey by a third-party professional survey company.

C. Type-written reports shall include a description of the interior and exterior condition of the various structures examined. Descriptions shall include the locations of any cracks, damage, or other existing defects and shall include information needed to identify and describe the defect, if any, and to evaluate the effects of construction operations on the defect.

D. Reports shall include hard copy color photographs sized at least 4 x 6 inches, printed in glossy format on paper designed for color photo images. If digital cameras are used, resolution of images shall be 5 megapixels or greater. Photos must be taken of all cracks and other damaged, weathered or otherwise deteriorated structural conditions. If necessary, macro lenses and flash illumination shall be used to ensure defects are shown clearly in the photographs. Photos shall contain an accurate date stamp.

E. Structure condition surveys shall be repeated at facilities or properties where damage concerns have been expressed. Details of any observed changes to surveyed structures and documenting photos shall be reported and submitted as required. All reports shall be type written.

1.10 SEQUENCING, SCHEDULING AND NOTIFICATION

A. Provide notification to LVMWD'S Representative at least 24 hours in advance of each blast.

## PART 2 PRODUCTS

2.1 ALLOWABLE EXPLOSIVE MATERIALS AND INITIATORS

A. Only fixed cartridge explosives shall be used for blasting. Use of flowable explosives including ANFO or bulk emulsion is prohibited.

B. Only non-electric initiation systems shall be used for blasting.

C. Use of cap and fuse is prohibited.

## PART 3 EXECUTION

### 3.1 BLASTING

A. All explosive charges shall be stemmed with clean washed angular crushed stone sized from 3/8 to 3/4 inches. The amount of stemming shall be at least 25-charge-diameters. For instance, if charge diameter is 2 inches, minimum stemming is 50 inches or 4.2 feet.

B. The diameter of explosive charges shall not exceed 2.0 inches.

C. The minimum confining burden on all explosive charges with exposure to open rock or ground surfaces shall be at least 25-charge-diameters.

D. All blasts shall be covered with woven steel cable or steel-cable and rubber-tire blasting mats. Woven polypropylene or similar weed-barrier fabric, covered with at least 6 inches of soil or sand shall be placed over blast areas to protect initiators before mats are placed. Mats shall be overlapped at least 3 feet and shall completely cover the blast area and extend at least three feet beyond the blast area in all directions. If any flyrock or blasted material is thrown more than 10 feet or half the distance to the nearest structure, whichever is less, blasting shall be suspended until LVMWD's Representative has approved the Contractor's revised blasting plan showing revisions to the procedure adequate to reduce the flyrock.

E. Before blasts are covered, all loose soils above the blast and located within10 feet of the blast shall be thoroughly wetted with water to suppress airborne dust. Sand or soils placed over weed-barrier fabric shall be similarly wetted before placing blast mats.

F. The depth of blasted rock benches, excluding 2-feet of sub-drilling, shall not exceed 15 feet.

G. Perform blasting Monday through Friday only between the hours of 8:00 a.m. and 5:00 p.m. only.

H. The Peak Particle Velocity (PPV) limits shall not exceed:

1. 2.0 in/s at Dam Embankments.
2. 5.0 in/s at ground above buried utilities.
3. 0.5 in/s at residential structures.

4. 2.0 in/s at LVMWD Buildings and Facilities

I. The maximum charge-per-delay for all blasts shall not exceed 100 pounds.

J. Scaled distance to nearest residential property shall be 65 or greater.

K. Scaled distance to the LVMWD Facilities Building shall be 21 or greater.

K. Intensity of air-overpressure at any off-site structures shall not exceed 133 decibels (0.01295 psi).

L. The diameter of holes drilled in rock for blasting shall not exceed 3.0 inches.

M. If specified vibration limits are exceeded, blasting operations shall cease immediately and a revised blasting plan shall be submitted to LVMWD'S Representative. Blasting shall not resume until a revised blasting plan has been reviewed by the ENGINNER and the LVMWD'S Representative has expressed in writing the conditions that will be applied to further blasting work.

N. After a blast has been fired, the Blaster-in-Charge shall inspect the area to determine that all charges have fired as planned and that no hazards exist in the blast area before the all clear signal is sounded and workers and others are allowed to return to the area.

3.2 BLAST MONITORING

A. Blast Monitoring

1. The CONTRACTOR shall provide a minimum of four seismographs for monitoring peak ground vibration and air-overpressure. The equipment and its use shall conform fully to the standards developed by the Vibration Section of the International Society of Explosive Engineers (ISEE).

2. For all blasts, monitor ground motion and air-overpressure at the nearest abutment of the existing dam. Two instruments shall be operated at nearest residential properties. Another instrument shall be operated at the Water Treatment Plant. At least four locations shall be monitored for each blast and LVMWD'S Representative may require the CONTRACTOR to monitor at other locations if complaints or other issues arise.

3. Minimum trigger levels for monitoring shall be 0.05 in/s for ground motion and 120 dB for air-overpressure. Trigger level may be adjusted to higher levels if authorized by LVMWD'S Representative.

## 3.3 TEST BLAST

A. At the start of blasting, perform at least two test blasts to establish that rock movement is adequately controlled and intensities of specified ground motion and air-overpressure are in conformance with specified levels. The scaled distance to the nearest residential property for the test blasts must be 75 or greater.

## 3.4 REPAIR OF DAMAGE

A. When blasting operations damage offsite properties, or a portion of the work, or material surrounding or supporting the work, the Contractor shall promptly repair or replace damaged items to the condition that existed prior to the damage, to the satisfaction of LVMWD’s Representative.

## 3.5 SUSPENSION OF BLASTING

A. Blasting operations may be suspended by LVMWD’s Representative for any of the following reasons:
   1. Contractor's safety precautions are inadequate.
   2. Ground motion vibration levels exceed specified limits of maximum particle velocity or maximum particle displacement.
   3. Air-overpressure levels exceed specified limits.
   4. Existing structural conditions are aggravated or adjacent improvements are damaged as a result of blasting.
   5. Blasting endangers the stability or causes damage to rock outside the prescribed limits of excavation.
   6. The results of the blasting, in the opinion of LVMWD’s Representative, are not satisfactory.

B. Blasting operations shall not resume until LVMWD’s Representative has approved the Contractor's revised blasting plan providing modifications to correct the conditions that resulted in the suspension.

**END OF SECTION**

# ATTACHMENT II

# U.S BUREAU OF RECLAMATION (USBR), DRAFT POSITION PAPER ON CONSTRUCTION BLASTING VIBRATION LIMITS. APRIL, 2008

# ISEE
# Field Practice Guidelines For Blasting Seismographs
# 2009 Edition

™
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Cleveland, OH 44139

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**This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.*

**Committee Scope:** This Committee shall have primary responsibility for documents on the manufacture, transportation, storage, and use of explosives and related materials. This Committee does not have responsibility for documents on consumer and display fireworks, model and high power rockets and motors, and pyrotechnic special effects.

# ISEE Field Practice Guidelines For Blasting Seismographs

International Society of Explosives Engineers™
30325 Bainbridge Road
Cleveland, OH 44139

**International Society of Explosives Engineers**

**ISEE Field Practice Guidelines**
**For**
**Blasting Seismographs**
**2009 Edition**

This edition of *ISEE Field Practice Guidelines for Blasting Seismographs* was revised by the ISEE Standards Committee on February 4, 2008 and supersedes all previous editions. It was approved by the Society's Board of Directors in its role of Secretariat of the Standards at its February 5, 2009 meeting.

**Origin and Development of**
**ISEE Field Practice Guidelines for Blasting Seismographs**

In 1994, questions were raised about the accuracy, reproducibility and defensibility of data from blasting seismographs. To address this issue, the International Society of Explosives Engineers (ISEE) established a Seismograph Standards Subcommittee at its annual conference held in February 1995. The committee was comprised of seismograph manufacturers, researchers, regulatory personnel and seismograph users.

