Challenges and solutions for the shipping of NORM

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Introduction

Zircon and many of other industry products are radioactive by definition of radioactive material in relevant regulations. The applicable transport regulations only provide a "10-times" exemption for NORM, irrelevant of its processing and of its final use.

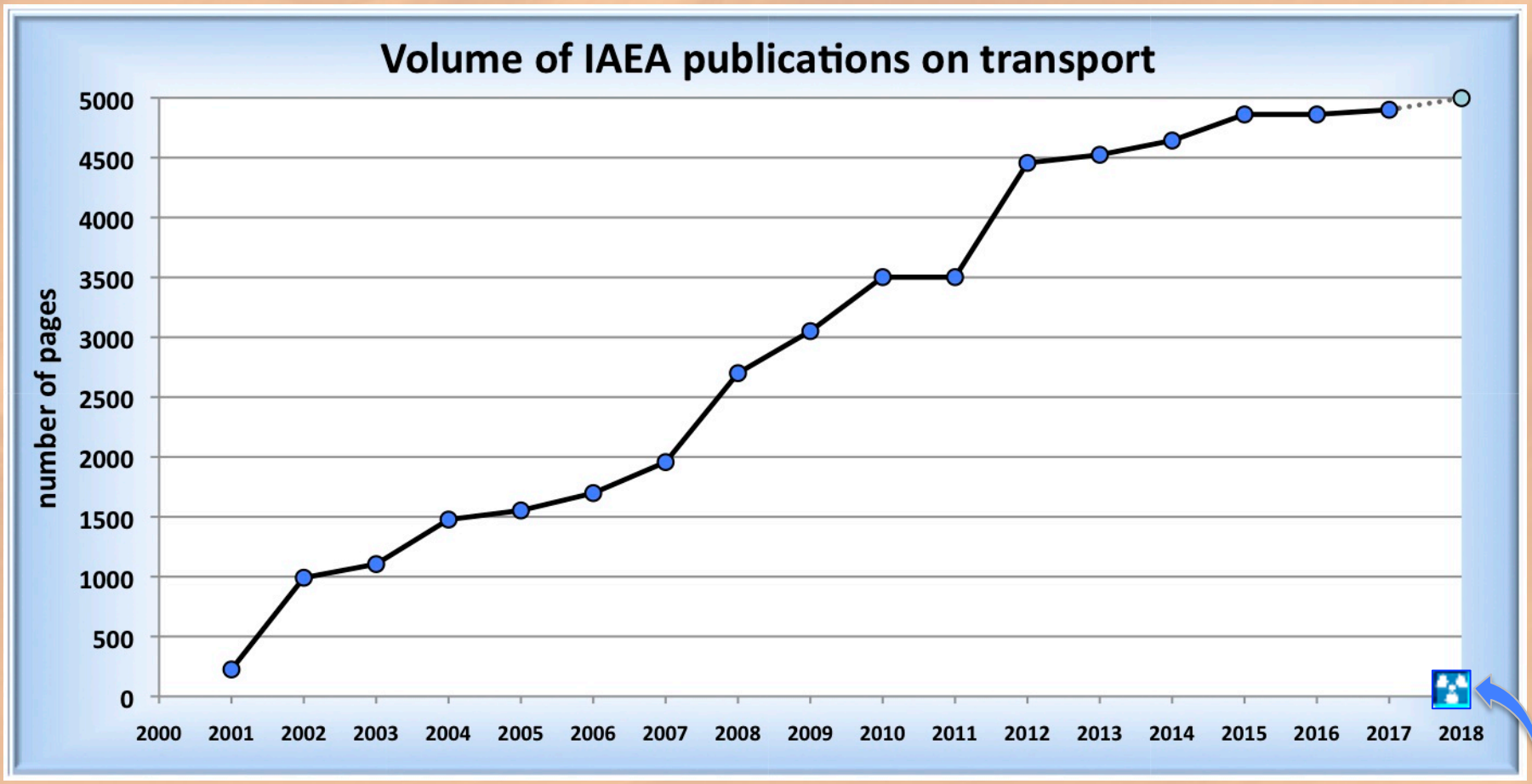
However, numerous problems still exist, including:

- Companies and government departments often do not have a full understanding of the legislative requirements and associated issues, or not aware of them at all;
- Erroneous assumptions and calculations used in transport planning;
- Denial of shipment occurs, minerals returned to the countries of origin or held for a long time at customs;
- Many stakeholders are reluctant to obtain specialist advice, typically "until it is too late".

