Groupe Blastforce Canada Inc.

424 Churchill Avenue (corner Byron Avenue)
Ottawa, ON

Technical Report

Recommendations and vibration estimations for urban blasting applications

BBA Document No. / Rev.: 64620004-000000-4M-ERA-0007-R00
August 1, 2025

FINAL

2020 Robert-Bourassa Blvd.
Suite 300
Montréal, QC H3A 2A5
T +1 514.866.2111 **F** +1 514.866.2116
BBAconsultants.com
All rights reserved. © BBA

Contributed by:
Paulo Gamez Campos, EIT /CPI (OIQ)

Prepared and checked by:
Riccardo Del Bosco, P.Eng.
PEO No. 100569037

LICENSED PROFESSIONAL ENGINEER
R. L. DEL BOSCO
100569037
PROVINCE OF ONTARIO
2025-08-01

REVISION HISTORY

Revision	Document Status – Revision Description	Date
R00	Final	2025-08-01

This document has been prepared by BBA for its Client and may be used solely by the Client and shall not be used nor relied upon by any other party or for any other purpose without the express prior written consent of BBA. BBA accepts no responsibility for losses, claims, expenses or damages, if any, suffered by a third party as a result of any decisions made or actions based on this document.

While it is believed that the information contained herein is reliable under the conditions and subject to the limitations set forth in the document, this document is based on information not within the control of BBA, nor has said information been checked by BBA, and BBA, therefore, cannot and does not guarantee its sufficiency and accuracy. The comments in the document reflect BBA's best judgment in light of the information available to it at the time of preparation

Use of this document acknowledges acceptance of the foregoing conditions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

Appendix A: OPSS 120

Appendix B: Third-party Requirements in the Vicinity of Natural Gas Facilities Standard (Enbridge Gas inc.)

Appendix C: Technical data sheets (Explosives and accessories)

.

1. Introduction

BBA has been mandated by Groupe Blastforce Canada Inc. to review and provide recommendations on the proposed drilling and blasting parameters required to undertake the rock excavation process for the residential development project located at 424 Churchill Avenue, Ottawa (ON). The footprint and approximate location of the planned excavation site are displayed in Figure 1. Standard bench blasting practices will be employed for cutting and fragmenting the rock mass to the planned design elevation required for structural components such as footings and foundation walls. The estimated volume of rock (banked) subjected to drilling and blasting for this project is ≈ 5,500 m^3.

Figure 1: Overall project location and footprint

The drilling and blasting process will occur in three (3) successive phases:

- Phase 1 - Includes the implementation of line-drilling along the perimeter of the zone where bench blasting will take place. The line-drilling is intended to serve two (2) main purposes, namely, to limit overbreak past the dig lines and reduce the propagation of blasting-

induced vibrations outside of the excavation perimeter. Line-drilling will be completed using 90mm-diameter drill holes spaced at every 200mm (center-to-center);

- Phase 2 will include the drilling and mechanical excavation of an attenuation trench implemented parallel to / along the boundary of the existing and neighbouring commercial building located to the West of the site (352 Danforth Ave.). The attenuation trench must be fully excavated to proper depth (i.e.: ≈ 2 ft or 0.6 m deeper than the projected blasthole depth) in order to be considered effective;
- Phase 3 encompasses the drilling, blasting and excavation of the rock mass contained within the perimeter of the zone to the desired grade and elevation.

Figure 2 displays the projected locations or areas for the three (3) main phases of work described previously, namely the projected line-drilling axes, the mechanically excavated attenuation trench, and the bench blasting activities.

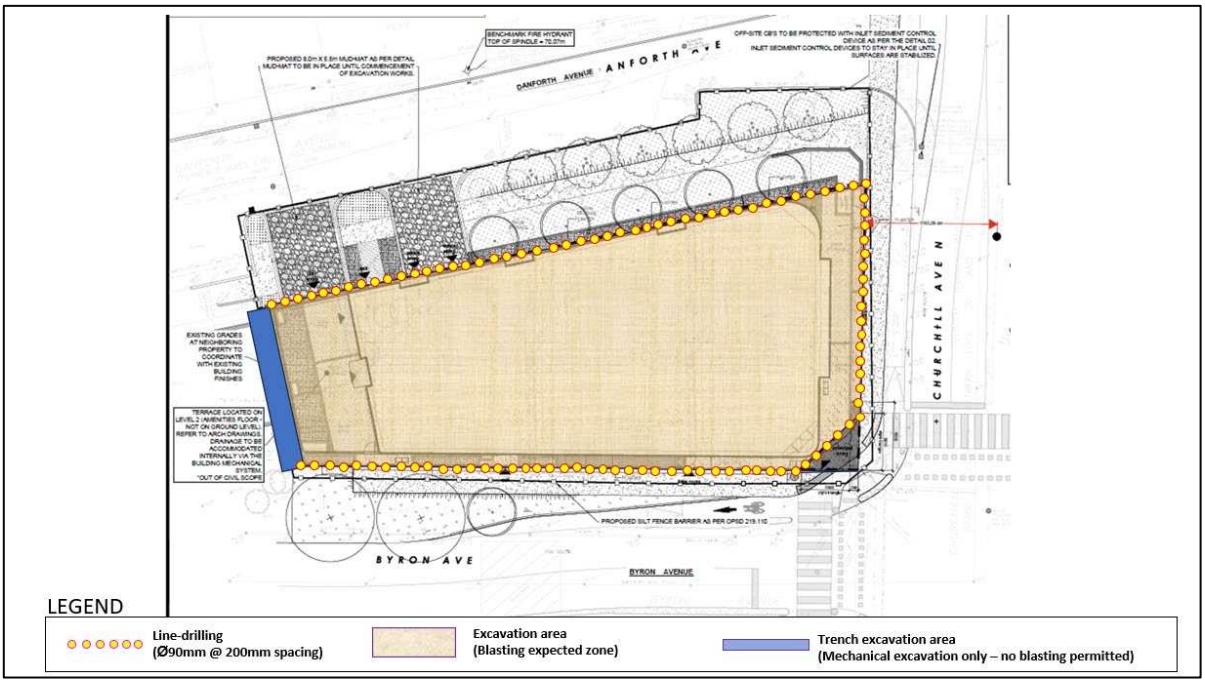


Figure 2: Projected phases of work leading to drilling and blasting activities

Given the site's urban setting as well as its proximity to neighbouring buildings, infrastructure, and utility lines, the principal aim of this review is to ensure the proposed drilling and blasting parameters and proposed methods abide to applicable regulations and that the necessary precautions are taken to mitigate the risk of damaging any private or public infrastructure in the vicinity of the excavation limit.

2. Methodology

The proposed blasting activities must comply with the *OPSS 120 – General Specification for the use of explosives – Municipal edition* (Nov. 2019 or most recent edition), as well as any additional standards, regulations, or contractual agreements in place.

Following the review of the supplied civil plans for the project, BBA confirms that existing service lines (i.e.: electrical, telecom, water, sanitary, storm, and gas) are present in the vicinity of the excavation site. Most of the underground facilities nearest to the site are located along the east axis of the site, running parallel to Churchill Avenue and along the North axis of the site, running parallel to Danforth Avenue. Additional details related to minimum distances between blasting zones and existing infrastructure will be provided in the upcoming sections of this report.

Vibrations generated by blasting activities must be measured using a network of seismographs placed at adequate locations surrounding the site. The seismographs must be calibrated and equipped with standard triaxial ISEE geophones. The blasting contractor must be advised of the vibration results to adjust loading parameters (if required to do so). If changes brought upon the blasting parameters do not mitigate or reduce the vibration spectrum below the designated thresholds, the Contractor will have to resort to mechanical means of rock breakage to achieve the design excavation depth.

2.1 Basis of calculations

Given the absence of site-specific geological attenuation constants, which in part define the transmissibility of blasting-induced ground vibrations towards surrounding infrastructure, an empirical formula developed through an extensive U.S.B.M (United States Bureau of Mines) study and refined by Holmberg-Persson is commonly used to estimate the vibration amplitudes generated by blasting events. The equation for the model and its variables are displayed below:

$$\boldsymbol{V = K \left(\frac{d}{\sqrt{w}} \right)^{\alpha}}$$

Where:

V : Peak Particle Velocity (mm/sec);

d : Distance separating the explosive charge and the area of concern (m);

K & a : Confinement and geological attenuation constants;

w : Explosive charge detonated per delay (kg).

To establish the K and a (site-specific) attenuation constants, blasting vibration data and parameters (i.e.: charge per delay and distance separating blasting events and monitoring locations) must be compiled, processed and analyzed accordingly as blasting operations progress.

Due to the absence of these specific variables (i.e., new site), the U.S.B.M. has established, following substantial field-based studies and compilations, typical attenuation constants that can be integrated into the equation to adequately predict ground vibration amplitudes stemming from blasting events. The equation, including the U.S.B.M. derived constants, is shown below:

$$\mathbf{V = 1143 \left(\frac{d}{\sqrt{w}}\right)^{-1.6}}$$

The following equation does not consider the frequency spectrum and therefore cannot predict the dominant vibration frequency at a specific point of interest. As a result, while completing this report, BBA assumes the blasting events will generate dominant frequencies in the > 40 Hz range. The blasting parameters have therefore been developed based on a 50 mm/s maximum vibration amplitude. Upon the start of operations, scaled-down blasting events can be foreseen to monitor the vibration amplitudes and frequency spectrums recorded at specific locations around the site using designated seismographs. This form of continuous monitoring will allow the blasting contractor to adjust the actual maximum charge per delay based on the distances between blasting events and all infrastructure and facilities subjected to vibration control.

In accordance with the OPSS 120, the blast designs reviewed in the following report assume dominant frequencies generated by blasting events will be > 40 Hz; therefore, the design vibration threshold (peak particle velocity) for all surrounding infrastructure and utilities is therefore assumed to be **50 mm/s**. Vibration monitoring will validate the dominant frequency spectrums obtained during blasting activities and provide additional guidance on the applicable peak particle velocity threshold.

2.2 Site overview and critical distances

Table 1 presents the shortest horizontal distances between the excavation boundaries and the nearest surrounding infrastructure, including private, commercial, and public elements. These structures were included in the analysis due to their proximity to the excavation site. For reference, the locations of the closest underground public utilities, such as sanitary sewers, storm

sewers, and water mains, are also shown. The distances portrayed correspond to the shortest horizontal distances separating excavation boundaries and identified infrastructure.

Table 1: Distances from critical residential, commercial, and underground (private/public) infrastructure

Infrastructure	Location	Distance (from bench blasting activities)	PPV threshold	Special considerations?
Existing Building	West of excavation zone	≥ 0,1 m	50 mm/s (at dom. freq. >40 Hz)	Attenuation trench in place, at least 2m wide (excavated mechanically to proper depth prior to blasting activities). In areas within 3 meters of the building, double decking will be implemented
Gas line	East (Chruchill Avenue)	≥ 17 m		
Telecom (Bell)		-		
Telecom (TV)		-		
Watermain (Ø300 mm)		≥ 14 m		
Sanitary sewer (Ø250 mm)		≥ 13 m		
Storm sewer (Ø675 mm)		≥ 11 m		
Electrical (100mm Hydro)		≥ 5,3 m		
Gas line	South (Byron Avenue)	-	50 mm/s (at dom. freq. >40 Hz)	
Sanitary sewer (Ø250 mm)		-		
Telecom (Rogers)		≥ 4,79 m		Mechanical excavation required due to proximity to infrastructureTo implement in areas within 12 meters of infrastructure (To be determined)
Storm sewer (Ø675 mm)		-		
Watermain (Ø300 mm)		-		
Electrical		-		
Gas line	North (Danforth Avenue)	≥ 16 m	50 mm/s (at dom. freq. >40 Hz)	
Sanitary sewer (Ø225 mm)		≥ 14 m		
Telecom (Bell)		-		
Storm sewer (Ø675 mm)		-		
Watermain (Ø150 mm)		≥ 13 m		
Telecom (TV)		-		
Electrical		≥ 4 m		
Building 349 Danforth Avenue		≥ 18,5 m		

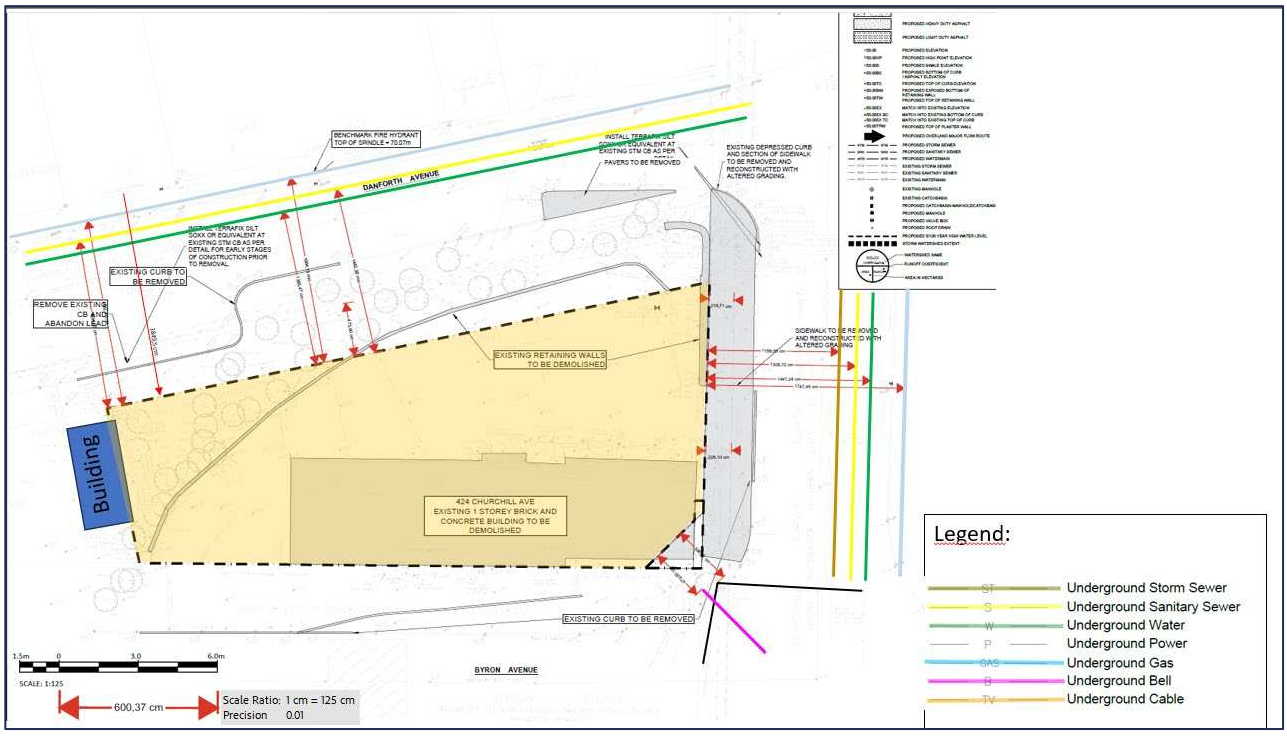


Figure 3: Plan view (civil drawings) used to identify critical surface and underground infrastructure and estimate distances relative to blasting activities (not all shown for clarity - see Table 1 for additional information)

3. Blast design parameters

Bench blasting design parameters have been established based on the required depth of cut range of 2.4 m:

- Scenario #1 (2.4 m cut) provides a decking option to reduce the unitary charge to ≈1.3 kg/delay (if required) due to proximity with sensitive infrastructure;
- Scenario #2 (2.4 m cut) considers a single column charge - equivalent to ≈ 3.1 kg/delay;
- Scenario #3 (3 m cut) considers a single column charge - equivalent to ≈ 3.9 kg/delay.

The provided scenarios are calculated empirically, and monitoring will confirm that the vibration amplitudes and frequencies are maintained within the applicable tolerances.

It is likely that a portion of the rock breakage requirements in areas closest to the existing service lines will have to be undertaken by mechanical means (i.e.: hydraulic rock-breaker). The areas

subjected to these constraints will be verified and confirmed through vibration monitoring initiatives.

The applicable blasting design scenarios are detailed in Table 2. The following scenarios have been developed to provide both operational flexibility as well as increased vibration control measures when blasting is taking place in proximity to critical infrastructure. It is the responsibility of the blasting contractor to establish the distances to the nearest infrastructure prior to each blasting event and adapt the loading configurations accordingly.

As operations progress, the compilation of vibration readings obtained from the network of seismographs monitoring the site may be used to review critical separation distances and to refine the site-based and additional attenuation factors being applied. It is also recommended to begin blasting operations as far as possible from existing and monitored infrastructure to validate the predicted (estimated) vibration amplitudes as well as the effectiveness of the vibration attenuation measures in place (i.e.: line-drilling).

Table 2: Blast design scenarios

Description	Units	Loading scenarios and parameters		
		1	2	3
		2.4 m cut - 2 decked charges	2.4 m cut - single charge	3 m cut - single charge
Blast type [**T**: Trench, **B**: Bench]		B	B	B
Rock density	[kg/m^3]	2700	2700	2700
Hole Diameter	[in]	2.5	2.5	2.5
	[mm]	64	64	64
Bench height	[m]	2.4	2.4	3
Sub-drill	[m]	0	0	0
Average Hole Depth	[m]	2.4	2.4	3
Stemming length - rock only	[m]	**1.2**	**1.2**	**1.5**
Total equivalent stemming length	[m]	**1.2**	**1.2**	**1.5**
Stemming / Explosive Diameter ratio	[-]	**24.0**	**24.0**	**30.0**
Scaled Depth Of Burial	[-]	**1.12**	**1.12**	**1.35**
Burden	[m]	1.2	1.5	1.5
Spacing	[m]	1.2	1.5	1.5
Theoretical Volume Per Hole	[m^3]	3.5	5.4	6.8
Number of Decked Charges	[un]	2	1	1
Total Inert Deck Length	[m]	0.3	0	0
Available Explosive column length	[m]	0.9	1.2	1.5
Explosive Products				
Explosive ID #1	[-]	Powerfrac 50 x 400	Powerfrac 50 x 400	Powerfrac 50 x 400
Explosive ID #2	[-]	Fortel Ultra 50 x 400	Fortel Ultra 50 x 400	Fortel Ultra 50 x 400
AVG Density - Explosive #1	[g/cm^3]	1.37	1.37	1.37
AVG Density - Explosive #2	[g/cm^3]	1.28	1.28	1.28
Charge Ø - Explosive #1	[mm]	50	50	50
Charge Ø - Explosive #2	[mm]	50	50	50
Deck A (BOTTOM CHARGE)				
Charge length - Explosive #1	[m]	0.40	0.40	0.50
Charge length - Explosive #2	[m]	0.0	0.80	1.00
Charge Summary DECK A (BOTTOM CHARGE)	[kg]	**1.08**	**3.09**	**3.86**
	[m]	0.40	1.20	1.50
Deck B (MID-COLUMN)				
Charge length - Explosive #1	[m]	0.3	0.0	0.00
Charge length - Explosive #2	[m]	0.2	0.00	0.00
Charge Summary DECK B (MID-COLUMN)	[kg]	**1.31**	**0.00**	**0.00**
	[m]	0.50	0.00	0.00
Summary of Drilling & Loading Parameters				
Drilling Yield	[m^3/m]	1.4	2.3	2.3
Explosive Charge Summary	**[m]**	**1.2**	**1.2**	**1.5**
	[kg/hole]	2.4	3.1	3.9
	[kg/delay]	**1.3**	**3.1**	**3.9**
	[kg/m.lin]	2.7	2.6	2.6
Theoretical Powder Factor Per Hole	[kg/m^3]	0.69	0.57	0.6
Initiation System	[-]	NONEL	NONEL	NONEL
Use of Blasting Mats	[-]	YES	YES	YES
Estimated seperation distances @ given vibration thresholds (USBM standard - K:1143, α: -1.6)				
Required seperation distance for **50 mm/s**	[m]	8	12	14

Figure 4 shows the projected excavation area identified using colour-coded zones representing the proposed rock fragmentation methods and designs based on critical distances to infrastructure.

