UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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SECTION 31 23 06.00

BLASTING - SURFACE
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NOTE: This guide specification covers the requirements for blasting at the ground surface and the avoidance of adverse impacts for any use of blasting, most commonly rock excavation. If during the contract period any of the materials being blasted and excavated are known to be, or may possibly be, near a water body or below water, also refer to Section 31 23 01 UNDERWATER BLASTING. For projects on a naval facility, consult with local NAVFAC office, Naval Ordinance Safety and Security Activity (NOSSA), and NAVSEA on requirements. NAVSEA OP5 Ammunition and Explosive Safety Ashore manual dictates many of the requirements and NOSSA has the final determination on any blasting on a Navy installation above or underwater. Reference NAVSEA OP5 manual and contact local Explosives Safety Officer and Planner for the base prior to revising the specification. Overall NOSSA approval process can take 12-18 months depending on the level of approval required.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

PART 1 GENERAL

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NOTE: Consult with a District Office that has most recently completed a similar type of blasting, while editing this section, to be appraised of recent, specific requirements, guidance, blasting developments or understandings for the subject project.

Consult with or have Specification reviewed by a Subject Matter Expert in Blasting for projects involving Blasting as a primary means of removing materials or where Blasting issues are particularly challenging.

There are likely decisions and/or requirements of other agencies, the Safety Manual, and/or internal offices/divisions/ branches, which could have an influence upon a project's blasting specs. Some of these issues may be: concerns from federal, state, and local jurisdictions and agencies; public use of nearby federal, state and/or local properties near the project; evaluations of acceptable vibrations and/or pressures affecting individuals or reaching nearby structures; natural resource impact reviews, negotiations and/or requirements; constraints on the drilling or blasting procedures; pre-blast inspections; special studies to facilitate lower cost of the bids or to encourage more bid submissions; the acquisition strategy for the payment; and, other concerns specific to the project.

This blasting guide specification covers the blasting of rock and including mucking. The details on excavation are typically covered by a separate Rock Excavation specification.

The following information will be indicated on the project drawings:

1. Surface elevations, existing and new;

2. All utilities, whether trenched, buried, at the surface or overhead to distances well beyond the project's limits;

3. Location and record of all soil and rock borings and test pits, including soil and rock classifications and their properties, weathered rock, bit drops and voids, ground water observations, and topsoil thickness encountered in boring;

4. Location and limits of hard material, whether rock or concrete, or other building materials;

5. Excavation or demolition limits, and clearing,

stripping and grubbing limits, and tolerances of excavation;

6. Details of any special limits that may require line drilling, presplitting, reduced subdrilling, and/or specialty blasting practices;

7. Location of borrow and disposal area, if located on Government property; or on site (as some sites may or may not remain government property, and disposal sites may be under control of project partners);

8. Hydrological, hydraulic and impoundment data, where applicable; and,

9. Details of all rights-of-way within the project boundaries.

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NOTE: The coordination with other federal, state and local jurisdictions and agencies, the public, and private entities must be completely resolved before finalizing the specifications. A project's excavation and/or foundation requirements, for which, dense materials are being removed, may require navigation, highway, structural and/or other regulations and codes to be followed. Depending upon the proximity of public-use areas, private residences or businesses, and the project's location within a county or township, various accommodations will need to be required for the protection of the public, and the safety of private entities in regard to local laws, regulations and ordinances. Avoiding natural resource impacts may overlay other measures and require: seasonal or daily time limitations of the initiation of the individual blast patterns; special observers for some or all the blasting; special studies or monitoring while the blasting is being conducted; and, other potential considerations.

Agency coordination will vary by project. Be certain that all government stakeholders have been involved with planning of the project and approved of all requirements for the specifications. List those important navigation or safety stakeholders. When there are navigable waters near the excavation zone, list in the controlled navigation perimeter's distance during the warning period of a shot. While the distance is project specific, the minimum distance is typically 300 m 1,000 ft.

It is essential that the agency/service person, using these Guide Specifications to prepare Plans and Specifications coordinate with the planners and environmental compliance specialists within their agency/Service to ensure that all the blasting

restrictions and mitigation measures are incorporated into the Plans and Specifications. Failure to comply with the requirements of Federal or state laws and regulations could result in project delays or stoppages.

****

1.1 SCOPE

The breakage of rock and hard/unyielding materials may be conducted by any means unless otherwise stated herein. If the contractor elects to use drilling and blasting for breakage or displacement of any units, this entire section is applicable and covers activities associated with drilling and blasting for rock excavation at the surface. Contained herein are procedures for all activities relating to drilling; blasting and the transportation, storage and use of explosives; breakage and displacement of rock. The Contractor's blasting program and methods are those necessary to accomplish the excavation shown on the Contract drawings in accordance with the provisions specified herein. Control the quantity of explosives fired in all blasting to prevent injuries to persons and to avoid damage to all structures, properties, governmental and nonprofit entities, commerce and businesses, and natural resources and their habitat.

1.2 RELATED WORK SPECIFIED ELSEWHERE

****

NOTE: List any specifications that are related, such as Earthwork, Excavation, Rock Bolts, Temporary Environmental Controls, Shotcrete, Natural Resources, are typical specs related depending on the project.

****

Section 01 33 00 SUBMITTAL PROCEDURES

1.3 REFERENCES

****

NOTE: These publications are not all inclusive, and it must remain the responsibility of the Contractor to obtain, know, and comply with applicable Federal, State, and Local regulations not included in the references. In case of a conflict between the regulations and specifications, the Contracting Officer will determine which applies.

Add and remove references as needed for the project. Reference the appropriate state regulations on blasting for where the project is to occur.

This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of

the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D5434	(2012) Field Logging of Subsurface Explorations of Soil and Rock
ASTM D6032/D6032M	(2017) Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Core

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)

ISEE PSBS	(2017) ISEE Performance Specification for Blasting Seismographs

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety -- Safety and Health Requirements Manual

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.109	Explosives and Blasting Agents
29 CFR 1926-SUBPART U	Blasting and the Use of Explosives
49 CFR 177	Carriage by Public Highway

1.4 DEFINITIONS

****

NOTE: Delete definitions that will not be used in the specification text for a specific project. A complete list of blasting definitions can be found in the GLOSSARY of the EM 1110-2-3800 and other references. Recommend only using definitions not already in GLOSSARY in the EM and definitions to further the define the work on the specific project in the specification. It may be necessary to add definitions depending on what the Earthwork and/or

Excavation specifications for the project have terms for Rock, Weathered Rock, Sound Rock, Voids, Sediment, etc.

****

1.4.1 Blast Site

The area where explosive material is handled during the loading of blastholes, including 15.2 m 50 feet in all directions from the perimeter formed by loaded holes. A minimum of 9.1 m 30 feet may replace the 15.2 m 50 feet requirement if the perimeter of loaded holes is marked and separated from non-blast site areas by a barrier. The 15.2 m 50 feet or 9.1 m 30 feet distance requirements, as applicable, apply in all directions along the full depth of the blasthole.

1.4.2 Blast Area

The area of a blast within the influence of flying rock and eject gases, and concussion that may cause injury to persons or property.

1.4.3 Buffer Zone

Buffer Zone is defined as a designated section of rock between a slope to be formed by line drilling or pre-splitting during excavation and the production blast. The explosives in each blast hole and the burden in the buffer zone must be reduced to prevent damage to the final rock slopes.

****

NOTE: Choose one of the following sentences depending on when to shoot the buffer holes, sometimes it is appropriate to shoot them as a separate shot in order to further control the excavation and prevent backbreak.

****

[The buffer zone blastholes must be fired in sequence after the adjacent production blastholes.

][The buffer zone blastholes must be fired as a separate blast, after the adjacent production shot.

]1.4.4 Controlled Blasting

Controlled blasting refers to blasting techniques used to better distribute the explosive charge to minimize impacts such as fracturing and loosening of the rock beyond the design excavation line (overbreak). This is accomplished by using small diameter, decoupled charges in closely spaced blastholes placed on the perimeter of an excavation. Methods including but not limited to line drilling, and pre-splitting (pre-shearing) cushion blasting, and buffer zone blasting.

1.4.5 Flyrock

****

NOTE: Choose the distances for the project, the typical values are listed. Edit definition as needed for project site.

****

Flyrock is defined as any airborne rock flying more than 61 meters 200 feet horizontally or 12 meters 40 feet vertically from the blast or if flyrock travels more than one-half the distance between the blast and the Contractor work limits, whichever distance is the lesser.

1.4.6 Green Concrete

****

NOTE: If no concrete placement is expected on the project then delete this definition. If concrete placements will occur when blasting operation is ongoing, further define green concrete here and include appropriate thresholds and monitoring for the green concrete in Part 3. There needs to be limits on vibrations when there is green concrete because of the strength loss due to vibrations while curing. Involve the Structural Engineer project development team members in these determinations.

****

Concrete that has undergone initial setting but has not hardened to design strength. Green concrete also includes the materials of shotcrete or cementitious grouts. Each Individual Shot Plan is required to consider vibrations emanating from its blast reaching the location of the reported newly placed concrete to remain below allowable vibration levels depending upon the age of the concrete. Note the paragraph Green Concrete.

1.4.7 Line Drilling

Line drilling is defined as a controlled excavation technique consisting of a series of closely spaced holes (spacing minimum of twice the hole diameter) that are either not loaded with explosives or lightly loaded and are drilled along the excavation line. The line drill hole spacing must be no greater than twice the hole diameter.

1.4.8 Pre-Splitting

Pre-splitting is defined as a method of controlled blasting utilizing a row of closely spaced, (typically 30 centimeters 12 inches or larger), lightly loaded blastholes placed on the perimeter of the excavation and fired before the production blast. The purpose of the pre-split blast is to form a crack between blastholes without serious damage, overbreak, heaving or cracking of the final wall.

1.4.9 Precision Pre-Splitting

****

NOTE: The loading density for precision pre-splitting holes needs to be evaluated and selected based on project design. The value may be reduced accordingly.

****

Precision pre-splitting is defined as a special pre-splitting method which utilizes closely spaced blastholes (61 centimeters24 inches or less center to center) with light explosives loads (no more than 0.5 kilograms 0.2 pounds of explosive per .3 meter foot of blasthole) to supply only sufficient energy to shear the web of rock between holes without any damage to the Presplit wall.

1.4.10 Airblast

Airblast are the overpressure waveforms that move though air as audible and sub-audible sound waves. These are also called compression waves.

1.4.11 Vibrations

Vibrations are one of the three, primary adverse impacts from blasting. Vibrations are the result of various wave forms emanating from the detonation or deflagration of ignited materials from a shot pattern. Peak particle velocity (PPV) is defined as the maximum absolute value among the three ground vibration velocities measured in the vertical, longitudinal and transverse directions over the period of a record. Peak, total vector-sum particle velocity is the peak value over the full-time history of each time-unit's value of the square-root sum of the squared, component velocities. Velocity units are expressed in centimeters per second (cps) or inches per second (ips).

1.5 SUBMITTALS

****

NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S"

classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Blasting Consultant's Qualifications; G[, [_____]]

Vibration Monitoring Specialty Firm; G[, [_____]]

Structural Inspection/Evaluation Technician; G[, [_____]]

Blasting Safety Plan; G, SO

Master Blasting Plan; G[, [_____]]

Survey Control Plan; G[, [_____]]

Test-Blast Plan; G[, [_____]]

Pre-Blast Surveys; G[, [_____]]

Public Notice Of Blasting Operations

SD-03 Product Data

Seismographs; G[, [_____]]

Lightning Detection Device; G[, [_____]]

SD-05 Design Data

Individual Shot Plan; G[, [_____]]

SD-06 Test Reports

Individual Shot Reports; G[, [_____]]

Post-Blast Surveys

Individual Shot Videos

Drilling Logs

Individual Shot Monitoring Report

SD-07 Certificates

Blasting Consultant; G[, [_____]]

Blasting Specialist; G[, [_____]]

Blaster In Charge; G[, [_____]]

Blasting Administrator; G[, [_____]]

Magazine Keeper; G[, [_____]]

Structural Inspection/Evaluation Technician; G[, [_____]]

Seismic Specialist; G[, [_____]]

1.6 COORDINATION

****
NOTE: The following paragraph can be used if working with multiple stakeholders/owners.
****

Blasting will be in the vicinity of the [existing lock, railroad, and highway, and river barge, train, hospital highway traffic, utilities and businesses] and their operation will not be impeded or delayed beyond that which has been coordinated with [TVA, U.S. Coast Guard, U.S. Army Corps of Engineers - [_____] District, [_____] environmental or natural resources offices, [_____] Department of Transportation, local government entities, [[_____] Railroad, regional or local utilities, and/private businesses]]. Include a coordination and traffic control sub-plan as part of the Blasting Safety Plan, with the appropriate authorities that mitigates navigation and traffic delays in the Master Blasting Plan.

Coordinate, through the Contracting Officer, with other Contractors working onsite to minimize work stoppages during blasting.

1.7 LIABILITY

Compliance with provisions in the contract will not relieve the Contractor of their responsibility for any damages or injuries caused by, related to or arising out of blasting or associated blasting activities. The Contractor assumes all liability and hold and save the Government, its agents, officers, and employees harmless for any and all claims for personal injuries, property damage, or other claims arising out of or in connection with the handling of explosives or blasting under this contract.