In 1997, the Committee became the Blast Vibrations and Seismograph Section. The Guidelines were drafted and approved by the Section in December of 1999. The Section completed two standards in the year 2000: 1) ISEE Field Practice Guidelines for Blasting Seismographs; and 2) Performance Specifications for Blasting Seismographs.

In 2002, the Society established the ISEE Standards Committee. A review of the ISEE Field Practice Guidelines and the Performance Specifications for Blasting Seismographs fell within the scope of the Committee. Work began on a review of the Field Practice Guidelines in January of 2006 and was completed in February of 2008 with this edition.

One of the goals of the ISEE Standards Committee is to develop uniform and technically appropriate standards for blasting seismographs. The intent is to improve accuracy and consistency in ground and air vibration measurements. Blasting seismograph performance is affected by how the blasting seismograph is built and how it is placed in the field.

The ISEE Standards Committee takes on the role of keeping the standards up to date. These standards can be obtained by contacting the International Society of Explosives Engineers located at 30325 Bainbridge Road, Cleveland, Ohio 44139 or by visiting our website at www.isee.org.

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**Disclaimer:** These field practice recommendations are intended to serve as general guidelines, and cannot describe all types of field conditions. It is incumbent on the operator to evaluate these conditions and to obtain good coupling between monitoring instrument and the surface to be monitored. In all cases, the operator should describe the field conditions and setup procedures in the permanent record of each blast.

**Preface:** Blasting seismographs are used to establish compliance with Federal, state and local regulations and evaluate explosive performance. Laws and regulations have been established to prevent damage to property and injury to people. The disposition of the rules is strongly dependant on the accuracy of ground vibration and air overpressure data. In terms of explosive performance the same holds true. One goal of the ISEE Standards Committee is to ensure consistent recording of ground vibrations and air overpressure between all blasting seismographs.

## Part I. General Guidelines

Blasting seismographs are deployed in the field to record the levels of blast-induced ground vibration and air overpressure. Accuracy of the recordings is essential. These guidelines define the user's responsibilities when deploying blasting seismographs in the field and assume that the blasting seismographs conform to the ISEE "Performance Specifications for Blasting Seismographs".

1. Read the instruction manual and be familiar with the operation of the instrument. Every seismograph comes with an instruction manual. Users are responsible for reading the appropriate sections and understanding the proper operation of the instrument before monitoring a blast.

2. Seismograph calibration. Annual calibration of the seismograph is recommended.

3. Keep proper blasting seismograph records. A user's log should note: the user's name, date, time, place and other pertinent data.

4. Document the location of the seismograph. This includes the name of the structure and where the seismograph was placed on the property relative to the structure. Any person should be able to locate and identify the exact monitoring location at a future date.

5. Know and record the distance to the blast. The horizontal distance from the seismograph to the blast should be known to at least two significant digits. For example, a blast within 1000 meters or feet would be measured to the nearest tens of meters or feet respectively and a blast within 10,000 meters or feet would be measured to the nearest hundreds of feet or meters respectively. Where elevation changes exceed 2.5h:1v, slant distances or true distance should be used.

6. Record the blast. When seismographs are deployed in the field, the time spent deploying the unit justifies recording an event. As practical, set the trigger levels low enough to record each blast.

7. Record the full time history waveform. Summary or single peak value recording options available on many seismographs should not be used for monitoring blast-generated vibrations. Operating modes that report peak velocities over a specified time interval are not recommended when recording blast-induced vibrations.

8. Set the sampling rate. The blasting seismograph should be programmed to record the entire blast event in enough detail to accurately reproduce the vibration trace. In general the sample rate should be at least 1000 samples per second.

9. Know the data processing time of the seismograph. Some units take up to 5 minutes to process and print data. If another blast occurs within this time the second blast may be missed.

10. Know the memory or record capacity of the seismograph. Enough memory must be available to store the event. The full waveform should be saved for future reference in either digital or analog form.

11. Know the nature of the report that is required. For example, provide a hard copy in the field, keep digital data as a permanent record or both. If an event is to be printed in the field, a printer with paper is needed.

12. Allow ample time for proper setup of the seismograph. Many errors occur when seismographs are hurriedly set-up. Generally, more than 15 minutes for set-up should be allowed from the time the user arrives at the monitoring location until the blast.

13. Know the temperature. Seismographs have varying manufacturer specified operating temperatures.

14. Secure cables. Suspended or freely moving cables from the wind or other extraneous sources can produce false triggers due to microphonics.

## Part II. Ground Vibration Monitoring

Placement and coupling of the vibration sensor are the two most important factors to ensure accurate ground vibration recordings.

### A. Sensor Placement

The sensor should be placed on or in the ground on the side of the structure towards the blast. A structure can be a house, pipeline, telephone pole, etc. Measurements on driveways, walkways, and slabs are to be avoided where possible.

1. Location relative to the structure. Sensor placement should ensure that the data obtained adequately represents the ground-borne vibration levels received at the structure. The sensor should be placed within 3.05 meters (10 feet) of the structure or less than 10% of the distance from the blast, whichever is less.

2. Soil density evaluation. The soil should be undisturbed or compacted fill. Loose fill material, unconsolidated soils, flower-bed mulch or other unusual mediums may have an adverse influence on the recording accuracy.

3. The sensor must be nearly level.

4. The longitudinal channel should be pointing directly at the blast and the bearing should be recorded.

5. Where access to a structure and/or property is not available, the sensor should be placed closer to the blast in undisturbed soil.

**B. Sensor coupling**

If the acceleration exceeds 1.96 $m/s^2$ (0.2 g), decoupling of the sensor may occur. Depending on the anticipated acceleration levels spiking, burial, or sandbagging of the geophone to the ground may be appropriate.

1. If the acceleration is expected to be:
    a. less than 1.96 $m/s^2$ (0.2 g), no burial or attachment is necessary
    b. between 1.96 $m/s^2$ (0.2 g), and 9.81 $m/s^2$ (1.0 g), burial or attachment is preferred. Spiking may be acceptable.
    c. greater than 9.81 $m/s^2$ (1.0 g) , burial or firm attachment is required (RI 8506).

The following table exemplifies the particle velocities and frequencies where accelerations are 1.96 $m/s^2$ (0.2 g) and 9.81 $m/s^2$ (1.0 g).

| Frequency, Hz | 4 | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| Particle Velocity mm/s (in/s) at 1.96 $m/s^2$ (0.2 g) | 78.0 (3.07) | 31.2 (1.23) | 20.8 (0.82) | 15.6 (0.61) | 12.5 (0.49) | 10.4 (0.41) | 7.8 (0.31) | 6.2 (0.25) | 3.1 (0.12) | 1.6 (0.06) |
| Particle Velocity mm/s (in/s) at 9.81 $m/s^2$ (1.0 g) | 390 (15.4) | 156 (6.14) | 104 (4.10) | 78.0 (3.07) | 62.4 (2.46) | 52.0 (2.05) | 39.0 (1.54) | 31.2 (1.23) | 15.6 (0.61) | 7.8 (0.31) |

2. Burial or attachment methods.
    a. The preferred burial method is excavating a hole that is no less than three times the height of the sensor (ANSI S2.47), spiking the sensor to the bottom of the hole, and firmly compacting soil around and over the sensor.

    b. Attachment to bedrock is achieved by bolting, clamping or adhering the sensor to the rock surface.

    c. The sensor may be attached to the foundation of the structure if it is located within +/- 0.305 meters (1-foot) of ground level (RI 8969). This should only be used if burial, spiking or sandbagging is not practical.

