

SECTION 02090 - BLASTING CONTROLS

PART 1 - GENERAL

1.1 DEFINITIONS

- A. Air Blast: A transient air pressure impulse generated by explosions.
- B. Blast Consultant: The Blast Consultant shall be a person with extensive knowledge of noise vibration, and visual impacts of blasting operations, and who is specialized in the detonation of explosives, particularly in the field of rock quarry operations. The Blast Consultant shall be provided by the CONTRACTOR.
 - 1. The Blast Consultant must have at least 20 years of experience in construction blasting. They must be able to demonstrate involvement in at least five (5) projects with blasting within 200 feet of residential structures. The Blast Consultant must be able to demonstrate attendance in at least ten (10) short courses, seminars, conferences on blasting technology, or engineering class studies during the past 15 years. For the past five (5) years, the Blast Consultant must have derived their primary source of income from providing specialized blasting consulting services.
- C. Blast Control Specialist: Person authorized to act on behalf of the CONTRACTOR and licensed by the state or local regulatory agency to possess, transport, and use explosives.
- D. Fly Rock: Debris that is ejected or propelled through air by blast.
- E. Frequency: Ground vibration oscillation at peak event, expressed in Hertz.
- F. Peak Ground Particle Velocity (PGPV): Maximum of three (3) velocity components measured in three (3) mutually perpendicular directions at a point.

1.2 SUBMITTALS

- A. Quality Control Submittals:
 - 1. Qualifications of Blast Control Specialist: Submit at least 30 days prior to blasting WORK.
 - 2. Rock excavation plan describing details for CONTRACTOR's proposed rock excavation methods. Submit at least 30 days prior to start of WORK.
 - 3. Detailed blasting plan for each blast shall be submitted at least 48 hours prior to beginning any WORK for that blast.
 - 4. Vibration and air-blast monitoring plan. Submit at least 30 days prior to blasting WORK.
 - 5. Qualifications of Blast Consultant. Submit at least 30 days prior to blasting WORK.
 - 6. Performance and Restoration Bond for all items of WORK.
- B. Blasting Plan and Blasting Schedule.
 - 1. One (1) week prior to commencing drilling and blasting operations, the CONTRACTOR shall submit a "Blasting Plan", reviewed and approved by the

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Blasting Consultant, to the ENGINEER for review. The Blasting Plan shall contain the details of the drilling and blasting patterns and controls proposed for both the controlled and production blasting. The Blasting Plan shall contain the following minimum information:

- a. Station limits of proposed shot, the number of blasts, time of each blast.
 - b. Plan and section views of proposed drill pattern indicating hole size, hole depths and angles, hole pattern and spacing and expected rock types.
 - c. Drill hole diameters (preshear, productions) and depth including subdrilling depths.
 - d. Drill steel diameter and bit types.
 - e. Stemming length and type of material used for stemming.
 - f. Loading details including trade names, types, sizes of explosives.
 - g. Average bench height.
 - h. Proposed initiation and delay sequence of blast holes.
 - i. Weight of explosives per hole and per delay and powder factors, including weight of explosives per square yard of finished backslope.
 - j. Anticipated vibration levels and peak particle velocities at locations specified by the ENGINEER.
 - k. Anticipated blasé decibel level at nearest dwelling.
2. At any time the CONTRACTOR proposes to change the drilling or blasting methods, the CONTRACTOR shall submit a revised Blasting Plan for the affected WORK not later than one (1) week prior to the proposed commencement of the change in the WORK.
 3. The Blasting Plan submittal is for quality control and record-keeping purposes. Review of the Blasting Plan by the ENGINEER or Blasting Consultant shall not relieve the CONTRACTOR of their responsibility for the accuracy and adequacy of the plan when implemented in the field.
- C. Project Closeout Submittals.
1. Summary Report: Submit within 30 days of completion of blasting.

1.3 QUALITY ASSURANCE

- A. Blast Control Specialist: Must have a minimum of ten (10) years experience with blast design and vibration and air-blast monitoring, and significant involvement as the Blast Control Specialist in a minimum of ten (10) previous projects of similar nature. The Blast Control Specialist shall be a licensed blaster in the State of Alaska and shall be subject to the approval of the Blast Consultant.

1.4 SEQUENCING AND SCHEDULING

- A. Blasting shall be restricted to the times given on the Rock Quarry Usage Plan.
- B. Blast only with direct written approval for each blast by the Blast Consultant.
- C. Warning signs and public notification are required to avoid all risks to the public that use the roadway. The CONTRACTOR shall provide to CBJ and to the State of Alaska

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Department of Transportation and Public Facilities (AK DOT&PF) with its proposed traffic control plan for review and approval prior to any blasting or hauling.

