SECTION 31 23 16.26 – DRILLING AND BLASTING

1.01 **SUMMARY**: This Section prescribes drilling and blasting requirements for the Works.

1.02 [A16]**REFERENCES**:[A16]

A. **Institute of Makers of Explosives (IME) Publications**:

No. 1-93	Construction Guide for Storage Magazines.
No. 2-91	The American Table of Distances.
No. 3-03	Suggested Code of Regulations for the Manufacture, Transportation, Storage, Sale, Possession and Use of Explosive Materials.
No. 4-92(93)	Warnings and Instructions for Consumers in Transporting, Storing, Handling, and Using Explosive Materials
No. 14-93	Handbook for the Transportation and Distribution of Explosive Materials
No. 17-87	Safety in the Transportation, Storage, Handling, and Use of Explosive Materials
No. 20-88	Safety Guide for the Prevention of Radio Frequency Radiation Hazards in the Use of Commercial Detonators.
No. 22-93	Recommendations for the Safe Transportation of Detonators in a Vehicle with Certain Other Explosive Materials and Generic Guide for the Use of IME 22 Container

B. **National Fire Protection Association (NFPA)**:

495-06	Explosive Materials Code.

C. **U.S. Army Corps of Engineers (USACE)**:

EM 385-1-1	Safety and Health Requirements Manual, November 2003.

D. **Code of Federal Regulations (CFR)**:

29 CFR 1910	Occupational Safety and Health Standards

29 CFR 1926	Safety and Health Regulations for Construction - Occupational Safety and Health Administration (OSHA), Department of Labor
[A19]49 CFR [A19]	Transportation

E. **Autoridad del Canal de Panama (ACP) Publications**: In addition to the documents explicitly referenced, the Contractor shall comply with all the applicable blasting safety regulations of the Employer, available online through the following shortcut: http://www.pancanal.com/esp/legal/reglamentos/security/index.html.

[A17]2600SEG-106(R3) [A17]	Norma de Seguridad para Trabajos con Actividad Eléctrica Atmosférica (Tormentas Eléctricas).
[A17]2600SEG-108 [A17]	Norma de Seguridad para el Manejo, Transporte, Almacenamiento y Uso de Explosivos y Municiones.
[A17]2600SEG-248 [A17]	Norma de Protección Intrínseca.
RMOCP	Reglamentos Marítimos para la Operación del Canal de Panamá.

F. **Publication of Panama's Ministerio de Gobierno y Justicia**:

Reglas del Dinamitero del 10 de marzo de 1994 de la Oficina de Seguridad del Cuerpo de Bomberos de Panamá.

[A13]Decreto Ejecutivo # 104 del 16 de Octubre de 1930, Capítulo V - Oficina de Seguridad del Cuerpo de Bomberos de Panamá, Versión mayo 29 de 2006. [A13]

G. **Law of the Republic of Panama**:

Ley Número 47 (21 de noviembre de 1980) dictada por el Consejo Nacional de Legislación por el cual se le asignan funciones a varias dependencias del estado y se dictan otras medidas (Gaceta Oficial Nº 19208).

[A13]H. **United States Department of the Interior, Bureau of Mines Publication**:

Report of Investigation 8507, Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting, by D. E. Siskind, M. S. Stagg, J. W. Kopp, and C. H. Dowding

I. **Other References**:

Drawbacks of Blast Vibration Regulations, Mark R. Svinkin, available at http://vulcanhammer.net/svinkin/BLST-CRT.pdf[A13]

1.03 REQUIREMENTS:

A. **Safety Regulations and Procedures**: When blasting is found to be necessary, the Contractor shall take precautions for the protection of individuals and property exposed to his operations. [A16]The Contractor shall comply with procedures and techniques recommended in handbooks of recognized explosives manufacturers and the references listed below. [A16]

1. **Publications**: The Contractor shall comply with the requirements of ACP [A17]2600SEG-108; [A17] [A13]Ministerio de Gobierno y Justicia, "Reglas del Dinamitero del 10 de marzo de 1994 de la Oficina de Seguridad del Cuerpo de Bomberos de Panamá", y Decreto Ejecutivo # 104 del 16 de Octubre de 1930, Capítulo V, Oficina de Seguridad del Cuerpo de Bomberos de Panamá, Versión mayo 29 de 2006; [A13] IME Nos. 2, 3, 4, 14, 17, 20, and 22; 29 CFR 1926, Subpart U - Blasting and the Use of Explosives; and Section 25, USACE EM 385-1-1. In case of a discrepancy between these requirements, the order of priority is those issued by the ACP first, followed by the Panama government, IME, OSHA, and USACE last. The Contractor shall employ a suitably qualified blaster(s), to oversee any operation involving explosives.

2. In addition to the aforesaid publications, the Contractor shall comply with the following requirements.

   a. **Importation of Explosives**: The importation of explosives into the Republic of Panama for use in the Contract requires previous authorization from the "Dirección Institucional en Asuntos de Seguridad Pública (DIASP), Ministerio de Gobierno y Justicia". [A20]During importation procedures, the Contractor shall store explosives in the DIASP magazine(s) agreed upon between the Contractor and DIASP for this purpose.[A20]

   b. **Handling to and from Vessels**: Handling of explosives during loading or unloading operations to or from vessels in Canal waters shall be governed by the requirements specified in RMOCP Chapter IX – "Mercancía Peligrosa" and the DIASP regulations for these operations in conformance with "Ley 47". However, as stipulated by the RMOCP and for safety reasons, ACP tug and launch landings (at Mindi Dock, Gatun Lighthouse, Diablo, Corozal, Las Cruces, and Paraiso) will not be available for loading and unloading explosive cargo.

   c. **Surface Transportation of Explosives**: [A19]This shall be in accordance with NFPA 495; 29 CFR 1926, Subpart U; IME No. 3, Paragraph 1926.902; "Ley 47"; and DIASP regulations.[A19] As required for the transportation of explosives on public roads, such transportation shall be escorted by the "Policía Nacional de Panamá" (PNP) and the

"Cuerpo de Bomberos de Panamá". These escorts shall be arranged by the Contractor and previously coordinated with the DIASP. Explosives shall be transported only in a vehicle specially equipped for the transportation of explosives. Unless the explosives are in proper containers, caps and explosives shall not be carried on the same vehicle. Blasting caps may be transported with certain other explosives in an IME No. 22 approved container (refer to IME 22 for further details).

d. Any damaged or leaking packages containing explosives shall not be touched, and the blaster in charge and Employer's Representative shall be informed immediately.

e. Boxes of explosives shall be handled one at a time. They shall not be tossed or slid across floors or the beds of trucks.

f. The blaster shall be responsible for all phases of the blasting operation and shall ensure that all standard procedures for safe operations are followed. He cannot delegate this responsibility to any other employee of the Contractor's Personnel. He shall keep a record of all holes loaded and the explosives used in each. He shall check out his firing system prior to each use to ensure proper operation.

g. Boxes of explosives shall be carried by hand. No cranes or hoisting equipment shall be used for loading/unloading boxes on board launches, barges, or floating equipment.

h. [A19]Shall comply with blasting requirements established in the Environmental Impact Study (including those within the environmental management plan); see Volume II, Part 3, Subpart 3.[A19]

3. **Blasting Warnings**:

a. **Blasting Signs**: Signs of adequate size shall be built by the Contractor to indicate that blasting operations are taking place in the area and that radio transmission there is prohibited. Signs shall comply with 29 CFR 1926.900(k)(3)(i) and (k)(3)(ii). They shall be posted in English and Spanish and shall be clearly visible day and night at all points of land access to the area. Definition of "the area" shall be determined in accordance with the tables of minimum distances recommended in IME No. 2. Details are available online at http://www.ime.org/; by mail from 1120 Nineteenth Street NW, Suite 310, Washington, D.C. 20036, USA; by phone: (202) 429-9280; by fax: (202) 293-2420; or through e-mail: info@ime.org.

b. **Blasting Signals**: Blasting signals shall be provided by the Contractor with horns, whistles, or sirens. A sound warning system shall be developed by the Contractor and shall be consistent throughout the [A17]Performance of the Works. [A17]

1) **Contents of Signal**: The signal shall consist of a 5-minute warning signal to notify all in the area that a blast will be fired within a 5-minute period. A second warning signal shall be

sounded 1 minute before the blast. After the blast is over, there shall be an all-clear signal sounded so all personnel in the area understand that blasting operations are finished.