3. Other sensor placement methods.
    a. Shallow burial is anything less than described at 2a above.

    b. Spiking entails removing the sod, with minimal disturbance of the soil and firmly pressing the sensor with the attached spike(s) into the ground.

c. Sand bagging requires removing the sod with minimal disturbance to the soil and placing the sensor on the bare spot with a sand bag over top. Sand bags should be large and loosely filled with about 4.55 kilograms (10 pounds) of sand. When placed over the sensor the sandbag profile should be as low and wide as possible with a maximum amount of firm contact with the ground.

d. A combination of both spiking and sandbagging gives even greater assurance that good coupling is obtained.

**C. Programming considerations**

Site conditions dictate certain actions when programming the seismograph.

1. Ground vibration trigger level. The trigger level should be programmed low enough to trigger the unit from blast vibrations and high enough to minimize the occurrence of false events. The level should be slightly above the expected background vibrations for the area. A good starting level is 1.3 mm/s (0.05 in/s).

2. Dynamic range and resolution. If the seismograph is not equipped with an auto-range function, the user should estimate the expected vibration level and set the appropriate range. The resolution of the printed waveform should allow verification of whether or not the event was a blast.

3. Recording duration - Set the record time for 2 seconds longer than the blast duration plus 1 second for each 335 meters (1100 feet) from the blast.

## Part III Air Overpressure Monitoring

Placement of the microphone relative to the structure is the most important factor.

**A. Microphone placement**

The microphone should be placed along the side of the structure, nearest the blast.

1. The microphone should be mounted near the geophone with the manufacturer's wind screen attached.

2. The microphone may be placed at any height above the ground. (ISEE 2005)

3. If practical, the microphone should not be shielded from the blast by nearby buildings, vehicles or other large barriers. If such shielding cannot be avoided, the horizontal distance between the microphone and shielding object should be greater than the height of the shielding object above the microphone.

4. If placed too close to a structure, the airblast may reflect from the house surface and record higher amplitudes. Structure response noise may also be recorded. Reflection can be minimized by placing the microphone near a corner of the structure. (RI 8508)

5. The orientation of the microphone is not critical for air overpressure frequencies below 1,000 Hz (RI 8508).

**B. Programming considerations**
Site conditions dictate certain actions when programming the seismograph to record air overpressure.

1. Trigger level. When only an air overpressure measurement is desired, the trigger level should be low enough to trigger the unit from the air overpressure and high enough to minimize the occurrence of false events. The level should be slightly above the expected background noise for the area. A good starting level is 20 Pa (0.20 millibars or 120 dB).

2. Recording duration. When only recording air overpressure, set the recording time for at least 2 seconds more than the blast duration. When ground vibrations and air overpressure measurements are desired on the same record, follow the guidelines for ground vibration programming (Part II C.3).

**References:**

1. American National Standards Institute, Vibration of Buildings – Guidelines for the Measurement of Vibrations and Evaluation of Their Effects on Buildings. ANSI S2.47-1990, R1997.

2. Eltschlager, K. K., Wheeler, R. M. Microphone Height Effects on Blast-Induced Air Overpressure Measurements, 31st Annual Conference on Explosives and Blasting Technique, International Society of Explosives Engineers, 2005.

3. International Society of Explosives Engineers, ISEE Performance Specifications for Blasting Seismographs, 2000.

4. Siskind, D. E., Stagg, M. S., Kopp, J. W., Dowding, C. H. Structure Response and Damage by Ground Vibration From Mine Blasting. US Bureau of Mines Report of Investigations RI 8507, 1980.

5. Siskind, D. E., Stagg, M. S. Blast Vibration Measurements Near and On Structure Foundations, US Bureau of Mines Report of Investigations RI 8969, 1985.

6. Stachura, V. J., Siskind, D. E., Engler, A. J., Airblast Instrumentation and Measurement for Surface Mine Blasting, US Bureau of Mines Report of Investigations RI 8508, 1981.

International Society of Explosives Engineers

30325 Bainbridge Road, Cleveland, OH 44139
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# ATTACHMENT III

# SIMILITUDE RELATIONSHIPS FOR BLAST-INDUCED VIBRATION, OVERPRESSURE AND STRAIN PREDICTION AND CONTROL

# Similitude Relationships for Blast-Induced Vibration, Overpressure and Strain Prediction and Control

Gordon F. Revey – REVEY Associates, Inc. –April 2011

It is common industry practice to use empirical equations derived from geometric scaling theory to predict intensities of blast-induced vibration, over-pressure in air or water, and strain in materials of concern. The amount of energy produced by exploding charges confined in drilled holes is proportional to the weight (W) of the charge. This is a fair approximation because the unit weight strength of all commercial explosives is generally between 650 and 800 calories/g.

Distance (D) to the point of measurement defines the volume of ground, air or water into which energy from the charge is dispersed. Based on geometric scaling, these two variables can be combined to create a single variable called "scaled distance" that essentially defines the relative energy at any point of concern.

Square-Root Scaling**:** For linear explosive charges placed in holes drilled in rock, the energy of vibration-inducing strain waves radiating into the ground would generally disperse in a radial fashion; hence as the distance increases energy disperses inversely with the increasing distance radius. For this geometry, distance is divided by the square root of the charge size and the resulting dependent variable is the "scaled distance."

Cube-Root Scaling**:** When the height-to-width ratio of a charge is less than 6:1, the charge is considered a spherical charge and scaled distance is established by dividing distance by the cube-root of the charge weight. Cube-root charge scaling is also used for air-overpressure calculations and curves because the shape of pressure waves transmitted to air from blasted ground are generally spherical in shape.

To demonstrate the principle of dimensional similitude, consider the following comparison. If a 1-kg charge is fired in the ground, a specific intensity of vibration would occur in the ground at a distance of 10 m. Theoretically, it stands to reason that a larger charge of some size located 100 m from the same measurement point would also generate a similar level of vibration.

With square-root scaling, the scaled distance for the 1-kg charge at a distance of 10 m is 10-m-kg$^{-0.5}$ [10/1$^{-0.5}$]. If the size of charge in hole at a distance of 100 feet is increased to 100-kg, the scaled distance is also 10-kg-lb$^{-0.5}$ [100/100$^{-0.5}$]. Based on the principle of dimensional similitude, as shown in Figure 1, the estimated intensity of vibration expressed as the peak particle velocity or PPV in both cases would be approximately equal.

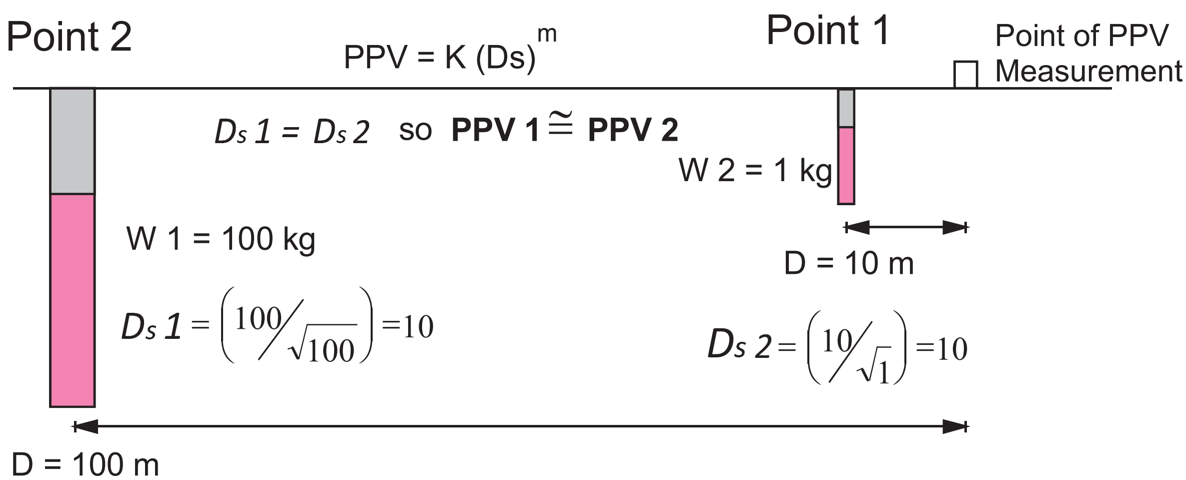


Figure 1 – Principle of Dimensional Similitude Scaling

Expressions of formulas demonstrating how square-root scaling is used for peak particle velocity (PPV) prediction follow.

