IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

THE ENVIRONMENTAL CONDITIONS EXPERIENCED BY PACKAGES DURING ROUTINE TRANSPORT

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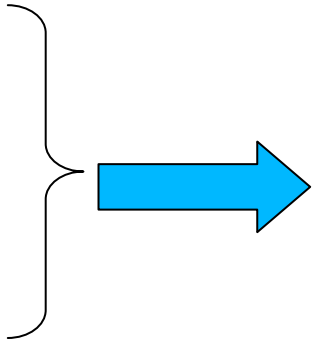
PATRAM 2010

Presented by S. Fourgeaud

SURVEY FOR ACCELERATIONS IN ROUTINE CONDITIONS

- Road transport
- Rail transport
- Sea transport
- Air transport



Identification of lack of data and proposals of specific measurement campaigns

THE WAY FORWARD

SURVEY FOR ACCELERATIONS IN ROUTINE CONDITIONS

- Package + retention system
  - Designed to prevent yield or rupture in routine conditions
    - Effects of acceleration of inertia of package
    - Acceleration factors may differ depending on CA acceptance
    - TS-G-1.1 proposed values (tables IV.1 & IV.2)
  - Need for more clarity about acceleration levels to be used:

    ➔ **Survey performed by IRSN**

SURVEY FOR ACCELERATIONS IN ROUTINE CONDITIONS

- Values recommended by norms (TS-G-1.1 considered as most relevant)

- Results from measurement campaigns (especially transport of radioactive materials)

- In case of absence of measure
  - Temporary upper bound of values in norms/guide
  - Identification of specific measurement campaigns to be performed

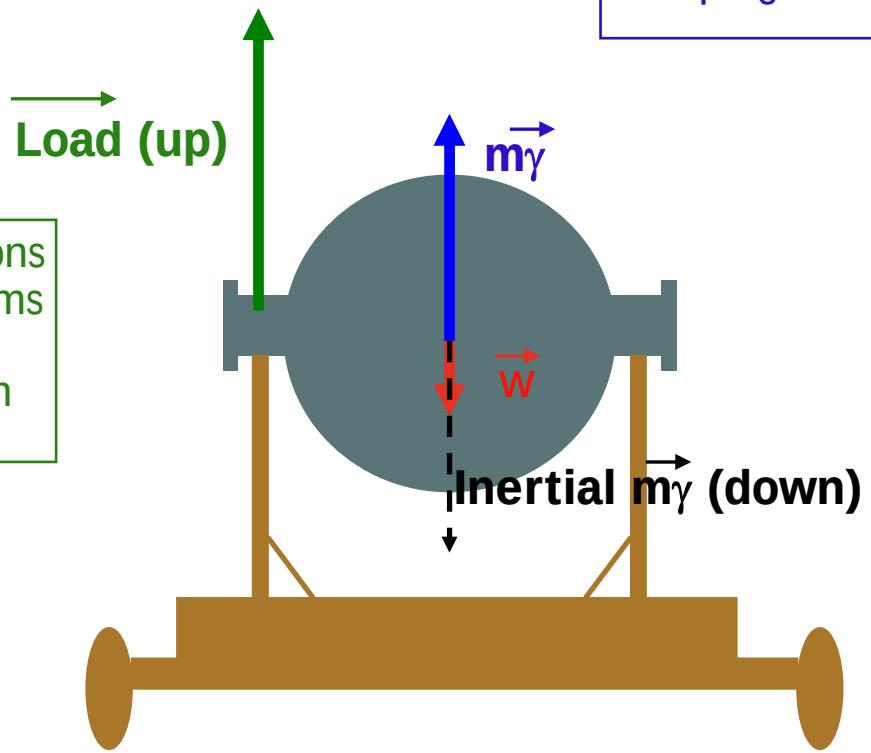
- Accelerations depend on:
  - Transport mode (road, rail, air, sea or river)
  - Direction of acceleration (longitudinal, lateral or vertical)
  - Conditions of transport, mass range of package, stowing provisions

SURVEY FOR ACCELERATIONS IN ROUTINE CONDITIONS

- Convention for vertical direction

For norms, guides and measurements campaigns: inertial $m\vec{\gamma}$ is given

IRSN recommendations are expressed in terms of load applied to package by retention system



! In some cases, there is an ambiguity in TS-G-1.1: no difference in vertical inertial accelerations up and down (eg. Rail transport ± 2 g)

ROAD TRANSPORT

- Loadings depend on:
  - State of road, vehicle suspensions, pressure and state of tyres
  - Way of driving, speed of vehicle
  - Respective weights of package and vehicle