2) **Warning Signals**: Five minutes prior to the blast, 5 long signals on an air horn or siren shall be sounded. One minute prior to the blast, 5 short signals on an air horn or siren shall be sounded.

3) **All-Clear Signal**: One long signal of at least 30 seconds in duration shall be used as the all-clear signal to indicate that all blasting has ceased. This signal shall only be given after the blaster has physically inspected the blast area.

4) **Nitrogen Oxides**: The Contractor shall perform random monitoring of nitrogen-oxide (NO-NO_2-NO_3) concentrations after every blast. All personnel shall stay clear of the after-blast cloud and high concentrations of nitrogen oxides until the blaster has determined that is safe to enter the blast site.

4. [A20]**Storage of Explosives**: Explosives shall be stored in the DIASP magazine(s) agreed upon for this purpose between the Contractor and DIASP. The storage of explosives shall be the Contractor's responsibility.

a. The Contractor may arrange directly with DIASP the establishment and operation of temporary storage facilities [transit area], outside the perimeter of the Contractor's Areas, all in accordance with the requirements of this Section, and the relevant Panamanian Laws and provisions of the Conditions of Contract. This includes obtaining the required permits and authorizations according to its land use and performing environmental evaluations.

b. The Contractor shall be responsible for determining the location and size of the temporary storage facilities [transit area] which shall be used only as staging points for the transfer of explosives between the Government's main storage facilities and the place where the explosives will actually be used.

c. The Contractor shall submit for approval by the Employer's Representative the proposed plan for deployment and operation of the transit area proposed to maintain for the temporary shelter of trucks carrying explosive loads. The plan shall consider the required physical distribution, safety measures, protection measures, lighting, security, surveillance and administrative controls. The Contractor shall provide the required maintenance for the installation. The Employer's Representative may, without previous notice, revoke the permit and/or temporarily or permanently shut down the installation as a result of a breach of compliance, evident or not, with the requirements of this Section, and/or due to suspicion of inadequate use or use different to that approved for the installation.

d. The Contractor shall submit whatever reports, information, proof or evidence that may be required by the Employer's Representative to verify that the transit area is being used within the established parameters. Should the Contractor deny providing such required evidence or should the Contractor fail to provide it in a diligent manner, the installation shall be closed without a right to claim by the Contractor.[A20]

5. **Responsibility for Security**: The PNP will ensure compliance with the regulations concerning the handling and storage of explosives. The security of the magazines for explosive is under the jurisdiction of the PNP, in accordance with the regulations of the "Ministerio de Gobierno y Justicia".

6. **Inspection of Magazines**:

a. The Contractor shall designate a responsible employee of the Contractor's Personnel to make a daily physical inventory of explosive materials stored at the magazines. Such inventory shall be made at the end of each day and checked against requisitions and issues for that day. Stock shall be inventoried again in the morning to ensure that no material has been issued or taken from the magazine during the night.

b. A responsible employee of the Contractor's Personnel shall compile the daily inventory reports into a weekly inventory report and submit it to his supervisor. This report shall be checked against the stock record to see that they coincide; any discrepancies shall be investigated immediately. The Contractor shall expeditiously submit the weekly inventory report to the Employer's Representative on a weekly basis.

7. **Blasting Schedule**: A blasting schedule shall be prepared by the Contractor. This schedule shall be coordinated with the executive manager of the Employer's "División de Operaciones de Tránsito" (OPT) and the Employer's Representative. OPT will ensure that vessels refrain from the use of radio transmitters or radar within 1.6 kilometers (1 mile) of the blasting site.

a. **Responsibility**: The drilling and blasting plan is for quality control and record purposes and will not relieve the Contractor of his responsibility for using proper drilling and blasting procedures for obtaining adequate results.

b. **Contents**: Each plan shall include the following information.

1) Station limits of the proposed shot.

2) Plan and section views drawn to scale of the proposed drill pattern, including free face, burden, blasthole spacing, blasthole diameters, blasthole angles, lift height, and sub-drill depth.

3) The loading and drilling pattern for each shot, showing types and amounts of explosives, primers, and initiators; the location and depth of stemming; and charge density.

4) Total amount of explosives in the blast and maximum kilograms of explosive per delay interval.

5) Delay-arrangement scheme showing delay interval proposed for each hole. Blast sequence, point of initiation, and direction of movement shall be shown on the plan view on a delay pattern grid. The type and brand of delays shall also be shown.

6) Character and source of firing current, size and length of lead lines, current requirement, sequence of firing, and the combined resistance of the complete blasting circuit. Blasting caps and detonating cords shall be indicated.

7) Technical reference for the design method applied.

8) The blasting technique.

9) Provisions to avoid fly rock, such as blasting mats.

10) Provisions or means (such as an appropriate fence) to prevent rock from falling down into the Canal and nearby areas.

c. **Blasting Plan Form**: In his plan for each blast, the Contractor shall include the information required above, as well as any other information included in the sample blasting report plan, but not explicitly mentioned above. Additional information on the actual explosive loading and shot evaluation shall be added after the blast to provide a complete shot record.

8. **Advanced Notification to Proceed with Blasting**: Shall conform to ACP [A17]2600SEG-108.[A17] Each shot shall be scheduled to ensure approval by the Employer's Representative, in coordination with the OPT Division, at least 48 hours in advance. This notification is required to allow for the notification of agencies operating in the vicinity of the work site or requiring information concerning scheduled or unscheduled blast times. Drilling shall be at least 80 percent complete before the request for the initiation of blasting operations is submitted for approval. The following scheduling restrictions will apply.

a. Blasting will be permitted only between 7:00 a.m. and 6:00 p.m.

b. Blasting will be permitted only when the Employer's Representative has determined that the safety of transiting vessels near the blast area is ensured through coordination with the OPT Division and when the blasting does not interfere with other ongoing dredging or excavation activities near the site.

c. [A19]To minimize the impact on nearby communities, blasting will not be allowed on Saturdays and Sundays, unless approved by the Employer's Representative. When approved on these days, it will be allowed only from 8:00 a.m. to 6:00 p.m. on Saturdays and from 10:00 a.m. to 6:00 p.m. on Sundays. Blasting activities shall be coordinated with the Contractor's community relations office and the Employer's Representative, so that nearby stakeholders who might be affected can be

notified; the Contractor shall be responsible for this notification.[A19] Refer to Section 01 57 19.13 (*Environmental-Management System*), Subparagraph 1.05 C.

9. **Blasting Notification**: After the blast schedule for each shot has been approved, the Contractor shall notify the Employer's Representative, on site, at least 15 minutes in advance of the shot to be performed.

10. **Radio Transmitters**:

    a. Contractor's Personnel using radio transmitters shall have operator's permits with them, as required by the "Autoridad Nacional de Servicios Públicos" (www.asep.gob.pa) of the Panama government. Radio-transmitter operators shall be carefully instructed by the Contractor as to the precautions that shall be exercised in using such transmitters in or around areas where blasting operations are conducted.

    b. The Contractor shall provide the radio-communication equipment to be used during blasting to the concerned Contractor's Personnel and the Employer's Personnel designated by the Employer's Representative.

    c. The use of radio transmitters, cell phones, and other electronic communication devices in areas of potential risk (due to the presence of explosive material/activities) is restricted. Refer to ACP [A17]2600SEG-248.[A17]

11. **Lightning Protection**:

    a. **Equipment Provision**: The Contractor shall procure, furnish, maintain, and operate lightning-detection equipment equal to the cited example, from preparation up to completion of blasting operations at the Site. Acceptable equipment includes the Model 350 Lightning Detector by Thomas Instruments, Route 9, P.O. Box 50, Spofford, N.H., USA, telephone (603) 363-4500, accessible online using URL address http://vibration.com/v2/index.php?main_page=products_all. The equipment shall be installed close to every blasting site before blasting operations begin and later removed, as required. It shall be capable of detecting and indicating lightning within ranges of 10, 25, 50, and 100 miles.

    b. **Battery Backup**: Unless equipped with an uninterruptible power supply (UPS), the system shall also have a battery charger and a battery pack for backup.

    c. **Blasting-Hazard Potential**: Refer to ACP [A17]2600SEG-106.[A17] When the lightning detector detects an electrical storm at the minimum setting (10 miles), the blaster shall monitor and evaluate the advance of the storm and indicate the appropriate time to stop the drilling operation and put the following safety procedures into effect.

