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SEISMIC TESTS ON DOUBLE DOOR ENCLOSURE TEOS PLUS+

TEST REPORT

ON BEHALF OF:TEKPAN TEKNIK ELEKTRIK - ULUCAK KEMALPASA / IZMIR - TURKEY

RT-AB-085/12, rev. 00

Document of 69 pages

Written:	Davide Recalcati	23/10/2012
Verified and approved:	Alessandro Bonzi	24/10/2012

REVISIONS TRACK

Date	Version	Description of changes	Reference
October 2012	00	First issue	

The results are referred only to the tested items.

The quality system of P&P LMC fulfills the requirements of the ISO 9001 Standard for engineering services for structures and industrial products: qualification, experimental tests, numerical analyses, design and consultancy (CSQ Certificate No. 9175.ILMC – IQNet Certificate No. IT – 20582).

P&P LMC laboratory is qualified by RINA for the performance of Tests (3 – 12 – 13 – 17 – 20) listed in Annex IX of D.L. 299/2001 “Attuazione della direttiva 96/48/CE relativa all’interoperabilità del sistema ferroviario transeuropeo ad alta velocità” (Technical specification for interoperability relating to the infrastructure subsystem) (Qualification Certificate No. 05/2007 Rev. 1).

CONTENTS

1. GENERAL DATA

1.1. Customer

TEKPAN TEKNIK ELEKTRIK,
Ankara Asfalt 14. km. Istiklal Mh. 17. Sk. No.8
Ulucak Kemalpasa / Izmir

TURKEY

1.2. Unit under test

The tests were performed on the following unit:

- TEOS plus+ double door enclosure, with a total mass of 395 kg.

1.3. Manufacturer

TEKPAN TEKNIK ELEKTRIK.

1.4. Reference documents

1.4.1. Contract documents

a. Offer P&P LMC No. OF-AB-041/12 rev.01, dated June 18th, 2012.

b. Order Tekpan dated June 19rd, 2012.

1.4.2. Technical documents and standards

1. Telcordia Generic Requirement GR-63-CORE, NEBS Requirements: Physical Protection, Issue 1, October 1995;
2. IEC 60068-3-3: Environmental testing - Part 3: Guidance – Seismic test methods for equipment;
3. IEC 60068-2-6: Environmental testing - Part 2: Tests - Test Fc: Vibration (sinusoidal);
4. IEC 60068-2-57: Environmental testing - Part 2: Tests - Test Ff: Vibration - Time-history method;
5. ISO 2041 Vibration and Shock – Vocabulary.

1.5. Test objective

The purpose of the tests were to demonstrate that the unit behave in compliance with the requirements stated in doc. |1| to |4| referring to a seismic risk classified as Zone 3.

1.6. Tests overall results

At the end of the tests, at a visual inspection, any damages on the unit were detected.

1.7. Testing laboratory

P&P LMC S.r.l.
via Pastrengo, 9
24068 Seriate (BG)
ITALY

1.8. Test date

October 17th – 18th – 19th – 22nd, 2012.

1.9. Responsibilities

A. Bonzi, test responsible
M. Civera, test engineer
D. Recalcati, test engineer

2. TESTING PROCEDURES

2.1. General remarks

To perform the tests, three reference directions have been considered for the unit: X (front - rear), Y (side - side) and Z (vertical).

The sequence of the tests for the unit has been:

- *Seismic tests*, performed in three directions (X, Y, Z) and consisted in:
  - vibration response investigation
  - earthquake
  - vibration response investigation

All the applied vibrations were monodirectional.

Tests in Z direction were performed on a vertical shaking table moved by an electro-dynamic shaker. For the other excitation directions, a horizontal shaking table was used. Excitation directions are shown in the photographs.

All the performed tests are listed in the table of page from 15. Tests were numbered following the chronological sequence.

2.2. Mounting techniques

For all tests the unit was mounted in its intended operating configuration.

The unit was fixed to the shaking table with No. 12 M14 screws with a tightening torque of 80 Nm.

2.3. Control and measuring positions

During the tests, for the motion control the signal of a monoaxial accelerometer in the excitation direction (CP1) was used. Moreover two triaxial accelerometers (MP1 and MP2) were placed on the unit for the vibration measurement (see photos). In the table reported below are summarized model and serial number of the transducers mounted in the control and measuring positions during the tests.

