MRI

CONSIDERATION OF SAFETY REQUIREMENTS FOR LARGE PACKAGES WITH Q SYSTEM

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Introduction

Transport of a large component is approved as a “Special Arrangement” package in European countries and as “Special Permit” in the US. But “Special Arrangement” and “Special Permit” are not familiar in Japan.

The transport of the used Reactor Pressure Vessel (RPV) of the nuclear ship Mutsu was the only instance in Japan. There are no cases where a planned series of multiple consignments were accepted for “Special Arrangement”.

For understanding Special Arrangement properly, we consider the safety requirements for large component transport with the Q system as established in TS-R-1.

Basic Safety Concept

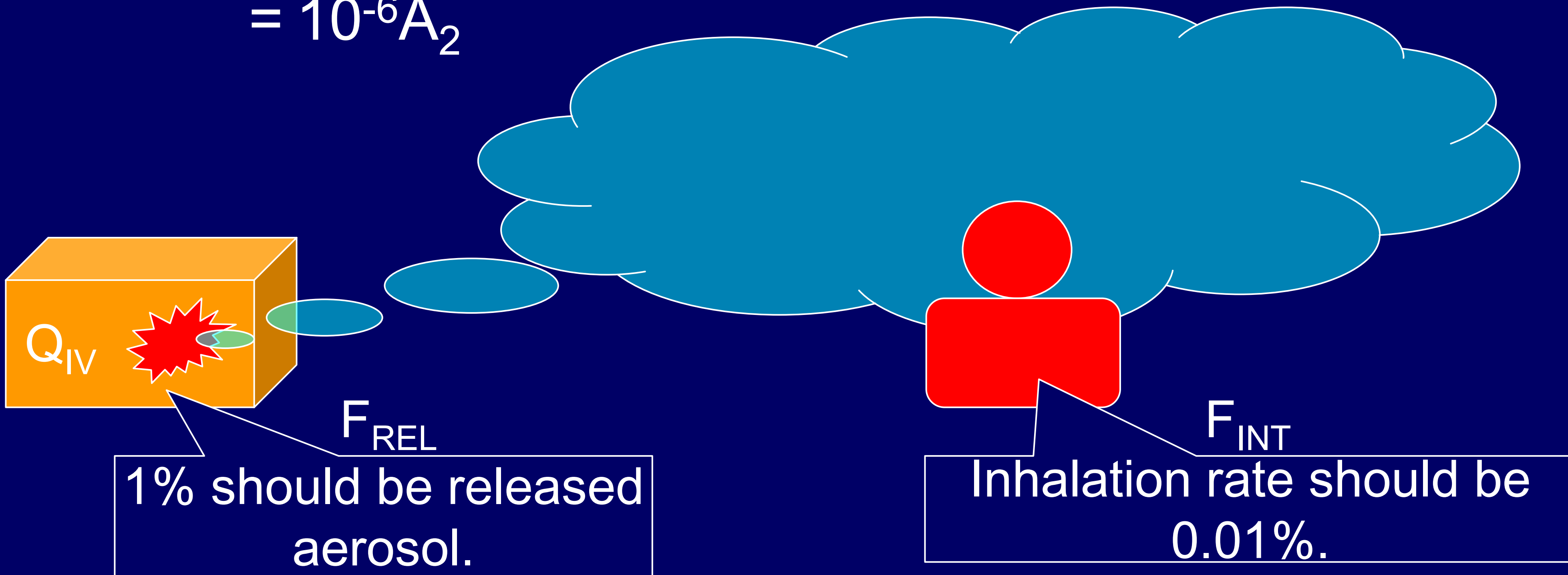
Special Arrangement requires demonstrating satisfaction of the requisite standards of safety established by TS-R-1.

