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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

DEC 15 1978

Mr. Tom Snead
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Dear Mr. Snead:

Enclosed is a discussion of "Development of Present Packaging Standards", which I brought to the ACRS in 1975. This is the information I had agreed to send to you.

Sincerely,

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Standards Branch
Office of Standards Development

cc: Public Document Room

Enclosure: As Stated

ACRS PRESENTATION - October 23, 1975

Development of Present Packaging Standards

Mr. Chairman, members of the Committee, I will briefly review the development of the present packaging standards with particular emphasis on the impact accidents in the air mode. My remarks are offered as further discussion of the basis for the existing standards.

The first comprehensive set of regulations governing the transportation of radioactive materials was adopted by the Interstate Commerce Commission in 1947. However, except for giving some material specifications for packaging for relatively small amounts of radioactivity, no packaging standards were set out in those regulations. As the nuclear power reactor program began to develop in 1957-58, I and other members of AEC staff met with the utilities and other groups and discussed need for standards for packaging for shipment of nuclear fuel. In March 1960, the AEC published a proposed regulation for shipment of solid, irradiated nuclear fuel. That standard specified that the container should be capable of withstanding the corner edge coming in contact with a solid object (such as a concrete pavement) traveling at 44 ft/sec (30-foot drop). In 1961, a revision was issued (26 FR 8982) specifying a 15-foot drop on an unyielding horizontal flat surface. A force equal to 60g's lasting not less than 16 milliseconds was deemed equal to the drop test.

In 1959 and 1960, the International Atomic Energy Agency convened two panels to consider international standards for safety in the transportation of radioactive materials. The panels adopted standards based on the ICC regulations but went further to specify that the packaging shall be adequate to

prevent any loss of dispersal of the radioactive contents and to retain the shielding efficiency, for type A packaging, under conditions normally incident to transport and, for type B packaging, under conditions normally incident to transport and for the maximum credible accident relevant to the mode of transport.

In 1963 and 64, the IAEA convened two panels to revise the international transport regulations; one a special panel on packaging standards. Thurber George of the Bureau of Explosives of the Association of American Railroads, which at that time approved all packages, on an ad hoc basis, for the ICC and I attended the packaging panel.

Considerable work had been done in the U.S. and a detailed report on tests for approval of packaging (AHSB(S)R-19- Interim Recommendations for the Application of Environmental Tests to the Approval of Packaging, Messenger and Fairbairn, 1963) had been developed by the United Kingdom Atomic Energy Authority in preparation for the packaging panel. I will review some of the information covered in R-19 and the objectives agreed on by the Packaging Panel for their work. But first let us complete the history of the development of the standards. In 1964, the IAEA issued revisions of the international regulations in which the type B tests, essentially the same as those currently in Part 71, were specified as: (1) mechanical tests - 9 meter free fall on an unyielding surface and 1 meter drop on the end of a 15 centimeter diameter mild steel bar; (2) thermal test - heat impact from a radiation environment of 800°C for 30 minutes with an emissivity of 0.9, assuming the package had an absorption coefficient of 0.8; and (3) immersion test - for certain fissile packages - 0.9m

of water for 24 hours divided by number of joints to be tested. The IAEA issued further revisions in 1967 and 1973 but those type B packaging test standards have been changed very little. In 1966, AEC issued 10CFR Part 71 which replaced the proposed 10CFR Part 72 and incorporated the type B packaging test standards in the 1964 version of the IAEA regulations.

Basis for the Standards The UKAEA report, R-19, and the IAEA Packaging Panel examined the transport environment and in particular the "Maximum credible accident". The main purpose of both the report and the panel was to recommend tests to be applied to packaging for large amounts of radioactivity designed to provide adequate safety against both normal transport and the "maximum credible accident." It was recognized that no tests can exactly reproduce actual transport conditions but procedures recommended should provide means of showing, at a reasonable cost, whether packaging could be expected to withstand such conditions.

