Technical Specification for Design, Fabrication, Use and Maintenance of Tie-Down System

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INTRODUCTION

IAEA Safety Series n°6 states that to ensure compliance with the Regulation the programs of quality assurance must be put in practice either for design, manufacture, testing , documentation, use and maintenance and inspection of all packages or for transport and in-transit storage operations. Therefore in view of a standardisation coming from Q.A. criteria, the Italian Competent Authority for transport of radioactive material (ENEA-DISP) is preparing a technical guide for the design, construction, use and maintenance of tie-down system for road transport of packages containing radioactive materials. The paper shows some phases of the program started by ENEA-DISP for the redaction of the technical guide.

TIE-DOWN SYSTEMS

Transport of dangerous goods

With the purpose of establishing design criteria for tie-down systems, we carried out a comprehensive outlook of the international and national regulations existing for the modal transport of **dangerous goods**. International regulations establish reference values for the accelerations to be taken into account in the design and/or to verify the tie-down structure. These values are equivalent in the various modes of transport to permit the use of the packages in different countries and/or different conveyance.
ICAO regulation gives values of accelerations (or load factors) that are rather different from the values of other transport modes. In fact , the UN Recommendations, with IMO, ADR and RID, require that the attachments on the packages shall resist to the following loads:

- in the direction of travel, twice the total mass of the package;
- horizontally at right angle to the direction of travel, the total mass (where the direction is not clearly determined, twice the total mass);
- vertically upwards, the total mass;
- vertically downwards, twice the total mass.

Under the action of each mentioned force , the safety factors shall be in compliance with the following criteria:

- for metals having a clearly-defined yield point, a safety factor of 1,5 in relation to the guaranteed apparent yield stress;
- for metals with no clearly-defined yield point , a safety factor of 1,5 in relation to the guaranteed 0,2% proof stress (in the case of austenitic steel the 1% maximum elongation).

Otherwise, ICAO establishes only range of vibrations, and consequently accelerations that the package undergoes aboard the aircraft. The range of vibrations is from an amplitude of 5 mm. at 7 Hz (corresponding to an acceleration of 1g) to an amplitude of 0,05 mm. at 200 Hz (corresponding to an acceleration of 8g).

Transport of radioactive materials

IAEA Safety Series n°37 states some values of acceleration for different modes of transport. These values are summarised in the following table:

LOAD FACTORS TABLE

mode of transport	longitudinal acceleration	lateral acceleration	vertical acceleration
road	2 g	1 g	3 g down, 2 g up
rail	10 g	2 g	4 g
sea	2 g	2 g	2 g
air	9 g	1,5 g	6 g down , 2 g up

For road transport the values indicated are similar to those present in other regulations and code of practice.

We intend to adopt the values reported in the Table , that are in compliance with the values reported in the ADR for design of tank-containers fastenings. These criteria could simplify international road transport of radioactive material among the European countries. Anyway international regulation gives poor attention to vibration and shock phenomena which tie-down system, and consequently the package, can undergo during transport. Only the ANSI Draft "Design Basis for Resistance to Shock and Vibration of Radioactive Material Packages Greater than One Ton in Truck Transport", takes into account the said phenomena. This draft reports graphs and tables containing response peak accelerations at range frequency from 1 to 1000 Hz for the Truck Transported Package/Tie-down System. ENEA-DISP has started a measurement program for taking into account the Italian road and vehicle characteristics and to support the values chosen for the design of tie-down system. The complete program will include:

- measurements carried out on vehicles and packages during shipments of radioactive materials;
- measurements carried out with vehicles over roads with "ad hoc" surface discontinuities;
- analysis of the recorded accelerations during the shipments with spectrum analyser;
- statistic analysis on data .

The poster describes the first shipment monitored and is referred to the transport of an irradiated fuel package. The choice of monitoring this shipment has been adopted for the particular interest , presented by this kind of transport in our country .

