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Technical Report

実験で今後使用する包装試験法を開発するために実施した、ボリビア国 オルロ～ヤクイバルートにおける輸送環境データの計測

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Measuring environmental data in the Oruro - Yacuiba route in BOLIVIA to develop testing methods for packaging for future implementation in the laboratory.

アルゼンティンの包装試験室で、道路輸送に対する包装の性能試験を行う場合に、我々は、JIS、ASTM 及びMIL 規格を用いている。しかし、我々は、これらの試験条件が我々の実態に即していないことに気付くことがしばしばある。そこで、製品―包装―輸送を最適化する分析を行うために、我々は、南米の色々な地域から、振動、衝撃、温室度のデータを集め、これらを共有することを開始した。この研究は、ボリビア国の物流環境をよりよく知ることを目的としたものである。全行程について、3方向の加速度レベルを収集した。その結果、道路の状態が最も悪い区間で、垂直方向に12 Gという厳しい衝撃が2回発生した。更に言えば、垂直方向のパワースペクトル密度も、また、2Hzから10Hzの間で、ASTM規格4528のレベルよりも大きな振動であることを示した。

キーワード：振動、衝撃、PSD(パワースペクトル密度)、物流環境、輸送環境

As a Testing Packaging Laboratory in Argentina, we have been working with JIS, ASTM and MILSTD standards when testing packaging performance in road transportation. However, we are aware that sometimes these testing conditions do not reflect our reality. In order to optimize the product package-transport analysis, we started to collect and share vibration, temperature and humidity data from different regions of South America. Thus, this study aims to acquire a better understanding of the distribution environment in Bolivia. Acceleration levels were collected in three directions all way long. Consequently, on the worst road condition section, two severe vertical shocks of 12G and 7.3G were presented. Moreover, the power spectral density also showed higher vibration levels than the standard ASTM 4528, between 2Hz and lOHz in the vertical direction.

Keywords : vibration, shock, power spectral density, distribution environment, transport environment

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1. Introduction

Bolivia is a country that can be considered, by its geographical location, an integrating link of the economic regions of the Pacific and the Atlantic, through competitive corridors of international trade. But it faces some adverse situations, such as its rough topography and its enclosure, demanding over costs due to the physical transferring of products passing country borders.

The purpose of this report is lo analyze dynamics forces and climate conditions transport environment information. This information was collected from a 1225km long road. Specially, the data studied were shocks, vibration, temperature and humidity. The remainder of the paper is organized as follows. In Section I the truck characteristics, load type and route description are introduced. Section 2 explains the measurement procedures, Section 3 provides results and finally, discussion and conclusion are presented in Section 4.

2. Truck, load and route description

In this case a semitrailer truck, with clastic suspension on every axle was used. Axles arc distributed as follows : two in the semitrailer and three in the truck tractor.

The semitrailer is loaded and unloaded through lateral side and rear gates. It lacks an iron structure to prevent canvas and load from touching each other.

Empty aluminum cans of 473 cm were transported for this study. The unitized load contained a

Photo 1. Loaded Truck

Table 1 Summary of the different conditions of the 7 zones

Zone	From	To	Duration (h)	Distance (km)	road category	condition	speed (km/h)
1	Oruro	Cochabamba	05:04	217	asphalt	good	43 , 40
2	Cochabamba	Chimore	05:45	217	asphalt	good	37,74
3	Chimore	Santa. Cruz	07:47	220	asphalt	good	28,39
4	Santa. Cruz	Abapo	03: 13	117	asphalt	good	36,00
5	Abapo	Herradura	05:53	75	no paved, gravel	bad	12,67
6	Herradura	Camiri	06:50	79	no paved, gravel	bad	11,42
7	Camiri	Yacuiba	04:40	267	asphalt	good	57.30

total of 5320 cans staked fourteen layers high, 380cans per layer. A paperboard between layers was placed and corner boards were used to protect the load. Finally, the payload total weight of 16 unitized loads was 1981 kg.

Rubber straps over the pallets tense the protection canvas that covers the load. In order to avoid damages on the top layer cans, each unitized load covers its top with a table or shelf. This table acts as a lid, preventing straps from being in touch with the cans. (Photo 1)

The entire route was split into 7 different zones. The duration and length of each part is described in Table 1. Notations of the trip starts and stop locations were made on the way by following the semitrailer in a second vehicle. Such notations help identify particular segment of the information during later data analysis. The surface condition of the roads was good except in zones 5 and 6, where the non-paved, graveled state of the road made transportation very difficult. Table 1 illustrates the low speed, as a consequence of the road condition.

