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Preparing Activity: USACE New

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated July 2023**
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SECTION 31 23 00.00

TUNNEL EXCAVATION - BLASTING
**11/21**

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**NOTE: This guide specification covers the requirements for tunnel excavation for underground construction by blasting. Tunnel Excavation guide specifications for excavation using mechanical methods such as Tunnel Boring Machine (TBM) or roadheader presently do not exist but may be developed in the future. This specification is currently for use in tunnel excavation in bedrock conditions equivalent to at least two tunnel diameters below top of rock (i.e., ledge) only. For mixed-face or soft ground tunneling conditions (i.e., soil-like conditions), consider alternate mechanical excavation methods to account for anticipated ground conditions for appropriate equipment selection and methods of ground support and groundwater control. For localized ground conditions including fault zones or other specialized ground conditions, revise specification to account for potentially adverse rock characterization conditions identified in the Geotechnical Baseline Report or other geotechnical design documents. This section was originally developed for USACE Civil Works projects.**

**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 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

**********

**NOTE: For USACE: Consult with Subject Matter Experts (SME) from the Geotechnical Engineering, Structural Engineering, Engineering Geology, and Materials Community of Practice or District Office that has most recently completed a similar type of underground construction project, while editing this section, to be appraised of recent, specific requirements, guidance, excavation methods or understandings for the subject project.**

**Consult with or have Specification reviewed by a Subject Matter Experts in Underground Construction for projects involving Tunnel Excavation as a primary component of a project, or where Underground Construction 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 underground construction specifications. 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 or adjacent to the project; evaluations of acceptable construction vibrations, noise and/or pressures affecting individuals or reaching nearby structures; natural resource impact reviews, negotiations and/or requirements; constraints on the excavation means and methods; pre-construction 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 Tunnel Excavation guide specification covers the construction of underground facilities by means of blasting in rock and includes mucking. The details on excavation are typically covered by a**

**separate Rock Excavation specification.**

**The following minimum requirements for project 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. Spatial location and record of all soil and rock borings and test pits, instrumentation, and/or geophysical surveys including soil and rock classifications and the pertinent engineering properties. For example this data may include, but is not limited to, weathered rock, material strength, bit drops, circulation loss, voids, ground water observations, SPT, Recovery, RQD, RMR, lab testing results, permeability, stratigraphy, geologic features and structure, and topsoil thickness encountered in boring (NOTE: This is a list of examples of data pertinent to the tunnel design that may be provided in the project drawings or GBR/GDR but does not include all possible engineering properties or conditions of soil and rock that characterize a specific site.);**

**4. Reference to project Geotechnical Data Report (GDR), Geotechnical Interpretation Report (GIR) and/or Geotechnical Baseline Report (GBR) for additional site characterization information not contained on the project drawings.**

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

**6. Excavation or demolition limits, and clearing, stripping and grubbing limits, and tolerances of excavation;**

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

**8. 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);**

**9. Hydrological, hydraulic and impoundment data, where applicable; and,**

**10. Details of all rights-of-way within the project boundaries.**

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**********

**NOTE: Typical Measurement and Payment language is to be inserted into the Measurement and Payment specification section. This is typical language used that will need to be tailored for the project needs.**

**********

## 1.1 METHOD OF MEASUREMENT

Tunnel support for the various support categories must be measured and paid by the individual components comprising each support category (e.g., Rock Bolts, Steel Arch Ribs, Shotcrete), under their respective specification or special provision section.

Tunnel Excavation must be measured by the[ meter][ cubic meter][ linear foot][ cubic yard] excavated in accordance with the 'B' line payment limit shown on the Drawings. Tunnel drainage must be measured and paid under Section 01 20 00 PRICE AND PAYMENT PROCEDURES.

## 1.2 BASIS OF PAYMENT

The accepted quantities measured as specified above must be paid for at the contract unit price for the pay items listed below.

Pay Item Pay Unit

Tunnel Excavation[ Meter][ Cubic Meter][ Linear Foot][ Cubic Yard]

Payment for Tunnel Excavation must constitute full compensation for all excavation, scaling, scaling reports, support, blasting, blasting reports, removal, hauling and disposal of excavated materials, construction ventilation and illumination, control of water and groundwater inflow including groundwater testing, supply of potable water, and all other work necessary for completion of the tunnel in accordance with the Contract Documents.

**********

**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 regarding 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 underground construction work; special studies or monitoring while blasting operations 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 appropriate restrictions and mitigation measures for hazards associated with tunnel excavation and underground construction are incorporated into the Plans and Specifications. Failure to comply with the requirements of applicable Federal or state laws and regulations could result in project delays or stoppages, as well as the potential for increased project costs.**

**********

## 1.3 SCOPE

This work must consist of excavation and disposal of all material within the rock tunnel limits indicated on the plans, in accordance with these specifications and in conformity to the lines, grades, stations and tolerances shown on the plans or as established in the field by the Contracting Officer. Some general guidelines to maintain the inherent strength of the ground surrounding the tunnel opening have been included. In addition, the work also includes geotechnical instrumentation for monitoring rock displacement and water management in the tunnel; including but not limited to, furnishing, installing, and monitoring of optical survey targets in the tunnel, collection and interpretation of data and furnishing all other necessary material, equipment and labor incidental to such work, [furnishing of optical survey targets], including installation and monitoring of instruments in accordance with the specifications. The Contractor must monitor all geotechnical instrumentation and interpret the data obtained from them. The data must be made available to the Contracting Officer [upon request][within 24 hours of reading].

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 units, this entire section is applicable and covers activities associated with drilling and blasting for rock excavation at the surface for portal and shaft construction, or underground tunneling operations. 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. Contractor's blasting plan must address site-specific conditions affecting the control, quantity, and magnitude of explosives fired in all blasting operations to

prevent injuries to persons and avoid damage to all structures, properties, governmental and nonprofit entities, commerce and businesses, and natural resources and their habitat.

## 1.4 RELATED WORK SPECIFIED ELSEWHERE

**********

**NOTE: These specifications for related work specified elsewhere are not all inclusive. Add and remove specifications as needed for the project.**

**List specifications that are related, such as Earthwork, Excavation, Soil and Rock Anchors, Temporary Environmental Controls, Shotcrete, Natural Resources, are typical specs related depending on the project.**

**The specifications without numbers listed below presently do not have a corresponding UFGS Guide Specification. The designer will need to write a project-specific specification to address those features of work**

**********

Section 01 35 26 GOVERNMENT SAFETY REQUIREMENTS
Section 01 33 00 SUBMITTAL PROCEDURES
Section 02 32 13 SUBSURFACE DRILLING AND SAMPLING
Section 03 30 00 CAST-IN-PLACE CONCRETE
Section 31 00 00 EARTHWORK
Section 31 23 06.00 BLASTING - SURFACE
Section 31 68 13 SOIL AND ROCK ANCHORS
Section 31 73 19 TUNNEL AND SHAFT GROUTING
Section XX XX XX GEOTECHNICAL DATA REPORT
Section XX XX XX SURVEYING AND LAYOUT
Section XX XX XX GEOTECHNICAL AND STRUCTURAL INSTRUMENTATION
Section XX XX XX TUNNEL AND SHAFT DEWATERING
Section XX XX XX GROUNDWATER TREATMENT SYSTEM
Section XX XX XX TEMPORARY LIGHT AND POWER
Section XX XX XX TEMPORARY ELECTRICAL SYSTEMS
Section XX XX XX TUNNEL EXCAVATION SUPPORT

## 1.5 REFERENCES

**********

**NOTE: Add and remove references as needed for the project. Reference the appropriate state and local laws, regulations and ordinances concerning blasting 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 |

U.S. ARMY CORPS OF ENGINEERS (USACE)

| | |
|---|---|
| EM 385-1-1 | (2014) Safety -- Safety and Health Requirements Manual |
| EM 1110-1-1804 | (2001) Engineering and Design -- Geotechnical Investigations |
| EM 1110-2-1009 | (2018) Engineering and Design -- Structural Deformation Surveying |
| EM 1110-2-2901 | (1997) Engineering and Design -- Tunnels and Shafts in Rock |

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 |

## 1.6 RELATED ATTACHMENTS AND SPECIFICATIONS

**********

**NOTE: Geotechnical Data Report (GDR) and Geotechnical Baseline Report (GBR) Importance. Project-specific site data should be presented in Geotechnical Data Report (GDR); design interpretations of the expected subsurface conditions and expected behavior should be presented in the Geotechnical Baseline Report (GBR). GDR/GBR**

**data must be consistent with information presented in the project specifications and drawings without conflict. Agencies may require different types of documents; there may be a Geotechnical Interpretive Report (GIR).**

**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.**

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

"Geotechnical Data Report" (GDR) dated [_____], prepared by [_____].

"Geotechnical Baseline Report" (GBR) dated [_____], prepared by [_____].

"Geotechnical Interpretive Report" (GIR) dated [_____], prepared by [_____].

## 1.7 DEFINITIONS

**********
**NOTE: Delete definitions that will not be used in the specification text for a specific project. A complete list of frequently used tunneling terms can be found in Appendix B of the EM 1110-2-2901, blasting definitions can be found in the GLOSSARY of the EM 1110-2-3800, and other references. Recommend only including definitions not already referenced in the EM and definitions to further 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.**
**********

### 1.7.1 Controlled Blasting

**********
**NOTE: This section may be applicable for the shaft/portal blasting construction.**
**********

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) and limit vibration effects. 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.

