U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration

Proposed Revision of the International RAM Transportation Activity Limits

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November 16, 2023

Disclaimer

Today's presentation discusses proposed changes to the IAEA Transportation Regulations. The proposal is mature, though not finalized, and is subject to change.

Some information and figures in this presentation are taken from publicly available IAEA presentations and an IAEA report document currently in final draft.

The views expressed in this presentation are solely those of the presenter and do not necessarily reflect the views of PHMSA, US DOT, IAEA, its affiliates, or employees.

RAM Transport Regulations Activity Limits

1 Background and History

2 New Methodology

3 What's Changed?

4 Current Status

5 Conclusion

What are the "A values"?

- A values - radionuclide specific activity limits used throughout the RAM transportation regulations.
  - A_1 – "Special Form" undispersible source, external exposure only
  - A_2 – "Normal Form" all other cases, internal/external exposure and contamination

Symbol of radionuclide	Element and atomic number	A_1 (TBq)	A_1 (Ci)[b]	A_2 (TBq)	A_2 (Ci)[b]	Specific activity	
						(TBq/g)	(Ci/g)
Ac-225 (a)	Actinium (89)	8.0×10^{-1}	2.2×10^{1}	6.0×10^{-3}	1.6×10^{-1}	2.1×10^{3}	5.8×10^{4}
Ac-227 (a)		9.0×10^{-1}	2.4×10^{1}	9.0×10^{-5}	2.4×10^{-3}	2.7	7.2×10^{1}
Ac-228		6.0×10^{-1}	1.6×10^{1}	5.0×10^{-1}	1.4×10^{1}	8.4×10^{4}	2.2×10^{6}
Ag-105	Silver (47)	2.0	5.4×10^{1}	2.0	5.4×10^{1}	1.1×10^{3}	3.0×10^{4}
Ag-108m (a)		7.0×10^{-1}	1.9×10^{1}	7.0×10^{-1}	1.9×10^{1}	9.7×10^{-1}	2.6×10^{1}
Ag-110m (a)		4.0×10^{-1}	1.1×10^{1}	4.0×10^{-1}	1.1×10^{1}	1.8×10^{2}	4.7×10^{3}
Ag-111		2.0	5.4×10^{1}	6.0×10^{-1}	1.6×10^{1}	5.8×10^{3}	1.6×10^{5}
Al-26	Aluminum (13)	1.0×10^{-1}	2.7	1.0×10^{-1}	2.7	7.0×10^{-4}	1.9×10^{-2}
Am-241	Americium (95)	1.0×10^{1}	2.7×10^{2}	1.0×10^{-3}	2.7×10^{-2}	1.3×10^{-1}	3.4
Am-242m (a)		1.0×10^{1}	2.7×10^{2}	1.0×10^{-3}	2.7×10^{-2}	3.6×10^{-1}	1.0×10^{1}

Excerpt from 49 CFR 173.435

Where Can you Find the "A values"?

- IAEA - SSR-6 – Table 2
- UN Model Regulations, Transport of Dangerous Goods Vol I – Table 2.7.2.2.1
- DOT - 49 CFR 173.435
- NRC - 10 CFR 71, Appendix A, Table A-1
- Many State RAM Regulations
- UN Member States' Regulations
- UN Modal Regulations (IMO, ICAO)

All are harmonized*

*Mo-99 has alternative "domestic use" A_2 value in US.

What are the "A values" Used For?

A_1 and A_2 values are key in characterizing RAM packages :

- Type A or Type B,
- Excepted Packages,
- LSA and SCO activity limits,
- LSA-II and LSA-III specific activity limits,
- Content activity limit for the transport of RAM by air,
- Unilateral vs Multilateral Type B approvals.

What are the "A values" Used For?

Other Uses:

- Criteria for release rate of radioactive content in normal and accident transport conditions for Type B and Type C packages (10^{-6} A_2/h and 1 A_2/week).
- In modal regulations, security activity threshold for "high consequence radioactive material" per single package, requirement for a transport security plan (3,000 A_2).
- NASA/DOD/FAA use A_2 for Mission Multiple to assess risk category for radiological space launches (100,000 A_2).

