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	Wi	nd:		Still	PAGE 1 A Arvada, CO 80007 Magazine Site Used: ACA Shot No: 006 CI Job No: //6 86 Date: 3 //6 //6 Type Shot: Depth Cover: O Type Stemming: % 5 TotAl Depth Cover: O Type Stemming: % 5 TotAl 5 TotAl Depth Cover: O Total Lbs Expl: 6,997.7.61 Max Lbs. Per 8 ms: 6 7.74 Powder Factor: 79 Pace Dist. & Dir: PPV: DB: DB: 124 Dist. & Dir: PPV: DB: 124 124 Dist. & Dir: PPV: DB: 124 124 Dist. & Dir: PPV: DB: 124 124						
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nber of	Hole	Hole	Sub	Burde	n	Wet	Total Vertica			Total Varia	
oles	Diameter	Depths	Drill	& Spacir	ng	or Dry					r.
39	31/."	8'-29'	12	8' 4 1	111	2	2 0		or nental	WIGI SUD Dri]

Holes	Diameter	Depths	Drill	& Spacing	or Dry	Bore Hole Feet	of Trench	with Sub Drill
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Hole	Ho	le Numbe	er of Bot	tom Deck (lbs.)	Feet of	Der	k 2 (lbs)				
(303)279-4458 PAGE 1 B SHOT INFORMATION Magazine Site Used: Blaster: Mike RAWSPM Job No: 16:80:000 Location: TROUT CREEK QUARAY Type Shot: Production Type Material: Overburden: Type Cover: Depth Cover; Max Holes Per 8 ms: Max Lbs. Per 8 ms: Blasters Signature: Seismic Firm & Analyst: Yenter/Jim Knoll Other: Unit No: Location: Dist. & Dir: WEATHER INFORMATION Timp: To 32 Weather: Sunny Clear Overcast Wind: Still Moderate Hi HOLE PROFILE INFORMATION Still Moderate Hi Hole Hole Number of Bottom Deck (lbs.) Feet of Deck 2 (lbs.) Feet of				Feet of		k 3 (lbs.)	Feet of				
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YENTER COMPANIES, INC.
BLAST REPORT PAGE 3
BLASTER: MIKE RANSON DATE: 3/16/16
JOB NO: 16-80-006 SHOT NO: 006-01
NARRATIVE:
SHOT WENT GOOD - Some C. A.
SHUT WENT GOOD - SOME FLY ROCK - NONE LEFT BLAST AREA GOUD MOVEMENT & BREAKADE - SOME OVER SIZE FROM OUTSIDE EDGES - SOME OFERSIZE ROLLED DOLLA STREE FROM OUTSIDE
EDGES - SOME OFERSIZE ROLLED DOWN SLOPE
51 HOLES WITH WATER (1'TO 10') USED 350 BOOSTERS & BLASTER REPRIME AFTER EVERY 3 CARTE DUE & E BLASTER
REPRIME AFTER EVERY 3 CARTRIDGES OF BLASTEX - USED 5 XTRA
DELAYS FOR TIMINE