        1) Personnel shall be relocated from all areas where explosives are present in an expeditious and orderly fashion.

2) Explosives handling/loading shall stop immediately.

3) Detonating cords shall be removed from the drilling platforms.

4) All explosives shall be key-locked in the storage area for explosives.

5) The Employer's Representative shall be notified.

6) If blastholes are loaded and would pose a hazard to traffic if detonated, all access shall be closed until the lightning hazard has passed.

7) When the blasting hazard potential dissipates, the Employer's Representative shall be notified before blasting operations are continued.

12. **Check for Misfires**:

a. **Minimum Observation Period**: The Contractor shall observe the entire blast area for a minimum of 5 minutes following a blast to guard against rock fall before commencing work. During this time, which is needed to make sure that no misfires have occurred, nobody but the blaster shall be allowed to enter the area.

b. **Blaster's Responsibility**: During the delay, it shall be the blaster's responsibility to go into the shot area and check all holes to make sure they have detonated. If any holes have not fired, these misfires shall be handled by the blaster in accordance with Subparagraph d. before others enter the area. The Contractor shall notify the Employer's Representative for proper coordination.

c. **Authority of the Employer's Representative**: The Employer's Representative shall, at all times, have the authority to prohibit or halt the Contractor's blasting operations if he believes that the required slope stability is not being obtained through the methods being employed or that the safety, convenience, or both of the Employer's Personnel, the Contractor's Personnel or the public is being violated.

d. **Improper Use of Explosives or Inadequate Procedures**: If the cause for the failure in firing the charge is the use of inadequate explosives for the given conditions (for example, improper or defective explosives, explosives that are not sufficiently water- or humidity-proof, or explosives that cannot be used with certain bore diameters), the Contractor shall, replace this type of explosive with one that is appropriate for the given conditions or necessary to solve the problem.

13. **Misfire Handling Procedures**: Should a visual inspection indicate that complete detonation of all charges did not take place, the following procedures shall be followed.

a. For non-electric systems, the tube shall be checked to make sure that the detonation has entered the blast area.

b. Should an inspection of the lead in the tubing line indicate that there is a break in the line or if the tubing did not fire, then the system shall be repaired and the blast re-fired.

c. If the inspection indicates that the trunk line has fired and misfired charges remain:

1) The blaster shall exclude all Contractor's Personnel except those who are necessary to rectify the problem.

2) Nearby roads shall be closed to traffic if a premature explosion could be a hazard to such traffic.

3) The blaster shall correct the misfire in a safe manner. If the misfire poses problems that cannot be safely corrected by the blaster, a blasting expert or an explosive company representative, skilled in the art of correcting misfires, shall be called to rectify the problem.

14. **Safety Meetings**: Safety meetings, including explosive handling and blasting safety, shall be conducted by the Contractor and the Contractor's Personnel to ensure proper working practices and compliance with the safety regulations and to review any lessons learned from past experience. The Contractor shall provide the Employer's Representative with reports from these meetings. Meetings shall be scheduled at least 3 times a week, or daily if required.

15. **Blast Guarding and Area Security**: A checklist for clear-out procedures and access control shall be developed and used by the Contractor so that these precautions are effectively carried out every time. Everyone working on a blast evacuation site and those in charge of area security shall have clearly defined responsibilities.

16. **Wind Direction**: The Contractor shall provide a wind sock to get an orientation of the wind direction prior to the shot in order to move the personnel to a safe location and prevent unnecessary exposure to toxic fumes.

17. **Drilling and Blasting According to Design**: To guarantee slope stability, the Contractor shall drill and blast only as necessary to reach the design configuration of the slopes being executed**.**

B. **Packaging**, Transportation, and Handling Explosives:

1. **Packaging**: All boxes shall be clearly labeled with information, such as the type of explosive, manufacturer's brand name, class, date of manufacture, weight, cartridge number, and size. Packaging for explosives should not exceed [A11]22.63 kilograms (50 pounds)[A11] in net weight per packaging unit. This is to prevent back injuries and the striking of the explosives.

2. **Transportation and Handling at the Work Site**: The Contractor shall be responsible for the transportation and handling of the explosives from the storage magazine to the Site. Explosives shall be provided by the Contractor daily and only in the amounts that will be used for blasts scheduled for that day. If, for any reason, not all the explosives issued are used during the scheduled blasts, the

excess amounts shall be returned to the storage magazine immediately, as indicated in 29 CFR 1910.109(e)(3)(vii). Explosives shall not be stored at the excavation area. According to regulations, they may be stored at a work site, but at a safe distance from the excavation area. The Contractor shall develop a tracking system to ensure that all the issued explosive materials are really used for the project.

C. **Materials**: All required material and equipment for the performance of blasting shall be the responsibility of the Contractor. Explosives and initiation devices shall be certified by IME, OSHA, the U.S. Bureau of Mines, or USACE.

1. **Explosive**:

a. **Acceptable and Unacceptable Explosives**: Explosives made with nitroglycerine-based material will not be permitted for safety, health, and environmental reasons. Dry blasting agents and slurries or water gels and emulsions are acceptable. Explosives are known to age and deliver much less than the rated energy. For this reason, it is required that all explosives used on this Contract be 1 year or less in age. Products that do not meet manufacturers' specifications shall not be used on the project.

b. **Bulk Explosives**: Bulk explosives, such as ammonium nitrate and fuel oil, may not contain the proper amount of diesel oil due to evaporation or improper mixing. Low diesel oil drastically reduces the energy content of the explosive and commonly produces reddish brown or yellow fumes upon detonation, even in dry blastholes. Products that do not meet the manufacturer's specifications shall not be used on the project.

c. **Aged or Deteriorated Explosives**: When, in the opinion of the Employer's Representative, any blasting product is either of excessive age or in what appears to be a deteriorated condition, all blasting shall cease until the product's age or quality can be determined. No blasting product shall be brought to the job site if the date codes are missing.

d. **Product Testing by the Employer's Representative**: At the option of the Employer's Representative, products may be tested by an independent organization to determine performance, as compared to the manufacturer's data sheet. . If the product performance or composition deviates by more than the percentage amount established by the manufacturer in the manufacturer's data sheet, that lot number will be rejected. Acceptable deviation depends on the standard used for a particular test. When the blasting product is rejected, the cost of testing shall be paid by the Contractor.

2. **Initiating Devices**:

[A11]a. **Approved Type**: Non-electric caps, safety fuses, primers, electronic detonators, and detonating cords shall be of an approved type.[A11]

b. **Age of Blasting Caps**: The delay elements in blasting caps are known to deteriorate with age. For this reason, it is required that all blasting caps used on this Contract be 1 year or less in age.

c. **Accuracy of Firing Times**: To ensure the accuracy of firing times of blasting caps, it is required that each cap period come from one lot number. Mixing of lot numbers for any one cap period is prohibited.

3. **Blasting Accessories**: Blasting accessories, including testing instruments, shall be of a non-electric firing system type approved by the Employer's Representative.

D. **Scheduling – Drilling and Blasting Plan(s)**: In addition to complying with Subparagraph 1.03 A.7., the Contractor shall consider nearby excavation work, the presence of green concrete, vessels that transport combustible liquids, etc.

E. **Scaling and Stabilization**:

1. **Scaling**: The slopes shall be scaled throughout the span of the Contract and at such frequency as required to remove all hazardous loose rock or overhangs. The slopes shall be hand-scaled using a suitable steel mine-scaling rod. Other methods such as machine scaling, hydraulic splitters, or light blasting may be used to supplement hand-scaling.

2. **Removal and Stabilization**: All rock on the cut face that is loose or hanging, or which creates a potentially dangerous situation, shall be removed or stabilized to the Employer's Representative's satisfaction during or upon completion of the excavation in each lift. Drilling of the next lift will not be allowed until this removal and stabilization work has been completed.

F. **Production Blasting Operations**: All production blasting, including that carried out with the test-pattern requirements (Paragraph 1.06), shall be performed in accordance with the following general requirements.

