Client	MADAS S.r.l.
Address of the client	Via Moratello, 5 37048 – San Pietro di Legnago (VR) ITALIA
Order	CESI prot. n. A7027295 del 16/10/07
Tested items	**MADAS Seismic M16**
Tests carried out	**Sinusoidal and Seismic Vibration Tests**

Standards/Specifications

- EN 1998-1 Eurocode 8 - Design of structures for earthquake resistance, December 2004
- ASCE Standard 25-97 "Earthquake-Actuated Automatic Gas Shuto0.f Devices" American Society of Civil Engineer
- ICS 23.060 TURK Standard "Manually operated taps for gas burning appliances"

Tests date **from** 25/10/2007 **to** 25/10/2007

No. of pages	21 **No. of pages annexed**
Issue date	15/01/2008 rev. 0
Prepared	Unit LABORATORIES – P. Bontempi
Verified	Unit LABORATORIES – G. Pucci
Approved	Area COMPONENTS – V. Scarioni

Table of contents

1 GENERAL DATA

1.1 Customer

MADAS S.r.l.

Via Moratello, 5

37048 – San Pietro di Legnago (VR)

1.2 Unit under test

Tests were carried out on the electronic component of:

MADAS Seismic M16: :Gas Shut-Off Device

The tested component is shown in photos 1 and 2; the complete device is shown in photo 3.

1.3 Manufacturer

MADAS S.r.l.

1.4 Reference documents

1.4.1 Technical docs and standards

|1| EN 1998-1 Eurocode 8 - Design of structures for earthquake resistance, December 2004

|2| ASCE Standard 25-97 “Earthquake-Actuated Automatic Gas Shutoff Devices” American Society of Civil Engineer.

|3| ICS 23.060 TURK Standard “Manually operated taps for gas burning appliances”

1.4.2 Contract documents

|4| MADAS order; CESI prot. n. A7027295 del 16/10/07.

1.5 Test objective

The purpose of these tests was analyze the behaviour of the unit with respect to:

- sinusoidal single axis vibration following requirements stated in docs. |2| and |3|
- triaxial multifrequency vibration indicated in Standards |1|.
- triaxial multifrequency vibration of natural Italian earthquake.

1.6 Testing laboratory

CESI
LPS Laboratory – DIVEN
via Pastrengo, 9
24068 SERIATE BG
ITALY

CESI quality management system for performing laboratory investigations and tests in structural field is conforming with standard UNI EN ISO 9001:2000, as certified in SQS N.24295-01.

CESI LPS laboratory is qualified for testing railway items by R.I.N.A. (Registro Navale Italiano Div.Ferroviaria).

1.7 Test date

All tests have been performed on 25/10/2007.

1.8 Responsibilities

Mr. G. Pucci, test responsible and Mr. P. Bontempi, Mr. R. Baldassarri test engineers.

1.9 Witnesses

Dr. M. Marangoni, MADAS S.r.l..

2 MOUNTING AND MEASUREMENTS

2.1 Mounting techniques / fixture

The unit (MADAS Seismic M16: :Gas Shut-Off Device) was fixed on the shaking table by means of a wood test fixture. The general lay out of the tests is shown in photo 1.

2.2 Orientation and control position

In control position (placed on the shaking table near the unit) a set of three accelerometers was mounted. So every accelerometer was identified as AT, indicating the position, followed by a letter (X or longitudinal, Y or lateral and Z or vertical) which specifies the accelerometer sensitivity direction.

3 EXPERIMENTAL ACTIVITIES

3.1 Performed tests

Tests consisted in:

- Single axis sinusoidal vibration test (X direction in photo 2);
- Triaxial Seismic tests (X, Y and Z directions).

3.2 Sinusoidal tests

Test objective was to analyse the dynamic response of the unit with respect to a simple sinusoidal motion checking the acceleration level, depending from frequency, able to cause the electrical gas block signal.

For each frequency in range 1 – 10 Hz, the amplitude of the sinusoidal motion of the shaking table was slowly increased until the electrical gas block signal of the unit was detected and the corresponding acceleration was reported in a table (value of the acceleration relevant to the fundamental harmonic).

3.3 Triaxial seismic tests

3.3.1 Reference Time Histories

Three different earthquakes have been considered during the tests:

Synthesised Time History obtained from doc. |1|:

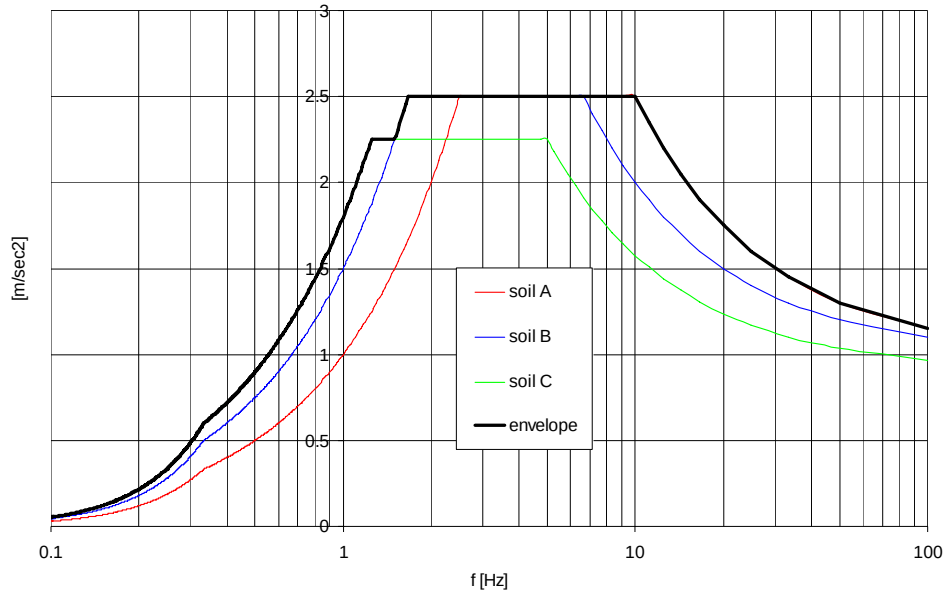
Three uncorrelated Time Histories (two horizontal and one vertical see fig. 3) have been synthesised from CESI using the following RRS (Required Response Spectrum):

