YENTER COMPANIES, INC.
(303)279-4458

BLAST REPORT
PAGE 1 A

20300 West Hwy 72
Arvada, CO 80007

SHOT INFORMATION

Magazine Site Used: ACA

Shot No: 006-01

Blaster: MIKE RANSUM	Job No: 16-80-006	Date: 3/16/16
Location: TROUT CREEK QUARRY	Type Shot: PRODUCTION	Shot Time: 4 30
Type Material: GRANITE	Overburden: 0	Type Stemming: ½" STONE
Type Cover: N/A	Depth Cover: 0	Total Lbs Expl: 6,997.61
Max Holes Per 8 ms: 1	Max Lbs. Per 8 ms: 67.74	Powder Factor: .79
Blasters Signature: Mike Ransum		

SEISMIC INFORMATION

Seismic Firm & Analyst: Yenter/Jim Knoll

Type of structure: DAM Operator: MMC

Other:

Unit No: MMC Location: DAM	Dist. & Dir: 485' NW	PPV: .38	DB: 124
Unit No: Location:	Dist. & Dir:	PPV:	DB:
Unit No: Location:	Dist. & Dir:	PPV:	DB:

WEATHER INFORMATION

Weather:	Sunny	Clear	Overcast	Rain	Snow
Temp:	To 32	33-55	56-70	71-85	86 & Up
Wind:		Still	Moderate	High	

HOLE PROFILE INFORMATION

Hole Depth	Hole Diameter	Number of Decks	Bottom Deck (lbs) Hi. Ex.	Bottom Deck (lbs) B. Agent	Feet of Stem	Deck 2 (lbs.) Hi. Ex.	Deck 2 (lbs.) B. Agent	Feet of Stem	Deck 3 (lbs) Hi. Ex.	Deck 3 (lbs) B. Agent	Feet of Stem
8'	3½"	1	.33	6.75	6'						
9'				6.75	7'						
11'				10.29	8'						
12'				12.84							
13'				16.05							
14'				19.26							
17'				28.89							
19'				35.31							
20'				38.52							
21'				41.73							
22'				44.94							
23'				48.15							

PRODUCTION SHOT PROFILE INFORMATION

Number of Holes	Hole Diameter	Hole Depths	Sub Drill	Burden & Spacing	Wet or Dry	Total Vertical Bore Hole Feet	Lin. Feet of Trench	Total Yards with Sub Drill
139	3½"	8'-29'	0	8' x 10'	BOTH	2,969'	0	8,797.03

YENTER COMPANIES, INC.
(303)279-4458

BLAST REPORT
PAGE 1 B

20300 West Hwy 72
Arvada, CO 80007

SHOT INFORMATION

Magazine Site Used:

Shot No: 006-01

Blaster: MIKE RANSOM	Job No: 16-80-006	Date: 3/16/16
Location: TROUT CREEK QUARRY	Type Shot: PRODUCTION	Shot Time: 4:30
Type Material:	Overburden:	Type Stemming:
Type Cover:	Depth Cover:	Total Lbs Expl:
Max Holes Per 8 ms:	Max Lbs. Per 8 ms:	Powder Factor:
Blasters Signature:		

SEISMIC INFORMATION

Seismic Firm & Analyst: Yenter/Jim Knoll

Type of structure: _____ Operator: _____

Other:

Unit No:	Location:	Dist. & Dir:	PPV:	DB:
Unit No:	Location:	Dist. & Dir:	PPV:	DB:
Unit No:	Location:	Dist. & Dir:	PPV:	DB:

WEATHER INFORMATION

Weather:	Sunny	Clear	Overcast	Rain	Snow
Temp:	To 32	33-55	56-70	71-85	86 & Up
Wind:		Still	Moderate	High	

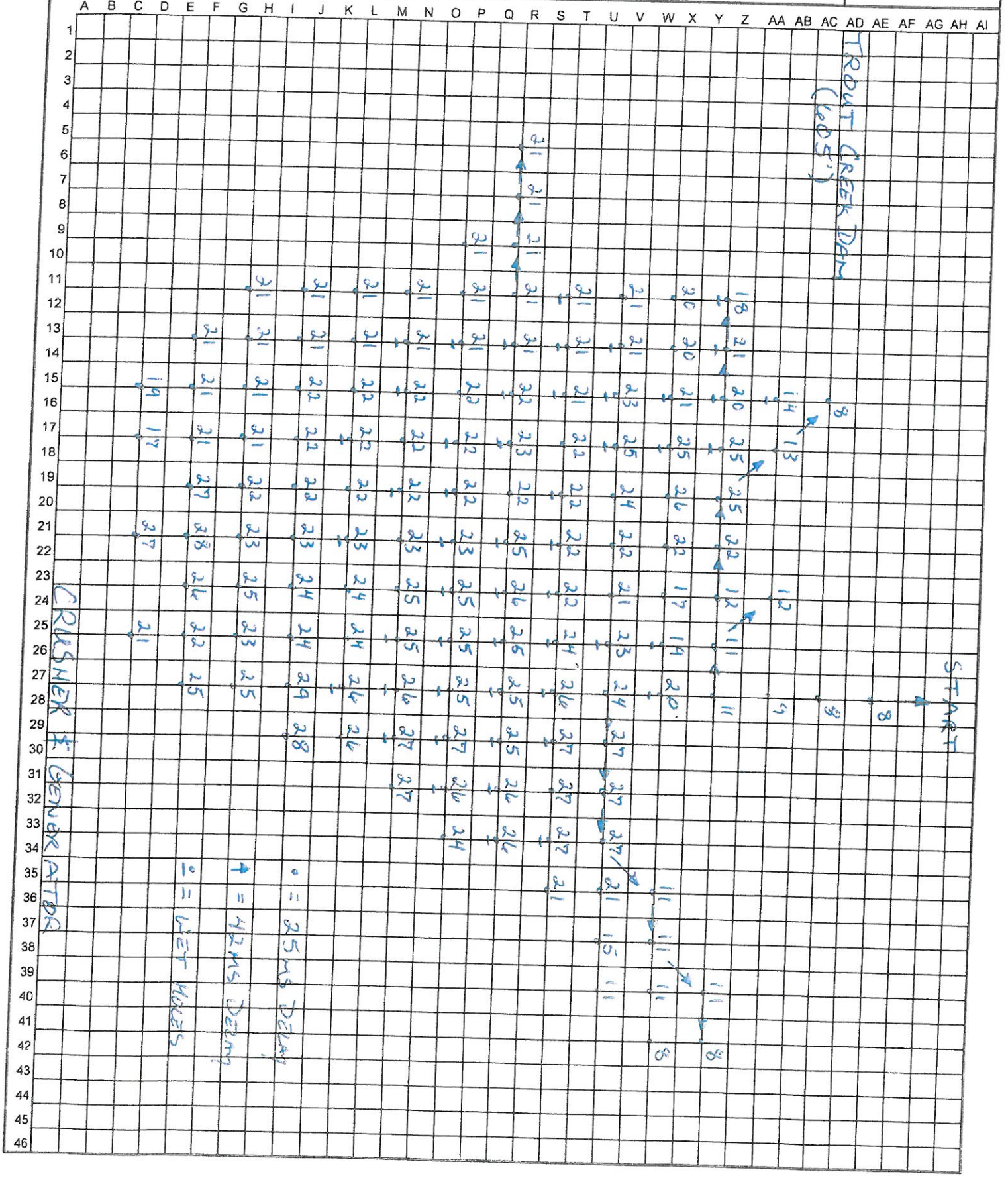
HOLE PROFILE INFORMATION

Hole Depth	Hole Diameter	Number of Decks	Bottom Deck (lbs.) Hi. Ex.	Bottom Deck (lbs.) B. Agent	Feet of Stem	Deck 2 (lbs) Hi. Ex.	Deck 2 (lbs) B. Agent	Feet of Stem	Deck 3 (lbs.) Hi. Ex.	Deck 3 (lbs.) B. Agent	Feet of Stem
24'	3½"	1	.33	51.36	8'						
25'				54.57							
26'				57.78							
27'				60.99							
28'				64.20							
29'	"	"	"	67.41	"						

PRODUCTION SHOT PROFILE INFORMATION

Number of Holes	Hole Diameter	Hole Depths	Sub Drill	Burden & Spacing	Wet or Dry	Total Vertical Bore Hole Feet	Lin. Feet of Trench	Total Yards with Sub Drill

BLASTER: Mike Ransom	YENTER COMPANIES, INC.	SHOT NO:	NORTH
DATE: 3/16/16	BLAST REPORT	006-01	
JOB NO: 16-80-006	PAGE 2		



YENTER COMPANIES, INC.
BLAST REPORT
PAGE 3

BLASTER: Mike Ransom DATE: 3/16/16

JOB NO: 16-80-006 SHOT NO: 006-01

NARRATIVE:

SHOT WENT GOOD - SOME FLY ROCK - NONE LEFT BLAST AREA GOOD MOVEMENT & BREAKAGE - SOME OVER SIZE FROM OUTSIDE EDGES - SOME OVERSIZE ROLLED DOWN SLOPE

51 HOLES WITH WATER (1' TO 10') USED 350 BOOSTERS & BLASTEX RE PRIME AFTER EVERY 3 CARTRIDGES of BLASTEX - USED 5 XTRA DELAYS FOR TIMING

YENTER COMPANIES, INC.
(303)279-4458

BLAST REPORT
PAGE 1

20300 West Hwy 72
Arvada, CO 80007

SHOT INFORMATION

Magazine Site Used: BUENA VISTA

Shot No: 006-02

Blaster: MIKE RANSOM	Job No: 16-80-006	Date: 3/29/16
Location: TROUT CREEK QUARRY	Type Shot: PRODUCTION	Shot Time: 1:40
Type Material: GRANITE	Overburden: 0	Type Stemming: ½" STONE
Type Cover: N/A	Depth Cover: 0	Total Lbs Expl: 8,177.69
Max Holes Per 8 ms: 1	Max Lbs. Per 8 ms: 67.26	Powder Factor: .86
Blasters Signature: Mike Ransom		

SEISMIC INFORMATION

Seismic Firm & Analyst: Yenter/Jim Knoll

Type of structure: DAM Operator: MMC Other:

Unit No: MMC	Location: DAM	Dist. & Dir: 475' N.W	PPV: .45	DB: 117
Unit No:	Location: (125' FROM DAM)	Dist. & Dir:	PPV:	DB:
Unit No:	Location:	Dist. & Dir:	PPV:	DB:

WEATHER INFORMATION

Weather:	Sunny	Clear	Overcast	Rain	Snow
Temp:	To 32	33-55	56-70	71-85	86 & Up
Wind:		Still	Moderate	High	

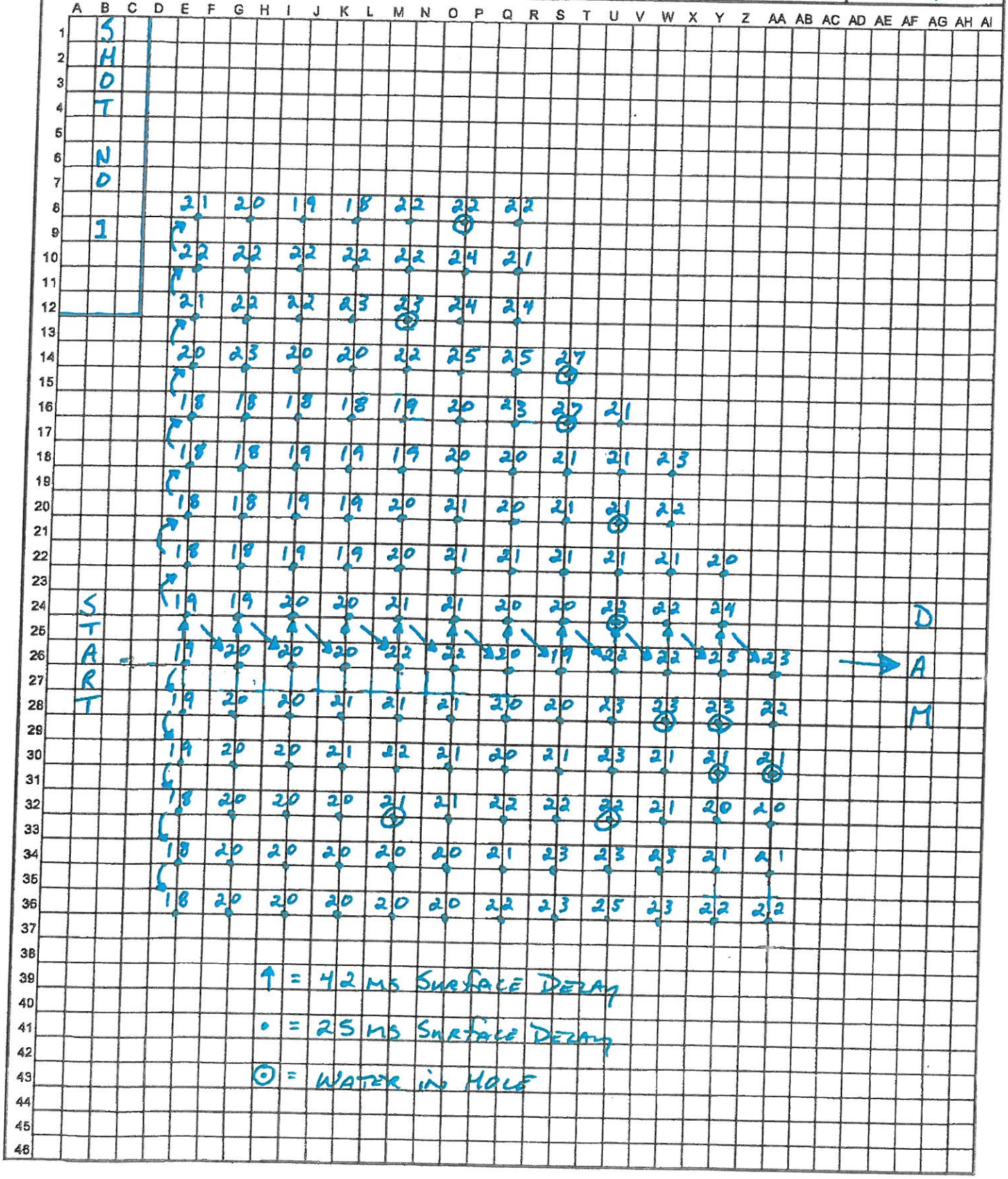
HOLE PROFILE INFORMATION

Hole Depth	Hole Diameter	Number of Decks	Bottom Deck (lbs.) Hi. Ex.	Bottom Deck (lbs.) B. Agent	Feet of Stem	Deck 2 (lbs.) Hi. Ex.	Deck 2 (lbs.) B. Agent	Feet of Stem	Deck 3 (lbs.) Hi. Ex.	Deck 3 (lbs.) B. Agent	Feet of Stem
18'	3¾"	1	.33		8'						
19'	↓	↓	↓		↓						
20'											
21'											
22'											
23'											
24'											
25'											
26'											
27'	↓	↓	↓		↓						

PRODUCTION SHOT PROFILE INFORMATION

Number of Holes	Hole Diameter	Hole Depths	Sub Drill	Burden & Spacing	Wet or Dry	Total Vertical Bore Hole Feet	Lin. Feet of Trench	Total Yards with Sub Drill
152	3¾"	18'-27'	0	8' x 10'	BOTH	3,175'	0	9,407.40

BLASTER: Mike Ransom	YENTER COMPANIES, INC.	SHOT NO:	NORTH
DATE: 3/29/16	BLAST REPORT	006-02	
JOB NO: 16-80-006	PAGE 2		



YENTER COMPANIES, INC.
BLAST REPORT
PAGE 3

BLASTER: Mike Ransom DATE: 3/29/16

JOB NO: 16-80-006 SHOT NO: 006-02

NARRATIVE:

SHOT WENT GOOD - NO Fly Rock
12 WET HOLES LOADED WITH BLASTEX

ger Source	Geo: 0.050 in/s
ge	Geo: 10.000 in/s
mple Rate	8.0 sec At 1024 Sps
es	
est:	Trout Creek Quarry
nt:	ACA Products
ation	Chaffee
r:	MMC Inc.