1. **Production Blasthole**:

a. **Patterns**: Production blastholes shall be drilled on the patterns reviewed by the Employer's Representative.

b. **Tolerance**: The production blastholes shall be drilled within two blasthole diameters of the staked collar location.

c. **Restitution**: If more than 5 percent of the holes are drilled outside of this tolerance, at the option of the Employer's Representative, the Contractor may be required to refill these holes with crushed stone and re-drill them at the proper location.

2. **Plugged Blastholes**: If the blastholes are plugged or unable to be fully loaded, the Contractor shall deepen or clean out these holes. The blastholes shall all be checked and measured before any explosives are loaded into any of the holes to eliminate any safety hazard resulting from drilling near loaded holes.

3. **Proper Depth**: All blastholes shall reach their desired depth. If more than 5 percent of the holes are shallow before loading, the Contractor may re-drill the shallow holes to the proper grade.

[A11]4. **Burden Distance**: In order to control blasting effects, the Contractor is required to design, for every blast, an adequate burden distance (stiffness ratio).[A11]

5. **Hole Protection**: Blastholes shall be covered to prevent overburden from falling into the holes after drilling.

6. **Production Blasthole before Final Slope**:

   a. **Plane of Blasthole Drill**: The row of production blastholes immediately adjacent to the final slope face of the excavation shall be drilled on a plane approximately parallel to the final slope face.

   b. **Minimum Distance from Final Slope Face**: Production blastholes shall not be drilled closer than 1.8 meters (6 feet) to the final slope face. The Employer's Representative shall be notified of any deviation from this limit.

   c. **Bottom of Production Blasthole**: The bottom of the production holes shall not be lower than the bottom of the controlled blastholes (final slope face line) when controlled blasting techniques are used. If necessary, the Contractor shall seek approval from the Employer's Representative to allow the bottom of the production hole to be lower than the controlled blastholes by the amount of sub-drilling used on the production holes.

   d. **Maximum Diameter**: Production holes shall not exceed 150 mm (6 inches) in diameter. The Employer's Representative shall be notified of any deviation from this limit.

8. **Detonation**: Detonation of production holes shall be on a delay sequence toward a free face.

9. **Stemming Material**: Stemming material used in production holes shall be angular granular material or sand fine enough to pass entirely through a 9.5 mm (3/8 inch) sieve.

10. **Minimum Damage to Back Slope**: It shall be the Contractor's responsibility to take all necessary precautions in the production blasting so as to minimize blast damage to the rock back slope. The Contractor shall make every effort to design the blast direction away from the Canal.

G. **Pre-splitting**: Requirements mentioned here for pre-splitting shall also apply for cushion blasting.

1. **Forbidden Explosives for Pre-splitting**: Bulk ammonium nitrate fuel oil (ANFO) shall not be allowed in the pre-split holes. Only standard explosives manufactured especially for pre-splitting shall be used in pre-split holes. If the Contractor submits a non-standard type of explosive, he shall conduct a test to demonstrate its adequacy. Subparagraphs G.2, 3, 5, 6, 7, 8, 9, 10, and 11 are based on the Employer's practice and should be considered as a reference. The

Contractor shall submit data on these items as part of his blasting plan, especially if he plans to use any alternative practices.

2. **Limits to Hole Diameter**: The pre-split drill-holes shall not be less than 65 mm (2.5 inches) and not more than 100 mm (4 inches) in diameter.

3. **Explosive Diameter**: The diameter of explosives used in pre-split holes shall not be greater than one half the diameter of the pre-split hole.

4. **Tolerances**:

   a. **Tolerance in Hole Location**: Pre-split holes shall be drilled within 75 mm (3 inches) of the staked collar location. If more than 5 percent of the pre-split holes are outside of the 75 mm (3 inches) tolerance, they shall be filled with crushed stone, stemmed, and drilled again.

   b. **Tolerance in Hole Alignment**: The Contractor shall control the drilling operations by the use of proper equipment and technique to ensure that no hole shall deviate from the plane of the planned slope by more than 225 mm (9 inches), either parallel or normal to the slope. All drilling equipment used to drill the pre-split holes shall have electromechanical or electronic devices affixed to it to accurately determine the angle at which the drill enters the rock. Pre-split hole drilling shall not be permitted if these devices are either missing or inoperative.

5. **Length of Pre-Split Holes**: The length of pre-split holes for any individual lift shall not exceed 9 meters (30 feet), unless the Contractor can demonstrate to the Employer's Representative that he can stay within the above tolerances and produce a uniform slope. If more than 5 percent of the pre-split holes are misaligned in any one lift, the height of the lifts shall be reduced until the 225 mm (9 inch) alignment tolerance is met.

6. **Determining that Holes Are Free of Obstructions**: Before placing charges, the Contractor shall determine that the hole is free of obstructions for its entire depth. All necessary precautions shall be exercised so that the placing of the charges will not cause caving of material from the walls of the holes.

7. **Drill Hole Conditions**: Drill hole conditions may vary from dry to filled with water. The Contractor shall be required to use whatever type or types of explosives, blasting accessories, or both are necessary to accomplish the specified results.

8. **Fractional Portions of Standard Explosive Cartridges**:

   a. **Fixing to Detonating Cords**: If fractional portions of standard explosive cartridges are used, they shall be firmly affixed to the detonating cord in such a manner that the cartridges will not slip down the detonating cord nor bridge across the hole.

   b. **Spacing**: Spacing of fractional cartridges along the length of the detonating cord shall not exceed 750 mm (30 inches) center to center and shall be adjusted to give the desired results.

9. **Continuous Column Cartridges**: Continuous-column-cartridge explosives used with detonating cords shall be assembled and affixed to the detonating cords in accordance with the explosive manufacturer's instructions, a copy of which shall be furnished to the Employer's Representative.

10. **Bottom and Top Charges of a Pre-Split Hole**: The bottom charge of a pre-split hole may be larger than the line charges, but shall not be large enough to cause overbreak. The top charge of the pre-splitting hole shall be placed far enough below the collar and reduced sufficiently to avoid overbreak and heaving.

11. **Stemming**: The upper portion of all pre-split holes, from the top charge to the hole collar, shall be stemmed. Stemming materials shall be sand or other dry angular granular material fine enough to pass through a 9.5 mm (3/8-inch) sieve.

12. **Alternatives to Pre-Split Hole Drilling**: As long as equally satisfactory pre-split slopes are obtained, the Contractor, at his option, may either pre-split the slope face before drilling for production blasting or may pre-split the slope face and carry out the production blast at the same time, provided that the pre-splitting drill holes are fired first.

13. **Ground Vibration and Noise Reduction**: If required to reduce ground vibrations or noise, the detonations for pre-split holes may be delayed, providing the hole-to-hole delay is no more than 25 milliseconds.

14. **Tolerance in Pre-Split Slope Faces**: A pre-split slope face shall not deviate more than 300 mm (1 foot) from a plane passing through adjacent drill holes, except where the character of the rock is such that irregularities are unavoidable, as determined by the Employer's Representative. The 300 mm (1 foot) tolerance shall be measured perpendicular to the plane of the slope. In no case shall any portion of the slope encroach on the lower bench.

H. **Cushion (Trim) Blasting**:

1. **Alternative to Pre-Splitting Blasting**: Where the horizontal distance from the cut face to the existing face is less than 4.5 meters (15 feet), cushion blasting may be performed instead of pre-splitting. With the following exception, requirements previously given for pre-splitting shall also apply to cushion blasting.

2. **Difference between Cushion Blasting and Pre-Splitting**: Cushion blasting is similar to pre-splitting, except that the detonation along the cut face shall be performed after the detonation of all production holes. Differences in delay times between the line and the nearest production row shall not be greater than 75 milliseconds or less than 25 milliseconds.

I. **Line Drilling**: Unless otherwise shown on the drawings, the following shall apply for line drilling.

1. **Definition**: Line drilling is a technique where blastholes are drilled within 2 to 4 diameters of one another.

2. **Purpose**: Under proper geological conditions, these unloaded closely spaced drill holes can act as stress concentrators or guides to cause cracks to form between them.

3. **Exception**: In geologically complicated material, line drilling may not function as desired since fractures tend to concentrate at naturally occurring weakness planes rather than at the manmade weakness plane created by the line drilled holes.

4. **Use of Line Drilling**: Unloaded line drill holes shall be used in tight corners to guide cracks into a specific angle. Line drilling shall also be used between pre-split or trim blastholes to help guide the cracks.