References		Longitudinal	Lateral	Vertical
Norms and guides	Guide TS-G-1.1 (table IV.1)	2	1	3 down, 2 up
measurement campaigns	NTL 8 (36 ton package)	1.8	1.8	± 2.2
	NTL 11 (80 ton package)	1	1	± 1.4
	TN 12/2 (100 ton package)	0.15	0.5	± 0.4
	Singh [1]	0.51	0.85	± 2.26
IRSN recommendations for maximum loads applied to packages by retention systems (unit m.g, with m mass of package and g = 9.81 m/s²)		**2**	**2**	**4 up, 2 down**

value rounded up to ± 3 + effect of gravity

+ measurement campaigns for low-mass packages

[1] Test protocol for simulating truck and rail vibration in rail impacts in shipments of automotive engine racks – S. Paul Singh, Gary J. Burgess, Paween Rojnuckarin, 1994

RAIL TRANSPORT (1/2)

- Loadings depend on:
  - Marshalling methods: hump / gravity methods prohibited for wagons with label n°15 of RID
  - Respective weights of package, wagon, whole train
  - Damping properties of buffers between wagons

References		Longitudinal	Lateral	Vertical
Norms and guides	Guide TS-G-1.1 (table IV.1)	5	2	± 2
	UIC	4	0.5	0.3
measurement campaigns	NTL 11 (80 ton package)	1	1	± 1.4
	TN 12/2 (100 ton package)	0.6	0.4	± 0.5
	Singh [1]	5.56	3.5	± 3.36
IRSN recommendations for maximum loads applied to packages by retention systems (unit m.g, with m mass of package and g = 9.81 m/s²)		**2.5[1] 4[2] 6[3]**	**4**	**4 up, 2 down**

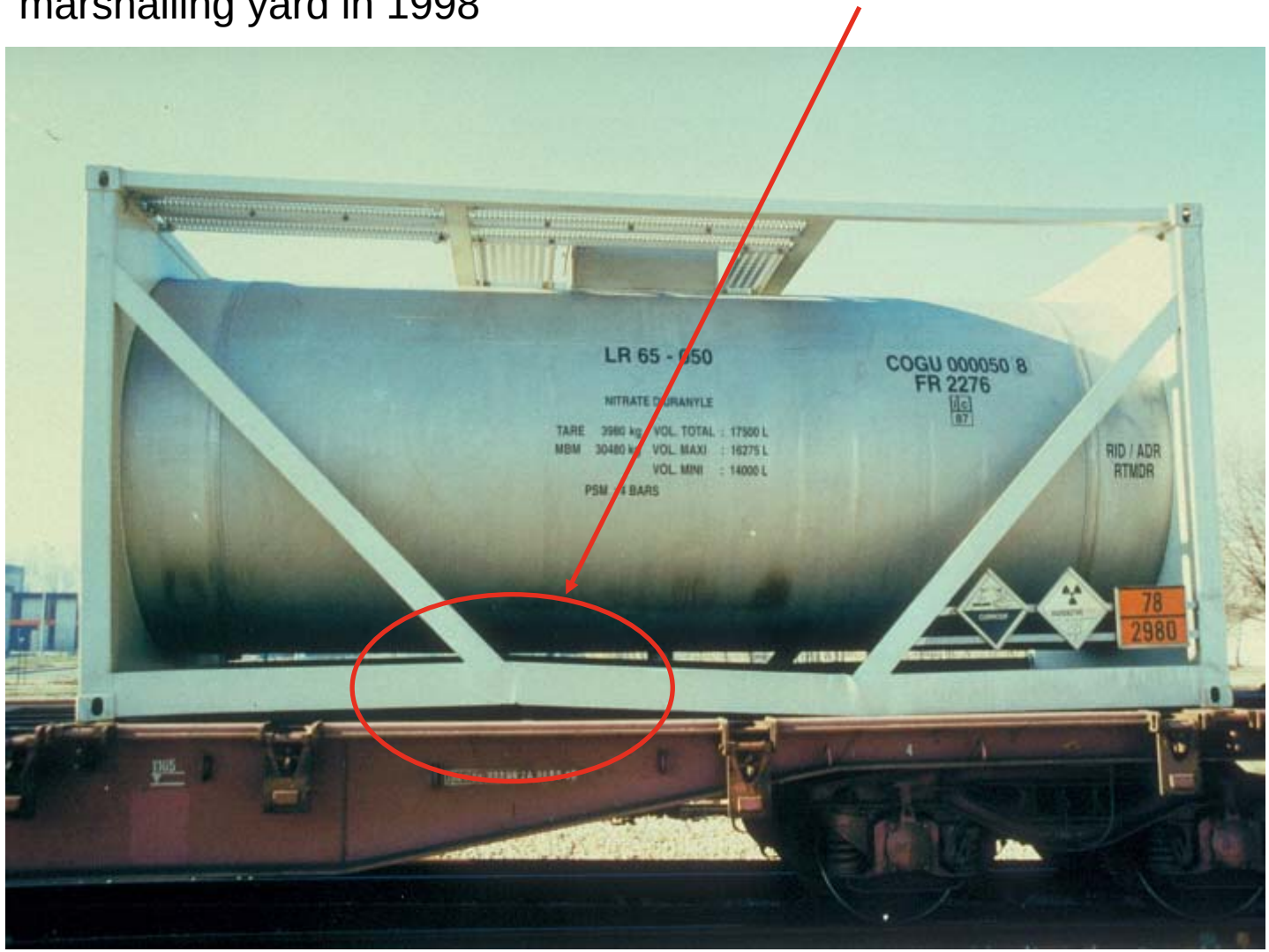
value rounded down to ± 3 + effect of gravity