Battery Level	6.8 Volts
Unit Calibration	December 3, 2016 by Instantel
File Name	C047GAYO.PROW
Post Event Notes	

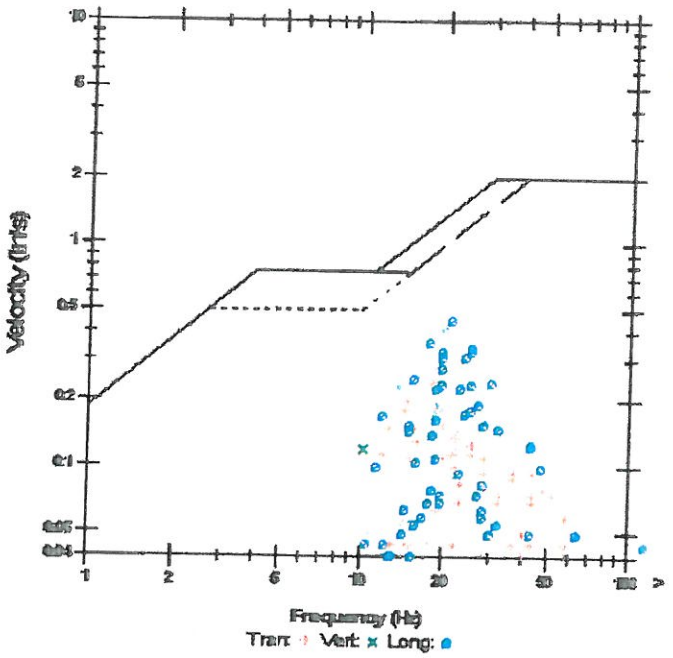
ended Notes:

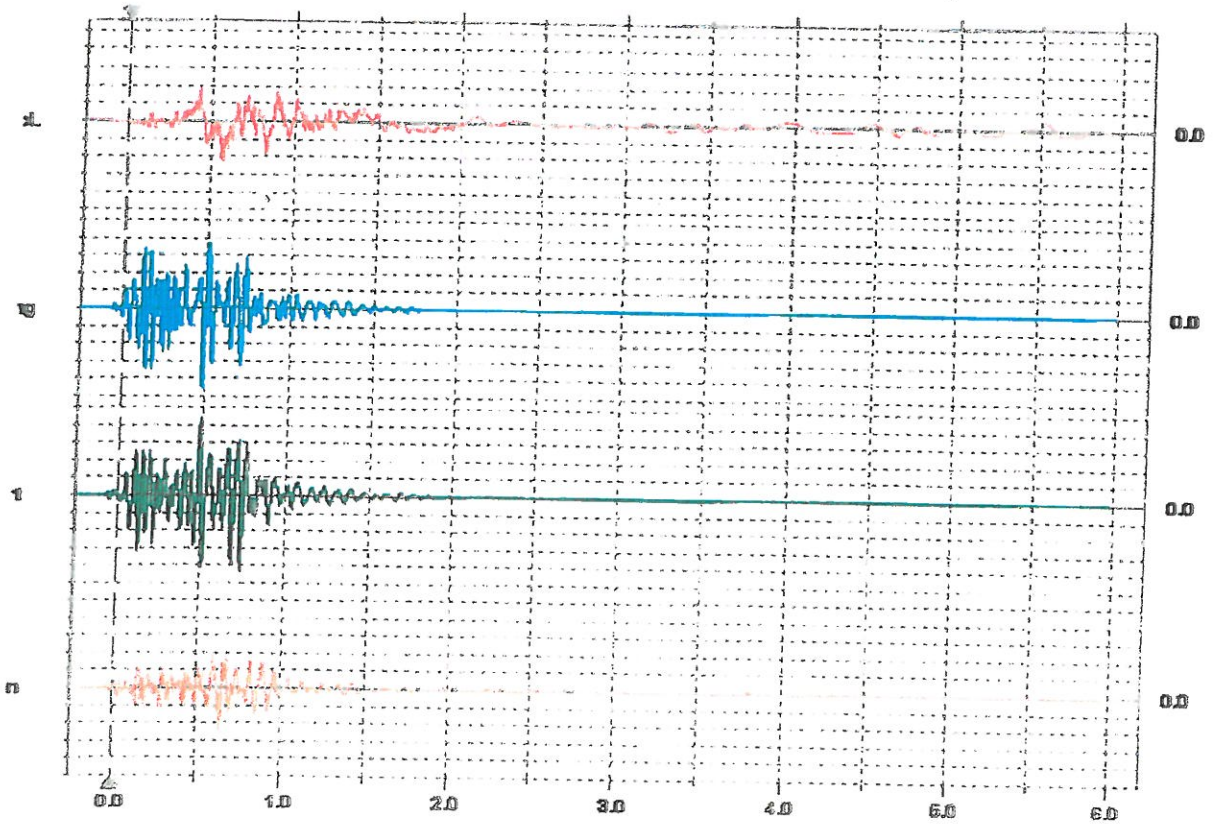
USBM RI8507 And OSMRE

mophone	Linear Weighting
PL	117.6 dB(L) at 0.575 sec
Freq	4.5 Hz
nnel Test	Passed (Freq = 19.7 Hz Amp = 657 mV)

	Tran	Vert	Long	
k	0.240	0.435	0.465	in/s
Freq	18	20	21	Hz
e (Rel. to Trig)	0.648	0.469	0.457	sec
k Acceleration	0.106	0.148	0.169	g
k Displacement	0.002	0.003	0.003	in
ector Check	Passed	Passed	Passed	

k Vector Sum 0.620 in/s At 0.468 sec





Time/Seconds: 0.50 sec/div Amplitude Geo: 0.100 in/s/div Mic: 0.001 psi/Lv/div

YENTER COMPANIES, INC.
(303)279-4458

BLAST REPORT
PAGE 1 A

20300 West Hwy 72
Arvada, CO 80007

SHOT INFORMATION

Magazine Site Used: ACA - BUENA VISTA Shot No: 006 - 03

Blaster: MIKE RANSOM	Job No: 16-80-006	Date: 4/12/16
Location: ACA QUARRY	Type Shot: PRODUCTION	Shot Time: 12:30
Type Material: GRANITE	Overburden: 0	Type Stemming: ½" STONE
Type Cover: N/A	Depth Cover: 0	Total Lbs Expl: 7,130.40
Max Holes Per 8 ms: 1	Max Lbs. Per 8 ms: 81.42	Powder Factor: .79
Blasters Signature: Mike Ransom		

SEISMIC INFORMATION

Seismic Firm & Analyst: Yenter/Jim Knoll

Type of structure: DAM Operator: MMC

Other:

Unit No: MMC Location: 125' FROM DAM	Dist. & Dir: 475' NW	PPV: .23	DB: 117	
Unit No: Location:	Dist. & Dir:	PPV:	DB:	
Unit No: Location:	Dist. & Dir:	PPV:	DB:	

WEATHER INFORMATION

Weather:	Sunny	Clear	Overcast	Rain	Snow
Temp:	To 32	33-55	56-70	71-85	86 & Up
Wind:		Still	Moderate	High	

HOLE PROFILE INFORMATION

Hole Depth	Hole Diameter	Number of Decks	Bottom Deck (lbs.) Hi. Ex.	Bottom Deck (lbs.) B. Agent	Feet of Stem	Deck 2 (lbs.) Hi. Ex.	Deck 2 (lbs.) B. Agent	Feet of Stem	Deck 3 (lbs.) Hi. Ex.	Deck 3 (lbs.) B. Agent	Feet of Stem
14'	3½"	1	.33	20.91	8'						
16'				27.99							
17'				31.53							
18'				35.07							
19'				38.61							
20'				42.15							
21'				45.69							
22'				49.23							
23'				52.77							
24'				56.31							
25'				59.85							
26'				63.39							

PRODUCTION SHOT PROFILE INFORMATION

Number of Holes	Hole Diameter	Hole Depths	Sub Drill	Burden & Spacing	Wet or Dry	Total Vertical Bore Hole Feet	Lin. Feet of Trench	Total Yards with Sub Drill
135	3½"	14'-31'	0	8' x 10'	BOTH	3,031'	0	8,980.74

YENTER COMPANIES, INC.
(303)279-4458

BLAST REPORT
PAGE 1B

20300 West Hwy 72
Arvada, CO 80007

SHOT INFORMATION

Magazine Site Used: ACA - BUENA VISTA Shot No: 006-03

Blaster: MIKE RANSOM	Job No: 16-80-006	Date: 4/12/16
Location:	Type Shot:	Shot Time: 12:30
Type Material:	Overburden:	Type Stemming:
Type Cover:	Depth Cover:	Total Lbs Expl:
Max Holes Per 8 ms:	Max Lbs. Per 8 ms:	Powder Factor:
Blasters Signature:		

SEISMIC INFORMATION

Seismic Firm & Analyst: Yenter/Jim Knoll Type of structure: _____ Operator: _____ Other:

Unit No:	Location:	Dist. & Dir:	PPV:	DB:
Unit No:	Location:	Dist. & Dir:	PPV:	DB:
Unit No:	Location:	Dist. & Dir:	PPV:	DB:

WEATHER INFORMATION

Weather:	Sunny	Clear	Overcast	Rain	Snow
Temp:	To 32	33-55	56-70	71-85	86 & Up
Wind:		Still	Moderate	High	

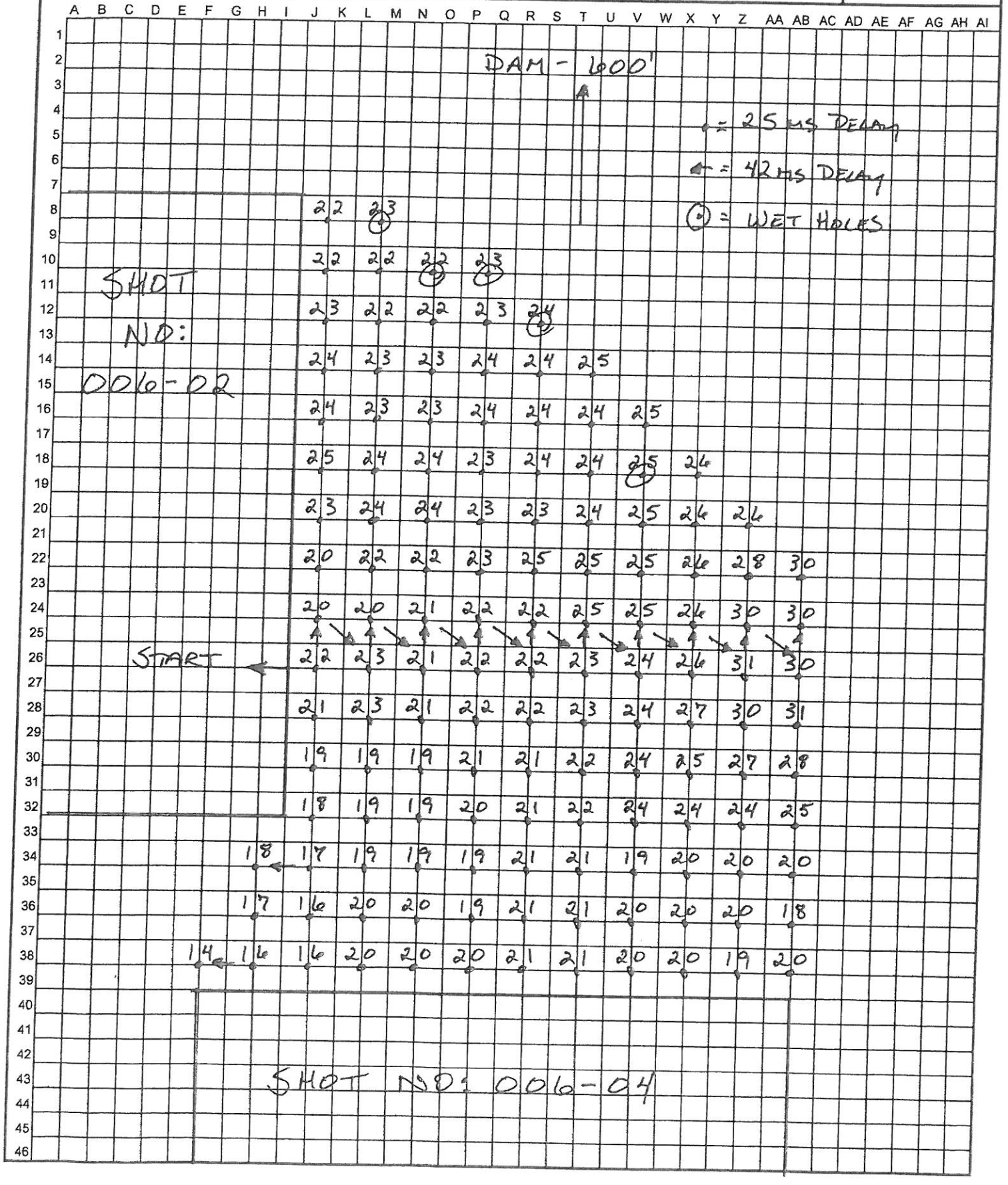
HOLE PROFILE INFORMATION

Hole Depth	Hole Diameter	Number of Decks	Bottom Deck (lbs.) Hi. Ex.	Bottom Deck (lbs.) B. Agent	Feet of Stem	Deck 2 (lbs.) Hi. Ex.	Deck 2 (lbs.) B. Agent	Feet of Stem	Deck 3 (lbs.) Hi. Ex.	Deck 3 (lbs.) B. Agent	Feet of Stem
27'	3½"	1	.33	66.93	8'						
28'	↓	↓	↓	70.47	↓						
30'	↓	↓	↓	77.55	↓						
31'	↓	↓	↓	81.09	↓						

PRODUCTION SHOT PROFILE INFORMATION

Number of Holes	Hole Diameter	Hole Depths	Sub Drill	Burden & Spacing	Wet or Dry	Total Vertical Bore Hole Feet	Lin. Feet of Trench	Total Yards with Sub Drill

BLASTER: Mike Ransom	YENTER COMPANIES, INC. BLAST REPORT PAGE 2	SHOT NO: 006-03	NORTH
DATE: 4/12/16			
JOB NO: 16-80-006			



YENTER COMPANIES, INC.
BLAST REPORT
PAGE 3

BLASTER: Mike Ransom DATE: 4/12/16

JOB NO: 16-80-006 SHOT NO: 006-03

NARRATIVE:

SHOT WENT GOOD - NO FLY ROCK - GOOD MOVEMENT & BREAKAGE

5 WET HOLES LOADED WITH BLASTEX & 350 BOOSTERS

Date/Time	Vert At 12:29:33 April 12, 2016
Trigger Source	Geo: 0.050 in/s
Range	Geo: 10.000 in/s
Sample Rate	6.0 sec At 1024 Sps
Notes	
Project:	Trout Creek Quarry
Client:	ACA Products
Location	Chaffee
User:	MMC Inc.