$$PPV = K\left(D/\sqrt{W}\right)^m \qquad Where: D_s = \left(D/\sqrt{W}\right) \qquad So: PPV = K\ (D_s)^m$$

Where: PPV = Peak Particle Velocity - in/s (mm/s)
D = Distance – ft (m)
W = Maximum Charge-weight-per-delay – lb (kg)
K = Rock Energy Transfer Constant (K-Factor)
m = Decay Constant (always negative value)
$D_s$ = Scaled Distance – ft/lb$^{1/2}$ (m/kg$^{1/2}$)

Log-Log Linearity: The empirical exponential-decay relationships used to predict intensity of ground vibration or air/water overpressure become linear in logarithmic form similar to the standard straight-line formula of the form Y = m X + B. In this case, Y = Log PPV, m is the slope of the curve with a negative value that generally defines the attenuation of energy with distance and Log K is the Y-Intercept (B).

When vibration data from specific sites is available, standard least-squares regression methods can be used to determine constants (K and m) for site-specific best-fit 50% and 95% upper envelope curves. For new projects where site specific data is not available, blasting engineers can estimate appropriate constants based on the strength of rock, elastic properties of the ground, water content, and confinement of blast charges.

As shown in Figure 2, vibration data and curves generally fall within the bounds defined by Oriard (1970). For curves with a presumed slope of -1.6, K values generally vary from 24 to 605 (171 to 4316 Metric) Curve slopes (m) for both imperial and metric (S.I.) units generally vary from -1.0 to -1.9.

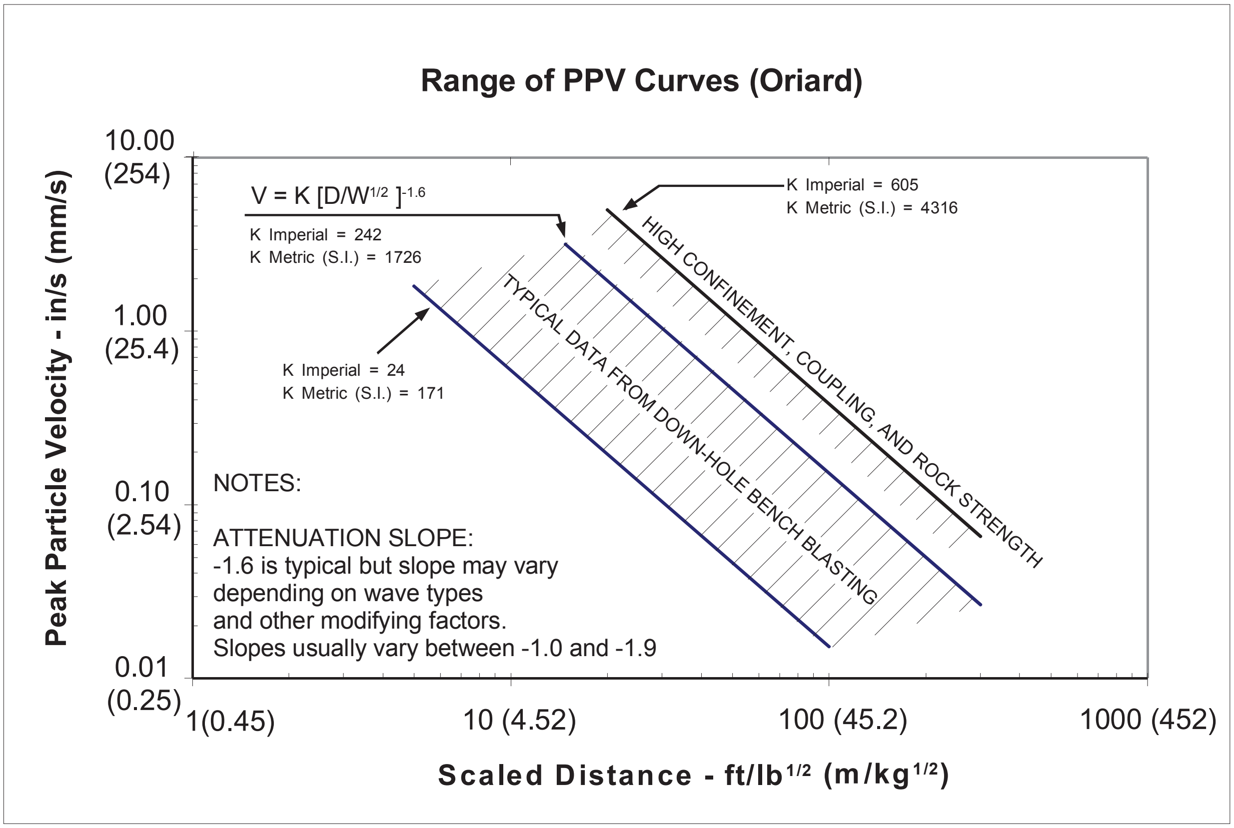


Figure 2 – Typical Boundaries of Vibration Data (Oriard, 1970)

When appropriate site constants are used, these empirical equations, based on the principle of dimensional similitude, generally compare quite well with equations derived by regression of actual site data. Sample regression curves for vibration, overpressure, strain and acceleration measurements made in various studies by REVEY Associates, Inc. are shown in Figures 3, 4, 5 and 6.