POSTER DESCRIPTION

The poster shows some phases of measurements and data elaboration recorded during a shipment of NTL-3A package for transport of irradiated fuel. It is referred to a shipment from ENEL Trino nuclear power plant to Centro Merci Agognate, in the North of Italy, where the package was transferred to a rail wagon to be transported to Sellafield (UK) reprocessing plant. The measurement program was carried out through a cooperation with the authorised carrier Borghi Nucleare . In particular the carrier provided to:

- Cargo (package and tie-down system).
- Truck for the shipment.
- Part of instrumentation.
- Arrangements for on-board transportation of ENEA technicians during the actual testing.

Instrumentation

The truck used was a special flat bed qualified for the transport of irradiated fuel package (Max Load 90 ton.). The loaded truck is shown in Fig.5.
Six accelerometers were located on two opposite columns of tie-down system in the longitudinal, transversal and vertical directions. Fig. 6 shows the position of three of six accelerometers. The whole instrumentation for recording the signals was located in the truck cab. The linkage between the accelerometers and the instrumentation located in the truck cab was realised by cables joined in a flexible tube.
Fig. 7 shows the instrumentation used for recording data. This instrumentation was composed by:

- Six charge preamplifiers
- One portable recorder (24 channels + 1 channel for voice recording).
- One oscilloscope for input signal observation .

Test description

The shipment route was of 70 km.(44 miles) divided in about 20 km (13 miles) of local road and 50 km (31 miles) of highway. The more significant events from a shock/vibration standpoint gathered during the journey were caused by holes in paved road, bumps, joints bridge, parking manoeuvres, braking, manhole.

The speed truck was limited to 30 km/h (18 miles per hour) for the entire route and the trip took about two and half an hour.

First data evaluation

A first data evaluation was made to obtain , through the spectrum analyser, the Power Density Spectrum for the entire trip as reported in the following in Fig.1. This graph confirms the general good condition of road surface, with low acceleration amplitude recorded at almost all frequencies. Subsequently the shock events gathered during the route have been analysed to determine the most important events and the kind of shock. The following table shows a summary of the more relevant peaks shock acceleration of the bed truck, spring mounted, at a speed of about 30 km/h for different discontinuities of road surface. These acceleration values were recorded at a range frequencies 0 - 200 Hz .

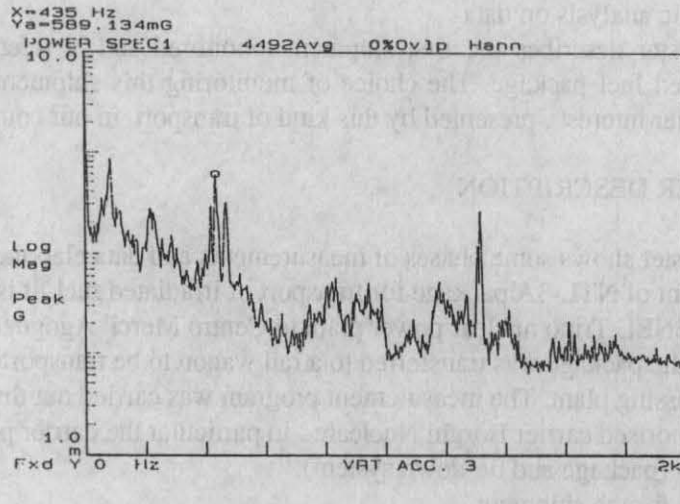

Fig. 1 Power Density Spectrum for vertical acceleration

Peak Shock Acceleration of Bed Truck

Shock type	Acceleration (g)		
	vertical	longitudinal	transversal
joint bridge	5	1.3	1.3
manhole	5	1.2	1.2
breaking	1.8	3	0.5

Fig. 2, 3 and 4 report respectively the time histories of the shock events with the amplitude of acceleration.