Serial Number	BE13047 V10.72-8.17 MiniMate Plus
Battery Level	6.8 Volts
Unit Calibration	December 3, 2015 by Instantel
File Name	C047GBOI.P90W
Post Event Notes	

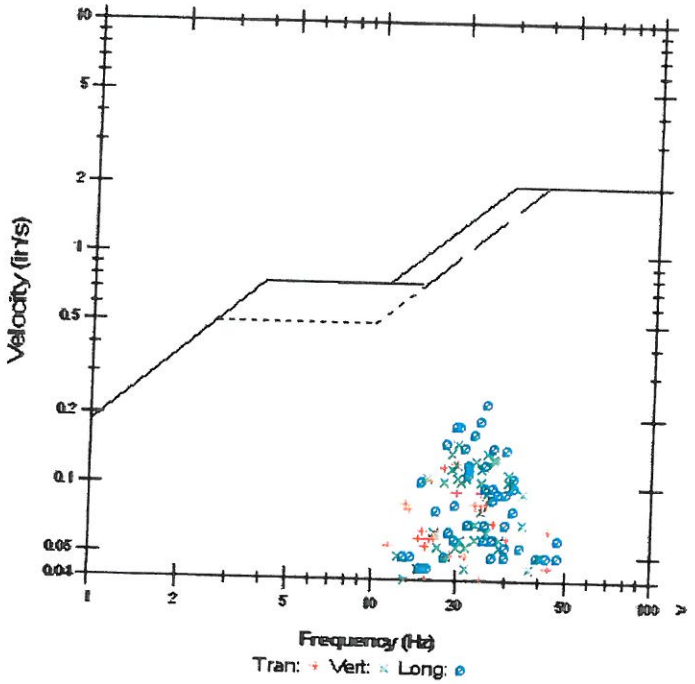
Extended Notes:

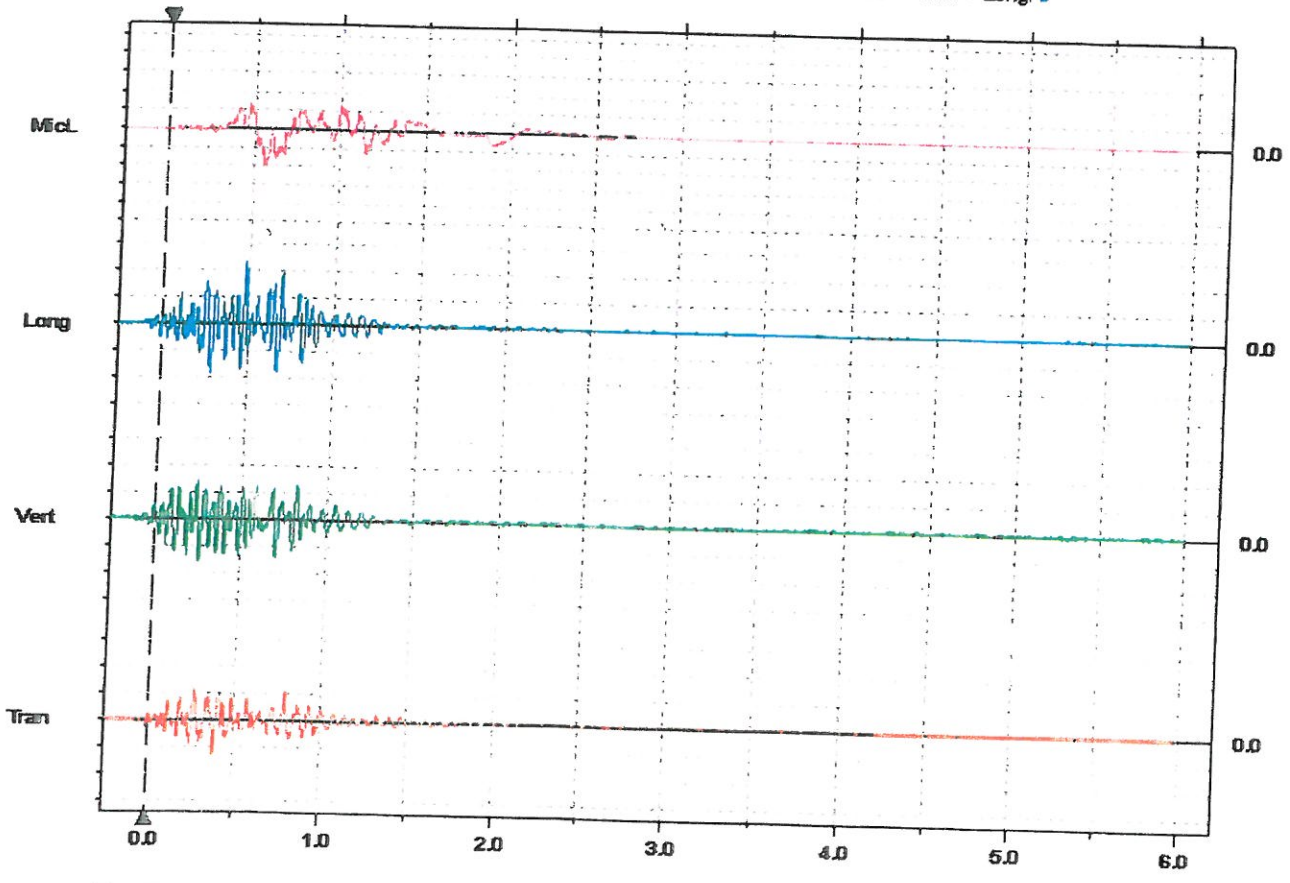
Microphone	Linear Weighting
PSPL	116.7 dB(L) at 0.566 sec
ZC Freq	5.3 Hz
Channel Test	Passed (Freq = 20.1 Hz Amp = 528 mv)

	Tran	Vert	Long	
PPV	0.125	0.155	0.230	in/s
ZC Freq	20	20	26	Hz
Time (Rel. to Trig)	0.386	0.265	0.483	sec
Peak Acceleration	0.053	0.080	0.106	g
Peak Displacement	0.001	0.001	0.002	in
Sensor Check	Passed	Passed	Passed	

Peak Vector Sum 0.249 in/s At 0.484 sec

USBM RI8507 And OSMRE





Time(Seconds) 0.50 sec/div Amplitude Geo: 0.100 in/s/div Mic: 0.001 psi(L)/div

Trigger =

Created April 13 2016 (V 10.74)

YENTER COMPANIES, INC.
(303)279-4458

BLAST REPORT
PAGE 1 A

20300 West Hwy 72
Arvada, CO 80007

SHOT INFORMATION

Magazine Site Used: ACA & BUCKLEY Shot No: 006-04

Blaster: MIKE RANSOM	Job No: 16-80-0016	Date: 4/26/16
Location: TROUT CREEK QUARRY	Type Shot: PRODUCTION	Shot Time: 3:10
Type Material: GRANITE	Overburden: 0	Type Stemming: ½" STONE
Type Cover: N/A	Depth Cover: 0	Total Lbs Expl: 4,855.57
Max Holes Per 8 ms: 1	Max Lbs. Per 8 ms: 49.56	Powder Factor: .51
Blasters Signature: Mike Ransom		

SEISMIC INFORMATION

Seismic Firm & Analyst: Yenter/Jim Knoll Type of structure: DAM Operator: MMC Other:

Unit No: MMC Location: 125' From DAM	Dist. & Dir: 635' NW	PPV: .09	DB: 117
Unit No: Location:	Dist. & Dir:	PPV:	DB:
Unit No: Location:	Dist. & Dir:	PPV:	DB:

WEATHER INFORMATION

Weather:	(Sunny)	Clear	(Overcast)	(Rain)	(Snow)
Temp:	(To 32)	(33-55)	56-70	71-85	86 & Up
Wind:		Still	(Moderate)	(High)	

HOLE PROFILE INFORMATION

Hole Depth	Hole Diameter	Number of Decks	Bottom Deck (lbs.) Hi. Ex.	Bottom Deck (lbs.) B. Agent	Feet of Stem	Deck 2 (lbs.) Hi. Ex.	Deck 2 (lbs.) B. Agent	Feet of Stem	Deck 3 (lbs.) Hi. Ex.	Deck 3 (lbs.) B. Agent	Feet of Stem
8'	3½"	1	.33	10.29	5						
9'				10.29	6						
10'				13.83	6						
11'				13.83	7						
12'				17.37	7						
13'				17.37	8						
14'				20.91							
15'				24.45							
16'				27.99							
17'				31.53							
18'				35.07							
19'				38.61							

PRODUCTION SHOT PROFILE INFORMATION

Number of Holes	Hole Diameter	Hole Depths	Sub Drill	Burden & Spacing	Wet or Dry	Total Vertical Bore Hole Feet	Lin. Feet of Trench	Total Yards with Sub Drill
270	3½"	8'-22'	0	8' x 10'	BOTH	3,202'	0	9,487.40

YENTER COMPANIES, INC.
(303)279-4458

BLAST REPORT
PAGE 1 B

20300 West Hwy 72
Arvada, CO 80007

SHOT INFORMATION — Magazine Site Used: — Shot No: 006-04

Blaster: Mike Ransom	Job No: 16-80 006	Date: 4/26/16
Location:	Type Shot:	Shot Time:
Type Material:	Overburden:	Type Stemming:
Type Cover:	Depth Cover:	Total Lbs Expl:
Max Holes Per 8 ms:	Max Lbs. Per 8 ms:	Powder Factor:
Blasters Signature:		

SEISMIC INFORMATION
Seismic Firm & Analyst: Yenter/Jim Knoll — Type of structure: — Operator: — Other:

Unit No: Location:	Dist. & Dir:	PPV:	DB:	
Unit No: Location:	Dist. & Dir:	PPV:	DB:	
Unit No: Location:	Dist. & Dir:	PPV:	DB:	

WEATHER INFORMATION

Weather:	**Sunny**	**Clear**	**Overcast**	**Rain**	**Snow**
Temp:	**To 32**	**33-55**	**56-70**	**71-85**	**86 & Up**
Wind:		Still	Moderate	High	

HOLE PROFILE INFORMATION

Hole Depth	Hole Diameter	Number of Decks	Bottom Deck (lbs.) Hi. Ex.	Bottom Deck (lbs.) B. Agent	Feet of Stem	Deck 2 (lbs.) Hi. Ex.	Deck 2 (lbs.) B. Agent	Feet of Stem	Deck 3 (lbs.) Hi. Ex.	Deck 3 (lbs.) B. Agent	Feet of Stem
20'	3½"	1	.33	42.15	8						
21'	↓	↓	↓	45.69	↓						
22'	↓	↓	↓	49.23	↓						

PRODUCTION SHOT PROFILE INFORMATION

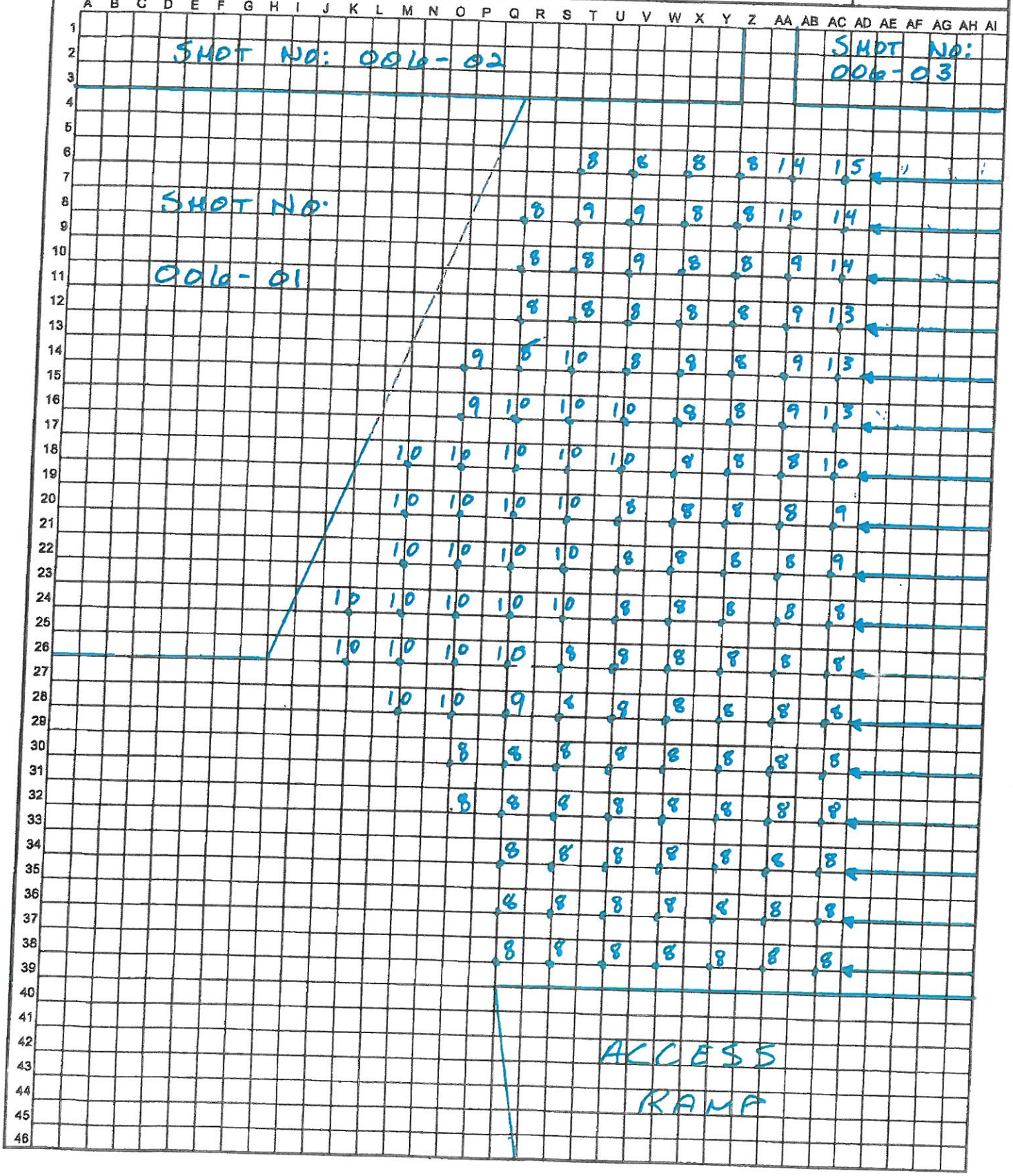
Number of Holes	Hole Diameter	Hole Depths	Sub Drill	Burden & Spacing	Wet or Dry	Total Vertical Bore Hole Feet	Lin. Feet of Trench	Total Yards with Sub Drill