PART 2 PRODUCTS

2.1 STORAGE AND USE OF EXPLOSIVES

2.1.1 General

****
NOTE: The specification writer may choose to list reasons the Contracting Officer may restrict blasting but not always necessary. Confirm and follow federal, state and local regulations and guidance on the transport, storage and use of all Explosives. State and local agencies and/or authorities may not easily allow the receipt of Explosives in a timely manner. State and local agencies and/or authorities may have specific reporting, certifications, adverse impact concerns, or distance regulations from the blast zone to private properties governing the use of Explosives. The Agency/Service may wish to allow storage of Explosives on federal premises. The winning contractor should independently assess and cite in the Master Blasting Plan all federal, state and

local laws, regulations, ordinances or authorities that impact the transportation and storage of Explosives.
****

Store, transport, handle, use, and otherwise secure explosives in accordance with best practices as approved by the Contracting Officer and in accordance with all Federal, State and Local laws and regulations. Comply with all special rules, regulations and ordinances that may be made by the authorities having jurisdiction, or by the Contracting Officer, regarding construction of, and storage in, magazines and precautions in handling and transporting explosives for blasting. Times and imposed restrictions concerning the use of explosives must be conducted in accordance with local, State, and Federal regulations. The Contracting Officer reserves the right to establish further restrictions or time windows when blasting will not be allowed beyond the Local, State, and Federal requirements; these windows may include times of day of high traffic volumes, times when school traffic is present, or during funerals. The Contractor is responsible for all claims for damages and injuries caused by or arising out of blasting activities. Perform all blasting operations in accordance with the current edition of EM 385-1-1.

2.1.2 Blasting Products

****
NOTE: This paragraph may need to be adjusted, some projects it is not appropriate to allow bulk explosives, such in karst because the bulk explosives could fill voids if care is not taken while loading to monitor the amount being added to each hole.
****

All blasting caps used on the project must be one year or less of age. Millisecond delay, [shock tube] initiators, must be used as the initiation system. To ensure the accuracy of firing times of blasting caps, it is required that each cap period come from one lot number. Mixing of lot numbers for any one cap period is strictly prohibited. All explosives used on the project must be six months or less of age or no older than one half the shelf life shown on the explosives manufacturer's technical data sheet for that product. Cartridged [and bulk] explosives may be used in different sections of the project. Ammonium nitrate and fuel oil (ANFO) is not allowed in wet environments.

****
NOTE: In projects where controlled blasting techniques are required to produce final walls which require presplit blasting, only explosives designed for this application must be allowed. Ammonium nitrate and fuel oil (ANFO) is not to be allowed in wet environments. Consider requiring cartridge explosives within a specified distance from any new structure which requires neat excavation lines; i.e. "Bulk explosives such as ANFO or bulk emulsion or emulsion blends will not be allowed for production blasts at the area of the Labyrinth Weir foundation or within 61 meters 200 feet of it or within 15.2 meters 50 feet of presplit walls."
****

Explosives that do not meet the manufacturer's specifications must not be used. When, in the opinion of the Contracting Officer, any blasting product is either of excessive age or appears to be in a deteriorated condition, all work must cease until the products age and quality can be determined. Blasting products without date and batch codes will not be permitted on site. The Contracting Officer may require any product to be tested by an independent organization to determine its performance as compared to the manufacturer's data sheet. If product performance or composition deviates by more than 10 percent in any manner from the manufacturer's data sheet, that lot number will be rejected. The Contractor is responsible for any required testing and no additional compensation will be made for any product testing directed by the Contracting Officer.

2.1.3 Magazines

****
NOTE: Two paragraph options here first paragraph is for where explosives must be stored off site (off site magazine). The other covers the storage of explosives onsite. The designer will need to ensure these requirements are fully detailed and the appropriate regulations are followed.
****

Explosives must be stored offsite. Obtain all necessary Federal and State magazine permits. Magazines must be located at safe distances as defined by the Bureau of Alcohol, Tobacco and Firearms (ATF) in addition to the State of [_____] requirements. There must be no permanent explosive storage or overnight explosive storage on site. Procure off-site explosive storage and expect to have daily explosives deliveries to the site. Secure a permit to transport explosives from the [_____] Highway Patrol when the amount of explosives to be transported exceeds 454 kilograms 1000 pounds, and transport explosives in accordance with 49 CFR 177 when carried on public highways.

****
NOTE: If explosives will be stored in an onsite magazine, it will be required to follow the requirements in EM385-1-1, including a submittal for an Explosive Site Safety Plan and the following paragraph can be used.
****

Explosives may be stored onsite. Obtain all necessary Federal and State magazine permits. Magazines must be located at safe distances as defined by the Bureau of Alcohol, Tobacco and Firearms (ATF) in addition to the State of [_____] requirements. Secure a permit to transport explosives from the [_____] Highway Patrol when the total weight of explosives to be transported is less than 454 kilograms 1001 pounds, and transport explosives in accordance with 49 CFR 177 when carried on public highways.

2.1.4 Magazine Keeper

Each magazine keeper must be experienced and familiar with the laws and general practices concerning the handling, care, use, and storage of explosives and detonators. The magazine keeper is responsible for maintaining a cleared area around each magazine. The magazine keeper will

not be required to perform any duties that will in any way interfere with their duties as magazine keeper, and being physically present at the magazines for every entry to the magazines for delivery, disbursement and review of explosives at the magazines. If explosives are delivered and returned daily from the manufacturer or supplier to the project, the driver of the truck will serve as the magazine keeper.

PART 3 EXECUTION

3.1 GENERAL

****

NOTE: This paragraph should agree with the designations under paragraph SUBMITTALS, the Master Blasting Plan will always be for approval. The Individual Shot Plan may be approved ("G") or accepted ("FIO").

****

Obtain approval, or revise for approval, of the submitted Master Blasting Plan and Individual Shot Plans, acquire all required permits, and comply with all laws, regulations, ordinances, applicable safety code requirements, and regulations relative to the transportation, handling, storage, and use of explosives and the protection of life and property. Perform vibration and airblast monitoring at the Contracting Officer's specified locations to record blast effects. The peak particle velocity must be limited to the values in Paragraph BLAST EFFECTS MONITORING in these specifications. Minimize rock over-break and blast damages beyond the design excavation line. The Contracting Officer will, always, have the authority to prohibit or halt the blasting operations, if it is apparent that the required lines and grades and stable rock slopes are not being obtained with the methods being employed.

3.2 SAFETY PROCEDURES

3.2.1 General

Ensure all work completed under this Contract is executed safely. Follow the safety procedures outlined in EM 385-1-1. EM 385-1-1 will govern all activity unless more stringent safety requirements are specified here and in other applicable Federal, State, and local laws, regulations, and ordinances.

3.2.2 Weekly Coordination Meeting

Coordinate all blasting schedules with the Resident Engineer's Office at least one week in advance and hold a weekly blasting coordination meeting with the Resident Office. Provide an agenda for the blasting coordination meeting that lists the prior week's shots, the forecasted shot schedule and displays a scale site plan showing the locations of the scheduled shots. The Blasting Specialist, Blaster in Charge, and Seismic Specialist are required to participate in discussion of agenda items and lessons learned.

3.2.3 Public Notice of Blasting Operations

At least thirty calendar days, and prior to any blasting operations, prepare and submit to the Contracting Officer a public government notification letter of the proposed blasting activities. The Government

will distribute copies of this notification letter by certified mail to law enforcement, local governments, public utilities, public users of project recreational facilities, and residents and commercial interests located within 0.8 kilometers one half mile of the blast site. This notification letter must contain at minimum:

a. Name, address, telephone number and e-mail address of the Contractor;

b. Plan maps identifying the specific areas in which blasting will take place, and major and secondary roads, geographic features and auxiliary features;

c. Proposed duration of blasting activities, and on which days of the week and hours of the day that blasts can be expected to occur;

d. Vehicular and pedestrian traffic control measures to be taken;

e. Methods to limit access to the blasting area; and,

f. Types, patterns and duration of audible warning and all clear signals to be used before and after blasting.

3.2.4 Public Meetings

****

NOTE: Communicate with the project manager and stakeholders about whether specific requirements for a meeting or multiple meetings are needed. It may be necessary to advertise the meeting in a local newspaper and specify the meeting room capacity.

****

Fifteen calendar days prior to any blasting operations, provide the approved Seismic Specialist, Blasting Specialist and Blasting Consultant to attend a public relations meeting to be conducted on an evening to be determined by the Contracting Officer. This meeting will inform the public about the anticipated blasting operations. The Blasting Specialist, Blasting Consultant and Seismic Specialist must make a short presentation of blasting operations and answer any questions pertaining to public concerns dealing with the blasting operations, the magnitude of seismic vibrations, airblast and potential for flyrock that may impact the public. Distribute points of contact for the public and local entities in the event of concerns related to the blasting program.

3.2.5 Warnings and Signals

Establish a method of warning all employees on the job site of an impending blast following the guidance of the EM 385-1-1. The signal must consist of a five-minute warning signal to notify all in the area that a blast will be fired in five minutes. A second warning signal must be sounded one minute before the blast. After the blast is over, sound an all-clear signal, after the blast site has been inspected for misfires by the Blaster in Charge to provide notification to all personnel in the area that the blasting operation is finished. No personnel other than the Blaster in Charge must enter the blast area until it has been determined to be all clear.

3.2.6 Time Restrictions for Blasting

****

NOTE: Research the specific State requirements. This paragraph will need to be tailored for the specific site conditions, for example, avoiding blasting during rush hours in the morning and afternoon. Most locations prohibit blasting on Sunday but may allow on Saturdays and some Holidays.

****

Blast only during daylight hours, one-half hour before sunrise and one-half hour after sunset, and between 7 AM and 7 PM, local time, on weekdays and only during the approved time periods each day and at the same time each day, in concert with the approved closure time for area roads. No blasting is allowed on Saturdays, Sundays, or official holidays recognized by the Federal Government or the State of [_____] unless consent is granted by the State Fire Marshal. Drilling activities and blasthole loading are not time restricted, except as noted in Section 01 14 00 WORK RESTRICTIONS.

3.2.7 Traffic Control During Blasting

****

NOTE: This section should be edited for the specific project sites traffic control issues. Communicated with stakeholders and local utilizes, DOTs, Railroads, businesses during design phase to capture any special needs the Government will need to specify for the Contractor to carry out during blasting. This Paragraph is an example.

****

During blasting operations traffic may need to be temporarily halted to allow safe execution of blasting and possible removal of rock fragments and debris. Traffic control, including such delays must be the sole responsibility of the Contractor. Traffic control must be in close coordination with the [_____] Department of Transportation[and the town of [_____]]. Include the traffic control plans with the Blasting Safety Plan.

It is not anticipated that blasting activities will impact traffic due to the distance of the blasting from the road. The Contractor will need to coordinate with [_____] for blasting [_____]. In addition, use protective blasting mats for all shots [_____], unless otherwise directed by the Contracting Officer to minimize any fly rock near [_____] may be required, if, in the opinion of the Contracting Officer, flyrock becomes an issue. If traffic stoppages are warranted, coordinate with the Contracting Officer. A sentinel boat must be stationed [_____] of the work area to prevent any boaters from entering the blast area.

Recreational boats, swimmers, fisherman and the public, on land or in the water must be prohibited access within 762 meters 2500 feet of the blasting area. Station sentinel boats to prevent any boaters from entering the blast area.

3.2.8 Notification to Navigation

****

NOTE: Use the following paragraph when working in or near navigable waters or navigation lock.
****

Notify the lockmaster at [_____] Lock, the US Army Corps of Engineers, [_____] District, Navigation Branch a minimum of [14] calendar days prior to the commencement of blasting operations to allow for sufficient time to send out navigation notices. The information to be supplied will include the dates and time window of blasting operations.

3.2.9 Lightning Detection Equipment and Safety

Furnish, maintain and operate Lightning Detection Device during the entire period of blasting operations and during the periods that explosives are used at the site. Equipment must provide real time audio and visual alarm/signal and detection based on combined detection of electromagnetic, electrostatic, light wave spectral and audio disturbances, or a commercial service based on these as a minimum as approved. Equipment must be capable of detecting lightning within 40 kilometers 25 miles as minimum of the blast area.

****
NOTE: Obtain technical feedback from the rest of the design team for minimum lightning detection distance.
****

Provide the equipment after approval of lightning detection device. When and where the lightning detection device indicates a blasting hazard potential, immediately evacuate personnel from all areas where drilling is being conducted or explosives are present. When a lightning detector indicates a blasting hazard, perform the following:

a. Clear the blasting area of all personnel. Place guards at all access points to the blast area.

b. Immediately notify the Contracting Officer of the potential hazards and precautions being taken.

c. Terminate the loading of holes and secure the unused explosives to an approved location.

d. When the hazard dissipates, inform the Contracting Officer that the drilling and loading of holes will continue.

3.2.10 Check for Misfires

The Blaster in Charge must closely inspect 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 commencing work is needed to ensure that no misfires have occurred. During the five-minute delay, it is the responsibility of the Blaster in Charge to go into the shot area and check all holes to make sure that all explosives have been detonated.