IAEA Transport Safety Regulations

But that is not everything…

Not at all…



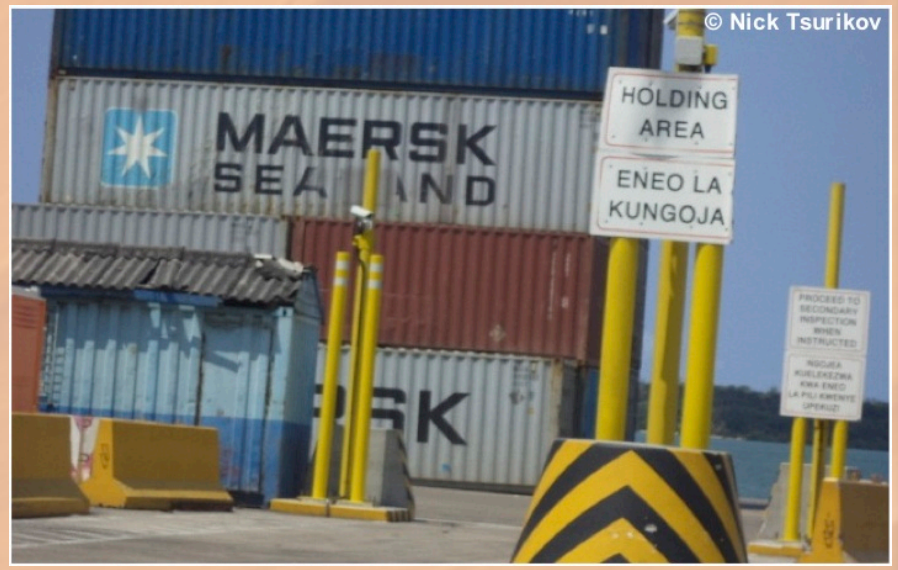
The aim of IAEA TRANSCC working group on NORM – 25-30 pages document

Detection of radioactivity at border crossings

<u>Applies to the transport of all NORM, whether it is exempted from the Transport Regulations or it is not.</u>

Issue:

The concentrations of radionuclides may cause elevated gamma radiation levels outside their packaging (e.g. sea containers). Equipment that is used at border crossings and in ports worldwide easily detects these levels.



Detection of radioactivity at border crossings

Solution:

The transport documentation for a particular material **must** contain detailed information about the concentrations of naturally occurring radionuclides in this material, irrespective of its classification. Having at least a note detailing which radionuclides may be detected is highly advisable.

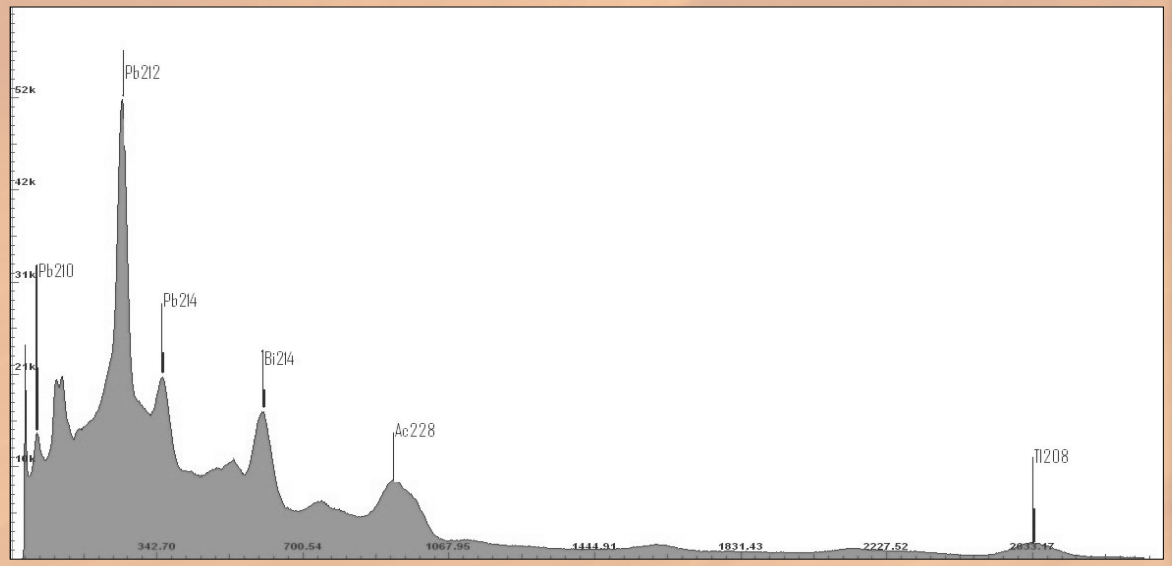
MATERIAL SAFETY DATA SHEET

ZIRCON

1. IDENTIFICATION OF MATERIAL AND SUPPLIER	
Product Identification	
Product Name	Zircon – Standard, Premium, Refractory,
Other Names	Zircon Sand, Zirconium Silicate,
Recommended Uses	Opacifier in ceramic products, such as high temperature refractory products, for sand, particularly for investment castings.
Supplier Identification	
Company	
Address	
Telephone Number	
Facsimile	
E-Mail	
Emergency Telephone (24 hours)	

Radionuclides in the product detectable by spectral portal monitors:

Th-232, Ra-226



Detection of radioactivity at border crossings

Large number of containers can be scanned, and there are three stages in this process:

1. Passage through the portal – radiation detected

   Is radiation evenly distributed or there are peaks or localised sources, is it expected (possible NORM…)? **IF NOT =>**

2. Radionuclide identification

   Radionuclide identification, using spectral portal or handheld / vehicle-mounted spectrometers. If 'natural' but possibly above the locally applicable limits – is there an import licence? **IF NUCLEAR MATERIAL DETECTED =>**