### 1.7.2 Airblast

Airblast are the overpressure waveforms that move though air as audible

and sub-audible sound waves. These are also called compression waves. Airblast is one of the three, primary adverse impacts from blasting.

1.7.3 Vibrations

**********

**NOTE: There are other impacts that may be related to blasting that should be considered, such as ground settlement, disruption to structures or activities, hazardous environments.**

**********

Vibrations are the second of the three, primary adverse impacts from blasting. The third primary adverse impact from blasting is flyrock. 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).

1.7.4 Initial Support

Installed at and adjacent to the excavation face following a heading advance to minimize ground movement and loosening and to maintain stability of the opening prior to construction of the permanent lining. Initial support for the rock tunnel generally refers to all elements of rock support required to provide a safe, stable rock excavation at all times during construction. Elements of rock support include, but are not limited to, such items as steel ribs, timber blocking, spiling, rock dowels and anchors, steel straps, welded wire fabric or shotcrete.

1.7.5 Additional Initial Support

May include rock bolts and dowels, crib and lagging, steel straps, spot-holds, steel sets, steel liner plates, shotcrete and pre-reinforcement spiling in addition to the initial support types and quantities for the support categories as shown on the Contract Drawings. Additional ground support measures should be installed in a systematic or non-systematic manner, for local stabilization and safety during tunneling operations

1.7.6 Final Lining

**********

**NOTE: Tailor this paragraph to the type of final lining for the project, this may be a cast-in-place or precast reinforced concrete liner, steel liner that is backfilled with contact grout, or left unlined, maybe with shotcrete or reinforced (steel fiber) shotcrete or other.**

**********

[Cast-in-place reinforced concrete, steel] lining that is installed after the tunnel has been excavated and supported with initial support. Backfill concrete and contact grout are also included in the final lining.

1.7.7 Design (Excavation) Line

**********

**NOTE: This nomenclature should be defined during the development of the plans and specifications as it will be specific for each project.**

**********

A line within which no unexcavated material must remain. Only shotcrete, structural steel rib supports with limited blocking, rock dowels, including bearing plates and metal hardware, and tie rods may extend beyond the design line as shown on the Drawings. The minimum concrete cover over these elements is shown on the Drawings. Embedments shown on the Drawings within the design line must be placed as shown. The Contractor may select the size of the excavated opening provided that finished minimum excavation tolerances are maintained and the design line requirements and diameter constraints given in this section are satisfied.

1.7.7.1 A-line (Theoretical Excavation Line)

The A-line, shown in the contract drawings is the line within which unexcavated material must not be permitted to remain.

1.7.7.2 B-line (Pay Line)

The B-line shown in the contract drawings is the outside limit to which measurement for payment for excavation must be made. Measurement for payment must be made to this line regardless of whether the limits of the actual excavation are inside or outside of the B-line. Excavations beyond the B-line performed by the Contractor for purpose or reason except as shown on the Drawings or as may be ordered in writing by the Contracting Officer, must be at the expense of the Contractor.

1.7.8 Heading

A general term used to refer to the advancing (excavation) tunnel face.

1.7.9 Face

The position of the underground works that has been advanced the furthest for the respective section of the overall construction sequence adopted for the large span tunnels. Also referred to as "Working Face" or "Heading."

1.7.10 Forward Area

Is that area within which the initial ground support is to be installed behind the heading (depends on rock mass conditions, stand up time, and heading advance rate).

1.7.11 Initial Ground Support

**********

**NOTE: Other common terminology may include wood lagging and liner plate (gasketed and un-gasketed), splines, strapping, mesh, steel sets, steel-fiber reinforced shotcrete, expandable bolts.**

**********

**********

**NOTE: In addition, the initial support systems indicated on the Drawings for additional openings in the tunnel, must form part of the Permanent Support.**

**********

The support system installed after an excavation advance within the tunnel forward area to minimize ground deformation and loosening and to maintain stability and safety of the opening. Initial support measures include, but may not be limited to, rock bolts and dowels for rock reinforcement, shotcrete lining, steel ribs, and pre-reinforcement for the duration of construction and prior to installation of the permanent support.

1.7.12 Length of Advance Interval

Length of the unsupported span of ground exposed during one excavation advance increment (depends on rock mass conditions, stand up time, and heading advance rate).

1.7.13 Line Drilling

Line drilling may be applicable in and around tie-in structures where precise ground control is needed. Within tunnel blasting operations, perimeter holes, back holes or heading rounds may be line drilled for overbreak control along the rib, springline and through the crown. Typically line drilling is applied during shaft or portal construction.

1.7.14 Excessive Overbreak

The amount of ground unintentionally removed beyond the pay line, or B-Line. The Contractor should attempt to minimize overbreak.

1.7.15 Over-Excavation

Excavation of ground beyond the theoretical excavation line, or A-Line.

1.7.16 Probe Hole

An exploratory hole drilled in advance of an excavation to explore ground conditions or water infiltration conditions. Supplemental probe holes are those installed in addition to the probe holes shown on the Drawings or required herein and at the direction or approval of the Contracting Officer.

1.7.17 Scaling

Consists of barring, wedging, and picking to remove loose, shattered, or unstable pieces of rock around the heading advance. Individual pieces not in accordance with the specified tolerance must also be removed during scaling.

1.7.18 Shotcrete

Mortar or concrete conveyed through a hose and pneumatically projected at high velocity onto a surface.

1.7.19 Staged Excavation

**********

**NOTE: Advancing multiple headings is often performed in poor ground or for larger final tunnel dimensions, where a top (left and/or right) heading is advanced, supported then the other heading or bench removed, potentially also removing the center support system separating the headings.**

**********

Sequence of excavation by which the final excavation is divided into a group of smaller drifts, also referred to as slashes and cuts, or top heading and bench.

1.7.20 Support Type

Method of excavation and initial support defined in the Drawings for use at a particular location.

1.7.21 Tights or Underbreak

Projections of rock in a tunnel inside the minimum excavation profile (A-line) that need to be removed prior to placement of lining.

1.7.22 Water Sheet or Panning and Drain Hose

PVC-sheet, PVC-pan and PVC-hose used to collect and drain off ground water from areas at either the excavated surface behind the shotcrete lining or to collect and drain seepage through the shotcrete lining.

1.7.23 Smooth Wall Blasting

**********

**NOTE: Smooth wall blasting can be used around openings and sensitive structures.**

**********

Refers to a technique involving perimeter holes drilled along the excavation limits which are lightly loaded to remove the final burden and are fired on the last delay of the detonation sequence. The objective is to obtain smooth walls with minimum overbreak and minimal damage to the rock outside the excavation limits.

1.7.24 Hangfire

Occurs where the explosive in the borehole begins burning and may eventually detonate when the fire reaches the area of the base charge of the failed detonator. This detonation may take place a few seconds after the blasting machine was fired or a few minutes later.

1.8 RESTRICTIONS

Tunnels must be excavated and supported using a continuous or incremental excavation- observation-support approach to provide the necessary and justifiable levels of ground control and permanent stabilization. The use of a staged excavation approach with integral, concurrent initial support and permanent stabilization of the tunnel periphery is fundamental to the successful execution of the project and recognizes that tunnel spans of

different dimensions must be developed in variable and fractured rock mass conditions.

Do not begin underground tunnel blasting excavation operations until the following conditions have been met:

1. Do not begin tunnel excavation until all required submittals in paragraph SUBMITTALS have been submitted and the Contracting Officer has reviewed and approved the submittals.

2. Pre-construction inspections near the tunnel excavation have been completed by the Contracting Officer and pre-construction documents have been provided to Contractor.

3. Installation of geotechnical and structural instrumentation for monitoring surface structures near the tunnel excavation have been completed and initialized by the Contractor.

4. All issues related to health and safety have been met and all submittals have been made in accordance with OSHA requirements, EM 385-1-1, and other applicable codes and regulations of Federal, State, and local agencies having jurisdiction.

5. Required personnel with qualifications specified in paragraphs BLASTING PERSONNEL and TUNNELING PERSONNEL are available on site to perform work.

6. Temporary construction power substation has been installed and tested in accordance with the Division 16 specifications

7. Blasting will not be carried out without the prior approval of the Contracting Officer.

8. The Contractor must take all necessary precautions to prevent premature detonation of explosive charges.

9. The Contractor must be responsible for safe transportation, storage, security/guarding and use of explosives, blasting agents, primers, initiators, and ancillary equipment and materials in accordance with 29 CFR 1910.109, 29 CFR 1926-SUBPART U, and all applicable federal, state, and local Regulations. All cost associated with the transportation, storage, security/guarding and use of explosives must be considered incidental to the cost of tunnel excavation and included in their respective unit costs.