3.2.11 Misfire Handling Procedures

Should a visual inspection indicate that complete detonation of all charges did not occur, only critical personnel involved in the blasting

operation or excavation of the unexploded material are allowed within the established blasting area. Restrict the site until the Blaster in Charge and the Blasting Specialist indicate the site is safe. If the misfire poses problems that cannot be safely corrected by the Blaster in Charge or the Blasting Specialist, a consultant or an explosives company representative skilled in correcting misfires must be called to resolve the problem. Compliance with this or any other provision in the Contract must not relieve the Contractor of responsibility for any damages or injuries caused by, related to, or arising out of blasting or associated blasting activities. Detail the misfire procedures in the Blasting Safety Plan including the distance of the restricted area when a misfire is discovered.

3.3 BLASTING PERSONNEL

3.3.1 Blasting Consultant

****

NOTE: Depending on the scope of the project, it may not be necessary to require a Blasting Consultant. This will be determined during design, an Agency/Service Blasting SME or Government Blasting Consultant should be consulted to discuss this. Projects where slope blasting, away from sensitive structures minor and lightly used public areas may be a consideration to not including this requirement. One option is to still require a blasting consultant to be engaged but only for reviewing the Master Blasting Plan and engaged on very serious issues with the blasting (exceedance of vibration and/or airblast limits, misfires, flyrock, or excessive backbreak and/or overbreak). Excessive backbreak will need to be defined prior to issue of the specifications. This specification is geared towards IFB (Invitation for Bid) where there is no mechanism to select contractors prior to award. If another contract mechanism is used it may be necessary to include the bracketed text requiring a letter of commitment from the consultant.

****

The Blasting Consultant, Blasting Specialist, Blasting Administrator, Blaster in Charge, and Vibration Specialist cannot be the same person. Retain a recognized Blasting Consultant to assist in the blast design. The Blasting Consultant must be approved by the Contracting Officer prior to the submission of the Master Blasting Plan. Submit the Blasting Consultant Qualifications including resume, experience, current blasting licenses, credentials and training of the proposed Blasting Consultant[, and a formal letter of commitment from the consultant verifying their availability on an "as needed" basis for the duration of the Contract prior to the award of the Contract]. The consultant must be an expert in the field of drilling and blasting who has derived their primary source of income by providing specialized blasting and blasting consulting services. The consultant must not be an employee of the Contractor, explosives manufacturer, or explosives distributor or any other sub-contractor. There must be no additional cost to the Government for the Blasting Consultant's duties, even when required by the Government.

****

NOTE: The paragraph below should be used when controlled blasting techniques are required.
****

The Contractor's Blasting Consultant with the Blasting Specialist must develop controlled blasting techniques to be utilized in the areas specified in the drawings during the Test Blasting program. The Blaster in Charge is responsible for the technical application of the controlled blasting methods specified during and following the Test Blasting. The Blasting Consultant must modify controlled blasting methods, as necessary, to meet safety requirements, airblast and vibrations limits, and protect the rock foundation. Proposed controlled blasting methods must be submitted to the Contracting Officer for approval.

The Blasting Consultant must review the Master Blasting Plan and Individual Shot Reports and attend the public meeting and be available for consultation on an "as needed" basis, as determined by the Contractor, Contracting Officer, or both. The Blasting Consultant is not required to be on the job site for review of the Master Blasting Plan or Individual Shot Reports. The Blasting Consultant must submit a short, signed Blasting Consultant's Report each month stating that the Blasting Consultant has briefly reviewed the Individual Shot Reports including blast videos, and any problems, concerns or errors in the reports were addressed. This report is due within [_____] days after the end of the month.

3.3.1.1 Blasting Consultant's Qualifications

The consultant must be able to demonstrate involvement in at least 15 projects with blasting. The consultant must have as a minimum the credentials and experience outlined below:

a. The consultant must have at least 20 [_____] years of experience in construction blasting within [_____] meters [_____] feet of protected structures, [natural resource concerns and environmentally sensitive areas], final presplit slopes or walls.

****
NOTE: "Natural resource concerns and environmentally sensitive" areas need to be defined elsewhere in this guide specification.
****

b. The consultant must be able to demonstrate that he has attended at least 15 short courses, seminars, or conferences on blasting technology, or university engineering class studies on blast design during the past 20 years including a complete understanding of blasting seismology with emphasis on vibration frequency, acceleration, and displacement (ground strain).

c. For the past 10 years the consultant must have derived their primary source of income from providing specialized blasting consulting services.

d. Project list will contain a description of the projects, details of the blast plans, and any modifications made during the project.

e. The names and telephone numbers of at least three project owners with enough knowledge of the projects to verify the submitted information.

f. The Blasting Consultant must be approved by the Contracting Officer prior to the beginning of any drilling and blasting work including submission of the Master Blasting Plan.

g. Hands-on experience as a blaster for at least three years, and

h. The Blasting Consultant, Blasting Specialist, Blaster in Charge, and Vibration Specialist cannot be the same person.

3.3.1.2 Issues Requiring the Blasting Consultant

If problems with vibration, flyrock, airblast, presplitting, or production blasting, or adverse impacts on natural resources occur the Contracting Officer will require the Contractor to immediately summon the approved Blasting Consultant and have their presence on site within 10 days after the problem develops for the following:

a. To approve the blasting plans for each individual blast.

b. To be present to review the blasthole layout on the ground before drilling begins.

c. Observe blasthole loading.

d. To sign each blasting plan and each Individual Shot Report, at no additional cost to the Government. The consultant must have full authority to stop or delay any blast the Blasting Consultant considers unsafe.

e. To submit and sign a written checklist that all necessary precautions were reviewed and followed by the drilling and blasting crews. The checklist must be as defined under the section on Individual Shot Reports. The signed checklist must be attached to each blasting report.

f. Submit Blasting Consultant's Reports after each site visit.

3.3.2 Blasting Specialist

Submit the Blasting Specialist's Qualifications including resume, experience, education, training, and valid blasting licenses of the Blasting Specialist for approval, at least 60 days before drilling and blasting operations commence. Detail the experience and training, which qualifies the specialist for work under this Contract. The duties of the Blasting Specialist are to prepare all necessary paperwork, to conduct quality control and to coordinate with the Contracting Officer on all issues dealing with blasting. The Blasting Specialist must be an employee of the Contractor on the job site each day.

a. The Blasting Specialist must have at least 10 years of verifiable experience utilizing controlled blasting techniques.

****

NOTE: Include this sentence under paragraph a. if the project requires precision presplitting: [and Precision Presplitting methods to create uniform presplit faces in mixed rock types like the bedrock strata present at the project site].

****

b. Within the last five years, the specialist must have completed at least five days of classroom training that has familiarized the specialist with the most current drilling and controlled blasting methods.

c. In the last five years he must have been responsible for the blast design or execution of large rock excavation projects similar in scope and complexity as this project.

****

NOTE: Include this sentence under paragraph a. if the project requires precision presplitting: [or projects where at least 30,500 meters 100,000 linear feet of Precision Presplitting was used].

****

d. Their credentials must include a list of the projects, including the location, duration, scope, description, geologic conditions, and the challenges that developed though the course of the projects and how the challenges were resolved.

e. Each project description must be accompanied with photos which exhibit the Blasting Specialist's competency and ability to create the designed cut slope configuration to the specified tolerances. The list of projects must also contain the names and phone numbers of the project owner or their representative, Contracting Officer, or project engineers who has enough knowledge to verify the submitted information. The Contracting Officer will invalidate any project submitted as reference that cannot be verified.

3.3.3 Blaster in Charge

****

NOTE: Some USACE projects may require an Alternate Blaster in Charge based on the frequency, size, and complexity of the blasting operations. The Alternate Blaster in Charge must meet the same qualification requirements as the Blaster in Charge.

****

Submit the Blaster in Charge's Qualifications including resume, experience, education, blasting licenses and training of the Blaster in Charge for approval, at least 60 days prior to the commencement of drilling and blasting. Also submit the Contractor's Federal ATF License. Detail the experience and training, which qualifies the Blaster in Charge for work under this Contract. The Blaster in Charge is responsible for preparing the Individual Shot Plans that will be approved by the Blasting Specialist. The Blaster in Charge is responsible for marking the blasthole locations for drilling, accounting for the relevant geology, loading the blastholes according to the Individual Shot Plans and firing the blast.

a. The Blaster in Charge must be a licensed blaster in the State of [_____] per that State's regulations or issuing agency.

****

NOTE: If presplitting, precision presplitting, or

both, is included in the project, include paragraph below as an additional requirement for the Blaster in Charge.
****

b. Blaster in Charge will have at least [_____] years of verifiable experience utilizing controlled blasting techniques [and at least [_____] years of experience with "Precision Presplitting" to create uniform presplit faces with blasthole spacing at 61 centimeters 24 inches or less in variably weathered and fractured rock similar to the bedrock strata present at the project site].

c. Within the last five years, the Blaster in Charge must have completed at least five days of classroom training that has familiarized the Blaster in Charge with the most current controlled blasting methods.

d. Blaster in Charge must have been responsible for at least [_____] large rock excavation projects similar in scope and complexity as this project

****
NOTE: Include this sentence under paragraph d. if the project requires precision presplitting: [The projects must have included experience totaling at least [_____] linear meters [_____] linear feet of drilled blastholes for "Precision Presplitting".].
****

e. The Blaster in Charge credentials must include a list of the projects, including the location, duration, scope, description, geologic conditions, and the challenges that developed though the course of the projects and how the challenges were resolved. Each project description must be accompanied with photos, which exhibit the Blaster in Charge's competency and ability to design the blast.[Create the designed cut slope configuration to the specified tolerances.] The list of projects must also contain the names and phone numbers of the project owner or their representative, Contracting Officer, or project engineers who has enough knowledge to verify the submitted information. The Contracting Officer will invalidate any project submitted as reference that cannot be verified.

3.3.4 Blasting Administrator

****
NOTE: For smaller projects this position may not be necessary. The Blasting Administrator was added for large projects to aid the Blasting Specialist with paperwork.
****

The duties of the Blasting Administrator are to be the direct assistant the Blasting Specialist to prepare all necessary paperwork, and quality control on all issues dealing with blasting. The primary function is to assist the Blasting Specialist in the preparation and completion of submittals, prepare the detailed post blast report, and the individual shot videos for submittal to the Contracting Officer, and submit the drilling logs with the post blast report. The Blasting Administrator cannot sign any paperwork. The Blasting Administrator must be approved by the Contracting Officer. Submit the Blasting Administrator's

Qualifications.

The Blasting Administrator will possess the following minimum qualifications and experience:

a. Hold a current Blaster's license;

****

NOTE: If the Blasting Administrator will not be performing blasting duties (handling explosives in the field) this requirement may be waived but will have to be evaluated on a project specific basis.

****

b. Have at least [5] [_____] years of credible and verifiable experience in the industry utilizing controlled drilling and blasting techniques;

****

NOTE: If presplitting is required in the project, include "c" below, if not, delete.

****

[c. Have at least five years of specialized experience with presplitting techniques;

] d. Must have completed at least five days of classroom training within the last five years that has equipped the Blasting Administrator with the most current knowledge in controlled blasting or perimeter control techniques.

e. Have proven proficiency with blasting software and spreadsheets.

3.3.5 Magazine Keeper

Each magazine keeper must be experienced and familiar with the laws and general practices concerning the handling, care, use, and storage of explosives and detonators. The magazine keeper is responsible for maintaining a cleared area around each magazine. The magazine keeper will not be required to perform any duties that will in any way interfere with their duties as magazine keeper. If explosives are delivered daily from the manufacturer, the driver of the truck will serve as the magazine keeper.

3.3.6 Vibration Monitoring Specialty Firm

****

NOTE: This is requirement is a new format from previous specifications. The firm is submitted for approval, having the appropriate experience and the firm must have on staff the Seismic Specialists and Seismograph Technicians, typically a firm is subcontracted by the Contractor and having multiple experienced people approved allows them to have flexibility on supporting the site work. The people coming to the project or responding to the work must be within the group approved but does not need to be a single person anymore.

****

Retain the services of a vibration monitoring specialty firm that specializes in the prediction, monitoring and control of ground vibration and airblasts. The firm must have experience conducting installation of seismographs for vibration monitoring, communicating vibration and airblast results, and developing and maintaining a site attenuation curve. The firm must have on staff at least two Seismic Specialists that specialize in vibration monitoring and analysis. The firm must have on staff at least four Seismograph Technicians that have five years or more experience with seismograph installation and vibration monitoring. Submit resumes for all personnel and for the firm for approval citing, in additional to other pertinent data, experience, training, and education, at least 60 days prior to the commencement of blasting. The Seismograph Technicians must be persons capable of setting up the seismographs at designated locations, effectively recording the blast, and appropriately interpreting results. The Seismic Specialists must interpret the seismograph records to ensure that the seismic data must be effectively utilized in the control of the blasting operations with respect to the existing structures. The Seismograph Technicians must supervise the placement, operation and maintenance of the seismographs. The Seismic Specialists must conduct the airblast and particle velocity regression analysis as described in this Section. The Contracting Officer may require the Seismic Specialists and Seismograph Technicians to be present during the test blast program, production blasting, or both.

3.3.7 Structural Inspection/Evaluation Technician

****

NOTE: Five years is the minimum requirement experience, depending on the project it might be necessary to increase the minimum if there is a special concern or sensitive structures, consult with USACE SME to help determine.

****

Pre and Post Blast structural inspections must be performed by technicians with at least [five] years' experience in pre-blast and post blast surveys in the State of [_____]. Submit a copy of the qualifications and certificates to the Contracting Officer.