BLASTER: Mike Ransom
DATE: 4/26/16
JOB NO: 16-80-006

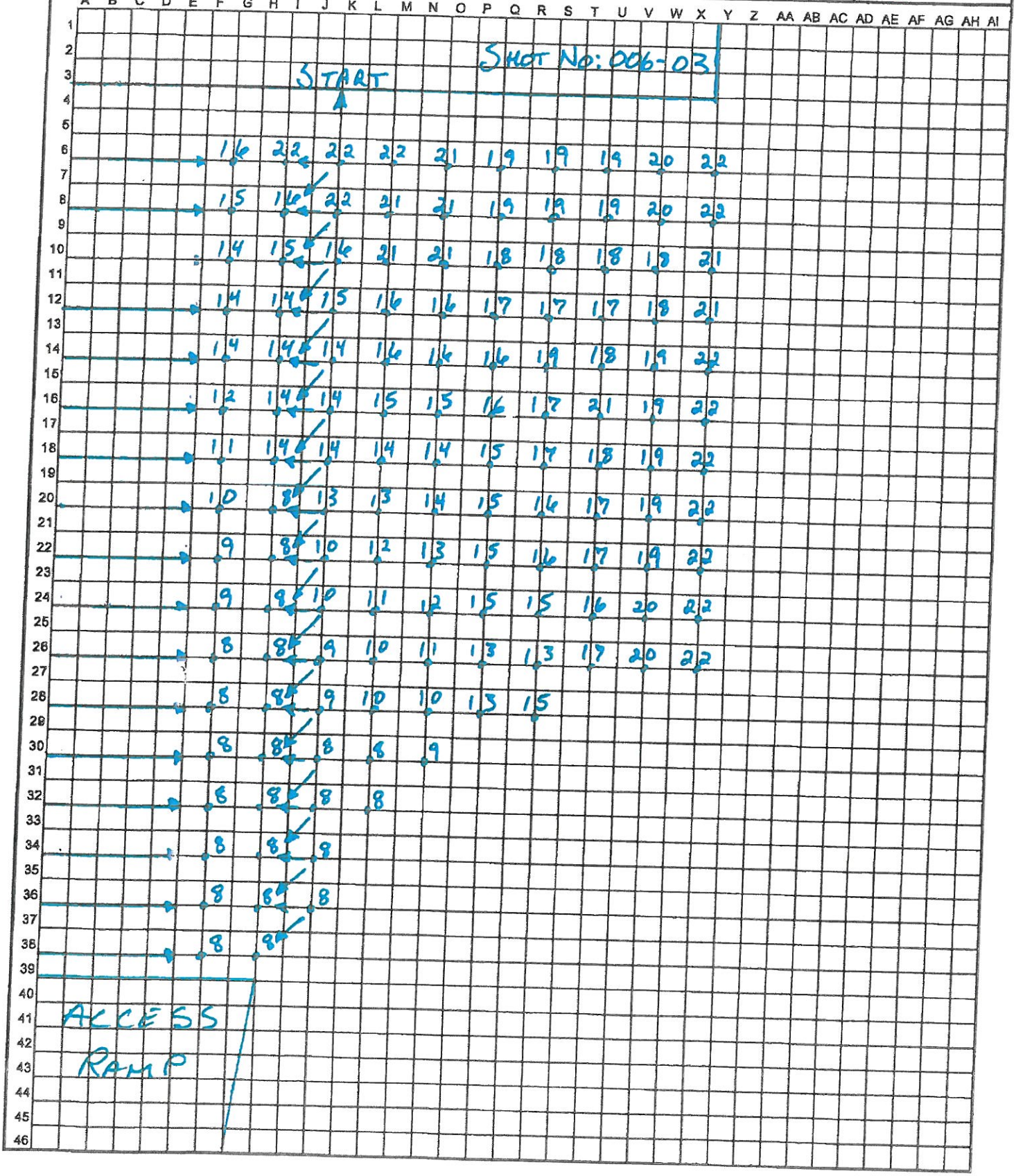
YENTER COMPANIES, INC.
BLAST REPORT
PAGE 2A

SHOT NO: 006-04

NORTH



BLASTER: Mike Ransom	YENTER COMPANIES, INC.	SHOT NO:	NORTH
DATE: 4/26/16	BLAST REPORT	006-04	
JOB NO: 16-80-0064	PAGE 28		



YENTER COMPANIES, INC.
BLAST REPORT
PAGE 3

BLASTER: Mike Ransom DATE: 4/26/16

JOB NO: 16-80-006 SHOT NO: 006-04

NARRATIVE:

Blast went good - Some Fly Rock (None left Blast Area) - Good Movement & Breakage
170 Holes with water (3 ft. to 14 ft. each)
Wet Holes Loaded with 350 Boosters & 2½" Blastex 1, 2, 3 & 4 Primers per hole (Depending on Depth of water) - Dry Holes Loaded with 150 Boosters & Anfo - 25 ms Between Holes & 84 ms Between Rows

igger Source Geo: 0.050 in/s
ige Geo: 10.000 in/s
mple Rate 6.0 sec At 1024 Sps
es
ect: Trout Creek Quarry
nt: ACA Products
ation Chaffee
r: MMC Inc.

Battery Level 6.8 Volts
Unit Calibration December 3, 2015 by Instantel
File Name C047 GOEN GF0W
Post Event Notes

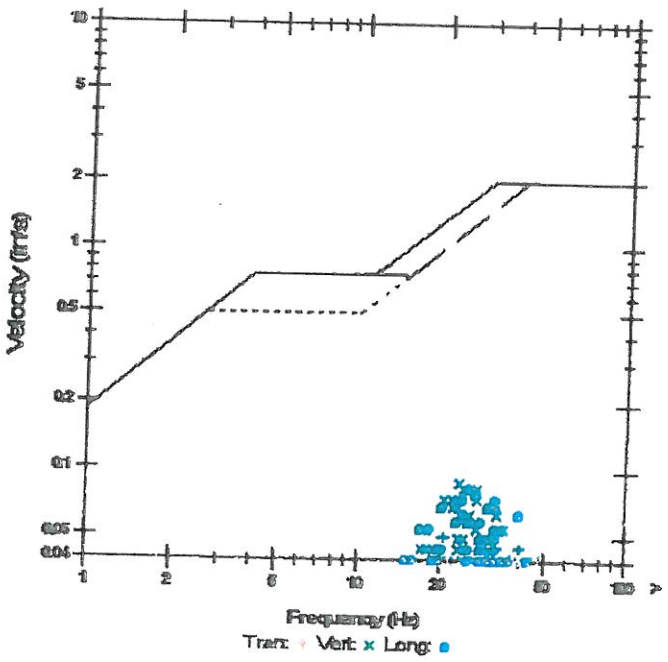
ended Notes:

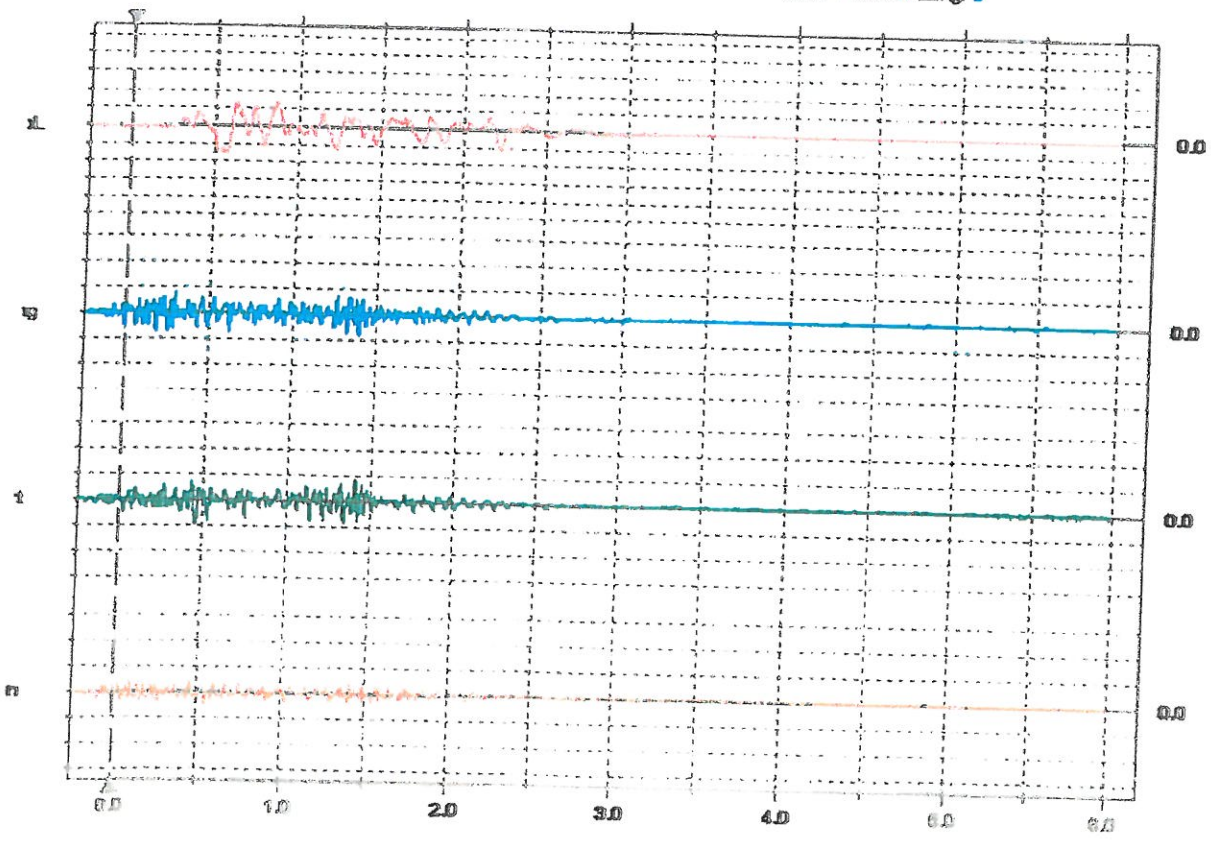
USBM RI8507 And OSMRE

nsphere Linear Weighting
PL 114.6 dB(L) at 0.575 sec
Freq 4.0 Hz
ernal Test Passed (Freq = 20.1 Hz, Amp = 695 mV)

	Tran	Vert	Long	
V	0.050	0.090	0.095	in/s
Freq	20	23	28	Hz
e (Rel. to Trig)	0.460	0.462	1.326	sec
k Acceleration	0.040	0.040	0.063	g
k Displacement	0.000	0.001	0.001	in
tor Check	Passed	Passed	Passed	

k Vector Sum 0.117 in/s At 0.462 sec





Time/Seconds: 0.50 sec/div Amplitude Geo: 0.100 in/s/div Mic: 0.001 psi/Vdiv

Matheson Mining Consultants, Inc.

2801 Youngfield Street, Suite 171
Golden CO 80401-2266
PHONE: 303-456-5638
TOLL FREE: 888-456-5638
FAX: 303-456-5639
www.mathesonmining.com

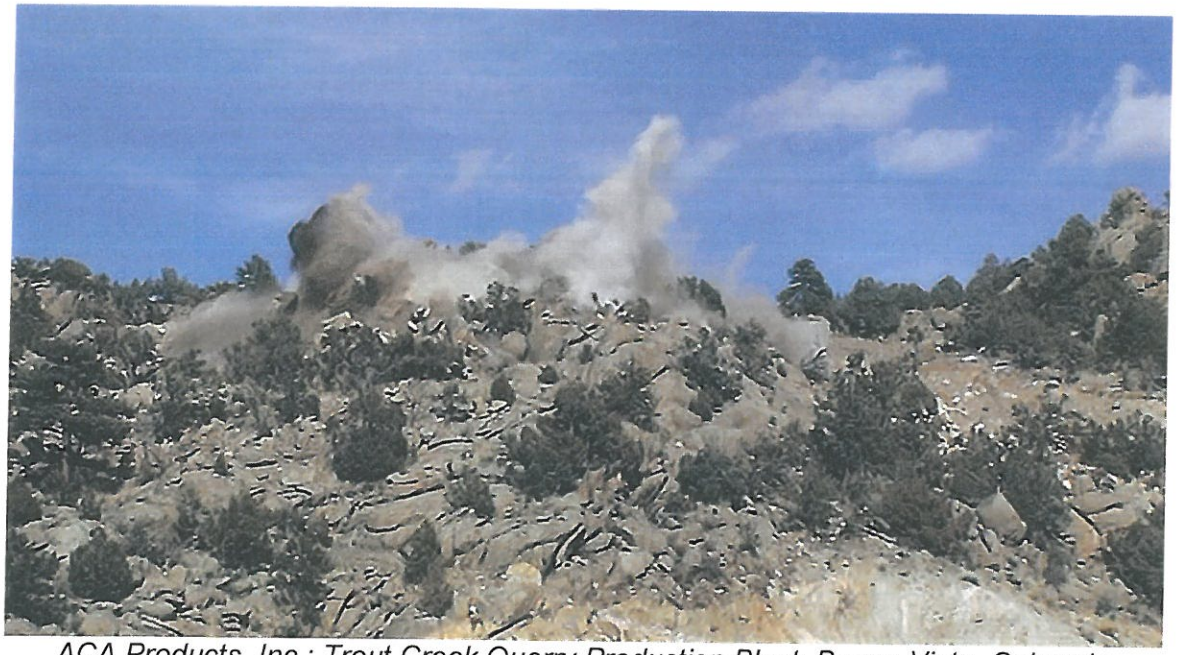
March 21, 2016

Mr. Michael Coleman
ACA Products, Inc.
702 Gregg Drive
Buena Vista, CO 81211

Re: Trout Creek Quarry - Blast Monitoring: Buena Vista, CO – March 16, 2016.