RRS Horizontal		RRS Vertical	
Frequency [Hz]	Spectral acceleration [m/s^2]	Frequency [Hz]	Spectral acceleration [m/s^2]
0,10	0,05	0,10	0,01
1,00	7,27	0,32	1,20
1,25	9,00	1,00	3,60
1,47	9,00	1,23	4,50
1,67	10,00	1,50	4,50
10,00	10,00	1,64	5,00
100,00	4,6	2,00	5,00
		7,00	7,00
		10,00	7,00
		100,00	3,21

(damping 5%)

This Spectrum is obtained from envelop Eurocode spectra (see doc. [1]) corresponding to Soils A, B and C.

In the following diagram, the soil A, B, C and envelope are illustrated here below drawn normalized (horizontal component).



Synthesis was made with the following characteristics:

- overall duration: 32 sec;
- strong part duration: 10 sec;
- frequency range: 1 to 37 Hz;
- comp./oct.: 12

Natural Earthquakes (real Time Histories):

Two natural earthquakes have been considered during the tests:

- Irpinia Earthquake 1980: acquisition of three perpendicular components (North-South; East-West and up-down) made in Calitri (South Italy); the reference Time Histories have the following characteristics (see fig. 4):

overall duration: ≈ 80 s
peak acceleration: 1,58 m/s^2 horizontal
1,5 m/s^2 vertical

- Friuli Earthquake 1976: acquisition of three perpendicular components (North-South; East-West and up-down) made in Tolmezzo (North Italy); the reference Time Histories have the following characteristics (see fig. 5):

overall duration: ≈ 12 s
peak acceleration: 3,3 m/s^2 horizontal

3.3.2 Tests execution

Triaxial multifrequency seismic tests with simultaneous time histories along the horizontal axes X, Y and vertical axis Z was performed;

Test objective was to analyse dynamic response of the unit and check the acceleration level able to cause the electrical gas block signal.

Starting from very low level each earthquake was repeated with increasing the amplitude until the electrical gas block signal of the unit was detected and the corresponding acceleration was reported in a table. The programmable level of earthquake detection on the device was set to 0,1 g (1 g = 9,81 m/s^2); in case of synthesised Time History also the value 0,3 g was checked.

4 TESTING EQUIPMENT

The block diagram relevant to the test equipment (excitation equipment, excitation control and data acquisition/processing instrumentation) is shown in figure 1.

4.1 Excitation equipment

The shaking tables “MASTER” was used:

- CESI “MASTER” Triaxial 4m×4m Shake Table for the tests performed on Z axis:
  - weight: 11.000 daN;
  - max peak displacement: ±100 mm;
  - max peak sinusoidal velocity: 0,44 m/s;
  - max peak acceleration: 5g;
  - frequency range: 0 ÷ 120 Hz.

4.2 Excitation control, data acquisition and processing equipment

Digital system SIGNAL STAR multichannels manufactured by DATA PHYSIC France (DELL workstation Precision 410 with analog/digital converter on 32 channels and 16 bits).
The acquisition and control system generates the motion with the requested features and feedsback the shaking table motion using the signal coming from the control accelerometer. Analog signals coming from the control and measuring transducers were amplified and conveyed to an analog/digital converter which sent the data to the hard disk of the aforementioned computer for the recording and subsequent processing. The block scheme of the excitation and processing equipment is shown in figure 5.

4.3 Control transducers

During the tests single axis piezoresistive accelerometers with the following features were employed:

- manufacturer: Entran
- model EGCS-D1S-100-Z1
- measuring range: ± 100 g
- sensitivity: 1,5 mV/g
- resonance frequency: 2500 Hz
- frequency response: 0 to 600 Hz ± 5%
- transverse sensitivity: < 3%

Serial numbers of the employed transducers are listed in figure 6. The instrumentation is submitted to a calibration program in accordance with internal procedures.

5 TEST RESULTS

5.1 Sinusoidal tests

All the performed tests and results are summarised in the following table:

Frequency [Hz]	Period (s)	Madas Seismic M16: acceleration level of block signal detection [%g]
1,00	1,000	14,9
2,00	0,500	18,2
3,00	0,333	21,3
4,00	0,250	24,4
5,00	0,200	29,5
6,00	0,167	32,1
7,00	0,143	39,7
7,00	0,143	38,2
8,00	0,125	42,2
9,00	0,111	49,4
10,00	0,100	139,8

In figure 6 the results obtained during sinusoidal vibration tests are reported in comparison with International Standards of documents |2| and |3|.