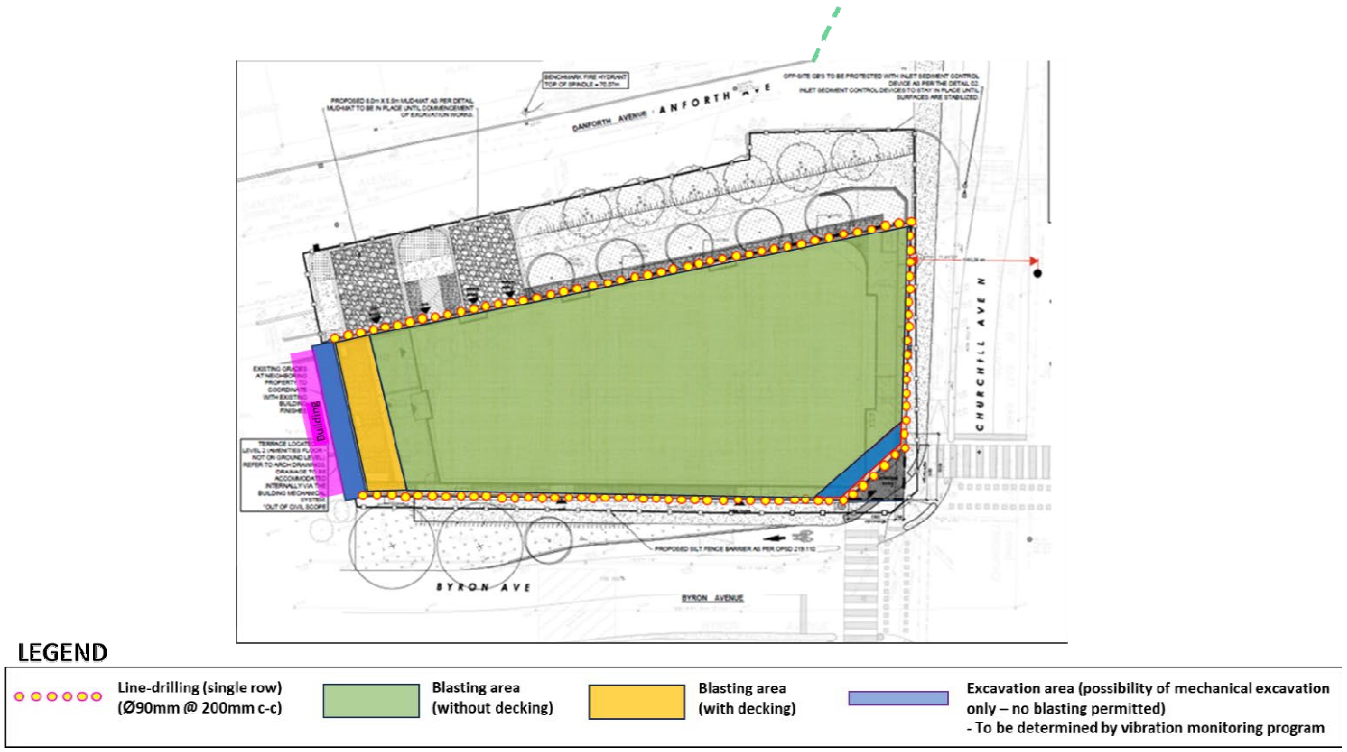


Figure 4: Excavation area identified with proposed rock fragmentation methods (sectors)

A summary of the drilling and loading parameters and additional recommendations are provided below:

- Drilling depth range: 2.4 m to 3 m;
- Drilling diameters: 65 mm;
- Stemming height: ≥ 1.2 m;
- Charge length: ≤ 1.2 m;
- Type of explosives: Packaged emulsion (Ø50 mm) and/or extra-gelatinous dynamite (Ø50 mm);
- Primer: Extra-gelatinous dynamite and/or cast primer;
- Detonators / initiation system: NONEL 25/500 ms;
- Use of blasting mats (min. 3 layers) for every blasting event;

- The use of decked charges must be considered if the allowable charge per delay at a given distance cannot be maintained or if vibration limits are exceeded. Depending on the size of the blasting events and the measured vibration readings, alternate initiation systems may have to be considered for certain scenarios composed of multiple decked charges to ensure dominant frequencies are maintained within acceptable levels;
- Zones approaching critical infrastructure may initially be restricted to mechanical excavation due to the blasting-induced vibrations projected to be above the 50 mm/s threshold. The dimensions and locations of these preliminary zones are subject to change as vibration recordings are compiled and actual site attenuation parameters are determined.

The technical data sheets for the packaged explosive products, accessories and initiation system have been included in Appendix C.

4. Analysis

4.1 Vibration estimations

The following table summarize the estimated vibration amplitude (PPV) as a function of the distance separating the blasting event and critical infrastructure, as well as the assigned unitary charge per delay. The values presented in this table are estimates and shall be validated though the vibration monitoring program that will be in place for the duration of the blasting activities. Loading configurations can also be subject to change based on actual field conditions and the trends identified through the vibration monitoring program for the project.

Table 3: PPV estimation table per loading scenario

Scenarios	#1 2.4 m cut - decked charge	#2 2.4 m cut - column charge	#3 3 m cut - column charge
Distance	Charge Per Delay 1,4 Kg Estimated Vibration	Charge Per Delay 3,1 Kg Estimated Vibration	Charge Per Delay 3,9 Kg Estimated Vibration
[m]	[mm/s]	[mm/s]	[mm/s]
3	258,0	487,2	585,5
4	162,8	307,5	369,5
5	113,9	215,2	258,6
6	85,1	160,7	193,1
7	66,5	125,6	150,9
8	53,7	101,4	121,9
9	44,5	84,0	101,0
10	37,6	71,0	85,3
12	28,1	53,0	63,7
14	21,9	41,4	49,8
16	17,7	33,5	40,2
18	14,7	27,7	33,3
20	12,4	23,4	28,1
30	6,5	12,2	14,7
40	4,1	7,7	9,3
50	2,9	5,4	6,5
60	2,1	4,0	4,9
70	1,7	3,2	3,8
80	1,3	2,5	3,1
90	1,1	2,1	2,5
100	0,94	1,8	2,1
150	0,49	0,93	1,12
200	0,31	0,59	0,71
250	0,22	0,41	0,49
300	0,16	0,31	0,37
350	0,13	0,24	0,29
400	0,10	0,19	0,23

For information purposes only, Table 4 consists of a general guideline for establishing permissible maximum charge per delay configurations assuming a 50 mm/s peak particle velocity (PPV) threshold. This table is displayed for reference only to provide guidance in case minor adjustments to explosive charge configurations must be considered during the project. The maximum charge per delay range has been exaggerated to illustrate the potential attenuation linked to separation distances.

Table 4: Quantity-distance calculations for 50 mm/s

Maximum charge per delay estimation in order to respect a fixed vibration limit		
Vibration limit	50	mm/s
K	1143.00	
Alpha	-1.60	

Distance	Maximum Charge per delay
m	kg
1	No blasting
1.5	No blasting
2	No blasting
3	0.2
4	0.3
5	0.5
6	0.7
7	1.0
8	1.3
9	1.6
10	2.0
12	2.9
15	4.5
17	5.8
20	8.0
25	12.5
30	18.0
35	24.5
40	32.0
45	40.5
50	50.0
55	60.5

5. Instrumentation

A network of seismographs must be deployed to accurately measure blasting-induced vibrations (and air overpressure if applicable) at critical infrastructure and other sensitive receptors. A combination of fixed and mobile vibration monitoring stations is recommended for added flexibility and accuracy. Multiple recording units also facilitate measurements along the different axes of the projected excavation zone, rendering subsequent modelling and vibration prediction more accurate. Instrumentation should be prioritized for inhabited structures and infrastructure closest to blasting activities.

Instantel seismographs, more specifically the Series III (MiniMate Plus) or the MicroMate are typically the instruments of choice for vibration monitoring initiatives; however, other brands of monitoring equipment can also be deployed assuming that the specification of the alternate equipment follows overall compliance. All units and sensors deployed for vibration and air over-pressure monitoring must have valid calibration certificates.

Figure 5 shows the proposed locations for seismographs, strategically placed to ensure optimal coverage of the study area and accurate monitoring of ground vibrations.

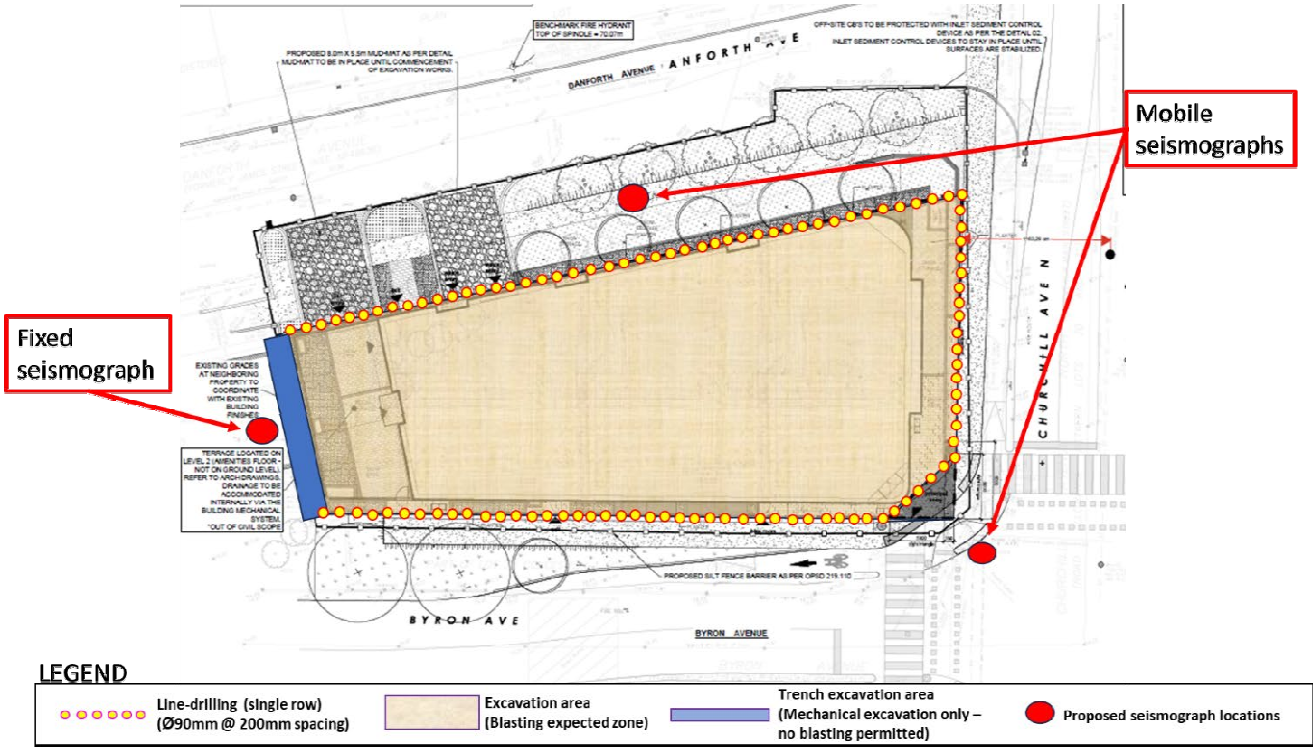


Figure 5: Proposed Locations for Seismographs

Blast monitoring shall be reported daily to ensure that any exceedances, if any, are managed and rectified prior to continuing blasting activities.

It is BBA's understanding that vibration monitoring (including seismograph locations and deployment) for the project will be undertaken by a third-party supplier and/or Blastforce Canada Inc. BBA remains available to support efforts linked to blasting vibration compilation and predictive modelling, if these initiatives are ever deemed necessary or required during the project.

6. Discussion

The drilling and blasting contractor must abide by the regulations and standards in place for blasting in proximity to both public and private infrastructure.

When operating near conduits, underground public utilities or other nearby structures, the contractor must adapt the excavation process to mitigate any risk of damaging adjacent infrastructure. Generally, if deemed permissible, a 5 m minimum standoff distance is recommended between controlled blasting events and critical infrastructure, however this distance may vary as a function of site layout and conditions, as well as through vibration monitoring. Rock fragmentation by mechanical means may be required at distances ≤5 m assuming vibration monitoring is in place. At the event of an exceedance, the work will be stopped, and an alternative method must be employed. The use of explosives is evidently prohibited in this area.

Infrastructure such as public utilities, as well as residential and commercial buildings in proximity to the site are subjected to the vibration thresholds stipulated in the OPSS 120 (50 mm/s: ≥40Hz).

The blast vibration data recorded throughout the entirety of the project must be preserved and analyzed periodically as it will be used as a primary reference for establishing alternate blasting scenarios, if deemed necessary over the course of the work.

7. Additional control measures

- All vibration data recorded over the duration of the project should be stored and periodically analysed to determine the actual site attenuation constants, and facilitate adjustments to the blast design parameters, if required;
- Blasthole positions must be established by a qualified and competent person, and must be verified by the blaster-in-charge;
- Blasting operations should begin by completing a scaled-down blasting pattern (4 to 6 holes only, ideally single row) located as far as possible from critical infrastructure. Monitoring equipment shall be used to record vibration data at these locations to allow adjustments to be made once blasting operations reach full-scale. If possible, near-field vibration monitoring (i.e.: measurements taken at short distances from the blasting event) can be implemented during these trial blasts in order to characterize overall vibration transmissibility in the rock mass prior to approaching sensitive receptors.

- The driller must complete a log recording all pertinent information relating to the drilling conditions and status of the blast holes being drilled. Information such as the intersection of voids, joint sets, and seams of softer rock, as well as the presence of water and broken ground in the collared area of the pattern must be reported and documented;
- The burden for all holes along the first row of the blasting event must be measured and validated (visually);
- Loading parameters of the blastholes along the first row must be adjusted according to the actual (measured) burden and actual site conditions;
- Blasthole stemming heights must be adjusted accordingly and at times individually to account for the actual topography of the blast pattern;
- Stemming material consists of crushed angular stone (5-7mm net);
- Ensure the as-loaded explosive column or decked charge does not surpass the allowable charge weight per hole;
- A detailed blasting journal must be completed for each individual blasting event;
- All blastholes must be drilled and oriented vertically – no angled holes are permitted;
- Properly identify the blast perimeter during loading operations;
- Properly delineate and identify the blast area and location;
- Fragmented rock material located at the free face(s) of a blasting pattern must be excavated to expose the toe (floor) elevation achieved by the previous blasting event, measure the actual burden distance, and facilitate blast movement. Additional fly rock control measures can be implemented by backfilling the trenched area with loose (non-compacted) material or rock fill;
- All regulations and standards pertaining to controlling and monitoring carbon monoxide emissions from blasting activities must be followed by the blasting contractor;
- Regulations pertaining to safety distances for drilling and blasting activities in proximity to suspended overhead power lines (if applicable) must also be respected;
- It is the responsibility of the drill and blast contractor as well as that of the general contractor to ensure the appropriate blast clearance zone is established and respected prior to undertaking blasting protocol;
- As per the contractor's procedure, audible signals emitted from an air horn or siren will be used to communicate the onset of blasting activities on the site. The signal sequence is the following:
  - Prior to blasting: 12 x rapid siren signals (in line);
  - 30 seconds prior to blasting: pause (silence);

  - Blast initiation;
  - All clear post-blast: 1 x extended siren signal;
- Blasting mats must be used for every blasting event. Blast mat layering and placement are the responsibility of the blaster-in-charge and must follow best-practice guidelines. Blasting mats must be in good working condition (i.e.: fully intact along the exposed surfaces) and clear of any embedded rock debris;
- If applicable, the attenuation trench or line-drilling holes need to kept empty of any fill material and water to promote the desired vibration attenuation effects.

8. Conclusion

BBA has analysed the blasting parameters that will be used to facilitate the rock excavation process for the above-mentioned project. Following our review, and according to the information available when compiling the report, the proposed methods and design criteria provide sufficient control measures to ensure compliance with applicable provincial and municipal regulations relating to blasting vibrations.

Appendix A: OPSS 120

GENERAL SPECIFICATION FOR THE USE OF EXPLOSIVES

TABLE OF CONTENTS

120.01 SCOPE

This specification covers the requirements for the use of explosives.

120.01.01 Specification Significance and Use

This specification is written as a municipal-oriented specification. Municipal-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of many municipalities in Ontario.

Use of this specification or any other specification shall be according to the Contract Documents.

120.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

120.02 REFERENCES

When the Contract Documents indicate that municipal-oriented specifications are to be used and there is a municipal-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.MUNI, unless use of a provincial-oriented specification is specified in the Contract Documents. When there is not a corresponding municipal-oriented specification, the references below shall be considered to be the OPSS listed, unless use of a provincial-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

Ontario Ministry of Transportation Publications

Ontario Traffic Manual (OTM):
Book 7 - Temporary Conditions

Department of Fisheries and Oceans (DFO) Publication

Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters, 1998

International Society of Explosives Engineers (ISEE)

Performance Specifications for Blasting Seismographs, 2011 Edition

120.03 DEFINITIONS

For the purpose of this specification, the following definitions apply:

Blaster means a competent person knowledgeable, experienced, and trained in the handling, use, and storage of explosives and their effect on adjacent property and persons.

Blast Monitoring Consultant means a consulting engineering firm with a minimum of five years experience related to blasting retained by the Contractor to provide blast monitoring services. The blast monitoring consultant shall be a third party that is not owned or corporately affiliated with the Contractor responsible for the Work.

Consulting Engineering Firm means a firm or an individual that has been issued a Certificate of Authorization and a Consulting Engineer designation by the Professional Engineers Ontario.

Designated Blast Area means the area where the Contractor has notified, in writing, and provided information to all Utilities, public and private property owners, and as the area where the Contractor has made arrangements to evacuate all persons whose safety might be threatened by the blasting operation.

Fish Habitat means as defined by the Fisheries Act.