J. **Pre-Blast Survey**: The Contractor shall conduct a pre-blast survey of the adjacent areas. The pre-survey shall encompass the area for probable range of vibration and air blast generated from the blasting operations. In spite of the fact that all parameters depicted in the specialized structural response to vibration bibliography have been determined statistically ─ and even if the Contractor complies with the distance or speed parameters ─ there is still a possibility of damage to structures surrounding the blasting site. Performing analysis of structures response and pre-blast inspections shall be required to minimize such problems.

1. Within the authority of this Contract, it is mandatory to conduct joint pre-blast inspections to document the condition and status of all structures, activities, and individuals that might be exposed to vibration, noise, [A13]air-blast,[A13]or other effects from blasting. Such inspections will be done one week before detonations start and followed up immediately after blasts. Depending on the duration of the blasting phase, the Contractor and the Employer's Representative will coordinate further joint follow-up and final visits, maintaining records to evaluate claims presented for damages resulting from the blasts.

2. The Contractor is responsible for the formal communication of blasting plans and notification of related activities to all commercial, private, and local governmental authorities regarding the performance of the drilling and blasting operations. [A17]Such notification shall be made directly to the people or organizations involved, announced in a nationwide newspaper or on television, or disseminated by any other means of publication that will ensure notification.[A17]

3. At least 30 days before initiation of blasting, the Contractor shall notify all residents or owners of dwellings, any nearby building, utilities, and other structures located in nearby areas that may potentially be at risk from blasting damage and shall perform the joint pre-blast inspection. The Contractor shall provide the amount of persons from his organization that he considers necessary, including his specialist on vibration control, to work with a representative team of specialists named by the Employer's Representative in conducting the pre-blast structural survey.

4. All nearby existing structures that would be subjected to wave motions with peak particle velocities greater than 1.0 inch per second or air-blast overpressure

greater than 0.05 psi (pounds per square inch), shall be inspected and their conditions documented in a "Pre-blast Inspection Form or Report" presented to the Employer's Representative before any blast is performed. For all the new infrastructures and structures, the Contractor shall establish his own threshold values for peak particle velocity and [A13]air-blast[A13] overpressure.

5. The survey method used shall be acceptable to the Contractor's insurance company and the Employer's Representative.

6. The Contractor shall be responsible for any damage resulting from blasting. The pre-blast survey and inspection records shall be made available to the Employer's Representative for review and filing.

7. [A17]The Contractor shall, in addition, process, document, and present to the acknowledgement of the Employer's Representative any and all claims of private citizens arising out of said use of explosives within 24 hours of receipt.

8. Subject to the requirements of relevant insurance policies, all property-damage claims shall be acknowledged by the Contractor (or his agent) and the claimed damage shall be inspected within 24 hours following initial notification, and a concerted effort shall be made to process the claim to a conclusion (acceptance, denial, or compromise) within 30 days after receipt, and the Contractor shall make every possible attempt to bring any remaining unresolved claims to final conclusion in no more than 90 days after cessation of all blasting in the Contract, documenting such attempts and providing status reports to the Employer's Representative.[A17]

K. **Drilling**: The Contractor shall submit his proposed methods for handling these items as part of his blasting plan, especially if he plans to use any alternative practices.

1. **Drill Hole Size**: Drill holes shall be of a size to give sufficient clearance to insert the explosives and shall be in accordance with the blasting plan.

2. **Drill Hole Depth**: The depth of the holes shall be decided by the Contractor in conformance with his method for excavating the rock.

3. **Casing**: Casing shall be used where drill holes are in loose gravel or other material that may cause the loss of the hole.

4. **Stemming**: Holes shall be stemmed with suitable angular-type stemming material immediately upon completion of loading.

5. **Decking**: Decking shall be allowed only for the bridging of severe voids. When decking is used, additional boosters shall be placed.

6. **Forbidden Drilling**: Drilling will not be permitted where horizontal distances to adjacent charged holes are less than 15 meters (50 feet) or the depth of the hole, whichever is greater. The Contractor should increase this distance to accommodate for angled holes that may intersect a loaded borehole. Drilling between loaded holes shall never be performed.

L. **Blasting**:

[A13]1. **Vibration Damage Criteria**: [A20]The blasting-design criteria are to limit blasts that could affect nearby structures, such as, but not limited to, earth dams, locks, housing units, or rock/soil embankments.[A20] The condition and sensitivity of these structures is critical in the blasting operations.

a. The Employer has [A17]developed the [A17] following limits to the peak particle velocity at:

1) [A20]the face of the final slopes and benches; and at the existing Gatun, Miraflores and Pedro Miguel Lock structures, and other nearby structures listed below in L.3.d) and e) shall not exceed a value higher than 50 millimeters per second (2 inches per second); and[A20]

2) [A20]the housing complexes at José Dominador Bazan (Davis), La Boca, Diablo, Clayton and Employer's facilities at Gatún and Corozal and similar type of facilities surrounding the Sites shall not exceed a value higher than 13 mm per second (0.5 inches per second)[A20]

b. Notwithstanding the above, the criteria to avoid damage shall be to limit peak particle velocity based upon the frequency of the blast vibration. Therefore the Contractor shall include in his blasting plan the methods used for monitoring vibration and calculating frequency. [A19]The Contractor shall use the safe-level criterion as described in the U.S. Department of the Interior, Bureau of Mines Publication, based on RI 8507 (Siskind et al, 1980) or the latest version.[A19] Refer also to "Drawbacks of Blast Vibration Regulations" by Mark S. Svinkin", Figure 1. The Contractor shall consider, also, the structure susceptibility rating, proximity to construction sources of vibrations and the sensitivity of the local population to nuisance.

c. [A17]The Contractor shall perform [A17] test blasts in advance of the Works and in accordance with this Section in order to verify the maximum peak-particle velocities that the nearby structures of concern, including the existing locks, can take without damage and to finish defining the safe limits of vibration for these structures (refer also to Paragraph 1.06) based on the criteria presented in Subparagraph b. above.

d. These limits may be modified by the Employer's Representative for certain locations where areas of geological instability appear to be too close for safety, as determined from studies and from devices installed by the Employer in the area. [A13]

e. Blasting records of previous projects nearby the Site of the Works [A17]are included in Volume VI (Reference Documents), Part 10.[A17] The Contractor shall use limit values that are commensurate with international standards to protect these structures. These limits shall take

into consideration factors such as structure type and age, frequency, vibration levels, and [A13]air-blast.[A13]

f. The Contractor shall run a pre-blast survey and shall monitor vibration from blasting to verify that the limits used are safe for slopes, benches, and structures. As an added precaution and for quality assurance, simultaneous monitoring of blast vibrations will be carried out by the Employer's Representative for the same purpose. The Contractor shall coordinate, prior to every shot, with the Employer's Representative, in order to have the monitoring equipment ready before the shot takes place.[A5]

2. **Blasting Monitoring**: The Contractor shall exercise utmost care so as not to endanger life or property while using explosives. The Contractor shall complete drilling and blasting requirements with **no damage** to any structure, vessels, or Canal side-slopes and without injuries to any person.

a. **Monitoring**: Whenever vibration damage to adjacent structures is possible, the Contractor shall design each blast and monitor it with approved seismograph(s) located between the closest and the farthest structure subject to vibration damage. The seismograph(s) used shall be capable of recording particle velocity for the three mutually perpendicular components of vibration in the range generally found with controlled-blasting techniques.

b. **Vibration Control**: Where blasting is necessary, the Contractor shall employ a specialist qualified in vibration-control methods and capable of analyzing results obtained from seismograph readings.

1) [A19]The Contractor shall provide the Employer's Representative with the qualifications of the seismic specialist, as specified under Subparagraph 1.05 A.1., to include, but not be limited to, past experience, training, and education.[A19] The acceptability of the specialist is subject to the approval of the Employer's Representative.

2) The Contractor shall provide a minimum of six seismographs to measure and record ground movements caused by each blast detonated under the Contract. Seismograph operators shall be qualified personnel capable of setting up instruments at designated locations and efficiently recording the blast, [A13]i.e. measurement of structure vibrations.[A13] The seismographs shall be placed at locations to include, but not be limited to, the nearest buildings, structures, or utilities and such locations are to be approved by the Employer's Representative.

3) Blasting shall be controlled in such a manner that the maximum ground vibration level at any structure that is vulnerable to damage shall not exceed a value of peak particle velocity (inches

per second) or an energy ratio previously predetermined by the Contractor.