10. Vibration monitoring equipment must be installed, calibrated and operating before blasting begins.

11. Public notification and meeting held.

## 1.9 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

**********

**NOTE: The following Submittal requirements are for tunnel excavation using excavation methods and should be included in all project specifications.**

**Several other considerations include Tunnel and Confined space rescue team training and setting up an independent emergency communication lines within the tunnel. If the local fire department is not trained in confined space tunnel or mine rescue, they may have to be trained in confined space tunnel/mine rescue procedures prior to excavation of tunnel or a private specialty company can be hired for rescue services as required by federal, state, and local work ordinances.**

**Haul routes for muck disposal can also be an issue in densely populated areas. Haul routes may need to be coordinated with local and state officials as required by local ordinances.**

**********

Tunneling Superintendent and Supervisors; G[, [_____]]

Drill and Blast Supervisors; G[, [_____]]

Geotechnical Engineer or Engineering Geologist; G[, [_____]]

Survey Control Plan; G[, [_____]]

Dust Suppression System; G[, [_____]]

Muck Handling Plan; G[, [_____]]

Ventilation System; G[, [_____]]

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

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

Blaster-In-Charge's Qualifications; G[, [_____]]

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

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

Blasting Safety Plan; G, SO

Master Blasting Plan; G, SO

Test-Blast Plan; G, AO

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

Public Notice of Blasting Operations; G[, [_____]]

Tunnel Excavation Plan; G[, [_____]]

**********

**NOTE: The section below should be used when rock blasting excavation techniques are required.**

**********

SD-03 Product Data

Explosives; G[, [_____]]

Lightning Detection Device; G[, [_____]]

Seismographs; G[, [_____]]

SD-05 Design Data

Individual Shot Plan; G[, [_____]]

SD-06 Test Reports

Individual Shot Reports; G[, [_____]]

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

Drilling Logs

Daily Explosive Material Consumption

Daily As-built Survey; G[, [_____]]

SD-07 Certificates

Blasting Consultant; G[, [_____]]

Blasting Specialist; G[, [_____]]

Blaster-In-Charge; G[, [_____]]

Magazine Keeper; G[, [_____]]

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

Seismic Specialist; G[, [_____]]

## 1.10 COORDINATION

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

Underground construction employing blasting methods 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.

## 1.11 LIABILITY

**********
**NOTE: This section can be included in the front end documents (General Conditions) instead of here, consult with Contracting Officer.**
**********

Compliance with provisions in the contract will not relieve the Contractor of their responsibility for 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 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 the use of various tunnel excavation methods such as blasting, but not always necessary. Confirm and follow applicable federal, state, and local regulations and guidance on the transport, storage and use of all Explosive materials and components. 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 applicable federal, state, and local laws, regulations, ordinances, or authorities that impact the transportation and storage of Explosives if authorized on the project.**

**********

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 Federal State, and local regulations. The Contracting Officer reserves the right to establish further restrictions or time windows when blasting will not be allowed beyond the Federal State, and local requirements. 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, for some projects it is not appropriate to allow bulk explosives, such as in karst conditions 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 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. Cartridge [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 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 within 60 meters 200 feet of it or within 15 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, 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 are / will not be permitted on site. The Contracting Officer may require products 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 from the manufacturer's data sheet, that lot number will be rejected. The Contractor is responsible for required testing and no additional compensation will be made for 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 duties that 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.

## 2.2 SAFETY EQUIPMENT

**********

**NOTE: This section requires tailoring for the specific project design and geology.**

**********

a. Provide safety equipment and monitoring instruments according to requirements of Safety and Health Plan in accordance with Section 01 35 26 GOVERNMENT SAFETY REQUIREMENTS, to be included in the Materials Handling Plan as required in Section 01 33 00 SUBMITTAL PROCEDURES.

b. Provide personal protective equipment for protection against respirable dust, and all other protective measures that may be deemed necessary for dust control as per Federal Requirements. Submit the details of the Dust Suppression System.

c. All rock reinforcement, including spiling and other ground support in accordance with the requirements set forth in Section 31 68 13 SOIL AND ROCK ANCHORS and 03 37 13 SHOTCRETE.

d. Lattice girders and shotcrete lining must be in accordance with the requirements of Section XX XX XX GROUND SUPPORT SYSTEMS, and Section 03 37 13 SHOTCRETE.

e. Steel sets must be in accordance with the requirements of Section XX XX XX GROUND SUPPORT SYSTEMS, and Section XX XX XX REINFORCING STEEL.

f. Shotcrete materials must be in accordance with the requirements of Section 03 37 13 SHOTCRETE.

g. Water sheet and drain hoses as part of temporary construction measures to drain off local water inflows:

1. PVC sheet, or approved equal by the Contracting Officer, for application at exposed ground surface or shotcrete surface.

2. Flexible PVC hose with end couplings as required

## 2.3 PROBEHOLE DRILLING EQUIPMENT

A continuous probe must be maintained at [_____] meters [_____] feet, or least [_____] tunnel diameters ahead of the tunnel face. If the probing results indicate the presence of poor ground requiring the installation of pre-reinforcement, the Contractor must make adjustments as necessary to achieve the required excavation profile prior to excavating through the anticipated poor ground. During the probing operation the Contractor must monitor and measure the amount of in-flowing water.

Probe hole drilling equipment must be capable of drilling a minimum [_____]-inch diameter holes through sound and decomposed rock and concrete. Provide all necessary core hole drilling personnel, equipment, and accessories.

**********

**NOTE: Designer of record to provide input on the flow pressures for packer tests. Consideration must be taken by reviewing other data such as other data (piezometers, pressure cells, rock mass features).**

**********

The drill must be suitable for drilling in wet ground conditions, highly sheared or fractured zones, and through fault gouge. The drilling equipment must be capable offsetting packers in the hole against a pressure of [_____] kg/cm$^2$ [_____] psi.

# PART 3 EXECUTION

**********

**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 and underground excavation developments or understandings for the subject project.**

**********

**********

**NOTE: This specification is for use for tunnel excavation. For mixed face tunneling conditions, revise specification to account for anticipated ground conditions. This specification requires a Geotechnical Baseline Report (GBR) that defines the ground properties, conditions, and behavior related to tunnel excavation, support, and constructability along the tunnel alignment, portals, or along**

**separate tunnel segments that is expected. The Geotechnical Data Report (GDR) contains all the testing, and rock mass characterization data used to characterize the conditions and behavior of the ground along the tunnel alignment to establish the base line conditions for the project. The GBR defines what constitutes a differing site conditions for claim resolution per the frameworks of the contract.**

**********

## 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. Adhere to the general requirements as outlined below:

a. Care must be exercised to minimize overbreak, to prevent immediate or subsequent rock falls from within the tunnel or from portal areas and other rock slopes outside the tunnel, and to preserve the integrity of the rock outside the limits of tunnel excavation.

b. Clean working conditions must be always maintained inside the tunnel. All muck, slush, grout spills, and any other material not required for tunneling must be removed from the tunnel in a timely manner.

c. Detailed construction sequencing must be the responsibility of Contractor, consistent with the requirements of these Specifications, and those shown on the Contract Drawings.

d. Perform work in a manner that minimizes safety hazards and exposure of personnel and equipment to hazardous and potentially hazardous conditions in accordance with specified safety requirements and Contractor's Safety and Health Plan.

e. Minimize ground movement at the tunnel face and in the surrounding excavation, and prevent ground loss, subsidence, and movement in surface features, overlying structures, and utilities above and around the vicinity of the tunnel excavation.

f. Provide additional face and excavation stabilization by means of discretionary ground support wherever ground conditions dictate.

g. In case of stoppages, maintain qualified personnel on-duty to monitor conditions that may threaten stability of the heading.

h. If monitoring of ground vibrations and air blast indicate that vibration levels, or noise levels are exceeding response levels as defined under paragraph BLAST EFFECTS MONITORING, and Section XX XX XX TUNNEL INSTRUMENTATION; adjust procedures for excavation and initial support installation in accordance with the accepted Contingency Plan to reduce the levels to within acceptable limits.

i. Maintain sufficient quantities of shotcrete materials at the tunnel face, ready for immediate application, during the entire excavation period. Excavation will not be permitted without this requirement being met or as approved by the Contracting Officer.

**********

**NOTE: The need to maintain sufficient quantities of tunnel support materials/equipment will vary per project. Define this quantity during design phase and incorporate in GBR. The Government will map the tunnel according to ASTM D4879.**

**********

j. As the excavation progresses, the Contracting Officer will perform inspection, photogrammetry, LiDAR scanning, and geologic mapping or other documentation of the exposed tunnel sections. This mapping will be accomplished after excavation and either before or in conjunction with support installation. The Contractor must provide cleaning of the heading and completed crown and sidewalls and a safe means of access to these areas to allow this mapping. Mapping of the crown and sidewalls will be conducted for documentation of the actual geologic conditions encountered and assessment of rock mass characteristics of the heading. The Contractor should assume that this inspection and mapping will be performed once each shift for a period of minimum [20 minutes] in each heading. Lighting and access will be provided for close inspection of the face. Where necessary the excavated surfaces may need to be cleaned by air or water jets to provide surfaces suitable for mapping, as directed by the Contracting Officer; provided, however, such cleaning will be minimal in areas where softer materials can be gouged out to depths greater than three inches. The Contractor must cease operations to the extent necessary to permit such mapping as directed by the Contracting Officer. Such work will be coordinated by the Contracting Officer in a manner to avoid undue disruption to Contractor's operations.

k. Establish and maintain surveyed tunnel station markers throughout both lined and unlined excavated tunnel. Placed station markers indicating the tunnel stationing at 50 feet intervals by spray painting the rock or shotcrete surface in a color to contrast with background. Intermediate station markers should be made at 10-foot intervals with visible paint marks located at or near tunnel spring-line

l. Sequence and Direction of Construction:

1. Sequence and direction of tunneling to be as shown on the drawings and as reviewed by the Contracting Officer.

m. Temporary niches or adits, temporary or future pump sump pits and other temporary openings:

1. Excavate these temporary openings conforming to excavation and support criteria of this Specification and as reviewed by the Contracting Officer.