5.2 Triaxial Seismic tests

All the performed tests and results are summarised in the following tables:

Reference Time History:
EC8 Triaxial Earthquake
(0 dB horizontal peak acceleration: 0,44 g)

Factor reduction (dB)	Horiz. peak acceleration obtained on the shaking table surface (g)	Madas Seismic M16: block signal detection	Madas Seismic M16: value of programmable level of earthquake detection (g)
-15	0,080	No	0,100
-12	0,110	Yes	0,100
-15	0,080	No	0,100
-12	0,120	Yes	0,100
-9	0,160	Yes	0,100
-6	0,220	Yes	0,100
-15	0,080	No	0,100
-12	0,114	Yes	0,100
-6	0,220	No	0,300
-3	0,310	Yes	0,300

Reference Time History:
Irpinia (Calitri) Triaxial Earthquake
(0 dB horizontal peak acceleration: 0,158 g)

Factor reduction (dB)	Horiz. peak acceleration obtained on the shaking table surface (g)	Madas Seismic M16: block signal detection	Madas Seismic M16: value of programmable level of earthquake detection (g)
-15	0,040	No	0,100
-12	0,060	No	0,100
-9	0,075	No	0,100
-6	0,100	Yes	0,100
-3	0,132	Yes	0,100
-3	0,132	Yes	0,100
0	0,182	Yes	0,100
3	0,250	Yes	0,100

Reference Time History:
Friuli (Tolmezzo) Triaxial Earthquake
(0 dB horizontal peak acceleration: 0,33 g)

Factor reduction (dB)	Horiz. peak acceleration obtained on the shaking table surface (g)	Madas Seismic M16: block signal detection	Madas Seismic M16: value of programmable level of earthquake detection (g)
-15	0,070	No	0,100
-12	0,100	Yes	0,100
-12	0,100	Yes	0,100
-9	0,130	Yes	0,100
-6	0,180	Yes	0,100
-5	0,200	Yes	0,100
-4	0,222	Yes	0,100