Flyrock means rock that becomes airborne as a direct result of a blast.

NAV CANADA means the company that owns and operates Canada's civil air navigation service (ANS).

Peak Particle Velocity (PPV) means the maximum component velocity in millimetres per second that ground particles move as a result of energy released from explosive detonations.

Pre-Blast Survey means a detailed record, accompanied by film or video as necessary, of the condition of private or public property, prior to the commencement of blasting operations.

120.04 DESIGN AND SUBMISSION REQUIREMENTS

120.04.01 Design Requirements

A blast design shall be prepared by an individual or firm with a minimum five years experience and be certified by an Engineer. The blast design shall include, as a minimum, the following:

a) Design PPV and design peak sound pressure level at 250 m radius or nearest Utility, residence, structure, or facility.

b) Number, pattern, orientation, spacing, size, and depth of drill holes.

c) Collar and toe load, number and time of delays, and mass and type of charge per delay.

d) Setback distances to affected fish habitat.

e) The explosive products to be used.

f) The designated blast area.

120.04.02 Submission Requirements

The following shall be submitted to the Contract Administrator:

a) A minimum of two weeks prior to the use of explosives:

   i. The name and statement of experience of the firm carrying out the blasting.
   ii. The name of the blaster including a record of experience and safety training.
   iii. The name of the individual or firm responsible for the blast design, including a record of experience and statement of qualifications.
   iv. A letter from an Engineer certifying the design.
   v. The name of the blast monitoring consultant, including a record of experience and a record of qualifications.
   vi. A certificate of insurance indemnifying the Owner from all claims and damages arising from the use of explosives.

b) A minimum of 48 hours prior to the use of explosives:

   i. A letter signed by the Engineer certifying the blast design indicating the areas for which the blast design has been completed.
   ii. A letter signed by the blaster indicating receipt of the blast design and agreement that the blasting shall be according to the design.
   iii. A letter signed by the Contractor certifying that a pre-blast survey has been carried out in accordance with the Pre-Blast Survey subsection and a copy of the pre-blast survey.
   iv. A copy of the blast design, including all items shown in the Design Requirements subsection.
   v. The designated blast area.
   vi. A blasting schedule.
   vii. A list of all locations to be monitored.
   viii. Proof of calibration of all monitoring equipment.

c) Upon request, any blasting permits, approvals, and agreements required for the use of explosives or to carry out blasting operations.

120.05 MATERIALS

120.05.01 Explosives

Only explosive products approved for use in Canada shall be used.

120.06 EQUIPMENT

120.06.01 Detonation Apparatus

Detonation apparatus shall be of the type approved by the detonation system manufacturer for the type of blasting operation to be undertaken. All apparatus shall be kept in working order and shall be thoroughly inspected before and after each blasting operation.

All wiring connected to electrical detonation apparatus shall be properly insulated.

120.06.02 Monitoring Equipment

All monitoring equipment shall be capable of measuring and recording ground vibration PPV up to 200 mm/s in the vertical, transverse, and radial directions. The equipment shall have been calibrated within the last 12 months either by the manufacturer or other qualified agent. Proof of calibration shall be submitted to the Contract Administrator prior to commencement of any monitoring operations.

Monitoring equipment shall be according to ISEE Performance Specifications for Blasting Seismographs.

120.07 CONSTRUCTION

120.07.01 General

Blasting shall be carried out only during daylight hours and at a time when atmospheric conditions provide clear observation of the blast when practical from a minimum distance of 1,000 m. Blasting shall not be conducted on Sundays, statutory holidays, or during electrical storms.

Blasting shall not be carried out within 30 m of concrete placed less than 72 hours when the ambient temperature falls below 20 °C or for 36 hours when the ambient temperature is continuously greater than 20 °C, unless otherwise authorized by the Contract Administrator.

Protection of fish and fish habitat shall be according to the Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters.

120.07.02 Radio-Frequency Hazards

Prior to blasting, investigations shall be done to determine if radio-frequency hazards exist. When such hazards exist, necessary precautions shall be taken.

120.07.03 Pre-Blast Survey

A pre-blast survey shall be prepared for all buildings, Utilities, structures, water wells, and facilities likely to be affected by the blast according to Table 1 where explosives are to be used. The standard inspection procedure shall include the provision of an explanatory letter to the owner or occupant and owner with a formal request for permission to carry out an inspection.

The pre-blast survey shall include, as a minimum, the following information:

a) Type of structure, including type of construction and if possible, the date when built.

b) Identification and description of existing differential settlements, including visible cracks in walls, floors, and ceilings, including a diagram, if applicable, room-by-room. All other apparent structural and cosmetic damage or defect shall also be noted. Defects shall be described, including dimensions, wherever possible.

c) Digital photographs or digital video or both, as necessary, to record areas of significant concern.

Photographs and videos shall be clear and shall accurately represent the condition of the property. Each photograph or video shall be clearly labelled with the location and date taken.

A copy of the pre-blast survey limited to a single residence or property, including copies of any photographs or videos that may form part of the report shall be provided to the owner of that residence or property, upon request.

120.07.04 Notification

120.07.04.01 General

A minimum of 15 Business Days prior to blasting, the Contractor shall provide written notice to Utilities and all owners and tenants of improved property within 250 m of the right-of-way in the vicinity of the blast. The notice shall include a blasting schedule, information about the audible blast warning system, and contact name for questions or other concerns.

The Contractor shall ensure that a competent person is available to receive, document, and deal with public inquiries before and after blasting operations.

A minimum 48 hours prior to blasting, sufficient detail regarding the blasting operations shall be provided to NAV CANADA and the Contract Administrator.

120.07.04.02 Utilities

Authorities of all likely affected Utilities shall be notified a minimum of 72 hours prior to blasting.

120.07.04.03 Properties

Not more than five Business Days and not less than four hours prior to each blast, the Contractor shall provide notice of the blasting schedule to all owners and tenants of buildings or facilities within 150 m of the blast. All blasts scheduled for the following seven Days may be included in one notice. The notice shall include information about the audible blast warning system.

When blasting operations may incur property damage or require temporary evacuation, notification shall include evacuation information and instructions. The Contractor shall take all reasonable steps to ensure that the property owner acknowledges, by their signature, that they have received the information and shall comply with any evacuation requirements. When such signature is withheld, the Contractor shall maintain records showing the date and time that the information was delivered.

120.07.05 Monitoring

120.07.05.01 General

The Contractor shall employ a blast monitoring consultant to carry out monitoring for PPV, peak sound pressure levels, and water overpressures as required. During each blast, ground vibration PPV and the peak sound pressure level shall be monitored at 250 m from the area of the blast or at the closest portion of any Utility, residence, structure, or facility. Water overpressure in affected fish habitats shall be monitored adjacent to the shore closest to the blast. The monitoring equipment shall be repositioned as required.

120.07.05.02 Ground Vibration

Ground vibration as measured by PPV shall be limited to the maximum levels shown in Table 2. Should readings from any two consecutive blasts exceed these values or any single reading exceed these values by more than 30 mm/s, the blast operation shall cease until a revised blast design, certified by the Engineer, has been submitted to the Contract Administrator.

120.07.05.03 Water Overpressure

Instantaneous pressure change as measured by water overpressure in or near fish habitat shall not exceed 100 kPa.

120.07.05.04 Trial Blasts

The Contractor shall confirm the suitability of the blast design for the ground vibration PPV limits and sound pressure levels by carrying out a minimum of three limited test blasts at locations agreed upon by the Contract Administrator and the Contractor. The trial blasts shall be carried out with appropriate blast vibration and noise level monitoring equipment. Based on the results, the initial blast design shall be revised as necessary.

120.07.06 Protective Measures

Immediately prior to the blast, the designated blast area shall be cleared of all vehicular and pedestrian traffic.

All traffic shall be stopped and prevented from entering the area until the blaster gives permission. Traffic control shall be according to the Ontario Traffic Manual, Book 7. Signs shall be posted to inform the public of blasting operations and to turn off radio transmitters. Audible blast warning devices, capable of alerting workers and the public up to a radius of 1,000 m, shall be used before and after blasting.

Blasting mats or other suitable means of controlling flyrock shall be used to limit potential hazardous effects of the blast.

120.07.06.01 Protection of Utility Lines

Where temporary rearranging and shielding of utility lines are detailed within the Contract Documents, such temporary rearranging and shielding is the minimum protection required. The Contractor shall remain responsible for any unauthorized disruptions of service and any damage to utilities arising out of the Contractor's work, notwithstanding such protection. The Utility authorities shall carry out the temporary rearranging and shielding of lines as detailed within the Contract Documents and more extensive rearranging and shielding if requested to do so by the Contractor. The cost of all such protective measures, together with the cost of restoring the lines to their original state and location, shall be at the expense of the Contractor, and shall be billed to the Contractor by the Utility authority.

Notwithstanding the preceding paragraph, the Utility authorities shall, subject to the Contractor's obligation under the Contract to assume responsibility for disruption of services and damage, consider alternative measures which the Contractor may suggest. Such alternative measures, if approved by the Utility authorities in writing, shall be provided at the Contractor's expense and billed to the Contractor by the Utility authority.

Whenever, in the opinion of the Utility authority, standby crews are necessary during blasting operations, the Contractor shall make the necessary arrangements with the Utility authority and the cost of such crews and equipment shall be billed to the Contractor by the Utility authority. These measures shall apply to those utilities located within all rock blasting areas.

120.07.07 Records

A post-blast record shall be prepared and signed by the blaster for each blast completed. The post-blast record shall report the following conditions and be made available to the Contract Administrator for site review:

a) The date, time, and location of the blast.

b) The wind direction and approximate speed at the time of the blast.

c) The general atmospheric conditions at the time of the blast.

d) The actual blast details.

e) PPV, peak sound pressure level, and water overpressure results of each blast.

A report summarizing the results of the ground vibration and peak sound pressure levels shall be submitted to the Contract Administrator at the end of each work day that blasting was carried out.

120.07.08 Damage

Upon completion of blasting or immediately following the receipt of a complaint, a site condition survey shall be performed to determine if any damage has resulted. The Contractor shall record all incidents of any damage or injury, which shall be reported immediately in writing to the Contract Administrator. All other complaints shall be reported to the Contract Administrator in writing within 24 hours of receipt. Each complaint report shall include the name and address of the complainant, time received, and description of the circumstances that led to the complaint.

120.07.09 Management of Excess Material

Management of excess material shall be according to the Contract Documents.

120.10 BASIS OF PAYMENT

Payment at the Contract price for the appropriate tender items that requires the use of explosives shall be full compensation for all labour, Equipment, and Material to do the work.

When the Contract contains separate items for work required by this specification, payment shall be at the Contract prices and according to the specifications for such work.

The cost of standby crews and equipment required by Utility authorities shall be the responsibility of the Contractor.

120.10.01 Claims

The Contractor shall be responsible for the management of all claims and payment arising from the hauling, handling, use of, and storing of explosives and all effects, directly or indirectly related to the blasting operation.

TABLE 1
Radius of Pre-Blast Survey

Depth of Rock Excavation	Radius of Pre-Blast Survey from Blast Site
< 5 m	75 m
≥ 5 – 10 m	150 m
> 10 m	150 m If no buildings exist within 150 m, the closest building within 500 m

TABLE 2
Maximum Peak Particle Velocity Values

Element	Frequency Hz	Peak Particle Velocity (PPV) mm/s
Structures and Pipelines	≤ 40	20
	> 40	50
Concrete and Grout < 72 hours from placement	N/A	10

Appendix 120-A, November 2019
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

This specification should be included on all projects that require the use of explosives.

The designer should determine if Utility authorities have any special measures or minimum offset distances and include them in the Contract Documents.

The designer should identify if there are site-specific conditions or environmental issues that may affect blasting design and alter monitoring requirements, pre-blast survey limits, pre-blast survey requirements, or notification limits as necessary, and include them in the Contract Documents.

The designer should provide names of Utility authorities and contacts involved in the Contract.

The designer should ensure that the General Conditions of Contract and the 100 Series General Specifications are included in the Contract Documents.

Related Ontario Provincial Standard Drawings

No information provided here.

Appendix B: Third-party Requirements in the Vicinity of Natural Gas Facilities Standard (Enbridge Gas inc.)

Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard

STANDARD

2024-01-31
ST-1E-30A8-8E30.1.2.1
Enbridge Inc.

Table of Contents

Uncontrolled when printed. Controlled copy is in the GDS Document Library.

Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard

1 Introduction

This document is intended for anyone involved in planning or carrying out work in the vicinity of Enbridge Gas Distribution and Storage's (GDS) network. It summarizes the requirements to be followed and specifies the technical requirements aimed at protecting GDS's facilities, and by extension, ensuring public and worker safety.

Within this document, "third party" refers to an individual or organization that is not employed by, or performing work under, contract to GDS. These requirements are applicable to work done by individuals such as homeowners, landowners, other utility companies, excavators, constructors, and contractors.

Third parties must follow the regulations and legislation applicable to their work in addition to these requirements. It is understood that all legal provisions applicable to work carried out around natural gas facilities take precedence over this document.

The terms "gas lines", "gas pipelines", and "mains" used throughout this document apply equally to natural gas mains and service lines, as well as any other component of GDS's natural gas systems found on public or private land.

All work in the vicinity of gas facilities must adhere to the requirements set forth in this document. Work includes, but is not limited to, any ground disturbance in the vicinity of facilities or equipment crossing. Ground disturbance includes, but is not limited to, activities associated with excavation, directional drilling, blasting, piling, compaction, boring, ploughing, grading, backfilling, and hand digging.

A locate of the facilities must be requested at least five business days prior to beginning any work. Locates are required before ground disturbance takes place.

2 Terms and Definitions

The following is a list of terms found in this document and their definitions.

applicant: The owner of the proposed work.

blaster: The person or persons responsible for setting the charges and performing the blast.

blasting, surface: An operation involving the excavation of rock foundations for various types of structures, grade construction for highways or railroads, or canals (trenches) for water supply or collection purposes.

blasting, tunnel: Operations involving the piercing of below-ground (generally horizontal) opening in rock.

compaction: Any vibration-generating operation that will result in a potential increase of the density of soils or controlled backfill materials. The means to increase the density may be static or dynamic.

constructor: A person who undertakes a project for an owner and includes an owner who undertakes all or part of a project by himself or by more than one employer (as defined by Occupational Health & Safety Act).

contractor or excavator: Any individual, partnership, corporation, public agency, or other entity that intends to dig, bore, trench, grade, excavate, hammer into, or break ground with mechanical equipment or explosives in the vicinity of a gas pipeline or related facility.

EGI: Enbridge Gas Inc.

facility: Any Enbridge Gas Distribution, Transmission, Storage pipeline, main, service, regulator station or storage facility and its related components.

Gas Distribution and Storage (GDS): Enbridge Gas Distribution and Storage, Gazifère Inc., Niagara Gas Transmissions Limited, 2193914 Canada Limited.

ground disturbance: Any work, operation, or activity on or under the existing surface resulting in a disturbance or displacement of the soil or ground cover. Ground disturbance can include, but is not limited to: activities associated with excavation, directional drilling, blasting, piling, compaction, boring, ploughing, grading, backfilling, and hand digging.

hand dig: To excavate using either a shovel with a wooden or fiberglass handle, or using hydro vacuum excavation equipment. The use of picks, bars, stakes, or other earth piercing devices are not considered hand digging.

independent engineering consultant: A professional engineer who is registered with the provincial or state professional engineering association and a holder of a certificate of authorization (C of A).

locate service provider: Any entity that performs locates under the terms of a locate service agreement.

pile: Any vertical or slightly slanted structural member introduced or constructed in the soil in order to transmit loads and forces from the superstructure to the subsoil; the structural member can also be used as a component of a retaining wall system.

pile driving: The placement of piles carried out by gravity hammer, vibratory hammer, auger, pressing, screwing, or any combinations of the above methods.

positive identification: Visually locating (daylighting, exposing, digging test holes to determine) the location, depth, and size of a below-grade facility by using either vacuum excavating or hand digging. This includes elevation or alignment changes that can alter the depth or direction of the pipe (e.g., 45° and 90° elbows, fittings, plugs, weldolets, flanges, branch piping, known abandoned facilities, etc.).

pre-Engineering review: A process by which third parties can request a pre-engineering review for any potential conflict analysis.

professional engineer: An engineer registered and licensed with the provincial professional engineering association in the jurisdiction in which the engineer is practicing.

rural: All areas outside urban areas.

temporary support: The support of gas pipelines before or during an excavation to protect the pipeline from its own weight and to minimize deflection stresses.

third party: An individual or organization that is not employed by or performing work under contract to GDS (e.g., homeowners, other utility companies, contractor, excavators, constructors, etc.).

urban: An area with a population of at least 1,000 and a density of 400 or more people per square kilometer.

vital pipeline: A subset of pipelines that are critical to the safe and reliable operation of the natural gas system. Damages to vital mains could result in significant negative impact to public and worker safety or significant customer outages. This subset of mains consists of CER-regulated (Canada Energy Regulator) pipelines, transmission pipelines, and select distribution pipelines.

3 General Requirements

3.1 CER-Regulated Pipelines and Vital Pipelines

The CER regulates natural gas, oil, and commodity pipelines that extend beyond provincial, territorial, or national boundaries. All work in the prescribed area (within 30 m [100 ft] from each side of the CER-regulated pipeline) must be reviewed by the applicable CER-regulated operating company prior to commencing. This review is a regulatory requirement of the CER.

Mains are designated as vital pipelines by GDS. These include, but are not limited to, any pipeline NPS 16 or larger, transmission pipelines, CER-regulated pipelines, all pipelines operated by Storage and Transmission Operations (STO), and select distribution pipelines. The designation of a vital pipeline may change at the discretion of GDS. Vital Pipelines will be identified through locates. In these requirements, special considerations for CER-regulated pipelines and vital pipelines will be highlighted.

All work within 5 m (16 ft) from either side of lines operated by STO must be approved by GDS prior to commencing. For all other vital pipelines, all ground disturbance work within 3 m (10 ft) from either side of the vital pipeline must be approved by GDS prior to commencing. Approval by GDS may include specific conditions that third parties must follow. GDS may require representation on site for any ground disturbance work within the vicinity of vital pipelines and CER-regulated pipelines.

3.2 When Observation Is Required

A GDS representative is required to be on site to ensure the excavation or third-party activity is being safely completed near a pipeline when:

- Excavation with mechanical equipment will occur within 5 m (16 ft) of CER-regulated pipelines and all lines operated by STO.
- Excavation with mechanical equipment may take place within 3 m (10 ft) of vital pipelines and pipeline segments.
  Once the pipeline is exposed, mechanical excavation is then permitted up to 1 m (3.3 ft) from the pipeline.
- It is anticipated that blasting will take place within 30 m (100 ft) of any pipeline.
- Any other situations which requires observation, as deemed necessary by EGI.