4) The instrumentation shall record frequency and ground particle velocity in three orthogonal directions (vertical, radial, and transversal directions with respect to the location of the blast) or shall have sufficient resolution of acceleration or displacement such that particle velocity can be readily and accurately determined from the records. The instantaneous vector sum of the three directional components of vibration shall be used to compute the maximum vibration level. The record for each blast shall consist of seismograph records identified by instrument number; location of instruments; date, time and location of blast; amount of explosives used; peak particle velocity; and all other data necessary to adequately control blasting operations.

c. [A13]**Air-blast**[A13] **Control**:

1) The Contractor shall employ a specialist qualified in making air-blast overpressure measurements on selected detonations, analyzing the results obtained, and making air-blast[A13] predictions for succeeding detonations.

2) [A19]The Contractor shall provide the Employer's Representative with the qualifications of the air-blast specialist, as specified under Subparagraph 1.05 A.1., to include, but not be limited to, past experience, training, and education.[A19] The acceptability of the specialist is subject to the approval of the Employer's Representative.

3) The maximum peak positive [A13]air-blast [A13] overpressure at any structure, vehicle, or vessel (moored or underway) with glass windows shall not exceed 0.05 psi. In case the Contractor plans to exceed this value, a pre-blast survey shall be conducted.

4) Blasting operations shall not be conducted from 1 hour before sunset to 2 hours after sunrise or when a temperature inversion or heavy low-level cloud cover exists.

5) The peak positive [A13]air-blast [A13] overpressure developed by a test blast shall be measured within +/-10 percent at three or more locations and to peak overpressure levels at or below 0.01 psi.

6) The [A13]air-blast [A13] overpressures from the test events should be monitored at ranges extending from the range of the closest structure to any planned detonation outward of an overpressure level of 0.01 psi or over a range from 150 to 915 meters (500 to 3,000 feet), whichever is greater.

7) Results from the initial monitoring of a test blast shall be used to predict [A13]air-blast[A13] overpressures for succeeding events and to ensure that peak positive overpressures do not exceed 0.05 psi at the closest structure or vessel moored or underway.

8) At the completion of the initial test blasts, one copy of the [A13]air-blast[A13] records from each test blast conducted shall be furnished to the Employer's Representative, showing the date, time, and location of the blast; the amount of explosives used; peak positive overpressure; and all prediction curves necessary to adequately control future blasting operations.

d. **Structures of Concern**:

1) Blasting may be required near structures located within the polygons defined in the following tables. The structures in this group are considered structures of concern. This group is not considered complete, and blasting may not be required near all of the locations included.

2) The purpose of the group is to orient the Contractor on the type and location of structures that could be within the [A13]affected[A13] range of the blasts and might require his designs to be carefully controlled to prevent damages.

3) The Contractor shall demonstrate that, during any blasting operation, peak particle velocity and frequency are within the tolerable limits of the type of structure concerned.

Gatun Locks	
Easting	**Northing**
618418.2269	1026044.098
618271.6563	1025765.118
618139.6223	1024670.655
618102.8651	1024671.803
618086.8951	1024658.156
618056.1949	1024488.864
618114.0774	1024397.609
618157.6826	1024100.064
618283.4731	1024377.259
618406.0477	1024480.324
618418.5964	1024566.274
618372.0934	1024722.693
618423.7042	1025124.272
618479.6249	1025734.833

Pedro Miguel Locks	
Easting	**Northing**
651944.4663	997285.4873
652083.3154	996957.4129
652356.4829	996715.6407
652673.6388	996496.0393
653011.4119	996339.4152
652818.1283	996665.7836
652610.0512	996885.3625
652283.4078	997178.4686

Miraflores Locks	
Easting	**Northing**
654152.1097	995231.7899
654322.6679	994899.2633
655063.0274	994155.211
655389.52	993968.9209
655209.9287	994302.9142
654937.9854	994595.6346
655004.2293	994670.598
654911.984	994750.2215
654864.7728	994693.6583
654718.2347	994845.2897
654549.0191	994989.035
654464.1832	995033.8569

Gatun Cemetery	
Easting	**Northing**
618987.2831	1025364.135
618986.7047	1025365.197
618958.3916	1025417.214
618923.5671	1025405.815
618918.6485	1025397.168
618936.3556	1025366.511
618952.2921	1025343.91
618987.7784	1025363.225
618987.2831	1025364.135

Building 206 Gatun	
Easting	**Northing**
618977.5938	1025005.549
619094.0269	1025002.301
619080.7289	1024897.158
618956.9093	1024914.583

Corozal Launch Landing	
Easting	**Northing**
656069.3429	992982.2024
656246.5248	993047.1725
656327.2849	992803.1243
656157.2085	992735.8658

Diablo Tug Landing	
Easting	**Northing**
656788.9679	991157.5945
656788.716	991119.5664
656958.8073	991117.8041
656966.87	991101.4334
656974.6822	991068.9455
657005.531	991060.6346
657035.576	991131.6055
657007.1878	991161.1201

Balboa Docks	
Easting	**Northing**
658069.7601	990791.0985
657700.096	990669.7688
657035.576	991131.6055
657005.531	991060.6346
657798.2411	990179.0847
657483.6318	989828.8874
657533.8969	989569.6703
657543.2471	989507.0709
657462.4192	989431.625
657480.7608	989246.1716
657515.7164	989183.3879
657543.9382	989185.8582
657669.738	989250.9781
657723.1657	989331.693
657740.9366	989417.1667
657827.3275	989567.5404
657945.3671	989934.4517
658154.4916	990158.1189
658110.3795	990213.6276
658195.3364	990311.584
658114.3328	990682.2283

Rodman Docks	
Easting	**Northing**
656432.1816	989825.3432

Rodman Docks	
Easting	**Northing**
656827.7654	990139.1667
656901.7541	990012.4064
657078.9687	989516.576
656794.0626	989332.3948

La Boca	
Easting	**Northing**
657783.3679	989220.3586
657886.687	988998.5745
658012.9649	988910.626
658247.6773	988922.3031
658294.7724	989070.3685
658266.822	989124.6407
658316.7049	989254.7908
658225.1458	989410.329
657874.1693	989315.7862
657834.4937	989443.8765
657740.9366	989417.1667
657723.1657	989331.6931

Industrial Tank Farm	
Easting	**Northing**
657834.4937	989443.8765
657874.1693	989315.7862
658225.1458	989410.329
658316.7049	989254.7908
658266.822	989124.6407
658294.7724	989070.3685
658199.4825	988770.7806
658500.8926	988614.1109
658558.7164	988564.4111
658647.7648	988551.6973
658733.3437	988560.9438
658774.9767	988586.3715
658814.1761	988763.7778
658673.7855	989135.8497
658338.0688	989639.0618
658096.9631	989590.2657

Balboa Yacht Club	
Easting	**Northing**
658769.957	987591.4103
659073.5495	987944.5769

Balboa Yacht Club	
Easting	**Northing**
658158.8264	988667.668
658001.3665	988558.4277

4) **Other Structures**: These include range towers, dams, cofferdams, bridges over nearby rivers, and the Centennial Bridge.

e. **Protection of Property**:

1) When drilling and blasting is performed, the Contractor shall take all necessary precautions for the protection of individuals, equipment, and property exposed to the effects of this operation.

2) In terms of the operation, the Contractor shall take all necessary precautions to minimize risks for transiting vessels and those tied-up at nearby docks, moorings, and/or marinas. In this respect, the Contractor is required to utilize all means possible (including signs, signals, announcements, evacuation, and the deployment of launches or cars) to keep transiting vessels, other craft, vehicles, and individuals from entering the blast site.

3) In terms of protecting the integrity of structures and private operations in the vicinity of the blasting site, the Contractor is required to plan, notify, and execute the detonations in close coordination with the Employer's Representative in order to adjust the design parameters, procedures, and execution as necessary to minimize the negative impact on properties, Canal traffic scheduling, individuals, or the quality of life in housing and commercial areas close to the work.

4) This requirement will be deemed to be fulfilled by the Contractor's compliance with procedures and techniques detailed in the Contractor's submitted safety and blasting plans and by following applicable safety codes and regulations recommended in handbooks of recognized explosives manufacturers and in the references listed in Paragraph 1.02 (*References Standards*).

