ESCUELA TÉCNICA SUPERIOR DE INGENIEROS DE MINAS

PROYECTO FIN DE CARRERA

DEPARTAMENTO DE INGENERÍA QUÍMICA Y COMBUSTIBLES

PREDICCIÓN DE LA LEY DE ATENUACIÓN, FRECUENCIA DOMINANTE Y ESPECTRO DE RESPUESTA EN VIBRACIONES PRODUCIDAS POR VOLADURAS A CIELO ABIERTO

DOCUMENTO Nº3: ANEXOS

ANEXO A:
MONITOREO CON SISMÓGRAFOS

A.1 Especificaciones de los sismógrafos

Minimate Plus™

Advanced Vibration and Overpressure Monitor

Range of Applications:

- Blast-monitoring for compliance
- Near-field blast analysis
- Pile driving
- Construction activity
- Demolition activity
- Heavy Transportation
- Bridge monitoring
- Structural analysis
- Underwater blast monitoring
- 4 or 8 channel data acquisition
- Remote monitoring - Auto Call Home™
- Structural monitoring - Flex™

When we asked what you wanted in a vibration monitor, you said "Everything." So, we designed the **Instantel® Minimate Plus™** vibration and overpressure monitor. Ever since, it has become a favourite of contractors, consultants, engineers and blasters, because it offers unrivalled features and versatility in a rugged and easy-to-use package.

Versatile

Use the **Minimate Plus** monitor with an **Instantel Standard Triaxial Geophone** (ISEE or DIN version) and an overpressure microphone (Linear or A Weight) to provide a rugged, reliable compliance monitoring system. Add the **Instantel 8-Channel** option and a single monitor may be used with two triaxial geophones and two microphones.

For more demanding monitoring applications, the **Instantel Blastware® Advanced Module** software provides the capability to monitor a broad selection of vibration and overpressure sensors, as well as sensors for structural and environmental measurements. Monitor vibration, ambient environmental conditions, and the movement of structural cracks, all at the same time, all using the same **Minimate Plus** monitor.

Intelligent

For remote installations, the **Instantel Auto Call Home™** feature will automatically transfer event files from field to office as they are recorded using a variety of wired or wireless modems. From there, the **Blastware Mail** feature of the **Blastware** software automatically distributes files or summary information to multiple e-mail or text messaging addresses.

Easy to use

Even with all of these features, the **Minimate Plus** system is still easy for anyone to use. A high-contrast LCD, eight-key tactile keypad, coupled with simple menu-driven operations, provides complete control and confidence.

Minimate Plus - everything you need and more.

Key Features

- **Instantel Histogram Combo™** mode allows capture of full waveform records while recording in histogram mode.
- **Auto Call Home** feature automates remote monitoring applications.
- Sample rates from 1,024 to 4,096 S/s, per channel with up to 65,000 S/s available on a single channel.
- Available **Instantel 8-channel** option allows for two standard geophones and two microphones to be operated from one **Minimate Plus** monitor.
- Non-volatile memory with standard 300-event storage capacity (optional 1,500-event capacity).
- Records waveform events up to 100 seconds long with standard setup, or up to 500 seconds with advanced setup.
- Continuous monitoring means zero dead time, even while the unit is processing.
- Any channel can be matched to a wide variety of sensors - geophones, accelerometers, or hydrophones.

