A DISCUSSION ON THE SECURE STOWAGE OF PACKAGES

Iain Davidson
Her Majesty's Principal Inspector
Department for Transport (Central)
Zone 2/26, Great Minster House,
76, Marsham Street, London, SW1P 4DR, UK
Ph: +44 (0)20 7944 5776
Email: iain.davidson@dft.gsi.gov.uk

The views are those of the author and do not constitute official UK Competent Authority policy.

ABSTRACT

The meaning of 'secure stowage of packages' within the UK (and elsewhere) is not consistently understood. There are obviously variations across industry with each organisations specialist preferring a particular method. There are also variations in package stowage (or tie-downs) within package types, for example Type B package are routinely held rigidly in place by trunnions or lashings and chocks or occasionally more freely in a well area that the package can not topple or bounce out of. There are greater variations across package types e.g. Type A or excepted packages in the medical sector are often freely placed in the boot of a car or a Type A nuclear density gauge may be loosely tied in the back of a van with rope. Further variations can be found in the techniques used to demonstrate 'secure stowage' some form of dynamic or static stress analysis either by hand calculation or numerical analysis usually takes place. Again, there are many variations as to what is a conservative analysis. More variations in understanding occur across the modes where each mode has its own guidelines which may not always concur with the IAEA guidelines and are also enforced by different organisations. Significant variations (or the risk of misunderstanding) can occur between the Design Safety Report, the Operating, Handling and Maintenance Instructions and the Local Work Instructions. Finally two conditions must be considered for secure stowage: routine and normal; and under accident conditions the tie-down points, if they fail, must fail in such a way so as not to reduce the capacity of the package to meet the regulations.

The intention of the author is to explore these variables and produce guidance for industry on best practice and also to highlight areas that may still not be clear so that they may be resolved in the future.

INTRODUCTION

This paper had intended to explore the issues outlined in the abstract above but has been scaled back because of time constraints, which meant that a detailed technical paper was not possible. The paper now poses several questions and proposals, which may benefit from wider discussion. The author has come to these positions following 20 years employment in the nuclear sector, 12 of which have been spent with the UK Competent Authority (predominantly within the engineering design assessment team but more recently with the compliance assurance inspection team).

[565][1] CONSIGNMENTS SHALL BE SECURELY STOWED

[606]: each package shall be designed with due consideration being given to its retention systems relevant to each intended mode of transport.
[612]: the components of the package, its contents and their respective retention systems shall be designed so that the package integrity will not be affected during routine conditions of transport.
[636]: the integrity of the package shall not be impaired by the stresses imposed on the package or its attachment points by the tie-downs or other retention systems in either normal or accident transport conditions.

The above regulations (ref 1) and their corresponding advisory material (ref 2) are what must be interpreted in order to inform our judgment on what is a secure load. Within the UK, TCSC 1006 (ref 3) is frequently used by industry and, recently, BS ISO 10276:2010 (ref 4), which advises on trunnions, has become approved.

<u>Observations from inspections:</u>

1. Non-nuclear RAM sector (UK)

59 organizations have been inspected (against ADR 2009 i.e. road transport) of those 11 (~20%) have been advised of non-compliance with the requirement to securely stow a package. If you consider that we have 1000 duty holders in this sector then it is probable that nearly 200 of them are not securing their packages correctly. Approximately half of these organizations are owners and carriers, the other half are solely 3rd party carriers. Consignments are typically carried in a small van. Methods of 'securing' are:

1. nothing (the package is free to move about the car boot or van);
2. rope, cargo netting or 'bungy' cord attached to points on the conveyance;
3. the package is held in a 'strong box', which is bolted to the conveyance (but can move freely within it); or
4. between 'bulkheads', which may be a simple wooden beam or something more sophisticated.

(NB VOSA[2], an agency of DfT, enforces general UK transport under the Road Traffic Act 1991 and the UK Construction and Use Regulations[3], it found that between 2009 to 2010 nearly 80% of loads were dangerous. They were able to issue fixed penalties but these only amounted to about £60 each).