- D. The CONTRACTOR shall provide the Juneau Flight Service Station, the Juneau Police Department and the Juneau Fire Department with written notice of blasting a minimum of 24 hours in advance of each blast.

1.5 CONTROLLED BLASTING

- A. Material which would classify as rock and which requires drilling and blasting to remove will be accomplished by controlled blasting. Controlled blasting is defined as the establishment of a free surface or shear plane in rock along the lines of the specified backslope by the controlled usage of explosives and blasting accessories in appropriately aligned and spaced drill holes.
- B. The CONTRACTOR shall perform short test lines of holes consisting of presplit or cushion blasting if changes in conditions warrant, to determine the loading, spacing and depth or lift required to obtain desired PGPV, air blast pressures and excavation geometry. These tests will be monitored by the Blast Consultant using CONTRACTOR supplied seismographs. As part of the blasting plan, the CONTRACTOR shall prepare graphs depicting the PGPV as function of the distance from the detonation point, for each explosion loading. Explosive loading for production blasting will then be selected from the graph to limit PGPV to less than two inches per second measured next to the closest structure adjacent to the blast.

1.6 CBJ OVERSIGHT

- A. The CONTRACTOR shall submit a copy of the Blast Consultant-approved general blast plan description and a copy of each Blast Consultant-approved individual blast plan to the ENGINEER and the CBJ Project Manager prior to blasting. The CONTRACTOR shall also submit a copy of their AK DOT&PF-approved traffic control plan to the ENGINEER and CBJ Project Manager prior to any blasting.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION

- A. All explosives shall be of such character and in such amount as permitted by the state and local laws and ordinances and all respective agencies having jurisdiction over them.
- B. The CONTRACTOR shall implement a blast notification program, as approved by the ENGINEER, and in accordance with applicable standards.
- C. The CONTRACTOR shall use the utmost care so as not to endanger life or property, or disturb materials outside the limits of the excavation.
- D. Explosives, including blasting caps, shall be transported and stored in a safe, secure manner in accordance with the requirements of the appropriate public body having

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jurisdiction in such matters. Only persons experienced in the handling of explosives are to be allowed to use them on the WORK. Where state or local laws require, explosives are to be handled only by licensed personnel.

- E. The CONTRACTOR shall provide all necessary approved types of tools and devices required for handling and using explosives, blasting caps, and accessories. The CONTRACTOR shall conform to and obey all federal, state and local laws that may be imposed by any public authority having legal jurisdiction.
- F. When blasting, ample warning shall be given to all persons within the vicinity prior to blasting. Warning signs shall be erected a minimum of 24 hours prior to the blast time, and workers shall be stationed to warn people before firing any blasts. The warning signs will state the time and date of each blast.
- G. After a blast has been fired, the Blast Control Specialist shall make a careful inspection to determine that all charges have exploded before employees are allowed to return to the operation. Misfires shall be corrected in accordance with the requirements of the applicable portions of the federal, state, or local safety codes for blasting. The CONTRACTOR shall be responsible for any and all damage to property or injury to persons resulting from blasting or accidental or premature explosions that may occur in connection with his use of explosives.
- H. All rock that is loose, hanging or creating a dangerous situation shall be removed or stabilized, to the Blast Consultant's satisfaction, during or upon completion of the excavation in each lift as an integral sequence in each cycle of excavation. Drilling of the next lift will not be permitted until this WORK, and any rock stabilization that is necessary has been completed.
- I. Material outside of the planned neatline slopes which, in the opinion of the Blast Consultant, is unstable and constitutes potential slides shall be excavated and removed.
- J. No blast shall exceed an in-place volume of 5,000 cubic yards.

3.2 GENERAL

- A. The CONTRACTOR shall be required to submit a description of the blast plan to the Blast Consultant no less than 21 days prior to the blasting operation. The proposed method shall be subject to the approval of the Blast Consultant. The description shall include at least the following:
 - 1. Limits of cut or lift
 - 2. Average bench height
 - 3. Hole positions, including angle and depth
 - 4. Blast hole diameters
 - 5. Type and quantity of explosives (including manufacturer's data sheets)
 - 6. Method of initiation and firing sequences
 - 7. Powder factor
 - 8. Depth and type of stemming