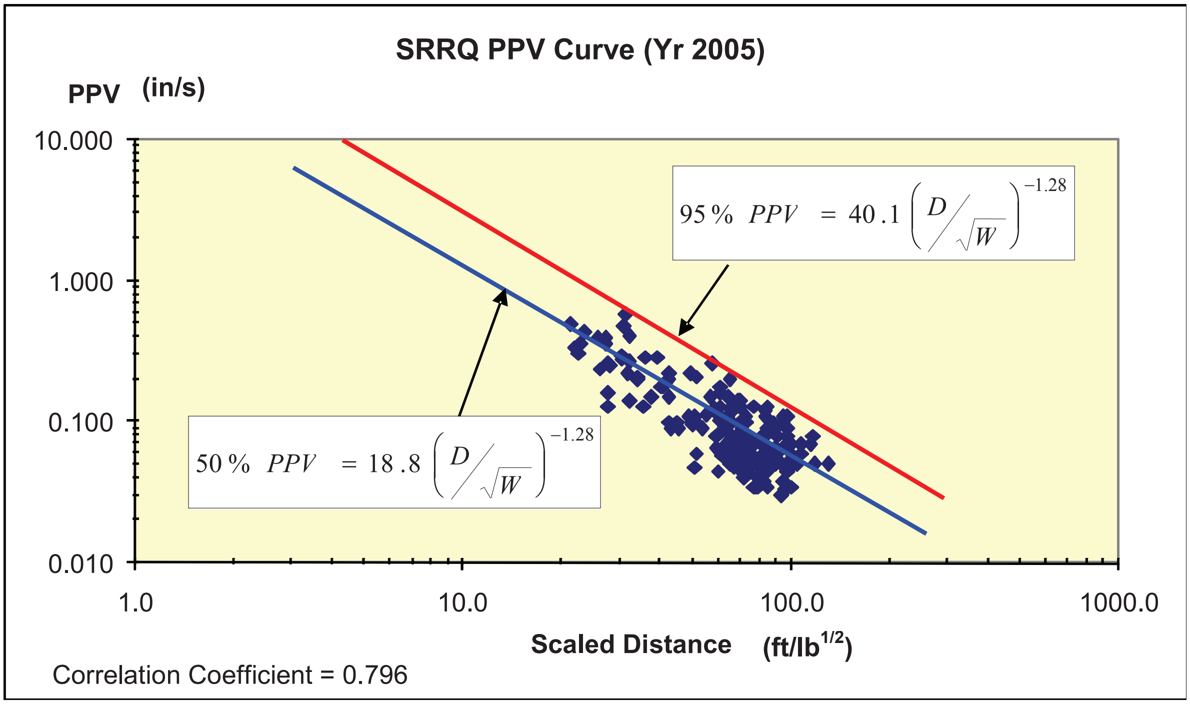


Figure 3 – Vibration attenuation curves for San Rafael Rock Quarry – Marin County, CA

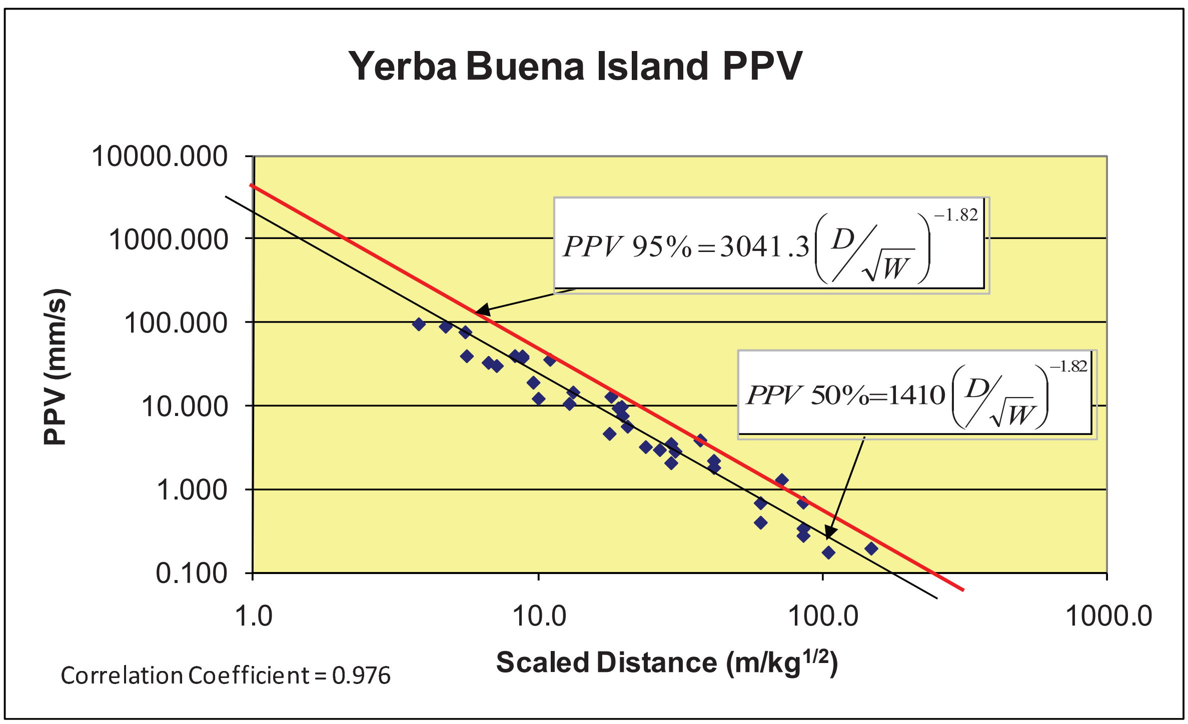


Figure 4 – Vibration attenuation curves for Yerba Buena Island – San Fransisco, CA

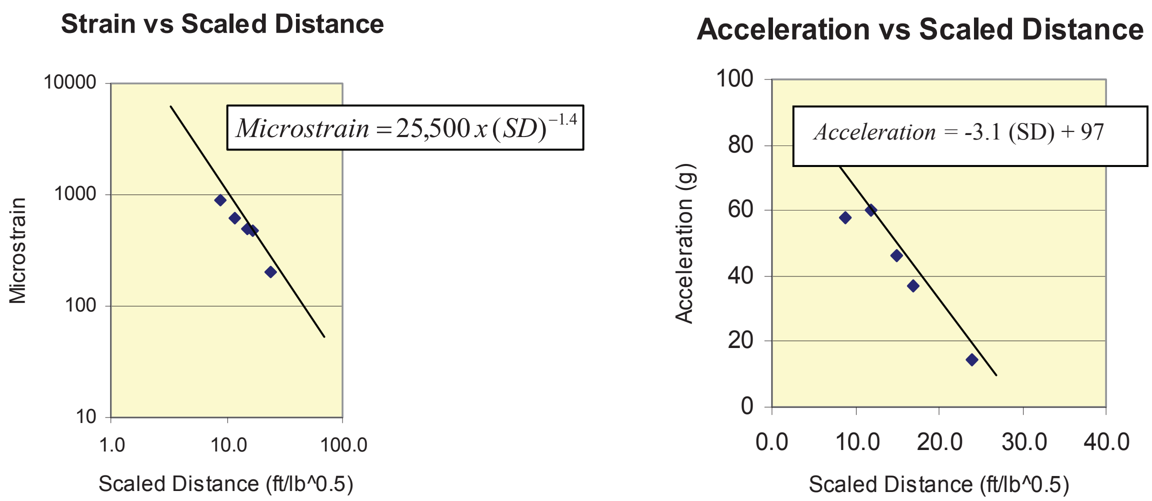


Figure 5 – Data and Curves for Blast-Induced Strain & Acceleration Measured in Concrete

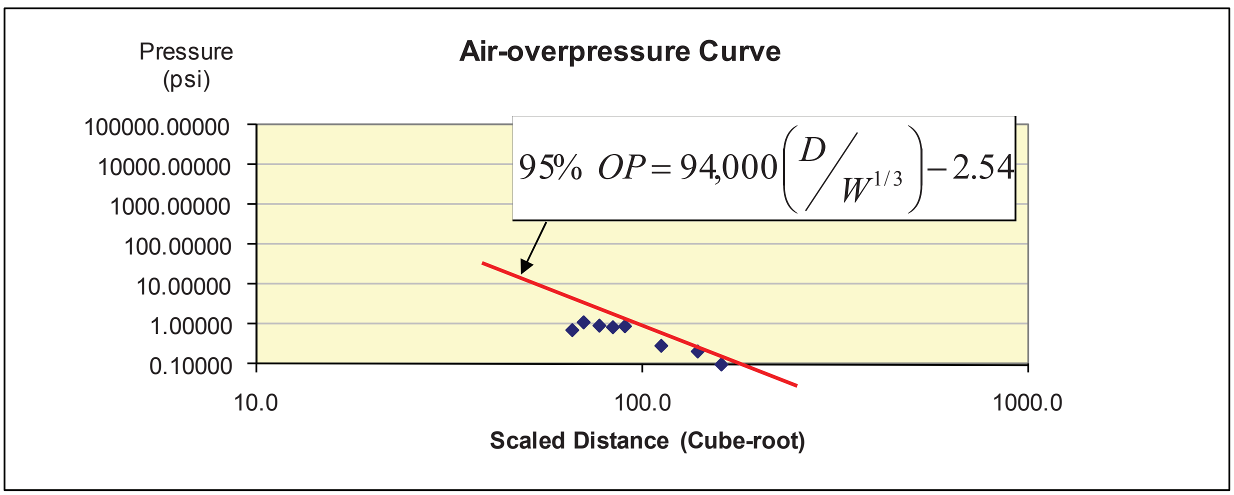


Figure 6 – Air-Overpressure Curve based on Cube-Root Scaling

## Using Scaled Distance Relationships to Establish Safe Charge Weights

By setting PPV, overpressure or strain equal to a mandated limit, prediction equations can be rearranged to calculate a minimum Scaled Distance ($D_s$) value that blasters can use to calculate maximum charge weight-per-delay. The form of the rearranged formula for particle velocity follows. Similar relationships are used for overpressure, strain, acceleration, etc.

$$Ds = \left(PPV / K\right)^{1/m}$$

For example, if the desired PPV-limit for buried pipes is 5.00 in/s, with cautious constants with K = 240 and m = -1.6, the limiting Scaled Distance ($D_s$) is 11.2 ft-lb$^{-0.5}$ [(5.00 / 240) $^{(1 / -1.6)}$].