Mr. Coleman:

Matheson Mining Consultants, Inc. (MMC) was retained by ACA Products, Inc. to provide blast monitoring services in support of production blasting operations at the Trout Creek Quarry in Buena Vista, Colorado. Ground vibration monitoring was performed adjacent to the base of the privately owned Trout Creek Dam structure located to the north of the quarry operations. Both a stationary monitoring system and a portable seismograph were deployed, side by side, in order to measure ground vibration levels resulting from the quarry blasting. Instrument specifications along with current Calibration Certificates, for the seismographs used, are included in this report.



ACA Products, Inc.: Trout Creek Quarry Production Blast; Buena Vista, Colorado

The shot was initiated at 16:30 MST and consisted of 139 3-1/2" inch diameter holes drilled on an 8' X 10' pattern with hole depths ranging from 8 to 29 feet. The holes were loaded with a combination of ANFO & Blast-ex explosives, along with Spartan 150 & 350 Boosters totaling 6997.61 pounds. This combination resulted in a maximum of 74.34 lbs. of explosives per delay. EZ-DET®: 25-350ms "caps" were placed in each hole and the holes were then stemmed with 8 feet of 5/8" crushed stone and tied in using EZ-TL®: 42ms surface delays. The 'Blaster' was Mike Ransom and the weather was clear, cool, and breezy, w/ temps in the low-mid 40s.

Seismograph BE13047 was used in the stationary monitoring system deployed near the base of the Trout Creek Dam structure, approximately 485 feet north of the closest hole in the shot area. The instrument recorded ground motion of 0.38 inches per second (ips) peak particle velocity with a dominant frequency of 20 Hertz (Hz) and air-overpressure of 123.8 dB(L).

Seismograph BE10051 was deployed side by side with the stationary monitor, approximately 481 feet north of the closest hole in the shot area. This instrument recorded ground motion of 0.39 ips peak particle velocity also with a dominant frequency of 20 Hz and air-overpressure of 124.3 dB(L).

Conclusion

Matheson Mining Consultants, Inc. recommends adherence with USBM and/or the United States Department of the Interior, Office of Surface Mining Reclamation and Enforcement (OSMRE) variable particle velocity vs. frequency criteria. Adherence to these criteria provides a maximum level of liability protection and is the least restrictive in allowing the highest particle velocities at close distance. Documented cases of structural damage have never been observed in any structure, historic, exceptionally fragile, residential, or commercial, at particle velocities less than those recommended in the USBM and OSMRE standards.

The USBM and OSMRE variable particle velocity vs. frequency criteria is plotted on each vibration event report. The upper line represents the threshold level for possible sheetrock damage, while the lower, dashed line represents the threshold level for possible plaster-on-lath damage.

Field measurements obtained during this blast did not exceed the USBM damage curve.

Sincerely,

Craig Morrison,
Technical Consultant,
Matheson Mining Consultants, Inc.

Matheson Mining Consultants, Inc.

2801 Youngfield St., Suite 171
Golden, CO 80401
303-456-5638
Toll Free 888-456-5638
Fax 303-456-5639
www.mathesonmining.com

BLAST AND SEISMOGRAPH REPORT FORM

GENERAL

CLIENT: ACA / VENDOR COMPANIES DATE: 3/16/16

PROJECT NAME: TROUT CREEK QUARRY TIME: 1630

LOCATION: SOUTH OF HWY 24/285 BUENA VISTA, CO

BLAST DETAILS

# HOLES	DIAMETER	BURDEN & SPACING	DEPTH	STEMMING
139	3½"	8'X10'	8'-2"	8'-5/8" CRUSHED STONE

EXPLOSIVES

TYPE	AMOUNT
ANFO	6050#
BLAST-EX	840#
150 BOOSTERS	30.36#
350 BOOSTERS	71.25#

(POWDER FACTOR: 0.79)

TOTAL POUNDS: 6991.61#

DELAY TYPE: EZ-DET: 25-350MS
DELAY MAKE & NUMBERS: 42MS EZ-TLS
MAX.POUNDS PER DELAY: 74.34
BLASTER: MIKE RAMSON
WEATHER: COOL, CLEAR, BREEZY, LOW 40'S

SEISMOGRAPH INFORMATION

1) SERIAL# BE13047 CAL. DATE: 12/3/15 DIST. & DIR. FROM BLAST: ~485' NORTH
PEAK PARTICLE VELOCITY: 0.38 IPS FREQUENCY: 20 HZ AIR OVERPRESSURE: 123.8 dBL
LOCATION: BETWEEN THE SHOT AREA & THE SMALL
NOTES: TROUT CREEK DAM ~120 SOUTH OF THE STRUCTURE
2) SERIAL# BE10051 CAL. DATE: 4/8/15 DIST. & DIR. FROM BLAST: ~481' NORTH
PEAK PARTICLE VELOCITY: 0.39 IPS FREQUENCY: 20 HZ AIR OVERPRESSURE: 124.3 dBL
LOCATION: SEE ABOVE; UNITS WERE DEPLOYED
NOTES: SIDE BY SIDE FOR PPV COMPARISON (~4' CLOSER)
3) SERIAL# _____ CAL. DATE: _____ DIST. & DIR. FROM BLAST: _____
PEAK PARTICLE VELOCITY: _____ FREQUENCY: _____ AIR OVERPRESSURE: _____
LOCATION: _____
NOTES: _____

OPERATOR NAME: CS MORRISON SIGNATURE: CS Morrison DATE: 3/16/16

Date/Time	Vert At 16:30:45 March 16, 2016
Trigger Source	Geo: 0.020 in/s
Range	Geo: 10.000 in/s
Sample Rate	6.0 sec At 1024 Sps
Notes	
Project:	Trout Creek Quarry
Client:	ACA Products
Location:	Chaffee
User:	MMC Inc.

Serial Number	BE13047 V10.72-8.17 MiniMate Plus
Battery Level	6.9 Volts
Unit Calibration	December 3, 2015 by Instantel
File Name	C047GAAT.V80W
Post Event Notes	

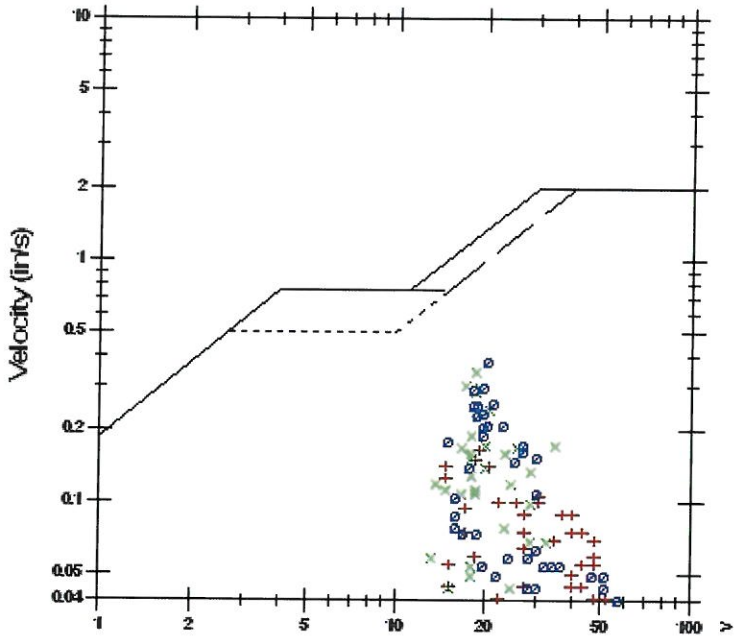
Extended Notes:

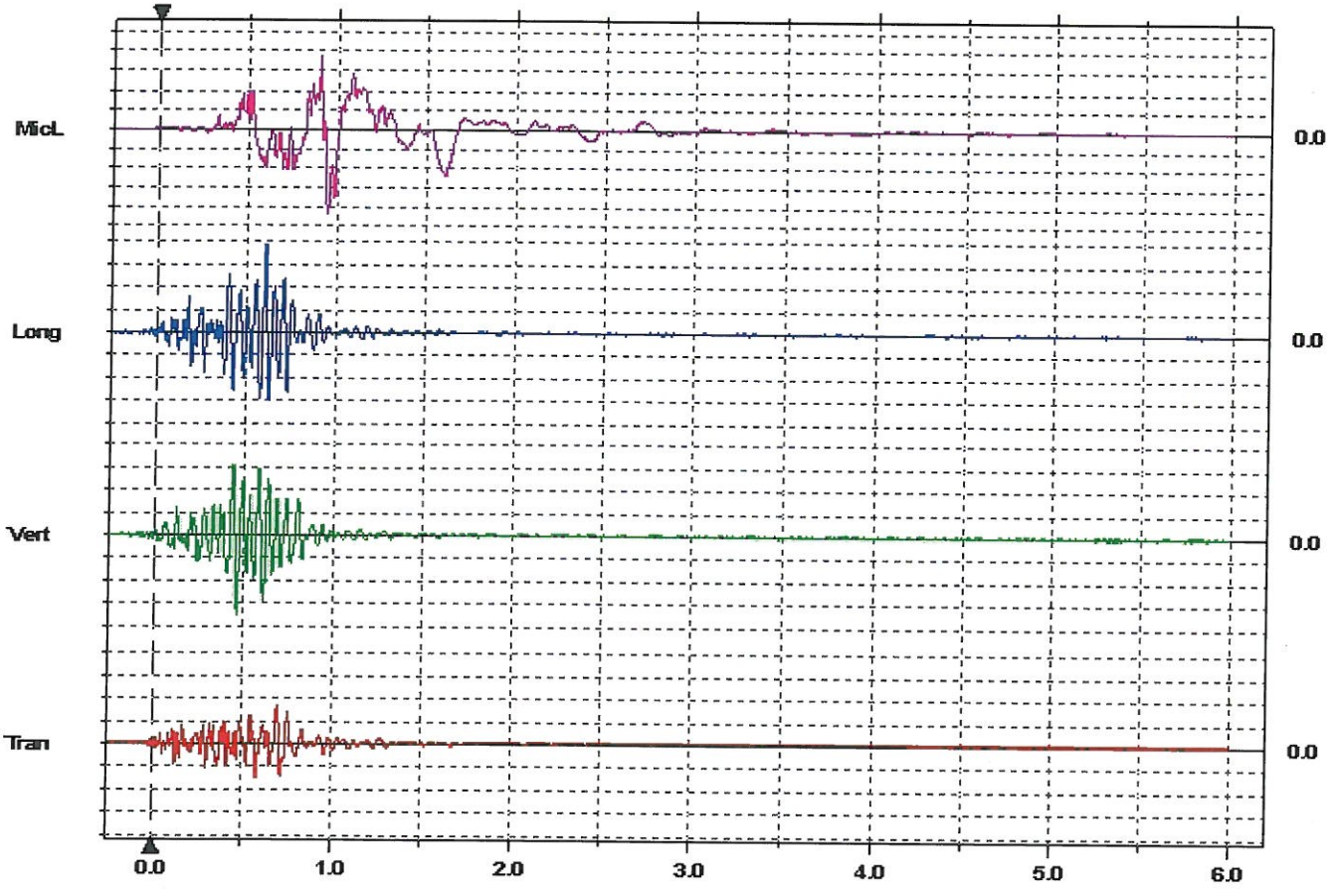
Microphone	Linear Weighting
PSPL	123.8 dB(L) at 0.943 sec
ZC Freq	6.6 Hz
Channel Test	Passed (Freq = 20.1 Hz Amp = 637 mv)

	Tran	Vert	Long	
PPV	0.165	0.350	0.385	in/s
ZC Freq	19	18	20	Hz
Time (Rel. to Trig)	0.700	0.468	0.607	sec
Peak Acceleration	0.066	0.119	0.133	g
Peak Displacement	0.001	0.003	0.003	in
Sensor Check	Passed	Passed	Passed	

Peak Vector Sum 0.470 in/s At 0.609 sec

USBM RI8507 And OSMRE





Time(Seconds) 0.50 sec/div **Amplitude** Geo: 0.100 in/s/div Mic: 0.001 psi(L)/div

Trigger = ▶—— —— ——◀

Instantel Event Report

Date/Time	*Long at 16:30:42 March 16, 2016*
Trigger Source	*Geo: 0.005 in/s*
Range	*Geo: 1.250 in/s*
Record Time	*3.75 sec (Auto=1Sec) at 1024 sps*

Notes

Project: *Trout Creek Quarry*
Client: *ACA Products*
Location: *Chaffee*
User: *MMC Inc.*

Extended Notes:

Microphone	*Linear Weighting*
PSPL	*124.3 dB(L) at 1.048 sec*
ZC Freq	*6.6 Hz*
Channel Test	*Passed (Freq = 20.1 Hz Amp = 645 mv)*