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- B. Review of the blast plan by the Blast Consultant shall not relieve the CONTRACTOR of responsibility for the accuracy and adequacy of the blast plan when implemented in the field. This includes, but is not limited to, obtaining adequate fragmentation, using proper detonation procedures and following proper safety procedures prior to and after the blast.
- C. The WORK shall be conducted in such a manner that rock outside the excavation limits will be undisturbed, nearby structures will not be disturbed in any way, and the shape of the excavation will conform as nearly as possible to the lines and grades shown on the Drawings.
- D. It is imperative that the blasting WORK does not disturb or impair the existing overhead electrical lines in any way. Any damage shall be immediately repaired. To help ensure against potential damage beyond the lines of intended excavation, the CONTRACTOR shall employ the best modern practice of controlled blasting methods.
- E. The CONTRACTOR shall assign a supervisor of mature experience specialized in the use of explosives to the blasting operations, who shall be maintained on a full-time basis during the time that blasting is in progress.
- F. The CONTRACTOR is forewarned that existing residential and commercial properties may be located in close proximity of the blast and that these properties shall be protected. The CONTRACTOR shall be responsible for all damage to these properties, including providing suitable temporary housing to residents or business occupants until repair WORK is completed.
- G. Blasting shall be monitored by the Blast Consultant using CONTRACTOR-furnished monitoring devices. The Blast Consultant will be responsible for the location and placement of these monitoring devices. The CONTRACTOR will be responsible for the protection of these monitoring devices from its equipment and operations.
- H. To ensure the accuracy of firing times of blasting caps, it is required that each cap period come from one lot number. Mixing lot numbers for any one cap period is prohibited.

3.3 CONTROLLED BLASTED SURFACES

- A. For all rock slopes the CONTRACTOR shall use controlled blasting along the lines of the final rock cut slope face.
- B. Controlled blasting refers to the controlled use of explosives and blasting accessories in carefully spaced and aligned drill holes to produce a free surface or shear plane in the rock along the specified excavation backslope. Controlled blasting techniques covered by this Specification includes pre-splitting and cushion (trim) blasting.
- C. The purpose of controlled blasting is to ensure long-term rock slope stability by minimizing damage to the rock backslope. The ENGINEER may require the CONTRACTOR to use controlled blasting to form the faces of slopes, even if the main excavation can be ripped.
- D. Cuts over 30 feet in height shall be drilled and blasted in more than one lift, with each lift being limited to a maximum of 30 feet. A maximum of a two foot offset between lifts

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shall be permitted to allow for drill equipment clearances. The CONTRACTOR shall begin the control blast hole drilling at a point which will allow for necessary offsets and shall adjust, at the start of the lower lifts, to compensate for any drift which may have occurred in the upper lifts. The use of horizontal lifters will not be allowed.

- E. The CONTRACTOR will be required to drill from the top of the cut downward for rock cuts greater than ten (10) feet in height.
- F. The diameter of the control blast holes shall not be smaller than two and one half inches or greater than three inches. The deviation of these drill holes either parallel or normal to the backslope shall not exceed eight inches. If greater than five percent of the controlled blast holes are misaligned in any one lift, the CONTRACTOR shall reduce the height of the lifts until the eight inch alignment tolerance is met.
- G. Buffer holes shall be drilled three feet out from the controlled blast holes on four foot centers. The buffer holes shall be drilled parallel to the controlled blast holes. The load per buffer holes shall not exceed 50 percent of the average load per production hole next to the buffer line.
- H. All drilling equipment used to drill the control blast shall have mechanical devices affixed to that equipment to accurately determine the precise angle at which the drill steel enters the rock. Control blast hole drilling will not be permitted if these devices are either missing or inoperative. Hand held devices, including levels, shall not be used.
- I. Prior to drilling the control blast holes, all overburden and/or loose disintegrated rock shall be removed down to solid rock in the vicinity of the holes.
- J. All rock backslope faces shall be scaled of loose fragments.
- K. Blast holes for controlled blasting shall be drilled within three-inches of the staked collar location. If more than five percent of the holes are outside of the three inch tolerance, they shall be filled with crushed stone and re-drilled at the proper location.

3.4 LINE DRILLING, CUSHION BLASTING, PRESPLITTING

- A. Methods such as line drilling, cushion blasting, or pre-splitting shall be used to control damage beyond the final cut faces shown on the Drawings. Methods such as line drilling and pre-splitting are used to ensure that a shear plane is established between the periphery holes, thus minimizing strain or cracks in the rock beyond the blasting perimeter. Except as otherwise directed by the Blast Consultant, pre-splitting and line-drilled holes shall not be larger than three inches in diameter, and spaced no more than two feet and six inches apart, center to center, respectively.
- B. Cushion blasting is similar to pre-splitting, except that the detonation along the cut face shall be performed after the detonation of the production holes.
- C. The CONTRACTOR shall line drill, perform cushion blasting, or pre-split all native, permanently exposed, or steeply inclined cut faces (1H to 1V, or steeper).