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liente			VC.							20300 W	est Hwy 7
E CHO		and the second secon			Contractor Designation in the party of	and the second	1		and the second	Arvada,	CO 80007
	Statement of the second second	select and the second se		1				VISTA	Sł	not No: 00	6-02
	-				Job I	No: 110 -	80-006		Døte:	8/29/1	4
				IARAY	Туре	Shot: PA	Duction	J	Shot Tim	le: 1:4	0
			ITE		Over	burden: 🚄	>		Type Ste	mming: 1/2 "	STONE
Type Co	ver: 🖊	V/A	· ····		Depti	h Cover: 🕻	>		Total Lbs	Expl: 8.1	77.69
	and the second states a	Construction of the local division of the lo			Max I	bs. Per 8 m	s: 67.20	•			
Blasters	Signatu	re: Ma	6Ka	non					1		
SEISMIC	INFOR	MATION		com Participan dan adda.	Type o	of structure:	DAM		hannet on h	-Mr	
r			Analyst: Y	enter/Jim Kno					perator:	TIC	
Unit Not	1100		the second se			Dist. & I	Dir: 475	N.1	PPV:	45 DB	117
Unit No:	Lo	cation:	125' 4	con D	m)	Dist. & I					
Unit No:	Lo					Dist. & D	Dir:		PPV:		
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HOLE P	ROFILE	INFORM	ATION					1981		an a	l
Hote	Hole	Number	of Bott	om Deck (lbs.)	Feeto	f Dert	2 (lbs)	Tran			<u> </u>
Depth	Jnit No: Location: Dist. & Dir: PPV: DB: WEATHER INFORMATION Weather: Summy Clear Overceast Rain Snow Temp: To 32 33-65 56-70 71-85 B8 & Up Wind: Still Moderate High Hole Still Moderate High HOLE PROFILE INFORMATION Hole Number of Bottom Deck (lbs.) Feet of Deck 2 (lbs.) Heet of Deck 3 (lbs.) Feet of Jain else Decks Hi. Ex. B. Agent Stem Hi. Ex. B. Agent Stem 18' 3 ½' 1 -33 8'' Image: Stem										
18'	(303)279-4458 PAGE 1 Aveda, CD 80007 SHOT INFORMATION Magezine Site Used: Dir EAN V/STA Shot No: Dole Dete: 3/29/1/4 Location: IACT CRETE Quickey Type Shot As DUCTION Shot No: Dole Dete: 3/29/1/4 Location: IACT CRETE Quickey Type Shot As DUCTION Shot Time: /: 40 Type Cover: N/A Dete: 3/29/1/4 Dete: 3/29/1/4 Dete: 3/29/1/4 Dete: 3/29/1/4 Type Shot As DUCTION Type Cover: N/A Dete: 3/29/1/4 Dete: 3/29/1/4 Dete: 3/29/1/4 Type Cover: N/A Dete: 3/29/1/4 Dete: NPC Dete: NPC Dete: NPC										
	(303)279-4458 F OT INFORMATION Magazin r: Mike Lawson Joi on: TRAAT CREEK QUARAY Ty Aaterial: GRAN ITE OV Cover: N/A De bles Per 8 ms: / Ma s Signature: Milo Ramon CINFORMATION Type Seismic Firm & Analyst: Yenter/Jim Knoll MMC locetion: DAM : Location: (12 S' From Dam) : Location: (12 S' From Dam) : Location: MA Weather: Sunny Clear Temp: To 32 33-55 Wind: Still PROFILE INFORMATION Hole Number of Bottom Deck (lbs.) Fee Diameter Decks Hi. Ex. B. Agent Sta 3 X° 1 .33 8 Vind: Still CTION SHOT PROFILE INFORMATION Hole Hole Sub Burden Diameter Depths Drill & Specing				Ĭ		+	+			
20'	3030279-4458 PAGE 1 Avade, CO 80007 SHOT INFORMATION Magezine Site Used: SurENA ViSTA Shot No: Colspan="2">Colspan="2">Shot No: Colspan="2">Colspan="2">Colspan="2">Shot No: Colspan="2">Colspan="2"Colspan="2">Colspan="2"Colspa										
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YENTER COMPA BLAST REF PAGE 3	NIES, INC. PORT
BLASTER: Mike RANSOM	DATE: 3/29/16
JOB NO: /6 - 80 - 004	
NARRATIVE:	
SHOT WENT GOOD - NO FL	g fock
12 WET HOLES LOADED WITH 1	BLASTEX

Jean Source Geo: 0.000 In/s Tage Geo: 10.000 in/s Tagle Rate 8.0 seo. At 1024 Sps res ext: Trout Creek Query rt: ACA Products attor: Chalf ce s: MMC Ins.

rended Notes:

 Impliance
 Linear Weighting

 PL
 117.6 dB(L) at 0.575 sec.