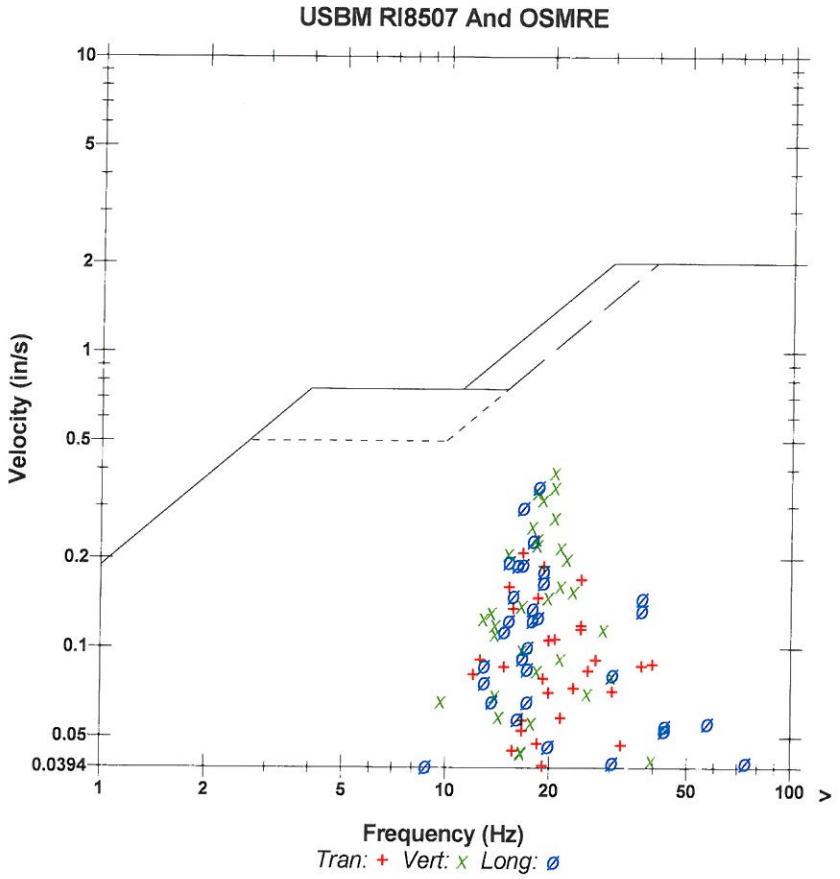
	Tran	Vert	Long	
PPV	*0.209*	*0.394*	*0.352*	*in/s*
ZC Freq	*17*	*20*	*18*	*Hz*
Time (Rel. to Trig)	*0.687*	*0.707*	*0.568*	*sec*
Peak Acceleration	*0.066*	*0.136*	*0.103*	*g*
Peak Displacement	*0.002*	*0.003*	*0.003*	*in*
Sensor Check	*Passed*	*Passed*	*Passed*	
Frequency	*7.1*	*7.7*	*7.5*	*Hz*
Overswing Ratio	*4.2*	*3.5*	*3.8*	

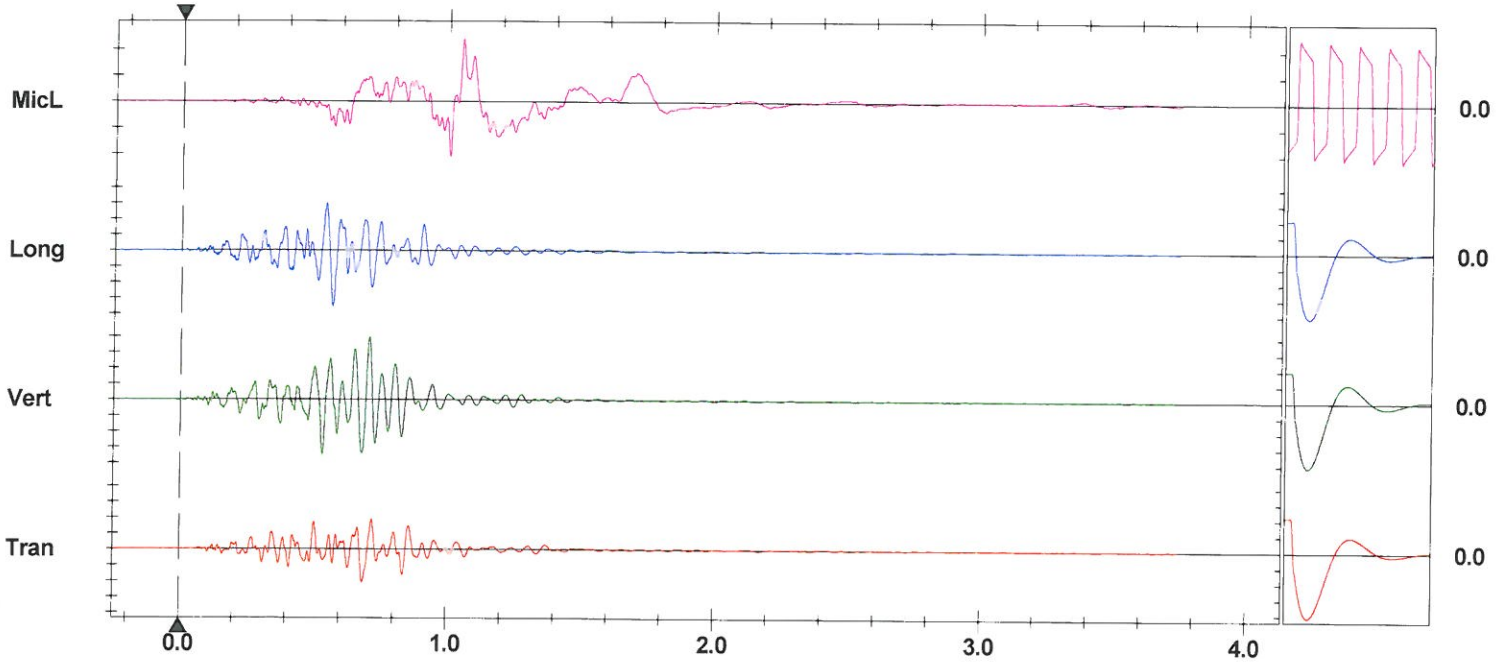
Peak Vector Sum *0.437 in/s at 0.708 sec*

Serial Number	*BE10051 V 10.72-8.17 MiniMate Plus*
Battery Level	*6.4 Volts*
Unit Calibration	*April 8, 2015 by Instantel*
File Name	*L051GAAT.V60*

Post Event Notes

Seismograph was positioned between the shot area and the dam. Distance from the shot to the instrument was approximately 485 feet, and the distance from the instrument to the closest dam structure was approximately 120 feet.





Time Scale: *0.20 sec/div* **Amplitude Scale:** *Geo: 0.100 in/s/div Mic: 0.002 psi(L)/div*
Trigger = ▶——

Sensor Check

Calibration Certificate

Part Number:	716A0403
Description:	MINIMATE PLUS W/EXT. GEO
Serial Number:	BE13047
Calibration Date:	December 3, 2015
Calibration Equipment:	718A1501

Instantel certifies that the above product was calibrated in accordance with the applicable Instantel procedures. These procedures are part of a quality system that is designed to assure that the product listed above meets or exceeds Instantel specifications

Instantel further certifies that the measurement instruments used during the calibration of this product are traceable to the National Institute of Standards and Technology; or National Research Council of Canada. Evidence of traceability is on file at Instantel and is available upon request.

The environment in which this product was calibrated is maintained within the operating specifications of the instrument.

Please note that the sensor check function is intended to check that the sensors are connected to the unit, installed in the proper orientation and sufficiently level to operate properly. This function should not be confused with a formal calibration, which requires the sensors be checked against a reference that is traceable to a known standard. Instantel recommends that products be returned to Instantel or an authorized service and calibration facility for annual calibration.

Calibrated By: Martin Hogue

Instantel

Calibration Certificate

Part Number:	714A9701
Description:	TRIAXIAL GEOPHONE (ISEE)
Serial Number:	BG12070
Calibration Date:	December 3, 2015
Calibration Equipment:	714J7401

Instantel certifies that the above product was calibrated in accordance with the applicable Instantel procedures. These procedures are part of a quality system that is designed to assure that the product listed above meets or exceeds Instantel specifications

Instantel further certifies that the measurement instruments used during the calibration of this product are traceable to the National Institute of Standards and Technology; or National Research Council of Canada. Evidence of traceability is on file at Instantel and is available upon request.

The environment in which this product was calibrated is maintained within the operating specifications of the instrument.

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Calibrated By: _____

Martin Hogue

Instantel

Calibration Certificate

Part Number:	714A9801
Description:	LINEAR MICROPHONE 2-250HZ
Serial Number:	BH11574
Calibration Date:	December 3, 2015
Calibration Equipment:	714J7401

Instantel certifies that the above product was calibrated in accordance with the applicable Instantel procedures. These procedures are part of a quality system that is designed to assure that the product listed above meets or exceeds Instantel specifications

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The environment in which this product was calibrated is maintained within the operating specifications of the instrument.

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Calibrated By: Martin Hogue

Martin Hogue

Instantel

Calibration Certificate

Part Number:	716A0403
Description:	MINIMATE PLUS W/EXT. GEO
Serial Number:	BE10051
Calibration Date:	April 8, 2015
Calibration Equipment:	718A1501

Instantel certifies that the above product was calibrated in accordance with the applicable Instantel procedures. These procedures are part of a quality system th designed to assure that the product listed above meets or exceeds Instantel specif.

Instantel further certifies that the measurement instruments used during the calib. of this product are traceable to the National Institute of Standards and Technolog National Research Council of Canada. Evidence of traceability is on file at Insta and is available upon request.

The environment in which this product was calibrated is maintained within the operating specifications of the instrument.

Please note that the sensor check function is intended to check that the sensors ar connected to the unit, installed in the proper orientation and sufficiently level to c properly. This function should not be confused with a formal calibration, which requires the sensors be checked against a reference that is traceable to a known standard. Instantel recommends that products be returned to Instantel or an auth service and calibration facility for annual calibration.

Calibrated By: _____

Tuyen Bui

Instantel

Calibration Certificate

Part Number:	714A9701
Description:	TRIAXIAL GEOPHONE (ISEE)
Serial Number:	BG8875
Calibration Date:	April 8, 2015
Calibration Equipment:	714J7401

Instantel certifies that the above product was calibrated in accordance with the applicable Instantel procedures. These procedures are part of a quality system th designed to assure that the product listed above meets or exceeds Instantel specif.

Instantel further certifies that the measurement instruments used during the calib. of this product are traceable to the National Institute of Standards and Technolog National Research Council of Canada. Evidence of traceability is on file at Insta and is available upon request.

The environment in which this product was calibrated is maintained within the operating specifications of the instrument.

Please note that the sensor check function is intended to check that the sensors ar connected to the unit, installed in the proper orientation and sufficiently level to c properly. This function should not be confused with a formal calibration, which requires the sensors be checked against a reference that is traceable to a known standard. Instantel recommends that products be returned to Instantel or an auth service and calibration facility for annual calibration.

Calibrated By: _____

Tuyen Bui

Instantel

Calibration Certificate

Part Number:	714A9801
Description:	LINEAR MICROPHONE 2-250HZ
Serial Number:	BH8108
Calibration Date:	April 8, 2015
Calibration Equipment:	714J7401

Instantel certifies that the above product was calibrated in accordance with the applicable Instantel procedures. These procedures are part of a quality system th designed to assure that the product listed above meets or exceeds Instantel specif.

Instantel further certifies that the measurement instruments used during the calib. of this product are traceable to the National Institute of Standards and Technolog National Research Council of Canada. Evidence of traceability is on file at Insta and is available upon request.

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Calibrated By: _____

Tuyen Bui

Instantel

b) Series III Specifications

Seismic	Range	10 in/s (254 mm/s).
	Resolution	0.005 in/s (0.127 mm/s), to 0.000625 in/s (0.0159 mm/s) with built–in preamp.
	Trigger Levels	0.005 to 10 in/s (0.127 to 254 mm/s) in steps of 0.001 in/s (0.01 mm).
	Frequency Analysis	National and Local Standards for all countries (see text).
	Accuracy	3% at 15 Hz.
	Acceleration, Displacement	Calculated using entire waveform, not estimated at peak.
Air Linear	Range	88–148 dB, 7.25 x 10^{-5} psi to 0.0725 psi, 0.5 Pa to 500 Pa.
	Resolution	0.1 dB above 120 dB (0.25 Pa).
	Trigger Levels	100–148 dB in 1 dB steps.
	Accuracy	0.2 dB at 30 Hertz and 127 dB.
"A" Weight (optional)	Range	50 to 110 dB in steps of 0.1 dB. (Impulse Response – 35 milliseconds)
Sampling Rate		Standard 1024 samples per second per channel to 16,384 (8,192 for 8 channel).
Event Storage	Full Waveform Events	300 standard and 1500 optional at standard sample rate of 1024.
	Summary Events	1750 standard and 8750 optional at standard sample rates of 1024.
Frequency Response	2 to 300 Hz	Ground and Air, Independent of record time.
Full Waveform Recording	Fixed Record Modes	Manual, single shot, continuous and programmed start/stop.
	Fixed Record Time	1 to 100, 300 or 500 sec plus 0.25 sec pre-trigger.
	Auto Record Mode	1 to 100, 300 or 500 sec plus 0.25 sec pre-trigger.
Strip Chart Recording	Record Method	Record to memory and/or internal printer. Program interval 2, 5, 15, 60, 300 or 900 sec.
	Days Storage	2.8 or 14 days at 5 second interval. 34 or 170 days at 60 second interval.
Histogram Combo Mode	Histogram Record Method	Record to memory and/or internal printer. Program interval 2, 5, 15, 60, 300 or 900 sec.
	Histogram Days Storage	2.4 or 12 days at 5 second interval. 29 or 147 days at 60 second interval.
	Waveform Events	Up to 13 one-second events (1024 sample rate, four channels recording).
	Waveform Record Times	1 to 13 seconds plus 0.25 sec pre-trigger.
Special Functions	Timer Operation	Programmed start/stop.
	Self Check	Programmable daily check.
	Scaled Distance	Weight and distance stored with event.
	Monitor Log	History printout programmable up to all events stored.
	Automatic download	Automatic downloading of data from a unattended monitor with Auto Call Home.
	Measurement Units	Imperial or metric, dB or linear air pressure, or in units of custom sensors.
Printer	Resolution	576 dots/line and 0.0049 inches (0.125 mm) per dot.
	Print Time	Less than 10 seconds for typical 1 second event with full analysis.
	Paper Control	Paper tear slot or automatic paper takeup, separate keys for feed and takeup.
	Rated Life – print head	18 miles (30 km) of printing.
	Number of Copies	1 to 10 copies automatic, any number manual.
User interface	Keyboard	64 domed tactile with separate keys for common functions.
	Display	4 line by 20 character high contrast backlit display with on line help.
Battery Life		30 days continuous recording, 70 days with timer, printing will decrease life.
Fuse		5 A/250 V

3. COMPLIANCE MODULE

This chapter provides instructions to install and setup the BlastMate III.