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- D. The line drilling, cushion blasting or pre-splitting blast holes shall be between two and one half and three inches in diameter.
- E. Cuts with a vertical height greater than ten feet and an average horizontal thickness of greater than 25 feet as measured from the free face to the back row of blast holes shall be "Pre-split" blasted.
 - 1. Pre-splitting shall be performed for all rock slopes over ten feet in height. It shall consist of drilling holes on the plane of the final backslope then loading the holes with a continuous or well disturbed explosive charge, and then firing the holes to create a crack along the line of the backslope. Ground vibration is a consideration. The CONTRACTOR shall delay the pre-split holes no more than 25 milliseconds along the pre-split line. The detonation of the pre-split line must precede the detonation of all other blasting in the cut. The pre-split line may be detonated in advance of the main production blasting or fired along with the production blasting, providing that the pre-split line is detonated a minimum of 25 milliseconds ahead of all other blasting.
 - 2. The pre-split holes shall be drilled initially on 30-inch center spacing. Prior to loading these pre-split holes, each hole shall be inspected and tested for the entire length to determine that the hole is free and clear of obstructions. If the hole is obstructed, the hole shall be cleaned prior to loading. All necessary precautions shall be exercised so as to prevent debris from falling into the holes prior to loading, and that the placing of the charge shall not cause caving of materials from walls of the hole.
 - 3. The maximum initial explosive charge used in these holes shall be no more than 0.14 pounds per square foot of rock surface of the final slope face. Ammonium nitrate and fuel oil (ANFO) shall not be allowed to be loaded in the pre-split hole.
 - 4. Depending on the condition of the rock encountered and the smoothness of the final slope face, the explosive loads per square foot and the spacing of the pre-split holes may be altered, as required, after an inspection and evaluation by the ENGINEER.
 - 5. The space in each pre-split hole not occupied by explosives may or may not be stemmed depending on the condition of the rock encountered. In all cases, the top three feet of the pre-split holes shall be stemmed.
 - 6. The maximum diameter of the explosives used in pre-split holes shall not be greater than one-half the diameter of the pre-split hole.
 - 7. Only standard explosives manufactured especially for pre-splitting shall be used in pre-split holes, unless otherwise approved by the ENGINEER.
 - 8. If fractional portions of standard explosive cartridges are used, they shall be firmly affixed to the detonating cord in such a manner that the cartridges shall not slip down the detonating cord nor bridge across the holes. Spacing of fractional cartridges along the length of the detonating cord shall not exceed 30 inches center to center, and shall be adjusted to give the desired results.
 - 9. Continuous column cartridge-type of explosives used with detonating cord shall be assembled and affixed to the detonating cord in accordance with the explosive manufacture's instructions; a copy of which shall be furnished to the ENGINEER. No detonating cord shall be used on the surface.
 - 10. The bottom charge of a pre-split hole may be larger than the line charges, but shall not be large enough to cause overbreak. The top charge of the pre-splitting

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hole shall be placed far enough below the collar, and reduced sufficiently, to avoid overbreaking and heaving.

- F. Cuts with a vertical height greater than ten feet and an average horizontal thickness less than 25 feet as measured from the free face to the back row of blast holes shall be "cushion" blasting.
 - 1. Where the horizontal distance from the cut face to the existing rock face is less than 25 feet, the CONTRACTOR may cushion blast in lieu of pre-splitting. Cushion blasting is similar to pre-splitting, except that the detonation along the cut face shall be performed after the detonation of all production holes. The difference in delay time between the trim line and the nearest production row shall not be greater than 75 milliseconds, nor less than 25 milliseconds. With the exception of the above criteria, requirements previously stated for preshearing shall also apply to cushion blasting.

3.5 SILVER CUTS

- A. For silver cuts, pioneering the top of cuts and preparing a working platform to being the controlled blasting drilling operations may require unusual working methods and use of equipment. The CONTRACTOR may use angle drilled holes or fan drilled holes during the initial pioneering operations to obtain the desired rock face. The hole diameter requirements for controlled blasting are applicable for pioneering work. Hole spacing shall not exceed 30 inches.

3.6 PRODUCTION BLASTING

- A. Production blasting, as covered herein, refers to the rock fragmentation blasts resulting from more widely spaced production holes drilled throughout the main excavation area, adjacent to the controlled blast line. Production holes shall be detonated in a controlled delay sequence.
- B. All production blasting, including that carried out in conjunction with the blasting test section requirements, shall be performed in accordance with the following general requirements:
 - 1. Production blast holes shall be drilled on the patterns submitted by the CONTRACTOR and approved by the ENGINEER. The production blast holes shall be drilled within two blast hole diameters of the staked collar location. If more than five percent of the holes are drilled outside of this tolerance, at the option of the ENGINEER, the CONTRACTOR may be required to refill these holes with crushed stone and re-rill them at the proper location.
 - 2. The production holes shall not exceed four inches in diameter and shall be drilled to a depth that is below the finished surface elevation, such that unbroken rock does not extend above the finish surface.
 - 3. The depth of individual horizontal lifts, the depth of blast holes, and the amount of explosive per hole and per delay shall vary depending on the average thickness of the lift as measured from the cut face to the existing rock face, and shall not exceed the following amounts:

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<u>Lift Thickness</u>	<u>Pounds of Explosive</u>
0' to 20'	50
21' to 50'	Add 15 lbs. Per foot of thickness
Over 50'	500

4. If the blast holes are plugged or unable to be fully loaded, the CONTRACTOR shall be required to deepen or clean out those holes. The blast holes should all be checked and measured before any explosives are loaded into any of the holes to eliminate any safety hazard resulting from drilling near loaded holes.
5. All blast holes should reach their desired depth, and if more than five percent of the holes are short before loading, the CONTRACTOR may be required by the ENGINEER to re-drill the short holes to proper grade at the CONTRACTOR's expense.
6. In order to control blasting effects, the CONTRACTOR must maintain a burden distance that is not more than one-half the bench height.
7. Blast holes shall be covered after drilling to deep overburden from falling into the holes.
8. The row of blast holes immediately adjacent to the controlled blast line shall be drilled on a plane approximately parallel to the controlled blast line. Production blast holes shall not be drilled closer than three feet to the controlled blast line, unless approved by the ENGINEER. The bottom of the production holes shall not be lower than the bottom of the controlled blast holes, or by approval of the ENGINEER may be lower than the controlled blast holes by the amount of subdrilling used on the production holes. Detonation of production holes shall be on a delay sequence towards a free face. Stemming material used in production holes shall be crushed stone and shale, not sand or drill cuttings.
9. It is the CONTRACTOR's responsibility to take all necessary precautions in the production blasting so as to minimize blast damage to the rock backslope.
10. Do not begin production blasting prior to the line drilling, pre-splitting, or as required to preserve the rock beyond the limits of the excavation.

3.7 CONTROL CRITERIA, MONITORING AND EXPLOSIVE PRODUCT REQUIREMENT

- A. The CONTRACTOR shall submit for review the proposed methods and sequence of blasting for rock excavations. The CONTRACTOR shall identify the number, depth, and spacing of holes; stemming and number and type of delays; methods of controlling overbreak at excavation limits, procedures for monitoring the shots and recording information for each shot; and other data that may be required to control the blasting.
- B. The CONTRACTOR shall submit to the Blast Consultant for review a completely detailed blasting plan of each blast at least 48 hours prior to preparing for, drilling or loading the holes. These details shall include the location of all holes relative to the excavation plans and sections, the size of all holes, the typical loading pattern of each hole, the distribution of charge within each hole, and the number of each delay.
- C. The CONTRACTOR shall develop a trial blasting technique that identifies and limits the vibrations and damage at varying distances from each shot. This trial blasting information shall be collected and recorded by beginning the WORK at points farthest from areas to remain without damage. The CONTRACTOR can vary the hold spacing,

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depths and orientations, explosive types and quantities, blasting sequence, and delay patterns to obtain useful information to safeguard against damage at critical areas.

1. If at any time during the progress of the WORK, the methods of drilling and blasting do not produce the desired result of a uniform slope and shear face, within the tolerance specified, the CONTRACTOR shall be required to drill, blast, and excavate in short sections, not exceeding 50 feet in length, until a technique is developed that shall produce the desired results.
- D. Drilling logs shall be kept on each blast hole to show open bedding, jointing and open or mud filled seams, zones of soft or weathered rock, mud pockets, etc. These logs shall be provided to the ENGINEER before any blast holes are loaded. The logs shall be used to properly design and load blast holes and use stemming decks in weak zones to protect residents from blowout, fly rock and unusual or hazardous blasting effects.
- E. The stemming decks shall be of crushed stone. The material used for stemming decks shall be well graded between one-eighth inch and three-eighth inches in diameter. Drill cuttings shall not be used.
- F. Concentrated charges will not be permitted; only special, controlled blasting procedures will be permitted.
- G. Bulk explosives such as ammonium nitrate and fuel oil that do not meet manufacturer's specifications, shall not be used on the Project. When in the opinion of the ENGINEER, any blasting product is either of excessive age or in what appears to be a deteriorated condition, all WORK shall cease until the product's age or quality can be determined.
- H. No blasting product shall be brought to the job site if the date codes are missing. At the option of the ENGINEER, the product may be tested by an independent organization to determine its performance as compared to the manufacturer's data sheet. If product performance or composition deviated by more than ten percent in any manner from the manufacturer's data sheet, that lot number shall be rejected.
- I. The CONTRACTOR shall submit manufacturer's certification for the blasting agents and explosives, and that the products sent to the job meet their specifications on the technical data sheet.
- J. The CONTRACTOR shall videotape, take high-speed photographs or collect other print or other electronic images of each blast. The images, photographs, film and videotape shall become part of the Project records.