3.4 PRE-CONSTRUCTION DOCUMENTS

3.4.1 Master Blasting Plan

Submit a Master Blasting Plan at least [_____] days prior to commencing drilling and blasting operations that includes a section called Blasting Safety Plan for review and approval. The Master Blasting Plan must contain the full details of the typical drilling and blasting patterns [and control for line drilling and for the presplit, buffer and production blasting, in the situation where controlled blasting is required for the project]. The Master Blasting Plan must contain the following information, at a minimum:

a. Typical plan and section views drawn to scale of proposed drill patterns including free face, burden, blasthole spacing, blasthole diameters, blasthole angles, lift height and subdrilling depth, where allowed except for the blast that will carry the excavation to foundation grade where subdrilling is restricted as specified in the article SUBDRILLING. Base the typical plan and section views on the geology and excavation plan for this project site, it cannot be a

blast plan from a previous project.

b. Typical loading diagrams for each blast design being proposed showing type and amount of explosives, primers, boosters, decks, initiators and location and depth of stemming in each blasthole.

c. Typical initiator sequence of blastholes including delay times and delay system.

d. Predicted vibration and airblast amplitudes, and the mathematical equations used to calculate them. The Contractor must monitor the results of the test blasts and with the seismic data collected can determine the site-specific ground vibration equations and the site specific airblast equations for the project. After the first 10 blasts the Individual Shot Plansmust use the site-specific estimates at the 95 percent confidence level.

****

NOTE: Some states or counties may have specific vibration amplitude and airblast equations for specific locations.

****

e. Manufacturer's data sheets, including Safety Data Sheet (SDS), for all explosives, primers, and initiators to be employed. Provide copies of SDS for all explosives and detonators and define specific details about hazard communication programs for employees and specify where copies of SDS will be kept.

f. The Master Blasting Plan submittal is for quality control and record keeping purposes. Approval of the Master Blasting Plan does not relieve the Contractor of responsibility for the accuracy and adequacy of the plan when implemented in the field. Retain the professional services of a Blasting Consultant to assist with the blast designs included in the Master Blasting Plan.

g. Provide the Test Blast Plan and procedures for test blasting and modifying shot plans during production blasting in the Master Blasting Plan. Also provide the expected results from each shot including, but not limited to, the likely maximum peak particle velocity and airblast levels at the nearest inhabited structures

h. Indicate that the Individual Shot Report design and blast record documents must provide all the data of each blast in sufficient detail; for example, the exact same blast design data conduct by anyone else from the Individual Shot Plan provided with no other information would produce similar blast results and impacts.

i. Include samples of all completed submittal forms and diagrams (Pre-Blast Surveys, Individual Shot Plan, Drilling Logs, Individual Shot Reports, Individual Shot Vibration Monitoring Report, Results of Vibration and Airblast Monitoring, and Individual Shot Video).

j. Manufacturer's specifications on equipment to be used including but not limited to drills, air compressors, drill bits, drilling equipment specifications, manufacturer's literature of the drill rods, bits, casing, etc..

k. Plans for construction sequencing line drilling, presplitting,

blasting, and mucking operations to complete the rock excavation with the limitations of the peak particle velocities. Describe the change in placement any of the seismographs with regards to the progressing blasting and excavation. Provide the names of individuals responsible for the instruments, data retrieval, and analyses.

l. Single Sheet plan view showing location of all seismographs. This sheet must be amended and resubmitted whenever seismographs are moved.

m. Sample checklist that the Contractor will use to ensure that all required information is included in each blasting plan.

n. Survey Control Plan: Establish survey control as approved by the Contracting Officer for horizontal and vertical control of all line drill, presplit and production blasts. Assure that all blast holes are drilled on the specified pattern and at the location and the depths as detailed in the blast plan.

3.4.2 Blasting Safety Plan

In addition to the Master Blasting Plan, a Blasting Safety Plan must also be prepared, as specified and outlined in EM 385-1-1, Section 29. All blasting work must be conducted in accordance with the requirements specified in EM 385-1-1.

****

NOTE: Minimum safe distance from blast point will vary with each project. Local, state, county and federal regulations must be taken into consideration. Ensure NEPA, 408 permits, and environmental studies incorporated the blast safety radius.

****

The required minimum safe distance is [_____] meters [_____] feet from the blast point. All the public, including swimming and boating recreationists must be excluded from the safety zone during blasts, including pre- and post-blast operations. The safety zone must be marked with an intrusion prevention barrier and high hazard warnings. Patrol by boat before and during blasting to prevent the recreational public from entering the safety zone.

The Blasting Safety Plan must provide a complete description of the clearing and guarding procedures that must be employed to ensure personnel, staff, visitors, and all other persons are at safe locations during blasting. A Blasting Safety Plan simply stating: "all regulations will be followed" is not acceptable and will be rejected. This plan must be developed and signed by the Contractor's Blasting Specialist with input from the Contractor's Site Safety and Health Officer (SSHO) with the intent to show how the Contractor's procedures and methods meet or exceed applicable rules, regulations and standards established by the Regulatory Agencies, codes and professional societies, and specifications listed herein. The guarding procedures must also consider aircraft and water vehicles that may enter the danger zone. This information must include detailed descriptions and maps, when appropriate of traffic control, visible warning signs or flags, audible warning signals, method of determining blast areas (all areas affected by any potentially harmful blast effects), access blocking methods, guard placement and guard release procedures, primary initiation method, and the system by which the Blaster

in Charge must communicate with site security guards or other appropriate site supervisory personnel. The Blasting Safety Plan must be in accordance with and include items required in the EM 385-1-1, Section 29, 29 CFR 1910.109, 29 CFR 1926-SUBPART U.

The Blasting Safety Plan must state that explosive distributor will be delivering explosives on the day of the planned operation and recovering unused explosives at the end of the day. In the event of lightning detected at 16 kilometers 10 miles or less from the project site requirements for ceasing operations must be described. Provide a plan for controlling the temporary onsite storage of explosives or of securing an area of loaded holes until the threat has passed.

The Blasting Safety Plan must contain detailed descriptions of how and from where explosives will be transported and used at the various project work areas, and a map of the transportation route. The Blasting Safety Plan must explain how explosive transport vehicles will satisfy all applicable ATF, OSHA, Federal, State, County, and local regulations. The Blasting Safety Plan must also include the following.

a. Specific details about hazard communication programs for employees.

b. Equipment that will be used to monitor the approach of lightning or dust storms and in such event, the site evacuation and site security plans, and the criteria for determining if the site is safe to re-occupy.

c. Methods for preventing spills or losses of explosives, drilling fluids, oil, or any other pollutants onto the ground during handling and blast hole loading operations. Include details of spill containment and contingency plans for quickly and effectively cleaning up spilled materials.

d. Method of safe and approved disposal of all explosive packaging materials.

e. Detailed contingency plans for detection and disposal of misfires resulting from cutoffs or other causes, hangfires, inadvertent initiator extraction, or accidental loss of downlines. A narrative describing in detail job steps, controls, and hazards associated with but not limited to hung or bridged powder, overloaded holes, cutoffs during placement of blast mats, failure of communication system during pre and post blasting protocols, recovery protocols for unexploded objects (UXO), etc.

f. Misfire mitigation procedures, including but not limited to restrictions of entry, securing the area prior to investigating and inspection, additional safety measures, time-sequence of operations, and mitigation protocols.

g. Fire Prevention Plan details, including tobacco smoking policies, procedures and limitations for work involving open flames or sparks, description and location of firefighting equipment, and firefighting and evacuation plans.

h. Digital copies of a valid [state] blasting license for the Blaster in Charge, Blasting Specialist and all personnel required to have one.

i. State required certifications for the Contractor's explosives

supplier's Federal, ATF Explosives license or permit.

j. Other required county or state permits required for explosive transportation, use and offsite storage.

k. Explosive transporters' commercial driver's licenses with HazMat endorsements.

l. A reference in Attachment II (under misfire) when a misfire is declared the Blaster in Charge must wait 1 hour before inspecting site and provide proper safeguards for excluding employees from the danger zone except those necessary to do the work.

m. Submit updates, modifications and additions to the Master Blasting Plan in an appropriate and timely manner.

n. Complete project team organization with duties, responsibilities and authorities clearly defined. This organizational outline must also include names, addresses, resumes, responsibilities, and qualifications of all personnel authorized to sign for, receive and use explosives on this Contract.

o. Traffic Control Plan.

3.4.3 Pre-Blast Surveys

****

NOTE: During design consult with the adjust businesses/stakeholders to determine what Pre-Blast Survey needs to be conducted and whether access is allowed, or special considerations are needed. This needs to be outlined in the specifications for a proper bid to be made for the scope. It is important to include the entire Project Development Team in design to ensure all project features of importance are documented before blasting. Lessons learned on one lock where blasters caused damage and it was not realized until well after the work was completed, the Government had no means to prove the damage occurred from blasting because there was no Pre-Blast Survey of the structures damaged.

****

Prior to the commencement of blasting, conduct a Pre-Blast Survey of any nearby buildings, structures and utilities within [_____] meters [_____] feet from the blast area that may potentially be at risk of blasting damage to document pre-existing conditions. The survey extent and method used must be acceptable to both the Contractor's insurance company and the Contracting Officer. The Contractor is responsible for any damages or injuries resulting from blasting. Submit all Pre-Blast Surveys 30 calendar days before the start of blasting. There will be no blasting allowed until the Pre-Blast Survey is submitted and approved by the Contracting Officer. Provide owners of surveyed features a copy of their feature's Pre-Blast Survey results before or with the notice of blasting commencement. Notify owners and occupants of local buildings prior to the commencement of blasting. Perform the following when conducting Pre-Blast Surveys:

a. Provide methodology to be used in conducting the Pre-Blast Survey and

listing of structures, determined from the survey to be sensitive, with reasons for these structures being sensitive.

b. Each structure must be documented (including high resolution photography and videotaping) as to its construction, foundation type, condition, and closest distance to excavation blasting. The general condition and all observable defects of each structure must be documented. This includes measurements of the defects.

c. The Commodity storage facilities that may be impacted by blasting must be addressed by the Contractor for safety and continued operation during the blasting program.

d. Freestanding structures (such as retaining walls) must be inspected on the exterior and on the interior as a room. All concrete walks, driveways, etc. must be inspected for cracks, level condition, holes, and defects.

e. Industrial structures, silo/elevators and special facilities, and office space must be described relative to their present conditions and tolerance to vibration. Besides the inspection of walls, columns and stairwells, the Contractor must survey the work areas and structures for distress.

f. An inspection of accessible structures must be made and a list of all structures, which could not be surveyed or refused to allow survey, must be completed. The dates of possible subsequent surveys and physical constraints prohibiting the survey must be documented. The requirement to perform Pre-Blast Surveys is not an indication of Right-of-Entry by the Contractor. Any Right-of-Entry associated with Pre-Blast Surveys, monitoring during blasting and Post-Blast surveys are the responsibility of the Contractor. In the event a property or properties identified as significant or intended to be included in the Surveys and monitoring are not included because access was denied, indicate this occurrence including the points of contact, dates contacted and any reasons provided for denial of access (if given.)

g. Certify that the survey was prepared prior to the start of any blasting under this Contract. Submit a copy of the Pre-blast survey in conjunction with the Master Blasting Plan.

3.5 RECORD KEEPING

3.5.1 Individual Shot Plan

The Blasting Plan must be consistent with the general concepts, designs and layouts shown in the approved Master Blasting Plan. The number of rows of blastholes and the number of blastholes per row can be changed from one individual shot plan to the next. Provide reasons and technical justification for all significant changes from the Master Blasting Plan.

Submit a Blasting Plan for each blast at least [24] hours prior to the planned initiation of drilling. The results of the previous blast are to be jointly evaluated by the Contractor and Contracting Officer prior to the submission of the Individual Shot Plan. The Individual Shot Plan must contain but be not limited to the following:

a. Plan view, and at least two sectional views drawn to scale, of the shot pattern showing blasthole locations, inclinations and

designations;

b. Individual blasthole depths, diameters, blasthole spacings, burden, depth intervals of stemming and depth of subdrill;

c. Type of shot, i.e. test, production, pre-split, line drilling or buffer and shot number;

d. Orientation and elevation of the collar and bottom of all blast holes;

e. Total volume of blasted material in cubic meters cubic yards;

f. Description of type of blast and indication if blast is on final slopes or inverts;

g. Amount, type, diameter and depth of explosives, stemming and delay in each hole, and amount, type, and location of boosters and centering devices and the lift elevation;

h. Plan view of blasthole shot pattern showing in-hole and surface delays and firing times of each blasthole or decked charge;

i. Anticipated time and date of blast;

j. Survey coordinates using State Plane coordinate system and, if appropriate, a local coordinate system;

k. Any significant geologic features, and techniques planned for mitigating their influence upon results must be included in plan and section with appropriate elevations;

l. Estimated/anticipated peak particle velocities and maximum peak airblast predictions at seismographs located at protected structures using site specific data and regression analysis and the accurate distances from the blast to seismographs;

m. Name of Contractor;

n. Name, signature, and license number of the Blaster in Charge;

o. The maximum charge weight per delay, pattern and sequence of delays, and firing times for the blast;

p. Type of detonators, initiation and down hole lines;

q. Powder factors both in charge weight per cubic yard of material shot and in charge weight per meter per foot of total drillhole depth;

r. An elevation sketch of a typically loaded hole depicting each hole pattern, top of overburden elevation, top of rock elevation, bottom of hole elevation and diameter of hole, sub-drilling, decking charges, locations of explosives and stemming, and the locations of primers and boosters; and

s. The location of the blast area on a scale plan map of the project indicating the location of the shot, and the distance and directional relationship between all seismic equipment and the nearest structure subject to damage using a scaled distance measured in a horizontal line from the blast site to the nearest building, or structure,

berthing facility.

t. A minimum of ten high resolution photos, taken with a camera with a resolution of at least eight megapixels, of the entire blast area, preferably from above, of surface and open face of the shot and surrounding rock to document conditions prior to the shot.

u. No blastholes must be drilled until the Individual Shot Plan for them is approved. Evaluate any problems or impediments of the prior shot and implement solutions for those issues with the next Individual Shot Plan. Provide the Individual Shot Plan to the Contracting Officer electronically. The Contracting Officer will review the plan and send comments to the Contractor within 24 hours of receiving the plan if the plan is submitted between Monday and not later than close of business Thursday.

v. Include a tabular listing by hole in the ascending time order of delays by the describing: row and number within the row of the shot hole, total delay time, the total charge weight of explosive materials for the entire hole, top of sound rock elevation, bottom hole elevation, stemming elevations, and detonator, primer and booster elevations in the hole; and for each seismic monitoring location the closest approach, the square-root scaled distance, the cube-root scaled distance, and the estimated PPV and airblast overpressure.