3. Non conformance

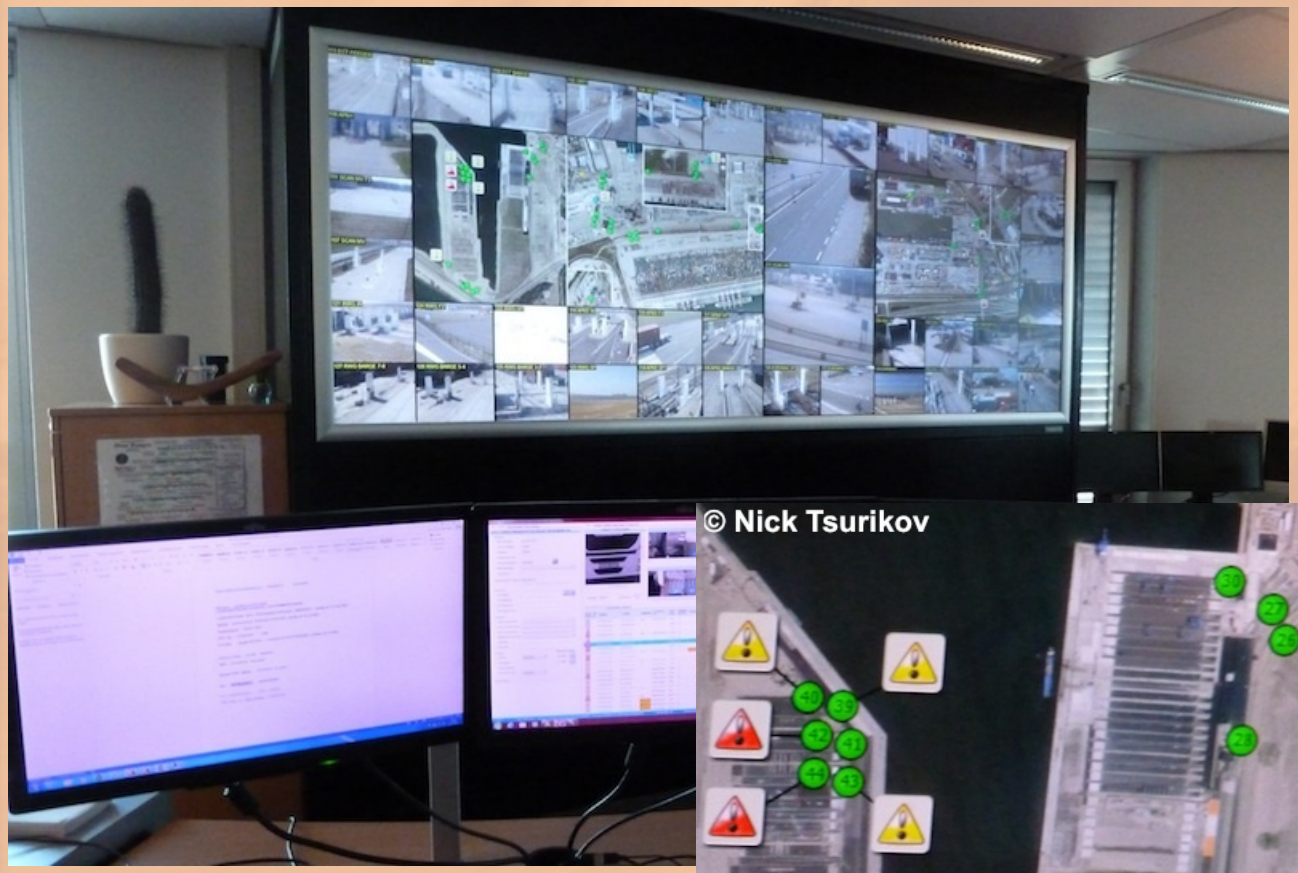
   Call relevant nuclear security department; open and unload the container (if safe), cordon off the area, involve police/military, emergency response; relocate material to safe storage.