2. Seal all temporary openings with [4,000-psi] 28-day strength concrete in accordance with the requirements of Section 03 30 00 CAST-IN-PLACE CONCRETE when no longer needed, before installation of the final lining and Contract completion and as reviewed by the Contracting Officer.

n. Survey:

1. Contractor is responsible for the development and implementation of a surveying program capable of satisfying all survey and accuracy requirements. This program is subject to the review of the Contracting Officer prior to the commencement of the work. The review does not release the Contractor of liabilities associated with or dependent on this part of the work.

2. Design and implement a functional underground network and determine all required measurements and the required accuracy of each measurement including horizontal angles, zenith angles, azimuth angles, distances, and height differences. Include analysis of required redundancy and measure of internal reliability associated with each planned observation.

3. Design and implement a functional surface control network, stations, positions, measurements, and accuracies. Measurements may include Global Positioning System (GPS) vectors, horizontal angles, zenith angles, azimuth angles, distances, and height differences. Include analysis of required redundancy and measure of internal reliability associated with each planned observation.

4. Obtain survey information prior to completing the last [100] feet of the tunnel excavation. Adjustments to line and grade to the tunnel over the last [100] feet may be necessary to meet project requirements. The purpose of conducting the survey is to obtain the true centerline alignment in 3-dimensions to locate the connections as shown on the Drawings. Vertical and horizontal alignment should be taken along both invert/sidewall construction joints. The center point on the invert is assumed as the dividing line between both invert/sidewall joints.

5. Obtain start point alignment for the survey from the surface at [_____] data for alignment consisting of at least 2 benchmarks with known elevation and geographic coordinates enabling tie-in to [NGVD29, NAVD88] elevation and the [_____] State Plane Coordinate System, respectively.

6. Perform in-tunnel survey to an accuracy of ½-inch in the horizontal and vertical dimensions. Record sufficient survey points to enable the complete horizontal and vertical profile of tunnel alignment to be detailed. Some tunnel alignment curves may not necessarily be circular arcs; they may be based on complex parabola or other geometric shape forms.

7. Assume that station of [_____] are as indicated in historical documents. All new survey stationing must reference these stations.

8. A survey was completed on [_____]. This information is available and must be reviewed by the Contractor, prior to conducting the tunnel survey.

9. Shaft centerline is the basis of all tunnel stationing up and down station of the shaft centerline.

10. Calibration and data processing:

    a. Calibrate all survey instrumentation as required and as recommended by instrument manufacturer.

    b. Data reduction must incorporate calibrations and meteorological correction, and reduction of measurements to the ellipsoid and thence to the [_____] State Plane Coordinate System. Correct distance measurements by electro-optical distance measurement instrument (EODMI) for scale, cyclic error, zero error, and meteorological effects. Correct azimuth angles using the Laplace correction and include the deflection of the vertical components on angles and azimuth measurements.

    c. Data regression processing must include least squares adjustments, as required. Employ data outlier detection. Determine horizontal and vertical confidence intervals.

## 3.2 TEMPORARY SYSTEMS

**********

**NOTE: Review applicable consideration in EM 385-1-1, Ch. 26 and/or consult with a Safety professional with tunneling background. Ensure groundwater conditions and overall regime through rock mass is well understood by tunnel reach and rock type.**

**********

a. Provide, operate, and maintain a complete groundwater control/ treatment system to collect water from within the tunnel and shaft and suitably treat it before discharge in accordance with the requirements of Section XX XX XX CONTROL OF WATER.

b. Water entering the tunnel from all sources must be controlled, managed, and disposed of in a manner to prevent damage to the tunnel and surrounding property and in accordance with all Federal, State, and local regulations.

c. Design, furnish, install, operate, and maintain a temporary lighting system in all underground and other working areas in strict compliance with all applicable Federal, State, and local regulations.

d. The system must provide a minimum light level in accordance with OSHA requirements and EM 385-1-1. In case of failure of the lighting system, provide an emergency lighting system in all work areas in strict compliance with all applicable Federal, State, and local

regulations, and industry standards.

e. Design, furnish, install, operate, and maintain temporary ventilation during all phases of construction complying with all applicable Federal, State, local regulations, and industry standards. Operate and maintain the entire temporary ventilation system. Details of the Contractor's ventilation system must be presented to the Contracting Officer for agreement at least 60 days prior to its installation.

f. Two battery-operated handlamps of 20-Watts minimum power must be provided and maintained at each working face and portal for emergencies and inspection of the work.

g. Electric heaters or radiators having exposed coils or elements must not be allowed in the tunnels.

h. All main electrical cables installed within the tunnels must comply with all applicable Federal, State, and Local Requirements.

**********

**NOTE: Designer will need to ensure safety requirements in specification at a minimum follow OSHA/EM385/MSHA.**

**********

i. Provide additional floodlighting and ventilation locally as required at active ground support installation, shotcrete, and other locations, and provide portable floodlighting and ventilation equipment, as needed, for localized construction operations. Equipment for short-term use may be battery-operated

j. For Contract requirements regarding temporary construction power, refer to Section XX XX XX TEMPORARY LIGHT AND POWER and Section XX XX XX TEMPORARY ELECTRICAL SYSTEM.

k. In all parts of the Underground Works, the atmosphere inhaled by those present must contain not less than 19.5 percent and maximum of 22.0 percent of oxygen and must not contain a concentration of contaminates such as gases, vapors and dusts greater than is safe for the health of the construction personnel having regard to the effects of exposure time, temperature, humidity and the combined effects of several contaminants. The concentration of inflammable contaminants must not exceed 10 percent of the lower explosive limit (minimum explosive concentration).

l. Wet drilling should be used. Where possible, drilling should be carried out using hollow bits with continuous water feed to reduce dust. Always wear suitable protective equipment.

**********

**NOTE: The potential for contaminants or hazardous conditions must be defined by the project owner (in the GBR) and assumed by the Contractor. If the conditions differ, owner is responsible for conditions more adverse than the baseline for this condition.**

**********

m. The Contractor must be responsible for obtaining all information

necessary to determine what concentrations of contaminants are harmless, without prejudice to the adoption of such lower figures as may be stated by competent authorities or directed by the Contracting Officer. The atmosphere inhaled by the workmen and other authorized persons in all parts of the tunnel must not contain more than 5 ppm of nitrous fumes (measured as NO2) for longer than 10 minutes after each blast, 30 ppm of nitrous fumes as an absolute maximum, 50 ppm of carbon monoxide as an absolute maximum, 5,000 ppm of carbon dioxide as an absolute maximum, or for other contaminants. The Safety Professional must field calibrate air quality monitoring instrumentation in accordance with manufacturer's recommendations.

n. In all parts of the Underground Works, throughout the period in which explosives or other materials producing contaminants are used, and at such time as may be necessary to maintain the standard of purity of air required in this subsection, clean fresh air must be supplied by forced ventilation, using an exhaust system at the face or other method as agreed by the Contracting Officer, at a rate not less than the greater of the following:

   1. [_____] cubic meters[_____] cubic feet per hour per person present in a tunnel;

   2. [_____] meters[_____] feet per hour per kilowatt of combustion-engine generated power operating simultaneously in the heading.

o. The Contractor must take special measures to minimize the effect of particular sources of fumes. These measures must include the use of efficient and properly maintained exhaust smoke washers (scrubbers) for all internal combustion engines in the tunnel. Gasoline engines must not be permitted in the tunnel.

p. The means of dealing with blasting fumes must include, but not be limited to water sprays on muck piles after blasting and ventilation of the Underground Works immediately after blasting for as long as necessary to restore the purity of the atmosphere.

q. Notwithstanding requirements of this subsection the method of ventilation and treatment of fumes, including blasting fumes, must be subject to whatever tests may be necessary in the opinion of the Contracting Officer. The Contractor must provide, maintain, and use as directed by the Contracting Officer, an instrument approved by the Contracting Officer to measure the velocity of air, and an approved gas detector. Maintenance of the gas detectors must include the supply of all detector tubes.