3.5.2 Drilling Logs

****

NOTE: It may be necessary on sites with complex geology and blasting is occurring near very critical structures or rock outside of neat lines needs special protection, or neat line tolerances are especially important to consider the blaster or Contractor to have geologist(s) on staff to log blast holes or assist in logging blast holes, and aide the blaster in understanding the geology and for more accurate drilling logs. For rock excavation's objective(s); the project truly requires the designed tolerances and quality/stability of the remaining rock, which cannot be overcome at the Contractor's cost of dental clean-up, rock bolting, shotcrete or mass concrete placement; and, an experienced, agency (or third-party) geologist will be onsite for Quality Assurance of the logging & blasting & retained rock stability or damage. Logging may need to be in accordance with ASTM D2487, ASTM D5434, ASTM D6032/D6032M in some instances.

****

The drillers are required to keep precise drilling logs on each blasthole to show the depth of the geological features. At minimum, each drilling log must include:

a. Blast number;

b. Blasthole designation and location station number, bench number and type of blast (production, presplit, buffer, etc.);

c. Blasthole depth and diameter;

d. Elevation of top and diameter of blasthole;

e. Subdrill depth as permitted in the article SUBDRILLING;

f. Depth(s) of geologic structural features, e.g., voids, gouge or mud seams, soft weathered or altered zones, rusty intervals, changes in rock chip color, and other features encountered in the blasthole pertinent to loading the hole;

g. Relative penetration rates;

h. Start and end times of drilling;

i. List any blasthole misalignment; and

j. Soft seams within the rock and sudden feed pressure changes on the rig;

k. If qualitative descriptors are used (e.g., soft, moderately hard, hard, very hard, decomposed, highly weathered, moderately weathered, slightly weathered, unweathered). Ensure consistency between drill operators in logging using these terms. Blasting Specialist and Blaster in Charge must ensure drillers are using consistent terminology between drillers. [Log soil and rock in accordance with ASTM D2487, ASTM D5434. ASTM D6032/D6032M.] Submit an example of the Drilling Logs with the Master Blasting Plan. Copies, both hard and electronic PDFs, of these drilling logs must be provided to the Contracting Officer at least 24 hours prior to loading any blastholes. The drilling logs must be used to determine the proper design and loading of blastholes and for locating the depths for use of stemming decks across intersected geological features to protect against blowout, flyrock and any unusual or hazardous blasting effects.

****

NOTE: The paragraph below may be necessary where preventing subdrilling and foundation damage is critical.

****

[Survey the elevation at the collar of each production hole in the final blast to foundation grade to ensure that the production blastholes are not subdrilled below final foundation grade, except as permitted in article SUBDRILLING. The survey must be included in the Individual Shot Plan.

]3.5.3 Individual Shot Reports

As a minimum, the Individual Shot Report must be the same form used in the Individual Shot Plan but provide all "as-built" information required for the blast plan. Furthermore, the Individual Shot Report must better describe any part of the blasting operation that wasn't adequately described by the Individual Shot Plan including information on misfires, observed field conditions, and information how the Blaster in Charge compensated for compromising field conditions, such as increased stemming amounts, or stemming decks where voids, cracks, spalls or mud seams were identified and resolved. The Blasting Specialist is responsible for recording all explosives loaded in the blasthole and for accurate documentation of daily blasting activities. Submit the Individual Shot Report no later than 24 hours after the blast. No additional blast will

be drilled or loaded in the immediate area of the completed blast until the previous day's Individual Shot Report is submitted to the Contracting Officer. The Contractor must plan on multiple work areas so that production can be maintained on schedule. The report must include at minimum the following information:

a. Blast number (i.e., R-L3-PS1);

b. Date and specific time the blast was initiated;

c. Blasthole designations, locations;

d. Amount, type and depth of explosives, decking, stemming, and delay in each hole;

e. Plan and section views, drawn to scale, of drill pattern including free face, burden, blasthole spacing, blasthole diameters, blasthole angles and azimuths, blasthole number, lift height, and subdrill depth. Show in-hole and surface delays, as well as actual firing times of each blasthole or decked charge. Use different symbols to distinguish the production, buffer, presplit and line-drilled blastholes. Include a north arrow and scale on each plan view. Label the direction of the sections on the sections. Include section parallel to, and perpendicular to the blasthole rows. Show final grade and slope lines as appropriate in the sections. Show the location of the two video recorders on the plan in relation to the blast.

f. Drilling logs for presplit, line, buffer and production blastholes. Each drill hole must be logged by the driller to provide additional information to the Blaster in Charge during loading operations. Drilling Logs must contain information pertinent to the rock characteristics and blast operations. At the minimum, drill logs must contain geological information on pertinent geologic structure, soft or weathered zones, voids, penetration rate changes, and driller's notes.

g. Loading diagram showing type, diameter, amount and depth interval of explosive, primers, initiators and location, depth and type of stemming for each blasthole. Show the charge weight of each type of explosive and the total explosive load per delay and per hole.

h. Diagrams showing the delay system in the initiation sequence in each blasthole and the location and delay time of all surface delays of each blast. Indicate which blastholes are firing with a delay of less than 8 milliseconds.

i. Trade names and sizes of all explosives, primers, and initiators to be employed.

j. Daily explosives material consumption record.

k. A description of all personal injuries and property damage caused by the blast; when the measured maximum peak particle velocity or airblast exceeded by 10 percent the anticipated values from the Blasting Plan; and, all problems with the Warning System and problematic results of the blast, such as overbreak or large fragmentation, or with the shot pattern, such as misfires.

l. The vibration and airblast report described in paragraph Vibration and Airblast Monitoring. Include a comparison of predicted and actual measured values.

m. Signature of the Blasting Specialist specifying that the Blasting Specialist has reviewed the Individual Shot Report for accuracy and completeness.

n. Signature of the Blaster in Charge.

o. Note if mats are used or required by the Contracting Officer then list the type of blasting mats or other protective covering used.

p. A brief weather description at or near the time of the detonation such as cloudy, clear, partly cloudy, and foggy, with approximate wind direction and velocity, and temperature.

q. Updated or "as-built" Plan drawings depicting the borehole pattern and the delay pattern employed as well as pounds of explosives utilized, hazard incidents, and blast holes not loaded.

r. Copies of drilling records and originals of the blast monitoring data.

s. A plan view map of each bench showing the location of each completed blast.

t. Include photos, after the shot, taken from the same locations and at the same resolution as the blasting plan photos.

u. Include an updated as-built tabular listing by hole in the ascending time order of delays by the describing: row and number within the row of the shot hole, total delay time, the total charge weight of explosive materials for the entire hole, top of sound rock elevation, bottom hole elevation, stemming elevations, and detonator, primer and booster elevations in the hole, by hole in the ascending total delay time order of delays by describing: row and number within the row of the shot; and for each seismic monitoring location the closest approach, the square-root scaled distance, the cube-root scaled distance, and the estimated PPV and airblast overpressure.

Include two log-peak particle velocity versus square root scaled distance as per RI8507 diagrams for each seismograph. One diagram including all shots. The second including only data from the last 10 shots.

Include seismic records with peak displacement, velocity and accelerations at their respective frequencies. Site curve modification may be required to ensure that vibration levels at the control room remain acceptable.

If a recorded seismic value appears anomalous, the Contracting Officer may request that the vibrations monitoring specialist interpret all of the collected seismic records from the seismographs for that blast and provide an explanation of the anomalous readings. Anomalous readings include, but are not limited to, unusually high or low particle velocities, failure of a seismograph to trigger, or atypical wave forms on the paper record. No additional blasting will be allowed until the issue is resolved to the Contracting Officer's satisfaction.

Signatures of the Blasting Specialist and Blaster in Charge will be considered as proof that the shot was laid out, drilled, loaded, and wired

as designed. Proof of the Blasting Specialist and Blaster-in Charge's qualification must include remaining below the allowable peak particle velocities at all structures. Inability to remain below the allowable vibration levels may be cause for dismissal of either or both parties.

The Blasting Specialist must oversee all loading operations and collect and keep accurate records of the information required for each Individual Shot Report. Submit an example of an Individual Shot Report to the Contracting Officer for approval as least 30 days before commencement of any blasting. Failure to submit satisfactory Individual Shot Reports must result in suspension of any additional drilling and blasting until the Contractor complies with this requirement. The Blasting Specialist will make sure that the drilling logs are used by the blaster when blastholes are loaded to prevent overloading in soft or weak rock in the borehole.

The Individual Shot Reports are for quality control and record keeping. Review of, and comments on, the blast reports by the Contracting Officer will not relieve the Contractor of his responsibility for the accuracy and adequacy of the blast design.

Supplement the Individual Shot Reports with the original digital copy of the printed results of vibration and airblast monitoring showing peak readings and frequencies for each blast to the Contracting Officer. This submittal must also include the distance from the blast to the seismograph in meters feet as well as the maximum kilograms pounds of explosive per delay. The seismograph locations must be clearly marked and located on a map in the blast report.

Supplement the Individual Shot Report with the original, handwritten, field notes showing any field changes on the approved blasting plan.

The Blasting Consultant must develop a checklist of tasks that must be completed and checked off by the Blasting Specialist for each blast. Complete the tasks in an orderly fashion before a blast is fired. Submit the draft checklist for approval. Submit the completed and signed daily checklist with the Individual Shot Report.

3.5.4 Individual Shot Videos

****

NOTE: Video size can be a point of discussion, larger files come out of the new high quality 1080 HD and 4K videos. It may be necessary to require a frames/second or use of HD/4K videos. It is likely technology will change faster than this guide specification. This paragraph can be updated by project. The use of sFTP allows for the larger files.

****

Record each blast with high resolution digital video cameras from two designated locations, approximately perpendicular to one another, that provide side, front and rear views of the blast and area above it. The video images must not contain any other text than the shot number. Include metadata consisting of the blast ID, date, and time of the blast. Index the two video recordings to properly identify each blast. Submit the proposed locations of the two video recorders on a map with the Individual Shot Plan for approval. Furnish electronic file copies of video recordings on the sFTP within 24 hours of a blast. If the

Contracting Officer requests that a copy of the video be submitted earlier, then deliver a copy within one hour of the request. Maintain a digital video library of all blasts. All drilling and blasting activities must cease after the 24 hours from the previous blast if the video recordings of the previous blast are not furnished to the Contracting Officer.

3.5.5 Post-Blast Surveys

****

NOTE: Pre- and Post-Blast Inspections and the Structural Inspection/Evaluation Specialist would only be required if there are structures or facilities requiring such inspections. Eliminate the paragraphs referencing Pre- and Post-Blast Inspections and the Structural Inspection/Evaluation Specialist if the project does not have a requirement for these inspections.

****

Post-blast surveys must be conducted at any location, where a reasonable notice of damage from blasting has been provided. Post-blast surveys will be conducted by, or under the supervision of, the Structural Inspection/ Evaluation Specialist, who will also sign and date each survey. The survey extent and method used must be acceptable to both the Contractor's insurance company and the Contracting Officer. The post-blast surveys must be conducted within a week of the notice of damage from blasting. The Contractor is responsible for any damages or injuries resulting from blasting. Submit a copy of all post-blast surveys within two business days of the on-premises surveys to both the structure's owner and the Contracting Officer.

3.6 BLAST EFFECTS MONITORING

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NOTE: Depending on the project, this section will vary and need to be tailored for the monitoring locations and thresholds specifically. The designer should engage any subject matter expert for various disciplines - Structural for concrete, Mechanical/Electrical for related equipment (powerhouses, locks, etc.).