Detection of radioactivity at border crossings

Portal detector video – The Netherlands

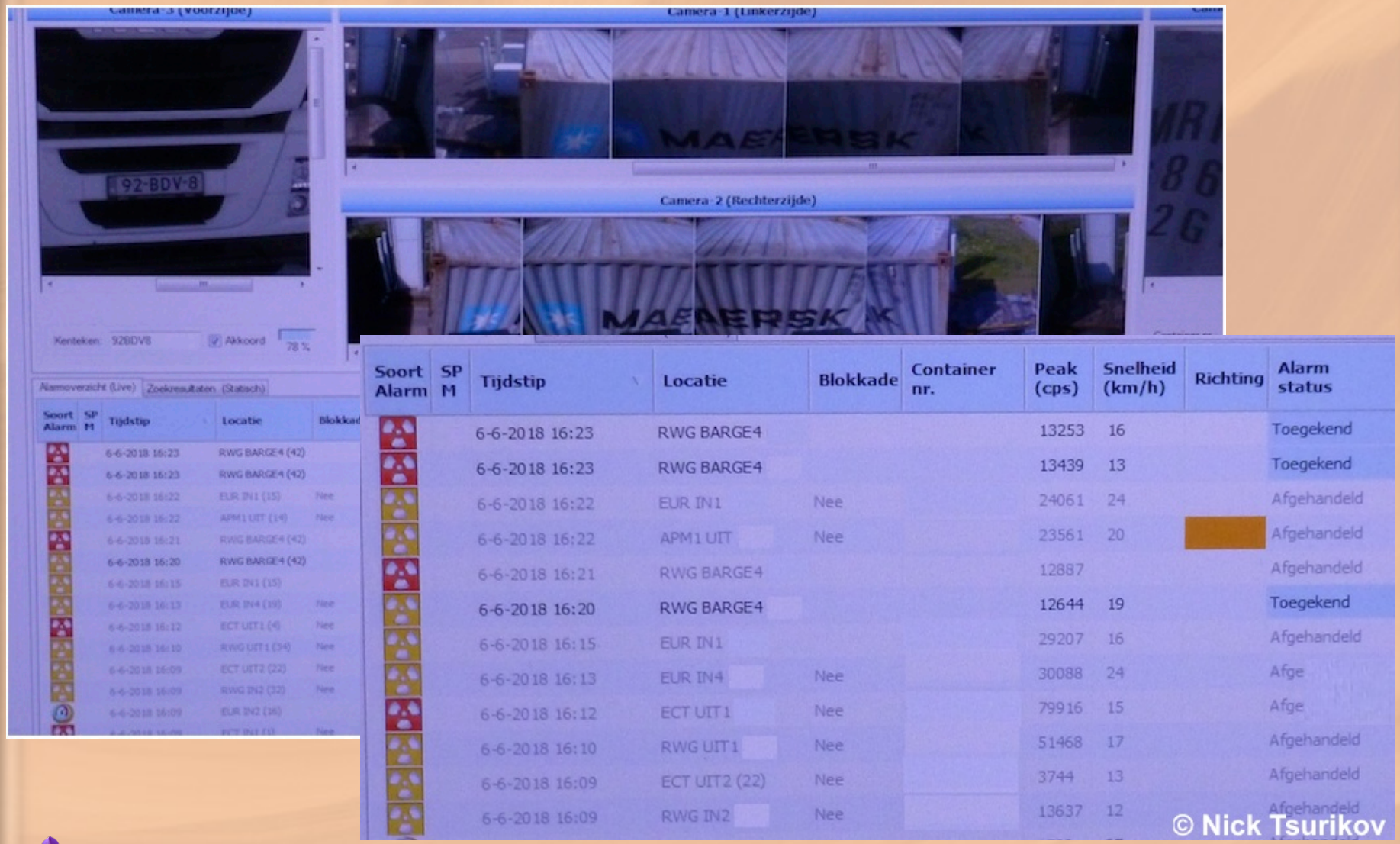
Detection of radioactivity at border crossings

Control room



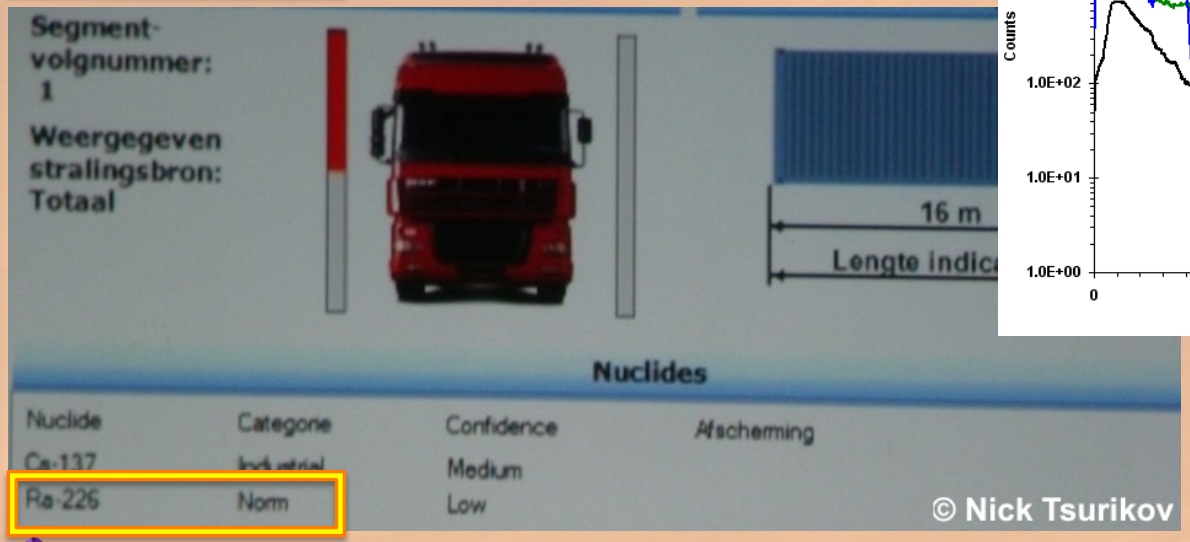
Detection of radioactivity at border crossings

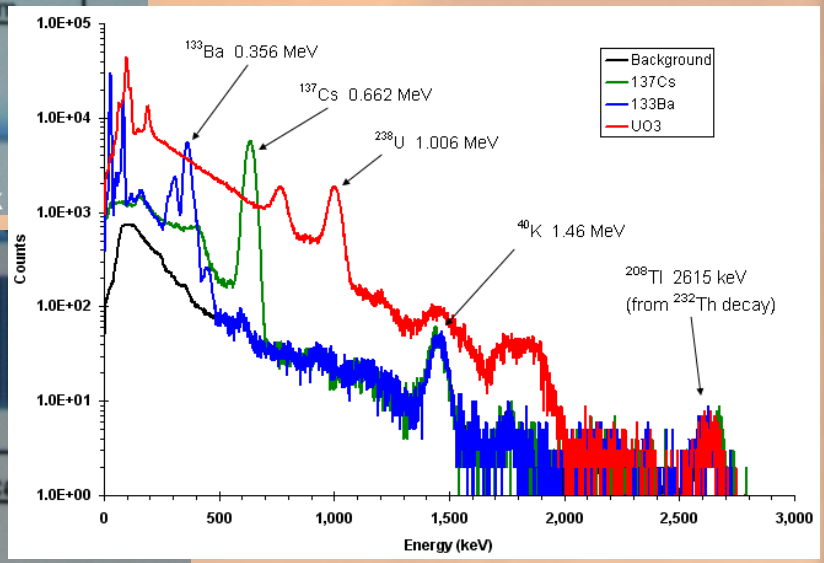
What the Customs Officer sees on the screen