Instantel

The World's Most Trusted Vibration Monitors www.instantel.com

Minimate Plus™

General Specifications	Minimate Plus
Channels	Microphone and Triaxial Geophone or 4 independent user-configurable channels (two Microphones and two Triaxial Geophones or 8 independent channels with optional 8-channel upgrade)
Vibration Monitoring (with Standard Triaxial Geophone)	
Range	Up to 254 mm/s (10 in/s)
Resolution	0.127 mm/s (0.005 in/s) or 0.0159 mm/s (0.000625 in/s) with built-in preamp
Accuracy (ISEE / DIN)	+/- 5% or 0.5 mm/s (0.02 in/s), whichever is larger, between 4 and 125 Hz / DIN 45669-1 standard
Transducer Density	2.13 g/cc (133 lbs/ft³)
Frequency Range (ISEE / DIN)	2 to 250 Hz, within zero to -3 dB of an ideal flat response / 1 to 315 Hz
Maximum Cable Length (ISEE / DIN)	75 m (250 ft) / 1,000 m (3,280 ft)
Air Overpressure Monitoring	
Weighting Scales	Linear or A-weight
Linear Range	88 to 148 dB (500 Pa (0.072 PSI) Peak)
Linear Resolution	0.25 Pa (0.0000363 PSI)
Linear Accuracy	+/- 10% or +/- 1 dB, whichever is larger, between 4 and 125 Hz
Linear Frequency Response	2 to 250 Hz between -3 dB roll off points
A-weight Range	50 to 110 dBA
A-weight Resolution	0.1 dBA
Waveform Recording	
Record Modes	Manual, Single-shot, Continuous
Seismic Trigger	0.125 to 254 mm/s (0.005 to 10 in/s)
Acoustic Triggers	
Linear	100 to 148 dB
A-weight	55 to 110 dBA
Sample Rate	1,024 to 4,096 S/s per channel (independent of record time), up to 65,536 S/s in single-channel mode with advanced software (max 8,192 S/s per channel for 8 channels)
Record Stop Mode	Fixed record time, **Instantel® AutoRecord™** record stop mode
Record Time	1 to 100 seconds (programmable in one-second steps) or 500 seconds plus 0.25 seconds pre-trigger
AutoRecord Time	Auto window programmable from 1 to 9 seconds, plus a 0.25 second pre-trigger. Event is recorded until activity remains below trigger level for duration of auto window, or until available memory is filled.
Cycle Time	Recording uninterrupted by event processing - no dead time
Storage Capacity	
Full Waveform Events	300 one-second events at 1,024 S/s sample rate (1,500 event capacity with optional memory upgrade)
Event Summaries	1,750 (8,750 event capacity with optional memory upgrade)
Histogram Recording	
Record Modes	Histogram and **Instantel Histogram Combo™** (monitor captures triggered waveforms while recording in Histogram mode)
Recording Interval	2, 5 or 15 seconds; 1, 5 or 15 minutes
Storage Capacity	46,656 intervals - 3 days at 5-second intervals or 486 days at 15-minute intervals (with memory upgrade - 15 days at 5-second intervals or 540 days at 15-minute intervals)
Physical Specifications	
Dimensions	81 x 91 x 160 mm (3.2 x 3.6 x 6.3 in)
Weight	1.4 kg (3 lbs)
Battery	Rechargeable 6 V sealed gel cell - capacity for 210 hours of continuous monitoring
User Interface	8-key keypad with domed tactile keys
Display	4-line x 20-character, high-contrast, backlit LCD
PC Interface	RS-232
Auxiliary Inputs and Outputs	External Trigger, Remote Alarm, coordinate download from GPS
Environmental	
LCD Operating Temperature	-10 to 50°C (14 to 122°F)
Electronics Operating Temperature	-20 to 60°C (-4 to 140°F)
Remote Communications	Compatible with Telephone, GSM, Cellular, RF, Satellite, Short-haul modems and Ethernet® device servers. Automatically transfers events when they occur through the **Instantel Auto Call Home™** feature.
Additional Features	Monitor start/stop timer

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Instantel

7148052 Rev 08 - Product Specifications are Subject to Change

The World's Most Trusted Vibration Monitors

Sísmica

Rango:	Hasta 127 mm/s, auto-rango.
Niveles de disparo:	de 0,25 a 127 mm/s
Análisis de frecuencias	Frecuencia pico, con los criterios USBM, OSMRE, DIN 4150, UNE 22381 y otros.
Precisión	calibrado a menos de 1% de la referencia B&K a 15 Hz.

Onda aérea

Rango:	de 100 a 142 dB.
Niveles de disparo	de 106 a 142 dB.
Precisión	calibrado a menos a 0,4 dB de la referencia B&K a 30 Hz.

General

Frecuencia de muestreo	1024 muestra por segundo cada canal, en todos los modos de medida.
Respuesta en frecuencia	Todos los canales de 2 a 250 Hz (-3 dB), independientemente del tiempo de registro.
Modo de registro:	Manual, registro continuo y automático.
Tiempos de registro automáticos	De 1 a 20 segundos.
Almacenamiento de registros:	40 registros de 1 segundo, incluyendo todos los parámetros del registro. Memoria de estado sólido, con más de 10 años de vida de almacenamiento.