****

3.6.1 Vibration and Airblast Monitoring

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NOTE: Vibration monitoring is required for every blasting project. Consult with the Structural, Mechanical, and Electrical Engineers on the project in developing the vibration and airblast thresholds. The paragraph's narrative is a generic description for most projects, where the nearest structure/facility is: Standard Construction Timber Frame, Brick, and Concrete Buildings; Lock Monoliths; Powerhouse Switchyard; Highway and Railroad Bridges; Buried Utilities; and, Wells and Aquifers. The Figure below in the notes is Figure 8-19 of EM 1110-2-3800. Some projects may require

assessment by a trained experienced blasting specialist or structural engineer of lower allowable vibration criteria at critical or historic or special structures or facilities or structures with continuous occupants. Vibrations can cause the occupants of structures to become physically uncomfortable at levels well below the allowable vibration levels to avoid damage to the structure itself. Projects a with a Powerhouse and Electrical Power Relay Equipment or Pipelines, besides those with continuous occupants, should be evaluated for lower allowable vibration criteria. Some projects could utilize the assessment by a trained experienced blasting specialist or structural engineer to include higher allowable vibration criteria for those projects where typical structures/facilities are more than twice the distance of the closest approach of blasting to: Steel and Reinforced-Concrete Structures; Mass Concrete Monoliths; and, Cured Shotcrete. The specification writer must include a limitation of the allowable vibration.
****

Vibration monitoring must conform to current industry standards and use equipment developed for that purpose. Peak particle velocity must be used as the unit of measure. Begin seismic vibration monitoring at least four weeks prior to the commencement of any blasting to determine vibration background levels on adjacent roads, and the [_____]. Permanently mount the seismograph to record seismic events for a 24-hour period daily. Submit the background vibration monitoring reports and the baseline vibrations levels determined from the data for approval at least two weeks prior to the commencement of blasting. When blasting commences, analyze all events shown on the seismograph including normal background or blast induced vibrations. Monitor all blasts for vibration. Control ground vibration levels always using properly designed delay sequences and allowable charge weights per delay. Base allowable charge weights per delay on vibration levels recorded during the test and production blasting that produced no adverse impacts. Monitor each blast with an approved seismograph located between the blast area and the closest structure(s) of interest. The seismograph used must be capable of recording particle velocities for three mutually perpendicular direction components of vibration in the range generally found with controlled, cautious blasting. The peak particle velocity of each component must not be allowed to exceed current local, State and Federal vibration limits, whichever is more stringent, and never exceed the safe limits of the nearest structure subject to vibration damage.

Report peak particle velocity, peak acceleration and peak displacement in the Individual Shot Monitoring Report. The Individual Shot Monitoring Report must include the summary report from each seismograph which will include the peak particle velocity and frequency of the peak, peak particle displacement, peak acceleration, distance from the blast, map location of each seismograph and the blast, and charge weight per delay. A single delay includes the weight of all charges fired within 8 milliseconds of each other. Compile all vibration data in an up to date database of distance, charge weight per delay and measured peak particle velocity. The Seismic Specialist must conduct a linear regression of the particle velocities to determine the equation of the 95 percent confidence

level propagation. Use the equation to predict the expected vibration in the next blast. Show the time history of the particle velocity in the vibration report.

The seismograph must also record airblast. This data must also be added to the Individual Shot Monitoring Report. The report must include the airblasts measured at each seismograph. Compile all airblast data in and up to date database with the Individual Shot Monitoring Report data. The Seismic Specialist must conduct a linear regression of the airblasts to determine the equation of the 95 percent confidence level airblast propagation. The equation must be used to predict the expected airblast in the next blast. Provide the linear regression data to the Contracting Officer in digital form to become part of the Individual Shot Monitoring Report.

****

NOTE: The following are the limitation of the allowable vibrations:

TABLE 1 below gives standards for allowable peak particle velocities as they relate to a variety of common construction materials. Do not exceed these vibration limits.

These vibration limits must not be incorporated in the blast design. Many projects have been constructed utilizing a fraction of these allowable values. Properly design the blasts, set allowable vibration limits, and maintain proper control throughout the duration of construction. The Contractor is responsible for all damages caused directly by, or as a result of the blasting operations. Compliance with this or any other provisions in the Contract must not relieve the Contractor of responsibility for any damages or injuries caused by, related to or arising out of blasting or associated blasting activities.

Here are two examples of vibration tables. The first is more generic and should be used the section shows for a specific project also requiring an initial peak particle velocity for test blasting ramp up.

TABLE 1: VIBRATION LIMITS FOR STRUCTURES		
STRUCTURE TYPE	ALLOWABLE PPV (ips)	ALLOWABLE PPV (cps)
Standard Construction Timber Frame, Brick, and Concrete Buildings	2.0	5.0
Reinforced Concrete Structures (not Mass Concrete)	4.0	10.0
Steel Structures	4.0	10.0
Buried Utilities	2.0	5.0

TABLE 1: VIBRATION LIMITS FOR STRUCTURES		
Wells and Aquifers	2.0	5.0
Steel Pipelines	5.0	12.7
Mass Concrete Monoliths (Cured Concrete) Shotcrete	10.0	25.4

Or similar, adjust these for project:

Features	Initial Peak Particle Velocity (ips)	Initial Peak Particle Velocity (cps)	Production Particle Velocity, ips	Production Particle Velocity, cps
Lock Control Room	0.5	1.2	2.0	5.0
Powerhouse Lower Level	0.2	0.6	1.0	2.5
Powerhouse Control Room 69kV relay	0.4	1.0	1.0	2.5
Powerhouse Switchyard	2.0	5.0	2.0	5.0
Transmission Tower	3.0	7.6	3.0	7.6
Existing Lock Monoliths	2.0	5.0	2.0	5.0
Segmental and Cellular Cofferdam	2.0	5.0	4.0	10.0
Downstream Highway and Railroad Bridges	1.0	2.5	2.0	5.0

Note that older deteriorated structures or utilities and structures housing computers or other sensitive equipment may require lower peak particle velocity limits than those provided in Table 1. Also, buried pipelines owned by private utility companies or bridge structures owned by other agencies may be subject to lower limiting values imposed by the owner. The safe vibration limits and charge weights per delay to achieve these vibration limits must be established by the Seismic Specialist and the Blasting Consultant. Vibration limits for all non-government owned structures must conform to the laws of the State of [_____].

Blast vibrations measured 30.5 meters 100 feet or less from final walls must not exceed 12.7 cm/s 5 ips. If any damage occurs to benches or final slopes above the blast area, the blast vibration levels may be reduced at the option of the Contracting Officer. The vibration limits will be subject to approval by the Contracting Officer.

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3.6.2 Blasting Near Green Concrete, Grouting, and Shotcrete

Blasting operations are typically ongoing in one section of a project

while placing concrete or applying shotcrete in another.

****

NOTE: The following are the limitations on allowable vibration:

Some guidelines for peak particle velocities related to time intervals after placing mass concrete/shotcrete/grout curtains are given in Tables 2 and 3 should be considered when designing a blast. The specification writer must include a limitation of the allowable vibration when there is green concrete expected on the project. Table 2 has two option, one is more conservative, designer should make engineering decision which to use or adjust based on data.

TABLE 2: VIBRATION LEVELS FOR GREEN MASS CONCRETE/SHOTCRETE/GROUT		
TIME AFTER PLACEMENT	ALLOWABLE PPV (ips)	ALLOWABLE PPV (cps)
0 - 4 Hours	2.00	5.0
4 - 24 Hours	3.00	7.6
1 - 3 Days	5.00	12.7
4 - 7 Days	7.00	17.7
8 - 10 Days	9.00	22.8
Over 10 Days	10.00	25.4

TABLE 3: VIBRATION LEVELS FOR GREEN CONCRETE/SHOTCRETE		
TIME AFTER PLACEMENT	ALLOWABLE PPV (ips)	ALLOWABLE PPV (cps)
0 - 10 Hours	0.10	0.2
10 - 24 Hours	2.00	5.0
24 - 48 Hours	3.00	7.6
2 - 3 Days	4.00	10.0
4 - 7 Days	6.00	15.2
8 - 10 Days	8.00	20.3
Over 10 Days	10.00	25.4

****

3.6.3 Measuring and Recording Instruments

Submit seismographs for approval. Provide up to [_____] blasting seismographs capable of sampling rates of 15,000 samples per second or higher that meets ISEE PSBS. The 15,000 samples per second accuracy is

required to acquire reproducible vibration readings. The units must be self-contained except for external geophones and microphones. The seismograph must be capable of providing a printout of each blast or downloading the data to a portable device for off-site printing. The units must be programmed with specific data for each site of seismograph placement, which includes seismograph location, geophone burial or mounting method, calibration signal, date, time and closest distance to the blast area. The seismic record must also indicate the maximum charge weight of explosives per delay in the blast. The seismographs must not be placed inside of a structure, unless required for the designated purpose and authorized by the Contracting Officer. The seismographs and geophones must be placed on and secured to sound bedrock or virgin soil, or mass concrete foundations. The seismographs should not be placed near a structure, unless the intent is to measure that structure's specific response to the blast. Include the raw data values from the seismograph of vibration and airblast.

3.6.4 Seismograph Locations

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NOTE: This paragraph will vary depending on the project, the designer should determine what structures need to be monitored. It may be necessary to require one or two extra seismographs that are placed at the Contracting Officer's direction.

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Install seismographs at the following locations:

a. Closest point on the existing main dam and auxiliary dam.

b. Main dam powerhouse or as otherwise directed by the Contracting Officer.

c. Three other locations selected by the Contractor with the agreement of the Contracting Officer.

These locations are subject to change as the project progresses.

3.6.5 Individual Vibration Monitoring Report

Provide the original digital results of vibration monitoring in the form of peak readings and frequencies for each blast prior to conducting any subsequent blasts, provide the Contracting Officer with access to the online data available immediately after the shot. Submit the vibration monitoring reports with the individual shot reports. Data recorded for each shot must include the following:

a. Identification of instrument used and location.

b. Name of qualified observer and interpreter.

c. Distance and direction of recording station from blast area.

d. Maximum pounds of explosive per delay period.

e. Type of ground at recording station and material on which the instrument is sitting.

f. How the geophone is anchored, if peak acceleration is greater than 0.2 g to prevent decoupling of the sensor.

g. Maximum particle velocity in each component direction.

h. A dated and signed copy of seismic records with their supporting information.

i. Regression analysis of seismic data measured at each seismograph for each blast. The Seismic Specialist must conduct an independent regression analysis for each seismic location after each blast. The regression analysis is necessary to understand vibration transmission throughout the site and must be used to accurately predict the vibration levels generated on the next blast design.

j. Airblast results.

Take all necessary precautions to assure that the peak particle velocity readings available from the blast record are accurate to the maximum extent possible, as defined by the manufacturer of the equipment. The equipment must be calibrated annually.

3.6.6 Airblast Monitoring

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NOTE: The peak overpressure threshold should be 133 dB in accordance with the EM385-1-1, some state regulations set a lower dB threshold. The designer must research state, county or local requirements and decide if the most stringent must be selected.

****

Take every precaution to minimize airblasts from all blasts. Install an airblast monitoring system between the main blasting area and the nearest structure subject to blast damage or annoyance. The equipment used to make the airblast measurements must be specifically manufactured for that purpose. Peak overpressure must be held below [133] dB (linear peak scale), 100 Pa 0.015 psi at the nearest residential or inhabited structure or other designated location. Appropriate blasthole patterns, detonation systems, and stemming must be used to prevent venting of blasts and to minimize airblast and noise levels produced by the blasting operations. A dated record of the peak overpressure measurements signed by the Seismic Specialist must be furnished to the Blasting Specialist immediately after each blast unless a variance is given by the Contracting Officer. Provide the Contracting Officer with access to the online data available immediately after the shot. Include the airblast data in the Individual Vibration Monitoring Report.

3.6.7 Flyrock Control

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NOTE: Use of blasting mats may be required in specific areas depending on the project needs and risks.

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Before firing any blast in areas where flying rock may result in personal injury or any damage to property or the work area, the rock to be blasted

must be covered with approved blasting mats, or other equally serviceable material, to prevent flyrock. The Contractor must ensure that enough blasting mats are available at the project site to cover the blast area. If flyrock occurs all blasting must cease until the Blasting Consultant files a report explaining the cause of the flyrock and methods that must be employed on all subsequent blasts to prevent flyrock. Submit this report to the Contracting Officer for review before any additional blasts are detonated. No additional compensation will be given to the Contractor for work stoppage after a flyrock incident.

3.6.8 Rock Damage Control

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NOTE: Tailor this paragraph to the specific site issues that may affect blasting.

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The rock formations are known to contain geological features including variable weathering, alteration, fracturing and shearing, voids, weathered joints and gouge seams. Rock cores recovered during drilling investigations disclose the site's geological conditions and are available for review by the Contractor. The Contractor is encouraged to review the [Geotechnical Data Report, Geotechnical Baseline Report, other reports provided with bid documents], the drill core, drill core photographs, cut slopes, and all geotechnical and structural information available before planning and conducting blasting operations.

Use stemming decks across weak or open geological features to confine the energy into the hard rock and minimize explosive gas penetration into these features. No rock mass damage, uplift or shifting or significant overbreak will be tolerated. Control drilling accuracy and delay timing to provide proper relief toward the free face away from final rock slopes. Any blasting damage or breakage into the excavation walls will be mitigated at the Contractor's expense. Damage is defined as the loosening of rock behind final lines and grades, opening of joints in the final wall and rock block displacement in the final wall. If any damage occurs to the final wall that requires remediation, it must be the responsibility of the Contractor to prove that the blasting method employed did not cause the damage.