3.8 BLAST DESIGN

- A. Design each blast to avoid damage to existing facilities, adjacent property and completed WORK. Consider effects of blast-induced vibrations and air blast, and fly rock potential in design of each blast.
- B. Whenever peak particle velocity exceeds vibration limits change design of subsequent blasts, as necessary, to reduce peak particle velocity to within limits established by CONTRACTOR's Blast Control Specialist.

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- C. Whenever air blast exceeds limits, change design of subsequent blasts or provide controls necessary to reduce air blast to within specified limits.

3.9 PRE-BLAST CONDITION SURVEY

- A. The CONTRACTOR shall arrange for a pre-blast survey of any nearby buildings, structure, or utilities that may potentially be at risk from blasting damage. The survey method used shall be acceptable to the CONTRACTOR's insurance company. The CONTRACTOR shall be responsible for any damage resulting from blasting. The pre-blast survey shall be made available to the ENGINEER for review two weeks before any blasting begins. Occupants of local buildings shall be notified by the CONTRACTOR prior to the commencement of blasting.
- B. The pre-blast survey shall be done on all buildings and structures within 600 feet of the blasting area. The pre-blast survey shall produce the following as a minimum requirement:
 - 1. Diagrams and information as required to accurately show the building or structure existing conditions.
 - 2. Photographs of existing damage.
 - 3. Comprehensive video of the entire structure.
- C. Pre-blast surveys shall be completed by a practicing civil engineer registered in the State of Alaska, who has experience in rock excavation, foundation design, and building design and construction.

3.10 VIBRATION LIMITS

- A. Establish appropriate maximum limit for peak particle velocity for each structure or facility that is adjacent to, or near blast sites. Base maximum limits on expected sensitivity of each structure or facility to blast induced vibrations and federal, state, or local regulatory requirements, but not to exceed two-inches per second when frequency is 40-Hz or greater, and 0.75 inches per second when frequency is less than 40-Hz.
- B. Allowable charge weights per delay shall be based on vibration levels that shall not cause damage. The allowable charge weights per delay shall be established by carrying out trial blasts and measuring vibration levels. The trial blasts shall be carried out in conformance with blasting test section requirements, modified as required to limit ground vibrations to a level which shall not cause damage. Regression analysis shall be performed by the CONTRACTOR's Blasting Consultant with the test blast data, and directional transmission characteristics shall be determined.
- C. The CONTRACTOR shall monitor each blast with three approved seismographs located, as approved, between the blast area and the closest structures subject to blast damage. The seismograph used shall be capable of recording particle velocity for three mutually perpendicular components of vibration in the range generally found with controlled blasting as well as air overpressure. The seismographs must be capable of storing data in digital form, which can be electronically transferred into a computer. The type of

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seismograph instrumentation, and the method of use, must conform to the general guidelines for proper use of seismographs.

- D. Peak particle velocity of each component shall not be allowed to exceed the safe limits of the nearest structure subject to vibration damage. The CONTRACTOR shall employ an ENGINEER-approved qualified vibration specialist to establish the safe vibration limits. The vibration specialist shall also interpret the seismograph records to ensure that the seismograph data shall be effectively utilized in the control of the blasting operations with respect to the existing structures. The vibration specialist used shall be subject to the ENGINEER's approval. The vibration specialist shall supervise the placement and operation of the seismograph.

Data recorded for each shot shall be furnished to the ENGINEER prior to the next blast and shall include the following:

1. Identification of instrument used.
2. Name of qualified observer and interpreter.
3. Distance and direction of recording station from blast area.
4. Type of ground at recording station and material on which the instrument is sitting.
5. Maximum particle velocity in each component and frequency.
6. The time history of each component.
7. The time history of air overpressure.
8. A dated and signed copy of records of seismograph readings.
9. A regression analysis shall be done after every blast to determine if conditions are changing as a result of geology of blast design.
10. Blast vibration levels must conform to the alternative blasting level criteria in United States Bureau of Mines (USBM) Report of Investigation (RI) 8507.

3.11 AIR BLAST LIMITS

- A. Three air blast-monitoring systems shall be installed between the main blasting area and the nearest structures subject to blast damage or annoyance. The equipment used to make the air blast measurements shall be the type specifically manufactured for that purpose.
- B. Peak overpressure shall be held below 90 decibels (dB) linear peak method at the nearest structures or other designated location. Appropriate blast hole patterns, detonation systems, and stemming shall be used to prevent venting of blasts and to minimize air blast and noise levels produced by the blasting operations. The overpressure limit shall be lowered if it proves too high based on damage.
- C. A permanent signed and dated record of the peak overpressure measurements shall be furnished to the ENGINEER immediately after each shot. Regression analysis shall be done by the CONTRACTOR's Blasting Consultant after each blast, and necessary adjustments made to ensure that air overpressure shall never exceed the 90 decibels (dB) linear peak method.