3.3 Safe Excavation

Mechanical excavation is not permitted within 5 m (16 ft) of CER-regulated pipelines and 3 m (10 ft) of vital pipelines, unless verified visually. After the exact location of the main is verified visually, mechanical excavation is allowed up to 1.0 m (3.3 ft) from the pipeline. Within 1 m (3.3 ft) of the CER-regulated or vital pipeline, only hand digging or hydro-excavation is allowed.

Mechanical excavation may not begin within 3 m (10 ft) of the pipe until:

- The pipe has been exposed by the excavator, under the supervision of GDS, by hand at the point of crossing, or the pipeline company has located the pipe and confirmed that it is at least 0.6 m deeper than the proposed excavation.
- The excavation is parallel, or the pipe has been exposed by handto confirm the location of the pipe.

For all non-vital pipelines, mechanical excavation is not allowed within 1 m (3.3 ft) of the locate marks of the pipeline, until the exact location of the pipeline has been visually verified. The excavator must expose the pipeline by hand digging or hydro-excavation. Once the pipeline is exposed, mechanical excavation is then permitted up to 0.3 m (1 ft) from the pipeline. Within 0.3 m (1 ft) of any pipeline, only hand digging or hydro-excavation is permitted.

Only handheld compaction equipment may be used within 1 m (3.3 ft) of the sides or top of all gas pipelines. When ground conditions make hand excavation impractical (e.g., frost), the pipeline company may permit excavation to within 1 m (3.3 ft) of the pipeline if the pipeline company considers it safe to do so and directly supervises the excavation.

Spoil from excavation must not be piled on the pipeline or its easement.

3.4 Minimum Cover Requirements

Table 3-1: Minimum Cover Requirements on page 8 defines mains and services cover requirements. In all cases where the depth of cover requirements cannot be met, contact GDS to review depth of the cover requirements.

Table 3-1: Minimum Cover Requirements

Pipeline	Location	Minum Cover m (ft)
Mains	Under traveled surfaces (roads), road crossings	1.2 m (4 ft)
	Right-of-ways	1 m (3.3 ft)
	Highways	1.5 m (5 ft)
	Water crossings, and below drainage and irrigation ditches	1.2 m (4 ft)
Services	Private property	0.5 m (1.6 ft)
	Road crossings	0.9 m (2.9 ft)

3.5 Points of Thrust

Additional precautions may need to be taken when working in the vicinity of points of thrust. Points of thrust occur at pipeline fittings such as elbows (45° or 90°), end caps, weld tees, reducers, closed valves, and reduced port valves. If a point of thrust is identified through the locate process, GDS may require additional time to review the proposed work area. In the event that the excavation involves exposing a point of thrust or exposing an area near a point of thrust, GDS may provide written specific instructions that are to be followed. Failure to follow these instructions can result in significant harm to persons, property, or the environment.

3.6 Repair of Damaged Pipe and Pipe Coating

In all cases where the pipeline or the pipeline coating is damaged by construction activities, GDS must be contacted immediately and the excavation left open until GDS personnel have made the necessary repairs.

3.7 Encroachment

Permanent awnings and roof structures are prohibited above GDS's facilities within public rights-of-way or GDS's rights-of-way. GDS will not accept responsibility for any damages resulting from maintenance or operation of its facilities to encroaching structures within the public or GDS rights-of-way. Examples of encroaching structures include: bus shelters, street benches, and garbage bins.

GDS requires approval for all permanent structures to be built within 7 m (22.9 ft) of GDS's vital pipelines. This requirement is in place to allow GDS sufficient access and working space should an inspection or repair be needed.

3.8 Tree Planting

When planting trees, the gas pipeline in and near the area of excavation must be located to ensure enough clearance is maintained between the pipeline and the tree.

For all vital pipelines (including CER and transmission pipelines), trees or large shrubs must maintain a horizontal clearance between the edge of the root ball or open bottom container to the adjacent edge of the existing pipelines of not less than 3.0 m (10 ft), or as specified in any applicable easement agreement.

For all other pipelines, a minimum horizontal clearance of 1.2 m (4 ft) is recommended between the edge of the root ball or open bottom container and adjacent edge of the existing gas pipeline.

In cases where the recommended clearance cannot be achieved, GDS may specify the installation of a root deflector.

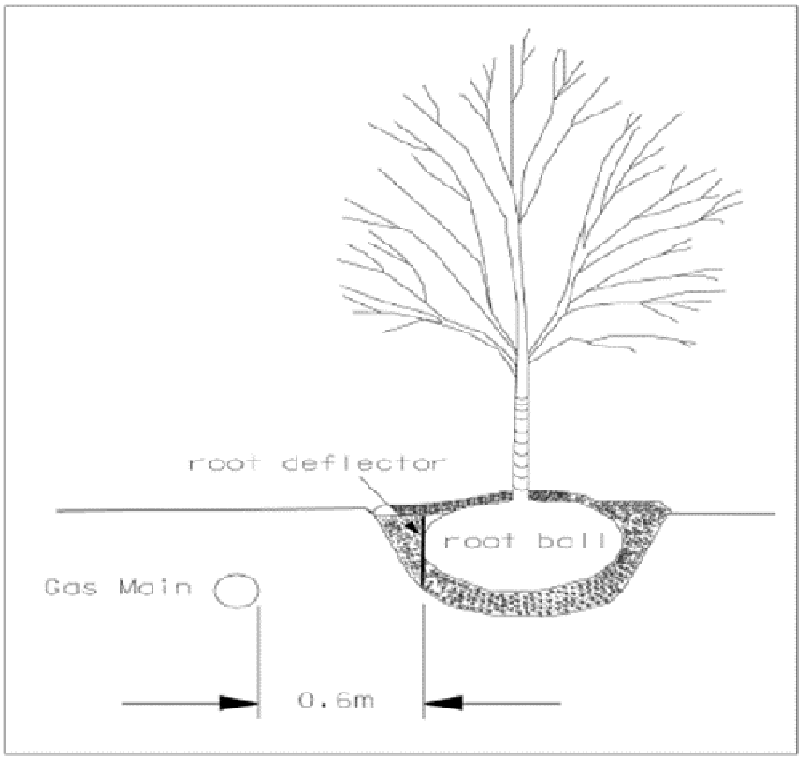
3.8.1 Root Deflectors

A root deflector is a physical barrier placed between tree roots and pipelines to prevent damage to the pipelines. A root deflector can be made from 1/4 in thick rigid plastic, fiberglass, or other non-degradable material. The root deflector is intended to prevent the root tips from attaching to the gas main.

Typically, root deflectors are straight barriers or encircle the tree. If installed as a straight barrier, the root deflector should be installed at a minimum 0.6 m (2 ft) from the pipeline on the tree-side of the pipeline. Also, it should extend parallel to the pipeline in both directions for 1.2 m (4 ft) measured from the centre of the tree trunk.

Root deflectors usually have a collar to keep the top of the deflector at ground level, and extend down to the bottom of the root-ball as shown in Figure 1: Example of a Root Deflector.

Figure 3-1: Example of a Root Deflector



3.9 Sewer and Drain Cleaning

Prior to sewer clearing activity using mechanical cutting or high pressure jetting equipment, the third party should call into Ontario One Call at 1-800-400-2255 for a

cross bore sewer safety inspection. An EGI employee or contractor will attempt to attend the site within two hours to complete the inspection.

4 Minimum Clearance from Other Structures

The following clearances must be maintained between the circumference of the gas pipeline and other underground structures:

Table 4-1: Minimum Clearance Between Gas Pipelines (Less than NPS 16) and Other Underground Structures

Direction	Minimum Clearance m (ft)
Horizontal	0.6 m (2 ft)
Vertical	0.3 m (1 ft)

Table 4-2: Minimum Clearance Between CER-regulated Pipelines and Vital Pipelines and Other Underground Structures

Direction	Minimum Clearance m (ft)
Horizontal	1 m (3.3 ft)
Vertical	0.6 m (2 ft)

Additional clearance or mitigation may be required for installations (such as transit systems or power transformers) that will introduce DC stray current interference or AC fault hazards.

Note

For all pipelines (including vital pipelines), when drilling parallel to the pipeline, a minimum horizontal clearance measured from the edge of the pipeline to the edge of the final bore hole of 1 m (3.3 ft) is required.

5 Pipeline Location Verification

5.1 Surface Road Work

Surface road work applies to ground disturbance on travelled roadways related to the removal of hard-surfaces only. For any ground disturbance work, locates must be obtained prior to commencing and the excavator must ensure accuracy of the locate by reviewing the locate paperwork with the physical locate markings. Surface road work can be completed without the requirement to positively identify EGI pipelines, provided no mechanical equipment will be used within 1 m (3.3 ft) horizontally of the located pipelines. If mechanical excavation is required within 1 m (3.3 ft) of the locate during any surface road work or work that will take place deeper than removal of the hard surface, the excavator must follow rules outlined in 5.2 Subgrade Road Work on page 11 for positive identification requirements.

5.2 Subgrade Road Work

Subgrade road work is any road work exceeding the depth required for removal of the hard surface that enters the sub-surface. The boundary area for the pipeline is the distance that is identified off the locate marks of the pipeline and applicable boundary areas are highlighted in Table 5-1: Boundary Areas on page 11.

Table 5-1: Boundary Areas

Pipeline	Boundary Area
Vital pipelines (≥ NPS 24)	3 m (10 ft)
Vital pipelines (< NPS 24)	2 m (6 ft)
Non-vital pipelines (all sizes)	1 m (3 ft)

Note

Work within the boundary areas must comply with the positive identification requirements set in Table 8-2: Pipeline Location Verification Requirements for Vital Pipelines on page 21 and Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines on page 21.

If these guidelines cannot be complied with, the excavator must submit a variance request work package. No variance will be provided for work within 1 m (3.3 ft) of any pipeline. The variance work package must include, at a minimum, the following information:

- Pre-Engineering design.
- Location of EGI facilities with respect to proposed excavation area (vertical and horizontal offsets).
- Location of proposed excavation area (vertical and horizontal offsets off permanent landmarks).
- Pipeline protection plan.

If a variance is requested, the excavator must also provide a physical barrier (e.g., silt fence), which would denote the boundary of the pipeline, where possible.

8.2 Drilling Parallel to Pipelines on page 20 and Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines on page 21 indicate GDS's minimum requirements for the verification of the pipeline location based on the nature of the work. The frequency and location of test holes may change at the discretion of GDS. Additional test holes may be required to sufficiently confirm the location of the pipeline (e.g., regulator stations).

Note

Non-mechanical equipment must be used when working within 1 m (3.3 ft) of any pipeline. If mechanical equipment is required for use around non-vitals, the pipeline must be positively identified using hand tools or hydro-excavation. Once the non-vital pipeline location has been visually identified through positive identification requirements listed in the 8.2 Drilling Parallel to Pipelines on page 20 and Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines on page 21, mechanical equipment can be used up to 0.3 m (1 ft) of the non-vital pipeline and 1 m (3.3 ft) of a vital pipeline.

When using hydro-vacuum excavation as an alternative to hand digging, see 9 Hydro-Excavation on page 24 for safe operating practices.

6 Operation of Heavy Equipment

6.1 General

Additional precautions are necessary when equipment in excess of the weights listed in Table 5: Vehicle Load Restrictions is operated in the vicinity of buried facilities where no pavement exists or where grading operations are taking place.

Table 6-1: Vehicle Load Restrictions

Pipe Material	Weight/Axle Maximum Allowable Load kg (lb)
Plastic	7,000 kg (15,400 lb)
Steel	10,000 kg (22,046 lb)

Prior to any crossing, the location of the gas main must first be staked out by a GDS representative.

The excavator is responsible for confirming the location and depth of the main. Test hole spacing must not exceed 50 m (160 ft).

6.2 Equipment Moving Across the Pipeline

Crossing locations for heavy equipment must be kept to a minimum.

The crossing locations must be determined by GDS after reviewing:

- The nature of the construction operation.
- The types and number of equipment involved.
- The line and depth of the existing gas main.

The use of equipment is contingent upon the review by GDS. Once the crossing locations have been established, heavy equipment is restricted to crossing at these locations only. It is the responsibility of the third party to inform their personnel of the crossing location restrictions.

Pipelines may require additional protection at crossing locations by constructing berms or installing steel plates over the pipeline.

Unless expressly allowed by the temporary crossing consent, equipment that crosses pipelines must be subject to the following conditions:

- The numbers of crossings back and forth must be kept to a minimum.
- Equipment must not remain stationary on top of a pipeline.
- Equipment must not cross with loaded side boom or other unbalanced loads.
- Equipment must cross perpendicular (not parallel) to the pipeline. The crossing angle for installations must be within 45° to 90° (with preference for as close to perpendicular as possible).
- Equipment must operate at slow speeds when crossing a pipeline in order to minimize loading impact.
- Existing cover over a pipeline must not be reduced; any loss of cover (e.g., due to rutting) must be promptly restored prior to crossing.
- Vibratory compaction equipment must not operate within 1.2 m (4 ft) of a pipeline.

6.3 Equipment Moving Along the Pipeline

Heavy equipment can be operated parallel to existing pipelines provided that a minimum offset of both:

- 1 m (3.3 ft) is maintained on pipeline sizes less than NPS 16.
- 2 m (6.6 ft) on pipeline sizes NPS 16 and larger, unless otherwise directed by GDS.

Only lightweight, rubber-tired equipment may be operated directly over the existing gas pipelines, unless a minimum pipe cover of twice the pipe diameter or 1 m (3.3 ft) (whichever is greater) can be verified. The use of all other equipment is contingent upon review and approval by GDS.

Unless expressly allowed by the temporary crossing consent, equipment moving along pipelines is subject to the following conditions:

- Equipment must operate at slow speeds when moving along a pipeline.
- Existing cover over a pipeline must not be reduced; any loss of cover (e.g., due to rutting) must be promptly restored prior to moving along the pipeline.
- Vibratory compaction equipment must not operate within 1.2 m (4 ft) of a pipeline.

Note

When crossing perpendicular to a pipeline that is smaller than NPS 16 (excluding vital pipelines), the vertical clearance outlined in Table 4-1: Minimum Clearance Between Gas Pipelines (Less than NPS 16) and Other Underground Structures on page 10 may be used as long as all positive identification requirements are also followed.

Uncontrolled when printed. Controlled copy is in the GDS Document Library.

Note

When crossing perpendicular to a pipeline that is NPS 16 or larger, or crossing any CER-regulated pipelines or vital pipelines, a minimum vertical clearance of 1 m (3.3 ft) is required; 8 Horizontal Directional Drilling on page 19.

7 Support of Gas Pipelines

7.1 General

The support requirements specified in this section are the minimum requirements. GDS must be notified regarding the support of any gas main. GDS has complete discretion in the approval of any support system. Additionally, if a pipeline is to be exposed for longer than one month, approval must be sought from GDS and work must follow the requirements outlined in 3 General Requirements on page 6. Third parties must not depart from these support requirements unless a professional engineer working for or on behalf of the third party has designed an alternative method. Any alternative method must be comparable to these specifications and be, in the opinion of the professional engineer, consistent with good engineering practices. The alternative specification must be documented, approved by a professional engineer and provided to GDS for review prior to the commencement of work. The third party is responsible for the adequate support of the buried gas pipelines exposed during excavation according to this section.

Prior to any crossing, the location of the gas main must first be staked out by a GDS representative.

7.2 Support of Gas Pipelines Perpendicular to Excavation

Temporary support refers to the support of gas pipelines prior to or at the time of excavation to protect the pipeline from deflection due to its own weight while it is exposed. Temporary support must remain in place until the backfill material underneath the pipeline is compacted adequately to restore support of the pipeline.

Before trenching beneath a main or service, temporary support must be erected for pipelines if the unsupported span of pipe in the trench exceeds the length indicated in Table 7-1: Maximum Span without Support Beam on page 15.

Note

For pipelines larger than NPS 16, GDS must be contacted. Contact information can be found in the 12 Contact Information on page 31.

When temporary support is required, Table 7-2: Support Beam Sizes and Maximum Span Between Beam Supports on page 15 indicates the required beam for a given span. The beam must be a continuous length grade No. 1 Spruce-Pine-Fir (S-P-F) or equivalent. For spans exceeding 4.5 m (15 ft), a continuous length timber

beam may not be available. In that case, steel I-beams (or equivalents) can be used as the support beam. Steel beam selection must be certified by a professional engineer and submitted to GDS for review.

Table 7-1: Maximum Span without Support Beam

Pipe Size (NPS)	Steel m (ft)	PE (polyethylene) m (ft)
1/2	2 m (6.6 ft)	1 m (3.3 ft)
3/4 to 1-1/4	2.5 m (8.2 ft)	1.25 m (4.1 ft)
2	3 m (10 ft)	1.5 m (5 ft)
3 to 4	4.5 m (15 ft)	1.75 m (6 ft)
6	6 m (20 ft)	2 m (7 ft)
8	7 m (23 ft)	2 m (7ft)
10	8.5 m (28 ft)	-
12	10 m (33 ft)	-
16	11.5 m (38 ft)	-

Table 7-2: Support Beam Sizes and Maximum Span Between Beam Supports

	Steel	Plastic	
Pipe Size (NPS)	≤ 4.5 m	≤ 2 m	≤ 4.5 m
1/2 to 2	4 × 6	4 × 6	6 × 8
3 to 6	-	6 × 6	8 × 8

Note

In all cases where the support beam size requirements cannot be met, GDS must be contacted to review support beam requirements.

The beam must be placed above the pipe with the ends of the beam resting on firm undisturbed soil. The beam must not bear directly on the gas pipeline. The pipe must be supported from the beam with rope, canvas sling, or equivalent in a manner that will prevent damage to the pipe and coating and eliminate sag. The spacing between the ropes must not exceed 1 m (3.3 ft); see Figure 7-1: Support of Gas Pipelines Crossing Excavations on page 17.

Backfill material underneath the exposed pipeline must be compacted to a minimum of 95% compaction. Sand padding must be placed to a level 150 mm (6 in) below and above the main. For additional details, see 10 Backfilling on page 25.

Perform compaction with the loose lift height not exceeding 200 mm (8 in) or one-quarter of the trench width, whichever is less. Injecting water into the backfill beneath the pipe is not an acceptable method of compaction.

All temporary support on pipelines must be removed before backfilling. Adequate support must remain in place until the backfill material has restored support.

7.3 Support of Pipelines Parallel to Excavation

Two cases exist for pipelines parallel to an excavation:

- Trench < 1.2 m deep
- Trench > 1.2 m deep

In either instance, the pipeline must not be exposed unless it is necessary to provide direct support.

Trench wall support may not be required for excavations provided the pipeline meets all of the following criteria:

- Depth is less than 1.2 m (4 ft).
- the pipeline is at least 0.6 m (2 ft) from the edge of the excavation or outside the 45° line projected upward from the trench bottom; see Figure 7-3: Influence Lines for Gas Pipelines Adjacent to Excavations on page 19.
- Soil is stable (type 1 or 2, see Table 15-1: Soil Types on page 33)

If the pipe does not meet these requirements and the soil is soft clay or sand (soil types 3 and 4), then the excavation must be suitably shored to prevent movement of the pipe. The shoring must remain in place until the backfill material has restored support.