Funciones especiales

Unidades:	Métricas o imperiales.
Temporizador:	Temporizador de encendido y apagado programable.
Identificación de los registros:	Identificación numérica de los registros programables desde el sismógrafo.
Batería:	Vida de 10 días (240 h) en modo de monitorización. Batería recargable.
Dimensiones:	8,1 x 0,2 x 16 cm.
Peso:	1,4 kg.
Temperatura:	De -20 a 60^0C.

A.2 Modelo del informe de medición

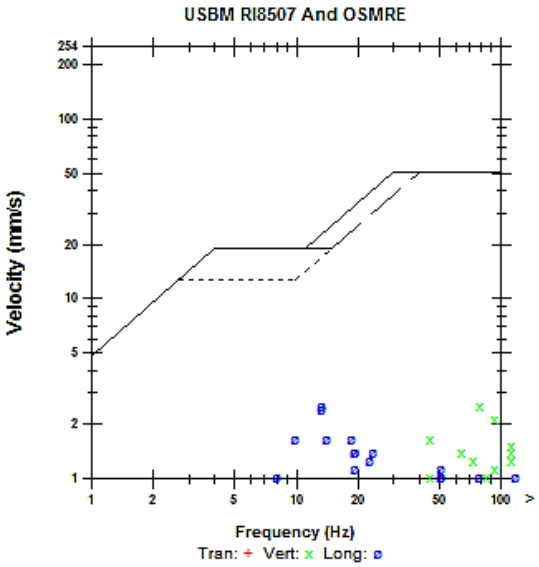
Date/Time	Vert at 13:25:47 July 1, 2012
Trigger Source	Geo: 0.800 mm/s
Range	Geo: 254 mm/s
Record Time	4.0 sec (Auto=3Sec) at 2048 sps
Notes	
Location:	
Client:	
User Name:	
General:	

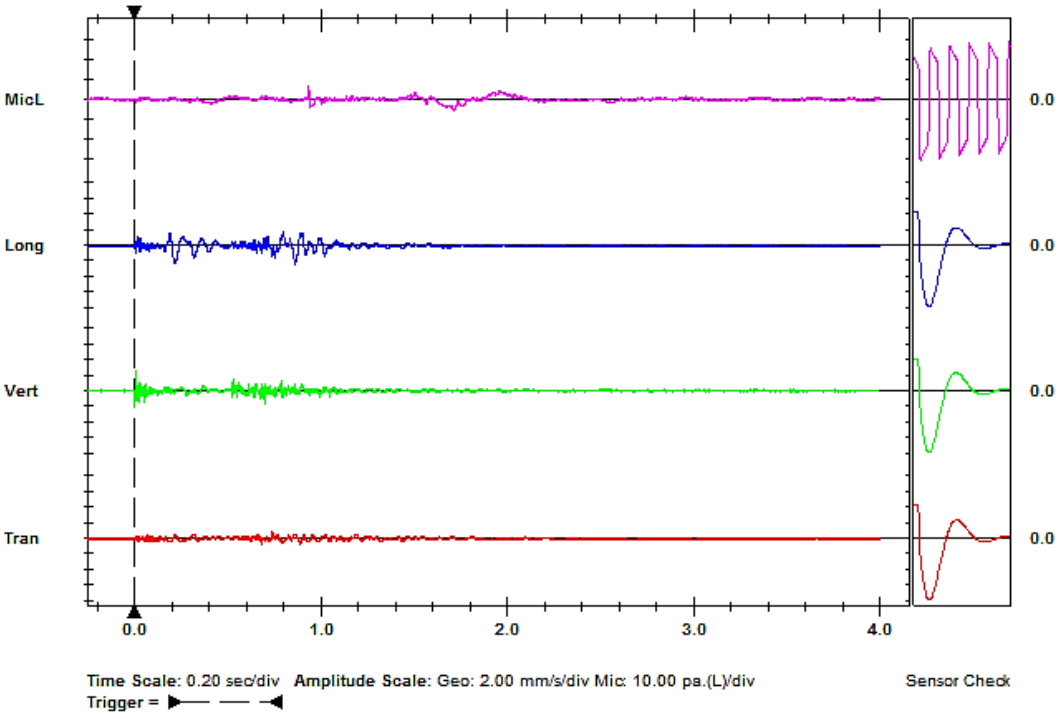
Serial Number	BE14569 V 8.12-1.0 Minimate Blaster
Battery Level	6.2 Volts
Unit Calibration	January 8, 2009 by Instantel inc.
File Name	P569DB1H.AZ0
Post Event Notes	
Sismograph: B69	
Location:	
Coordinates: 993129,8 / 654662,7	
Max. Instantaneous Charge (MIC): 65kg / Minimum Delay: 25ms	