Detection of radioactivity at border crossings

Why it is important to have the radionuclides' data in the MSDS:





A specific issue for zircon and zirconia industry

An example – an annual summary from one of the EU countries:

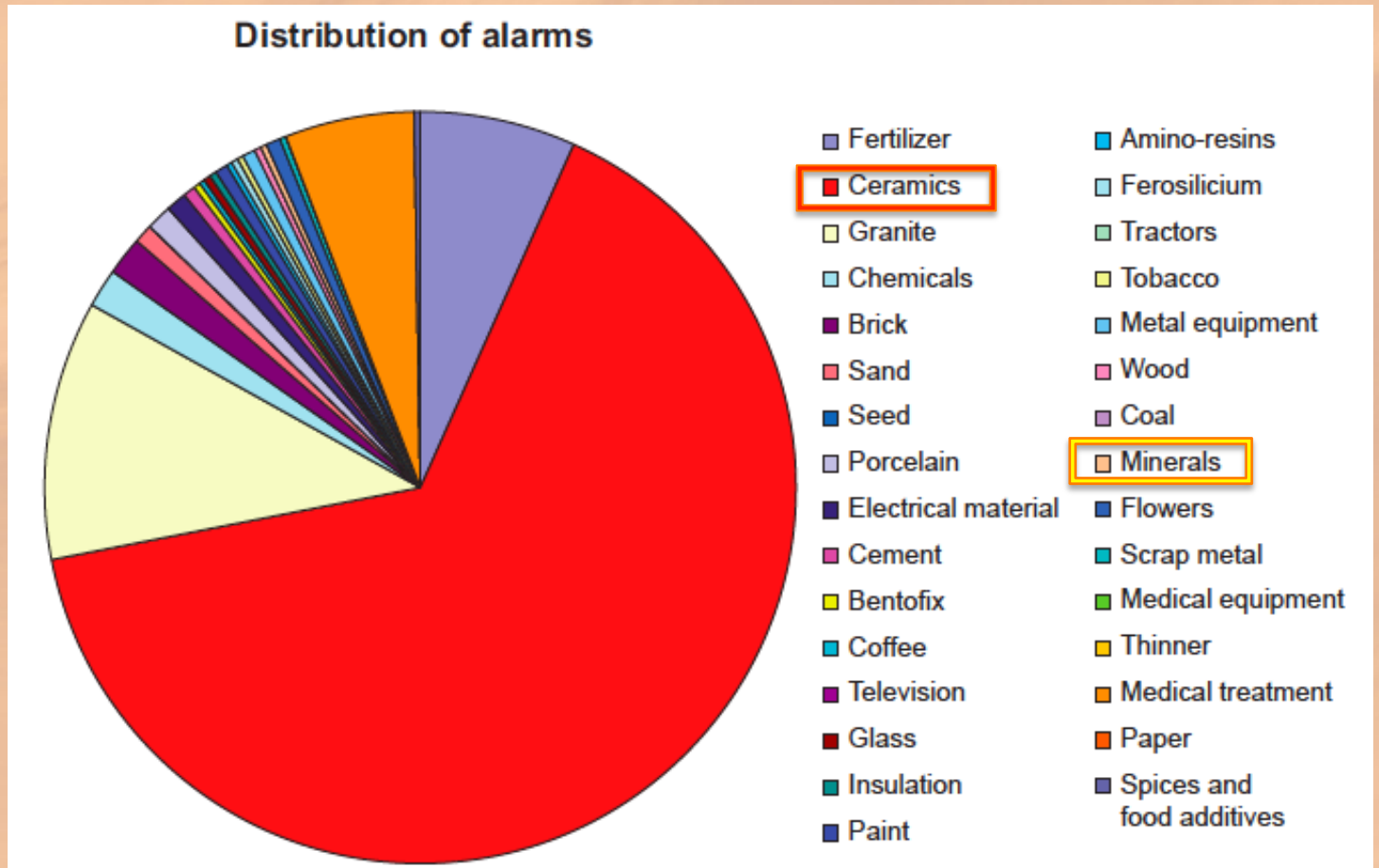


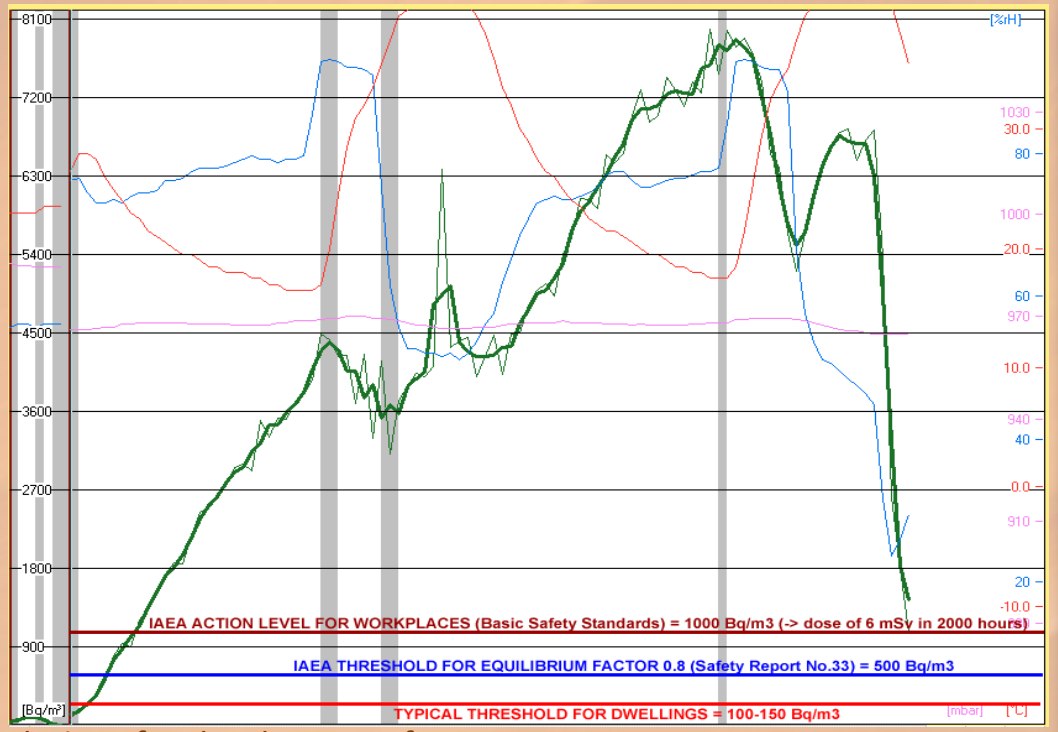
FIG. 1. Distribution of alarms according to commodity type.

Radon in containers and hulls of ships

Relevant to the transport of all NORM, whether it is exempted from the Transport Regulations or it is not.

Issue:

The concentrations of radionuclides (^{238}U and ^{226}Ra) may cause significant concentrations of radon inside the sealed shipping containers and in the hulls of ships when minerals are transported in bulk.



Radon in containers and hulls of ships

Solution:

Instruct workers opening containers and ship hulls at the destination to stay away from the material for a certain time (typically one hour) to allow for radon concentrations to decrease through natural ventilation.

The lack of communications in the International trade

Containers held at port – lack of documentation/information