Trench wall support is required for excavations if any one of the following conditions exist:

- Depth is ≥ 1.2 m (4 ft).
- The pipeline is closer to the edge of the excavation than the minimum allowed distance indicated Table 7-3: Minimum Allowed Distance from Main to Excavation on page 16.
- Depth is < 1.2 m (4 ft) and the soil is unstable (type 3 or 4, see Table 15-1: Soil Types on page 33).

Note

Adequate support must remain in place until the backfill material has restored support.

Minimum distances from the edge of the trench to the pipeline in which the excavation influences pipelines are shown in Table 7-3: Minimum Allowed Distance from Main to Excavation on page 16. The pipeline must be supported if these minimum distances cannot be met.

Table 7-3: Minimum Allowed Distance from Main to Excavation

Trench Depth (m)	Soil[a] Type 1 and 2	Soil[a] Type 3 and 4
1.2 m (3.9 ft)	0.9 m (3 ft)	0.9 m (3 ft)
1.5 m (4.9 ft)	0.9 m (3 ft)	0.9 m (3 ft)
1.8 m (5.9 ft)	0.9 m (3 ft)	0.9 m (3 ft)
2.1 m (6.9 ft)	0.9 m (3 ft)	0.9 m (3 ft)
2.4 m (7.9 ft)	0.9 m (3 ft)	0.9 m (3 ft)
2.7 m (8.9 ft)	0.9 m (3 ft)	1 m (3.3 ft)
3 m (9.8 ft)	0.9 m (3 ft)	1.5 m (4.9 ft)
3.3 m (10.8 ft)	0.9 m (3 ft)	1.8 m (5.9 ft)
3.6 m (11.8 ft)	0.9 m (3 ft)	2.2 m (7.2 ft)
3.9 m (12.8 ft)	0.9 m (3 ft)	2.5 m (8.2 ft)
4.2 m (13.8 ft)	0.9 m (3 ft)	3 m (9.8 ft)
4.5 m (14.8 ft)	1 m (3.3 ft)	3.4 m (11.2 ft)

Trench Depth (m)	Soil[a] Type 1 and 2	Soil[a] Type 3 and 4
4.8 m (15.7 ft)	1.5 m (4.9 ft)	3.8 m (12.5 ft)
5.1 m (16.7 ft)	2 m (6.6 ft)	4.1 m (13.5 ft)
5.4 m (17.7 ft)	2.5 m (8.2 ft)	4.6 m (15.1 ft)
5.7 m (18.7 ft)	3 m (9.8 ft)	5 m (16.4 ft)
6 m (19.7 ft)	3.4 m (11.2 ft)	5.5 m (18 ft)

a. As defined in the Occupational Health and Safety Act.

For pipelines where the trench bottom is below the water table, the trench must be suitably shored as per the trench wall support requirements.

Any pipeline that is exposed for a length greater than indicated in Table 7-1: Maximum Span without Support Beam on page 15 requires a field assessment.

For steel and polyethylene pipelines within the minimum distances given in Table 7-3: Minimum Allowed Distance from Main to Excavation on page 16, support must remain in place until backfill material restores support.

Figure 7-1: Support of Gas Pipelines Crossing Excavations

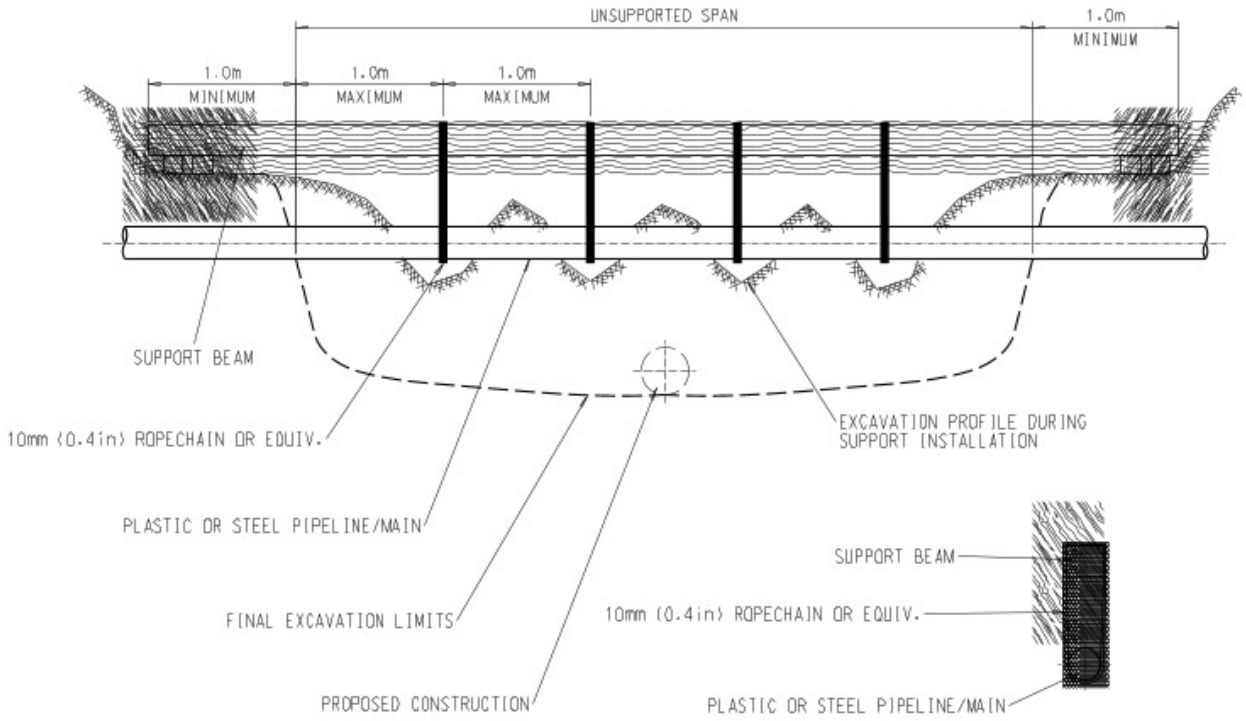
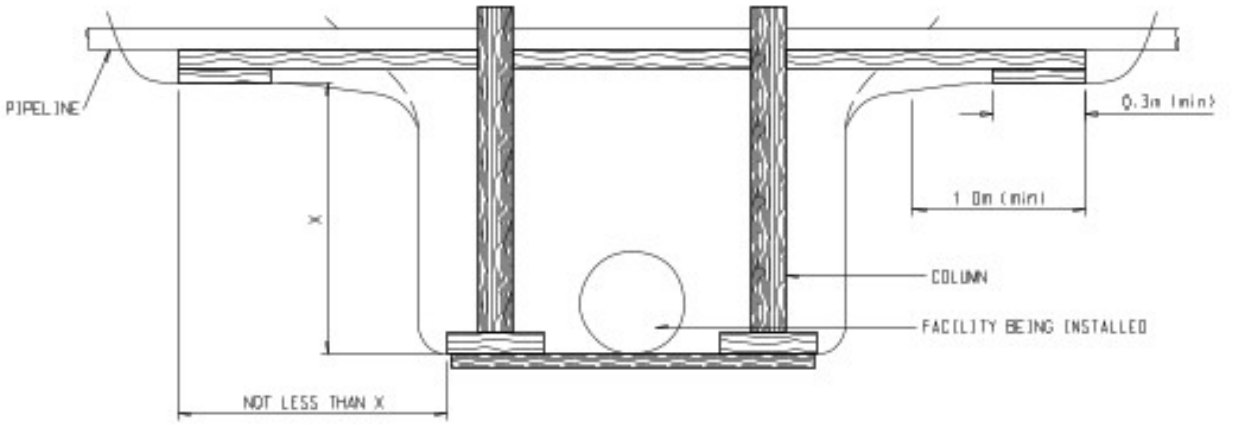


Figure 7-2: Typical Temporary Supports for Pipelines Crossing the Trench – Span Exceeds 4.5 m



NOTES:
1. LAMINATED 4X6 TIMBER BEAM REQUIRED BENEATH ALL NPS 1/2 - NPS 2.
2. LAMINATED 6X6 TIMBER BEAM REQUIRED BENEATH ALL NPS 3 - NPS 6.
3. LAMINATED 8X8 TIMBER BEAM REQUIRED BENEATH ALL NPS 8 - NPS 12.
4. COLUMN SIZE SHALL MATCH LAMINATED TIMBER BEAM REQUIREMENT.
5. COLUMN TO BE SPACED AS SPECIFIED BY PIPELINES AND STATIONS OPERATIONS ENGINEERING.
6. PLASTIC PIPE AND COATING ON STEEL PIPE TO BE PROTECTED FROM SUPPORTS AND STRAPPINGS WITH A PIECE OF RUBBER TIRE OR EQUIVALENT.
7. PLASTIC PIPE MUST BE SUITABLY STRAPPED O PREVENT MOVEMENT OFF THE BEAM.
8. ADDITIONAL SUPPORTS WILL BE REQUIRED AT MECHANICAL COUPLINGS OR VALVES.

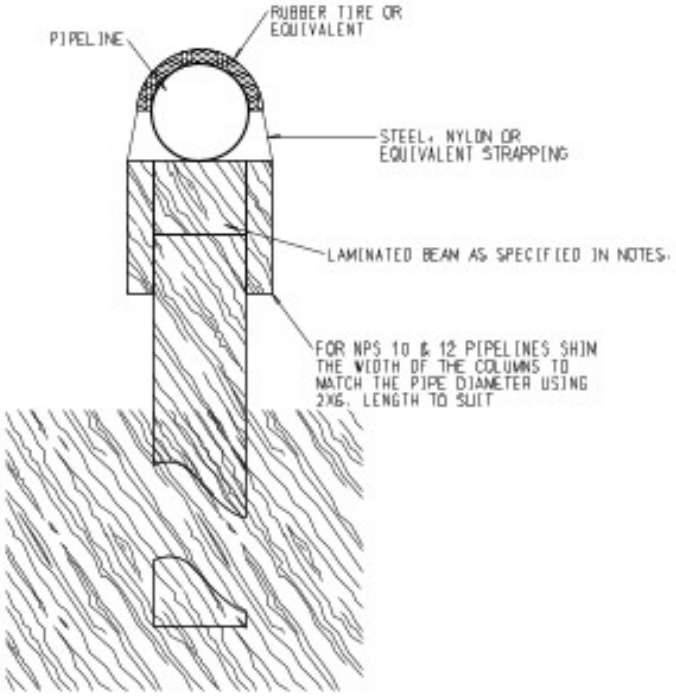
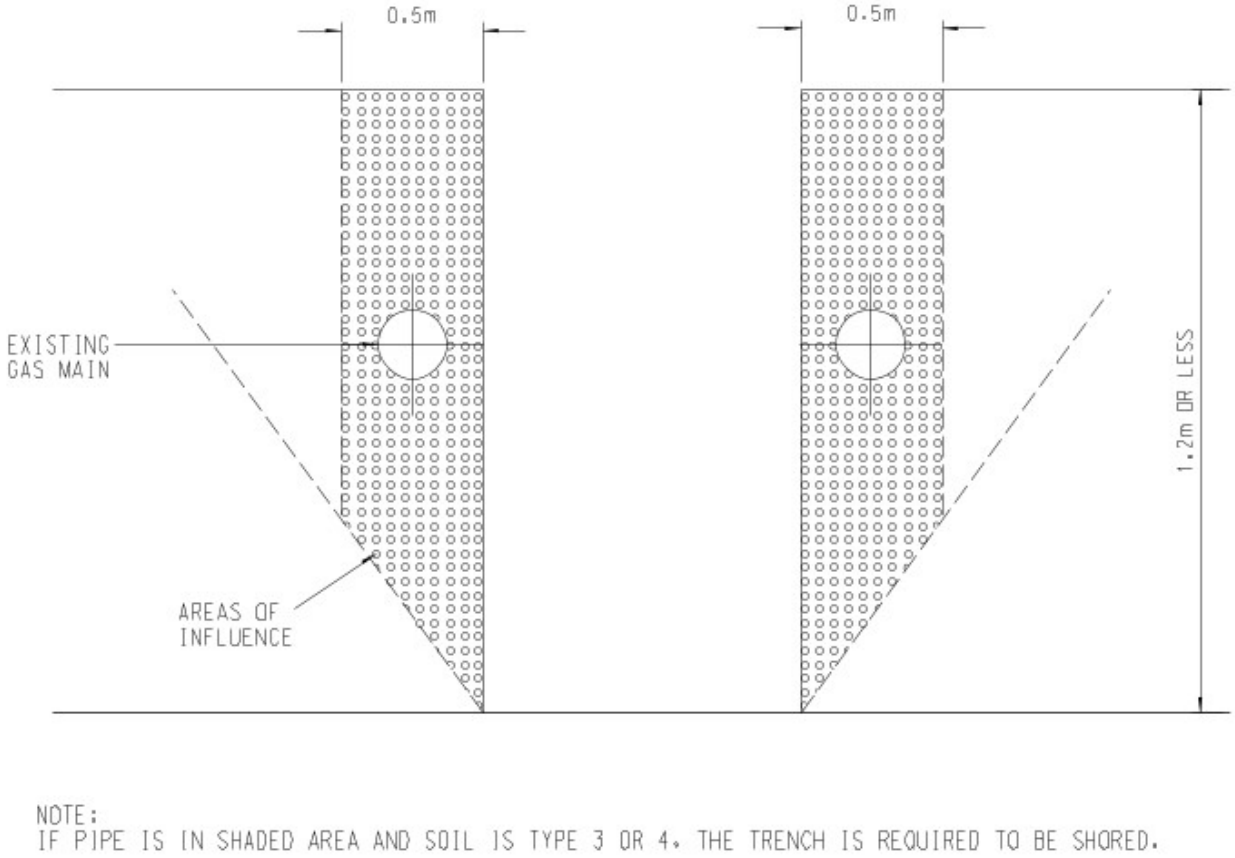


Figure 7-3: Influence Lines for Gas Pipelines Adjacent to Excavations



8 Horizontal Directional Drilling

8.1 General

Horizontal directional drilling (HDD) or directional boring is a steerable trenchless method of installing underground facilities. Trenchless technology is used where utilities being crossed are positively identified to confirm location.

For installations using any other type of drilling or augering equipment in the vicinity of gas facilities, GDS must be contacted.

In all cases, positive identification holes are required to visually verify the drill head's location (including depth) relative to the measurement of the tracking equipment. For positive identification hole requirements, see Figure 8-2: Pipeline Location Verification and Clearance Requirements for HDD for crossing all pipelines (including Vital Pipelines) on page 24. For pipeline location verification and clearance requirements for all horizontal directional drilling see Table 8-1: Pipeline Location Verification and Clearance Requirements for HDD for all Pipelines (including Vital Pipelines) on page 20.

If these guidelines cannot be complied with, a variance request work package must be submitted. No variance will be provided for work within 1 m (3.3 ft) of any pipeline. The variance work package must include, at a minimum, the following information:

- Pre-Engineering design.
- Location of EGI facilities with respect to proposed installation area (vertical and horizontal offsets).
- Location of proposed installation area (vertical and horizontal offsets off permanent landmarks).
- Pipeline protection plan.

If a variance is requested, a physical barrier (e.g., silt fence) must also be provided, which would denote the boundary of the pipeline, where possible.

Table 8-1: Pipeline Location Verification and Clearance Requirements for HDD for all Pipelines (including Vital Pipelines)

Location of Work Relative to Pipeline[a]	Required Verification of Pipe Location by Hand Digging or Hydro-Excavation
Crossing below pipeline (HDD)	All sides of pipeline (including below pipeline) exposed to 1.0 m (3.3 ft) from the pipeline's sidewalls. Additional positive identification hole at 2.0 m to 4.0 m (6.6 ft to 13.1 ft) prior to the daylight hole at the crossing, to verify depth and trajectory of drill head and backreamer.
Crossing above pipeline (HDD)	Top of pipeline and all sides exposed to 1.0 m (3.3 ft) or 1.0 m (3.3 ft) below the proposed installation. Additional positive identification hole at 2.0 m to 4.0 m (6.6 ft to 13.1 ft) prior to the positive identification hole at the crossing, to verify depth and trajectory of drill head and backreamer.

a. See Figure 8-2: Pipeline Location Verification and Clearance Requirements for HDD for crossing all pipelines (including Vital Pipelines) on page 24.

8.2 Drilling Parallel to Pipelines

When the proposed route is parallel to a natural gas pipeline at a perpendicular distance of 3 m (10 ft) or less, positive identification must be performed at intervals

of no more than 10 m (33 ft) along the drilling path so that the precise location of the drilling head and backreamers (if any) can be verified visually. These excavations must be sufficiently wide to see the entire width of the drilling head, backreamers, and structures from entry point to exit point.

Note

The location of the pipeline must be visually confirmed as per the requirements set out in Table 8-2: Pipeline Location Verification Requirements for Vital Pipelines on page 21 and Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines on page 21.

Note

For all pipelines (including vital pipelines), when drilling parallel to the pipeline, a minimum horizontal clearance of 1 m (3.3 ft) is required.

Table 8-2: Pipeline Location Verification Requirements for Vital Pipelines

Location of Work Relative to Pipeline[a]	Required Verification of Pipe Location by Hand Digging or Hydro-excavation
Work parallel to pipe, within 1 m (3.3 ft)	Spacing of test holes must not exceed 4.5 m (15 ft)
Work parallel to pipe, between 1 m (3.3 ft) and boundary area of pipeline based on size	Spacing of test holes must not exceed 4.5 m (15 ft)[b]
Crossing below pipeline (open excavation)	Top and sides of pipeline, and 0.6 m (2 ft) below the pipeline
Crossing above pipeline (open excavation)	Top and sides of pipeline, or 0.6 m (2 ft) below the proposed installation

a. Test holes must expose top and sides of pipeline

b. For work parallel to pipe, between 1 m (3.3 ft) and boundary area of pipeline based on size, for rural applications, test holes must be completed for any change in direction of the pipeline every 23 m (75 ft).