(1) **> 30 tons, label n°15, long buffers** (from *test carried out by SNCF with a NTL11*)
(2) **< 30 tons, label n°15, long buffers** (*from UIC*)
(3) **Other cases** (*rounded up value*)

Lack of experimental data for various kind of wagons / marshalling methods / package masses ➔ measurement campaigns needed

RAIL TRANSPORT (2/2)

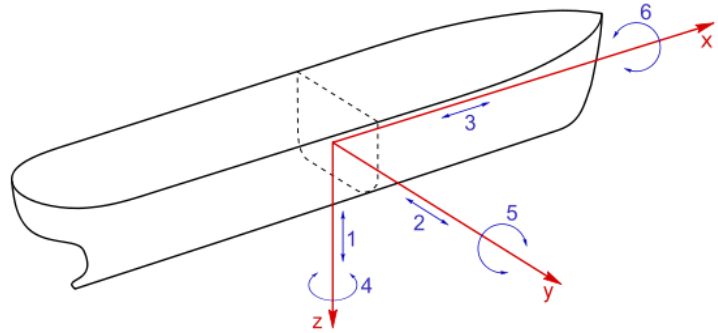
LR 65 tank damaged due to a rough operation at Sotteville marshalling yard in 1998



SEA TRANSPORT (1/2)

- Loadings depend on:
  - State of sea (levels on Beaufort scale up to 11)
  - Nature of sea (closed, open ➔ swell)
  - Type of ship, dimensions,
  - Position of package in the ship (its distance to rotation axes of the ship)

Damage to containers in rolling motion, caused by inadequately secured cargo and excessive loads on internal cargo tie-down system



1- Heave, 2- Sway, 3- Surge
4- Yaw, 5- Pitch, 6- Roll

Movements of a ship in translation and rotation around three axes

SEA TRANSPORT (2/2)

References		Longitudinal	Lateral	Vertical
Norms and guides	Guide TS-G-1.1 (table IV.1)	2	2	± 2
	INF Code	1.5	1.5	1 up 2 down
measurement campaigns	Excellox 3B (Channel, BS level 6)	0.2	0.2	± 0.4
	Singh [2]	0.7	-	± 4.2
IRSN recommendations for maximum loads applied to packages by retention systems (unit m.g, with m mass of package and g = 9.81 m/s²)		**0.6**	**0.6**	**2.2 up** **0.2 down**

Extrapolation to BS level 11

Corrective factor

$$\frac{\left(\frac{Wave\ height}{Period^2}\right)_{BS\ level\ 11}}{\left(\frac{Wave\ height}{Period^2}\right)_{BS\ level\ 6}} \approx 3$$

- **Transports of fresh products between Honduras, USA and Germany in holds (front or rear of cargo ships)**
- **Measured values not correlated to weather conditions**

➔ **More experimental data are needed**

[2] Packaging Technology and Science, Vol. 6, Pages 175-181 (1993) - Measuring the Package shipping environment in Refrigerated Ocean Vessels - S. Paul Singh, Gary J. Burgess, Jorge, A. Marcondes and John R. Antle

AIR TRANSPORT

- Almost no specific data found
  - Need for dedicated measurement campaigns for air transport
  - Values recommended by TS-G-1.1