3. Measurement procedure

To monitor the truck shipments, a distribution environment recorder DER-400 (Yoshida Sciki Co.) was used. This recorder incorporates internal acceleration sensors, piezorcsistance type 10 G, 50 G, in three directions, external temperature and humidity sensor and a memory capacity of 4 Mbyte RAM.

The DER 10 G (labeled E 1) was mounted on the floor on the lateral side of the semitrailer, and the DER 50 G (labeled E 2) in the middle, both in the rear part of the semitrailer (Photo 2)

The sampling rate[1] was set lms, so one frame was for 0,512s long. Acceleration waves for three axes during this period were recorded. The frequency domain

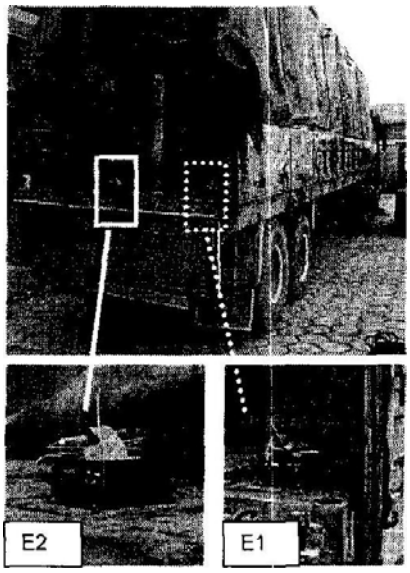

Photo2. DER 400 equipments

for the PSD analysis was set from 1 Hz. to 250 Hz[2].The trigger acceleration level was selected as 0,2G for the DER 10G and as 0,5G for the DER 50G. The dead time[3] was set at 300s. Finally, the time interval measurement recording for the external thermo, humidity sensor was set at 12 minutes.

[1] The sampling rate is the time interval to obtain record data digitizing accelerations waves. Wave recording is done by taking 512 samples; 102 samples before and 410 samples after the acceleration exceeds the trigger level.
[2] Depending on the sampling rate, the frequency range for the PSD analysis is determined.
[3] The dead time means the time between frame recording.

4.Results

4.1. Acceleration levels

The vertical acceleration levels of the whole trip arc presented in the (Fig. 1). The data in black belongs to the E2 equipment (DER 50G), where a total of418 frames were taken and the data in grey corresponds to the El equipment (DER-10G). In this case 411 frames stand for the route. The distribution of vertical acceleration levels is higher in the middle rear location than the lateral rear part. The following graphic (Fig. 1) summarizes data, assuming a -6G, 6G range. The blank spaces characterize the location where the semi trailer was stopped.

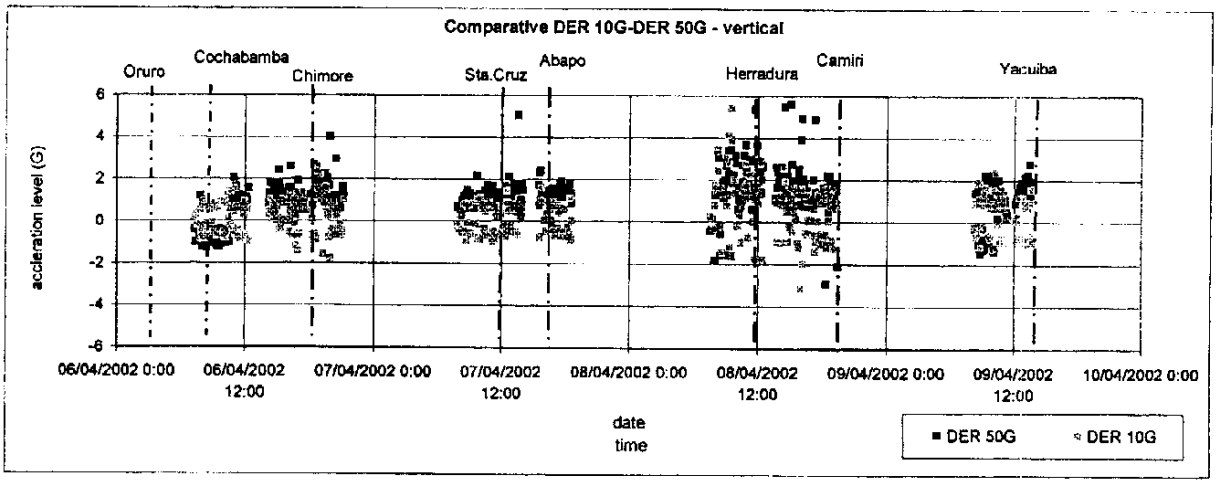

Fig. 1 Comparative DER 10G - DER 50G - transversal (vertical)