Case A:

Alarm triggered, no information, argument… Illicit trafficking of radioactive materials? → Containers held, shipping agent detained.

Case B:

Packed as per 2005 Regulations, received in jurisdiction with 2012 Regulations in force → Containers held until analysis for all radionuclides carried out.

Case C:

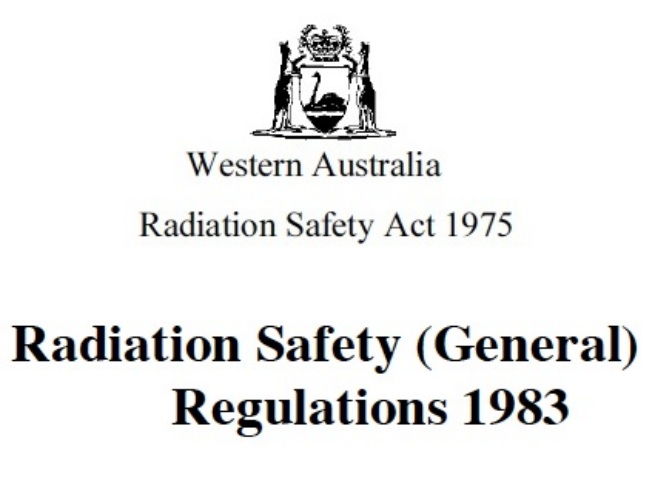
Packed as per 2005 Regulations, received in jurisdiction with 1987 Regulations in force → Containers with material exempt from current international regulations held until signposted as 'radioactive' in an importing country.

The lack of communications in the International trade

Locally-applicable regulations

A certain volume of NORM is almost always present at a transit location

- From one side, the material could be considered to be “in transport”,
- From the other side, continuous ongoing storage of material in a certain location may need to be regulated.

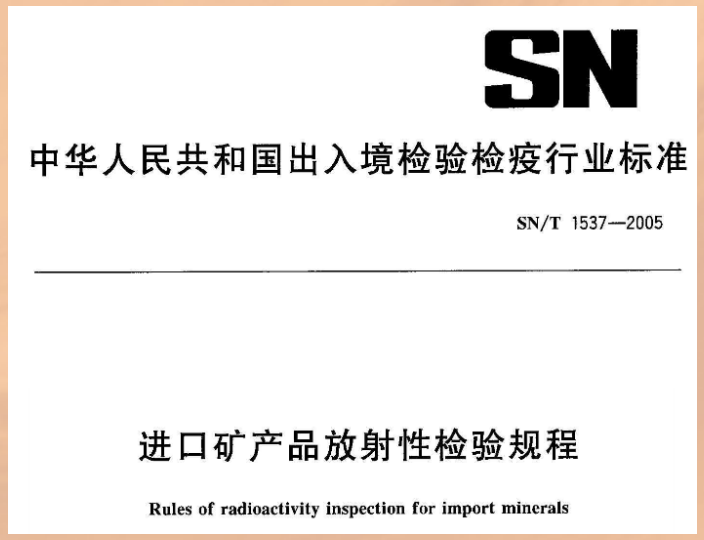


If the material such as zircon or zirconia is stored at any location for more than 24 hours – it is not considered to be “in transport”.