Part C of R-19 describes Transport Accident Conditions. As indicated in the text, the test requirements must represent "the whole scale of the accident features of all modes of transport in all parts of the world." The report goes on to say that the "maximum credible (i.e., foreseeable) accident" is the worst accident or combination of accident elements that is to be taken into account in a packaging design, having regard to the nature of the contents, the mode of transport and, in some cases, the route and ~~generating~~ operating procedures to be used. It was recognized that to achieve acceptance and uniformity of standards throughout the world, more precise test standards were required. This is

true since however severe a packaging test would be designed, it would be possible to conceive of a more severe accident which could cause a package to fail.

The report R-19, discusses various types of accidents and the probability of their occurence.

Collisions including aircraft to ground crashes were examined. The collision velocities indicated were: for take-off 170 miles/hour, cruising 600 mph and landing 135 mph. Discussion of factors modifying the impact velocity included: collisions between aircraft in normal flight are rare; collisions occur mostly in the vicinity of airports where speeds tend to be reduced; and most aircraft-to-ground crashes occur at take-off or in landing or taxiing, when speeds are lower.

On page 52, R-19 states that specifications for aircraft crash recorders assume 100g for 1/2 second which is equivalent to stopping from 1100 mph in 40 feet. The impact velocity of current commercial aircraft is unlikely to reach 250 mph. R-19 goes on to indicate that irregular ground contact may cause aircraft to break up under as little as 5g. R-19 suggests that since the chances of an impact at right angles to the ground are small, packages are likely to strike at an angle.

Accident statistics for air were given as follows:

Passenger:

UK 35,000,000 vehicle - miles per accident

US 20,000,000

Cargo: US 5,500,000

with 1 chance in 8 of an accident being able to cause an incident.

Tables of striking velocity vs drop heights are presented and considerable discussion of different types of tests - fireproof safes, AEC's 15 foot drop for irradiated fuel casks, etc. The recommended test was a 30 ft. (9m) drop into a 1 foot wide rolled steel beam.

The specification of the mechanical test required considerable discussion by the Packaging Panel and actual test work between meetings. The prototype test as proposed in R.19 aimed to combine "impact and shear" in one drop by incorporating a 1-ft-wide rolled-steel box beam on the target. For long packages the beam also has a "back-breaking" effect. The development of the 1-metre drop onto the "punch" resulted from considerable work in the USA in relation to the shear component and, although the Packaging Panel first proposed to retain the beam for packages less than 1 tonne in weight, it was finally agreed to dispense with it in order to facilitate the development of calculative methods and model tests which the Panel considered would be an essential development for heavier packages.

Fire and immersion were also discussed but air transport conditions were not overriding.

R-19 suggested the maximum credible accident, for practical purposes, for air transport was represented by:

(1) a crash to the ground, the aircraft suffering a decelaration of 50g followed by a 30 minute liquid fuel fire with a mean effective temperature of 800°C and (ii) as for (i) but preceded by a mid-air collision. It was thought unlikely that the double impact in (ii) would be greatly more damaging than the single impact in (i).

The UK report R-19, augmented by practical studies in various countries including the United States of America, France and Italy, formed a basis of the work by the Packaging Panel. During its first meeting, the Panel agreed on broad objectives and kept these in mind during its work. These are:

(a) "to be comparable with conditions experienced in the transport environment but not to represent or reproduce every conceivable condition or even any particular condition".

In this respect in R-19 is stated: "If a transport package were to be designed to withstand every conceivable accident resulting from man-made and natural forces it would be non-transportable". This means that the tests, whether Type A or Type B, aim to simulate the damage to a package which would result from its exposure to the transport environment. How well they do this is, of course, a matter for discussion.

(b) "to be practical in that the number of tests be kept to a reasonable minimum and their nature be such that, as far as possible, they might be carried out using readily available facilities and equipment".

It may be of interest to note that R-19 specified 18 tests for Type A and three tests for Type B; earlier drafts included more tests for Type A, hence the name "testomania", which is sometimes disrepectfully, yet, I like to think affectionately given to the document.

(c) "to promote the development of alternative methods, other than the actual submission of samples or prototypes to the tests, for determining whether packaging could satisfy the relevant tests".

R-19 emphasizes the importance of this objective and indeed states: "The adoption of the recommendations of this report is not expected to lead to an orgy of testing".