Microphone	Linear Weighting
PSPL	6.75 pa.(L) at 0.935 sec
ZC Freq	47 Hz
Channel Test	Passed (Freq = 20.5 Hz Amp = 476 mv)

	Tran	Vert	Long	
PPV	0.762	2.54	2.54	mm/s
ZC Freq	37	79	13.5	Hz
Time (Rel. to Trig)	0.680	0.006	0.861	sec
Peak Acceleration	0.0530	0.186	0.0795	g
Peak Displacement	0.00691	0.00555	0.0293	mm
Sensor Check	Passed	Passed	Passed	
Frequency	7.3	7.5	7.4	Hz
Overswing Ratio	3.6	3.7	3.8	

Peak Vector Sum 2.62 mm/s at 0.861 sec





ANEXO B:
EXPLOSIVOS USADOS

B.1 Características de los explosivos utilizados

B.1.1 Riogel

RIOGEL TRONER HE

Technical Characteristics	
Density Range (g/cm³)	1,25
Velocity of Detonation* (m/s)	2800 - 6800
Relative Effective Energy[1] (%)	
Relative Weight Strength	108
Relative Bulk Strength	169
Gas Volume (L)	933

1) ANFO: Density 0,80 g/cm³, Effective energy 2.59 MJ/kg.
* VOD is dependent on application, diameter, confinement, and density. The maximum value within the range is the ideal VOD.

Standard Packaging 1.1D
(Nominal values)

Diameter x Length (mm)	Cartridge Weight (g)	Cartridges/Box	Weight/box (kg)	Type of Encasing
32x250	260	96	25	Plastic film cartridge(HDPE)
40x500	781	32	25	Plastic film cartridge(HDPE)
50x500	1200	20	24	Plastic film cartridge(HDPE)
60x500	1786	14	25	Plastic film cartridge(HDPE)
70x500	2400	10	24	Plastic film cartridge(HDPE)
80x500	3125	8	25	Plastic film cartridge(HDPE)
90x500	4000	6	24	Plastic film cartridge(HDPE)
110x495	6000	3	18	Plastic film cartridge(HDPE)

Transport Classification	Standard Packaging
Class	1.1D
UN Number	0241

Contact your local MAXAM representative for further information.

B.1.2 Rioflex

RIOFLEX MX 7000

Technical Characteristics (Nominal Values)	
Average In-hole Density** (g/cm³)	1,0 - 1,30
Velocity of Detonation* (m/s)	3500 - 7200
RELATIVE EFFECTIVE ENERGY[1] (%)	
Relative Weight Strength	114 - 130
Relative Bulk Strength	142 - 211
Gas Volume (L/kg)	1002

1) ANFO: Density 0,80 g/cm³, Effective energy 2260 kJ/kg
* VOD is dependent on application, diameter, confinement and density. The maximum value within the range is the ideal VOD.
** ANFO doping prill density or truck configuration may not allow for the density range specified. Please Contact MAXAM prior to commitment to a specific density range.
NOTE: The average density in the borehole is dependent on hole length.

TYPE	ANFO%	Average In-hole Density** g/cm³	Water Resistance	Use in Wet Borehole	Delivery Method
RIOFLEX MX 7000	30	1,0 - 1,30	Excellent	Recommended	Pump

RECOMMENDATIONS FOR USE

RIOFLEX MX 7000 critical diameter is dependent on its density, for lower densities the critical diameter is 76mm.
Priming requirements - RIOFLEX MX 7000 is formulated to be booster sensitive and requires a minimum of a RIOBOOSTER 400g primer. Smaller primers may reduce the performance of the explosives and are not recommended with this product. It is recommended to use additional RIOBOOSTERS where there is a risk of column disruption and/or explosive column length exceeds 12m. RIOCORD detonating cord down lines are not recommended for use with this product range.
Water Resistance - Suitable for pumping into blastholes with water.
Sleep time - Up to 4 weeks in static ground water and dependent on hole diameter, density and ground conditions. Check with MAXAM before sleeping RIOFLEX MX 7000 for lengths in excess of 1 week to ensure optimal performance.