How are A values Calculated?

Baseline Assumptions:

- Loss of all safety functions/shielding,
- Individual located 1 meter from package for 30 minutes,
- 300 m^3 warehouse.

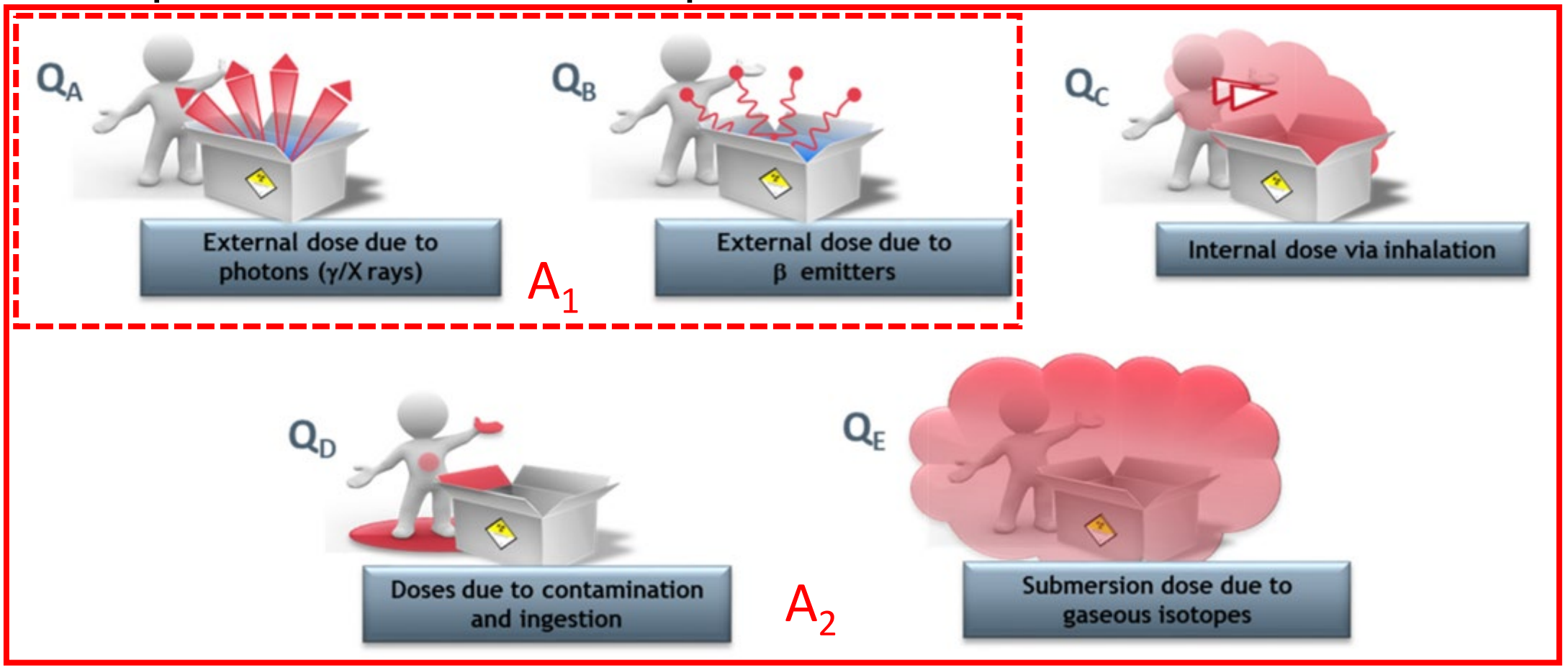
Accident Dose Limits:

- Effective dose of 50 mSv (5 rem),
- Skin equivalent dose of 500 mSv (50 rem),
- Lens equivalent of 150 mSv (15 rem).

Five Exposure Pathways…

How are A values Calculated?

The “Q System” - 1985 methodology to evaluate radiological consequences for RAM transportation accidents.