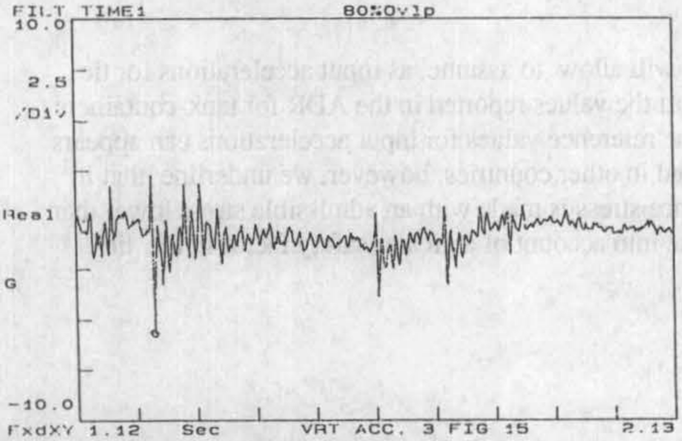

Fig.2 Time history for joint bridge shock event

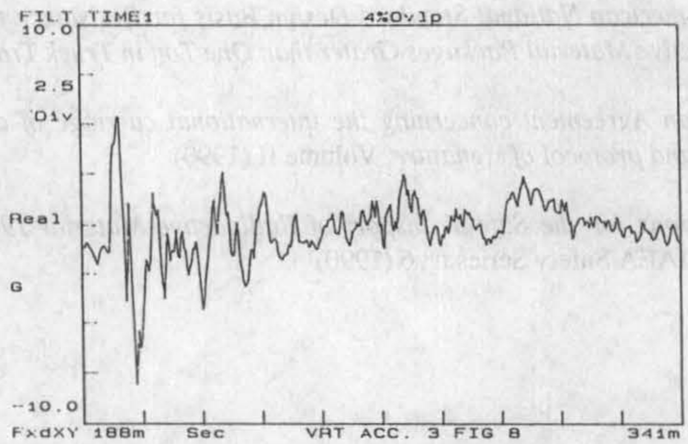

Fig. 3 Time history for manhole shock event

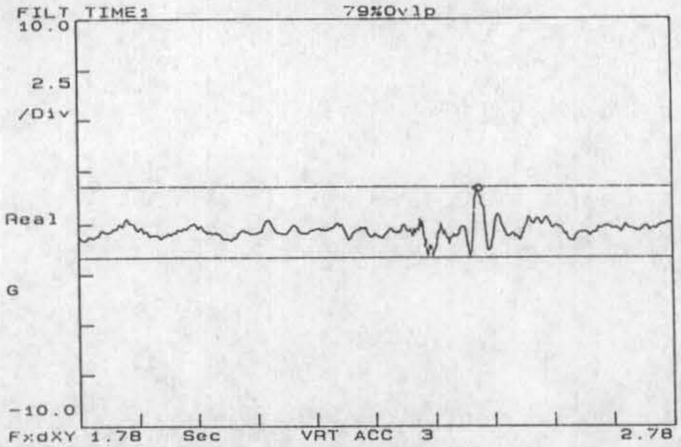

Fig.4 Time history for braking shock event

CONCLUSIONS

Bibliography and experimental data will allow to assume, as input accelerations for tie down systems design for road transport the values reported in the ADR for tank-containers fastenings at the marginal 212 127. The reference values for input accelerations can appears quite low if compared to values adopted in other countries; however, we underline that in Italy for steel constructions the reference stress is made with an admissible stress lower than a yield stress. This is equivalent to take into account of a greater safety factor in the tie-down structure design.