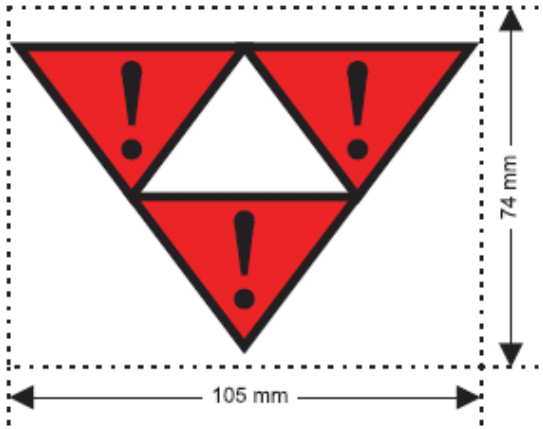
References		Longitudinal	Lateral	Vertical
Norms and guides	Guide TS-G-1.1 (table IV.1)	1.5 (9 g forward)	1.5	2 up, 6 down
IRSN recommendations for maximum loads applied to packages by retention systems (unit m.g, with m mass of package and g = 9.81 m/s²)		**1.5**	**1.5**	**? up, -1 down**

9 g = no protection of cockpit against shocks of cargo in case of emergency landing
➔ emergency landing ≠ routine conditions
➔ **1.5 g**

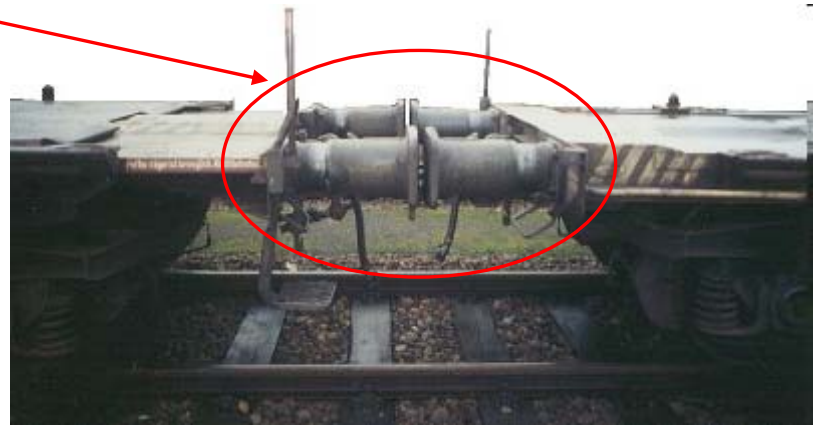
6 g value looks unrealistic

CONCLUSION OF THE SURVEY (1/3)

- Need for more experimental data and analyses to confirm values for dimensioning tie-down components
  - **Air transport** (take-off, flight, landing):
    - Various types of airplanes
    - Different package masses
  - **Rail transport**: various kinds of marshalling operations
    - Small packages containing RAM on standard wagons
    - A heavy package (100 tons) on a wagon with specific equipments (long buffers)



Label n°15 of RID



CONCLUSION OF THE SURVEY (2/3)

- **Sea transport**:
  - Various states of sea,
  - Different positions of package in the ship
  - Different ship lengths

➔ Measurement campaign currently performed by TN International on a specific INF-III ship

- **Road transport**:
  - Wide range of package masses (10 – 100 000 kg)
  - Different types of vehicles (light commercial vehicles – special heavy ones, kind of suspensions)

- **Clarification of type of measurement:**
  - Static load or power spectral density (PSD)?

  ➔ Use of PSD could be convenient for testing the dynamic behaviour + Fatigue analysis

CONCLUSION OF THE SURVEY (3/3)

- Proposal to organise a "**planning working group**"
  - Partnership in view of sharing expertise and financial supports
  - Definition of measurement campaigns for the different modes of transport
    - Identification of potential contributors
    - Definition of modalities of measurements
    - Schedule
  - Involvement of IAEA to facilitate the mutualisation of individual contributions

THE WAY FORWARD (1/2)

- General Conference Resolutions 2007-2009
  - IAEA should address changes in environmental conditions, infrastructures and industry operations
  - Recent application:

➔ Following industry changes: new Fissile Exceptions requirements have been studied and proposed

  - Other applications are still to be addressed:

    - ambient temperatures, pressures, …

    - routine dynamic loads on tie-down systems,

    - …

THE WAY FORWARD (2/2)

- The “Regulations” & “Advisory Materials” need to be living documents
  - Feedback mechanisms to take into account external changes
  - Steps to follow:

    - Identification of safety requirements that are linked to external parameters liable to change

    - Establish and document each safety requirement (purpose, standard to meet) with associated external parameters

  - ➔ **IAEA Technical Committee in week 41**: collection of available documentation
  - ➔ Further meetings with implication of other UN bodies regulating applicable requirements of other dangerous goods (submitted to same environmental conditions)

The Future - Working Together

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