[A16]f. The Contractor shall consider soil-structure interactions to ensure that vibrations will not affect housing areas. [A16]

g. [A20]The Contractor shall establish a monitoring program were a sample of houses, from a minimum of 3 up to a maximum of 5, at the locations indicated in Section 01 57 19.13 (*Environmental Management System*) Subparagraph 1.05 B.4., chosen randomly by the Contractor, are taken into consideration within the zone of influence of the blasting operations

for the installation of accelerometers and strain gauges on the walls and accelerometers and particle velocity transducers in the ground outside in coordination with the Employer's Representative. The selection criteria can be established by choosing the houses inside the range of influence established by the USBM RI 8507.[A20]

3. **Shots**: Equipment, explosives, and non-essential personnel shall be moved away to a safe distance prior to the blast. A minimum crew shall accomplish the shot. The blaster shall be in charge of the shot. Shots shall be checked and clear signals shall be sounded before the personnel and equipment are allowed to return to the blast area. The Contractor shall discontinue any method of blasting that leads to overshooting, is dangerous to navigation, is detrimental to slopes adjacent to the work site, or is otherwise determined objectionable by the Employer's Representative.

4. **Clearing Drill Holes**: Undetonated explosives shall be removed within 24 hours. Undetonated explosives shall be removed in accordance with IME safety procedures for handling and disposing of undetonated explosives and with the manufacturer recommendations for disposal.

5. **Repairs**: If damage to the material forming the final slopes and grades is caused by the Contractor's operations, the Contractor, at no additional expense to the Employer, shall perform additional excavation or wedging, as may be required to produce unbroken surfaces and uniform slopes. If damage to nearby structures is caused by the Contractor's operations, the Contractor, at no additional expense to the Employer, shall perform reparations, as may be required to restore them to their condition prior to damage.

M. **Disposal of Empty Explosive Boxes**: As indicated in 29 CFR 1910.109(e)(2)(i), empty containers, paper, and fiber packing materials that previously contained explosive materials shall be disposed of in a safe manner or reused in accordance with the Department of Transportation's Hazardous Materials Regulations (49 CFR parts 177–180). The Contractor shall follow approved written procedures to destroy old, misfired, or recovered products. If the disposal/destruction site for explosives is outside the limits of the Employer's operational areas, the Contractor shall comply with the regulations and procedures of the "Oficina de Seguridad para la Prevención de Incendios (OSEPI), Cuerpo de Bomberos de Panamá". (See *Capítulo V* of the *Reglamento general de las Oficinas de Seguridad para la Prevención de Incendios de la República de Panamá*, available through URL http://www.bomberosdepanama.gob.pa/5%20Explosivos.htm).

1.04 DESIGN CRITERIA/SYSTEM DESCRIPTION AND PERFORMANCE: The following descriptions apply to the work in this Section.

A. **Production Blasting**: Production blasting, as covered herein, refers to the rock-fragmentation blasts resulting from widely spaced production holes throughout the main excavation area adjacent to the final slope shown on the drawings. Production holes shall be detonated in a controlled delay sequence.

B. **Controlled Blasting**:

1. **Techniques**: Controlled blasting techniques are used to minimize damage to the rock back slope and to help ensure long-term stability. The Employer's Representative will require the Contractor to use controlled blasting techniques to form the faces of final slopes, even if the main excavation can be ripped.

2. **Description**: Controlled blasting refers to the controlled use of explosives and blasting accessories in carefully spaced and aligned drill holes to produce a free surface or shear plane in the rock along the specified excavation back slope. Controlled blasting techniques may include pre-splitting or another suitable method. Line drilling may be used in conjunction with pre-splitting or trim blasting.

   a. **Pre-Splitting**: Pre-splitting shall be thought of as a protective measure to keep the final wall, both those resulting from production blasting and from final slopes (see Subparagraph B.1. above), from being damaged by the production blasting. When pre-splitting, the detonation of the pre-split line shall be before the detonation of any production holes.

   b. **Cushion Blasting**: Cushion (trim) blasting offers no protection to the wall from the production blast and its sole purpose is to create a cosmetically appealing, stable perimeter. Cushion blasting is similar to pre-splitting, except that the detonation along the cut face shall be performed after the detonation of the production holes. Final faces shall be done with pre-splitting or line-drilling blasting techniques.

1.05 SUBMITTALS:

A. **Safety Submittals**:

1. **Personnel**: Qualifications for the blaster mentioned in Subparagraphs 1.03 A.1. and 1.03 A.2.f. and of the [A13]air-blast [A13] and seismic specialists shall be submitted to the Employer's Representative for approval at least 42 days before their services are required. Qualifications shall be in accordance with existing [A17]Laws, [A17] safety standards, and regulations that apply.

2. **Blasting Signals**: [A19]Details on the sound warning system specified in Subparagraph 1.03 A.3.b. shall be submitted to the Employer's Representative for review at least 14 days prior to any blasting.[A19]

3. **Lightning Protection**: [A19]The specifications for the lightning protection equipment specified in Subparagraph 1.03 A.11., shall be submitted for review to the Employer's Representative at least 42 days before being required.[A19]

4. **Inspection of Magazines**: A copy of the weekly inventory report shall be submitted to the Employer's Representative, as specified in Subparagraph 1.03 A.6.b., on a weekly basis.

5. **Blasting Schedule**: The blasting schedule specified in Subparagraph 1.03 A.7. shall be submitted to the Employer's Representative for approval at least 42 days prior to any blasting.

   a. For each shot, the Contractor shall furnish, at least 15 days prior to starting drilling and blasting operations, a drilling and blasting plan.

   b. The Employer's Representative shall have a maximum of 10 days to review the drilling and blasting plan submitted for each shot.

   c. **Changes**: Any change in the drilling or blasting plan shall be submitted for approval within the time frames indicated above.

   d. **Blasting Plan Form**: A sample blasting plan form is provided at the end of this Section to aid the Contractor in the proper submittal of blasting information to the Employer's Representative. Prior to drilling for each blast, the Contractor shall be required to submit this or another similar approved form with the information on the proposed shot.

   e. **Radio Transmitters**: [A19]Descriptive data, specifications, operating instructions, and any corresponding information on the radio equipment required under Subparagraph 1.03 A.10. shall be submitted for review together with the blasting plan.[A19]

B. **Explosive Materials**: Descriptive data, a material safety data sheet (MSDS), the manufacturer's quality certificate, and related literature for each type of explosive material to be used shall be submitted to the Employer's Representative for approval at least 42 days in advance of any blasting. Submittals shall include, as a minimum, the following:

1. **Relevant Characteristics**: Relevant characteristics of the material, such as the manufacturer's brand name, product name, packaging, weight and cartridge size, weight per box, and storage life or expiration date.

2. **Material Properties**: Material properties, such as base-material components (including ANFO or slurry), emulsions, explosive classification, sensitiveness, detonation velocity, energy, density, detonation pressure, fumes, flammability, water resistance, temperature sensitivity, and required detonating devices.

3. **Membership Certificate**: Certificate showing that the explosives furnished are manufactured by members or associate members of the Institute of Makers of Explosives or the Federation of European Explosives Manufacturers. Certification shall be provided from the manufacturer of the furnished explosive.

4. **Toxic Fumes Certification**: The Contractor shall submit toxic fumes certification from the manufacturer warranting that, 10 minutes after detonation of their product, nitrogen-oxide (NO-NO_2-NO_3) levels are below the 5 ppm OSHA permissible-exposure levels (PEL), assessed as a 15-minute time-weighted average exposure, which shall not be exceeded at any time during the

working day (29 CFR 1910.1000). Exposure levels shall also be below the American Conference of Government Industrial Hygienist short-term exposure limit (STEL) of 15 minutes for 3 ppm on a one-time basis for each day. Any concentration above 50 ppm is considered by OSHA as an immediate danger to life and health (IDHL).

C. **Production Blasting Submittals**: Production blasthole patterns specified under Subparagraph 1.03 F.1. shall be submitted by the Contractor and reviewed by the Employer's Representative.

D. **Velocity Limits**: The Contractor shall determine the maximum peak particle velocities so nearby structures are not affected, per Subparagraph 1.03 L., and submit them to the Employer's Representative for approval.

1. **Monitoring**: The location, type, and quantity of seismographs, per Subparagraph 1.03 L.2.a., shall be submitted for approval to the Employer's Representative.