3.1. What is Event Monitoring?

Event monitoring measures both ground vibrations and air pressure. The monitor measures transverse, vertical, and longitudinal ground vibrations. Transverse ground vibrations agitate particles in a side to side motion. Vertical ground vibrations agitate particles in an up and down motion. Longitudinal ground vibrations agitate particles in a forward and back motion progressing outward from the event site. Events also affect air pressure by creating what is commonly referred to as "air blast". By measuring air pressures, we can determine the effect of air blast energy on structures, measured on the Linear "L" scale, or as perceived by the human ear, measured on the "A" Weight scale.

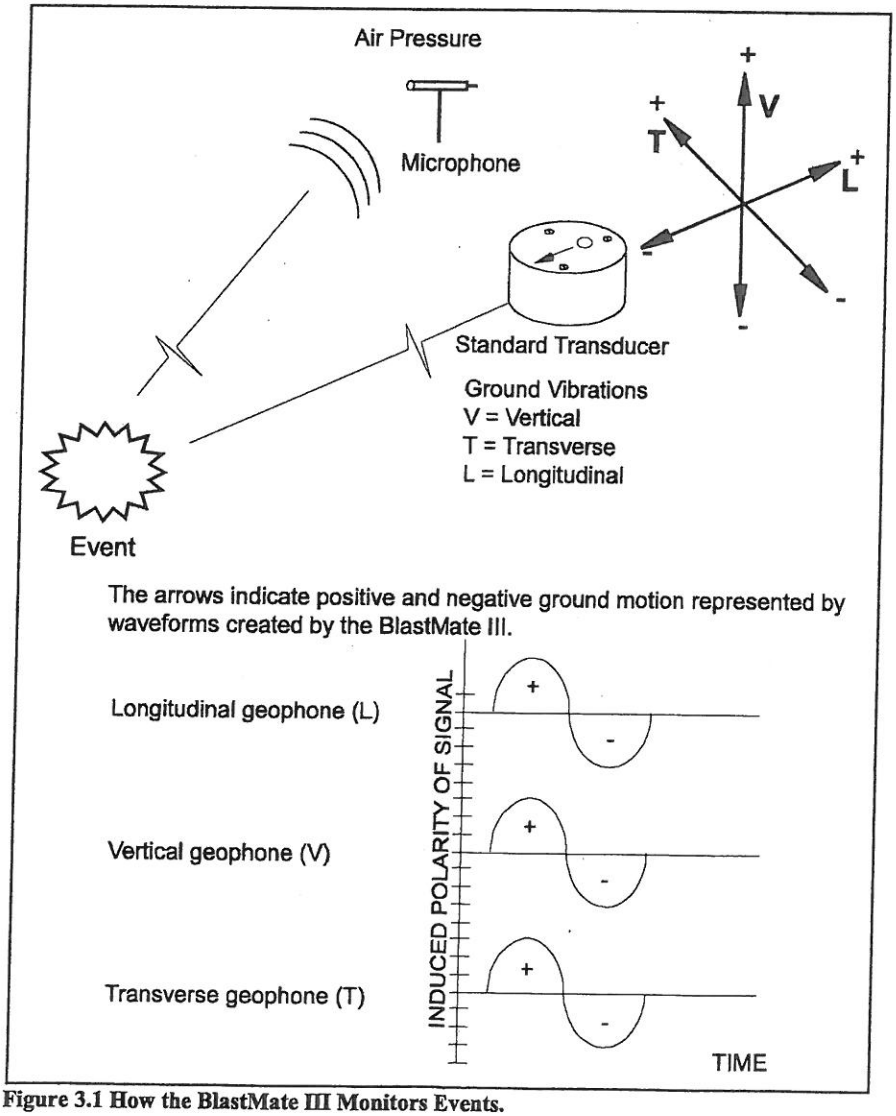

Figure 3.1 How the BlastMate III Monitors Events.

a. Geophone Operation

Functionally a geophone sensor is a coil of wire suspended around a magnet. The magnet is free to move in a field of magnetic flux lines. By Lenzs' Law, induced voltage is proportional to the speed at which flux lines are traversed. Induced coil voltage is therefore proportional to the relative velocity of the coil to the magnet. In practice, it does not matter whether the coil or the magnet moves. Only the motion and speed relative to each other are important.

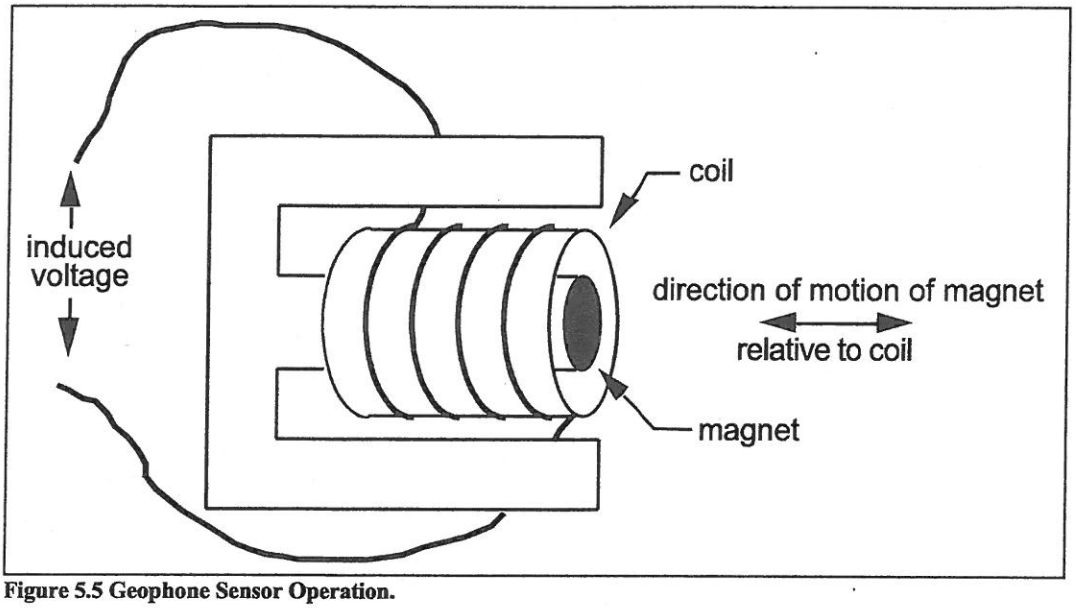

Figure 5.5 Geophone Sensor Operation.

Geophone sensor specifications give a number known as the Intrinsic Voltage Sensitivity. It is the coil voltage induced for a given coil versus magnet speed with units of V/in/s. In seismic applications, the magnet is moved by the blast energy because it is coupled to the particles of the surrounding terrain. The coil, because of its inertia, does not move and the resulting magnet versus coil motion induces a voltage which is proportional to particle velocity.

b. Instantel Standard Transducer

Instantel offers a 2 to 300 Hz standard transducer in a round package. The transducer may be installed on a floor, wall, or ceiling using a variety of installation procedures including ground spikes, burying, mounting rod, or optional leveling plate with leveling feet and integrated bubble level. The figure below includes an Instantel Standard Transducer (a) and a Standard Transducer with leveling plate (b).

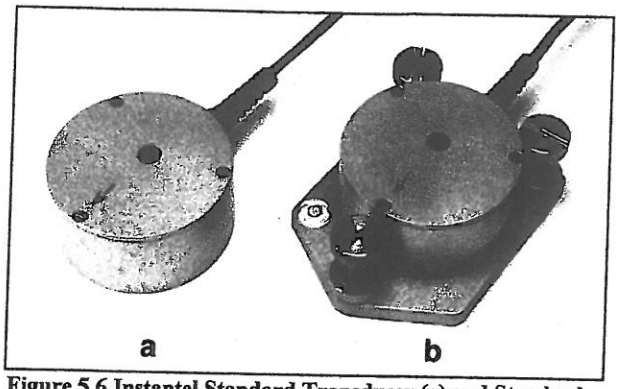

Figure 5.6 Instantel Standard Transducer (a) and Standard Transducer with Optional Leveling Plate (b).

c. Transducer Calibration Requirements

The geophone sensors inside Instantel's transducers must be calibrated annually by Instantel or an authorized Instantel service facility. Contact your dealer for further information.

5.2.2. Microphone

The microphone measures air pressure. Instantel offers two types, Linear "L" (standard) and "A" Weight (optional). Both come with a three foot (one meter) microphone mounting stand.

a. Measurement Scales

The BlastMate III supports two sound pressure measurement scales: Linear "L" and "A" Weight.

(1) Linear "L"

Linear measurement is generally used to measure the effect of low frequency air pressure on buildings. The linear scale records sound pressure without modification in the 2 to 300 Hz range. Measurement units may be in absolute, Pascal, or relative dB scales.

(2) Weight

"A" Weight measures noise levels people may consider an annoyance. The signal is then converted to root mean square (RMS). Units are measured using the decibel scale, dB(A).

b. Microphone Calibration Requirements

Instantel's microphone must be calibrated annually by Instantel or an authorized Instantel service facility. Contact your dealer for further information.

5.3. Sensorcheck

Sensorcheck performs a two stage test on the BlastMate III and its sensors. In the first stage, the program displays the BlastMate III serial number, software version, the total amount of memory installed in the BlastMate III, the total amount of memory available to store events, and the number of events presently stored in memory. The second stage tests each geophone within Instantel's transducer and the microphone operation. The program also tests the operation of the BlastMate III itself and the sensor connecting cables. Pass or fail results appear on the display. See the Basic Reference chapter of this manual to choose when Sensorcheck operates automatically.

5.3.1. Checking the Transducer's Geophones

Sensorcheck measures a geophone's natural frequency and damping indicated by an Overswing Ratio (OR). Sensorcheck sends an electric pulse to the geophones and measures the response. If the geophone's response falls within a specified calibration range, the geophone is in calibration and monitoring operations can continue. If the geophone's response does not fall within a specified calibration range, the geophone is not calibrated. You cannot record events until you fix or replace the geophones. See the troubleshooting section of this manual for the appropriate procedures to follow.

a. Natural Frequency

Waveform measurements check the natural period (t) of a geophone's sensor coil assembly. Referring to the figure below, the distance from P_1 to P_2 represents 0.125 seconds. Since Frequency is the reciprocal of the period, F=1/t, the frequency is approximately 8 Hz. A calibrated sensor has a natural frequency between 6.5 and 9.5 Hertz. Calculations for all geophones appear with each recorded event.

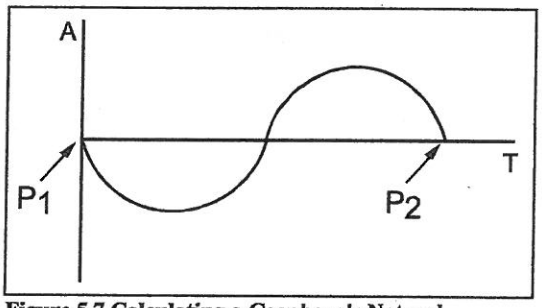

Figure 5.7 Calculating a Geophone's Natural Frequency.

b. Damping – Overswing Ratio (OR)

The overswing ratio (OR) measures damping and is calculated by computing the ratio of the magnitude of adjacent waveform peaks according to the following formula:

$$OR = \frac{A_1}{A_2}$$

Acceptable overswing ratios range from 2.8 to 4.8. The figure below displays a graph of a geophone coil's "free fall" response. A_1 and A_2 are used for overswing calculations.

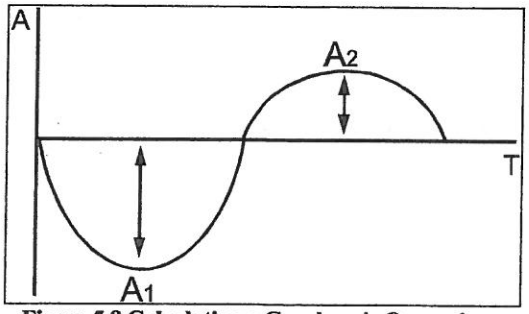

Figure 5.8 Calculating a Geophone's Overswing Ratio.

5.3.2. Checking the Microphone

Sensorcheck tests the microphone's operation by sending a signal to the microphone and measuring its frequency and amplitude response. If the results of the test fall within specified ranges, the microphone is within calibration.

5.3.3. Sensorcheck Report

The Sensorcheck report appears on the BlastMate III display. The message "All Channels Working, Press Print to Print" indicates the BlastMate III sensors have passed the Sensorcheck.

5.4. Anti-alias Filters

Aliasing occurs when a high–frequency signal appears as an erroneous low frequency because the waveform was sampled at too low a sampling rate. An anti-aliasing filter solves this problem by removing the high–frequencies.

5.5. Data Analysis Techniques

The following sections define the BlastMate III data analysis techniques. The first section, ground vibrations, discusses calculations applied to event data recorded by a transducer. The second section, sound pressure, describes the microphone event data calculations.

5.5.1. Ground Vibrations

The BlastMate III calculates the Peak Particle Velocity, Zero Crossing Frequency, Peak Acceleration, and Peak Displacement for each of the transverse, vertical, and longitudinal axes. The BlastMate III calculates Peak Vector Sum using data from all three axes.

a. Peak Particle Velocity (PPV)

Peak Particle Velocity indicates the maximum speed particles travel resulting from an event's ground vibrations. The BlastMate III calculates the PPV for each geophone.

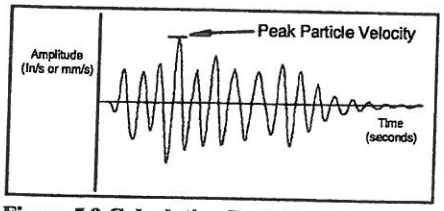

Figure 5.9 Calculating Peak Particle Velocity.

b. Zero Crossing Frequency (ZC Freq)

The Zero Crossing Frequency calculates the event waveform's frequency at the largest peak.

(1) Calculating Zero Crossing Frequency

To calculate the Zero Crossing Frequency, we need to determine the period of oscillation of the waveform. Convenient waveform positions for measuring period, the time for one complete cycle, occur between two successive peaks, troughs, or zero crossings. The BlastMate III measures between zero crossings. Frequency is the number of periods that occur in one second calculated by the formula: Frequency = 1/period.

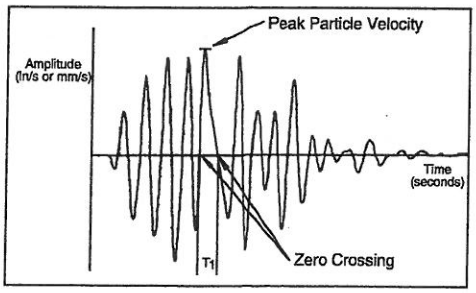

Figure 5.10 Calculating the Zero Crossing Frequency.