## 3.3 SAFETY PROCEDURES FOR DRILL AND BLAST UNDERGROUND EXCAVATION

**********

**NOTE: Use below for general blasting safety procedures for drill and blast tunnel construction. Consider other Tunnel H&S issues which are related to tunnel operations, equipment, slip-trip-fall, cave-ins.**

**********

### 3.3.1 General Blasting

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.

a. All blasting work must be carried out using controlled perimeter drilling and smooth wall blasting techniques to control the geometry of, and to minimize damage to, the final excavation profile and to minimize overbreak.

b. Only non-electric detonation systems must be used for tunnel blasting, unless another detonation system is approved by the Contracting Officer. Cap and fuse or safety fuse is prohibited. The Contractor will be allowed to use one electric blasting cap per round to initiate the shot. The electric blasting cap must not be tied into the blasting circuit until [traffic has been stopped and] the area has been secured.

c. The Contractor must carry out controlled blasting to achieve a blast surface that exhibits a regular fracture plane between perimeter holes with minimal overbreak. The excavation surface must be scaled to remove all loose and hollow sounding rock to leave a solid, intact surface. Special care must be required with such procedures in highly fractured rock.

d. If the methods of drilling and blasting do not produce a consistent, uniform profile with minimal overbreak within the tolerances specified, the Contractor must undertake further test blasts until a method is established that results in an excavation profile to the specified tolerances.

e. The blasting technique must be such as to ensure reproducibility of the blasting pattern, accurate positioning of drillholes and precision in drilling. It may include the use of a template, or other techniques as may be proposed by the Contractor, all of which must have the prior approval of the Contracting Officer, for setting out the blasting pattern.

f. During the progress of the excavation, this technique must be varied as necessary to suit rock conditions exposed and to obtain the best practicable excavation surface after blasting, to the satisfaction of the Contracting Officer.

g. All blasting rounds must incorporate smooth wall blasting techniques.

h. Blasting must not be carried out within [_____] hours of the application of shotcrete within [_____] meters [_____] feet of the face.

i. The shot firing and detonator delays pattern must be such that the peak particle velocity (PPV) must not exceed the requirements of paragraph BLAST EFFECTS MONITORING.

**********

**NOTE: The section below should be used when rock blasting excavation techniques are required.**

**********

### 3.3.2 Public Notice of Blasting Operations

At least thirty calendar days, and prior to 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.

### 3.3.3 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 commencing tunneling operations, provide for the approved Project Manager, Tunneling Superintendent, Seismic Specialist, Blasting Specialist and Blasting Consultant (as applicable) to attend a public information meeting to be conducted on an evening to be determined by the Contracting Officer. This meeting will inform the public about the anticipated tunneling and underground construction operations, including the need to use blasting (as applicable). The Project Manager and Tunneling Superintendent must make a short presentation on tunneling and underground construction and answer questions pertaining to concerns that may impact the public. The Blasting Specialist, Blasting Consultant and Seismic Specialist must make a short presentation of blasting operations and answer questions pertaining to public concerns dealing with the tunneling and blasting operations, the magnitude of ground 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.

### 3.3.4 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.

### 3.3.5 Time Restrictions

**********

**NOTE: Research the specific State and local 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 [_____] AM and [_____] 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 [or Commonwealth 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.

### 3.3.6 Lightning Detection Equipment and Safety

**********

**NOTE: This section is needed when conducting blasting at the surface for shaft or portal blasting.**

**********

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.**

**********

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.

3.3.7 Check for Misfires

**********

**NOTE: Federal, or local entities may have different regulations applicable to the minimum time required before entering blast site after firing the shot. The more stringent regulation must apply.**

**If a misfire is declared, then the appropriate regulations must be followed for wait time and handling the misfire.**

**********

The Blaster-In-Charge must closely inspect the entire blast area following a blast to check for misfires and guard against rock fall or cave-in before commencing work in the tunnel. 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.

3.3.8 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 access to the blast 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 brought to site to resolve the problem. Compliance with this or any other provision in the Contract must not relieve the Contractor of responsibility for 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.

3.4 BLASTING PERSONNEL

3.4.1 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, Blaster-In-Charge, and Vibration Specialist cannot be the same person, unless a justifiable request is presented and approved by the Contracting Officer. 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's Qualifications including resume, experience, current blasting licenses, credentials and training 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 underground blasting who has derived their primary source of income by providing specialized underground blasting and underground blasting consulting services. The consultant must not be an employee of the Contractor, explosives manufacturer, or explosives distributor or 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 vibration limits, and protect rock to be left intact. 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, attend the public meetings 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 problems, concerns or errors in the reports were addressed. This report is due within [_____] days after the end of the month.

3.4.1.1 Blasting Consultant's Qualifications

The consultant must be able to demonstrate involvement in at least [15] projects with underground 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 general construction blasting within [_____] meters [_____] feet of protected structures, [natural resource concerns and environmentally sensitive areas], final tunnel periphery, and presplit shaft or walls.

**********
**NOTE: "Natural resource concerns and environmentally sensitive" areas need to be defined elsewhere in this guide specification. Depending on the scope of the project and state requirement the number of short courses, seminars and conferences can be adjusted.**
**********

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 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 drilling and blasting work including submission of the Master Blasting Plan.

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

3.4.1.2 Issues Requiring the Blasting Consultant

If problems with vibration, airblast, smooth wall blasting, 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 Blasting Consultant must have full authority to stop or delay blast they consider 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.

### 3.4.2 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. The Blasting Specialist must be approved before submission of the Master Blasting Plan. 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 underground 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 underground controlled blasting techniques.

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 underground 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 tunnel periphery and shaft configuration if blasting at portals or shafts, 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 project submitted as reference that cannot be verified.

### 3.4.3 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.

b. The Blaster-In-Charge must have a minimum of 10 years of experience.

c. 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 shaft configuration or tunnel periphery 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 project submitted as reference that cannot be verified.

### 3.4.4 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 duties that will 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.

### 3.4.5 Vibration Monitoring Specialty Firm

**********

**NOTE: This 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 applicable for tunneling. 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.

### 3.4.6 Structural Inspection/Evaluation Technician

**********

**NOTE: This may be required for shaft/portal blasting/excavation. Depending on proximity of the tunnel it may be needed to document condition of structures in proximity to the work. Designers will need to determine project requirements/needs.**

**********

**********

**NOTE: Five years should be considered the minimum experience requirement. Depending on the project it might be necessary to increase the minimum if there is a special concern (i.e., complex ground conditions) or sensitive structures, consult with USACE SME to help determine appropriate experience requirements.**

**********

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.

## 3.5 TUNNELING PERSONNEL

### 3.5.1 Project Manager

Perform the work under the direct supervision of an experienced project manager with a minimum of 15 years (or as approved by the Contracting Officer) in civil and heavy construction of which a minimum of five years' experience (or as approved by the Contracting Officer) is in tunnel construction, including a minimum of two projects, or as directed by the Contracting Officer. Substitutions for the project manager during the Contract period should not be made without prior written acceptance by the Contracting Officer. Substitute personnel must have the same qualifications specified herein for the position to be held.

### 3.5.2 Tunneling Superintendent and Supervisors

**********

**NOTE: The nomenclature of tunneling "supervisors" could vary based on geographic location. Foreman or Shifters are common terms for supervisor.**

**********

Submit for approval the qualifications. Perform the work under the direct supervision of an experienced tunneling superintendent and tunneling supervisors with experience requirements in accordance with Section [_____], or as directed by the Contracting Officer. In addition, the Tunneling Superintendent's experience should include at least one project of a comparable size to this Project within the previous ten years (or as approved by the Contracting Officer). Duties of the tunneling superintendent and tunneling supervisors should include the requirements set forth in Section [_____]. Substitutions for the tunnel superintendent during the Contract period should not be made without prior written acceptance by the Contracting Officer. Substitute personnel must have the same qualifications specified herein for the position to be held.

**********

**NOTE: Use qualification criteria requirements for drill and blast tunnel superintendents and supervisors as described below.**

**********

Tunneling superintendents and supervisors must have a minimum of 15 years of comparable experience in supervising the excavation and support of tunnels in similar ground using the same construction methods and must have all necessary licenses and permits required by local agencies or others having jurisdiction. Supervisors and superintendents must have experience on at least two projects with full face hard rock drill and blast tunnel excavation. Tunneling must not be performed unless the tunneling superintendent, supervisors, drillers and miners meeting the above experience requirements are on site and in actual supervision of this portion of the work.

The following duties are also part of the responsibilities of tunneling supervisors and superintendents:

a. Supervising excavation to ensure safety and quality of construction.

b. Meeting daily [at the start of each shift] with the Contracting Officer at the tunnel face to discuss ground conditions encountered and corresponding excavation and support requirements including additional initial support and keeping records thereof.

c. Devising and implementing additional initial support measures as required by ground conditions or as directed by the Contracting Officer, coordinating remedial measures when ground loss at mined tunnel heading or instability of mined tunnel occurs, or appears likely to occur.

**********

**NOTE: It is standard practice to have drill and blast supervisors (in addition to Tunneling superintendents, Consultants, Blaster) in drill and blast tunnel construction. Nomenclature of these positions may vary depending on geographic area.**

**********

### 3.5.3 Drill and Blast Supervisors

Drill and blast supervisors must have a minimum of 10 years of experience in designing, supervising, loading, and firing of blasts for shaft or tunnel excavations, as applicable, and must have all licenses and permits required by state and local agencies and others having jurisdiction. Submit for approval the qualifications

### 3.5.4 Geotechnical Engineer or Engineering Geologist

**********

**NOTE: A licensed professional must be used, that may vary on the state, since some do not license Engineering Geologists or Geotechnical Engineers. Tailor this section appropriately for your project needs.**

**********

Contractor's Geotechnical Engineer or Engineering Geologist must be a licensed Civil Engineer, Professional Geologist or Engineering Geologist in the State of [_____] with a minimum of 10 years' experience designing underground excavations and constructing such excavations, installing slope stabilization support, designing tunnel and underground support, evaluating rock mass properties, and groundwater conditions for large underground excavations.