There is a remarkable difference between the Abapo-Camiri section and the others. Actually, high level shocks were presented, -12G (duration 3ms) consequently with the bad road conditions. In fact , this is an ordinary road with no asphalt or gravel, a building ground,

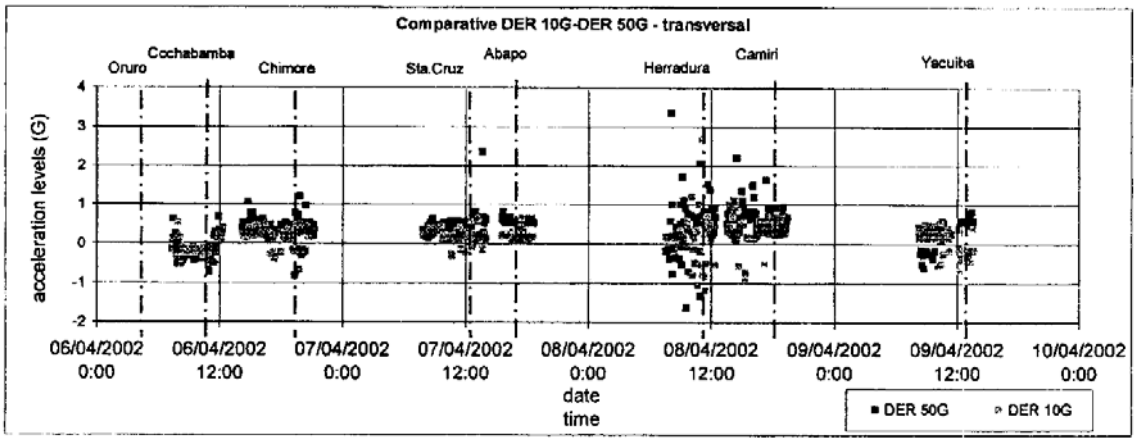

Fig. 2 Comparative DER 10G - DER 50G - transversal (lateral)

concisely a bumpy and very rough road. The driver was requested to be careful and it was aware the semi trailer speed with the road condition (Table 1).

The acceleration lateral and longitudinal levels are illustrated in Fig. 2 and Fig. 3. However, it is important to mention the light weight of the payload, nearly 2000 kg.

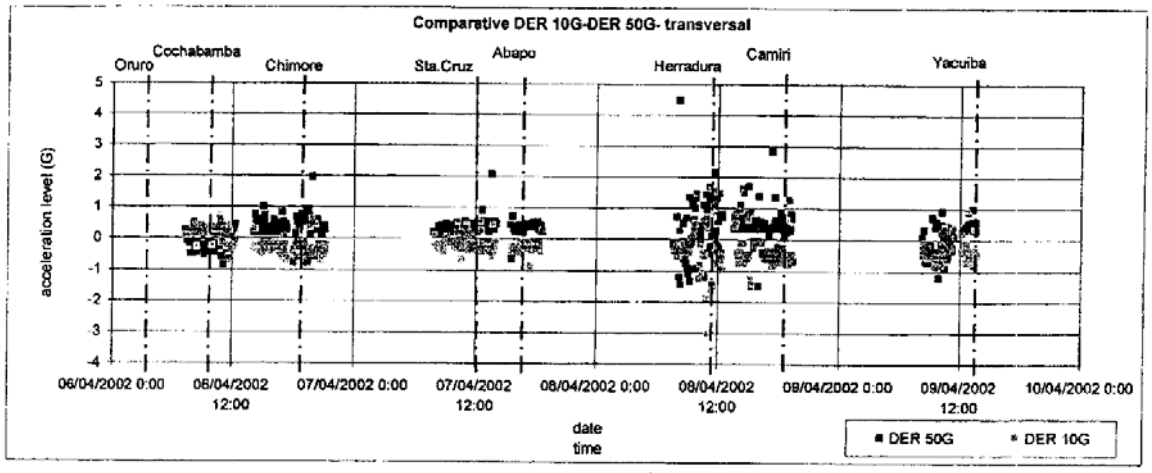

Fig. 3 Comparative DER 10G - DER 50G - transversal (longitudinal)

4.2. Temperature and Humidity

Temperature and humidity are introduced in the following graphic (Fig. 4). These data were collected by an external thermo-humidity pickup, model HN-L18, Yoshida Seiki Co, type platinum resistance thermo sensor. The equipment was mounted on the floor of the semitrailer truck over the DER equipments, and covered with canvas, the same as the load.