Once minimum scaled distance values are established in project specifications or blasting plans, field blasters can use very simple equations to determine maximum charge-weights-per-delay – or the maximum weight of explosive firing within any 8-millisecond time frame. When electronic-delay detonators are used, the delay windows can be reduced to 5 or so milliseconds without incurring cumulative effects of so separated charges. The simple relationship between scaled distance and maximum-charge-weight-per-delay (W) is:

$$W = \left(D / D_s\right)^2$$

Where: D = distance – ft (m)
$D_s$=Scaled Distance - ft-lb$^{-0.5}$ (m-kg$^{-0.5}$)
W = Maximum-charge-weight-per-delay – lb (kg).

All licensed and capable blasters are trained to understand and apply scaled distance equations. For example, if a blast occurs 50 feet from the buried pipe where a minimum scaled distance of 11.2 would be used to keep the intensity of vibration below 5.0 in/s, the maximum charge-per-delay would 19.7 pounds [$(50 / 11.2)^2$]. If the distance increases to 300 feet, the allowable charge-per-delay increases dramatically to 712 pounds [$(300 / 11.2)^2$].

Establishing minimum scaled distance controls, in addition to firm not-to-exceed PPV limits, provides additional protection by taking some of the guesswork out of learning what charge sizes are needed to conform to certain vibration and overpressure limits.

References:
Oriard, L.L., (1970). “Blasting Operations in the Urban Environment,” Association of Engineering Geologists Annual Meeting, Washington, DC, October 1970, published in Bulletin of AEG, Vol. IX. No. 1, October, 1972.

# ATTACHMENT IV

# SAMPLE MATERIAL SAFETY DATA SHEET FOR NON-EXPLOSIVE DEMOLITION AGENT

# Material Safety Data Sheet

**DEXPAN (Non-Explosive Demolition Agent)**

## 1. Product and company identification

**Product name** : DEXPAN (Non-Explosive Demolition Agent)

**Material uses** : For controlled demolition, reinforced concrete cutting, rock breaking, quarrying, stone dimension, mining, excavating...

**Supplier/Manufacturer** : Archer Co. USA, Inc.
1665 Futurity Dr.
Sunland Park NM. 88063
Phone # 575-874-9188
Fax: # 575-874-9108
Toll Free: 866-272-4378

**MSDS authored by** : KMK Regulatory Services inc.

**In case of emergency** : +1-575-874-9188

**Product type** : Powder.

## 2 . Hazards identification

**Emergency overview**

**Color** : Gray.

**Physical state** : Solid. [Powder.]

**Odor** : Odorless.

**Signal word** : WARNING!

**Hazard statements** : CAUSES EYE AND SKIN IRRITATION. MAY CAUSE RESPIRATORY TRACT IRRITATION.

**Precautions** : Avoid breathing dust. Avoid contact with eyes, skin and clothing. Use only with adequate ventilation. Keep container tightly closed and sealed until ready for use. Wash thoroughly after handling.

**OSHA/HCS status** : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

**Routes of entry** : Dermal contact. Eye contact. Inhalation. Ingestion.

**Potential acute health effects**

**Inhalation** : Slightly irritating to the respiratory system.

**Ingestion** : No known significant effects or critical hazards.

**Skin** : Irritating to skin.

**Eyes** : Irritating to eyes.

**Potential chronic health effects**

**Chronic effects** : Repeated or prolonged inhalation of dust may lead to chronic respiratory irritation.

**Carcinogenicity** : No known significant effects or critical hazards.

**Mutagenicity** : No known significant effects or critical hazards.

**Teratogenicity** : No known significant effects or critical hazards.

**Developmental effects** : No known significant effects or critical hazards.

**Fertility effects** : No known significant effects or critical hazards.

**Target organs** : No known significant effects or critical hazards.

**Over-exposure signs/symptoms**

**Inhalation** : Adverse symptoms may include the following:
respiratory tract irritation
coughing

**Ingestion** : No specific data.

# 2 . Hazards identification

**Skin** : Adverse symptoms may include the following:
irritation
redness

**Eyes** : Adverse symptoms may include the following:
pain or irritation
watering
redness

**Medical conditions aggravated by over-exposure** : None known.

**See toxicological information (section 11)**

# 3. Composition/information on ingredients

## United States

| Name | CAS number | % |
|---|---|---|
| Calcium hydroxide | 1305-62-0 | 60 - 100 |
| Silica, vitreous | 60676-86-0 | 5 - 10 |
| Diiron trioxide | 1309-37-1 | 1 - 5 |
| Aluminum oxide | 1344-28-1 | 1 - 5 |

## Canada

| Name | CAS number | % |
|---|---|---|
| Calcium hydroxide | 1305-62-0 | 60 - 100 |
| Silica, vitreous | 60676-86-0 | 5 - 10 |
| Diiron trioxide | 1309-37-1 | 1 - 5 |
| Aluminum oxide | 1344-28-1 | 1 - 5 |

## Mexico

| | | | | | Classification | | | |
|---|---|---|---|---|---|---|---|---|
| Name | CAS number | UN number | % | IDLH | H | F | R | Special |
| Calcium hydroxide | 1305-62-0 | Not regulated. | 60 - 100 | - | 1 | 0 | 0 | |
| Diiron trioxide | 1309-37-1 | Not regulated. | 1 - 5 | 2500 mg/m³ | 1 | 0 | 0 | |
| Silica, vitreous | 60676-86-0 | Not regulated. | 5 - 10 | - | 0 | 0 | 0 | |
| Aluminum oxide | 1344-28-1 | Not regulated. | 1 - 5 | - | 0 | 0 | 0 | |

**There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.**

# 4 . First aid measures

**Eye contact** : Immediately flush eyes with plenty of water for at least 20 minutes, occasionally lifting the upper and lower eyelids. Get medical attention.

**Skin contact** : In case of contact, immediately flush skin with plenty of water for at least 20 minutes. Get medical attention.

**Inhalation** : Move exposed person to fresh air. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. Get medical attention.

**Ingestion** : Wash out mouth with water. Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention immediately.

**Protection of first-aiders** : No action shall be taken involving any personal risk or without suitable training.

**Notes to physician** : No specific treatment. Treat symptomatically.

## 5. Fire-fighting measures

**Flammability of the product** : No specific fire or explosion hazard.

**Extinguishing media**

**Suitable** : Use an extinguishing agent suitable for the surrounding fire.

**Not suitable** : None known.

**Hazardous decomposition products** : No specific data.

**Special protective equipment for fire-fighters** : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

## 6. Accidental release measures

**Personal precautions** : Avoid breathing dust. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment (see section 8).