6 LIST OF FIGURES

7 PHOTO DOCUMENTATIONS

Fig. 1

BLOCK DIAGRAM RELEVANT TO THE DYNAMIC TESTS

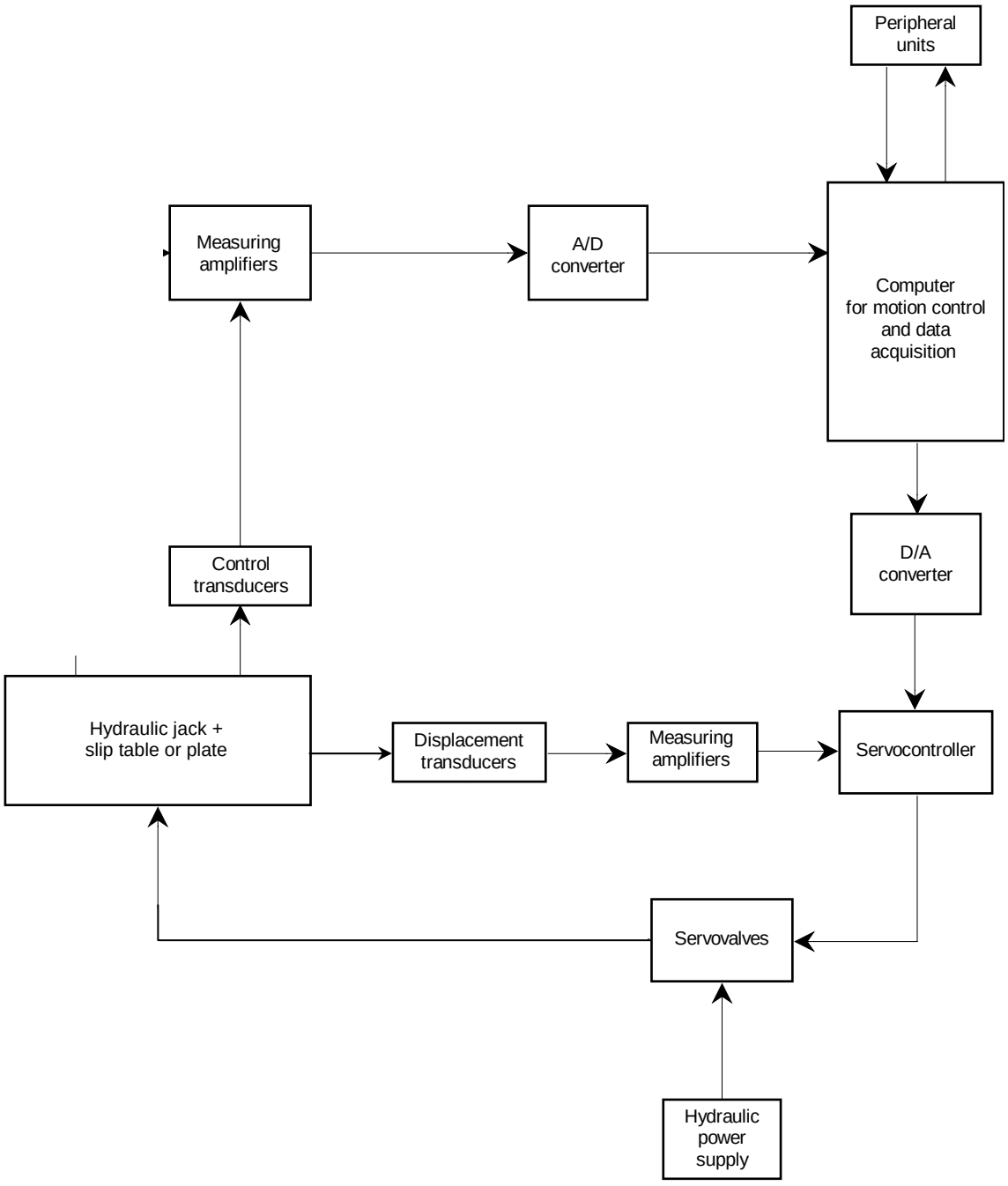


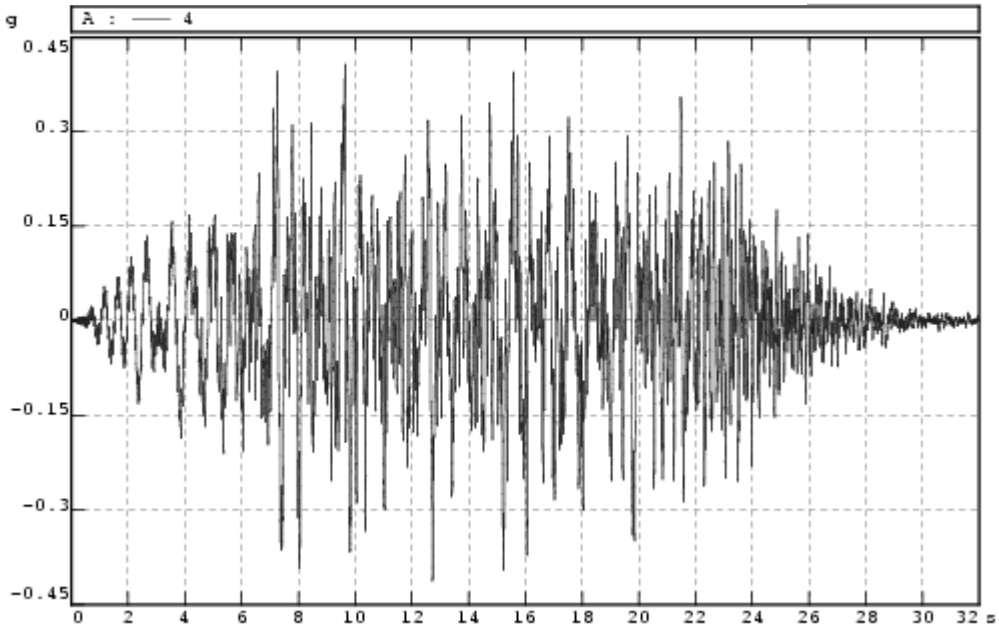
Fig. 2

LIST OF TRANSDUCERS

Ch. n.	Type Position		Producer	Model	s.n.
1	Accelerometer	ATx	Entran	EGCS-D1S-100-Z1	05X002
2	Accelerometer	ATy	Entran	EGCS-D1S-100-Z1	05X003
3	Accelerometer	ATz	Entran	EGCS-D1S-100-Z1	05X004

Fig.3

EC8 Time History - Horizontal Direction



EC8 Time History - Vertical Direction

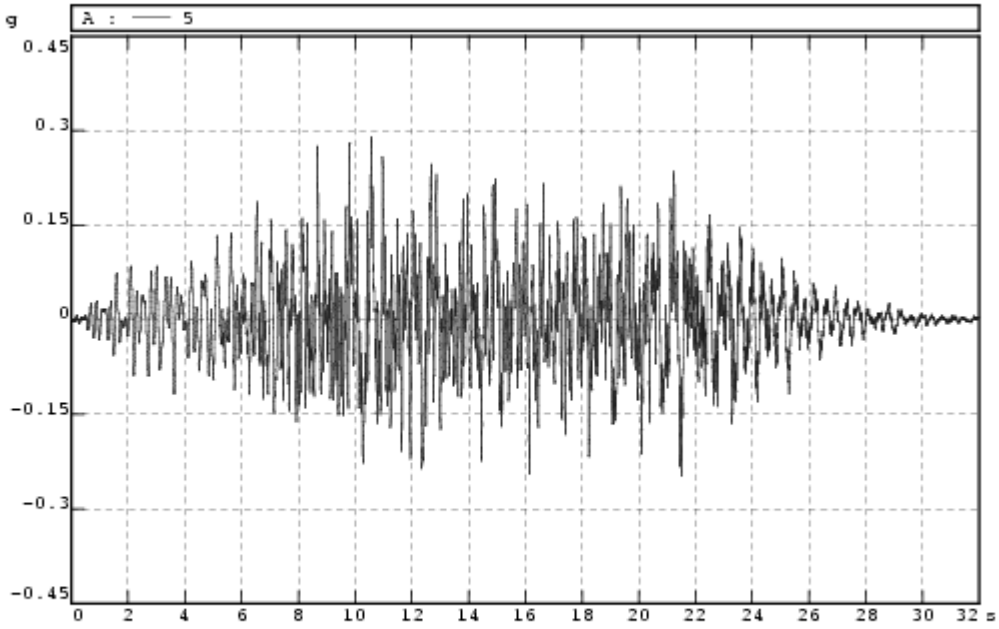
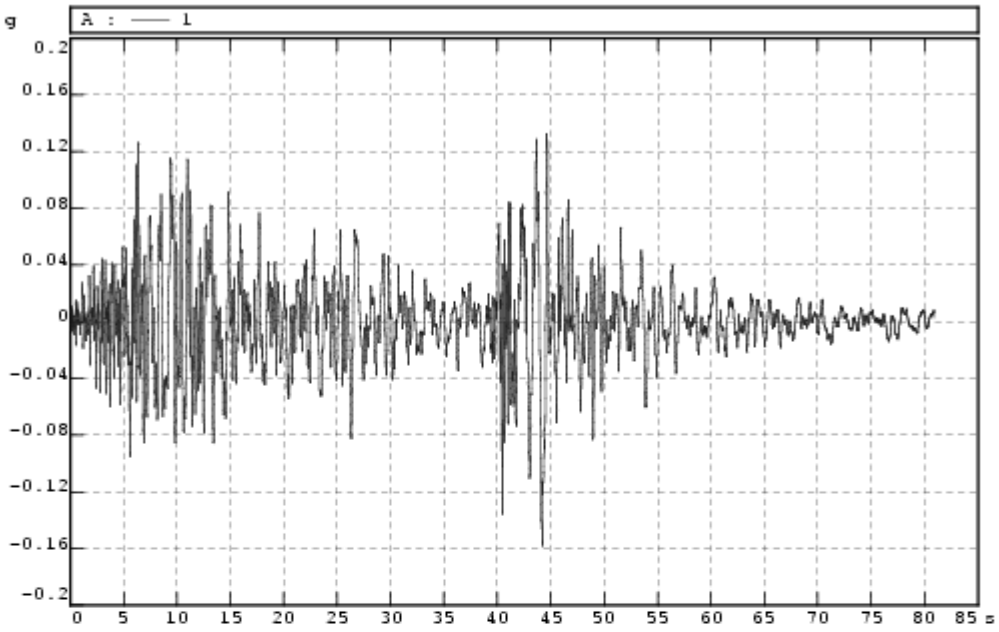