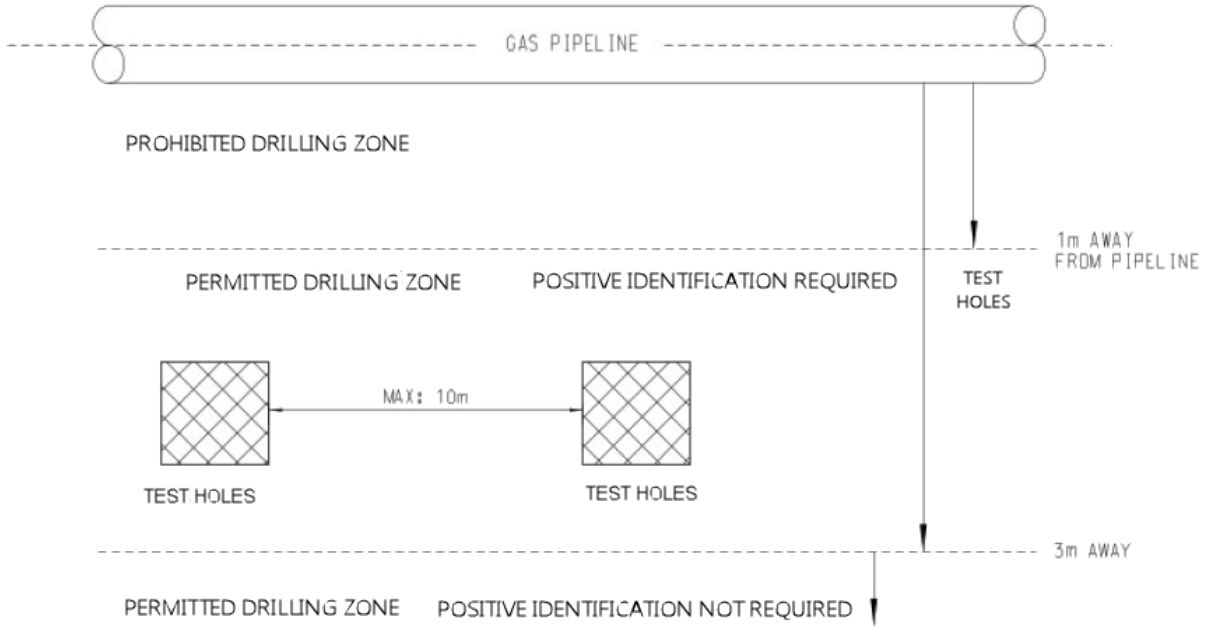
Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines

Location of Work Relative to Pipeline	Required Verification of Pipe location by hand digging or hydro-excavation
Work parallel to pipe, inside of boundary area (1 m [3.3 ft])	Spacing of test holes must not exceed 4.5 m (15 ft)
Crossing below pipeline (open excavation)	For less than NPS 12: Top of pipeline and all sides of the pipeline, or 0.3 m (1 ft) below the pipeline For NPS 12 and larger: Top of pipeline and all sides of the pipeline, or 0.6 m (2 ft) below the pipeline
Crossing above pipeline (open excavation)	For less than NPS 12: Top of pipeline and all sides of the pipeline,or 0.3 m (1 ft) below the proposed installation For NPS 12 and larger: Top of pipeline and all sides of the pipeline, or 0.6 m (2 ft) below the proposed installation

No drilling installation may be performed within a distance of 1 m (3.3 ft) or less from either side of the pipeline. This buffer zone must be clearly designated and

marked off around the work area. This prohibited zone may be widened in some cases.

Figure 8-1: Drilling Parallel to Pipelines



8.3 Drilling Across Pipelines

When the proposed drill path crosses a GDS pipeline, the pipeline must be exposed to the desired depth of the crossing to ensure that the natural gas pipeline is not affected and that the required clearance is maintained during all drilling operations. All minimum clearances must be measured from the outer edge of the drill, including backreamers (if any), to the outer circumference of the pipeline.

To ensure that the directional drilling operation will not result in damage to the pipeline, the following positive identification hole requirements must be followed:

- A positive identification hole must be created that is sufficiently wide enough to see the drill head and backreamer entering the excavation at a minimum of 1 m (3.3 ft) before crossing the pipeline. See Figure 8-2: Pipeline Location Verification and Clearance Requirements for HDD for crossing all pipelines (including Vital Pipelines) on page 24 positive identification hole 1.
- A second positive identification hole must be created prior to reaching the pipeline such that the precise location of the drill head and backreamer (if any) can be verified visually. The positive identification hole must be sufficiently wide to measure the depth and trajectory of the drill head and backreamer.

See Figure 8-2: Pipeline Location Verification and Clearance Requirements for HDD for crossing all pipelines (including Vital Pipelines) on page 24 positive identification hole 2.

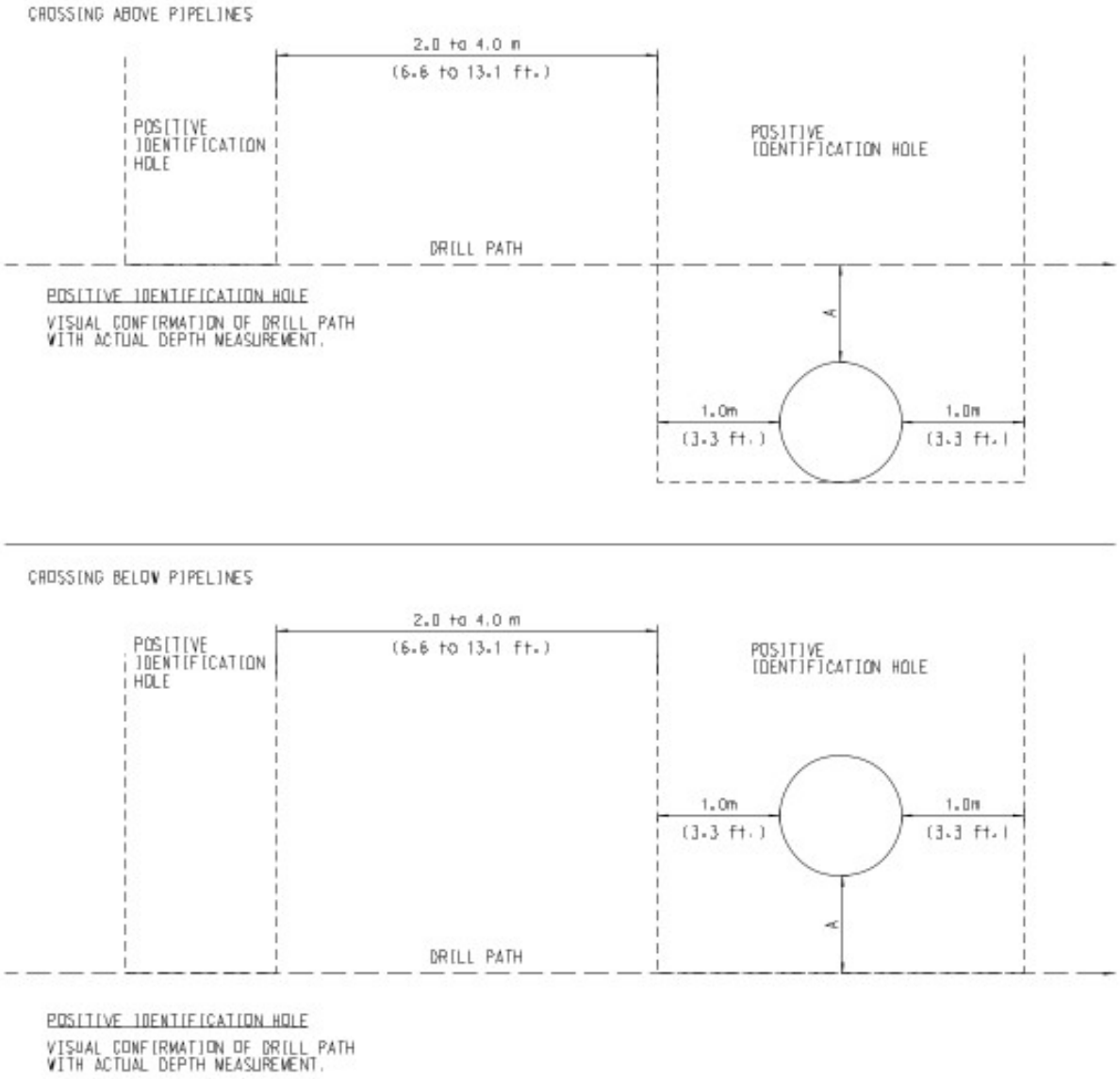
When drilling across pipelines that are smaller than NPS 16 (excluding vital pipelines), the vertical clearance, measured from the edge of the pipeline to the edge of the final bore hole, may follow the vertical clearance outlined in Table 4-1: Minimum Clearance Between Gas Pipelines (Less than NPS 16) and Other Underground Structures on page 10 as long as all positive identification requirements are also followed.

When drilling across pipelines that are NPS 16 or larger, or crossing any CER-regulated pipelines or vital pipelines, a minimum vertical clearance, measured from the edge of the pipeline to the edge of the final bore hole, of 1 m (3.3 ft.) is required.

Note

The location of the pipeline must be visually confirmed as per the requirements set out in Table 8-2: Pipeline Location Verification Requirements for Vital Pipelines on page 21 and Table 8-3: Pipeline Location Verification Requirements for All Other Pipelines on page 21. For specified minimum clearances, see 4 Minimum Clearance from Other Structures on page 10.

Figure 8-2: Pipeline Location Verification and Clearance Requirements for HDD for crossing all pipelines (including Vital Pipelines)



9 Hydro-Excavation

9.1 General

Hydro-excavation, also known as hydrovac, is the non-destructive process in which pressurized water is utilized as a method of excavation through loosening and suction of soil, rocks, and other earth materials. Hydro-excavation machines are an alternative to hand digging to locate and expose pipelines.

9.2 Hydro-Excavation Requirements

The following requirements must be met at all times when excavating with hydro-excavation technology:

Uncontrolled when printed. Controlled copy is in the GDS Document Library.

- Spinning tip nozzles must be used for hydrovac excavations with water pressures that must not exceed the maximum water pressure of 17,236 kPa (2,500 psi) during excavation. Pressure measures must be permanently monitored using a calibrated device mounted on either the hydro-excavation machine (truck and pump), or the wand when using a spinning tip nozzle.
- The wand must never remain motionless during excavation. The wand must never point to the plant at any time.
- A distance of 20 cm (8 in) between the end of the pressure wand nozzle and the plant or subsoil must be maintained. The nozzle must never be inserted into the subsoil while excavating above the plant.
- Hydro-excavation equipment and nozzles must have been specifically designed for use above buried gas lines or other reasonably expected underground gas plants.
- A device capable of stopping the excavation on demand must be installed, such as an approved automatic electronic shut-off or valve on the wand.
- If heated water is used during excavation, the temperature and pressure of the water must not exceed 100 °F (38 °C) and 17,250 kPa (2,500 psi), respectively.
- The excavator must contact the gas utility if any damage to a gas plant occurs while using hydro-excavation technology or any other method of excavation.

10 Backfilling

The gas pipeline must be inspected by GDS for damages before backfilling the excavation. It is the third party's responsibility to ensure that the gas pipeline is not undermined or endangered in any way. If any damage occurs, GDS must be contacted immediately.

The following principles must be followed:

- The backfill does not harm the pipe or coating throughout the installation process and while in service.
- The use of native material (especially with respect to anode installation) and minimize haul out must be maximized.
- A reliable and stable installation must be created and the use of dams included when appropriate.

The Company permits the use of any compacting device that:

- Will compact backfill sufficiently to eliminate any settlement of the pipe or ground surface.
- Will not cause any deformation or damage to the pipe or coating.
- Will not cause any damage to any adjacent building, structure or utility.
- Will not cause any damage to any tree, shrub, tended lawn, or ground cover.

When backfilling where the finished grade has not been established, sufficient soil must be placed over the trench to allow for settlement.

Backfilling must be done in such a manner as to prevent any rocks from being placed at or near the surface of the pipe. Native excavated material must be used

as backfill unless otherwise directed by GDS. Where native material is unsuitable, 150 mm (6 in) of approved earth or sand padding must be placed over the pipe for protection, to a minimum depth of 300 mm (12 in). Each layer must be compacted thoroughly by manual tamping. Topsoil must not be used for backfilling.

Aggregate backfill must be replaced in 200 mm (8 in) layers. Each layer must be thoroughly compacted by pneumatic tampers or an equivalent method acceptable to GDS to ensure no settlement. The final layer must be smoothed down with a grader (or a rake for small scale projects) and must be tamped flush or slightly higher than the surrounding ground surface in order to prevent ponding of water and accommodate any future soil subsidence over the trench line.

Backfilling a flooded trench is not allowed. The third party is responsible for the removal of water from the trench, before backfilling. If backfilling on a slope, the backfill must first be placed from the bottom of the slope, then the filling should continue by building upwards. This prevents large voids in the backfill that can occur when the backfill is dumped from the top of a slope.

Backfill and compaction within road allowances must be completed in accordance with the local governing authority.

Unshrinkable fill or other engineered backfill material must be installed only when requested by the municipalities, local governing authority, or as directed by GDS. The approved unshrinkable fill must be batched at a ready-mix plant with a specified maximum compressive strength of 0.7 MPa at 28 days and minimum slump of 150 mm (6 in). After curing, it must be excavatable using hand tools and must meet any governing agency requirements. The pipe and valve assemblies must be sand padded before placement of unshrinkable fill. The third party must ensure that placement of the unshrinkable fill does not displace sand padding or directly contact the pipeline.

If the bulk backfill material contains rocks, stones, or frozen material, pipelines must be padded with padding material to a minimum depth of 150 mm (6 in) over the pipe and fittings. If the location requires the backfill material to be tamped, the padding material must also be tamped.

The final covering of gas pipelines must adhere to municipal requirements.

11 Blasting and Pile Driving

11.1 General

Blasting and pile driving activities in the vicinity of GDS facilities require prior approval by GDS. The Blasting and Pile Driving Form, provided by GDS, must be submitted by the owner of the proposed work for all blasting and pile-driving operations. The request must be submitted a minimum of four weeks prior to the beginning work to allow sufficient time for review.

11.2 Blasting

Before any blasting operation in the vicinity of a gas pipeline can occur, the hazards to the GDS facility must be evaluated. Responsibility for the design of the blast and any resultant damage is borne entirely by the party using the explosives.

A recognized independent blasting consultant must be retained at the applicant's expense to perform an evaluation of the blast design. The independent blasting consultant must be an independent engineering consultant specialized in blasting. A copy of the stamped consultant's validation report must be submitted to GDS for review if blasting is to occur within 30 m (100 ft) of GDS facilities.

If in the opinion of GDS or an independent blasting consultant, blasting cannot be carried out without affecting the facility's integrity, alternatives must be considered, including the replacement or relocation of the affected facility at the applicant's expense. In these situations, additional time must be allowed to obtain the necessary permits and to complete the necessary construction work. In the event a third party is affected as a result of the blasting operations, all expenses associated therewith incurred by GDS must also be at the applicant's expense.

Ontario: The third party must comply with the Ontario Provincial Standard Specification (OPSS 120 – General Specification for the Use of Explosives) in addition to GDS's blasting requirements.

Quebec: The third party must comply with Quebec's Acts regarding explosives (CQLR c E-22 and CQLR c E-22, r 1) and Safety Code (CQLR c S-2.1, r 4), in addition to GDS's blasting requirements.

11.2.1 Surface and Tunnel Blasting Application Process

For subsurface blasting application requirements, refer to the Surface Blasting section of the Blasting and Pile Driving Form.

For tunnel blasting application requirements, refer to the Surface Blasting section of the Blasting and Pile Driving Form in addition to the Tunnel Blasting section.

To assist with the preparation of the form, locates must be requested to determine the location of the facilities.

11.2.2 Guidelines for Blasting

The information provided in this section is not to be construed as an exhaustive list of performance specifications, but rather a guide for conducting blasting in the vicinity of GDS's facilities. The third party is responsible for ensuring that all blasting work is performed in a good and workmanlike manner in accordance with all applicable laws, codes, by-laws, and regulations.

The third party will be held liable for and indemnify GDS in relation to any and all damage directly or indirectly caused or arising as a result of blasting operations carried out by the applicant, its employees, contractors, or those for whom the applicant is responsible by law. Prior to blasting operations, a site meeting must be arranged with an authorized representative of the applicant and a GDS representative to confirm the location of GDS's facilities and details of the proposed blast.

GDS's pipelines must not be excavated prior to blasting. If excavation is unavoidable, then the pipeline must be properly supported according to GDS's requirements as stated in 7 Support of Gas Pipelines on page 14.

The third party must take suitable precautions to protect the exposed pipeline from fly-rock .

Explosives must be of a type that cannot propagate between holes or be desensitized due to compression pressures. Explosives must not be left in the drill hole overnight.

If a surface blast islocated less than 10 m (33 ft) from pipeline; creates its first blast hole at a depth equal to the top of the pipeline; andthe depth of subsequent blast holes exceeds one half of the horizontal distance to the closest portion of the pipeline, then the required independent blasting consultant's report must specifically address the impact of these conditions. This is not applicable for tunnel blasting operations. The blasting consultant is responsible for the monitoring of blasting vibrations with a portable seismograph capable of transmitting data instantaneously (e.g., via email or cellular) to the required reviewer in the vicinity of GDS's facilities is mandatory to confirm that predicted vibration levels are respected. On a daily basis, a copy of the seismographic report must be provided to GDS.

Peak particle velocity (PPV) must be limited to 50 mm/s (2 in/s) and maximum amplitude must be limited to 0.15 mm (0.006 in).

11.2.3 Post Blasting

A leak survey must be completed at the end of each day of blasting. Upon completion of daily blasting operations and within 30 days after the final blasting, GDS will conduct a leak survey of the pipeline at the third party's expense. Leak surveys will also be completed at the end of each day of blasting. Damage that has resulted from the blasting will be repaired at the third party's expense. A summary of all blasting operations including blasting logs, vibration control, seismograph reports, and other pertinent information must be provided to GDS by the third party daily and at the completion of blasting operations.

11.3 Pile Driving

General pile installation or compaction activities in the vicinity of GDS's facilities must be evaluated by GDS prior to beginning. Any resultant damage as a result of these activities will be borne entirely by the third party undertaking the proposed work.

If in the opinion of GDS, the particular pile installation or compaction operation cannot be carried out without affecting the pipeline or facility integrity, the following must be considered:

- Risk analysis or mitigation program for the proposed operation.
- Alternative construction methods.
- Relocation or replacement of the facility.

All costs incurred will be covered by the third party undertaking the proposed work and final approval for the work will be granted by GDS.

Piles installed using an auger must satisfy the locating and clearance requirements listed in 5 Pipeline Location Verification on page 10 and 4 Minimum Clearance from Other Structures on page 10, respectively. GDS must provide approval for the installation of piles within 3 m (10 ft) of a vital pipeline.

The third party is responsible for all costs related to customer interruption as well as costs incurred because of work delays. In the event a third party is affected as a result of the pile installation or compaction operations, all expenses associated therewith incurred by GDS will be passed to the third party.

11.3.1 Pile Driving Application Process

The application to pile drive or do compaction work must be sent to GDS via the Blasting and Pile Driving Form.

This work must be completed under the supervisor of qualified personnel. Vibration results must be provided to GDS on a daily basis.

11.3.2 Pile Installation and Compaction Work

The information provided in this section is not to be construed as an exhaustive list of performance specifications, but rather a guide for conducting pile installation and compaction work in the vicinity of GDS's facilities. The third party is responsible for ensuring that all pile installation and compaction work is performed in accordance with all applicable laws, codes, by-laws, and regulations.

Operations must not be permitted within a standoff distance of 3.0 m (10 ft) from the pipeline or other natural gas facility, unless approved by GDS.