STORAGE AND TRANSPORT

RIOFLEX is transported as a non sensitized matrix suspension, classified as an oxidizer 5.1 and should be stored in tanks and silos in accordance with all local regulations for the storage of oxidizer materials.

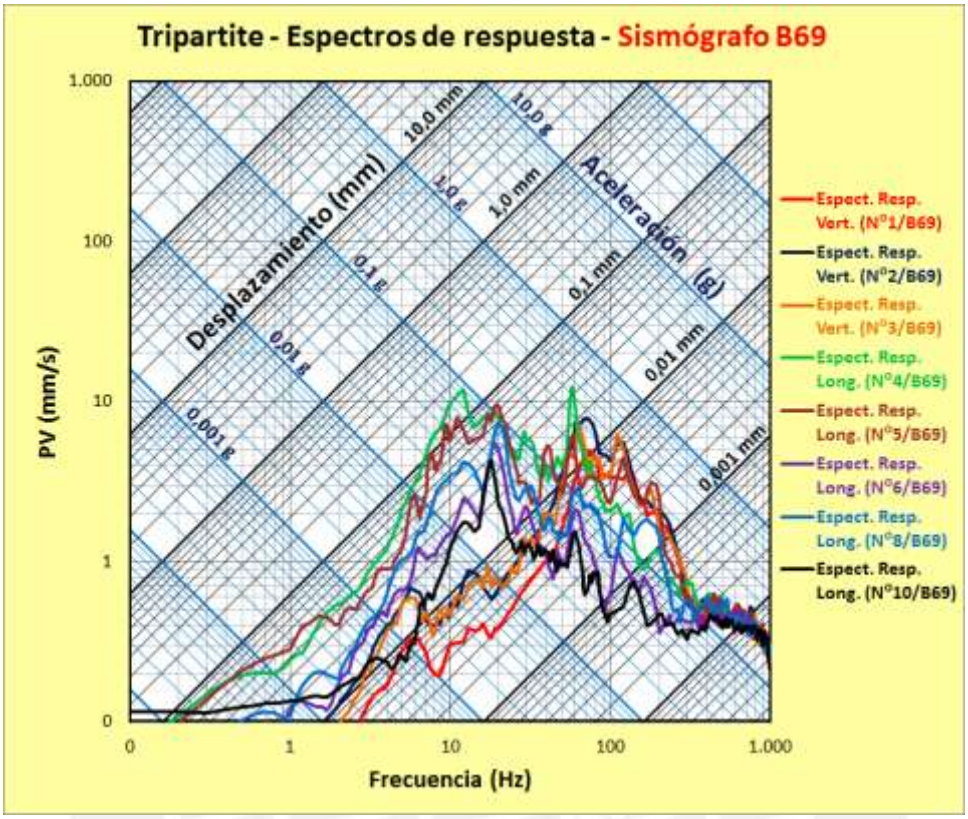
Product Classification	RIOFLEX
Class	1.1D
UN Number	0241

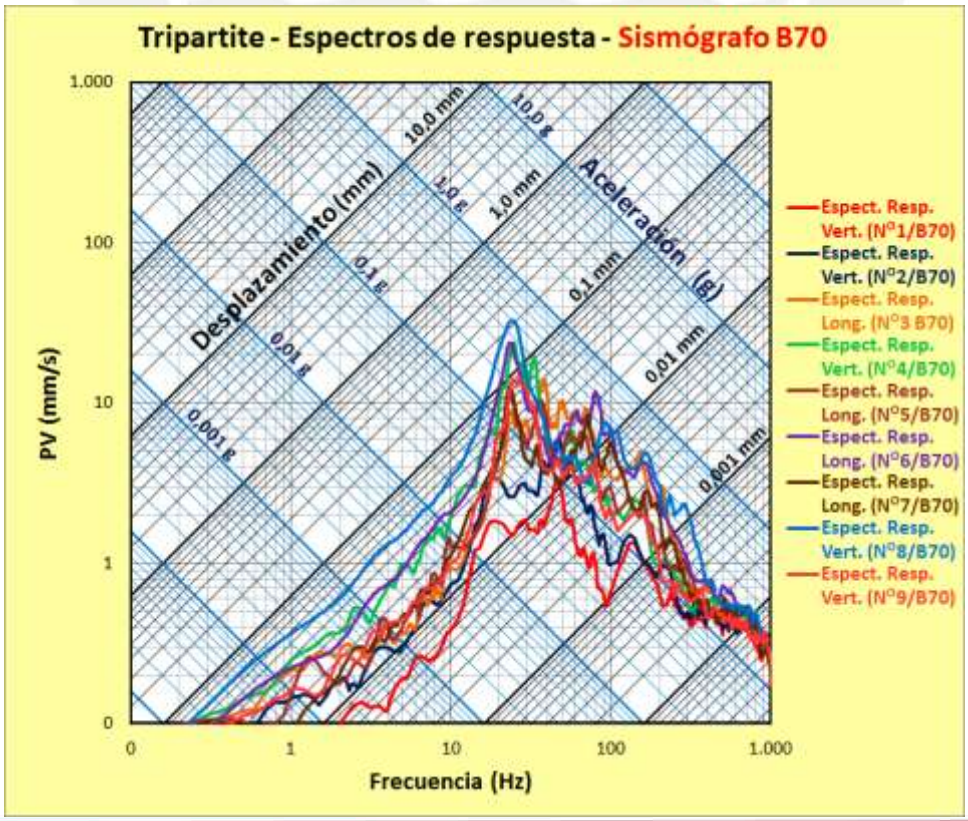
Contact your local MAXAM representative for further information.