Fig. 4

Calitri Time History - Horizontal Direction



EC8 Time History - Vertical Direction

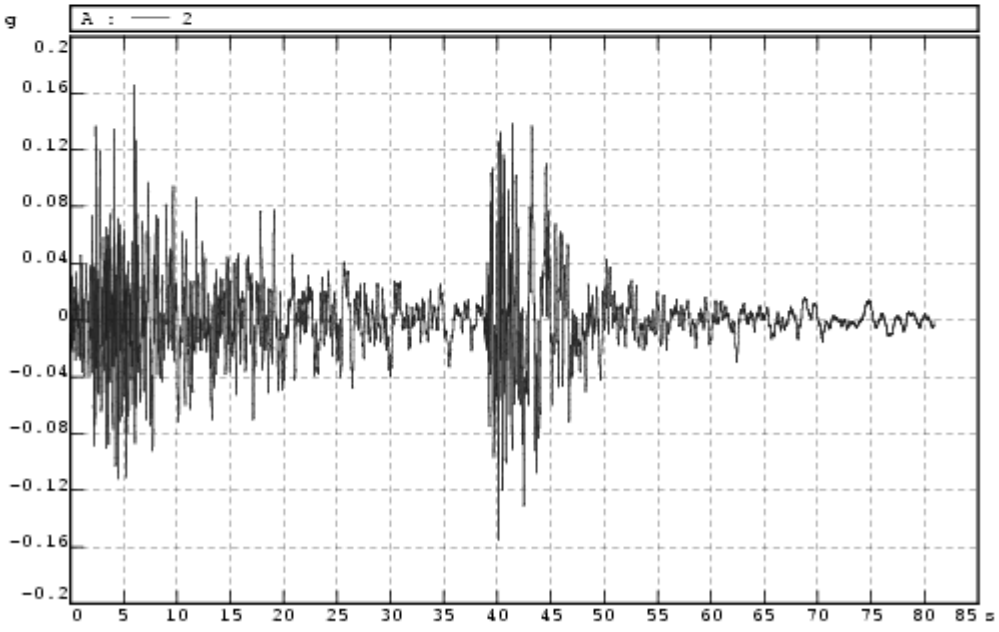
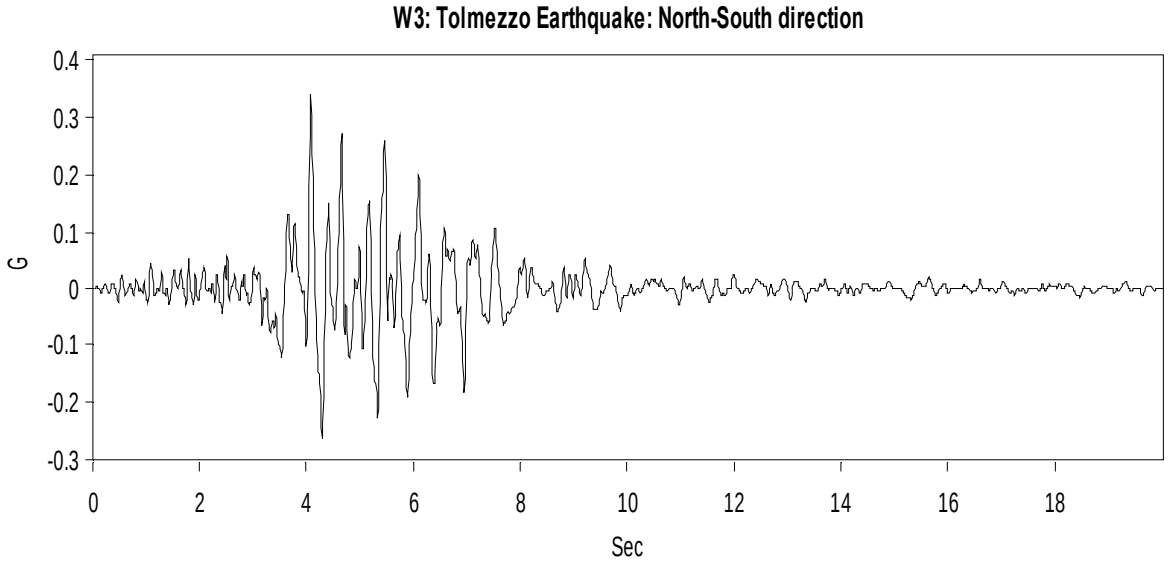