Point ID	*Accelerometer*		*Tests*
	Model	*Serial Number*	
CP1 (X,Y,Z) Control position located on shaking table	PCB 353A (monoaxial)	1374	All tests
MP1 (X,Y,Z) Measuring position located at middle height of the rack.	DYTRAN 3023A6 (triaxial)	982801 (X)	All tests
		982803 (Y)	
		982802 (Z)	
MP2 (X,Y,Z) Measuring position located on the top of the rack	DYTRAN 3023A6 (triaxial)	982901 (X)	All tests
		982902 (Y)	
		982903 (Z)	

2.4. Seismic tests

2.4.1. Vibration response investigation

The aim of these tests was to find the resonance frequencies of the unit.

In X, Y and Z direction, the unit was subjected to sine sweeps, with the following dynamic characteristics:

- Frequency range: 1 ÷ 50 Hz
- Constant peak displacement from 1 Hz to 1,58 Hz: 10 mm
- Constant peak acceleration from 1,58 Hz to 50 Hz: 1 m/s^2
- Sweep rate: 1 oct/min
- Duration: 1 sweep

Signals from measuring accelerometers were processed to obtain the absolute response functions of the control channel and the frequency transfer functions of the measuring channels on the unit.

2.4.2. Bellcore earthquake

In X, Y and Z direction, the earthquake was performed with reference to the Required Response Spectrum (RRS) reported in doc. |1| for Zone 3 risk areas:

- RRS:

frequency (Hz):	0.3	0.6	2	5	15	50
acceleration (m/s^2):	2	20	30	30	10	10

- Damping: 2 % (Q = 25)
- Duration: 30 seconds

The filtered time history was applied to the unit after acceptance of Customer's technicians, based on duration, amplitude, shape and degree of envelope of the Required Response Spectrum.

3. MEASURING, EXCITATION AND DATA PROCESSING EQUIPMENT

3.1. Excitation equipment

Vibration tests in vertical direction were carried out using an electrodynamic shaker manufactured by ELIN, type MZV 210 W 20 S/N 713255 with the following characteristics:

- maximum sinusoidal dynamic force: 100 kN;
- moving element weight: 1000 N;
- frequency range: 0 ÷ 2000 Hz;
- max. displacement (peak to peak): 51 mm;
- max. velocity: 2000 mm/s;
- max. acceleration: 98 g.

Vibration tests in horizontal directions were carried out using a magnesium slip table (operated by the previously described ELIN shaker) with the following characteristics:

- maximum sinusoidal dynamic force: 100 kN;
- moving element weight: 3,4 kN;
- frequency range: 0 ÷ 500 Hz;
- max. displacement (peak to peak): 51 mm;
- max. velocity: 2000 mm/s;
- fixing surface: 1100 x 950 mm.

3.2. Measuring equipment

Accelerometers employed during all the tests were PCB 353A, monoaxial accelerometers, and DYTRAN 3023A6, triaxial accelerometers, with incorporated amplifiers.
The main characteristics of the accelerometers are listed below:

PCB 353A:

- Nominal sensitivity: 20 mV/g;
- Transverse sensitivity (max): < 5%;
- Frequency range: 1 ÷ 4000 Hz;
- Max. acceleration: +/- 250 g;
- Resolution: 0,005 g;
- Weight: 0,10 N.

DYTRAN 3023A6:

- Nominal sensitivity: 5 mV/g;
- Transverse sensitivity (max): < 5%;
- Frequency range axis 1 & 2: 1,5 ÷ 5000 Hz;
- Frequency range axis 3: 1,5 ÷ 10000 Hz;
- Max. acceleration: +/- 1000 g;
- Resolution: 0,010g;
- Weight: 0,04 N.

The frequency response of the whole measuring chain is flat, in the frequency range from 3 to 3000 Hz, with an accuracy of ± 5%.

Serial number of the employed accelerometer is listed in the above reported table. The instrumentation is submitted to a calibration program in accordance with internal procedures.

3.3. Data acquisition and processing instrumentation

During all the tests, but free fall ones, the shaker was controlled by a computer based system (the digital system LMS International) which is composed by an acquisition panel of 16 channels and by a PC. This control system generates the motion with the requested characteristics and feeds-back the shaker motion using the signal coming from the accelerometer chosen for the control.