 Fireq
 4.5 Hz

 mmel Test
 Passed (Freq = 19.7 Hz Amp = 657 m/)

	Tran	Yet	Long	
¥	0.240	0.435	0.455	In/s
Freq	18	20	21	Hz
e (Rel. to Thig)	0.648	D.499	0.487	520
die Accoleration	0.105	0.148	0.169	8
nic Displancement	0.002	E000	0.003	In
nsor Onnak	Passed	Passed	Passed	

nic Ventor Sum 0.620 in/s At 0.469 sec.

Building Level 6.8 Volts Unit Ontibration December 3, 2016 by Instantel File Name CO47 GAYO, PFOW Post Event Nates

LEBMIRBOR And OSMRE





TinnerSecondel 0.50 seofdiv Annalitude Geo: 0.100 in/s/div Mic 0.001 ps/1_/div

YENT	ER COM	PANIES, II	NC.		RIAST	REPORT			0		
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HOLE	PROFILE	E INFORM	ATION	-				/ ngri			J
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Blasters \$	Signature										
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Depth	Diameter	Decks	Hi. Ex.	B, Agent	Stem	Hi. Ex.	B. Agent	Stem	Hi. Ex.	B. Agent	Stem
27'	3%"		-33	66.93	8'						a management of the second
28'				70.47							
30'				77.55							
31'	V	4	4	81.09							
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nber of	Hole	Hole	Sub	Burde	n	Wet	Total Vertica		Lin. Feet	Total Yards	

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

										NSE	DM			Y	'EI	NTI	ER	СС	DMI	PAI	VIE	S,	INC	с.	Τ		SH	го	- N	0:	10000000	7			NO	RT	н
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YENTER COMPANIES, INC. BLAST REPORT
BLASTER: Mike RAWSOM DATE: 4/12/16
JOB NO: 16-80-004 SHOT NO: 006-03
NARRATIVE:
SHOT WENT 600D - NO FLY POCK - 6000 MOVEMENT & BREAKAGE
5 WET HOLES LOADED WITH BLASTER & 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 6.0 sec. At 1024 Sps Sample Rate Notes Project: Trout Creek Querry Client: ACA Products Location Chaffee User. MMC Inc.

Extended Notes:

 Serial Number
 BE13047 \/ 10.72-8.17 MiniMate Plus

 Battery Level
 6.8 \/olts

 Unit Calibration
 December 3, 2015 by Instantel

 File Name
 0047 GBOL P30V/

USEMIR8507 And OSMRE



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Number of Holes	Hole Diamster	Hole Depths	Sub Drill	Burden & Spacing	Wet or Dry	Total Vertical Bore Hole Feet	Lin, Feet	Total Yards
270	3%"	8'-22'	0	8' x 10'	Both	3202 "	of Trench	with Sub Drill 9487.40
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YENTER COMPANIES, INC.					BLAST REPORT					20300 V	/est Hw	
(303)279-4458				PAGE 1 B					Arvada, CO 800			
SHOT INFORMATION Blaster: Mike RANSOM			and the second stands	M	lagazine S	And a state of the		-to	Ş	Shot No: 00	the second second second second	
Blaster:		RAN	JSOM		Job No	: 16-8	0 004	•	Date:	4/261		
Location: Type Material:				Type S	hot:			Shot Ti				
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YENTER COMPANIES, INC. BLAST REPORT
BLASTER: Mike RANSOM DATE: 4/26/16
JOB NO: 16-80-006 SHOT NO: 006-04
NARRATIVE:
BLAST WENT (900) - SOME FLY ROCK (NONE LEFT
BLAST AREA) - (3000 MOVEMENT & BREAKAGE
170 HOLES WITH WATER (3FT. TO 14 FT. EACH)
WET HOLES CONDED WITH 350 BOOSTERS & 21/2" BLASTEX
1,2,3 \$ 4 PRIMERS PER HOLE (DEPENDING ON
DEPTH of WATER) - DRY HOLES CONDED WITH
150 BOOSTERS & ANTO - 25 NS BETWEEN HOLES &
84 MS BETWEEN ROWS

gen Bournes Geo: 0.050 in/s 199 Geo: 10.000 in/s 199 Geo: 10.000 in/s 199 Geo: 10.000 in/s 199 Geo: 10.000 in/s 100 in/s

unded Notes:

Ballisty Level 6.8 Volts Unit Calibration December 3, 2015 by Instantel File Name CO47 GCEN GROW Post Event Notes

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2801 Youngfield Street, Suite 171 Golden C0 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.