The Geotechnical Engineer or Engineering Geologist must have worked on a minimum of two projects with full face hard rock drill and blast tunnel excavation. Tunneling must not be performed unless the Geotechnical Engineer or Engineering Geologist meeting the above experience requirements is on site and in actual supervision of this portion of the work. Submit for approval the qualifications.

The Contractor's Geotechnical Engineer or Engineering Geologist to provide inspection of excavations and evaluate rock and groundwater conditions during construction. The Geotechnical Engineer or Engineering Geologist must perform pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer or

Engineering Geologist must update the excavation, dewatering plans, geologic mapping, rock support mapping, and rock mass characterization as construction progresses to reflect changing conditions and changes in contract rock support based on in-situ conditions observed. The Geotechnical Engineer or Engineering Geologist must submit a written Monthly Excavation Status Report that informs the Contractor and Contracting Officer of the status of the excavation and provide an accounting of the Contractor's adherence to the plans and address present or potential problems or issues with ongoing construction. The Geotechnical Engineer or Engineering Geologist must be available to meet with the Contracting Officer and Government representatives throughout the Contract duration.

## 3.6 PRE-CONSTRUCTION DOCUMENTS

**********

**NOTE: The section below should be used when rock blasting excavation techniques are required.**

**********

### 3.6.1 Tunnel Excavation Plan

The following documents must be submitted to the Contracting Officer at least 60 days prior to commencing excavation:

a. A drawing of proposed tunneling operations. The drawing must include detailed working drawings of mobilization, proposed methods, and sequence of excavating and disposing of materials for each portion of the work, drilling and blasting, ventilation, illumination, installation of ground support including placing of shotcrete, steel sets and rock reinforcement, dimensions for excavation and types of equipment to be used.

b. A method statement of the proposed tunneling operations. This method statement must include details of the Contractors proposed tunnel-logging system such as the NGI "Q" system or Rock Mass Rating (RMR) system for determining ground support, as defined in the GBR, in concert with guidelines provided in Chapter 7 Design of Initial Support, EM 1110-2-2901. The report must present details of proposed methods and sequences of excavating and disposing of materials for each portion of the work, probing ahead of the tunnel face, pre-grouting, drilling, and blasting, ventilation, illumination, placing Shotcrete, steel sets and rock reinforcement, surveying, monitoring, and construction equipment to be used.

c. Catalog cuts of drilling, mucking and transportation equipment to be used.

d. Contingency Plan for the excavation and support of the tunnels in the event that monitoring of blasting operations in accordance with Section [_____] and monitoring of ground deformations in accordance with Section [_____] TUNNEL INSTRUMENTATION. Refer to EM 1110-2-1009 for further guidance on instrumentation. Indicate vibrations or movements exceeding threshold values defined in the drawings.

e. The following Optical Survey Target Details must be submitted to the Contracting Officer for approval:

    1. Manufacturer's address, phone number and name of the contact

person.

2. List and description of special modifications if there are changes.

3. Description of instrument's operational principle.

4. Plans or diagrams of instrument.

5. Maintenance requirements.

6. Reading procedures, including sample data, and data processing calculations.

7. Complete data on all tests done to calibrate instruments or verify accuracy.

f. Working Drawings - The following must be submitted in accordance with the specifications:

1. Drawings and details of the initial support of all excavations.

2. Procedures for the control [, treatment ]and disposal of groundwater and water supplied for use during tunneling.

3. Methods and and equipment for measuring and recording groundwater inflow. Methods, equipment, guidelines, and criteria for the use of fissure grouting must be proposed by the Contractor in method statement as required in Section 31 73 19 TUNNEL AND SHAFT GROUTING.

g. Instruments for monitoring air quality.

h. The following records of work accomplished must be submitted to the Contracting Officer within 24-hours of the installation of geotechnical instrumentation measuring tunnel convergence:

1. A list of instruments installed, including instrument identification numbers, calibration, elevation, orientation, stationing, offset, and initial coordinates as applicable to each instrument or installation.

2. Drawings showing details of installed instruments. All dimensions and materials used must be fully identified.

3. A statement describing the procedure used for the installation of each instrument.

i. Complete working drawings and system description of proposed equipment, materials, and method for handling water within the tunnel, measurement of pumped water, and disposal methods.

3.6.2 Blasting

3.6.2.1 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, relief hole data, [burn, v, fan] cut design, 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 Plans must 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.

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.

k. Plans for construction sequencing line drilling, presplitting, blasting, and mucking operations to complete the rock excavation within the limitations of the peak particle velocities. Describe the change in placement of the seismographs with regards to the progression of 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.

3.6.2.2 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. Federal, state, and local regulations must be taken into consideration. Ensure NEPA, 408 permits, and environmental studies incorporated the blast safety radius.**

**********

The required minimum safe distance for shaft blasting or when blasting at portal 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. 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 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, 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 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 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).

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. 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.

]3.6.2.3 Pre-Blast Surveys

**********

**NOTE: During design consult with the 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. Provide a letter from the insurance company to the Contracting Officer certifying that the proposed survey extent and methods are acceptable. The Contractor is responsible for 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 digital video) 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, and structures 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. 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 reasons provided for denial of access (if given.)

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

## 3.7 RECORD KEEPING

**********

**NOTE: The paragraph below applies to all excavation techniques.**

**********

Daily records should be maintained as excavation progresses and one copy of such records must be submitted to the Contracting Officer [before 12:00 PM ]of the following workday. Keep such other records as deemed

necessary. The following data must be included in the daily record for each tunnel heading:

a. Station of tunnel heading faces at start and end of each work shift.

   1. Daily As-built Survey: While tunnel excavation is in progress, submit to the Contracting Officer a daily as-built survey record showing line, level, and grade of centerline of tunnel at the invert relative to the theoretical alignment and profile and actual excavated tunnel cross-sections compared to the theoretical cross-sections shown on the Contract Drawings.

b. Type, quantity, and location of initial support and additional initial support installed. Geologic mapping and excavation records that comply with EM 1110-1-1804 Appendix B and C.

c. Evaluation of in-tunnel monitoring results.

d. Probe hole records in accordance with paragraph DRILLING LOGS of this Section.

e. Number of workers employed per shift for each workday categorized by union trade, idle equipment, active equipment, and site visitors.

   1. Air quality and gas monitoring data. Line and grade survey reports.

   2. Water inflows, if encountered, with locations and estimates of rates.

   3. Overbreak.

   4. Other geological and unusual features such as faults, shears, crushed or soft zones, and raveling areas.

### 3.7.1 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. 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, boosters.

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, structure, or facility.

t. A minimum of [_____] high resolution photos, taken with a camera with a resolution of at least twelve megapixels, of the entire blast area, preferably from above, of surface and open face, tunnel working face, tunnel crown, tunnel periphery, tunnel floor; of the shot and surrounding rock to document conditions prior to the shot.

u. Blastholes must not be drilled until the Individual Shot Plan for them

is approved. Evaluate 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, 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.

### 3.7.2 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 D2488, 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[, and other types]);

c. Blasthole depth, inclination and diameter;

d. Elevation of top 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 blasthole misalignment; and

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

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 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 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.

]3.7.3 Individual Shot Reports

**********

**NOTE: The Contractor must plan on multiple tunnel headings so that production can be maintained on schedule. The GBR may include recommendations as to how many headings can be expected in the project.**

**********

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 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. 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 responsibility for the accuracy and adequacy of the blast design. 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 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, stationing, 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 or 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, Weekly, and Monthly 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 blast hole 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.

**********

**NOTE: A pre-blast photograph may be required for some project, if so then including them with the post-blast photographs in the shot report may be required.**

**********

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

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.

v. 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[

structure of interest][ are] acceptable.

If a recorded seismic value appears anomalous, the Contracting Officer may request that the vibrations monitoring specialist interpret all 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.

w. 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 at least 30 days before commencement of blasting. Failure to submit satisfactory Individual Shot Reports must result in suspension of 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 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.

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 field changes on the approved blasting plan.

### 3.7.4 Daily Explosive Material Consumption

Accurate daily records must be kept and account for each piece of explosive, detonator, and equipment from the time of delivery at the site until its discharge and used. No explosives must be accepted until it is plainly labeled and delivered as new stock in sound condition. Dates of manufacture and lot numbers must be recorded for all explosives delivered to the site. Temporary containers for explosives must be approved in advance by the Contracting Officer. Remaining or unused explosives must be inventoried each day and discrepancies that would indicate a theft or loss of explosive material must be reported immediately as specified in Paragraph Report of Loss.

3.7.5 Report of Loss

Should a loss or theft of explosives occur, all circumstances and details of the loss or theft must be immediately reported to the nearest office of the Bureau of Alcohol, Tobacco, Firearms and Explosives and to the local law enforcement authorities and the Contracting Officer. The Blasting Specialist must prepare a memorandum describing and explaining problems in the accounting of explosives used.