Source: IAEA TRANSSC / ISRN

Brief History of RAM Transportation Regulations

1961	IAEA 1st published Safety Series No. 6 – Regulations for the Safe Transport of Radioactive Material.
1966/68	AEC (NRC) and US DOT adopt Safety Series 6.
1973	IAEA updates Safety Series No. 6 with 1st radionuclide activity limits. Concept of A_1 and A_2 introduced.
1983	US DOT and NRC adopt A values in 49 CFR 173 and 10 CFR 71.
1985	IAEA updates Safety Series No. 6 with revised A values based on the new Q-system (ICRP 26).
1995	US DOT and NRC adopt Q system-based A values in 49 CFR 173 and 10 CFR 71.

Brief History of RAM Transportation Regulations

1996 IAEA updates Safety Series No. 6 with revised A values based on an update to the Q-system with ICRP 60 data.

2004 US DOT and NRC adopt current A values in 49 CFR 173 and 10 CFR 71.

2018 IAEA published current revision of SSR-6 (no changes to A values).

2024(?) US DOT and NRC harmonize with SSR-6 (2018).

What's next?

Time for a Change

IAEA Transport Safety Standards Committee (TRANSSC) Working Group formed in 2013 to evaluate the Q system.

Several issues were identified:

- Calculations use outdated or inconsistent input data,
- Some calculations were un-reproduceable,
- Treatment of Progenies inconsistent,
- Approximations done for energy deposition,
- Improved probabilistic monte-carlo calculation methods and updated ICRP data now available.

New Methodology

The multi-national group began using improved methods to calculate new A values:

- Initial assumptions/accident scenarios are unchanged,
- Most recent ICRP sources,
- Modern Monte-Carlo tools:
  - MCNP, FLUKA, GEANT4, PHITS
- New software code, CORAL, developed to evaluate and output results. Easily updatable in the future,
- 1,252 radionuclides evaluated vs ~383 previously.

Input Data

	Current Q system	Update of the Q system
Recommendations	ICRP 60	ICRP 103
Spectra	ICRP 38	ICRP 107
	No data	SOURCES4C and TALYS for (α,nγ) spectra
		JEFF3.3 & ENDF/B-VIII databases for dual β^+/β^- emitters
External dose coefficients	ICRP 51 (Q_A)	ICRP 116 (Q_A, Q_B, $Q_{D,skin}$)
	Cross et al. (Q_B, $Q_{D,skin}$)	
	Federal Guidance Report 12 (Q_E)	ICRP 144 (Q_E)
Intake dose coefficients	ICRP 68 (Q_C, $Q_{D,ing}$) ICRP 32 (Q_C / Q_E for Rn)	ICRP 130, 134, 137, 141, 151 (Q_C, $Q_{D,ing}$)
Progenies	10-day rule	10-day rule, or no consideration of progenies (mixture rule to be considered by the users)
Calculations	Deterministic & Probabilistic	Probabilistic (Monte-Carlo)
	1 radionuclide → 1 value: necessity to perform lengthy calculations in case of updates of the spectra and dose coefficients	1 energy → 1 energy-dependent fluence or dose → 1 point of the transfer function → 1 value by convolution with the transfer function; quick updates with any spectra and dose coefficients
	Several sources, documentation missing	Unified method + detailed report