3.7 TEST BLASTING

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NOTE: The test blasting will may be highly specific for the project site. The designer may have a way to carry out the test blasting in order to have the Contractor demonstrate satisfactory results. Typically, the main reason for test blasting is to gain understanding of how the blasting on the site causes vibrations/air blast on monitored structures, develop a site attenuation curve to design future blasts with vibration in mind. The other is to demonstrate results, line drilling and presplitting that meets the specifications and no damage to final faces and foundation grade. Typically the test blasting occurs in an area where there is room for failure, if a test presplit causes significant back break it won't be to a finished face and can be removed. The designer must also keep in mind that a

poorly design shot can result in blast damage, such as induced cracks or even opening of rock joints, and can extend beyond the blast area more than 30 meters 100 feet. Typically an area that would be removed with full production blasting. Test blasting will be reviewed by the Contractor's consultant and the Government's consultant (if retained), blasting Subject Matter Expert (SME) within USACE.

The following is typical test blasting language.
****

Submit the Test-Blast Plan for review and approval. Allow 21 days for review after submittal. Allow 14 days for Government review after submitting the revised plan. Approval of the revised plan will not relieve the Contractor of their responsibility to produce safe and satisfactory results as set forth by these specifications.

Prior to commencing full-scale blasting operations in a different rock type, weathering grade or new bench elevation, demonstrate the adequacy and effectiveness of the proposed blasting plan by drilling, blasting, and excavating short test sections, not exceeding 15.3 meters 50 feet in length, to determine which combination of method, hole spacing, and explosive loads produces the proper split. If more than one presplit design is tested in one test blast, each presplit design section must be at least 6 meters 20 feet in length along the surface.

The first opening blast starting from a level plane that has only vertical relief (i.e. a sinking cut), must not be used as the production test blast. However, its results must be considered when designing the test blasts. The opening blast must be excavated to full depth if possible before drilling the blastholes for the test blast. The test blast must incorporate the planned methods of presplitting and must be near the center of the excavation and at least 4.5 meters 15 feet away from the final excavation walls [or invert]. The Contracting Officer has the option to adjust the location of the test blast areas to optimize for geology. Anticipate blasting up to 10 test sections with at least one test at each different geologic condition. The location of the test blast section must be approved in advance. The Contracting Officer may direct the Contractor to use test section lengths less than 15.2 meters 50 feet if field conditions warrant.

Unless otherwise directed, begin the presplit test blast with presplit holes spaced at 61 centimeters 24 inches center to center. Requirements for presplit and production blasting operations are covered elsewhere in this specification but apply to test blasts.

Do not drill ahead of the test shot area until the test section has been as fully excavated as possible and the results have been evaluated by the Contracting Officer. If the results of the test blast(s) are unsatisfactory, in the opinion of the Contracting Officer, the Contractor's Blasting Consultant must revise the blast design as necessary to achieve the specified results. Unsatisfactory test blast results include an excessive amount of fragmentation beyond the indicated lines and grade, extensive overbreak, flyrock, ground vibration, airblast or violation of other requirements or these specifications. All costs incurred by the Contractor in adopting revised blasting methods necessary to produce acceptable test blast results will be borne by the Contractor.

If at any time during the progress of the work, the methods of drilling and blasting do not produce the desired result of an undamaged rock slope within the specified tolerances, perform additional test sections by drilling, blasting and excavating short sections, not exceeding 15.2 meters 50 feet in length, until a technique is developed that produces the desired results. No additional compensation will be made for the additional test sections.

At the conclusion of the test blast program, produce a Post-Test Blast Evaluation Report which examines all reports, surveys, test data, and other pertinent information and conclusions reached. Submit a Test Blast Evaluation Report prepared by the Blasting Consultant and Blasting Specialist after testing blasting is completed.

3.8 BLASTHOLE DRILLING

Survey the elevation at the collar of each production hole in the final blast to foundation grade to ensure that the production blastholes are not subdrilled below final foundation grade, except as permitted in paragraph SUBDRILLING. The survey must be included in the Individual Shot Plan and must not be changed without prior approval from the Contracting Officer. Drill production blastholes according to the patterns in the approved Individual Shot Plan. Prior to commencement of drilling of any production blasthole, all holes must be located by survey and clearly marked and numbered. Drill the production blastholes within two blasthole diameters of the marked collar location. The blastholes must have no more than a plus or minus [_____] meter foot horizontal tolerance at the bottom. If holes are drilled outside of these tolerances, except for geologic reasons, fill these holes with crushed stone or neat grout and re-drill them at the approved location as directed by the Contracting Officer at no additional expense to the Government.

After drilling of blast holes, place approved, reusable plastic blasthole markers in each hole to identify all blasthole locations and keep material from falling into the holes. Check, measure and record the depth of all blastholes as soon as the drill is retracted from the blasthole. If any blasthole has become plugged or is unable to be fully loaded, re-drill or clean out those holes with air prior to commencement of loading operations. Check and measure the depth of all blastholes in a shot to ensure each blasthole is open to the original drilled depth prior to loading of any holes. If any blasthole is found not be open to the drilled depth, re-drill the shot holes to the proper depth at the Contractor's expense. If any holes are too deep, fill the holes to the proper depth with crushed stone. Blasthole loading and drilling may be ongoing concurrently in a shot area; nonetheless, drilling must be separated from loaded holes by a distance equivalent to at least the depth of the loaded hole but in no case less than 15.2 meters 50 feet.

The Contracting Officer may require inclined boreholes to reduce toe burdens and backbreak.

3.9 PRODUCTION BLASTING

The Contractor must provide a detailed narrative for the proposed sequence of production blasting for the project in the Master Blasting Plan, to be evaluated and approved by the Contracting Officer. The proposed sequence must be tailored primarily towards conducting a safe blasting operation and overall responsible, prudent, and professional blast design in efforts

to keep overbreak, flyrock, vibration and airblast levels to a minimum. If in the opinion of the Contracting Officer satisfactory results in the production blasts are not being produced, the Contracting Officer reserves the right to require changes in the blast design which could include variables such as burden, spacing, bench height, timing sequence and delays, subdrill depths, explosive loads, detonators, blast matting and the use of air decks or stemming in borehole bottoms. Such required revisions will be at no additional cost to the Government.

****

NOTE: The proposed language below can be used as guidance when both presplit and production blasting are used in the project. THE PRODUCTION BLASTING SECTION WILL BE HEAVILY TAILORED FOR THE PROJECT. THIS IS GENERAL TEXT THAT CAN BE ADJUSTED.

The drilling of presplit and production blastholes must be done one pattern at a time. Advanced drilling of adjacent presplit or production blastholes will not be permitted. The presplit wall conditions must be evaluated after each blast by both the Contractor and the Contracting Officer before the adjacent presplit blasting plan can be approved or drilled whenever possible.

The sequence of Production and Presplit blasting for any single blast must be as follows:

1. Submit an individual shot plan.
2. Individual shot plan approved or revisions requested before approval.
3. Conduct drilling and submit Drilling Logs to Contracting Officer and Blaster in Charge.
4. Submit Individual Shot Report with Daily Drill logs, video recordings, and vibration and airblast monitoring results.
5. Conduct rock removal, scaling and rock reinforcement Joint Evaluation of results by Contractor and Contracting Officer.
6. Submit an Individual Shot Plan for the subsequent blast in that work area.
7. Prepare a sufficient number of planned blasting areas in advance to maintain the project schedule.

The presplit wall conditions must be evaluated by the Contractor and the Contracting Officer after the Contractor exposes a minimum of 2.4 meters 8 feet (vertical) of the wall. If 2.4 meters 8 feet of exposure is not sufficient to determine the condition of the presplit wall, reinforce the exposed wall as necessary, then expose a minimum additional 2.4 meters 8 feet (vertical) of wall. Repeat this downward to the toe of the presplit wall or until the Contracting Officer can determine if the presplit wall condition is adequate before approving the Individual Shot Plan for the adjacent presplit blast. Evaluate the effects of each production blast on the presplit and line drilled walls before submitting a blasting plan for the next

blast.

The drilling tolerance must be evaluated and if drill tolerance exceeded the allowable tolerance then benches will be reduced in height to where the drilling tolerance was obtained on the subsequent blasts.

****

3.9.1 General Blasting Considerations and Limitations

In order to help control the effects of vibration, flyrock and airblast, maintain a burden distance that is not more than one-half the bench height and the burden must be between 25 to 35 times the diameter of the explosive charges in the blastholes. Deck loading must be placed across joints and seams that may direct energy and gases into the final walls. "Mud capping" for secondary blasting or blasting to reduce oversize rock fragments of blocks is prohibited.

****

NOTE: The language below is suggested example for projects requiring presplit as a controlled blasting method for a new spillway. Consult with USACE Blast Consultant or Blasting SME during design phase for suggested blasting considerations and limitations tailored to the project.

Production blasts must advance from the center of the spillway cut toward the left and right final cut slopes. The final shot for the left and right cut slopes must be a buffer shot. Blasting may be conducted on the upstream and downstream ends of the spillway at the same time.

Perform all production blasting, including that carried out in conjunction with the test blast section requirements, in accordance with the following general requirements.

Drill Production blastholes according to the patterns in the approved Individual Shot Plan. Bulk blasting agents will be permitted in specified locations. The use of cartridged explosives is required at locations described in paragraph 2.1.2 Blasting Products.

Set a buffer zone where the row of production blast holes in the row that is immediately adjacent to the presplit line are drilled on a plane approximately parallel to the plane of the presplit line. Drill the line of 3-inch diameter buffer holes no closer than one meter three feet to the design excavation line and with a hole spacing no closer than one meter three feet. The explosive loads in buffer holes must not exceed 50 percent of the full explosive load that is placed in a 3-inch production blastholes.

Detonation of the buffer holes must be on a delay

sequence towards a free face and fired in sequence after the adjacent production blastholes. Detonation of production holes must be on a delay sequence toward a free face. The delay between adjacent rows parallel to the final face must be sufficiently long to minimize blast damage to the final face. Other than for sinking cuts, all blasts within 15.2 meters 50 feet of the final walls must be designed such that the open face is parallel to the excavation walls to reduce excessive pressure on the presplit final walls.

The true burden of blasts along the final walls, must be designed to be perpendicular to the final walls.

Take all necessary precautions in the production blasting so as to prevent blast damage to the presplit or line drill face. If presplit results are not satisfactory and production or buffer blasts damage the presplit or line drill face (as evidenced by back-break or opening of joints beyond the presplit line, uplifted rock blocks at the presplit line or damage to the perimeter as determined by the Contracting Officer or Blasting Consultant), the Contractor may be directed to add another line of buffer holes on a parallel plane adjacent to the presplit holes for some or all of the successive buffer zone blasts.

Lift Height and Explosive Cartridge Diameter: Follow this specification for explosive diameter as a function of bench height. This may require the use of mixed drilling for maximum production efficiency. Tamping of explosive cartridges or cartridge compression will not be allowed.

Lifts up to 10 Feet Deep: Production blastholes that are designed for lifts or hole depths of 10 feet or less must be loaded with explosive cartridges no larger than 1.25-inches in diameter. The final lift above the design excavation line must be 10 feet high and use these small diameter charges at the Labyrinth Weir and within 200 feet of the Labyrinth Weir. Short blastholes along final cut slopes of 0.25H:1.0V or shallower must also use 1.25-inch diameter explosives. Tamping of explosive cartridges or cartridge compression will not be allowed.

Lifts from 10 to 15 Feet Deep: Load production blastholes designed for lifts of 10 to 15 feet deep with explosive cartridges no larger than 2-inches in diameter. Tamping of explosive cartridges or cartridge compression will not be allowed.

Lifts Greater Than 15 Feet Deep or within 50 Feet of Final Walls: Load production blastholes that are designed for lifts of 15 or more feet deep or within

50 feet of final walls with explosive cartridges no larger than 2.5-inches in diameter. Tamping of explosive cartridges or cartridge compression will not be allowed.

Lifts Between 20 and 35 Feet Deep and Greater than 50 Feet from Final Walls or Farther than 200 Feet from the Labyrinth Weir: Bulk explosives may be used in the area 200 feet beyond the Labyrinth Weir, and 50 feet beyond the final excavation walls. The blastholes may be up to 3.5 inches in diameter and bulk loaded with bulk blasting agents.

In the area less than 200 feet from the Labyrinth Weir, and/or less than 50 feet from the excavation walls, tamping of explosive cartridges or cartridge compression will not be allowed.

When blasthole alignment restrictions can be met and geological conditions permit, the lift depth may be increased to a maximum of 35 feet at the option of the Contracting Officer.

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3.10 PRESPLIT BLASTING

****

NOTE: Delete paragraph if presplit blasting is NOT to be used in the project.

****

Perform all presplit blasting, including presplit test blasts, in accordance with the following requirements:

Unless otherwise permitted by the Contracting Officer, completely remove all loose and decomposed rock along the top of the excavation floor for a distance of at least 9 meters 30 feet beyond the end of the production hole drilling limits or to the edge of the excavation cut slope to reduce the possibility of flyrock before drilling any presplit blastholes.

The presplit blastholes must be 7.6 centimeters 3 inches in diameter.

****

NOTE: Use the suggested paragraph when requiring precision presplitting methods.

Use the precision presplitting methods defined in paragraph Precision Presplitting, for all presplit blasting on this project. Presplit blasthole spacing must be 61 centimeters 24 inches on centers.

