International Civil Aviation Organization

ICAO-IAEA EXPERT WORKING GROUP ABOUT PRESSURE DIFFERENTIAL REQUIREMENT

World Nuclear Transport Institute
310-312 Regent Street, London, U.K.

Montreal – 21st to 22nd April 2017
Pressure differential in air carriage

• The current regulations

IAEA SSR-6 § 621 and ICAO-TI § 6;7.2.3

“Packages containing radioactive material to be transported by air shall be capable of
withstanding, without loss or dispersal of radioactive contents from the containment
system, an internal pressure that produces a pressure differential of not less than the
maximum normal operating pressure plus 95 kPa.”

Applies to all package types: excepted packages, industrial packages (IP-1, IP-2 and IP-3), type
A, type B(U), type B(M) and type C packages) independently of the physical form (solid, liquid,
gaseous)

• The possible issue

The requirement stated above may be difficult to achieve, especially in the case of packagings of large
dimensions, such as ISO freight containers which are commonly used as type IP-1 or IP-2 packages
for air carriage of tools and components as surface contaminated objects (SCO-I or SCO-II), and it
may seem excessively severe for low activity materials with little risk even in case of dispersion, such
as excepted packages loaded with solid radioactive materials for example.
Pressure differential in air carriage

- The proposal made by WNTI to solve the possible issue
  - First proposal submitted by WNTI in the IAEA 2013 review cycle
  - Submitted for comments to the ICAO DGP in November 2013
  - Redrafted proposal submitted in the 2015 review cycle.

- The decision taken by IAEA TRANSSC 31 in November 2015
  “No action taken. Decision on the proposal is deferred to the IAG (Inter Agencies Group) and other appropriate aviation organizations for further discussion and development.”

- The WNTI suggestion to TRANSSC 32 in June 2016
  - Creation of a dedicated WG of experts from aviation organizations, IAEA, interested competent authorities and the industry
Pressure differential in air carriage

• The purpose of the experts WG

✓ To share views on the implementation of para. 621 (ICAO-TI § 6.7.2.3)

✓ To reach a consensus on the interpretation of para. 621
  • If no consensus on the interpretation of para. 621, and/or
  • If the interpretation of para. 621 appears to be difficult to implement,

    To reach an agreement on the optimization of the pressure differential safety requirement which is needed.

✓ To review the IAEA SSG-26 & SSR-6 to assure that the wording accurately reflects the consensus on the interpretation of para. 621 and/or the optimization of the pressure differential safety requirement; to propose revision of SSR-6 (and ICAO-TI accordingly), if needed and revision of SSG-26 to provide additional guidance if needed

✓ To draft a working plan for further actions, if needed*

• The pace of the experts WG

  A two days meeting should be enough to provide the adequate recommendations to TRANSSC

• The attendance of the experts WG

  Dangerous Goods experts having some expertise in class 7 such as TRANSSC Members States representatives from Safety Authorities, WNTI, aircraft manufacturers and airworthiness experts.

*Actions, if needed can be implemented during the next IAEA review and revision cycle
Pressure differential in air carriage

ADDITIONAL INFORMATION
Pressure differential in air carriage

Current requirement:

• 621. *Packages* containing *radioactive material* to be transported by air shall be capable of withstanding, without loss or dispersal of *radioactive contents* from the *containment system*, an *internal pressure* that produces a pressure differential of *not less than maximum normal operating pressure* plus 95kPa.

1. How this requirement should be understood (engineer point of view)?

2. Current practices: three examples to illustrate the issue
   – Uranium ore samples.
   – Large contaminated equipment in ISO container as excepted package, IP-1 or IP-2
   – Solid radioactive material samples in excepted packages

3. Suggested list of items to be discussed by the WG

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How the requirement in para.621 should be understood?

- Example of a package containing a solid object, solid radioactive material or radioactive material in a capsule (no thermal power, no expected radiolysis phenomena)
- What is required:

- Containment system shall be able to withstand a differential pressure of 110 kPa. Are there other ways to demonstrate compliance?

At loading: inner pressure = atmospheric pressure at 15°C ≈ 100 kPa

MNOP: increase of inner pressure between 15°C and 55°C = 14.1 kPa

MNOP + 95 kPa = 14.1 + 95
≈ 110 kPa
Current practices – 1st example 1/3
Solid uranium ore samples: What they look like?