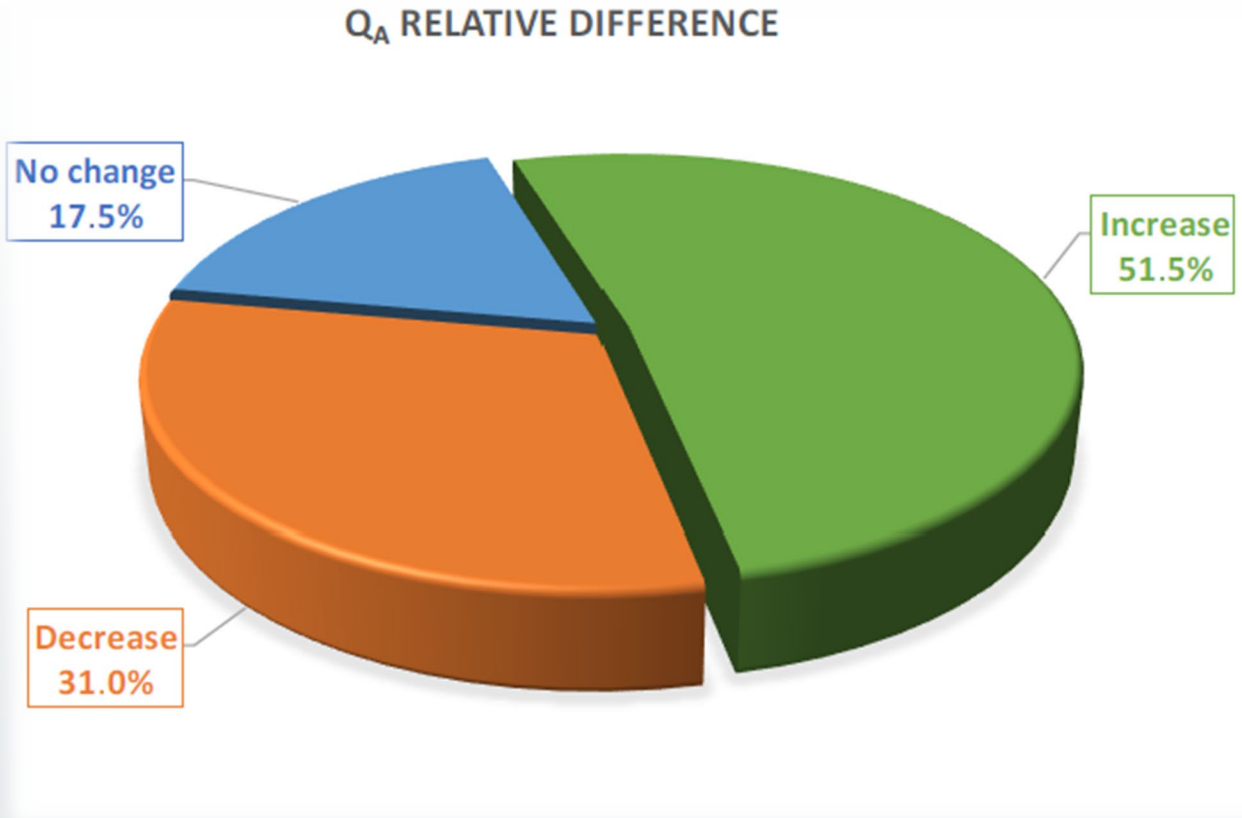
Source: IAEA TRANSSC / ISRN

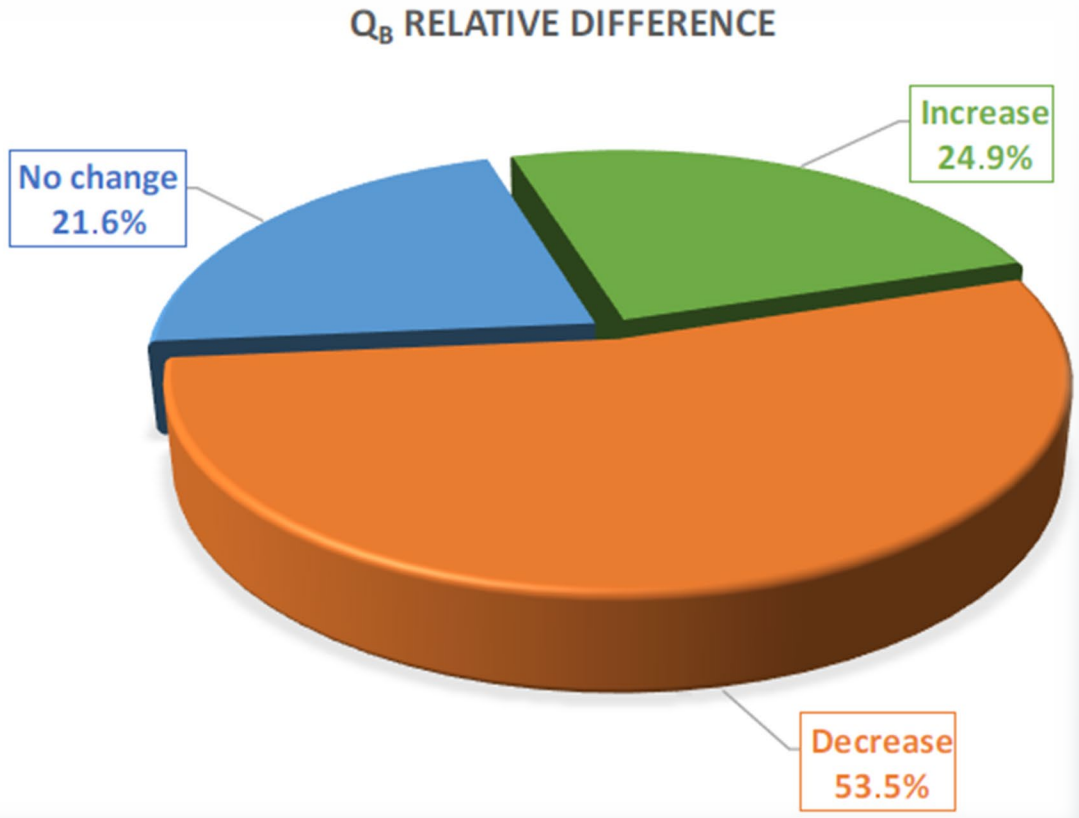
Radiation Types Evaluated

	Current Q system	Update of the Q system
Q_A	Effective dose (photons)	Effective dose (all radiations)
Q_B	Equivalent dose to the skin (beta radiations) Equivalent dose to the eye lens (beta radiations) mentioned but not evaluated	Equivalent dose to the skin (all radiations) Equivalent dose to the eye (all radiations)
Q_C	Effective dose due to inhalation (all radiations)	Effective dose due to inhalation (all radiations)
Q_D	Effective dose due to ingestion (all radiations) mentioned but not evaluated.	Effective dose due to ingestion (all radiations)
	Equivalent dose to the skin due to contamination (beta radiations)	Equivalent dose to the skin due to contamination (all radiations)
Q_E	Effective dose due to external exposure via submersion in noble gases (photons)	Effective dose due to external exposure via submersion in noble gases (all radiations)
	Equivalent dose to the skin due to external exposure via submersion in noble gases (beta radiations)	Equivalent dose to the skin due to external exposure via submersion in noble gases (all radiations)
Q_F	External effective dose due to alpha particles ($= 10^4 Q_C$)	Discarded: now included in Q_A and Q_B (effective and skin equivalent doses)