ANEXO C:
ESPECTROS DE RESPUESTA

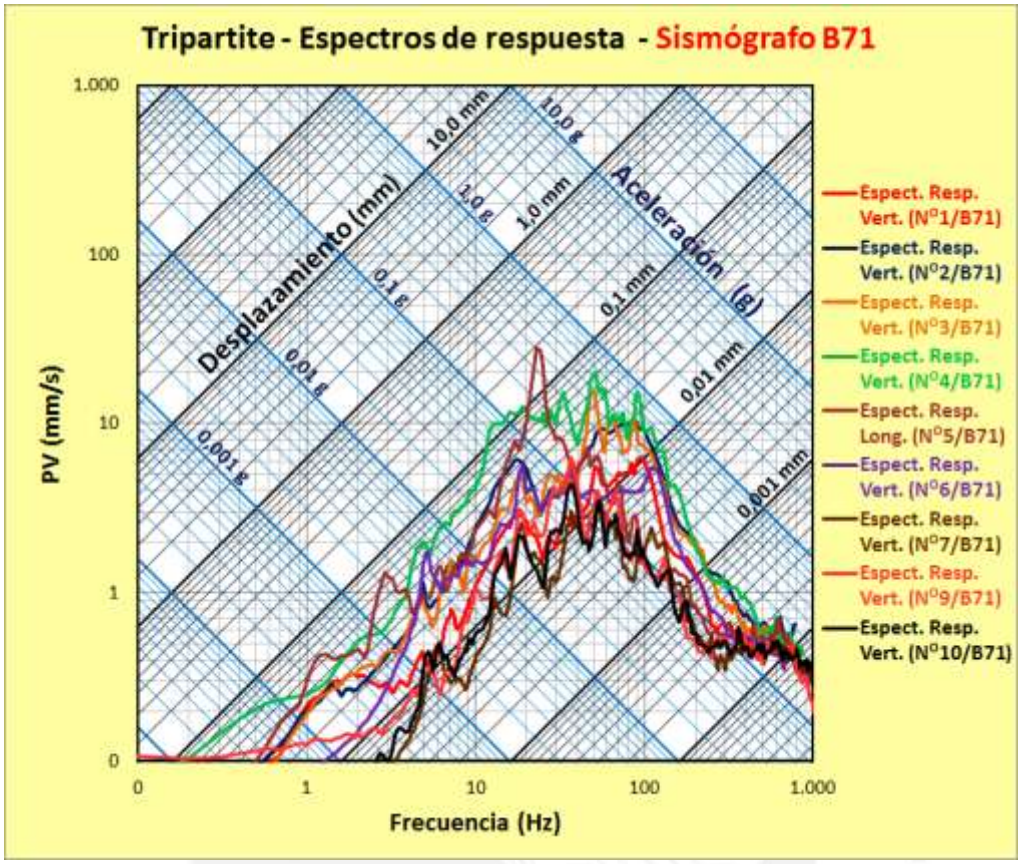
C.1 Relación de espectros de respuesta calculados