(2) Zero Crossing Frequency Limitation

The Zero Crossing Frequency calculation is limited because it assumes a single predominant frequency at the peak, typically represented by sinusoidal waveforms. In practice, the peak may be the result of two or more major frequency components representing compound waveforms as illustrated in the figure below. It is therefore only an approximation of the frequency of the Peak Particle Velocity.

Waveforms may have the same Peak Particle Velocities but different Zero Crossing Frequencies depending on the shape of the waveforms involved. With reference to the figures above and below; both waveforms have the same Peak Particle Velocities however their Zero Crossing Frequencies differ. In the figure above, the zero crossing frequency uses the 1/2 period indicated by T_1. In the figure below, the zero crossing frequency uses the 1/2 period indicated by T_2. Notice that T_1 is less than T_2 because of the different waveform shapes, therefore the Zero Crossing Frequency in figure above is greater than the Zero Crossing Frequency in the figure below. It is for this reason, the Zero Crossing Frequency may differ for peaks having the same Peak Particle Velocity.

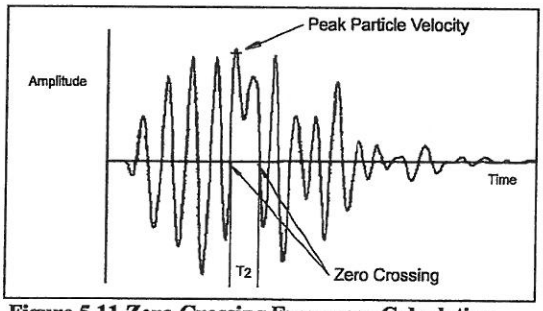

Figure 5.11 Zero Crossing Frequency Calculation Limitation.

(3) Sample Rate Error

The Zero Crossing Frequency requires the period of a wavelength before it can calculate the wavelength's frequency using the formula 1/period. A sampling error occurs for higher frequencies when wavelength periods become relatively small and the sampling rate begins to miss zero crossing points. In other words, the wavelength periods occur much faster than a BlastMate III can sample and use in the calculation.

At higher frequencies there are fewer sample points per cycle and therefore greater error. The following table illustrates how error increases with frequency.

Zero Crossing Frequency Sample Rate Error			
Frequency Range	Recording Rate		
	Standard (1024 Hz)	Fast (2048 Hz)	Faster (4096 Hz)
0 – 30 Hz	negligible error	negligible error	negligible error
31 – 50 Hz	up to 5 Hz error	up to 2.5 Hz error	negligible error
51 – 70 Hz	up to 8 Hz error	up to 4 Hz error	up to 2 Hz error
71 – 90 Hz	up to 18 Hz error	up to 9 Hz error	up to 4.5 Hz error
91 – 150 Hz	up to 50 Hz error	up to 25 Hz error	up to 12.5 Hz error

The BlastMate III does not calculate frequencies above 100 Hz because of the high error level at 1024 samples per second. The message ">100 Hz" displays. At 2048 samples per second, the message ">200 Hz" displays. When recording at 4096 samples per second, the message ">400 Hz" displays. Furthermore if a waveform is very complex, or if it contains a large offset value, the zero crossings may lie outside an acceptable window. Whenever a frequency cannot be calculated the message "<1 Hz" displays. The message N/A indicates an entire waveform was not captured and therefore no frequency could be calculated. More accurate analysis is available using the BlastWare III software.

c. Peak Acceleration

The BlastMate III calculates peak acceleration, the rate of change of velocity, by dividing the difference in velocity by the difference in time. To obtain the peak acceleration, the BlastMate III subtracts two velocity readings and divides the result by the elapsed time between them.

$$a = \frac{dV}{dT} \approx \frac{\Delta V}{\Delta T}$$

where:

Δt = a small interval

The BlastMate III calculates the peak acceleration at each point along the entire waveform and reports the peak value. Note that this is not necessarily at the peak velocity for an individual waveform.

d. Peak Displacement

The BlastMate III calculates peak displacement, or particle distance traveled, by multiplying speed by time. In the BlastMate III the interval velocity is multiplied by the time interval and the resulting displacement segments are summed.

$$s = \int V dt \approx \sum (V \Delta t)$$

where:

V = the velocity in each interval

To obtain the peak displacement, the BlastMate III integrates each wave segment of the entire waveform between zero crossings, selects the largest, then divides the value by half. Note that this is not necessarily at the peak velocity of the waveform.

e. Peak Vector Sum (PVS)

The figure below displays three event waveforms. The figure illustrates the procedure of graphically calculating peak vector sums. Measured magnitudes are tabulated for six different times and represent velocities in each of the three axes. The vector sum represents the resultant particle velocity magnitude and is calculated by squaring and adding the magnitudes and taking the square root.

$$PVS = \sqrt{T^2 + V^2 + L^2}$$

where:

T = particle velocity along the transverse plane
V = particle velocity along the vertical plane
L = particle velocity along the longitudinal plane

The BlastMate III calculates the peak vector sum for each point of the sampled waveforms and displays the largest value. Note that this is not necessarily at the peak velocity for an individual waveform.

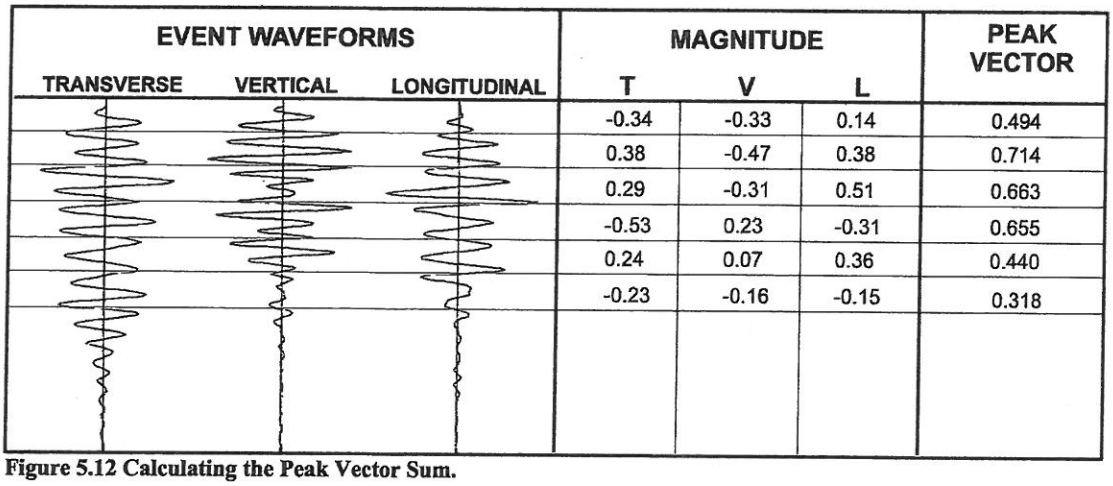

Figure 5.12 Calculating the Peak Vector Sum.

5.5.2. Sound Pressure

The BlastMate III calculates two sound pressure indicators, peak sound pressure and zero crossing frequency.

a. Peak Sound Pressure (PSP)

The BlastMate III checks the entire event waveform and displays the largest sound pressure called the Peak Sound Pressure (PSP), also referred to as the Peak Air Over–Pressure. Results appear on the BlastMate III display and in the Event Summary Report.

b. Zero Crossing Frequency (ZC Freq)

The Zero Crossing Frequency calculation for sound pressure is the same calculation used for ground vibrations. Please see above for a complete discussion.

Note: The Zero Crossing Frequency calculation is performed for Linear microphones only. This calculation does not appear on the BlastMate III display or on Event Summary Reports when using an "A" Weight microphone.

5.6. Alternate Manual Waveform Calculations

The following sections discuss manual waveform analysis techniques. These have been included for reference purposes only. They do not represent the calculation techniques employed by the BlastMate III.

Graphical methods for calculating area and slope depend on the shape of the waveform being analyzed. A complete discussion of the procedures is beyond the scope of this manual. Two useful reference texts are G. A. BOLLIGER, *BLAST VIBRATION ANALYSIS*, Southern Illinois University Press and CHARLES H. DOWDING, *BLAST VIBRATION MONITORING AND CONTROL*, Prentice-Hall Inc.

In each of the subsequent examples some formulae appear with no attempt at derivation. The following definitions apply:

A = amplitude in inches/second measured from the zero line

A_m = amplitude measured in millimeters/second

T = period in seconds

Y = absolute change in amplitude over time measured in inches/second

Y_m = absolute change in amplitude over time measured in millimeters/second

5.6.1. Sinusoidal Waveforms

The motion is essentially sinusoidal with gradual amplitude and frequency changes.

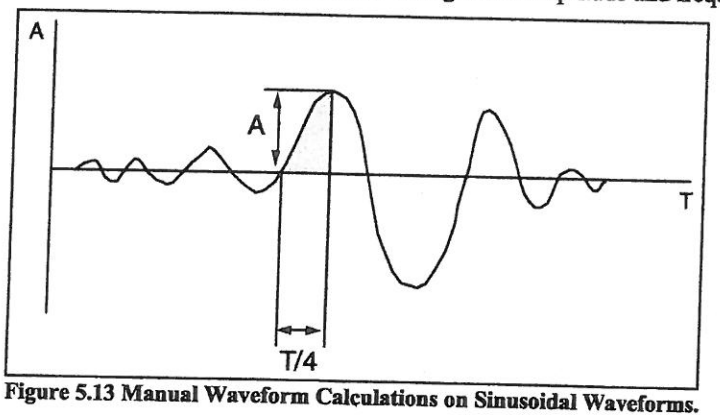

Figure 5.13 Manual Waveform Calculations on Sinusoidal Waveforms.

a. Calculating Displacement:

$$\text{Maximum Displacement (in.)} = \frac{T}{2\pi} \times A$$

$$\text{Maximum Displacement (mm)} = \frac{T}{2\pi} \times A_m$$

b. Calculating Acceleration:

$$\text{Maximum Acceleration (in./s}^2\text{)} = \frac{2\pi}{T} \times A$$

$$\text{Maximum Acceleration (mm/s}^2\text{)} = \frac{2\pi}{T} \times A_m$$

5.6.2. Nearly Triangular Waveforms

Motion is irregular and has large amplitude.

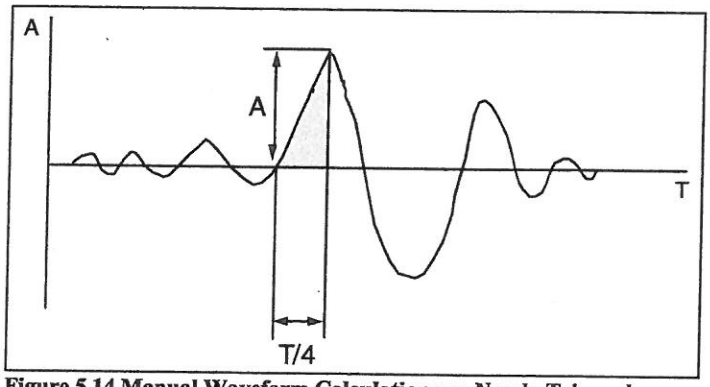

Figure 5.14 Manual Waveform Calculations on Nearly Triangular Waveforms.

a. Calculating Displacement:

$$\text{Maximum Displacement (in.)} = \frac{T}{8} \times A$$

$$\text{Maximum Displacement (mm)} = \frac{T}{8} \times A_m$$

b. Calculating Acceleration:

$$\text{Maximum Acceleration (in./s}^2\text{)} = \frac{1}{T} \times Y$$

$$\text{Maximum Acceleration (mm/s}^2\text{)} = \frac{1}{T} \times Y_m$$

5.6.3. Compound Waveforms

If the record exhibits interference by two or more predominant frequencies then the maximum displacement will be the sum of the maximum of each individual frequency component.

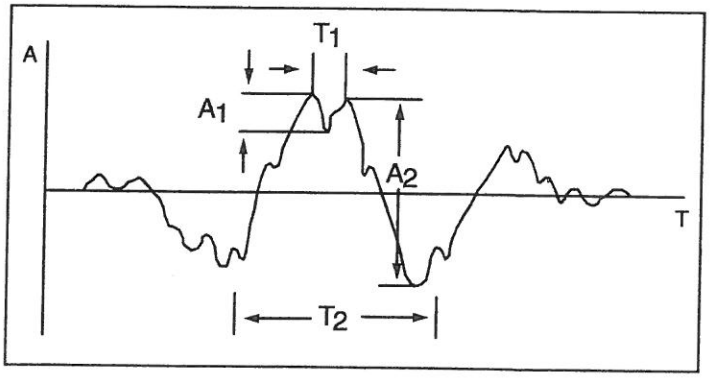

Figure 5.15 Manual Waveform Calculations on Compound Waveforms.

a. Calculating Displacement:

$$\text{Maximum Displacement (in.)} = \frac{T_1}{2\pi} \times A_1 + \frac{T_2}{2\pi} \times A_2$$

$$\text{Maximum Displacement (mm)} = \frac{T_1}{2\pi} \times A_{1m} + \frac{T_2}{2\pi} \times A_{2m}$$

b. Calculating Acceleration:

$$\text{Maximum Acceleration (in./s}^2\text{)} = \frac{2\pi}{T_1} \times A_1 + \frac{2\pi}{T_2} \times A_2$$

$$\text{Maximum Acceleration (mm/s}^2\text{)} = \frac{2\pi}{T_1} \times A_{1m} + \frac{2\pi}{T_2} \times A_{2m}$$

5.6.4. Irregular Waveforms

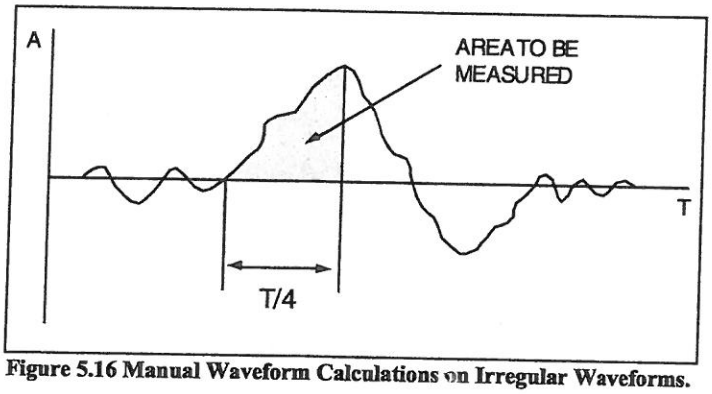

Figure 5.16 Manual Waveform Calculations on Irregular Waveforms.

a. Calculating Displacement:

Maximum Displacement = area under curve measured by a planimeter.