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: <u>ACA/VENJER COMPANIES</u> DATE: 3/16/16 PROJECT NAME: <u>TROUT CREEK QUMERN</u> TIME: 1630 LOCATION: <u>SOUTH OF HWY 24/285 BUENA VISIA</u> , CO
PROJECT NAME: TROUT CREEK QUMPRINT TIME: 1630
LOCATION: SOUTH OF HWY 24/285 BUENA VISIA, CO
BLAST DETAILS
HOLES DIAMETER BURDEN & SPACING DEPTH STEMMING 139 3½"
EXPLOSIVES
TYPEAMOUNT ANFODELAY TYPE:EZ-DET: 25-360MSANFOGOSTOPDELAY TYPE:EZ-DET: 25-360MSANFOBELAY TYPE:EZ-DET: 25-360MSANFOBELAY MAKE & NUMBERS:AZMSANTO BOOSTOPS30.36#DELAY MAKE & NUMBERS:AND BOOSTOPS71.25#BLASTER:AND BOOSTOPS71.25#AND BOOSTOPS
SEISMOGRAPH INFORMATION
1) SERIAL# <u>SE 13047</u> CAL. DATE: <u>12/3/15</u> DIST. & DIR. FROM BLAST: <u>485' North</u> PEAK PARTICLE VELOCITY: <u>0,38 iPS</u> FREQUENCY: <u>20 HZ</u> AIR OVERPRESSURE: <u>123,8 dec</u> LOCATION: <u>BETWEEN THE SHOT AREA & THE SMALL</u> NOTES: <u>TROUT CALERE DAM ~12C South of THE STRUCTURE</u> 2) SERIAL# <u>RE 10051</u> CAL. DATE: <u>4/8/15</u> DIST. & DIR. FROM BLAST: <u>481' NORTH</u> PEAK PARTICLE VELOCITY: <u>0,39 iPS</u> FREQUENCY: <u>20 HZ</u> AIR OVERPRESSURE: <u>124.3 dec</u> LOCATION: <u>SEE ATSONE</u> ; <u>UNITS</u> WERE <u>DEPLOYED</u> NOTES: <u>SIDE BU</u> <u>SIDE FOR</u> <u>PPV</u> <u>COMPARESON</u> <u>44'</u> CLOSCE 3) SERIAL#_ CAL. DATE: <u>FREQUENCY</u> : AIR OVERPRESSURE: <u>124.3 dec</u> NOTES: <u>SIDE BU</u> <u>SIDE</u> FOR <u>PPV</u> <u>COMPARESON</u> <u>44''</u> CLOSCE NOTES: <u>SIDE</u> <u>CAL. DATE</u> ; <u>DIST. & DIR. FROM BLAST</u> ; PEAK PARTICLE VELOCITY: FREQUENCY: AIR OVERPRESSURE: <u>124.3 dec</u> NOTES: <u>NOTE</u> FOR <u>PPV</u> <u>COMPARESON</u> <u>44''</u> CLOSCE

OPERATOR NAME: CSMORELSON SIGNATURE: CSMOning DATE: 3/16/16

Date/Time Vert At 16:30:45 March 16, 2016 Serial Number BE13047 V 10.72-8.17 MiniMate Plus Trigger Source Geo: 0.020 in/s Battery Level 6.9 Volts Geo: 10.000 in/s Range Unit Calibration December 3, 2015 by Instantel Sample Rate 6.0 sec. At 1024 Sps File Name 0047 GAAT. V90VV Post Event Notes Notes Trout Creek Quarry Project: Client: ACA Products Location Chaffee MMC Inc. User. Extended Notes: LEEM FI8507 And CEMPE .10 Microphone Linear Weighting PSPL. 123.8 dB(L) at 0.943 sec. ZCFreq 6.6 Hz Channel Test Pased (Freq = 20.1 Hz Amp = 637 m/) Tran Vert Long 2 PPV 0.165 0.350 0.385 in/s ZCFreq 19 18 20 Hz Velocity (in/s) Time (Rel. to Trig) 0.700 0.468 0.607 1 sec **Peak Acceleration** 0.066 0.119 0.133 g Peak Displacement 0.001 0.003 0.003 in 0.5 Sensor Check Passed Passed Passed Peak Vector Sum 0.470 in/sAt 0.609 sec. 0.2 0.1 0.05 0.04 100 > Frequency (Hz) Tran: + Vert: × Long: ø MicL 0.0 Long 0.0 Vert 0.0 Tran 0.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0