**Environmental precautions** : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

**Methods for cleaning up**

**Small spill** : Vacuum or sweep up material and place in a designated, labeled waste container. Dispose of via a licensed waste disposal contractor.

**Large spill** : Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labeled waste container. Avoid creating dusty conditions and prevent wind dispersal. Dispose of via a licensed waste disposal contractor. Note: see section 1 for emergency contact information and section 13 for waste disposal.

## 7 . Handling and storage

**Handling** : Put on appropriate personal protective equipment (see section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Do not ingest. Avoid contact with eyes, skin and clothing. Avoid breathing dust. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Empty containers retain product residue and can be hazardous. Do not reuse container.

**Storage** : Store in accordance with local regulations. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see section 10) and food and drink. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

## 8. Exposure controls/personal protection

**United States**

| Ingredient | Exposure limits |
|---|---|
| Calcium hydroxide | **OSHA PEL (United States, 11/2006).**<br>TWA: 5 mg/m³ 8 hour(s). Form: Respirable fraction<br>TWA: 15 mg/m³ 8 hour(s). Form: Total dust<br>**ACGIH TLV (United States, 1/2009).**<br>TWA: 5 mg/m³ 8 hour(s).<br>**NIOSH REL (United States, 6/2009).**<br>TWA: 5 mg/m³ 10 hour(s).<br>**OSHA PEL 1989 (United States, 3/1989).**<br>TWA: 5 mg/m³ 8 hour(s). |
| Silica, vitreous | **OSHA PEL 1989 (United States, 3/1989).**<br>TWA: 0.1 mg/m³ 8 hour(s). Form: Respirable dust |

# 8. Exposure controls/personal protection

| | |
|---|---|
| Diiron trioxide | **NIOSH REL (United States, 6/2009).**<br>TWA: 5 mg/m³, (as Fe) 10 hour(s). Form: Dust and fumes<br>**ACGIH TLV (United States, 1/2009).**<br>TWA: 5 mg/m³ 8 hour(s). Form: Respirable fraction<br>**OSHA PEL 1989 (United States, 3/1989).**<br>TWA: 5 mg/m³ 8 hour(s). Form: Respirable fraction<br>TWA: 10 mg/m³ 8 hour(s). Form: Total dust<br>STEL: 10 ppm, (as Fe) 15 minute(s). Form: Total particulates<br>**OSHA PEL (United States, 11/2006).**<br>TWA: 10 mg/m³ 8 hour(s). |
| Aluminum oxide | **OSHA PEL 1989 (United States, 3/1989).**<br>TWA: 10 mg/m³ 8 hour(s). Form: Dust<br>TWA: 5 mg/m³ 8 hour(s). Form: Respirable fraction<br>**NIOSH REL (United States, 6/2009).**<br>TWA: 5 mg/m³, (as Al) 10 hour(s). Form: PYRO POWDERS AND WELDING FUMES<br>**OSHA PEL (United States, 11/2006).**<br>TWA: 5 mg/m³ 8 hour(s). Form: Respirable fraction<br>TWA: 15 mg/m³ 8 hour(s). Form: Total dust<br>**ACGIH TLV (United States).**<br>TWA: 1 mg/m³, (Al) 8 hour(s). Form: Respirable fraction |

## Canada

| Occupational exposure limits | | TWA (8 hours) | | | STEL (15 mins) | | | Ceiling | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ingredient | List name | ppm | mg/m³ | Other | ppm | mg/m³ | Other | ppm | mg/m³ | Other | Notations |
| Calcium hydroxide | US ACGIH 1/2009 | - | 5 | - | - | - | - | - | - | - | |
| | AB 4/2009 | - | 5 | - | - | - | - | - | - | - | [3] |
| | BC 9/2009 | - | 5 | - | - | - | - | - | - | - | |
| | ON 8/2008 | - | 5 | - | - | - | - | - | - | - | |
| | QC 6/2008 | - | 5 | - | - | - | - | - | - | - | |
| Silica, vitreous | ON 8/2008 | - | 0.1 | - | - | - | - | - | - | - | [a] |
| | QC 6/2008 | - | 0.1 | - | - | - | - | - | - | - | [b] |
| Diiron trioxide | US ACGIH 1/2009 | - | 5 | - | - | - | - | - | - | - | [c] |
| Diiron trioxide, as Fe | AB 4/2009 | - | 5 | - | - | - | - | - | - | - | [d] |
| | BC 9/2009 | - | 5 | - | - | - | - | - | - | - | [e] |
| | | - | 5 | - | - | 10 | - | - | - | - | [f] |
| | | - | 3 | - | - | - | - | - | - | - | [g] |
| | | - | 10 | - | - | - | - | - | - | - | [h] |
| Diiron trioxide | ON 8/2008 | - | 5 | - | - | - | - | - | - | - | [a] |
| | | - | 10 | - | - | - | - | - | - | - | [i] |
| Diiron trioxide, as Fe | QC 6/2008 | - | 5 | - | - | - | - | - | - | - | [j] |
| Aluminum oxide, Al | US ACGIH | - | 1 | - | - | - | - | - | - | - | [c] |
| Aluminum oxide | AB 4/2009 | - | 10 | - | - | - | - | - | - | - | |
| | ON 8/2008 | - | 10 | - | - | - | - | - | - | - | [i] |
| Aluminum oxide, as Al | QC 6/2008 | - | 10 | - | - | - | - | - | - | - | [k] |

**Form:** [a]Respirable particulate [b]Respirable dust [c]Respirable fraction [d]Dust and fumes [e]Dust [f]Fume [g]Total dust [h]Al

## Mexico

| Ingredient | Exposure limits |
|---|---|
| Calcium hydroxide | **NOM-010-STPS (Mexico, 9/2000).**<br>LMPE-PPT: 5 mg/m³ 8 hour(s). |
| Silica, vitreous | **NOM-010-STPS (Mexico, 9/2000).**<br>LMPE-PPT: 0.1 mg/m³ 8 hour(s). |
| Diiron trioxide | **NOM-010-STPS (Mexico, 9/2000).**<br>LMPE-CT: 10 mg/m³, (as Fe) 15 minute(s).<br>LMPE-PPT: 5 mg/m³, (as Fe) 8 hour(s). |
| Aluminum oxide | **NOM-010-STPS (Mexico, 9/2000).**<br>LMPE-PPT: 10 mg/m³ 8 hour(s). |

**Consult local authorities for acceptable exposure limits.**

**Recommended monitoring procedures** : Personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

## 8. Exposure controls/personal protection

**Engineering measures** : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits.

**Hygiene measures** : Ensure that eyewash stations and safety showers are close to the workstation location. Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period.

**Respiratory** : Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator. Recommended: Use appropriate NIOSH approved dust respirator if PEL/TLV may be exceeded.

**Hands** : Use gloves appropriate for work or task being performed. Recommended: Impervious gloves.

**Eyes** : Safety eyewear should be used when there is a likelihood of exposure. If operating conditions cause high dust concentrations to be produced, use dust goggles. Recommended: Safety glasses with side shields.