Source: IAEA TRANSSC / ISRN

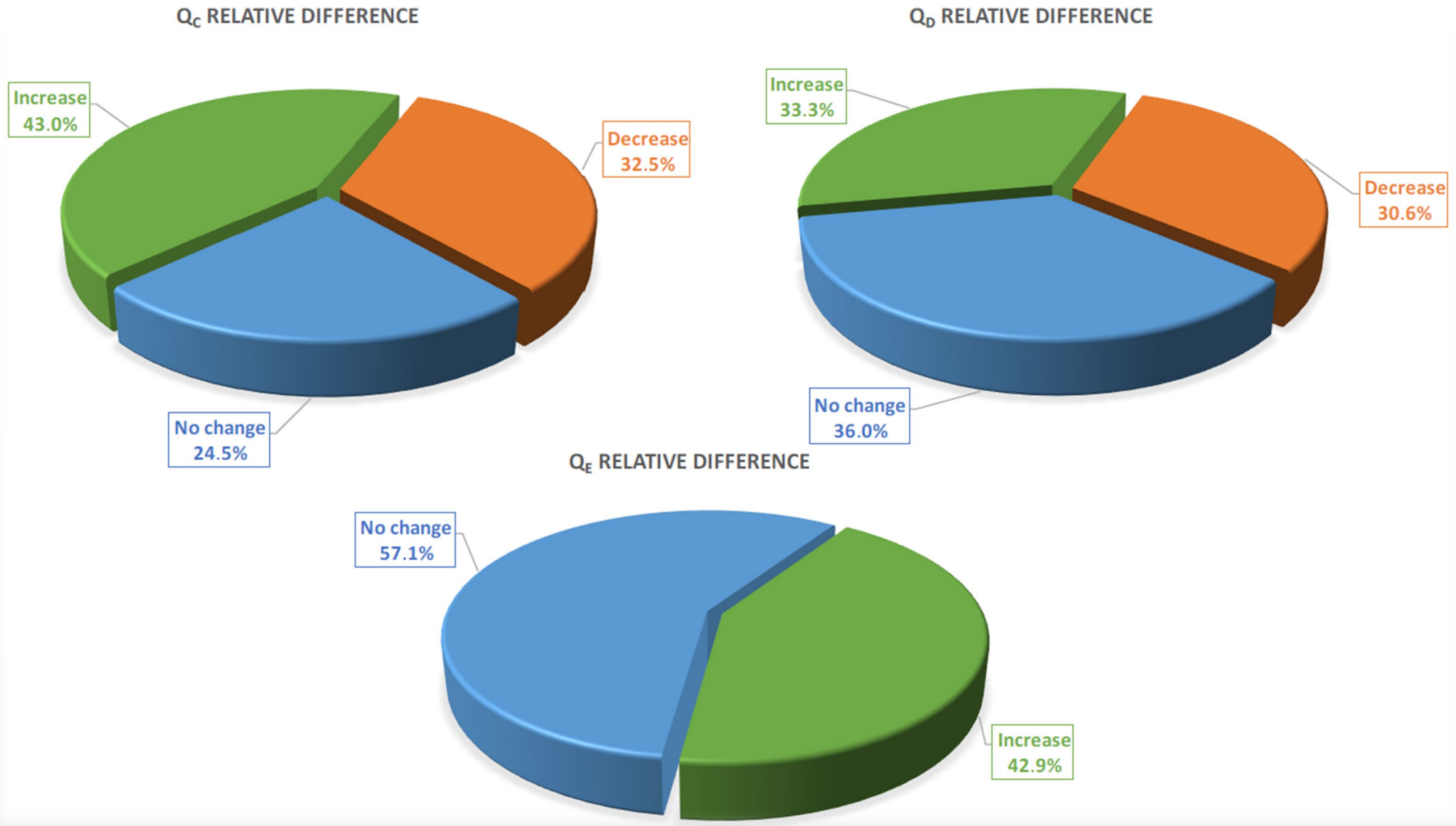
What's Changed ? - Q_A & Q_B





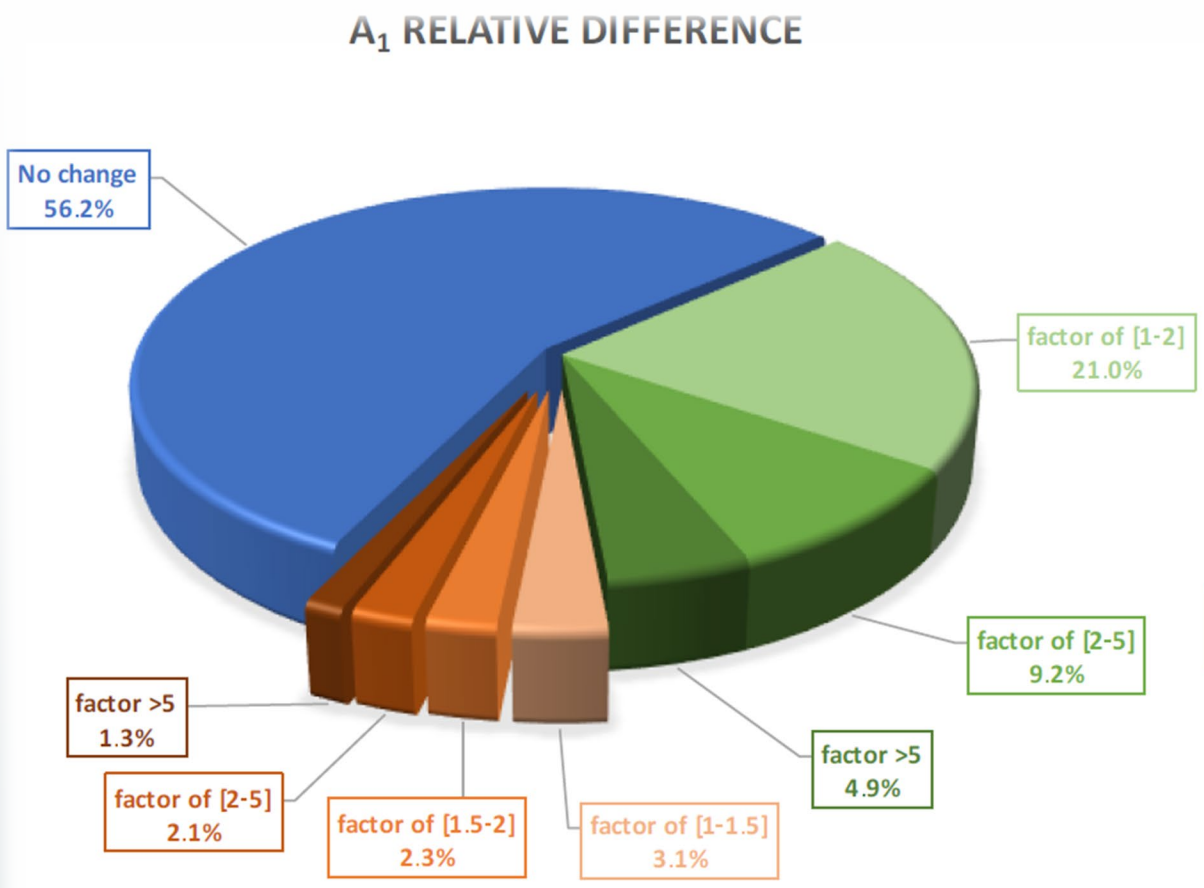
Source: IAEA TRANSSC / ISRN

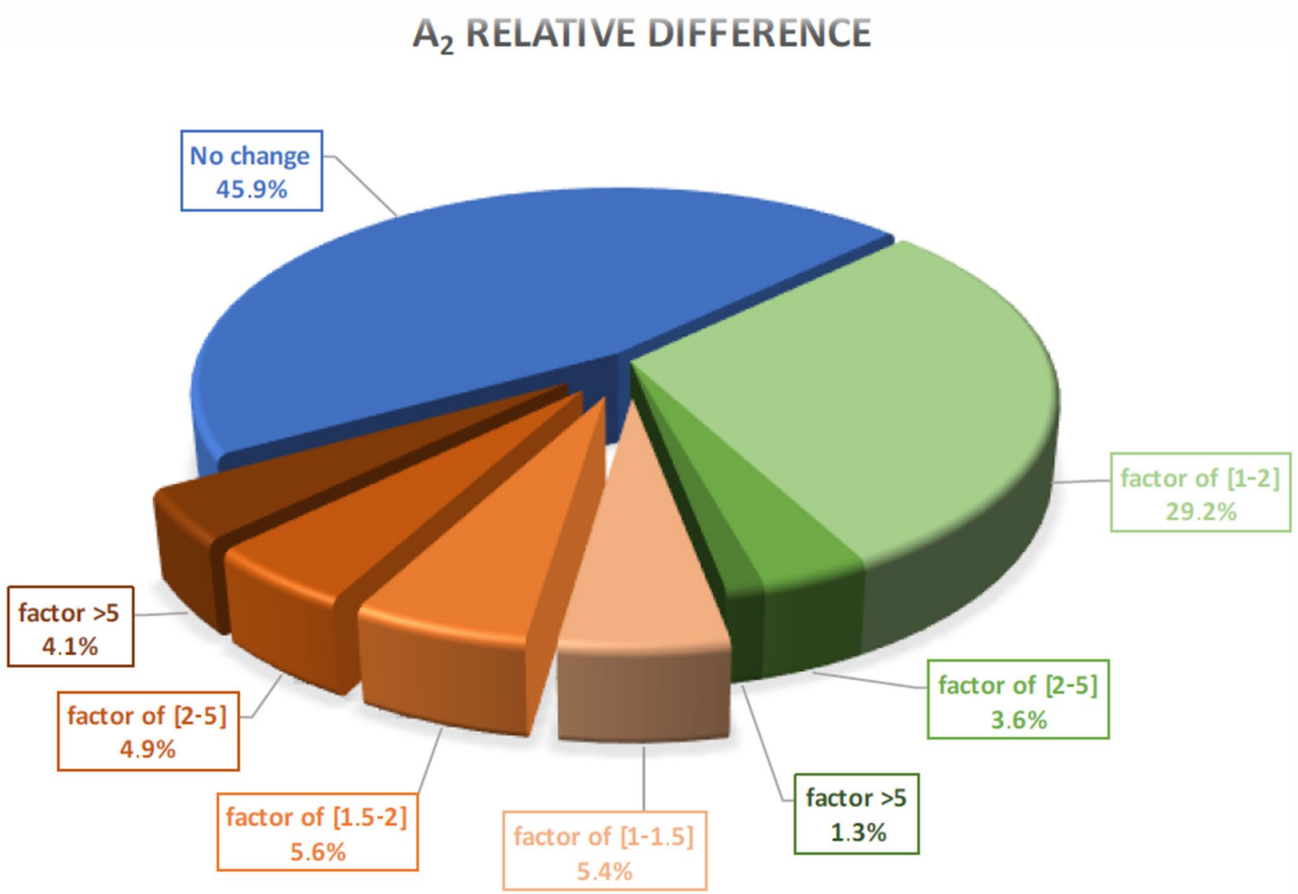
What's Changed ? - Q_C, Q_D, & Q_E



Source: IAEA TRANSSC / ISRN

What's Changed ? - A_1 & A_2





Blue: no change in A values *Orange gradient: decrease of A values* *Green gradient: increase of A values*

Source: IAEA TRANSSC / ISRN

New Methodology

The A_1 values of 15 radionuclides have significantly lower A_1 values:

Bi-212 (0.71)	Ca-47 (0.27)	Cf-250 (0.30)
Dy-166 (0.44)	Hf-182 (not unlimited)	