2. Nuclear sector (UK)

Stowage has been witnessed reasonably frequently by road, less frequently by rail, and rarely by sea and air. The reasons for this are due to the complicated nature of the UK enforcement regime – see Appendix 1. This shows that, whilst the RMTT[4] approve package designs for all modes, the responsibility for enforcement falls upon 4 different entities. Where transport is by one mode only, then this model would seem reasonable but for multi-modal transport the model relies on clear agreements between the various bodies, which define e.g. responsibilities. There should also be frequent communication and multi-body inspections to ensure common understanding and consistent regulation. Whilst these agreements exist in the UK, communication and joint

[1] The 2005 editions of TS-R-1 and TS-G1.1 have been used.
[2] Vehicle and Operator Services Agency
[3] SI 1986 No. 1078
[4] Radioactive Materials Transport Team – a division of the UK Department for Transport

inspections are not as good as they could be. A recent inspection that involved road and sea highlighted the different modal approaches. At sea, tie-down is done in accordance with the Cargo Securing Manual (CSM), which refers to the Cargo Stowage and Security (CSS) code. The CSS in turn is referenced by the INF code, which is referenced from TS-G-1.1 (for NCT). Two things struck me when reviewing these substantial documents:

(a) each mode provides its own (substantial) technical guidance for secure stowage; and
(b) At sea the tie-down features (lashings, shackles etc) only require an inspection by the ship's crew at the time of use. There is not the requirement to proof test equipment, for example, that you might see by e.g. road where the 'lifting equipment' mentality is adopted.

Suggestion 1:Could the technical guidance/requirements be rationalized and simplified across all modes and a common template used?

Some Examples:
An example of a flask on a rail wagon can be seen in Fig 1. This picture comes from the IAEA TranSAS appraisal of the UK (Ref 6). It can be seen that there are very rigid connections between the flask and the conveyance via trunnions.

Figure 1 Flask on a rail wagon.

An example of a flask on a boat can be seen in Fig 2. This picture is of an EDF/British Energy package and shows their fuel flask tied-down on a PNTL ship using chains. Both the package and the lorry were tied-down. It should be noted that this international consignment was inspected by DfT and found to be fully compliant with the UK design and shipment approval certificates.

Figure 2 (left shows package tied down to ship, right shows lorry tied down to ship)

Questions

(a) What does 'securely stowed' mean?

I could find no definition of this within the UK RAM transport arena. I looked at general health and safety legislation concerning securing loads on road conveyances. The Road Traffic Act 1991 introduced new provisions that made new offences, applicable to the state of loads on vehicle. Regulation 40A states that a person is guilty of an offence if he uses, or causes or permits another to use, a motor vehicle or trailer on a road when 'the weight, position or distribution of its load or the manner in which it is secured, is such that the use of the motor vehicle or trailer involves a danger of injury to any person'. Surprisingly, the definition of secure stowage has not been tested in UK courts. If an accident occurs it is deemed better to prosecute the driver for dangerous driving or excessive speeds, which are easier to prove than not securing the load effectively. Interestingly, within the UK, the trailer bed must be approved to a required standard but the trailer need not. The question arises as to what is the benefit of imposing strict requirements on tie-down when the tie-down points i.e. the conveyance may not be terribly robust? The DfT Code of Practice – 'Safety of Loads on Vehicles' in section 15 (Carriage of Dangerous Goods) advises '…it is essential that the package be so secured that they do not fall off the vehicle, even in the event of vehicle collision or overturn…' although this is not a regulatory document.

Suggestion 2: should the IAEA regulations define secure stowage in the same way as e.g. a rigid target is defined? For example '…a package shall be stowed in such a way that its displacement relative to the conveyance shall be no more than 2% of the package minimum dimension' under any condition of transport except accident' or should it be goal setting e.g. '..a package shall be secured in such a way that it is undamaged following routine and normal transport'? Should it include accident conditions?

(b) Should [565] etc be amended to account for package types?