2. **Vibration Reporting**: When blast intensity exceeds the maximum predetermined peak particle velocity, a field note or memorandum report on vibration intensity shall be attached and submitted with the respective event report within 24 hours after the blast to the Employer's Representative. The Contractor shall [A17]submit the record[A17] form for each blast on a daily basis.

E. **Initiating Devices**: Data on initiating devices such as non-electric caps, safety fuses, primers, detonating cords, and detonating cord delays shall be submitted for approval to the Employer's Representative. This submittal shall include the manufacturer's brand name, material safety data sheet (MSDS), and the manufacturer's quality certificate. Information such as detonating cord tensile strength, thickness, pentaerythrite tetranitrate (PETN) grains per foot, non-electric cap delays, primer dimensions, and initiation method shall be included in the submittal.

F. **Blasting Equipment**: Descriptive data and information for the blasting machine, alarm system, and communication devices shall be submitted for approval to the Employer's Representative.

G. **Method of Transportation and Handling Explosives**: Shall be submitted for approval to the Employer's Representative.

H. **Purchase Data**: Two copies of the Contractor's purchase orders and the manufacturer's invoice (including invoice number) and shipment packing list shall be submitted to the Employer's Representative.

I. **Daily Blasting Logs**: The Contractor shall provide the Employer's Representative, on a weekly basis, the daily logs of blasting operations. Each log shall be updated at the close of each day and shall include the number, times, and dates of blasts. The blasting logs are for quality-control and record-keeping purposes. Review of the blasting log by the

Employer's Representative shall not relieve the Contractor of his responsibility for the accuracy and adequacy of the log. The blasting log shall be a report of the actual blast and not a copy of the blasting plan. A sample blasting report form is provided at the end of this Section to aid the Contractor in the proper submittal of blasting information to the Employer's Representative. The Contractor shall include in his blasting report or log, the required information previously mentioned in this Subparagraph and any other information included in the sample blasting report plan, but not explicitly mentioned herein. The Contractor shall be required to submit this or another similar form with the information about the actual shot. Adoption of some type of similar simplified form for the blasting logs shall be required. The blasting locations and patterns and all the following information shall be submitted in the daily blasting log.

1. Station limits of the shot.
2. Plan and section views of drill pattern, including free face, burden, blasthole spacing, blasthole diameters, blasthole angles, lift height, and sub-drill depth.
3. Loading diagram showing types and amounts of explosives, primers, and initiators, as well as locations and depths of stemming.
4. Initiator sequence for blastholes, including delay times and the delay system in each blasthole.
5. Trade names and sizes of all explosives, primers, and initiators to be employed.
6. Signature of the blaster in charge.
7. From a visual examination of the broken mass, the Contractor shall determine and include in each log the approximate percentages of fragments, as follows.
    a. To 0.2 cubic meters (maximum particle dimension: 0.6 meters).
    b. From 0.2 to 1.7 cubic meters (maximum particle dimension: 1.2 meters).
    c. More than 1.7 cubic meters.

J. **Pre-Survey**: Shall be submitted to the Employer's Representative for record purposes.

K. **Video Recording of Blasts**: The Contractor shall take video recordings of each blast. Recordings shall start one minute before the blast and finish one minute after it. Video shall be indexed in a manner to properly identify each blast, including date/time and location; type of shot (e.g., close-up or pan left or right), and a brief description of what is being filmed. Video shall be in a digital format, which shall be readily played using most available media players. Copies of the recordings of blasts shall be furnished to the Employer's Representative on a weekly basis.

1.06 QUALITY ASSURANCE (TEST PATTERN):

A. **Demonstration**: After the Contractor submits his drilling and blasting plan and approval by the Employer's Representative is received, the Contractor shall demonstrate the effectiveness of his proposed plan on a short test section in a length compatible with the Contractor's blasting pattern.

B. **Test Section**: In general, a short test section shall not have more than 30 meters (100 feet) in length. The test section shall be drilled and blasted and sufficient material shall be excavated so that the Employer's Representative can determine if the Contractor's methods have produced an acceptable excavation slope.

C. **Unsatisfactory Results**:

1. **Results Considered Unsatisfactory**: Unsatisfactory tests shot results would arise from an excessive amount of fragmentation beyond the indicated lines and grade, excessive fly rock, or violation of other requirements of these specifications.

2. **Review of Drilling and Blasting Plan**: If, in the opinion of the Employer's Representative, the results of the test shot or shots are unsatisfactory, then, notwithstanding the Employer's Representative's prior review of such methods, the Contractor shall adopt such revised methods as are necessary to achieve the required results.

D. **Authorization to Proceed with the Work**: The Contractor will not be allowed to drill ahead of the test shot area until the test section has been excavated and the results reviewed by the Employer's Representative.

E. **Failure during the Progress of the Work**:

1. **Failure Even Though the Test Pattern Was Successful**: If, at any time during the progress of the work, the methods of drilling and blasting do not produce the desired result of a uniform slope and shear face within the tolerances specified for the excavation of the Works, the Contractor shall be required to drill, blast, and excavate in short sections, not exceeding 30 meters (100 feet) in length, until a technique is arrived at that will produce the desired results.

END OF SECTION

BLASTING PLAN

LOCATION_____ JOB_____ DATE_____
TYPE OF SHOT_____ STATION_____
TYPE OF MATERIAL_____
DISTANCE TO NEAREST STRUCTURE_____ METERS

PRODUCTION BLAST

NUMBER OF HOLES_____ HOLE DIAMETER _____ DRILL ANGLE _____
BURDEN_____ M SPACING_____ M DEPTH_____ M
STEMMING_____ M STEMMING MATERIAL_____
SUB-DRILLING_____ LIFT HEIGHT_____

METHOD OF FIRING (CHECK ONE) ELECTRIC_____ NON-ELECTRIC_____
SEQUENTIAL TIMER (CHECK ONE) YES_____ NO_____ TIMER SETTING(S)_____
SURFACE-DELAY PERIODS_____
DOWN HOLE DELAY PERIODS_____

TYPES OF EXPLOSIVES_____
SIZE OF PRIMERS_____
PRIMER LOCATIONS_____

TRADE NAMES OF EXPLOSIVES_____ AMOUNT_____
_____ AMOUNT_____
_____ AMOUNT_____
_____ AMOUNT_____
TRADE NAMES OF PRIMERS _____ AMOUNT_____
_____ AMOUNT_____
_____ AMOUNT_____
TRADE NAMES OF INITIATORS _____ AMOUNT_____
_____ AMOUNT_____
_____ AMOUNT_____

MAXIMUM KG/DELAY _____
ANTICIPATED VIBRATION LEVEL _____
SCALED DISTANCE _____

NOTES:
1. Provide drawing of pattern, initiator hookup, hole-firing times, and cross section of blasthole showing explosive loads and primer locations, depth, sub-drill, and stemming.
2. Include manufacturer's data sheet for all products.

BLASTING PLAN (continued)

CONTROLLED BLAST

CHECK ONE: PRE-SPLIT_____ CUSHION BLAST_____ LINE DRILL_____
DIAMETER OF DRILL HOLE_____ HOLE DEPTH_____
DRILL-HOLE ANGLE_____

METHOD OF INITIATION_____
DELAYS USED_____ HOLES/DELAY

DESCRIBE METHODS USED TO MAINTAIN HOLE ALIGNMENT:
_____
_____

DISTANCE FROM PRODUCTION HOLES_____
OR
DISTANCE FROM BUFFER ROW_____

BUFFER ROW HOLE DIAMETER_____ CHARGE DIAMETER_____
TOTAL CHARGE_____ BURDEN_____
SPACING_____ DEPTH_____

TRADE NAMES OF EXPLOSIVES_____ AMOUNT_____
_____ AMOUNT_____
_____ AMOUNT_____
_____ AMOUNT_____
TRADE NAMES OF PRIMERS _____ AMOUNT_____
_____ AMOUNT_____
_____ AMOUNT_____
TRADE NAME OF INITIATORS _____ AMOUNT_____
_____ AMOUNT_____
_____ AMOUNT_____

NOTE:
1. Provide drawing of pattern, initiator hookup, hole firing times, and cross section of blasthole showing explosive loads and primer locations, depth, sub-drill, and stemming.
2. Include manufacturer's data sheet for all products.

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