- These are solid natural mineral samples (rock, sand, soil,...) presenting no significant hazard except that their specific activity exceeds the exemption level for natural uranium (1 Bq/g ≈ 80 mg U/kg of material)

Soil samples (few tens of grams per plastic bag)

Geologic carrots (rocks, 8 cm in diameter, up to 1 m long, up to 15 kg each) in plastic tubes closed by adhesive tape, or in plastic sleeves, placed in a rack, made of plywood or natural wood
Current practices – 1st example 2/3
Solid uranium ore samples: How they are carried?

Plastic bags are gathered in fibreboard boxes (from few kg to few tens of kg each), placed in a plywood outer box. The whole package is UN2910

Several racks closed, placed in an outer steel box. The whole package is UN2910
Solid uranium ore samples: Why are they carried by air?

- The transport of these samples are needed for uranium exploration activities, often from geographical areas difficult to access (from everywhere in the world to few laboratories).
- It is necessary for the teams of geologists to know as soon as possible the results of analysis of their samples to continue their activities.
- Land transport combined with sea-carriage is not really adapted to meet these constraints.
- Carriage by air offers much more commodities for those shipments.
Current practices – 2nd example 1/4

Large contaminated equipment in ISO container

- Computer Numerical Controlled lathe used in NPPs for maintenance and/or repairing of control rod drive mechanism: in a 20-foot ISO container as excepted package, type IP-1 or type IP2 (SCO)
Current practices – 2nd example 2/4
Large contaminated equipment in an ISO container

• Other equipment used in NPPs for maintenance and/or repairing of control rod drive mechanism: in a 20-foot ISO container as excepted package, IP-1 or IP-2 (SCO)
Current practices – 2nd example 3/4

Large contaminated equipment in an ISO container

• ISO containers have holes fitted with high efficiency filters to allow the equalization of the pressure during the climb and descent phases (9 kPa/min)
Why these equipment are shipped primarily by air?

- Equipment used during maintenance or repair operations on NPPs are sometimes cumbersome, often expensive and very specific and usually belong to companies specializing in this type of intervention.
- The distances involved to bring this material in the different NPPs served can be large, and the required delay for intervention may be incompatible with a land and maritime transport.
Solid radioactive material samples in excepted packages - *Old configuration*

- Solid radioactive samples in sample tubes (not able to withstand 95 kPa gauge pressure) leak tight up to 55°C in atmospheric ambiance
- 12 sample tubes in 1 intermediate packaging qualified for 95 kPa (MNOP considered as being nil …)
- One intermediate packaging in an outer packaging

- Closing at 15°C, heating at 55°C, pressure increase = 14kPa
- Max depressurization = 75kPa (ICAO-TI); 75+14 = 89 kPa < 95 kPa
Current practices – 3rd example 2/2
Solid radioactive material samples in excepted packages – Current configuration

- Solid radioactive samples in sample tubes (not able to withstand 95 kPa gauge pressure) leak tight up to 55°C in atmospheric ambiance
- 2 Sample tubes in 1 intermediate packaging qualified for 150 kPa
- 3 intermediate packagings in an outer packaging

• Closing at 15°C, eating at 55°C, MNOP = 14 kPa
• 14 kPa + 95 kPa = 109 kPa; 109kPa < 150 kPa
• Strictly compliant with the rules, but more expensive and less practical than before
What about other dangerous goods?

- Packagings for **solid dangerous goods**, even in powder form, are **not required to remain leaktight** when considering the pressure variations that can occur in an aircraft;

- Some of the packagings allowed for **liquid dangerous goods** are **not able to withstand a combination of those 3 conditions** (see example for Ethanol, UN1070, Class 3, PGII, with the use of formulas (b) or (c) in 4;1.1.6 for inner packaging of combination packaging, or (b) or (c) in 4;1.1.16 or 6;4.5.3 for single packaging)
  - Filling and closing at 15°C at sea level (100 kPa),
  - Heating up to 55°C,
  - Ambient pressure decreased from 100 kPa to to 75 kPa (minimum pressure in a pressurized aircraft in normal flight conditions)

- **Only single packagings** for **PG-I liquid dangerous goods** are able to withstand the conditions described for emergency situations (rapid decompression) in IATA Std Specification 80/2 and in ISO 11242 Std. Inner packagings of combination packagings for PG-I liquid dangerous goods are **not able to withstand those conditions**
Non exhaustive list of items which could be discussed by the WG

- Minimum ambient pressure inside cargo holds of a commercial aircraft: 25 kPa as stated in ICAO-TI or other value?
- Maximum pressure rate variation in cargo holds of a commercial aircraft in phases of climb and descent: 9 kPa per minute (2500 feet / minute) or other value?
- Shall depressurization incident be considered as part of normal conditions of transport?
- Maximum ambient pressure decrease in case of depressurization incident? 50 kPa? 75 kPa? or other value?
- Which are the recommendations against the risk of over pressure for large packages or containers not able to withstand the pressure differential resulting of a depressurization incident?
- Could/should the requirement and/or the guidance be amended?
### Graded approach in package design