Time(Seconds) 0.50 sec/div Amplitude Geo: 0.100 in/s/div Miα 0.001 psi(L)/div Trigger = ▶ → → →

Format (c) 2006-2015 Xmark Corporation



Event Report

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

Notes

Project: Trout Creek Quarry Client: ACA Products Chaffee Location: 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 **Battery Level File Name**

BE10051 V 10.72-8.17 MiniMate Plus 6.4 Volts Unit Calibration April 8, 2015 by Instantel 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

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.

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Martin Hogue



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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.

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

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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.

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

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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.



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

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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.



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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 the 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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Appendix

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 st					
	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 se					
	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.					
rinter	Resolution	576 dots/line and 0.0049 inches (0.125 mm) per dot.					
정말 감독을 가지 않는	Print Time	Less than 10 seconds for typical 1 second event with full analysis.					
이 집에 가지 않아?	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.					
Iser 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.					
attery Life		30 days continuous recording, 70 days with timer, printing will decrease life.					
use		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.





3-1

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).

Chapter 5



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.

Reference

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.



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.

Reference



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.

Frequency Range	Recording Rate						
	Standard	Fast	Faster				
	(1024 Hz)	(2048 Hz)	(4096 Hz)				
0-30 Hz	negligible	negligible	negligible				
	error	error	error				
31 – 50 Hz	up to 5 Hz	up to 2.5 Hz	negligible				
	error	error	error				
51 – 70 Hz	up to 8 Hz	up to 4 Hz	up to 2 Hz				
	error	error	error				
71 – 90 Hz	up to 18 Hz	up to 9 Hz	up to 4.5 Hz				
	error	error	error				
91 – 150 Hz	up to 50 Hz	up to 25 Hz	up to 12.5 Hz				
	error	error	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:
$$\Delta t = a \text{ small interval}$$

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.

EVE	NT WAVEFO	RMS	N	DE	PEAK	
TRANSVERSE	VERTICAL	LONGITUDINAL	Т	V	L	VECTOR
			-0.34	-0.33	0.14	0.494
		A	0.38	-0.47	0.38	0.714
	1		0.29	-0.31	0.51	0.663
			-0.53	0.23	-0.31	0.655
\sim			0.24	0.07	0.36	0.440
	3	2	-0.23	-0.16	-0.15	0.318
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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:

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

b. Calculating Acceleration:

Maximum Acceleration (in./s²) =
$$\frac{2\pi}{T} \times A$$

Reference

Maximum Acceleration (mm/s²) =
$$\frac{2\pi}{T} \times A_{m}$$

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:

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

b. Calculating Acceleration:

Maximum Acceleration (in./s²) = $\frac{1}{T} \times Y$ Maximum Acceleration (mm/s²) = $\frac{1}{T} \times Y_m$

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:

Maximum Displacement (in.) = $\frac{T_1}{2\pi} \times A_1 + \frac{T_2}{2\pi} \times A_2$ Maximum Displacement (mm) = $\frac{T_1}{2\pi} \times A_{1m} + \frac{T_2}{2\pi} \times A_{2m}$

b. Calculating Acceleration:

Maximum Acceleration (in./s²) =
$$\frac{2\pi}{T_1} \times A_1 + \frac{2\pi}{T_2} \times A_2$$

Maximum Acceleration (mm/s²) =
$$\frac{2\pi}{T_1} \times A_{1m} + \frac{2\pi}{T_2} \times A_{2m}$$

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.