Fig.5


W3: Tolmezzo Earthquake: North-South direction
G
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
0
2
4
6
8
10
12
14
16
18
Sec

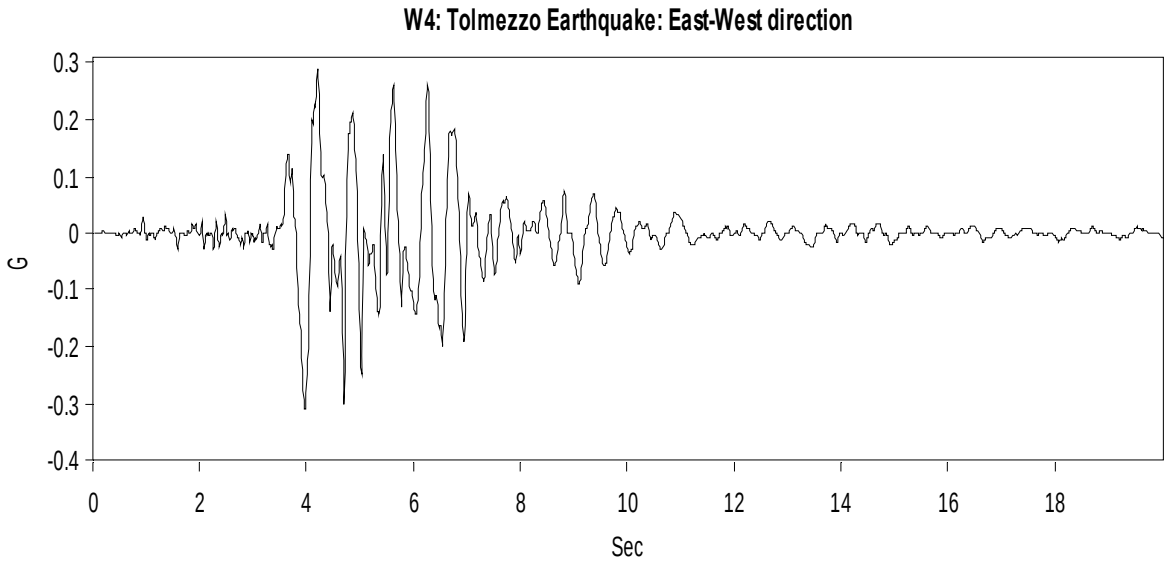
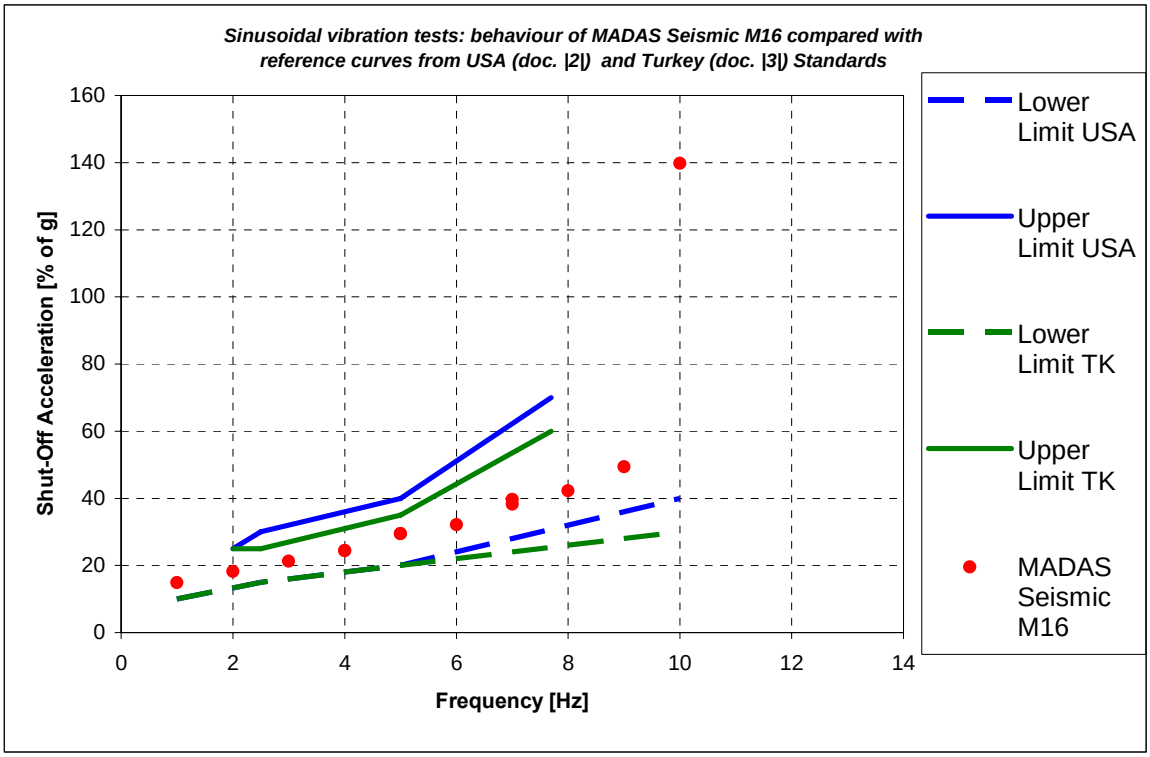

W4: Tolmezzo Earthquake: East-West direction
G
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
0
2
4
6
8
10
12
14
16
18
Sec