**Skin** : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. Recommended: Cotton-blend coveralls.

**Environmental exposure controls** : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

## 9 . Physical and chemical properties

**Physical state** : Solid. [Powder.]

**Color** : Gray.

**Odor** : Odorless.

**Melting/freezing point** : 1000°C (1832°F)

**Specific gravity** : 3.2 g/cm$^3$

**Relative density** : 3.2

**VOC** : 0 % (w/w)

**Solubility** : Very slightly soluble in the following materials: cold water.

## 10. Stability and reactivity

**Chemical stability** : The product is stable.

**Conditions to avoid** : No specific data.

**Materials to avoid** : Reactive or incompatible with the following materials: oxidizing materials, acids and moisture.

**Hazardous decomposition products** : No specific data.

**Possibility of hazardous reactions** : Under normal conditions of storage and use, hazardous reactions will not occur.

**Hazardous polymerization** : Under normal conditions of storage and use, hazardous polymerization will not occur.

# 11. Toxicological information

## Acute toxicity

| Product/ingredient name | Result | Species | Dose | Exposure |
|---|---|---|---|---|
| Calcium hydroxide | LD50 Oral | Rat | 7340 mg/kg | - |

## Chronic toxicity

### Classification

| Product/ingredient name | ACGIH | IARC | EPA | NIOSH | NTP | OSHA |
|---|---|---|---|---|---|---|
| Silica, vitreous | - | 3 | - | - | - | - |
| Diiron trioxide | A4 | 3 | - | - | - | - |
| Aluminum oxide | A4 | - | - | - | - | - |

# 12. Ecological information

**Environmental effects** : Not established

## Aquatic ecotoxicity

| Product/ingredient name | Result | Species | Exposure |
|---|---|---|---|
| Calcium hydroxide | Acute LC50 33884.4 ug/L Fresh water<br>Chronic NOEC 56 mg/L Marine water | Fish - Clarias gariepinus - Fingerling<br>Fish - Poecilia reticulata - Young - 3 weeks | 96 hours<br>96 hours |

**Other adverse effects** : No known significant effects or critical hazards.

# 13. Disposal considerations

**Waste disposal** : The generation of waste should be avoided or minimized wherever possible. This material and its container must be disposed of in a safe way. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Empty containers or liners may retain some product residues. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor.

**Disposal should be in accordance with applicable regional, national and local laws and regulations.**

**Refer to Section 7: HANDLING AND STORAGE and Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION for additional handling information and protection of employees.**

# 14 . Transport information

**DOT/TDG/MXT/IMDG/IATA** : Not regulated.

# 15 . Regulatory information

## United States

**HCS Classification** : Irritating material

**U.S. Federal regulations** : **United States inventory (TSCA 8b)**: All components are listed or exempted.

**SARA 302/304/311/312 extremely hazardous substances**: No products were found.
**SARA 302/304 emergency planning and notification**: No products were found.
**SARA 302/304/311/312 hazardous chemicals**: Silica, vitreous; Diiron trioxide; Aluminum oxide; Calcium hydroxide
**SARA 311/312 MSDS distribution - chemical inventory - hazard identification**: Silica, vitreous: Immediate (acute) health hazard; Diiron trioxide: Delayed (chronic) health hazard; Aluminum oxide: Immediate (acute) health hazard; Calcium hydroxide: Immediate (acute) health hazard, Delayed (chronic) health hazard

**Clean Water Act (CWA) 307**: No products were found.

**Clean Water Act (CWA) 311**: No products were found.

**Clean Air Act (CAA) 112 accidental release prevention**: No products were found.

**Clean Air Act (CAA) 112 regulated flammable substances**: No products were found.

**Clean Air Act (CAA) 112 regulated toxic substances**: No products were found.

# 15 . Regulatory information

**Clean Air Act Section 112(b) Hazardous Air Pollutants (HAPs)** : Not listed

**Clean Air Act Section 602 Class I Substances** : Not listed

**Clean Air Act Section 602 Class II Substances** : Not listed

**DEA List I Chemicals (Precursor Chemicals)** : Not listed

**DEA List II Chemicals (Essential Chemicals)** : Not listed

**SARA 313**

| | Product name | CAS number | Concentration |
|---|---|---|---|
| **Form R - Reporting requirements** | Aluminum oxide | 1344-28-1 | 1 - 5 |
| **Supplier notification** | Aluminum oxide | 1344-28-1 | 1 - 5 |

SARA 313 notifications must not be detached from the MSDS and any copying and redistribution of the MSDS shall include copying and redistribution of the notice attached to copies of the MSDS subsequently redistributed.

**State regulations** : **Connecticut Carcinogen Reporting**: None of the components are listed.
**Connecticut Hazardous Material Survey**: None of the components are listed.
**Florida substances**: None of the components are listed.
**Illinois Chemical Safety Act**: None of the components are listed.
**Illinois Toxic Substances Disclosure to Employee Act**: None of the components are listed.
**Louisiana Reporting**: None of the components are listed.
**Louisiana Spill**: None of the components are listed.
**Massachusetts Spill**: None of the components are listed.
**Massachusetts Substances**: The following components are listed: Calcium hydroxide; Silica, vitreous; Diiron trioxide; Aluminum oxide
**Michigan Critical Material**: None of the components are listed.
**Minnesota Hazardous Substances**: None of the components are listed.
**New Jersey Hazardous Substances**: The following components are listed: Calcium hydroxide; Silica, vitreous; Diiron trioxide; Aluminum oxide
**New Jersey Spill**: None of the components are listed.
**New Jersey Toxic Catastrophe Prevention Act**: None of the components are listed.
**New York Acutely Hazardous Substances**: None of the components are listed.
**New York Toxic Chemical Release Reporting**: None of the components are listed.
**Pennsylvania RTK Hazardous Substances**: The following components are listed: Calcium hydroxide; Diiron trioxide; Aluminum oxide
**Rhode Island Hazardous Substances**: None of the components are listed.

**Canada**

**WHMIS (Canada)** : Class D-2B: Material causing other toxic effects (Toxic).

**Canadian lists** : **CEPA Toxic substances**: None of the components are listed.
**Canadian ARET**: None of the components are listed.
**Canadian NPRI**: The following components are listed: Aluminum oxide
**Alberta Designated Substances**: None of the components are listed.
**Ontario Designated Substances**: None of the components are listed.
**Quebec Designated Substances**: None of the components are listed.

**Canada inventory** : All components are listed or exempted.

**This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.**

# 15 . Regulatory information

**Mexico**

**Classification** :


**International regulations**

**International lists** : **Australia inventory (AICS)**: All components are listed or exempted.
**China inventory (IECSC)**: All components are listed or exempted.
**Japan inventory**: All components are listed or exempted.
**Korea inventory**: All components are listed or exempted.
**New Zealand Inventory of Chemicals (NZIoC)**: All components are listed or exempted.
**Philippines inventory (PICCS)**: All components are listed or exempted.

# 16 . Other information

**United States**

**Label requirements** : CAUSES EYE AND SKIN IRRITATION. MAY CAUSE RESPIRATORY TRACT IRRITATION.

**Hazardous Material Information System (U.S.A.)** : **Health :** 1 **Flammability :** 0 **Physical hazards :** 0

**Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks Although HMIS® ratings are not required on MSDSs under 29 CFR 1910.1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered mark of the National Paint & Coatings Association (NPCA). HMIS® materials may be purchased exclusively from J. J. Keller (800) 327-6868.**

**The customer is responsible for determining the PPE code for this material.**

**National Fire Protection Association (U.S.A.)** : **Health :** 1 **Flammability :** 0 **Instability :** 0

**Canada**

**WHMIS (Canada)** :

**References** : ANSI Z400.1, MSDS Standard, 2004. - Manufacturer's Material Safety Data Sheet. - 29CFR Part1910.1200 OSHA MSDS Requirements. - 49CFR Table List of Hazardous Materials, UN#, Proper Shipping Names, PG. - Canada Gazette Part II, Vol. 122, No. 2. Registration SOR/88-64, 31 December 1987. Hazardous Products Act "Ingredient Disclosure List" - Canadian Transport of Dangerous Goods, Regulations and Schedules, Clear Language version 2005. - Official Mexican Standards NOM-018-STPS-2000 and NOM-004-SCT2-1994.

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**Notice to reader**

**To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein.**
**Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.**

## 16 . Other information