The graded approach of IAEA SSR-6

<table>
<thead>
<tr>
<th>Activity of the content</th>
<th>Transport conditions</th>
<th>Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 3000 A&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Type C</td>
<td>Routine + Normal + Accident</td>
</tr>
<tr>
<td>&gt; 1 A&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Type B(M)</td>
<td>Routine + Normal</td>
</tr>
<tr>
<td>&gt; 1 A&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Type B(U)</td>
<td>Non approved package designs</td>
</tr>
<tr>
<td>1 A&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Type A</td>
<td>Routine + Normal</td>
</tr>
<tr>
<td>LSA-III</td>
<td>Type IP-3</td>
<td>Routine + Normal</td>
</tr>
<tr>
<td>LSA-II/SCO-II</td>
<td>Type IP-2</td>
<td>Routine + Normal</td>
</tr>
<tr>
<td>LSA-I/SCO-I</td>
<td>Type IP-1</td>
<td>Routine + Normal</td>
</tr>
<tr>
<td>≈ 1/1000 A&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Excepted package</td>
<td>Routine</td>
</tr>
<tr>
<td>Content</td>
<td>Package type</td>
<td>Transport conditions</td>
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</table>

#### Fissile material

<table>
<thead>
<tr>
<th>FISSILE</th>
<th>Routine + Normal + Accident</th>
<th>Approved package designs</th>
</tr>
</thead>
<tbody>
<tr>
<td>FISSILE paras 674 or 675</td>
<td>Routine + Normal</td>
<td>Non approved package designs</td>
</tr>
<tr>
<td>Fissile excepted</td>
<td>Routine</td>
<td>Non approved package designs</td>
</tr>
<tr>
<td>Content</td>
<td>Transport conditions</td>
<td>Approval</td>
</tr>
</tbody>
</table>

#### UF6

| ≥ 0.1 kg UF6 | Routine + Normal + Fire | Approved package designs |
| < 0.1 kg UF6 | Routine                 | Non approved package designs |
| Content     | Transport conditions    | Approval |

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Pressure variation outside and inside an aircraft - routine

- Typical altitudes and pressure differentials

<table>
<thead>
<tr>
<th>Altitude</th>
<th>Pressure (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>34000 ft</td>
<td>75</td>
</tr>
<tr>
<td>8000 ft</td>
<td>25</td>
</tr>
<tr>
<td>8000 ft</td>
<td>75</td>
</tr>
<tr>
<td>0 ft (sea level)</td>
<td>100</td>
</tr>
</tbody>
</table>

Flying altitude all kinds of aircraft
Max cargo hold altitude
Non pressurized aircraft
Pressurized and partially pressurized aircraft
Pressurized and partially pressurized aircraft
Pressurized aircraft

- Rate of change of pressure:
  - 500 ft/minute = 1.8 kPa/minute
  - 2500 ft/minute = 9 kPa/minute

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Typical depressurization incident (A330 – Toulouse 2006)

- Pressure variation outside and inside an aircraft NCT or ACT?

<table>
<thead>
<tr>
<th>Flying altitude</th>
<th>Max cabin altitude</th>
<th>Normal cabin altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>41000 ft</td>
<td>34000 ft</td>
<td>8000 ft</td>
</tr>
<tr>
<td>25 kPa</td>
<td>25 kPa</td>
<td>100 kPa</td>
</tr>
<tr>
<td>&gt;7000 ft/minute</td>
<td>≈50 kPa</td>
<td>10000 ft</td>
</tr>
<tr>
<td>100 kPa</td>
<td></td>
<td>0 ft (sea level)</td>
</tr>
<tr>
<td>500 ft/minute = 1.8 kPa/minute</td>
<td></td>
<td>0, 1, 2, 5 min</td>
</tr>
</tbody>
</table>
Pressure variation outside and inside an aircraft  NCT or ACT?

- Typical depressurization incident (B747, N-W Manila, 2008)

<table>
<thead>
<tr>
<th>Flying altitude</th>
<th>Max cabin altitude</th>
<th>Normal cabin altitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>≈40 kPa</td>
<td>36.2 kPa</td>
<td>25900 ft</td>
</tr>
</tbody>
</table>

Depressurization

Emergency
descent

Pressurized aircraft

>20000 ft/minute

0 ft (sea level)

100 kPa

8000 ft

10000 ft

29000 ft

25900 ft

22000 ft

0 1 7 min

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