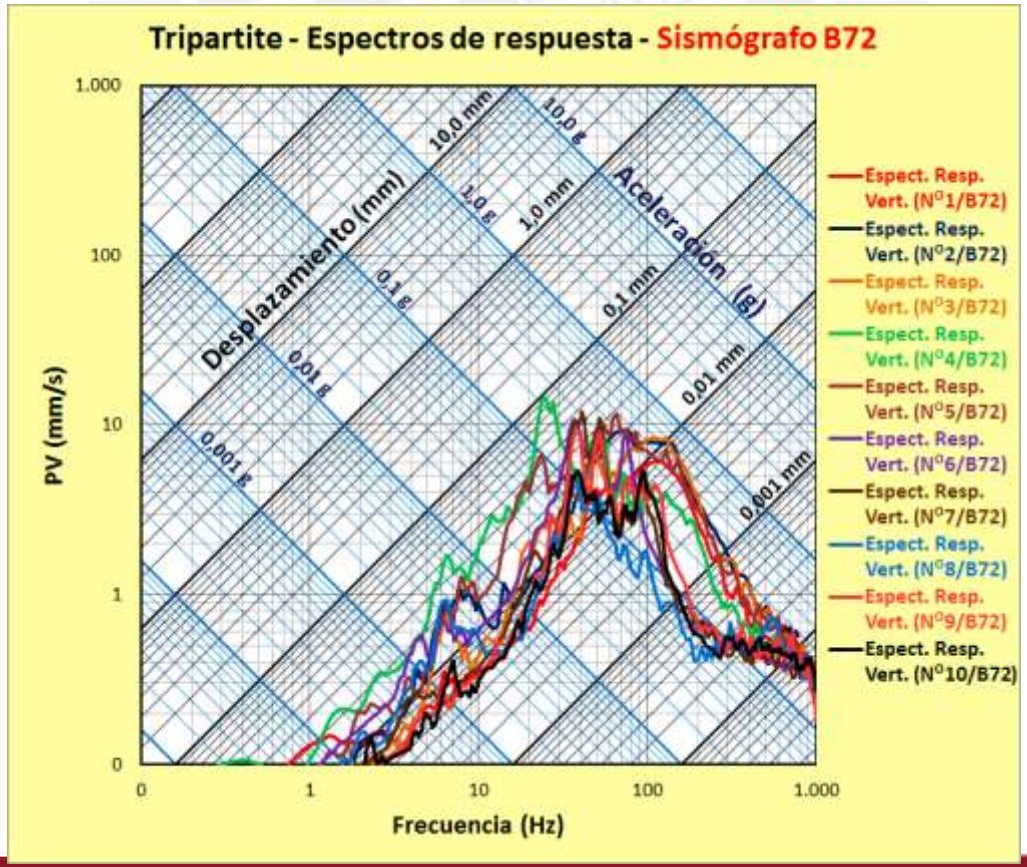
- **Sismógrafo B69 y B70**



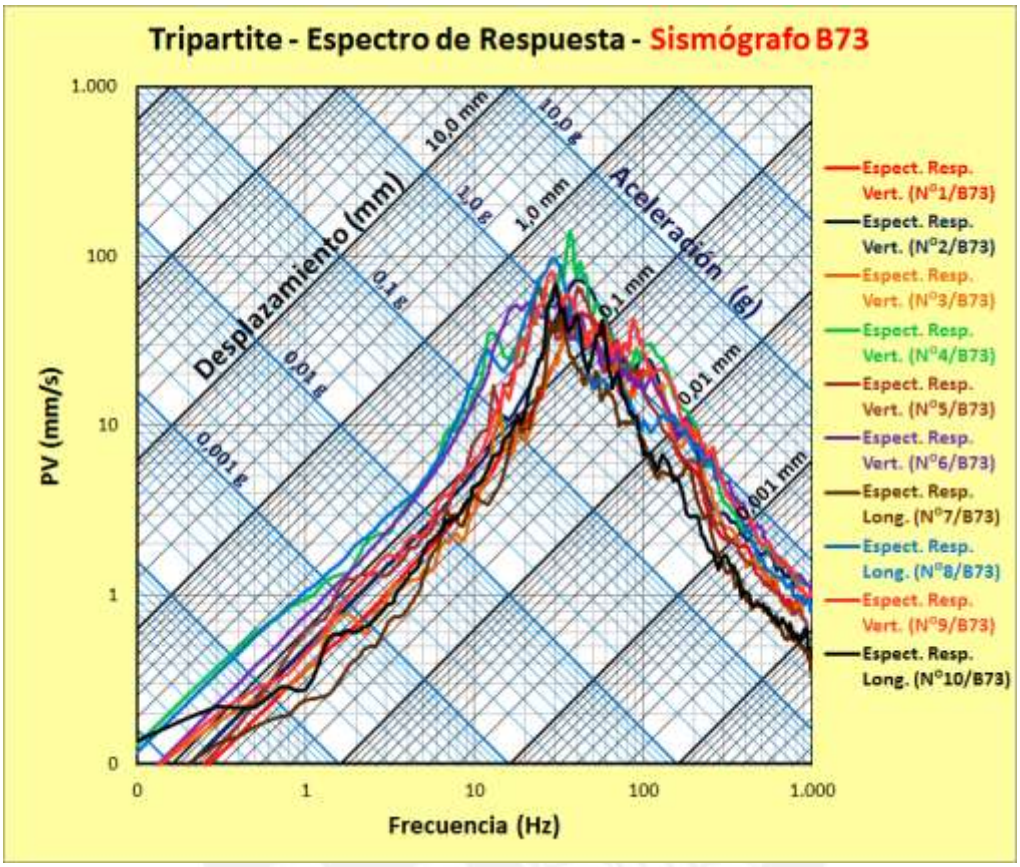