Prior to pile installation or compaction work, a site meeting with an authorized representative of the third party and a GDS representative (for the Damage Prevention contact, see 12 Contact Information on page 31) must be arranged by the third party, to confirm the location of GDS’s facilities and the details of the proposed work.

It is recommended that during the design phase, pile installation or compaction work drawings be sent to Markups for review (see 12 Contact Information on page 31).

The pipeline should not be excavated prior to the piling or compaction operation. If excavation of the pipeline is necessary, then it must be properly supported in accordance with 7 Support of Gas Pipelines on page 14.

The following situations require the opinion of an independent professional engineer:

- Compaction of soils or backfill rated at 10,000 ft-lbs (13,600 Nm) or higher at a stand-off distance of 6 m (20 ft) or less from the pipeline.
- Pile driving at a stand-off distance of 10 m (33 ft) or less from the pipeline facility.
- High-energy dynamic compaction for the rehabilitation of soils at a stand-off distance of 30 m (100 ft) or less from the pipeline.

- Type 4 soil as defined in Article 226 of the Occupational Health and Safety Act and Regulations for Construction Projects (see Table 15-1: Soil Types on page 33).

For these situations, the appropriate number of seismographs to monitor vibrations is mandatory. The seismographs must be portable with the capability of transmitting data instantaneously (e.g., via email or cellular). This control will confirm the intensity of the vibrations generated by the pile installation or compaction work as projected. Furthermore, reports of recorded intensities must be provided on a regular basis or at the request of GDS.

The peak particle velocity (PPV) measured on the pipeline, or at the closest point of the related structure with respect to the work, must not exceed 50 mm/s (2 in/s). Furthermore, the maximum displacement for the vertical or horizontal component corresponding to the above stated vibration intensity must not exceed 50 mm (2 in) at any given length of the pipeline in question.

If the PPV or displacement limit is surpassed, all operations must stop notwithstanding any delays or costs incurred by the third party or owner of the proposed work. GDS requires that the cause of these higher vibrations or displacements be investigated. GDS may arrange for a leak survey to be conducted. GDS Engineering must approve resumption of operations. Should a situation with low energy compaction operations with a soil cover of less than 1.5 m (5 ft) above the pipeline at a stand-off distance of 3 m (10 ft) or less from a pipeline be encountered, GDS may require the opinion of an independent engineering consultant.

In addition, if a Type 3 soil (see Table 15-1: Soil Types on page 33) is present on site, GDS may require the opinion of an independent engineering consultant.

The use of an auger may be required in order to avoid the use of piles.

All operations must comply with the Provincial Occupational Health and Safety Act and Regulations for Construction Projects, other applicable laws and regulations, as well as all applicable GDS specifications, standards, and guidelines.

11.3.3 Post Pile Driving Process

The third party must send GDS the items that follow within five business days of the completion of the pile installation via pile driving or compaction operations:

- A summary of all operations.
- Pile driving and compaction logs.
- Vibration control records.
- Seismograph records.

On completion of each day's work, and approximately 30 days after all work is completed, GDS will arrange to conduct a leak survey of the facility. If damage to GDS's facilities is found, it will be repaired by the third party. An invoice will be sent to the third party responsible for the work.

12 Contact Information

Location	Contact
Enbridge Gas Inc 500 Consumers Road North York, ON M2J 1P8	Markups: Mark-Ups@enbridge.com Ontario One Call Locates: 1-800-400-2255 Damage Prevention: 1-866-922-3622 Emergency: 1-866-763-5427 and 1-877-969-0999
Enbridge Gas Inc Storage and Transmission Operations Locates (Dawn) 3332 Bentpath Line P.O. Box 1180 Dresden, ON N0P 1M0	Ontario One Call Locates: 1 (800) 400-2255 Locates: 1-800-265-5260 ext 5102236 Stacey.Smith@enbridge.com Locates: 1-800-265-5260 ext 5102184 Janice.Langstaff@enbridge.com
Enbridge Gas Inc Storage and Transmission Operations Locates (Tecumseh) 3501 Tecumseh Road, Mooretown, Ontario N0N 1M0	Field Operations: 519-312-0176 jay.moore@enbridge.com Field Operations: 519-862- 6004 jason.japp@enbridge.com Tecumseh Control Room: 519-862-6012 Emergency: 1-800-255-1431
Gazifère 706 Boulevard Greber Gatineau, QC J8V 3P8	Locates: 1-800-663-9228 Planning Dept.: 1-819-776-8804 Emergency: 1-819-771- 8321, press 1

Note

The website www.clickbeforeyoudig.com gives access to the damage prevention centres in Canada, and allows locate requests to be made for each province.

13 References

- IS_F_172 Blasting and Pile Driving Form

14 Document Governance

For document control and maintenance purposes, the following tables capture important information related to this document.

Control and Maintenance

Category	Value
Owned By	Pipeline Engineering
Review Interval	Every three years
MOC-Related	No

Revision History

Table 14-1: January 2024 Release

Release Date	Version	Project Number	RFC Number	Prepared By	Approved By
2024-01-31	1.2.1	n/a	5399	Derek Brecht, Engineer Pipeline Engineering	Todd Piercey, Manager, Pipeline Engineering
Doc ID		**Scope**	**Document & Section**		**Summary of Changes**
ST-1E-30A8-8E30		GDS	Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard		Revised Figure 8-1.

Table 14-2: September 2021 Release

Release Date	Version	Project Number	RFC Number	Prepared By	Approved By
2021-09-29	1.1.1	n/a	4983	Hooman Zahedi, Supervisor, Pipeline Engineering	Todd Piercey, Manager, Pipeline Engineering
Doc ID		**Scope**	**Document & Section**		**Summary of Changes**
ST-1E-30A8-8E30		GDS	Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard		Corrected typo in 11.2 Blasting

Table 14-3: June 2021 Release

Release Date	Version	Project Number	RFC Number	Prepared By	Approved By
2021-06-30	1.1.0	n/a	4922	Hooman Zahedi, Supervisor, Pipeline Engineering	Todd Piercey, Manager, Pipeline Engineering
Doc ID		**Scope**	**Document & Section**		**Summary of Changes**
ST-1E-30A8-8E30		GDS	Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard		Revise tree clearance restrictions in section 3.8.

Table 14-4: April 2021 Release

Release Date	Version	Project Number	RFC Number	Prepared By	Approved By
2021-04-28	1.0.0	6513-20	None	Emily Varga, EIT I, Pipeline Engineering	Todd Piercey, Manager Pipeline Engineering

Doc ID	Scope	Document & Section	Summary of Changes
ST-1E-30A8-8E30	GDS	Third-Party Requirements in the Vicinity of Natural Gas Facilities Standard	Initial version.

15 Soil Types

Table 15-1: Soil Types

Type	Definition
Type 1	• Hard, very dense, and only able to be penetrated with difficulty by a small sharp object. • Low natural moisture content and a high degree of internal strength. • No signs of water seepage. • Can be excavated only by mechanical equipment.
Type 2	• Very stiff, dense, and can be penetrated with moderate difficulty by a small sharp object. • Low to medium natural moisture content and a medium degree of internal strength. • Damp appearance after it is excavated.
Type 3	• Stiff-to-firm and compact-to-loose in consistency or is previously-excavated soil. • Exhibits signs of surface cracking. • Exhibits signs of water seepage. • If dry, may run easily into a well-defined conical pile. • Low degree of internal strength.
Type 4	• Soft to very soft and very loose in consistency, very sensitive, and upon disturbance is significantly reduced in natural strength. • Runs easily or flows, unless it is completely supported before excavating procedures. • Almost no internal strength. • Wet or muddy. • Exerts substantial fluid pressure on its supporting system.

Appendix C: Technical data sheets (Explosives and accessories)

FICHE TECHNIQUE

Exel[MC] Handidet[MC]

Assemblages de détonateurs non électriques avec délais de surface / fond de trou combinés

Canada

Format Actual **Format Futur**

</= 8m/24ft **>/= 9m/30ft**

Description

Les assemblages Handidet[MC] non électriques avec délais de surface et délais de fond de trou combinés sont des composants faciles à utiliser dans les applications de sautage non électriques. Utilisés pour l'excavation de tranchées pour pipelines et services publics, dans les carrières, exploitations à ciel ouvert et projets de construction, les assemblages Handidet[MC] sont faciles à raccorder et à vérifier. Ils assurent la précision des séquences en surface et en fonds de trous.

Avantages

Les assemblages Handidet[MC]

- Diminuent le nombre de composants sur le site
- Permettent de modifier la conception du plan avant le tir
- Réduisent l'inventaire
- Offrent un excellent contrôle du tir
- Facilitent le raccordement – augmentent la productivité
- Permettent la vérification rapide des raccords
- Réduisent les risques de ratés dûs aux mouvements de terrain
- Fonctionnent sous toutes les conditions climatiques
- Ne s'entremêlent pas, pas de perte
- Diminuent les coûts d'exploitation

Caractéristiques

Détonateur de fond de trou	Haute puissance, charge de base de 12 grains (780 mg) de PETN (USBM 8+)
Amorce de surface	Nouveau design, peu d'éclats
Boîte-raccords	Capacité de 6 tubes, code couleur selon le délai de surface, impression indélébile de la longueur et des délais
Tube de choc Exel®	Couleur jaune vif

Durée nominale des retards	
Surface / Fond de trou (ms)	**Couleur de la boîte-raccords**
17/500	Jaune
25/475	Orange
# 25/500	Orange
42/500	Blanc
# Combinaison à micro-retard standard	

Combinaison à micro-retard standard

Fonctionnalités

Les assemblages Handidet[MC] sont :

- Des délais de surface et de fond de trou combinés
- Une nouvelle conception à faible d'énergie
- De haute précision
- Faciles et rapides à raccorder
- Munis de boîte-raccords ergonomique visibles acceptant 6 tubes
- Très voyants
- Robustes, avec nouvelle gaine résistante à l'abrasion
- Résistants à la chaleur,et au froid, enroulements en huit faciles à manipuler

Recommandations relatives à l'utilisation

Amorçage et mise à feu

Ne pas utiliser l'assemblage Handidet[MC] comme ligne de descente. Garder le tube de choc raide jusqu'à la fin du

orica.com

Exel[MC] Handidet[MC]

Assemblages de détonateurs non électriques avec délais de surface / fond de trou combinés

Canada

chargement. Éviter d'endommager le tube de choc pendant le chargement et les activités de bourrage.

Ne jamais tirer assez fort pour étirer ou briser le tube de choc. Une mise à feu prématurée pourrait se produire.

Les assemblages de détonateurs Handidet[MC] sont unidirectionnels. Ils peuvent être mis à feu à l'aide:

- de l'amorce de surface d'un autre Handidet[MC]
- un détonateur électronique Orica
- un détonateur électrique
- un système de délai de surface à tube de choc Orica

Remarque: La boîte-raccords de surface de l'assemblage Handidet[MC] renferme un dispositif explosif qui peut être mis à feu par la chaleur, un impact ou la friction. Le raccord de surface n'est pas conçu pour la mise à feu de cordeau détonant.

Emballage

Les assemblages de détonateurs Handidet[MC] sont des enroulements en forme de huit. Les assemblages sont livrés en vrac dans des caisses en carton dur.

Longueur (approximative)		Quantité par caisse		Poids par caisse Kg / lb	
Mètres	Pieds	1.1B	1.4B	1.1B	1.4B
4	12		90		6,9 / 15,3
5	16	100	90	7,2 / 15,9	7,4 / 16,3
7	23	75	70	6,5 / 14,4	7,0 / 15,4
8	24		70		7,4 / 16,3
9	30	65	60	6,6 / 14,5	7,0 / 15,4
12	40	50	50	6,2 / 13,6	7,0 / 15,4
15	50	45	45	6,4 / 14,1	7,2 / 15,9
18	60		36		7,1 / 15,7
21	70	35		6,4 /14,1	
25	80		25		6,3 / 13,8
30	100		25		7,0 / 15,4
37	120		20		6,7 / 14,8
45	150		15		6,2 / 13,7

Certaines combinaisons de longueur/délai peuvent ne pas être disponibles.

Entreposage et manutention

Classe du produit

Nom officiel:	Handidet[MC]
Nom d'expédition:	Assemblages de détonateur, non électriques
No ONU:	0360, PG II
Classification:	1.1B
UN ONU:	0361, PG II
Classification:	1.4B

Entreposage

Idéalement, entreposer à des températures modérées et au sec dans un dépôt bien ventilé et autorisé pour l'emmagasinage de détonateurs.

Durée de conservation

La durée de conservation maximum du Exel[MC] Handidet[MC] LP est de quatre ans, à partir de la date de fabrication, lorsqu'entreposé dans un dépôt frais, sec et bien ventilé et s'il est manipulé correctement.

Élimination

L'élimination de matières explosives peut présenter des dangers. Les méthodes d'élimination sécuritaires dépendent de la situation de l'utilisateur. Communiquez avec un technicien Orica concernant les pratiques sécuritaires.

Dénégation de responsabilité

© 2017 Orica Group. Tous droits réservés. Les renseignements contenus dans ce document sont uniquement transmis à titre d'information et sont modifiables sans préavis. Puisque l'Orica Group ne peut anticiper ou contrôler les conditions selon lesquelles les renseignements et ses produits seront utilisés,

orica.com

Exel[MC] Handidet[MC]

Assemblages de détonateurs non électriques avec délais de surface / fond de trou combinés

Canada

l'utilisateur doit examiner les renseignements dans le contexte particulier de l'application visée. Dans les limites autorisées par la loi, l'Orica Group dénie spécifiquement toute garantie explicite ou implicite Y COMPRIS L'EXACTITUDE, L'ABSENCE DE CONTREFAÇON ET TOUTE GARANTIE EXPLICITE OU IMPLICITE QUANT À LA QUALITÉ MARCHANDE OU QUANT À LA CAPACITÉ DES PRODUITS DE SERVIR À DES FINS PARTICULIÈRES. L'Orica Group ne pourra être tenu responsable de toute perte ou tout dommage résultant de l'utilisation de ces renseignements.

Le mot Orica et le dispositif Ring sont des marques de commerce du Orica Group.

Pour de plus amples renseignements, consultez : www.orica.com

Pour contacter l'administration centrale d'Orica, Amérique du Nord:
Tél.: +1 303 268 5000
Fax: +1 303 268 5250

Numéros d'urgence
Pour les urgences chimiques (24 heures) concernant le transport, un déversement, une fuite, un dégagement un incendie ou un accident:

Orica Canada, intervention d'urgence **1-877-561-3636**

orica.com

TECHNICAL DATA SHEET

Fortel™ Ultra

USA & Canada

Description

Fortel™ Ultra packaged emulsion explosive is a robust, booster sensitive explosive. The explosive is orange in color with a firm putty-like consistency.

Application

Fortel™ Ultra is a large diameter water resistant packaged explosive designed for use as a medium density column explosive in mining and general blasting work. Fortel™ Ultra can be used to build a toe charge out of water in conjunction with an Amex™ column charge.

Key Benefits

- Fortel™ Ultra is specifically formulated to reduce post blast Carbon Monoxide gasses in Underground, Surface and Construction blasting applications.
- Fortel™ Ultra is a cost efficient, emulsion formulation suitable for a range of blasting applications.
- Fortel™ Ultra improves digging and mucking efficiency in benching and other applications, even in deep holes.
- Fortel™ Ultra is pre-compression resistant with excellent heave energy.
- Fortel™ Ultra is highly water resistant, which minimizes leaching and reduces environmental impact.
- OH&S issues around the handling and storage of nitroglycerin are eliminated.
- The packaging and emulsion color of Fortel™ Ultra Provides high visibility in a range of environments.

Technical Properties

Fortel™ Ultra 65 x 400 mm (2 ½ x 16 in.)		
Cartridge Density		1.28 g/cc
Typical Velocity of Detonation[1]		5,200 m/s[3] 17,000 ft/s
Water Resistance		Excellent
Fume Class		1
Post Blast Carbon Monoxide Production		0.022 liters / kg
Relative Effective Energy (REE) [2]	Relative Weight Strength (RWS)	114
	Relative Bulk Strength (RBS)	174

Recommendations for Use

Blasthole Depth

Fortel™ Ultra is suitable for use in holes of any practical depth providing contained water does not exceed 20 m (65.6 ft.) depth.

Priming and Initiation

Fortel™ Ultra is a booster sensitive emulsion explosive and must be in direct contact with the largest possible diameter Senatel™ detonator sensitive explosive or an appropriately sized Pentex™ booster. Use of detonating cord with Fortel™ Ultra is not recommended. Detonating cord may adversely affect the performance of Fortel™ Ultra and could result in misfires in boreholes less than 75 mm (3 in.) in diameter. Consult an Orica representative before attempting to use with detonating cord.

Charging

Cartridges may be placed into blastholes intact or, where maximum energy is required, may be slit lengthways prior to loading to achieve a higher degree of coupling. Care should be taken when loading slit cartridges into wet blastholes as the explosive could bridge at the air-water interface.

Sleep-Time within Blastholes

The sleep-time in a blasthole is influenced by the extent of damage to the packaging and by the nature of any water present. Fortel™ Ultra will give good performance after two weeks immersion.

Ground Temperature

Fresh product is reliable down to –10°C (14°F) at 65 mm (2½ in.) primed in confinement with a 454 g (1 lb) cast booster.

Fortel™ Ultra

USA & Canada

Packaging

Fortel™ Ultra is distinctively packaged in high strength, tear-resistant blue Valeron plastic film, to clearly differentiate it from detonator sensitive packaged explosives. Standard cartridge sizes are as follows:

Sizes (mm)	Sizes (in.)	Cartridges per case	Film
50 x 400	2 x 16	25	Valeron
65 x 400	2½ x 16	16	Valeron
75 x 400	3 x 16	11	Valeron
90 x 400	3½ x 16	8	Valeron

Storage and Handling

Product Classification

Authorized Name: Fortel™ Ultra
Shipping Name: Explosive, Blasting, Type E
UN No: 0332
Class Code: 1.5D

All regulations pertaining to the handling and use of such explosives apply.

Storage

Store Fortel™ Ultra in a suitably licensed magazine for Class 1.5D explosives. The cases should be stacked in the manner designated on the case.

Fortel™ Ultra has a **shelf life** of up to 12 months from date of manufacture in a well ventilated, approved magazine, even in hot and humid extremes.

Fortel™ Ultra is best stored at temperatures above -15°C (5°F). This is especially important in cold weather "load and shoot" work sites where there is insufficient in-hole warm up time.

For recommended good practices in transporting, storing, handling, and using this Product, refer to the "Always and Never" booklet packed inside each case.

Transport

Fortel™ Ultra should be transported between -40°C (40°F) and +40°C (104°F).

Disposal

Disposal of explosive materials can be hazardous. Methods of safe disposal of explosives may vary depending on the user's situation. Please contact an Orica Technical Services Representative for information on safe practices.

Safety

The post detonation fume characteristics of Fortel™ Ultra make the Product suitable for both underground and surface blasting applications. Users should ensure that adequate ventilation is provided prior to re-entry into the blast area.