In Chapter 5, Tests for Type A and Type B Packaging and Capsules of the book Safe Transport of Radioactive Materials, edited by Rob Gibson, Alan Fairbairn of the UKAEA and Thumber George, BofE of the AAR, discuss the basis for the standards:

"The choice of 30 ft. for the impact part of the mechanical test results from practical judgement first that in the course of transport Type B packages are unlikely to suffer higher drops on to very hard targets such as dock wharves, and second that a part of the impact during collisions at high speeds will be absorbed by the vehicles. For example, an express goods train may suffer a crash at 60 mph, a commercial aircraft may crash at 250 mph, nevertheless information from such accidents [and they reference R-19] indicates that much of the energy of the impact is absorbed by damage to the rail vehicle or aircraft and, as a result, it was considered most unlikely that a package being carried would be subject to an impact significantly exceeding that in the 30 ft. drop onto the very hard target".

In summary when the early IAEA standards were prepared, information on transport accidents was not readily available and in that 1961 version, Type B packaging was required to meet the "maximum credible accident", a concept borrowed from the reactor safety field.

In the 1964 revision of the IAEA regulations, Type B packaging was required to be capable of withstanding a series of accident tests selected to simulate the effects of severe accidents known to be probable, for example impact followed by fire, impact followed by upsetting, immersion in water, etc.

Considered as a whole, the Agency's Regulations have led the way in applying the philosophy that, when the hazard potential of the package contents exceeds a certain amount, then the packaging should be so designed that its integrity will be essentially maintained should the package be involved in a severe accident. In replacing the "maximum credible accident" stop-gap in the 1961 Regulations, the Packaging Panel strove to develop tests, sometimes termed "hypothetical", which it considered to be reasonably comparable, as regards simulation of damage, to the damage which a package could suffer in a transport accident.

It is my personal view and, as far as I can judge, the view of the Packaging Panel at that time that, in terms of damage to the package, the combination of the mechanical and termal tests as specified represents a very severe test indeed.

Reference

Tests on Transport Packaging for Radioactive Materials IAEA, Vienna, 1971, STI/PUB/285

HISTORICAL DEVELOPMENT OF REGULATIONS FOR TRANSPORT OF RADIOACTIVE MATERIAL (with emphasis on impact standards for packaging)

1936 U.S. Post Office - Prohibited shipping radioactive material by mail - in effect until 1949

1948 Interstate Commerce Commission - Adopted first comprehensive regulations for safety in transportation of radioactive material; basic principles of radiation control still being followed; contained no packaging standards - drafted by National Academy of Science committee chaired by Dr. Robley D. Evans.

1960 Atomic Energy Commission - Published proposed 10CFR Part 72 first regulations specific to packaging for solid irradiated nuclear fuel - introduced 30 foot free fall on cover of cask - 1961 - Proposed revision specified 15 foot drop on unyielding surface or 60g's for 16 milliseconds.

1961 International Atomic Energy Agency - Published "Regulations for Safe Transport of Radioactive Material" recommended for adoption and use by international and national authorities based on work of 2 panels of experts from U.S. and a dozen other countries. Packaging for significant quantities must withstand "maximum credible accident relevant to mode of transport".

1964 IAEA - Revision of Transport Regulations based on work of 2 panels, one a Packaging Panel using work of several countries including UK's AHSB(S) R 19 on "Environmental Tests"; specified Type B packaging accident damage tests: 9 meter drop on flat unyielding surface, 1 meter drop on 15 centimeter steel plunger, 30 minute 800°C fire, immersion (for Fissile Material). 1967 and 1973 revisions retain essentially the same tests.

1966 AEC - Adopted 10CFR Part 71 to replace proposed Part 72 - incorporated 1964 IAEA Type B tests.

1968 U.S. Department of Transportation - (established and given ICC transport safety functions in 1967) - Adopted revisions of 49 CFR 170-179 based on 1964 IAEA Transport Regulations. Required AEC review of package designs against 10CFR Part 71 standards.

1975 Nuclear Regulatory Commission - (established and assigned regulatory functions of AEC) June 2, noticed rule making proceeding to review standards; preparing Environmental Impact Statement on Air Transport.