Demonstrate through alternative means

- Demonstrate the safety level in routine conditions of transport **(incident free)**
- Demonstrate the safety level in normal conditions of transport **(minor mishaps)**
- Demonstrate the safety level in accident conditions of transport **(accident)**
  - **Demonstrate the capacity** to keep containment of the radioactive contents, control external radiation levels, prevention of criticality and prevention of prevention caused by heat
    Demonstrate the capacity with Safety Analysis (idea similar to Type B package)
  - **Demonstrate little damage effect with contents limits**
    The contents limits should be able to be set with idea similar to a Type A package and LSA/SCO

Release Model with Q system 【Type A】

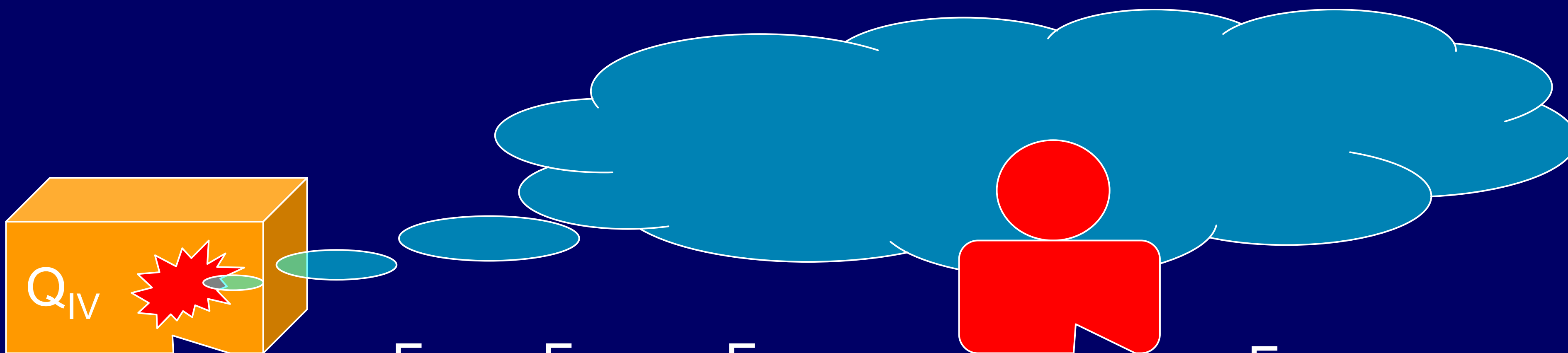
$$Q_{INT} = Q_{IV} \times F_{REL} \times F_{INT}$$
$$= A_2 \times 10^{-2} \times 10^{-4}$$
$$= 10^{-6} A_2$$



(ref) IAEA-TS-G-1.1

Release Model with Q system 【SCO-I】

$$Q_{INT} = Q_{IV} \times F_{RSUS} \times F_{SCRAP} \times F_{REL} \times F_{INT}$$
$$= (4 \times 10^{4}\ \mathrm{Bq/cm^{2}} \times 0.2 + 4\ \mathrm{Bq/cm^{2}}) \times 10^{5}\mathrm{cm^{2}} \times 0.2 \times 10^{-4}$$
$$= 0.8 \times 10^{-6}\ A_{2}\quad (A_{2}=0.02\mathrm{TBq})$$



F_{RSUS}, F_{SCRAP}, F_{REL}

An object with a surface area of 10 m² could have fixed contamination. 20% of the surface of the SCO-I object is scraped and 20% of the fixed contamination from the scraped surface is freed.

F_{INT}

Inhalation rate should be 0.01%.