Fortel™ Ultra can be initiated by extremes of shock, friction or mechanical impact. As with all explosives, Fortel™ Ultra should be handled and stored with care and must be kept clear of flame and excessive heat.

Disclaimer

© 2017 Orica Group. All rights reserved. All information contained in this document is provided for informational purposes only and is subject to change without notice. Since the Orica Group cannot anticipate or control the conditions under which this information and its products may be used, each user should review the information in the specific context of the intended application. To the maximum extent permitted by law, the Orica Group specifically disclaims all warranties express or implied in law, INCLUDING ACCURACY, NON INFRINGEMENT, AND IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. The Orica Group specifically disclaims, and will not be responsible for, any liability or damages resulting from the use or reliance upon the information in this document.

The word Orica and the Ring device are trademarks of the Orica Group.

For more information please visit our website: www.orica.com

Fortel™ Ultra

USA & Canada

Orica's North America headquarters can be reached at:
Tel: +1 303 268 5000
Fax: +1 303 268 5250

Emergency Telephone Numbers

For chemical emergencies (24 hour) involving transportation, spill, leak, release, fire or accidents:

Canada: Orica Canada emergency response 1-877-561-3636

USA: Chemtrec 1-800- 424-9300

Notes:

1) VOD will depend on application including explosive density, blasthole diameter and degree of confinement. The VOD range is based on minimum unconfined and calculated ideal.
2) The "Relative Effective Energy (REE) of an explosive is the energy calculated to be available to do effective blasting work. All energy values are calculated using the IDeX™ computer code owned by Orica for the exclusive use of its companies. Energy values are based on standard ANFO with a density of 0.84 g/cc and a cut-off pressure of 100Mpa. Other computer codes may give different values.
3) Unconfined at 5ºC (41ºF).

TECHNICAL DATA SHEET

Powerditch™ 1000

USA and Canada

Description

Powerditch™ 1000 is a high-energy premium specialty dynamite product that is pre-compression resistant.

Application

Powerditch™ 1000 has been formulated to reduce hole-to-hole propagation and can be utilized in various blasting applications, including; trenching, ditching, site preparation, and underwater blasting.

Key Benefits

- Powerditch™ 1000 provides superior breakage under severe conditions.
- Powerditch™ 1000 provides reduced hole-to-hole propagation.
- Impact and friction sensitivity is reduced with Powerditch™ 1000.
- Powerditch™ 1000 provides high detonation pressure.
- Excellent performance under high static pressures.
- Resistant to dynamic pre-compression.
- Powerditch™ 1000 has excellent water resistance, and is suitable for use in applications with moderate to severe water conditions.

Recommendations for Use

Priming and Initiation

Powerditch™ 1000 is recommended to be primed with a high strength detonator or 20 grain /ft detonating cord.

Technical Properties

Powerditch™ 1000 50 mm (2 in.)		
Cartridge Density (g/cc)		1.36
Velocity of Detonation[1]		5,150 m/s 16, 900 ft/s
Water Resistance		Excellent
Fume Class		1
Relative Effective Energy (REE) [2]	Relative Weight Strength (RWS)	106
	Relative Bulk Strength (RBS)	171

Packaging

Depending on size, Powerditch™ 1000 is packaged in easy to load rigid spiral wound shells, or convolute paper shells. Standard cartridge sizes are as follows:

Sizes (mm)	Sizes (in.)	Cartridge/ case	Paper Type	Kg/ case	lbs/ case
32 x 200	1¼ x 8	88	Convolute	19.16	42.25
40 x 200	1½ x 8	60	Convolute	19.05	42.01
40 x 400	1½ x 16	30	Convolute	18.51	40.81
45 x 400	1¾ x 16	20	Convolute	17.69	39.01
50 x 200	2 x 8	34	Convolute	19.28	42.51
50 x 400	2 x 16	17	Convolute/ Spiral	19.28	42.51
65 x 400	2½ x 16	10	Spiral	17.69	39.01

Powerditch™ 1000

USA and Canada

Storage and Handling

Product Classification

Authorized Name:	Powerditch™ 1000
Correct Shipping Name:	Explosive, blasting, type A
UN No:	0081
Classification:	1.1D

All regulations pertaining to the handling and use of such explosives apply.

Storage

For maximum **shelf life,** dynamite must be stored in cool, dry, and well-ventilated magazines. Dynamite that is stored under warm, wet, and/or humid conditions can deteriorate quickly, minimizing shelf life. Dynamite inventories should always be rotated, by using the oldest materials first.

For recommended good practices in transporting, storing, handling, and using this product, refer to the "Always and Never" booklet packed inside each case.

Transport

Powerditch™ 1000 should be transported between -40°F (-40°C) and 104°F (+40°C).

Disposal

Disposal of explosive materials can be hazardous. Methods of safe disposal of explosives may vary depending on the user's situation. Please contact an Orica Technical Services Representative for information on safe practices.

Safety

The post detonation fume characteristics of Powerditch™ 1000 make the product suitable for both underground and surface blasting applications. Users should ensure that adequate ventilation is provided prior to re-entry into the blast area.

Powerditch™ 1000 can be initiated by extremes of shock, friction or mechanical impact. As with all explosives, Powerditch™ 1000 should be handled and stored with care and must be kept clear of flame and excessive heat.

Disclaimer

© 2017 Orica Group. All rights reserved. All information contained in this document is provided for informational purposes only and is subject to change without notice. Since the Orica Group cannot anticipate or control the conditions under which this information and its products may be used, each user should review the information in the specific context of the intended application. To the maximum extent permitted by law, the Orica Group specifically disclaims all warranties express or implied in law, INCLUDING ACCURACY, NON INFRINGEMENT, AND IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. The Orica Group specifically disclaims, and will not be responsible for, any liability or damages resulting from the use or reliance upon the information in this document.

The word Orica and the Ring device are trademarks of the Orica Group.

For more information please visit our website: www.orica.com

Orica's North America headquarters can be reached at:
Tel: +1 303 268 5000
Fax: +1 303 268 5250

Emergency Telephone Numbers

For chemical emergencies (24 hour) involving transportation, spill, leak, release, fire or accidents:

Canada: Orica Canada emergency response 1-877-561-3636

USA: Chemtrec 1-800- 424-9300

Notes:

(1.) Unconfined at 5ºC (41ºF). VOD will depend on application including explosive density, blasthole diameter and degree of confinement. The VOD range is based on minimum unconfined and calculated ideal

(2.) The Relative Effective Energy (REE) of an explosive is the energy calculated to be available to do effective blasting work. All energy values are calculated using the IDeX™ computer code owned by Orica for the exclusive use of its companies. Energy values are

based on standard ANFO with a density of 0.84 g/cc and a cut-off pressure of 100Mpa. Other computer codes may give different values.

TECHNICAL DATA SHEET

Powerfrac™

USA & Canada

Description

Powerfrac™ is an ammonia gelatin dynamite.

Application

It is a detonator sensitive explosive designed to meet the needs of surface quarries and open pit applications. Uses include site preparation, utility work, construction projects, and as a high-energy bottom charge. Powerfrac™ explosive provides good shattering effect in hard breaking formations and is effective with heavy burdens.

Key Benefits

- Powerfrac™ detonator-sensitive explosive provides good sinking characteristics, and good shattering effect.
- The tampable paper means high loading factors; rigid cartridges make for easy loading in tough or ragged holes.
- Powerfrac™ has increased shock energy for initial crack development, excellent heave energy for muckpile displacement.
- Powerfrac™ has reliable performance in wet ground, and tough loading conditions.
- Powerfrac™ is resistant to dynamic pre-compression, and has excellent gap sensitivity.

Recommendations for Use

Priming and Initiation

Powerfrac™ is recommended to be primed with a high strength detonator or 20 grain /ft detonating cord.

Charging

In small diameter blastholes the maximum energy per meter of blasthole can be achieved by tamping the explosive with a wooden tamping rod appropriate to the hole diameter. No metal instrument should be used to tamp explosives. The primer cartridge containing a detonator must not be tamped.

Technical Properties

Powerfrac™ 50 mm (2 in.)		
Cartridge Density (g/cc)		1.37
Velocity of Detonation[1]		6,100 m/s 20,000 ft/s
Water Resistance		Excellent
Fume Class		1
Relative Effective Energy (REE)[2]	Relative Weight Strength (RWS)	113
	Relative Bulk Strength (RBS)	186

Sleep-Time within Blastholes

The sleep time in a blasthole is influenced by the extent of damage to the packaging and by the nature of any water present.

Packaging

Powerfrac™ is packaged in spiral-wound paper. Standard Cartridge sizes are as follows:

Size (mm)	Size (in.)	Kg / Case	Lbs / Case	Cart./ Case	Paper Type
25 x 200	1 x 8	19.69	43.42	140	Spiral Wound
45 x 400	1 ¾ x 16	19.78	43.61	23	Spiral Wound
50 x 200	2 x 8	18.51	40.81	34	Spiral Wound
50 x 400	2 x 16	18.51	40.81	17	Spiral Wound
65 x 400	2 ½ x 16	18.01	39.71	10	Spiral Wound

Powerfrac™

USA & Canada

Storage and Handling

Product Classification

Authorized Name:	Powerfrac™
Correct Shipping Name:	Explosive, blasting, type A
UN No:	0081
Classification:	1.1D

All regulations pertaining to the handling and use of such explosives apply.

Shelf Life

One year from time of manufacture. For maximum **shelf life**, dynamite must be stored in cool, dry, and well-ventilated magazines. Dynamite that is stored under warm, wet, and/or humid conditions can deteriorate quickly, minimizing shelf life. Dynamite inventories should always be rotated, by using the oldest materials first.

Storage

For best results, store at moderate temperatures and dry conditions in a well ventilated, approved explosives magazine.

For recommended good practices in transporting, storing, handling, and using this product, refer to the "Always and Never" booklet packed inside each case.

Transport

Powerfrac™ should be transported between -15°C (5°F) and +30°C (86°F).

Disposal

Disposal of explosive materials can be hazardous. Methods of safe disposal of explosives may vary depending on the user's situation. Please contact an Orica Technical Services Representative for information on safe practices.

Safety

The post detonation fume characteristics of Powerfrac™ make the product suitable for both underground and surface blasting applications. Users should ensure that adequate ventilation is provided prior to re-entry into the blast area.

Powerfrac™ can be initiated by extremes of shock, friction or mechanical impact. As with all explosives, Powerfrac™ should be handled and stored with care and must be kept clear of flame and excessive heat.

Disclaimer

© 2017 Orica Group. All rights reserved. All information contained in this document is provided for informational purposes only and is subject to change without notice. Since the Orica Group cannot anticipate or control the conditions under which this information and its products may be used, each user should review the information in the specific context of the intended application. To the maximum extent permitted by law, the Orica Group specifically disclaims all warranties express or implied in law, INCLUDING ACCURACY, NON INFRINGEMENT, AND IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. The Orica Group specifically disclaims, and will not be responsible for, any liability or damages resulting from the use or reliance upon the information in this document.

The word Orica and the Ring device are trademarks of the Orica Group.

For more information please visit our website: www.orica.com

Orica's North America headquarters can be reached at:
Tel: +1 303 268 5000
Fax: +1 303 268 5250

Emergency Telephone Numbers

For chemical emergencies (24 hour) involving transportation, spill, leak, release, fire or accidents:

Canada: Orica Canada emergency response 1-877-561-3636

USA: Chemtrec 1-800- 424-9300

Powerfrac™

USA & Canada

Notes:

(1.) Unconfined at 5ºC (41ºF). VOD will depend on application including explosive density, blasthole diameter and degree of confinement. The VOD range is based on minimum unconfined and calculated ideal.

(2.) The Relative Effective Energy (REE) of an explosive is the energy calculated to be available to do effective blasting work. All energy values are calculated using the IDeX™ computer code owned by Orica for the exclusive use of its companies. Energy values are based on standard ANFO with a density of 0.84 g/cc and a cut-off pressure of 100Mpa. Other computer codes may give different values.

TECHNICAL DATA SHEET

Senatel™ Ultrex™

USA & Canada

Description

Senatel™ Ultrex™ packaged explosive is a robust, high strength, detonator sensitive emulsion explosive. The explosive is orange in color with a firm putty-like consistency. This product is also available in High Wax (HW) formulations.

Application

Senatel™ Ultrex™ is a water resistant packaged explosive designed for use as a medium density column explosive in surface, quarry and construction, underground mining and general blasting applications.

Key Benefits

- Senatel™ Ultrex™ delivers excellent fragmentation for easy mucking.
- Senatel™ Ultrex™ reduces post-blast fumes and improves turnaround time.
- The tight diameter control specifications and wax formulation of Senatel™ Ultrex™ maximizes cartridge loader performance.
- Senatel™ Ultrex™ PMP film cartridges readily split during tamping to maximize coupling and bulk strength within a blasthole.
- Senatel™ Ultrex™ is highly water resistant which minimizes leaching and reduces environmental impact.
- OH&S issues around the handling and storage of nitroglycerin are eliminated.
- The packaging and emulsion color of Senatel™ Ultrex™ provides high visibility in a range of environments.
- Packaged in PMP, easy to tamp plastic film or high strength, tear resistant Valeron film cartridges that are ideal for ragged, medium size boreholes.

Technical Properties

Senatel™ Ultrex™		Less than 50 mm (2 in.)	Greater than 50 mm (2 in.)
Cartridge Density		1.13	1.19
Typical Velocity of Detonation[1]		4,500 m/s[3] 15,400 ft/s	5,400 m/s 17,700 ft/s
Water Resistance		Excellent	
Fume Class		1	
Relative Effective Energy (REE) [2]	Relative Weight Strength (RWS)	99	
	Relative Bulk Strength (RBS)	133	

Recommendations for Use

Priming and Initiation

An Orica high strength electric, electronic, or non-electric detonator can reliably initiate Senatel™ Ultrex™ at temperatures higher than -15°C (5°F) in diameters less than 50mm (2 in.). In diameters greater than 50mm (2 in.) or when temperatures are below -15°C (5°F), an appropriately sized Pentex™ Booster is recommended.

Use of detonating cord with Senatel™ Ultrex™ is not recommended. Detonating cord will adversely affect the performance of Senatel™ Ultrex™ and could result in misfires. Consult an Orica Technical Representative before attempting to use with detonating cord.

Charging

In small diameter blastholes the maximum energy per meter of blasthole can be achieved by tamping the explosive with a wooden tamping rod appropriate to the hole diameter. No metal instrument should be used to tamp explosives. The primer cartridge containing a detonator must not be tamped.

Senatel™ Ultrex™

USA & Canada

Sleep-Time within Blastholes

In dry blastholes, given the explosives packaging is undamaged, Senatel™ Ultrex™ may be charged and fired several months later. If the explosive packaging is damaged, the sleep-time in a blasthole is influenced by the extent of damage to the packaging and by the nature of any water present. Even with full length slitting of cartridges, the explosive will give good performance after two weeks immersion.

Packaging

Senatel™ Ultrex™ is packaged in white plastic film to clearly differentiate it from booster sensitive packaged explosives. Cartridges are packed in 25 kg (55 lb) fiberboard cartons. Standard cartridge sizes are as follows:

Sizes (mm)	Sizes (in.)	Nominal count per case	Film Type
25 x 300	1 x 12	162 (±5)	PMP
32 x 200	1¼ x 8	159 (±5)	PMP/Valeron
32 x 400	1¼ x 16	79 (±3)	PMP
40 x 200	1½ x 8	104 (±1)	PMP/Valeron
40 x 300	1½ x12	68 (±2)	PMP
40 x 400	1½ x 16	51 (±2)	PMP
40 x 600	1½ x 24	35 (±1)	PMP
45 x 400	1¾ x 16	35 (±1)	PMP/Valeron
50 x 200	2 x 8	57(±2)	Valeron
50 x 400	2 x 16	26	Valeron
65 x 400	2½ x 16	16	PMP/Valeron
75 x 400	3 x 16	12	Valeron
90 x 400	3½ x 16	9	Valeron

Storage and Handling

Product Classification

Authorized Name: Senatel™ Ultrex™
Proper Shipping Name: Explosive, blasting, type E
UN No: 0241
Classification: 1.1D

All regulations pertaining to the handling and use of such explosives apply.

Storage

Store Senatel™ Ultrex™ in a suitably licensed magazine for Class 1.1D explosives. The cases should be stacked in the manner designated on the case.

Senatel™ Ultrex™ has a **shelf life** of up to 12 months in a well ventilated, approved magazine, even in hot and humid extremes.

Senatel™ Ultrex™ is best stored at temperatures above -15°C (5°F). This is especially important in cold weather "load and shoot" worksites where there is insufficient inhole warm-up time. Senatel™ Ultrex™ should have an internal temperature of 0°C (32°F) or higher, before use with a pneumatic cartridge loading machine.

Transport

Senatel™ Ultrex™ should be transported between -40°C (-40°F) and +40°C (104°F).

Disposal

Disposal of explosive materials can be hazardous. Methods of safe disposal of explosives may vary depending on the user's situation. Please contact an Orica Technical Services Representative for information on safe practices.

Safety

The post detonation fume characteristics of Senatel™ Ultrex™ make the product suitable for both underground and surface blasting applications. Users should ensure that adequate ventilation is provided prior to re-entry into the blast area.

Senatel™ Ultrex™ can be initiated by extremes of shock, friction or mechanical impact. As with all explosives, Senatel™ Ultrex™ should be handled and stored with care and must be kept clear of flame and excessive heat.

Senatel™ Ultrex™

USA & Canada

Disclaimer

© 2017 Orica Group. All rights reserved. All information contained in this document is provided for informational purposes only and is subject to change without notice. Since the Orica Group cannot anticipate or control the conditions under which this information and its products may be used, each user should review the information in the specific context of the intended application. To the maximum extent permitted by law, the Orica Group specifically disclaims all warranties express or implied in law, INCLUDING ACCURACY, NON INFRINGEMENT, AND IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. The Orica Group specifically disclaims, and will not be responsible for, any liability or damages resulting from the use or reliance upon the information in this document.

The word Orica and the Ring device are trademarks of the Orica Group.

For more information please visit our website: www.orica.com

Orica's North America headquarters can be reached at:
Tel: +1 303 268 5000
Fax: +1 303 268 5250

Emergency Telephone Numbers

For chemical emergencies (24 hour) involving transportation, spill, leak, release, fire or accidents:

Canada: Orica Canada emergency response 1-877-561-3636

USA: Chemtrec 1-800- 424-9300

Notes:

(1.) VOD will depend on application including explosive density blasthole diameter and degree of confinement. The VOD range is based on minimum unconfined and calculated ideal.

(2.) The Relative Effective Energy (REE) of an explosive is the energy calculated to be available to do effective blasting work. All energy values are calculated using the IDeX™ computer code owned by Orica for the exclusive use of its companies. Energy values are based on standard ANFO with a density of 0.84 g/cc and a cut-off pressure of 100Mpa. Other computer codes may give different values.

(3.) Unconfined at 5ºC (41ºF).