Therefore, the transit warehouse/yard must be registered for storage of radioactive substances with the Radiological Council of WA.

The lack of communications in the International trade

Country- and port-specific guidelines and standards


SN

中华人民共和国出入境检验检疫行业标准

SN/T 1537—2005

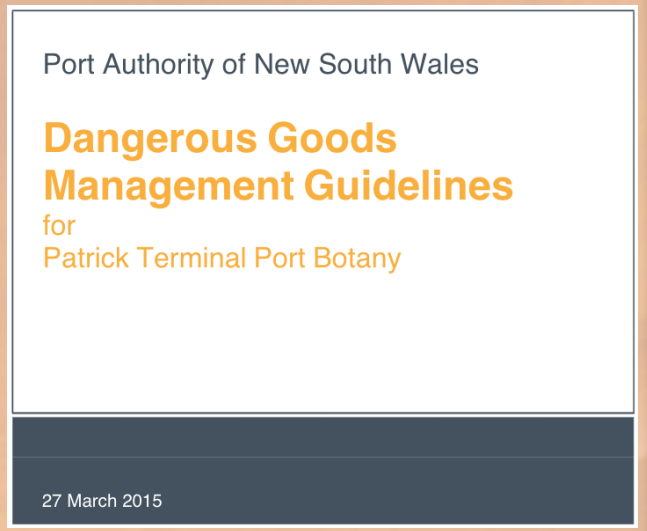
进口矿产品放射性检验规程

Rules of radioactivity inspection for import minerals

If the highest gamma dose rate detected is 5 to 10 times of the local background – additional regular inspections are required.

If at any time the highest dose rate detected is 10 times higher than the local background – unloading must be stopped immediately.

UN2912 Class 7 Category III Yellow, Low Specific Activity (LSA-I) – applies to zircon 'non-mags'.
These dangerous goods are only permitted to be on the terminal for a maximum time period of 12 hours. …in the event an exemption is granted… to exceed the permitted time period (12 hours) the following conditions apply… [two pages of those]


Port Authority of New South Wales

Dangerous Goods Management Guidelines

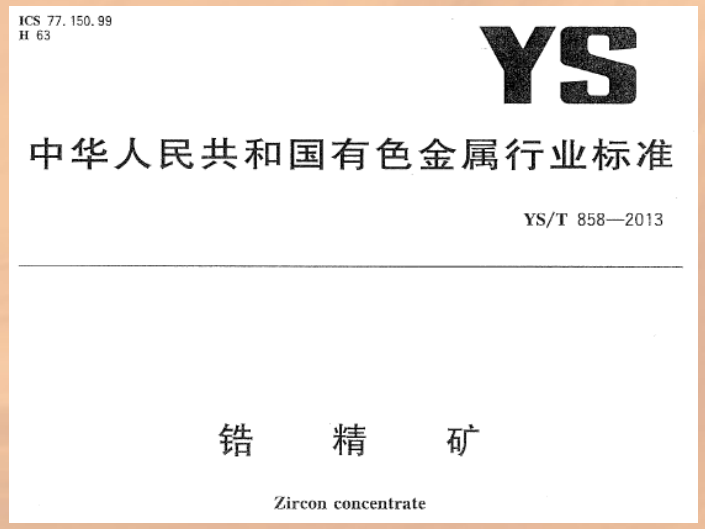
for

Patrick Terminal Port Botany

27 March 2015

The lack of communications in the International trade

Industry-specific standards



ICS 77. 150. 99
H 63

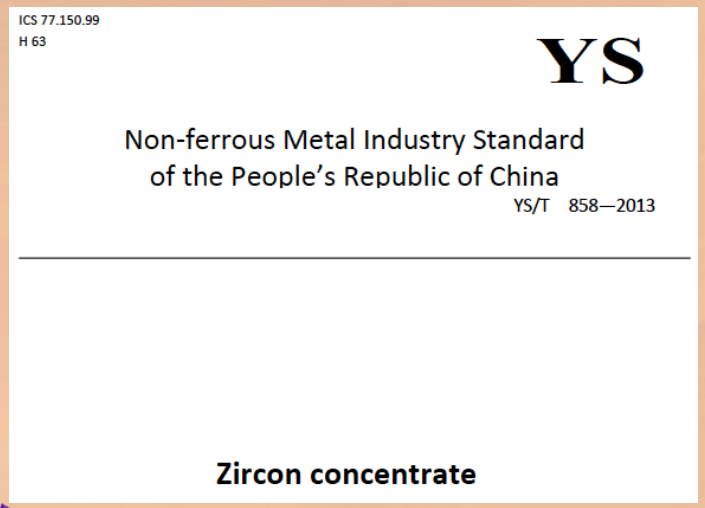
YS

中华人民共和国有色金属行业标准

YS/T 858—2013

锆 精 矿

Zircon concentrate



ICS 77.150.99
H 63

YS

Non-ferrous Metal Industry Standard
of the People's Republic of China

YS/T 858—2013

Zircon concentrate

If the dose rate from the product is not more than 5 μSv/h, it shall be regarded as passing the regulations.