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3.12 FLY ROCK CONTAINMENT

- A. Before the firing of any blast, the rock to be blasted shall be covered with approved blasting mats, soil, or other equally serviceable material, to prevent fly rock that may result in damage to life or property.
- B. The homeowners/renters determined to be in the design fly rock zone for a particular blast shall be notified 24 hours in advance of the pending blast, and at least two hours prior to the blast so that they may temporarily relocate during the blast. Signature along the roadway shall be used to supplement the notification process.
- C. Suggested methods of protecting structures and utilities from the effects of the blasting, blast induced fly rock, vibration, and air blast overpressure include, but are not limited to the following:
 - 1. New sisal rope blasting mats
 - 2. Wire rope or tire blasting mats
 - 3. Backfilling
 - 4. Stemming full depth
 - 5. Reduced explosive loads
 - 6. Use of millisecond delays
 - 7. Relocation of any or all existing utility lines
- D. The CONTRACTOR shall protect all overhead and underground utilities prior to blasting and immediately repair or replace any damaged by the blasting operations. If the CONTRACTOR wishes to temporarily relocate any utility lines that lie near a blast zone, he shall have written approval from the governing utilities and pay all relocation costs.
- E. If fly rock travels beyond the design fly rock zone limits, all blasting operations shall cease. The CONTRACTOR shall review the site and determine the cause and solution to the fly rock problem. Before any further blasting proceeds, a written report, prepared by the CONTRACTOR shall be submitted to the ENGINEER. In the event that the CONTRACTOR and the ENGINEERING cannot reach an agreement on the cause and solution to the fly rock problem, progress payments shall be suspended until an agreement is achieved.
- F. If after review of the report, the ENGINEER determines that the design fly rock zone shall be re-established and additional residences notified, all new homeowners/renters shall be offered the same temporary relocation benefit of \$250.00 for each blast event.
- G. Failure to pay the temporary relocation benefits due or to resolve fly rock incidents in a timely manner, as indicated in the Specifications, will result in delay of progress payments.
- H. Delays caused by fly rock incidents do not constitute grounds for extension of Contract Time.

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- I. If more than three fly rock incidents occur, at the option of the OWNER, the CONTRACTOR may be fined \$10,000 for each additional occurrence. A fly rock incident is defined as any fly rock that hits private property.

3.13 VIBRATION AND AIR BLAST MONITORING

- A. Monitor on, or at, structures or other facilities that are closest to point of blasting. Monitor more distant facilities that are expected to be sensitive to blast induced vibrations and air blast.
- B. The CONTRACTOR's Blast Control Specialist shall supervise establishment of monitoring programs and initial operation of equipment, review interpretation of records and recommended revisions of blast designs.

3.14 BLASTING RECORDS

- A. For each blast, document the following:
 - 1. Location of blast in relation to the coordinate system and elevations
 - 2. Date and time of loading and detonation of blast
 - 3. Number of blasts
 - 4. Name of person in responsible charge of loading and firing
 - 5. Plan view and section view of each blast with notes indicating free face, burden, spacing height of lift, hole diameter, stemming depth, hole angle, hole depth, subdrill depth
 - 6. Notes regarding conditions encountered in the drill holes, including soft or fractured zones, water table alignment problems
 - 7. Loading diagram indicating types and amounts of explosives, primers, initiators, stemming depth, powder factors, trade names, and sizes of explosives, primers and initiators
 - 8. Sequence plan of the shot, including surface delay times and initiator's delay times
 - 9. Comments by blaster-in-charge regarding damage to existing facilities, adjacent property, or completed WORK, misfires, fly rock occurrences, unusual results, or unusual effects
 - 10. Provide drilling logs as described in Article 3.7, D of this Section
 - 11. The CONTRACTOR shall videotape, take high-speed photographs or collect other print or other electronic images of each blast. The images, photographs, film and videotape shall become part of the Project records.

3.15 DAILY EXPLOSIVE MATERIAL CONSUMPTION AND LOSS

- A. The CONTRACTOR shall keep a daily record of transactions to be maintained at each storage magazine. Inventory records shall be updated at the close of every business day. The records shall show the class and quantities received and issued and total remaining on hand at the end of each day. Remaining explosive inventory shall be checked each day, and any discrepancies that would indicate a theft or loss of explosive material would be immediately reported.

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- B. Should a loss or theft of explosives occur, all circumstances and details of the loss or theft shall be immediately reported to the nearest office of Alcohol, Tobacco & Firearms, local law enforcement authorities and the ENGINEER.