****

The Contracting Officer reserves the right to determine whether blasting results are satisfactory after evaluating the final rock slopes. Successful demonstration of presplit blasting including blasthole spacing and the ability to meet allowable tolerances must be completed using test blasts during the beginning of blasting operations and when there is a change in rock materials character and bench elevations as outlined in the blasting test section of the specifications.

Use proper equipment and techniques to control drilling operations and ensure that no hole deviates from the plane of the planned final face by more than 6 inches normal to the slope or 15.2 centimeters 6 inches from its planned position along the slope. Presplit blastholes deviating more than these limits will not be paid for unless, if in the Contracting Officer's opinion, satisfactory rock slopes are being obtained.

Drill presplit blastholes along a line that is within 7.6 centimeters 3 inches of the design excavation line. If the presplit holes are outside of the tolerance given in Subpart c, fill the holes with crushed stone or neat grout and re-drill at the correct location. Use electro-mechanical or electronic devices installed on all equipment for drilling the presplit holes to accurately measure the angle at which the drill steel enters the rock. Presplit blasthole drilling will not be permitted if these devices are not being used. The drill rig used must have the ability to change feed, impact, and rotation pressures on demand to adjust for the varying rock conditions and maintain presplit hole alignment. If problems maintaining the blast hole tolerances persist, use an approved device, to determine blasthole orientation before the holes are loaded.

****

NOTE: Use this subpart if specific areas need more alignment control.

****

Measure the blasthole orientation of all presplit blastholes drilled at the [location(s) where this method is needed] using an approved device to check borehole alignment.

The row of presplit holes must extend 9 meters 30 feet beyond the limits of the production blast.

Measure and record the blasthole depth on the drilling log after drilling is completed. Place protection over each blasthole before moving the drill to the next blasthole location. The Blaster in Charge must also measure the blasthole depth to determine that it is free of obstructions for its entire depth before loading the blasthole. The Blasting Specialist must record the depths on the Individual Shot Report. Exercise all necessary precautions so that placing the charges does not cause caving of material from the walls of the holes. Blasthole conditions may vary from dry to partially to filled with groundwater. The depth of water in each blasthole must be recorded in the Individual Shot Report. The maximum diameter of explosives used in presplit holes must not be greater than one-half the diameter of the presplit hole. Perform presplitting before the production blast.

Line drilling along final walls may be required at corners where presplit lines meet.

Blastholes exceeding the allowable tolerances for location and alignment must be refilled with crushed stone or lean grout (at the option of the Contracting Officer) and re-drilled at the proper location and alignment.

Use only standard cartridge explosives manufactured specifically for presplitting or detonating cord in presplit holes. Do not use continuous columns of presplit explosives in the presplit holes. Use lighter loads composed of fractional cartridges affixed to detonating cord with inert spacers between charges or detonating cord in the blastholes. Firmly

affix the cartridges to the detonating cord in such a manner that the cartridges will not slip down the detonating cord nor bridge across the hole.

****
NOTE: Add this sentence if using precision presplitting.
****

Use "Precision Presplitting" methods as defined in paragraph DEFINITIONS.

Spacing between the fractional cartridges along the detonating cord must not exceed 91.4 centimeters 36 inches center to center and must be adjusted to give the desired results. Fractional sticks of presplit explosive must be assembled and affixed to the detonating cord in accordance with the explosive manufacturer's instructions, a copy of which must be furnished to the Contracting Officer. The "air deck" method of presplitting is not allowed. The bottom charge of a presplit hole may be larger than the line charges but must not be greater than one pound or so large as to cause overbreak or damage to the toe of the slope. Place the column charge of the presplit hole far enough below the collar, and reduce the upper charge(s) sufficiently to avoid overbreak and heaving of rock at the collar of the hole.

Place stemming in the upper portion of all presplit blastholes, extending from the uppermost charge to the hole collar. Stemming material must not extend more than 76.2 centimeters 30 inches below the collar of the hole. If test blasts produce unsatisfactory results adjustments must be made. Stemming material for presplit blastholes must consist of dry sand or drill cuttings supported by a stemming plug. Cover the presplit blasts as well as an adjoining production blast with blasting mats, if required to prevent flyrock.

If required to reduce ground vibrations or noise, presplit holes may be delayed, providing the hole-to-hole delay is no more than 25 milliseconds.

The presplit face must not deviate more than 15.2 centimeters 6 inches either side of a plane passing through adjacent drill holes, except where the character of the rock is such that, as determined by the Contracting Officer, irregularities are unavoidable. The geologic conditions affecting rock character include joints, shears, voids, gouge seams and variable weathering/alteration zones of various thicknesses and orientations. Design the blasts in such a manner to keep explosives gases from entering these planes and zones of weakness. Use of the Daily Drill Logs during explosive loading to identify the depth of weak zones and install stemming decks across them. The stemming decks must be filled with dry, angular, well graded crushed stone with the gradation specified in paragraph STEMMING.

****
NOTE: Typically cushion or trim blasting are not used on Civil Works projects. Exceptions must be decided early in the project design phase.
****

3.11 CUSHION OR TRIM BLASTING

Do not use cushion or trim blasting on this project.

****

NOTE: Note: Use the following paragraph templates if needing for precision Presplitting of specific areas of the excavation or project:

Precision Presplitting of Foundation Excavations at Service Spillway: For presplitting of excavations for concrete wall foundations at the Service Spillway, the Contractor must use a spacing between blastholes not to exceed 18 inches. The explosive load cannot exceed 0.04 pounds per square foot of face created for the column load. The bottom charge in these precision presplit blastholes cannot exceed 0.5 pounds.

Precision Presplitting at Main Dam Right Wall: Explosives must not be permitted for precision presplitting to form final cut slope surfaces at the Main Dam Right Wall. The Contractor must use non-explosive demolition agent to fracture bedrock. Presplit hole spacing must range from eight to 18 inches, center to center. Hole diameter, final hole spacing and grout mixing, and proportions must be in accordance with manufacturer's recommendations for bedrock conditions encountered. The Contractor must take care to assure proper temperature and other environmental considerations meet the manufacturer's recommendations prior to use. Nonexplosive demolition agent must be use in such a manner to shear the web of rock between holes without any damage to the presplit final wall.

****

3.12 LINE DRILLING

Perform all line drilling in accordance with the following requirements:

****

NOTE: Line drilling spacing is typically twice to four times the diameter of the drill hole size, it could be varied depending on the project.

****

a. The line drill holes must be 7.2 centimeters 3 inches in diameter and drilled with a spacing of 15.2 centimeters 6 inches on center.

b. Use proper equipment and techniques to control drilling operations and ensure that no line drill hole must deviate from the plane of the planned slope by more than 7.2 centimeters 3 inches normal to the slope or 7.2 centimeters 3 inches from its planned position along the slope plane. Line drill holes deviating more than these limits will not be paid for unless, in the Contracting Officer's opinion, satisfactory rock slopes are being obtained.

c. Drill line drill holes within [_____] centimeters [_____] inches of the marked collar location. If the line drill holes are outside of the 7.2-centimeters 3-inch tolerance, fill them with crushed stone or lean grout and re-drill at the correct location.

d. Locate line drill hole collars along a line that is within 7.2 centimeters 3 inches of the design excavation line. Line drilling will not be permitted if electro-mechanical or electronic devices are not being used to accurately determine the angle at which the drill steel enters the rock. The drill rig should have the ability to change feed, impact and rotation pressures on demand to meet the varying rock conditions and to maintain hole alignment. If problems maintaining the drill hole tolerance persist, use an approved device to determine blasthole orientation before the holes are loaded.

****
NOTE: Include the following paragraph if need to extend line drilling beyond lengths of cut:
****

Lined drill holes in those areas where located must extend a minimum of 9 meters 30 feet beyond the limits of the production holes to be detonated, or to the end of the cut, as applicable.

3.12.1 Line Drilling Locations

Line drilling must be performed at the following locations:

****
NOTE: Depending on the project geology and structure, it may be appropriate to lengthen the distances line drilling is to be conducted at corners, the bracketed lengths here should be considered a minimum. The orientation of the jointing/fractures/foliation may dictate this length.
****

a. [3][_____] meters [10][_____] feet on either side of outside corners with an angle equal to or less than 120 degrees.

b. [1.5][_____] meters [5][_____] feet on either side of inside corners with an angle equal to or less than 90 degrees.

****
NOTE: Use the following if project is in karst or areas of large cavities.
****

If cavities are encountered during presplit drilling, that section of presplit line must be lined drilled in order to prevent presplit gases from entering the cavity.

3.13 STEMMING

****
NOTE: Depending on the geology of the project site this paragraph should be tailored to the project, for example in places with karst a more detailed procedure should be specified or contractor required to submit a procedure for dealing with larger voids.
****

Variations in rock hardness, structure, and other geological conditions encountered at depth will require the Contractor to stem the blast holes

through soft weak areas, shears, open joints, and voids; therefore, close attention will be taken to classify the rock while drilling the blast holes. Where necessary, holes will be stemmed with dry, angular, well-graded crushed stone from .3-cm to 1-cm 1/8-inch to 3/8-inches in diameter without fines. The Blasting Consultant may submit a written, signed request to use drill cuttings for applications such as in presplit blastholes, must be submitted to the Contracting Officer for approval. Wet holes must not be stemmed with drill cuttings. No separate payment is made for stemming.

3.14 SUBDRILLING

****

NOTE: Depending on the project features it may be necessary to further specify where subdrilling is allow and to what depth. Describe depth range of subdrilling in the Master Blasting Plan. There may be places where subdrilling is prohibited or limited as in the case where structures are to be constructed on the blasted surface and anchored - as subdrilling can complicate and significantly alter planned anchorage.

****

Subdrilling of blastholes below the design excavation line of the foundation is restricted to limited areas of the excavation. Use precise survey control to attain accurate drill blasthole depths and locations in accordance with the approved Master Blasting Plan. The methods of controlling blasthole depths and locations are subject to approval. Describe in the Master Blasting Plan the depth range of subdrilling planned in areas where it is allowed.

If test blasts on higher benches in the same geologic material as that above foundation grade demonstrate that subdrilling with no explosive placed in the hole below grade (air or water cushion in subdrill) causes no cracking below the grade, a request to use the subdrilling procedure may be submitted for approval.

Backfill any blastholes that are not in compliance with these requirements with crushed stone to the appropriate depth at the Contractor's expense.

3.15 FRAGMENT SIZE DISTRIBUTION AND TOLERANCES

****

NOTE: This section should be written with direct coordination from the project designer of record, who will provide input on maximum rock size/gradation based on project (embankment fill zones, etc.). Large stones (riprap, armor stone, derrick stone) may be required in the project and the blast must be adequately designed to produce this large stone. Some projects will not need this paragraph. CAUTION: requiring stone gradation may imply that the stone may be conducive to that gradation - which may not be the case.

****

Produce rock fragmentation from blasts such that [_____] percent of the fragments are [_____] centimeters [_____] inches or less in diameter for

placement into the rock crusher and into the rock fill zones of the embankments. Reduce oversize material from blasting to meet the size range specified above. Predictive methods involving photo comparison and image analyses such as Wipfrag or Motion Metrics are encouraged to analyze size distribution of fragmented rock. Any secondary blasts of oversize fragments must be covered with blasting mats, and use a charge diameter no greater than 3 centimeters 1.25 inches.

****

NOTE: Include tolerance for each proposed structure from the excavation lines. For example, "The tolerance for the perimeter walls is minus 30.5 cm/ft 12 inches/foot from the design excavation line. The tolerance for the invert in the area of the Labyrinth Weir foundation and within 61 meters 200 feet downstream from the Weir is minus 31 centimeters 12 inches from the design excavation line. Elsewhere, the tolerance for the invert is plus or minus 31 centimeters 12 inches from the design excavation line."

****

3.16 REQUIRED MUCKING

Muck and scale following each shot after firing for inspection of the slopes, bottom of the shot lift, or foundation. Drilling and loading for the next shot must not be allowed before the required mucking of the previous shot. This requirement may be waived temporarily when in the opinion of the Contracting Officer, the Contractor's blasting is satisfactory (i.e. no backbreak, overbreak, vibration cracking, exceedance of vibration or airblast thresholds etc.). Notwithstanding this requirement, the face must fully be dug out after every shot to a distance not less than 6 meters 20 feet prior to drilling and loading the next shot to allow inspection and evaluation of the shot face and allow for adjustments to the blast design for adjacent shots. Required mucking after each shot must be reinstated, when in the opinion of the Contracting Officer blasting is unsatisfactory. Any excavation support deemed necessary by the Contractor or Contracting Officer for the safety of personnel in the excavation will be installed as the excavation proceeds. Blasting of the next lower lift will not be permitted until the slope has been accepted by the Contracting Officer.

3.17 SCALING

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NOTE: Typically a level of scaling is required for each project, an excavation spec may have more detail on this, or require bolting or other methods of stabilization before carrying down an excavation with more blasting.

****

Scale any loose and unstable or unsafe appearing material remaining on the rock slopes after blasting and as the excavation is carried down. Perform scaling immediately after each lift of the rock mass is removed by production blasting. The scaling must be accomplished by methods approved by the Contracting Officer. Drilling of the next lift will not be allowed until a rock slope has been properly scaled and rock reinforcement installed as determined by the Contracting Officer. No separate payment

is made for scaling.

-- End of Section --