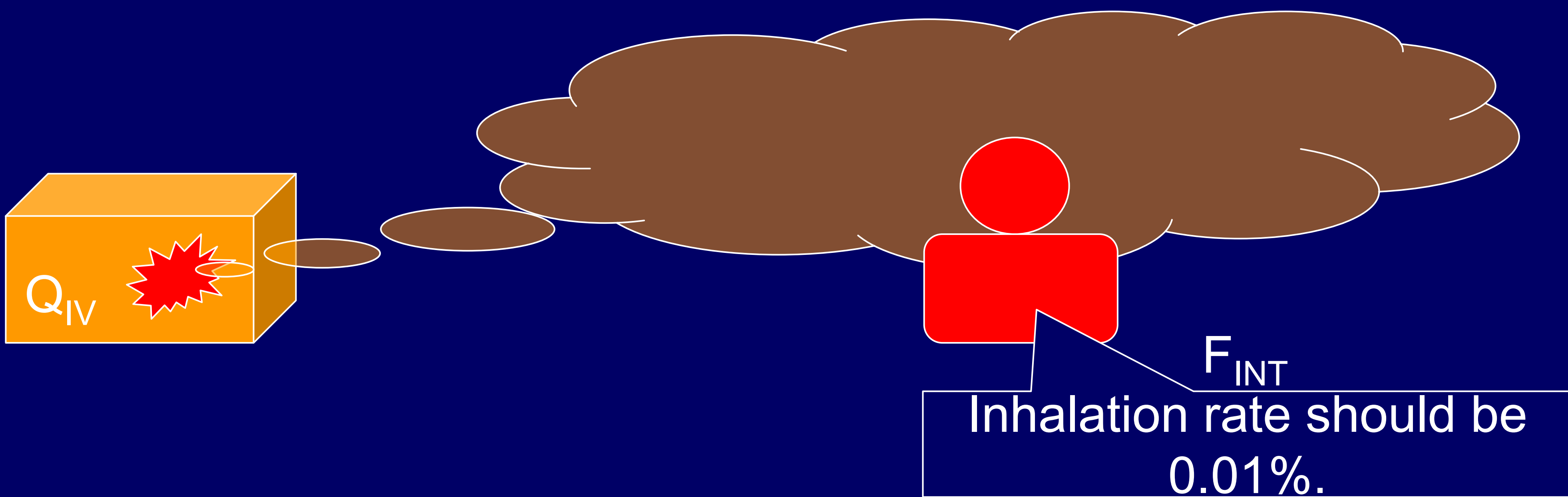
(ref) IAEA-TS-G-1.1

Release Model with Q system 【Large Component】:PROPOSAL

$$Q_{INT} = Q_{IV} \times F_{SCRAP} \times F_{RSUS} \times F_{REL} \times F_{INT}$$

or

$$Q_{INT} = Q_{IVtotal} \times F_{REL} \times F_{INT}$$



(ref) IAEA-TS-G-1.1

Release Fraction in US SG Replacement Cases

	H. B. Robinson	Point Beach	Surry
	1983	1983	1978
Activity in Steam Generator	310 Ci	300 Ci	1400 Ci
Fraction of Activity Becoming Airborne	0.1	0.1	0.001
Respirable fraction	0.01	0.01	ND
Site Boundary χ/Q	1.7×10^{-3} sec/m^3	7×10^{-3} sec/m^3	1.6×10^{-3} sec/m^3
Lung Inhalation Dose Conversion Factor	ND	7.46×10^{-4} sec/m^3	7.46×10^{-4} sec/m^3
Breathing Rate	ND	ND	3.47×10^{-4} sec/m^3
Dose	67 mrem	268 mrem	0.6 mrem

Airborne Release Fraction in Study of Commission for the European Communities

Material Type	Airborne Release Fraction on Mechanical Impact	Airborne Release Fraction in Thermal Accident
Gases	1	1[(1)]
Liquids	5×10^{-3}	1
Solids, easily dispersible, e.g. powder, combustible with melting point less than 300ºC	5×10^{-3}	1
Solids, not easily dispersible, combustible with melting point greater than 300ºC	5×10^{-4}	1×10^{-2}
Immobilized solids (non-combustible matrix)	5×10^{-6}	1×10^{-4}

NOTE: (1) This release fraction of 1 applies to gases and volatile elements.

Airborne Release Fraction in USDOE Handbook

	Free-Fall Spill	Impact, shock-vibration	Thermal Stress
Contaminated, Combustible Solids	No significant suspension	$1x10^{-3}$	Packaged Mixed Waste: $8x10^{-5}$ Uncontained Cellulosics: $5x10^{-4}$ Uncontained Plastics: $5x10^{-2}$
Contaminated, Noncombustible Solids	Most materials will not experience free-fall spill.	$1x10^{-3}$	$6x10^{-3}$
HEPA Filters	No applicable experimental data	Enclosed HEPA: $5x10^{-4}$ Unenclosed HEPA: $1x10^{-2}$	$1x10^{-4}$

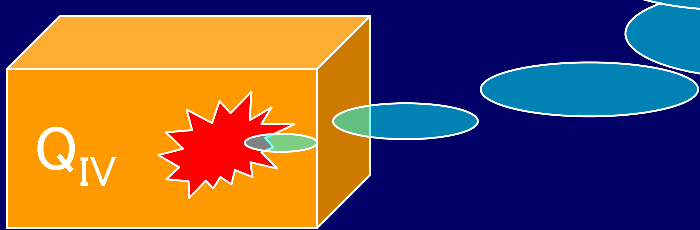
Release Model with Q system 【Large Component】:PROPOSAL