3.16 SUSPENSION OF BLASTING

- A. If damage to existing facilities or adjacent property occurs due to blasting, immediately suspend blasting and report damage to the Blast Consultant, the ENGINEER, and the CBJ Project Manager.
- B. Before resuming blasting operations, adjust design of subsequent blasts, or take other appropriate measures to control effects of blasting and submit complete description of proposed changes for reducing potential for future damage to the Blast Consultant.
- C. Do not resume blasting until authorized by the Blast Consultant.

3.17 SCALING AND STABILIZATION

- A. All rock on the cut face that is loose, hanging, or creates a potentially dangerous situation, shall be removed or stabilized to the ENGINEER's satisfaction during or upon completion of the excavation in each lift. Drilling of the next lift or WORK of any sort on the remaining rock cuts shall not be allowed until this WORK has been completed.
- B. The slopes shall be scaled throughout the span of the contract and at such frequency as required to remove all hazardous loose rock or overhangs. The slopes shall be hand scaled using a suitable standard steel mine scaling rod. Subject to the ENGINEER's approval, or other methods, such as machine scaling and hydraulic splitters, may be used in lieu of or to supplement hand scaling. Payment for scaling shall be incidental to the contract unit price for rock excavation.
- C. If in-place stabilization is required, as determined by the ENGINEER, rock bolting or other ENGINEER approved stabilization techniques shall be used. Stabilization necessitated, in the opinion of the ENGINEER, by the CONTRACTOR's blasting operations, shall be performed at the CONTRACTOR's expense.
- D. Material outside the planned neatline slope which, in the opinion of the ENGINEER, is unstable and constitutes potential slides, shall be excavated and removed. Such material shall be used in the construction of the embankment or disposed of as directed by the ENGINEER. The removal and disposal of this material shall be paid for at the contract unit price for rock excavation if WORK does not require blasting.

3.18 SAFETY PROCEDURES - WARNINGS AND SIGNALS

- A. The CONTRACTOR shall establish a method or warning all employees on the job site of an impending blast. The signal should consist of a five minute warning signal to notify all in the area that a blast shall be fired within a five minute period. A second warning signal shall be sounded one minute before the blast. After the blast is over, there shall be an "all clear" signal sounded so all in the area understand that all blasting operations are finished.

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- B. Five minutes prior to the blast, five long signals on an air horn or siren shall be sounded. One minute prior to the blast, five short signals on an air horn or siren shall be sounded. The "all clear" shall be one long signal of at least 30 seconds in duration to indicate that all blasting has ceased.

3.19 CHECK FOR MISFIRES

- A. The CONTRACTOR shall observe the entire blast area for a minimum of five minutes following a blast to guard against rock fall before commencing WORK in the cut. The five minute delay between blasting and allowing anyone but the Blast Control Specialist to enter the area is needed to make sure that no misfires have occurred.
- B. During the five minute delay, it is the Blast Control Specialist's responsibility to go into the shot area and check all holes to make sure that they have detonated. If any holes have not fired, the Blast Control Specialist shall handle these misfires before others enter the WORK area.
- C. The ENGINEER shall, at all times, have the authority to prohibit or halt the CONTRACTOR's blasting operations, if it is apparent that through the methods being employed, the required slopes are not being obtained in a stable condition or the safety and convenience of the public is being jeopardized.

3.20 MISFIRE HANDLING PROCEDURES

- A. Should a visual inspection indicate that complete detonation of all charges did not take place, the following procedures shall be followed:
 - 1. If the system was energized and no charges fired for electric systems, the lead wire shall be tested for continuity prior to inspection of the remainder of the blast. For non-electric systems, the lead-in or tube shall be checked to make sure that detonation has entered the blast area.
 - 2. Should an inspection of the electrical trunkline or lead-in tubing line indicate that there is a break in the line or if the tubing did not fire, then the system shall be repaired and the blast re-fired. If the inspection indicates that the trunkline has fired, and misfired charges remain, the Blast Control Specialist shall perform the following:
 - a. The Blast Control Specialist shall exclude all employees except those necessary to rectify the problem
 - b. Traffic shall be closed if a premature explosion could be a hazard to nearby traffic
 - c. The Blasting Consultant shall correct the misfire in a safe manner. If the misfire poses a problem that cannot be safely corrected by the Blasting Consultant, then an explosive company representative skilled in the art of correcting misfires shall be called to rectify the problem.

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3.21 PUBLIC MEETINGS

- A. The CONTRACTOR shall make their qualified vibration and air blast specialists and Blasting Consultant available for one (1) day to conduct a public meeting to better inform the public about anticipated drilling and blasting operations. The specialists shall be prepared to answer any questions dealing with the magnitude of seismic motion, air blast overpressure, and fly rock expected to impact the public.

END OF SECTION