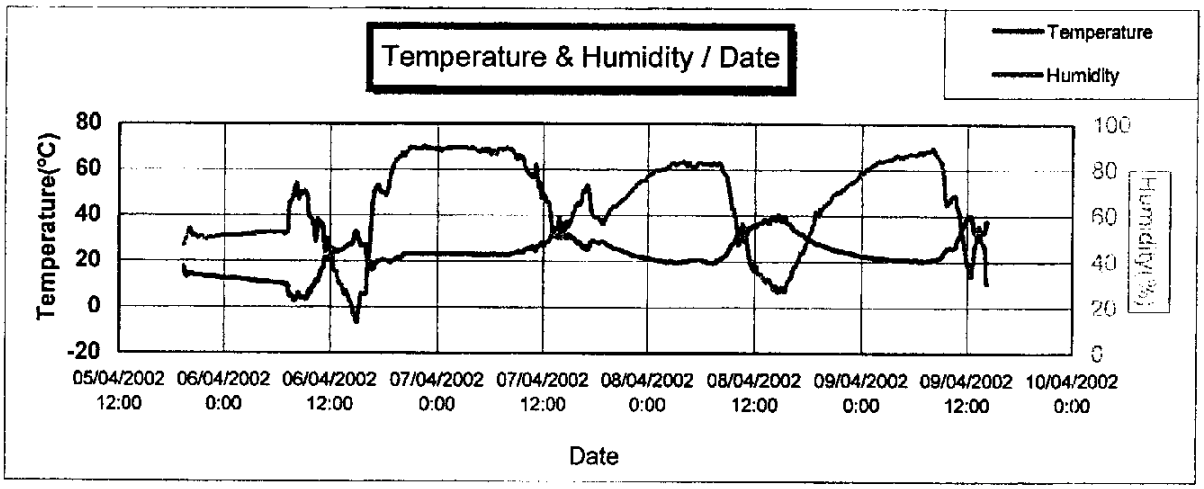

Fig. 4 Temperature & Humidity / Date

The data was registered all the way long, with an interval time of 12 min. As it is presented, there was 70% H.R. during long period and the temperature range was from almost 0℃ to 40℃.

4.3. Power Spectral Density

Finally, the PSD signal, characteristic o[the distribution environment data was performed for the vertical (Fig. 5, Fig. 6), lateral and longitudinal orientation. Two conditions

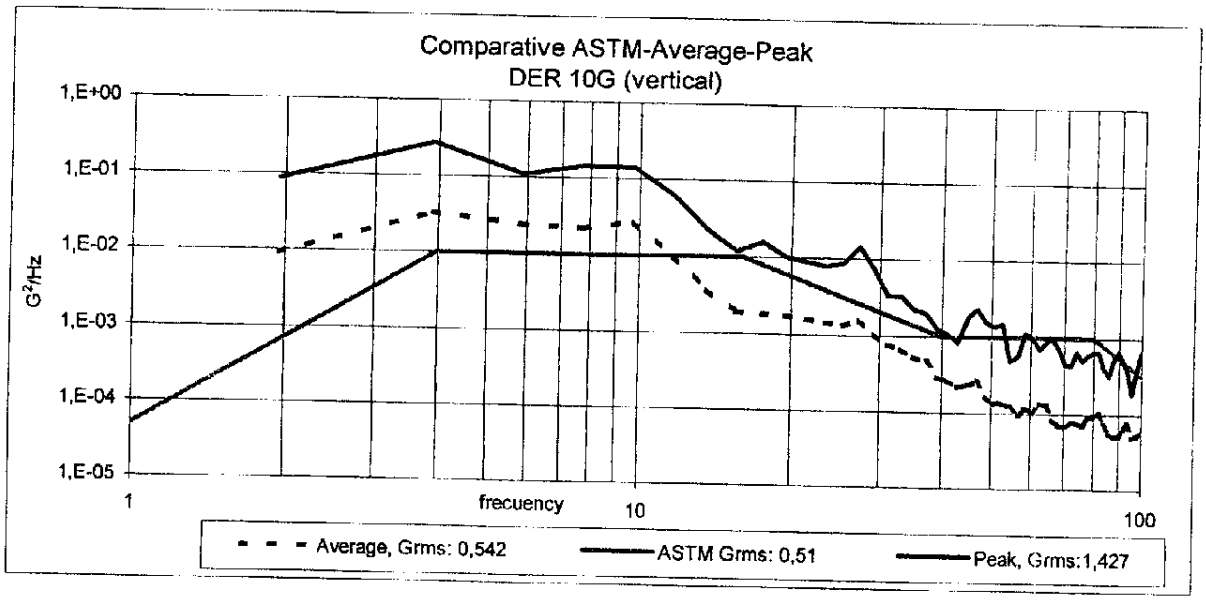

Fig. 5 Comparative PSD with ASTM - Average - Peak DER 10G (vertical)