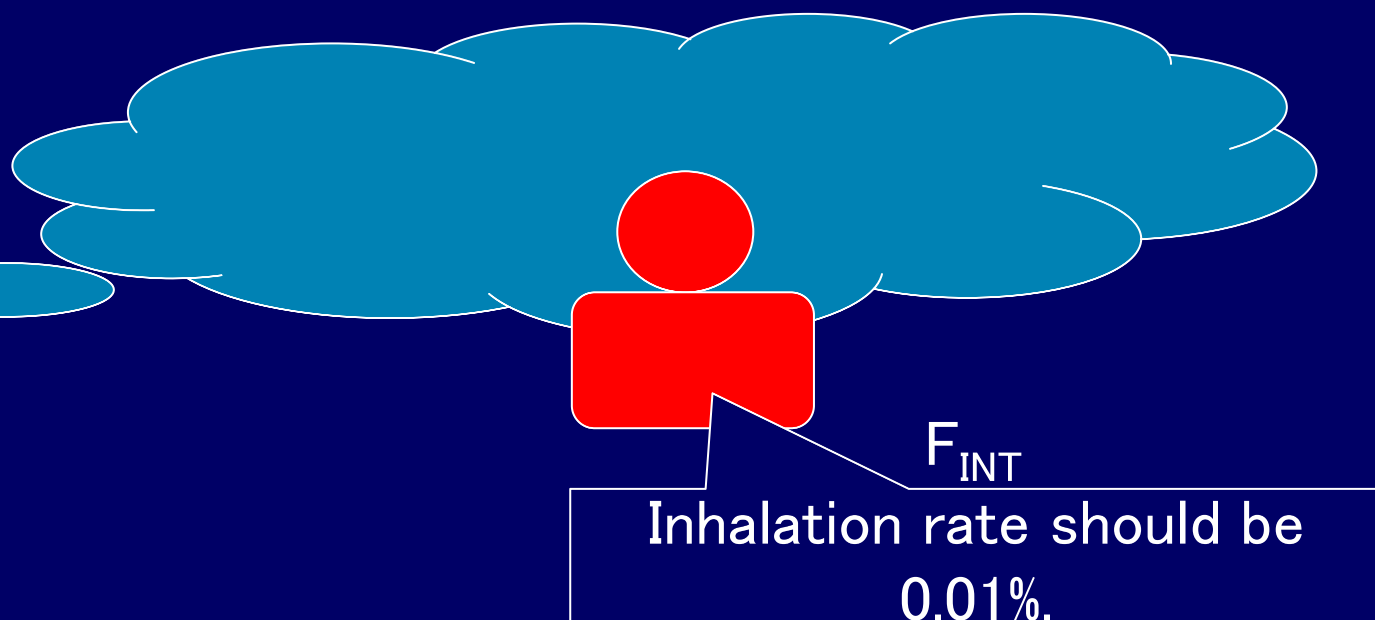
$$Q_{INT} = Q_{IVtotal} \times F_{REL} \times F_{INT}$$

If $F_{REL} = 0.001$

$$10^{-6} A_2 = Q_{IVtotal} \times 0.001 \times 0.0001$$

$$Q_{IVtotal} = 10 A_2$$





(ref)IAEA-TS-G-1.1

$10A_2$ Values

In a case where values used in the SCO-I model would be justified for parameters, and inventories up to 10A2 for fixed surface contamination plus the non-fixed contamination on the inaccessible surface can be allowed to maintain the same safety level.

Type	Activity = $10A_2$	Remarks
Mixed beta and gamma emitting fission products	0.2 TBq	A_2 = 0.02 TBq
^{60}Co	4 TBq	60Co : 0.4 TBq
Corrosion product or "crud" ^{60}Co : ^{63}Ni : ^{55}Fe = 14:85:1 [GNS report]	260 TBq	A_2 = 26 TBq ^{60}Co : 0.4TBq, ^{63}Ni : 30TBq, ^{55}Fe : 40TBq

CONCLUSIONS

- For "Special Arrangement", the safety level should be demonstrated in routine conditions of transport (incident free), in normal conditions of transport (minor mishaps), and in accident conditions of transport.

- Regulations in TS-R-1 require little damage effect with contents limits for Type A and Type IP packages.

- As a simple example scenario, we find that if 10% of the internal activity is released from the component and 1% of particles are in the respirable size range, then the activity limit will be $10A_2$ for fixed and non-fixed surface contamination, assuming this model is correct.