Fig.6


Sinusoidal vibration tests: behaviour of MADAS Seismic M16 compared with reference curves from USA (doc. |2|) and Turkey (doc. |3|) Standards
Shut-Off Acceleration [% of g]
Frequency [Hz]
Lower Limit USA
Upper Limit USA
Lower Limit TK
Upper Limit TK
MADAS Seismic M16

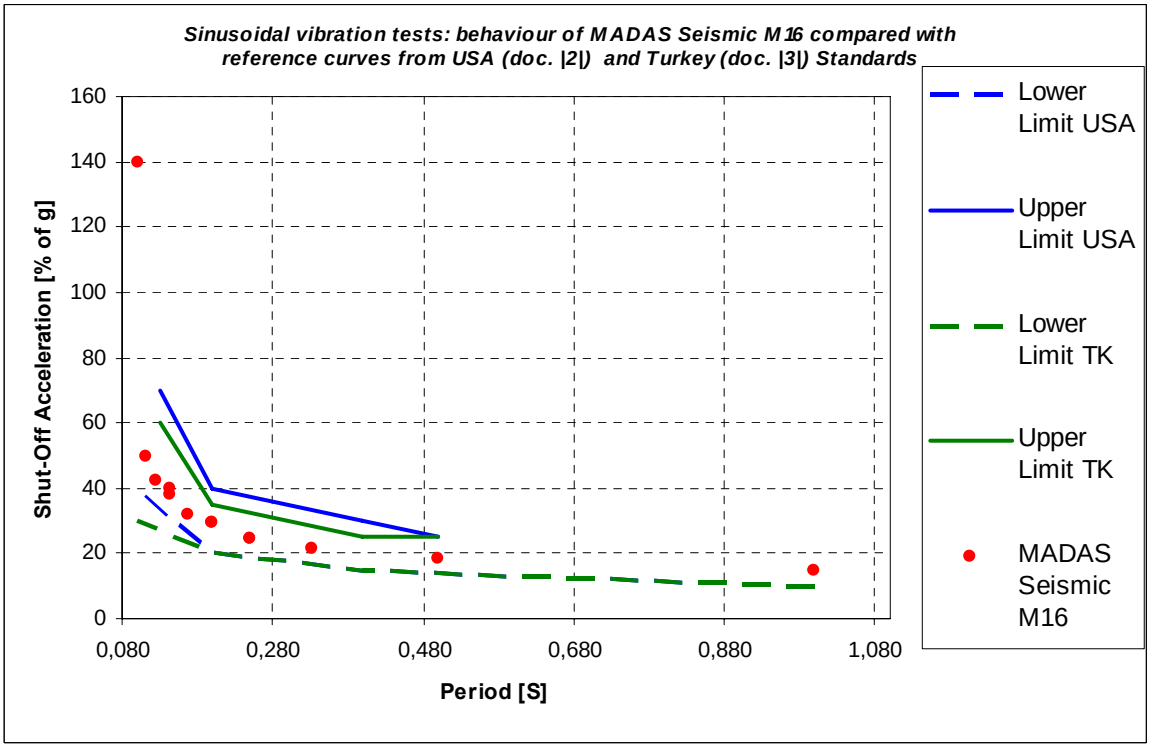
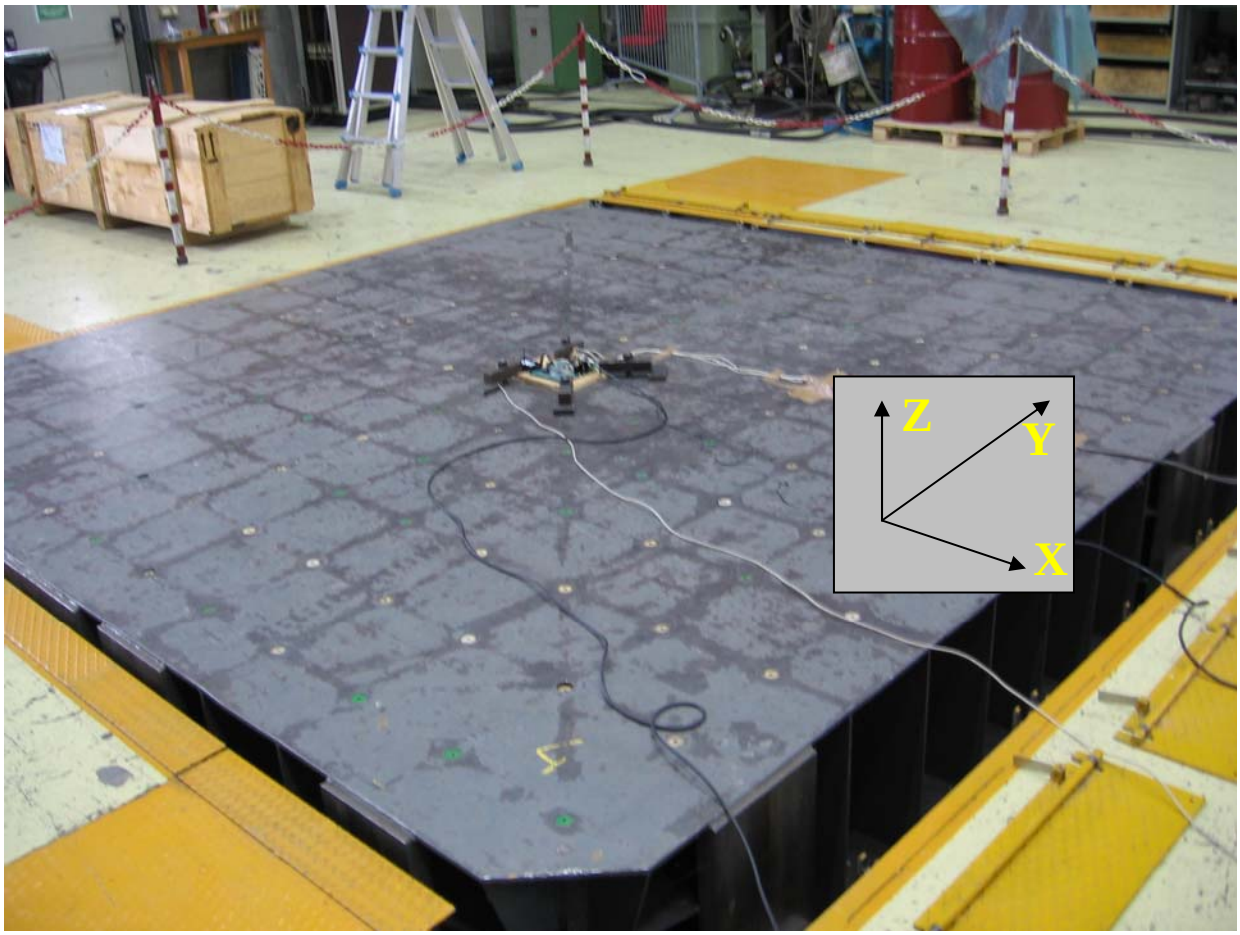
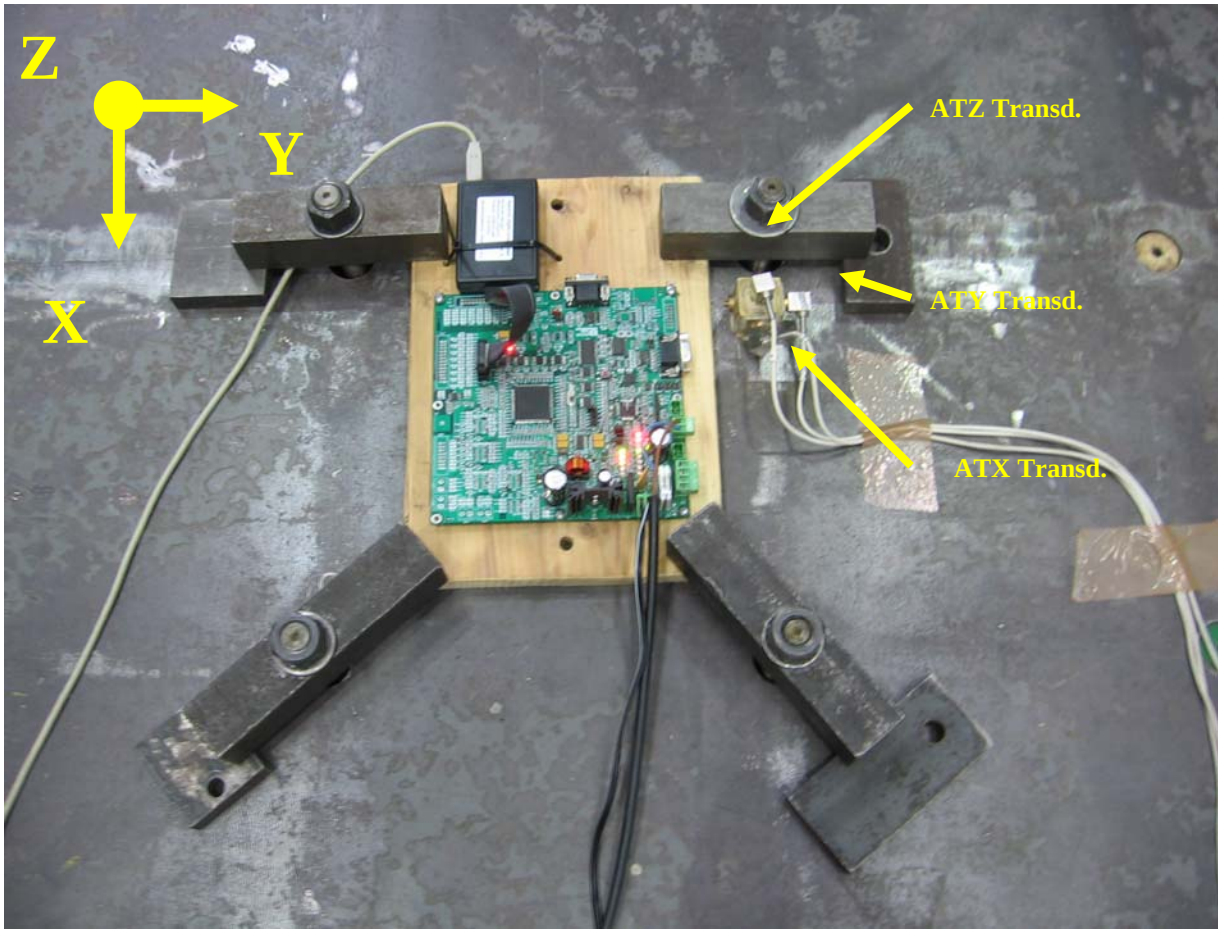

Sinusoidal vibration tests: behaviour of MADAS Seismic M16 compared with reference curves from USA (doc. |2|) and Turkey (doc. |3|) Standards
Shut-Off Acceleration [% of g]
Period [S]
Lower Limit USA
Upper Limit USA
Lower Limit TK
Upper Limit TK
MADAS Seismic M16

Photo 1



General view of the unit on the MASTER shaking table, in the photo the reference directions are reported

Photo 2



Position of the unit on the test fixture and control positio.

Photo 3