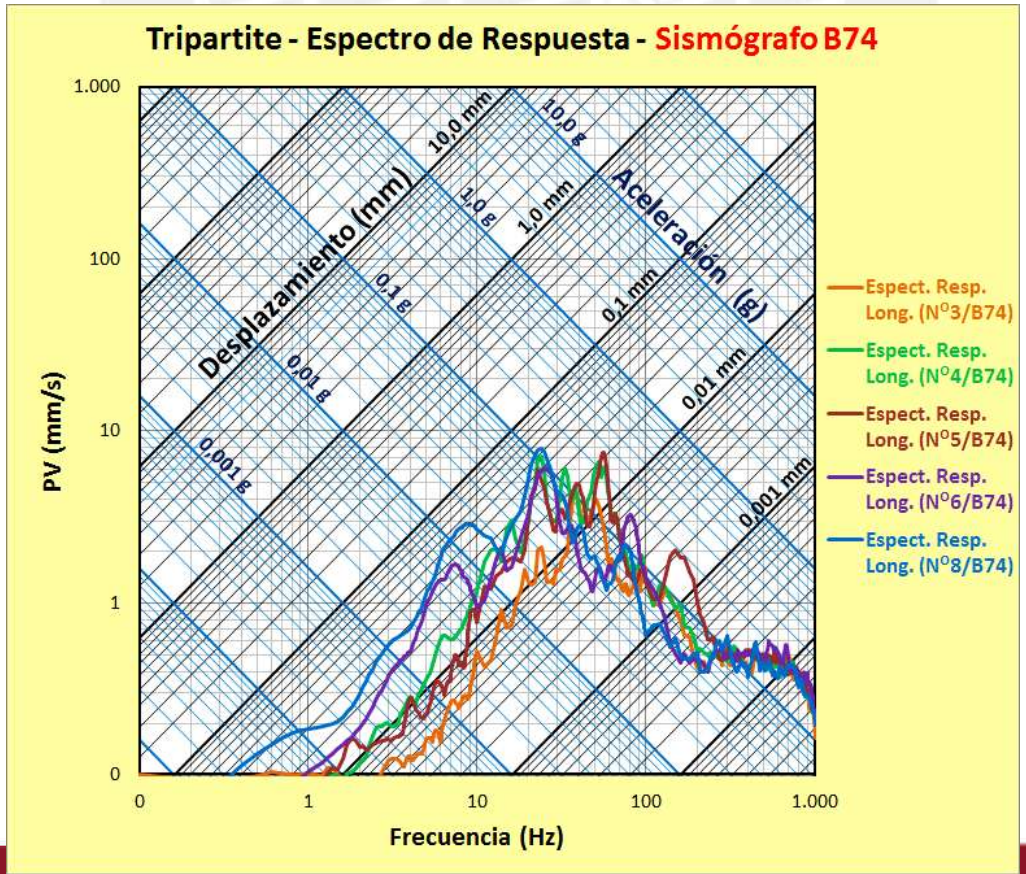
- **Sismógrafo B71 y B72**





- **Sismógrafo B73 y B74**





- **Sismógrafo P54**