REFERENCES

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European Agreement concerning the international carriage of dangerous goods by road (ADR) and protocol of signature, Volume II (1990)

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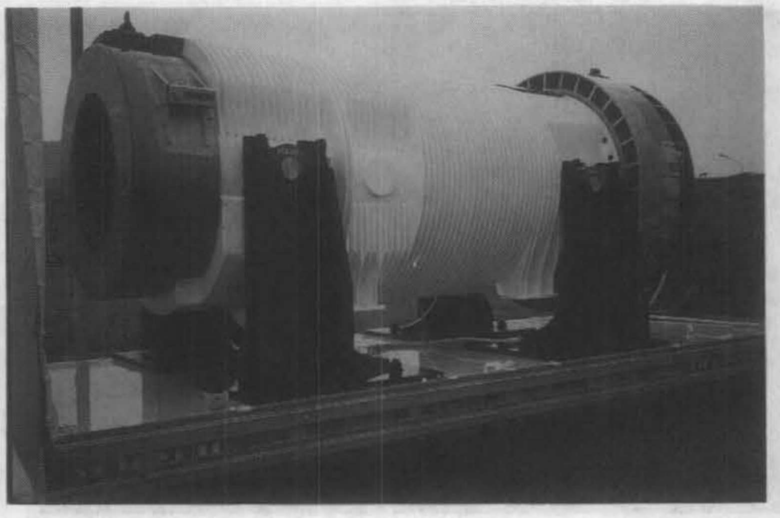

Fig. 5 Truck bed with NTL-3A package.

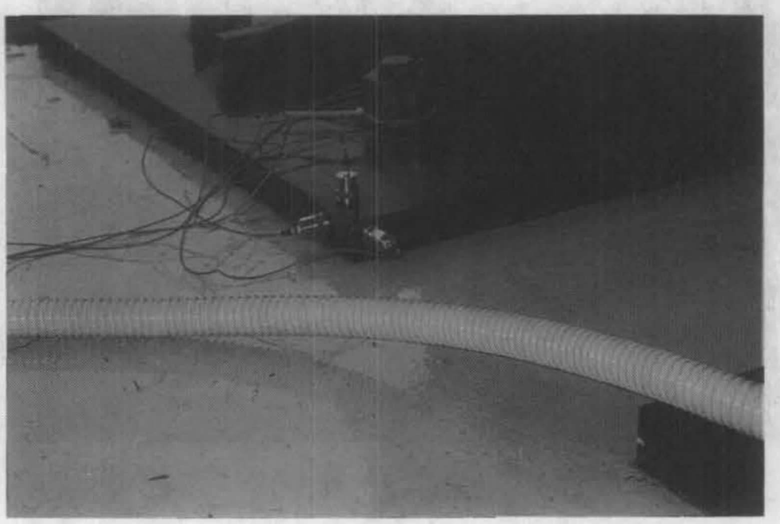

Fig.6 Accelerometers on the plate of tie-down system

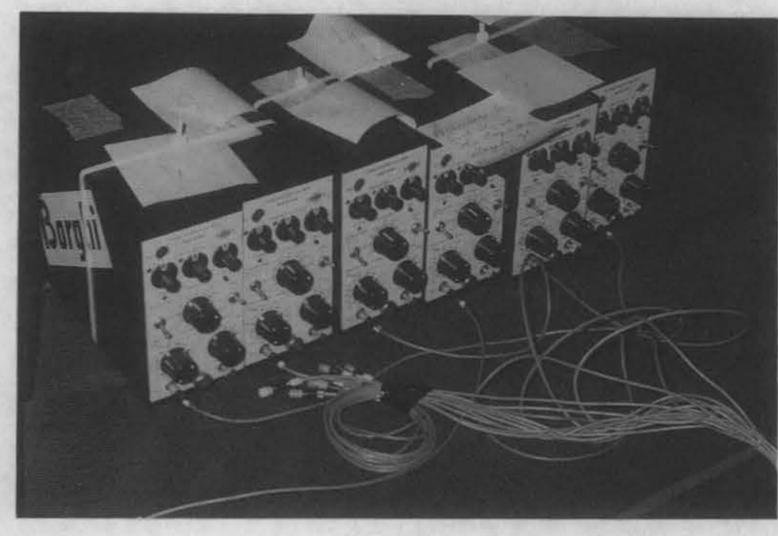

Fig. 7 Instrumentation used for measurement and recording data