In-114m (0.05)	Pb-212 (0.57)	Pm-148m (0.63)
Pt-188 (0.4)	Rh-102m (0.25)	Sr-92 (0.8)
U-230 (0.25 - 0.33)	Xe-122 (0.5)	

The A_2 values for were noted to have particularly decreased for:

Ac-225 (0.12)	At-211 (0.01)	Bi-212 (0.002)
Pb-212 (0.05)	Ra-223 (0.29)	Ra-224 (0.04)
Ra-225 (0.05)	Ra-226 (0.67)	U-230 (0.02 – 0.67).

New Chemical forms of Uranium are now listed and calculated (ICRP 137 added new S form and S/M form).

Current Status

TRANSSC has been in a revision cycle from 2021 – 2023.

TRANSSC met from November 6 – 10, 2023 and approved the draft for publication (including the new A values).

IAEA Member States will have one final opportunity to comment in Spring 2024.

Expected publication of new revision of SSR-6 in 2026.

Transition period for A values - effective date of 10 years after publication.

For More Information

The methodology for the current Q system is documented in IAEA's SSG-26 Rev 1:

Advisory Material for the IAEA Regulations for the Safe Transport of Radioactive Material (2018 edition)

The new methodology and updated values are thoroughly documented in a report available on the IAEA TRANSSC website:

WG A_1-A_2 Report for Review and Revision Cycle

QUESTIONS?

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