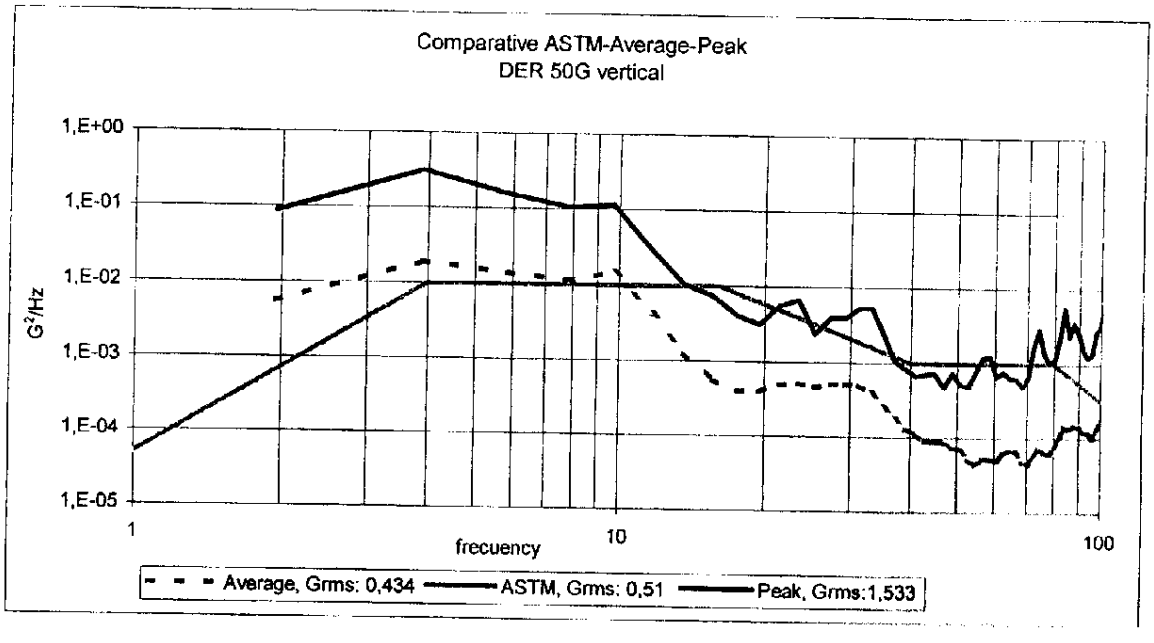

Fig. 6 Comparative PSD with ASTM - Average - PeaK DER 50G (vertical)

were considered to build up this signal. First, frames with an acceleration level higher than 5 G were removed and second, frames where 0,5 G level or higher are presented 5 times or more were selected.

As the following graphic (Fig. 5, DER 10 G, Fig. 6 DER 50 G) describes, high accelerations (PSD) levels at low frequencies were obtained. Comparison with data suggested by the ASTM (4728) standard were made, facing that similar shape and Grms values were achieved. However, there is an significant range from 2 Hz to 10 Hz where the registered data is higher than the one set by the ASTM standard.

5. Discussion and Conclusion

This work can be considered a new attempt to measure the distribution environment to collect data for laboratory test input[1)~5)]. We have instrumented vehicles with accelerometers to describe amplitude of vibration and transient impacts from roadbed variations and vehicle movements.

Technically, comparing this work with previous ones, there was a remarkable difference in the road characteristics. That is why such high accelerations levels were found. High level shocks as -12 G (3 ms) and 7,3 G (2 ms) were presented in the middle rear trailer.

There is no measurement data for real transport environment in this region of South America. This study is a starting point to work on collecting data and to share information. This study will have an important impact on the industrial sector since the goal is to have actual information about the conditions of international transport and thus, to be able to make decisions based on specific data from the area. However, this experience has to be repeated to increase the amount of data and to compare vibration levels for different load weight and different categories of vehicles.

Finally, there was an unexpected outcome to highlight : the technical transferring job to the company professional team. As a group we shared each step of the study and they learnt the close relationship between data collected and potential packaging damage. In the future, they will apply this information to optimize packaging transport and to look for its own standard.

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