The regulations do not distinguish between package types when it comes to secure stowage – perhaps they should, with stricter application of secure stowage applied to the high hazard package types. I don't think many of us would be too concerned about an excepted package that was unconstrained in the boot of a car.

Suggestion 3: should there be a graded approach to secure stowage that reflects reality?

(c) What is the best Competent Authority model to ensure effective compliance across all package types and modes?

Whilst the IAEA standard on compliance assurance (ref 5) advises on what a Competent Authority should do, it does not advise on how it should organize itself so that it can do those functions most effectively. The IAEA publications on their TranSAS appraisals offer useful insight into the merits or pitfalls of certain countries but these represent only a small sample of Competent Authorities.

Suggestion 4: perhaps a questionnaire could be issued to gather information about Competent Authority models with a view to disseminating best practice.

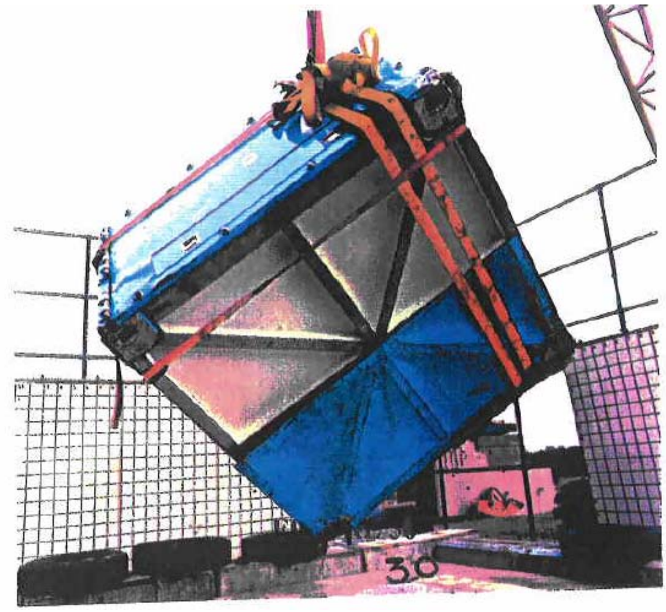
Assessment Experience: Demonstration of 'secure stowage'.

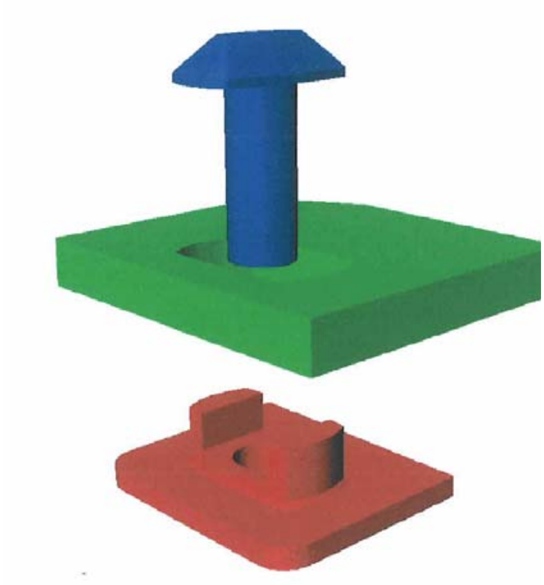
Predominantly hand calculations (or e.g. Mathcad calculations), which run on for many pages (I have seen 60 pages of calculations in support of a tie-down feature) and assess against many different allowables; or, very rarely, numerical analysis e.g. Finite Element Analysis (FEA). As an engineering assessor with nearly 12 years of experience in approving package designs, my preference would be for FEA – it is quicker to review and will (probably) give more information (if done correctly). (NB [701] of Ref 1 does allow other methods to demonstrate regulatory compliance). The models would be simple (rigid body with only tie-down features modeled as elastic-plastic) and there would be no complicated non-linear, large displacement issues to worry about – the parts are designed not to fail except possibly under accident conditions of transport. An additional advantage is that FEA can be used up-front, prior to manufacture i.e. as a design tool. The tie-down features can not only be optimized for restraint but also optimized for decontamination (which can be an issue) by designing out contamination traps. Packages are seldom dropped with their retention system attached, so ensuring that any weak link (that will fail preferentially to a packaging component) must be difficult to justify by hand calculations alone – surely testing or FEA are more robust methods?