3.7.6 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.**

**********

When blasting at portal(s)[ and shafts], 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 Contractor should anticipate at least one designated video camera location when blasting underground[ for each shot]. The video images must not contain other text than the shot number, date, and time. 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.

3.7.7 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 locations, 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 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.

3.7.8 Probe Hole Drilling

**********

**NOTE: The design team must evaluate expected ground conditions including but not limited to: zones of intensely jointed rock mass due to faults, shears, etc., rock types, weathering profiles, groundwater regime, other pertinent geological information available from the site investigations to determine the adequate length of probing ahead of tunnel. This information must be included in the Geotechnical Baseline Report as a recommendation.**

**Insert gallons per minute (gpm) based upon results of packer tests performed, or other estimates of water inflow. In lieu of available project data, assume nominal amount of water on the order of 15-20 gpm. The inflow information must be included in the GBR and/or GDR.**

**The number of supplemental probe holes expected for the project must be determined during design phase and clearly listed as a recommendation in the GBR.**

**Typically these probe holes are incidental to the tunnel excavation pay item (cu.f.or cu.m), designer should ensure this is stated in the specification or include a CLIN for payment.**

**********

a. The Contracting Officer must be informed 24 hours prior to probing activities in the tunnel so that the Government may be present during the probe hole drilling. The results of probing ahead along with proposed amendments to excavation profile, sequence or support must be submitted to the Contracting Officer[ immediately upon][ within [_____] hours of the] completion of the probing.

b. Probe holes must be drilled to provide advance warning of abnormal inflow of water or degradation in rock quality, which might occur. Probe hole locations and extent of hole drilling is shown on the Drawings and will be modified as needed in the field as approved by the Contracting Officer. The Contracting Officer may direct supplemental probe holes to be drilled based on ground conditions. Exploratory probe holes may also be required to explore the nature of subsurface formations or following grout operations to investigate the effectiveness of the grouting program.

c. If the inflow of water from the probe hole exceeds [_____] gpm, supplemental probe holes will be required, at the direction of the Contracting Officer, to probe the extent and character of the ground, and to drain the water, or for use as grout holes. If directed by the Contracting Officer, grout the face of the tunnel heading in accordance with Section 31 73 19 TUNNEL AND SHAFT GROUTING.

d. Probe holes must be drilled to a minimum of [_____] meters [_____] feet measured along the drilled hole and will overlap to maintain at least one hole a minimum of [_____] meters [_____] feet ahead of the plane of the tunnel face at all times. The Contracting Officer may reduce the drilling length based on ground conditions.

e. During probe hole drilling, the Contractor should stop at a minimum of each 3 meters 10 feet of hole advance to measure water flow and water pressure. The Contracting Officer waive this requirement on a hole-by-hole basis if little or no water is encountered.

f. Probe hole must be terminated [_____] meters [_____] feet beyond the first groutable feature, as determined by the Contracting Officer.

g. Probe holes must be sealed by grouting through a packer close to the first water producing feature to prevent water flows into the tunnel while the tunnel face is advanced.

h. If, in sections of the tunnel excavation, drilling is directed by the Contracting Officer for supplemental probe holes, other operations should be suspended or modified as may be necessary to permit such drilling; and the Contractor will not be entitled to compensation for delay nor will the Contractor be entitled to extension of time, such stopping of work being deemed an ordinary delay to be expected during construction operations.

**********

**NOTE: A conservative estimate for the number of supplemental probe holes should be defined in the GBR. Define how these supplemental probe holes are to be paid.**

**********

i. Follow format requirement in paragraph DRILLING LOGS.

## 3.8 BLAST EFFECTS MONITORING

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**NOTE: The vibration and air blast monitoring are covered under Section 31 23 06.00 BLASTING - SURFACE; it must be included when conducting blasting work.**

**********

### 3.8.1 Convergence Monitoring Construction Requirements

#### 3.8.1.1 General Tolerance

The instruments must be installed as close as practicable to the locations [shown on the Drawings][or as established in the field by the Contracting Officer]. The Contractor must submit to the Contracting Officer for consent, all final instrument locations prior to their installation. Where instruments are shown on the contract drawings to be installed in clusters, the Contractor must install all instruments shown within a [_____] mm [_____] in. radius

3.8.1.2 Availability of Data

The Contractor must monitor all instruments and provide data obtained to the Contracting Officer within a maximum of [24 hours] after taking the readings unless otherwise directed by the Contracting Officer.

Instrument monitoring data must not be disclosed to third parties and must not be published without the prior written approval of the Contracting Officer.

3.8.1.3 Instrument Installation Sequence

Optical survey targets must be installed following scaling and within [_____] meters [_____] feet of the advancing tunnel face.

3.8.1.4 Installation Requirements

The Contractor must assign an instrument identification number to each instrument. Each instrument identification number must be permanently affixed to a suitable material, such as the stamping of a brass tag. The tag must be attached to the instrument or must be secured at the instrument location.

Optical survey targets must be installed as shown on the drawings.

3.8.1.5 Protection of Instruments

Full responsibility must be borne by the Contractor for protecting the instruments from damage caused by construction operations. Damaged instruments must be promptly replaced or repaired, as directed by the Contracting Officer, at the expense of the Contractor.

The instruments must be clearly marked and protected to avoid being covered by shotcrete. Access must be maintained to permit reading of instruments. Shotcrete applied around instruments must be removed immediately.

3.8.2 Rock Damage Control

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 or made accessible], 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. Blasting damage or breakage into the excavation walls will be mitigated at the Contractor's expense. Damage is defined as the loosening of rock beyond the B-line, opening of joints in the final wall and rock block displacement in the final wall. If 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.

## 3.9 TEST BLASTING

**********

**NOTE: The test blasting may be highly specific for the project site. The designer may have a way to carry out the test blasting 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 when blasting at portals or final tunnel or shaft periphery when blasting underground. 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 following is typical test blasting language.**

**********

Submit the Test-Blast Plan for review and approval. 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 and underground blast design. 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 poor 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 during the progress of the work, the methods of drilling and blasting do not produce the desired result of an undamaged rock slope or tunnel design excavation lines 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.

## 3.10 BLASTHOLE DRILLING - PORTALS AND SHAFTS

Survey the elevation at the collar of each production hole in the final blast to foundation grade when at the portal excavation or to depth of advance when blasting in the tunnel to ensure that the production blastholes are not subdrilled below final foundation grade. 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 production blastholeS, 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 the 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 blastholes at the portals, 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 a 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 holes. If a blasthole is found not be open to the drilled depth, re-drill the blast hole to the proper depth at the Contractor's expense. If holes are too deep, fill the holes to the proper depth with crushed stone. When drilling and blasting at the portal areas, 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.

When blasting for portal excavation, the Contracting Officer may require inclined boreholes to reduce toe burdens and backbreak.

## 3.11 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 a 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 enough 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.**

**********

3.12 SUBDRILLING

**********

**NOTE: Subdrilling is typically not utilized in underground blasting, however it may be a component required for shaft excavations for connecting surface blasting operations with the underground environment. If Section 31 23 06.00 BLASTING - SURFACE is being used, tailor that specification for the project or include language here.**

**********

[_____]

3.13 PRESPLITTING

**********

**NOTE: Presplitting is typically not utilized in underground blasting, however it may be a component required for shaft or portal excavation for surface blasting operations. If Section 31 23 06.00 BLASTING - SURFACE is being used, tailor that specification for the project or include language here. Precision presplitting may also be utilized in these situations. It is a form of presplitting with closer spaced holes with an even lighter explosive load.**

**********

[_____]

3.14 STEMMING

**********

**NOTE: Stemming may be used in shaft sinking operations using controlled blasting methods. Stemming is not typically used in tunnel heading**

**advance. Depending on the geology of the project site this paragraph should be tailored to the project, for example in places with karst geologic conditions 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.

**********
**NOTE: Include tolerance for each proposed structure from the excavation lines. For example, "The tolerance for the perimeter walls is minus 100 cm/m 12 inches/foot from the design excavation line."**
**********

## 3.15 REQUIRED MUCKING

Required mucking operations should adhere to the details of the Muck Handling Plan. Prior to mucking operations, the Blaster-In-Charge and Tunneling Superintendent should perform an explosive safety check to ensure that all explosive materials have been detonated with the last tunnel heading advance. Undetonated explosive materials should be disposed of in advance of mucking operations in accordance with 29 CFR 1926-SUBPART U.

Muck and scaling follow each shot after firing for inspection of the heading, 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).

**********
**NOTE: The following paragraph should be tailored for the specific project, the GBR will provide recommendation on this distance. The Contracting Officer reserves the right to require additional ground support beyond that systematically required in the drawings.**
**********

Notwithstanding this requirement, the face must fully be dug out after every shot to a distance not less than [_____] meters [_____] 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. 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 heading advance or lift will not be permitted until the excavation has been accepted by the Contracting Officer.

The mucking system(s) must not restrict other operations including handling and erecting of initial support system materials.

For rail mucking systems, a track with ties and ballast or direct fixation system must be maintained for safe operation of trains. The head of the rails must not be submerged in water or covered with tunnel muck or other debris. Upon completion of excavation of the tunnel, remove all such trackwork prior to placement of final lining.