Analogue signals coming from the accelerometers were amplified and conveyed to an analogue/digital converter, which sent the data to the disk storage of the aforementioned minicomputer for subsequent processing.

The block scheme of the excitation, acquisition and processing equipment is shown at page 14.

4. TEST RESULTS

4.1. Seismic tests

The seismic tests were performed by applying an artificial time history obtained starting from the Required Response Spectrum (Bellcore RRS) as reported in doc. |1|, with a 200 Hz sampling frequency[1]. For every direction a comparison is given of the Required Response Spectrum with the test Shock Response Spectrum at a damping value of 2% analyzed with 12 points per octave. In any case the test was run in order to get a peak acceleration of the excitation time history greater than the Zero Period Acceleration of the specified Required Response Spectrum.

Figures at pages 16 - 22 show the absolute response function relevant to the control accelerometer and the frequency transfer functions relevant to the measuring positions placed on the item obtained during the vibration response investigation in Z direction before the earthquake.

Figures at page 23 show the obtained time history during the earthquake relevant to the control position CP1 and the relative displacement time history of the top of the rack in Z direction: the maximum peak displacement is less than 75 mm as stated in doc. |1|.

Figures at pages 24 - 25 show the obtained time histories during the earthquake relevant to the measuring positions MP1 and MP2 in Zdirection.

Figure at page 26 show the test Shock Response Spectrum (SRS - solid line) compared with Required Response Spectrum (RRS - dashed line) in Zdirection.

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[1] [1] In order to fit the required displacement with the maximum allowable displacement of the test equipment, the drive signal was filtered with a high-pass filter at 3 Hz: the filtering was agreed upon with the Customer on the basis of the results of the frequency response investigation performed in all the three excitation directions, showing that the lowest natural frequency of the equipment before the seismic tests was above 4 Hz. In this case the Shock Response Spectrum of the obtained shaking table acceleration is dominating the required SRS of the reference doc. |1| in the frequency range from 3 to 50 Hz and the test can be accepted because the specimen was correctly excited around its natural frequencies.

Figures at pages 27 - 33 show the absolute response function relevant to the control accelerometer and the frequency transfer functions relevant to the measuring positions placed on the item obtained during the vibration response investigation in Z direction after the earthquake.

Figures at pages 34 - 40 show the absolute response function relevant to the control accelerometer and the frequency transfer functions relevant to the measuring positions placed on the item obtained during the vibration response investigation in Y direction before the earthquake.

Figures at page 41 show the obtained time history during the earthquake relevant to the control position CP1 and the relative displacement time history of the top of the rack in Y direction: the maximum peak displacement is less than 75 mm as stated in doc. |1|.

Figures at pages 42 - 43 show the obtained time histories during the earthquake relevant to the measuring positions MP1 and MP2 in Y direction.

Figure at page 44 show the test Shock Response Spectrum (SRS - solid line) compared with Required Response Spectrum (RRS - dashed line) in Y direction.

Figures at pages 45 - 51 show the absolute response function relevant to the control accelerometer and the frequency transfer functions relevant to the measuring positions placed on the item obtained during the vibration response investigation in Y direction after the earthquake.

Figures at pages 52 - 58 show the absolute response function relevant to the control accelerometer and the frequency transfer functions relevant to the measuring positions placed on the item obtained during the vibration response investigation in X direction before the earthquake.

Figures at page 59 show the obtained time history during the earthquake relevant to the control position CP1 and the relative displacement time history of the top of the rack in X direction: the maximum peak displacement is less than 75 mm as stated in doc. |1|.

Figures at pages 60 - 61 show the obtained time histories during the earthquake relevant to the measuring positions MP1 and MP2 in X direction.

Figure at page 62 show the test Shock Response Spectrum (SRS - solid line) compared with Required Response Spectrum (RRS - dashed line) in X direction.

Figures at pages 63 - 69 show the absolute response function relevant to the control accelerometer and the frequency transfer functions relevant to the measuring positions placed on the item obtained during the vibration response investigation in X direction after the earthquake.

4.2. General remarks

At the end of the tests, at a visual inspection, no evident mechanical failure was detected on the unit.

The results of further checks on the unit are of CUSTOMER's responsibility.