Suggestion 5: FEA is routinely used to supplement or even replace physical testing for the 9m drop, punch and thermal tests. There is a reluctance to use FEA to prove the tie-down system – perhaps guidance could be up-graded to provide help in this matter?

An example of the successful use of numerical analysis is shown below: The package was designed to meet the 10g acceleration requirements for multimodal transport. The issue was to ensure that a stainless steel ISO plate would be capable of resisting the high bearing stresses resulting from contact between the standard ISO twist lock attachment and the machined hole in the plate.

The design solution was to use a high strength intermediate material pressed into the stainless steel plate and thus spread the load onto the stainless over a larger surface area. The design used a high strength inconel alloy material (this can just be seen in the drop test).





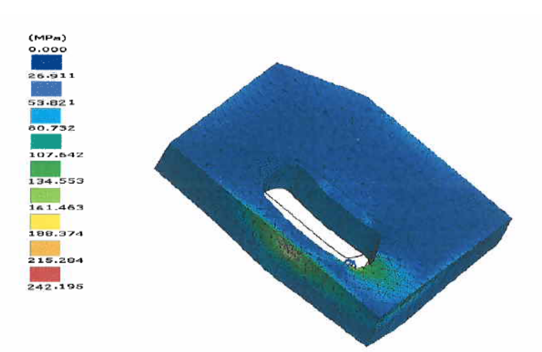


Figure 6A ISO Plate Stress Plot for Normal Conditions of Transport

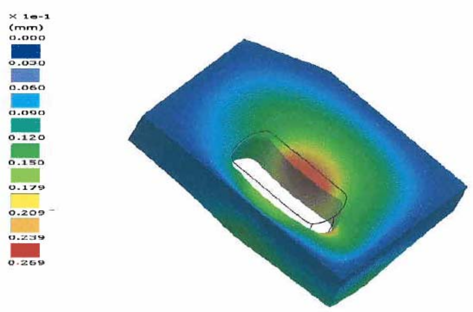


Figure 7A ISO Plate displacement Plot for Normal Conditions of Transport

Figure 3 (top left is package being dropped, top right is exploded FE model of tie-down, bottom left is stress plot and bottom right is displacement plot.

CONCLUSIONS

Regulatory experience in both the engineering package design assessment team and the compliance assurance inspection team has resulted in several observations. These have promulgated suggestions in the hope that their wider discussion might result in a combination of clarity, more effective design, appropriate regulations, safer packages and/or better regulation.

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REFERENCES

Ref 1 TS-R-1 – IAEA Safety Standards – Regulations for the Safe Transport of Radioactive Material, 2005 edition.
Ref 2 TS-G-1.1 – IAEA Safety Standards – Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material, 2005 edition.
Ref 3 TCSC 1006 – The Securing/Retention of Radioactive Material Packages on Conveyances, 2003 edition.
Ref 4 Standard BS ISO 10276:2010 – Nuclear energy – Fuel technology – Trunnions for packages used to transport radioactive material.
Ref 5 TS-G-1.5 – IAEA Safety Standards – Compliance Assurance for the Safe Transport of Radioactive Material, 2009 edition.
Ref 6 IAEA Safety Standards Applications – TranSAS-3 – Appraisal for the United Kingdom of the Safety of the Transport of Radioactive Material, 2002.

APPENDIX

1. Modal enforcement within the UK

Four different entities enforce the four different modes:

a. Road – Radioactive Materials Transport Team (RMTT) of Department for Transport (DfT);
b. Rail – railways Inspectorate (RI) of the Health and Safety Executive (HSE);
c. Sea – Maritime and Coastguard Agency (MCA); and
d. Air – Civil Aviation Authority (CAA)

The DfT, MCA and CAA all report to the Secretary of State for Transport. The DfT is the Competent Authority for all modes.