Submit for review at least [sixty (60)][_____] days before the start of tunnel excavation the Muck Handling Plan, the methods, procedures, and details of the proposed mucking system. Submit for review the manufacturer's information for the proposed equipment including, but not limited to, specifications, drawings, details, maintenance procedures and requirements, operating procedures, and such other information as may be requested by the Contracting Officer.

## 3.16 SCALING

**********

**NOTE: Typically, a level of scaling is required for each project to remove loose, unstable rock prior to mucking operations or prior to required bolting application or other methods of stabilization before carrying out additional excavation operations**

**********

A program of frequent inspection and scaling must be maintained in all portions of the tunnel. Immediately after each blast, the roof and walls of rock excavations must be inspected by experienced and suitably equipped scalers who must dislodge and scale down all loose and unstable rock. Scale loose and unstable or unsafe appearing material remaining on the tunnel periphery or rock slopes at the portal areas as the excavation proceeds. Perform scaling immediately after each blasting round. The removal must be accomplished by compressed air or water jetting, pry bars, rock picks, hoe-ramming, excavator bucket or other means as approved by the Contracting Officer. Drilling of the next blasting round will not be allowed until the current excavation has been properly scaled and all initial ground support has been installed as determined by the Contracting Officer. No separate payment will be made for scaling.

## 3.17 GROUTING

Conduct pre-excavation and post-construction grouting in accordance with Section 31 73 19 TUNNEL AND SHAFT GROUTING and as shown on the Contract Drawings.

If groundwater exceeds [____] liters per minute (lpm) gallons per minute (gpm) during probe hole advancement during tunnel construction the Contractor's Engineering Geologist or Geotechnical Engineer will submit a grouting and excavation plan or establish protocols for excavation if certain inflows exceed threshold lpm gpm values prior to tunnel

excavation. The Contracting Officer must be informed of the implementation of the aforementioned grouting plan if groundwater inflows exceed excavation plan established inflow thresholds.

## 3.18 INITIAL SUPPORT

**********

**NOTE: A UFGS for TUNNEL EXAVATION SUPPORT is being developed. The designer will need to include Initial Support as listed here and Permanent support. Often the contractor will be responsible for designing their own initial ground support types, and may not be defined in the GBR or specs. Alternatively, the GBR may give conceptual initial support types (spacing, types, lengths, etc...) to bid on but give multiple support Types that may be applied along different alignment stationing depending on the geologic conditions. Tailor this section as appropriate.**

**********

### 3.18.1 Support Classes and Support Class Ranges

All stations indicating limits of typical support classes referenced herein or as shown on the Contract Drawings are only approximate and may vary due to the geological and hydrological conditions encountered in the field. Tunnel excavation support classes, as shown on the Contract Drawings, are the minimum to be installed and should be adjusted above and beyond the said minimum based on the actual ground conditions encountered and be determined in the field in consultation between Contractor and the Contracting Officer.

Each support class defines installation of a specific initial support system. The support elements are as specified in Section XX XX XX TUNNEL EXCAVATION SUPPORT and as shown on the Contract Drawings.

Initial support measures have been derived based on anticipated ground conditions and the need to provide stabilization of the tunnel openings for enlargements to cavern size openings under this Contract or future contracts.

Excavation and support measures delineated hereafter are typical and should be supplemented by additional initial support measures as required by ground conditions encountered or as directed by the Contracting Officer. To minimize ground movement; the initial support must be installed following each heading round blast and as close to the working face as practical in accordance with Section XX XX XX TUNNEL EXCAVATION SUPPORT.

**********

**NOTE: Verify that a Geotechnical Baseline Report has been prepared for the project and has been referenced in Section Related Attachments and Specifications.**

**********

a. Ground support guidelines for the tunnel excavation are shown on the Drawings and provided in the GBR. In addition to the ground support

shown on the contract plans, the Contractor must install such ground support as necessary to always ensure the stability of the excavation and the safety of the construction personnel. Ground support installed by the Contractor without agreement or instruction from the Contracting Officer must be for the Contractors convenience and at the Contractor's expense.

b. The ground support must be installed as soon as practicable after tunnel excavation to minimize loosening or movement of the surrounding ground. The Contractor must be responsible for providing confirmation that the ground support system has produced a stable excavation. The support layouts shown on the contract drawings are a guide only and must be modified as required on the field during tunnel excavation.

c. The approval of the proposed excavation and support sequence by the Contracting Officer or failure to call attention upon improper or inadequate application of the related excavation sequence or tunnel support, pre-support, or face support or to require respective change must not relieve the Contractor of responsibility for the integrity of the tunnel support or the proper execution of the work.

[ d. Lengths of excavation rounds shown on the contract drawings are maximum values and may have to be reduced due to the ground conditions encountered.

] e. Pneumatically projected concrete, either fiber reinforced Shotcrete or plain Shotcrete must comply with provisions set forth in Section 03 37 13 SHOTCRETE.

f. Rock reinforcement for tunnel excavation must comply with Section 31 68 13 SOIL AND ROCK ANCHORS.

g. Steel arch ribs, liner plates and additional ground support elements must comply with Section XX XX XX TUNNEL EXCAVATION SUPPORT.

## 3.19 EXCAVATION SEQUENCE FOR TUNNELS

Tunnel excavation must be accomplished in either a full face or top heading and bench format as indicated on the contract drawings. All initial support must be applied or installed prior to drilling subsequent rounds.

## 3.20 STABILIZATION TYPES

[_____] ground support categories have been developed for the stabilization of the main tunnels as defined in Section XX XX XX TUNNEL EXCAVATION SUPPORT.

An estimate has been made as to the lengths of each of the ground support categories required to stabilize the tunnel. The estimated lengths are shown on the contract drawings and presented in the Geotechnical Baseline Report (GBR). Actual stabilization requirements may vary from those estimated based on the geologic conditions encountered. In accordance with Section 01 35 26 GOVERNMENTAL SAFETY REQUIREMENTS, the Contractor must be responsible for the safety of the work and for accomplishing the permanent stabilization of the tunnel opening.

## 3.21 EXCAVATION FOR TRENCHES AND SUMPS

Excavation for trenches and sumps must conform with Section 31 00 00 Earthwork and as shown on the contract drawings.

## 3.22 EXCESS EXCAVATION

**********

**NOTE: The type/class of shotcrete used to fill overbreak areas in the tunnel should be defined by the designer in early stages of the development of the bid documents. Similarly, the type of material used to fill overbreak in the tunnel invert must also be defined during early stages of the project design.**

**********

Excavation outside of the B-Line shown on the Drawings must be filled with Class I,II, III Shotcrete in accordance with Section 03 37 13 SHOTCRETE at the expense of the Contractor. Overbreak excavation in the tunnel invert must be filled with [compacted crushed rock, lean concrete].

## 3.23 TOLERANCES

The tunnels must be excavated in accordance with the A-line dimensions shown on the Drawings. No unexcavated rock or other material must protrude within the A-line.

## 3.24 CONTROL OF WATER

**********

**NOTE: This section will likely be incorporated into a future UFGS for Tunnel Dewatering. This section will need to be heavily tailored for your project needs. Adhere to the current version of the ETL 1110-2-586 DEWATERING: Methods, Installation, and Performance Monitoring.**

**********

a. The Contractor is responsible for control of water in the tunnel during construction and must take all means necessary for such control. Control of water must include but not be limited to, furnishing, installing, operating, and maintaining pumps and other equipment including temporary measuring devices must as per (b) below, constructing temporary ditches and drains and keeping ditches and drains free to carry all water to sumps or other disposal areas; and disposal of all water, tested daily, draining or pumped from the tunnel. Disposal of water must conform to all applicable Federal, State, and local laws.

b. Automatic measuring devices must be furnished by the Contractor and must be employed to measure the flow rate of water coming out of the tunnel portals. Water piped in for construction operations and water exiting at the portals must be separately measured. The difference between the total flow rate out of and the total flow rate into the tunnel must be considered the rate of groundwater inflow to the tunnel. This rate of flow must be measured and recorded on a [daily basis][hourly basis] for information only.

c. Fissure grouting must mean grouting carried out in the rock mass surrounding the Underground Works to stem water flows emanating from fissures in the rock where if left un-stemmed the inflows could initiate instability. Pressure grouting must be carried out when instructed by the Contracting Officer and, where necessary the Contractor must carry out lugeon permeability tests to establish the extent of the fissure to delineate zones that will take grout. Further requirements are in SECTION 31 73 19 TUNNEL AND SHAFT GROUTING.

## 3.25 PERMANENT TUNNEL DRAINAGE

A drainage geotextile must be installed on the walls and crown of the excavation against the shotcreted surface at locations where actual flows of water are encountered and at other locations as shown on the Drawings or as may be required to the satisfaction of the Contracting Officer. The installation must comprise full coverage for ground support in accordance with Section XX XX XX TUNNEL EXCAVATION SUPPORT.

The drainage membrane must be fixed and sealed to the approval of the Contracting Officer so that the placing of shotcrete does not block or obstruct the drainage geotextile.

Geotextile must be installed in accordance with Section XX XX XX and Waterproof Membrane must be installed in accordance with Section XX XX XX.

-- End of Section --