If the dose rate is more than 5 μSv/h, the specific activity concentrations should be within the limits in Table 4:

Table 4

Items	^{238}U	^{232}Th	^{226}Ra	^{40}K	Total
Specific activity (1×10^{3}Bq/kg) no more than	10	10	10	5	15

The lack of communications in the International trade

Transit of shipments through international ports

Issue:

The 'radiological screening' of containers would still take place

Solution:

Visit the port, explain the character of the material and present the samples of the material to the Port Chemist.

Issue:

Both import and export license may be required, even if a container with a mineral only stays in a port for a day or two.

Solution:

Involve a locally registered shipping agent to obtain all necessary import and export permits.

NORM in “secular equilibrium”

Means that the thorium and uranium decay chains in NORM have not been disturbed – no chemical or thermal processing of mineral took place.

Applies to materials such as zircon sand that has not been treated in any way.

The removal of grain coatings at zircon ‘upgrade’ or ‘finishing’ plants using acid solutions is likely to be considered as chemical treatment.

Calculation is very easy:

$$C(Bq/g) = \frac{Th(ppm) \times 4.055 + U(ppm) \times 12.384}{1000}$$

If the result is below 10 Bq/g, the NORM is exempt from Transport Safety Regulations (IAEA, SSR-6, 2012, §107(f)).

NORM NOT in “secular equilibrium”

The analysis of many mineral products and other materials only for uranium and thorium is no longer sufficient.

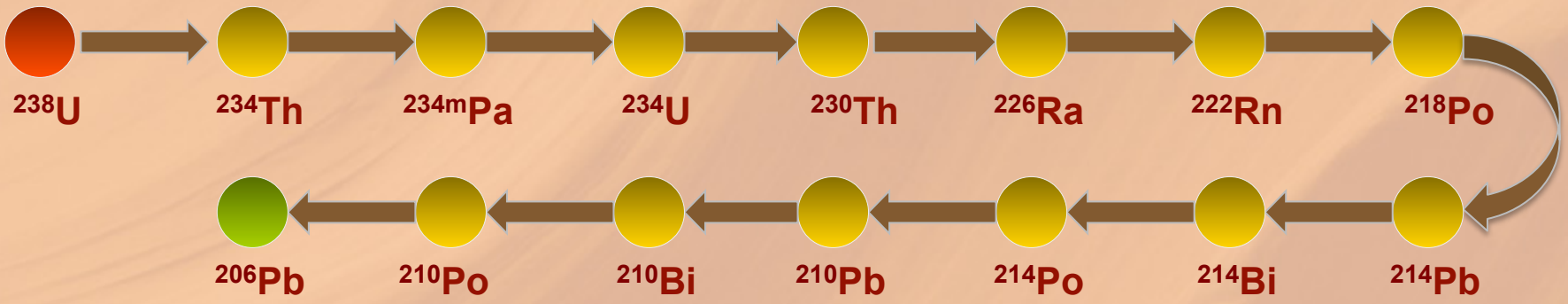
IAEA, SSR-6, 2012, §107(f): *“For natural materials and ores containing naturally occurring radionuclides that are not in secular equilibrium the calculation of the activity concentration shall be performed in accordance with para.405.”*

The analysis for ^{238}U, ^{230}Th, ^{226}Ra, ^{210}Pb, ^{210}Po, ^{232}Th, ^{228}Ra, and ^{228}Th would be required in these cases:

- Any chemical processing of the material, such as leaching or adding flotation agents to the process,
- Any thermal processing of the material (the value of 250-300^{o}C is suggested as a general guide),
- Any combination of chemical and thermal treatment.

NORM NOT in “secular equilibrium”

Uranium decay chain



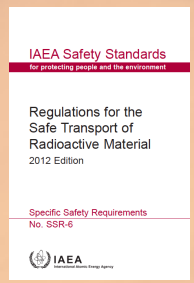
Zircon sand

Fused zirconia

Silica fume

+

NORM NOT in “secular equilibrium” – calculations



§107(f). For natural materials and ores containing naturally occurring radionuclides that are not in secular equilibrium the calculation of the activity concentration shall be performed in accordance with para.405

For the reference:

§405. For mixtures of radionuclides, the basic radionuclide values… may be determined as follows:

$$X_m = \frac{1}{\sum_i \frac{f(i)}{X(i)}}$$

$f(i)$ is the fraction of activity concentration of radionuclide i in the mixture.

$X(i)$ is the appropriate activity concentration limit for exempt material as appropriate for the radionuclide i

X_m is the derived value of activity concentration limit for exempt material

Note: the same equation applies to the ‘activity limit for an exempt consignment’ – but this value will always be exceeded in the transport of minerals

This calculation is not as complex as it looks…

NORM NOT in “secular equilibrium” – calculations

REFERENCE NOTE ON THE TRANSPORT OF NORM, BASED on IAEA SSR-6 (2012)
Version 3 – August 2018

NORM NOT IN EQUILIBRIUM

Prior to transport:
1. The analysis of the material is required
2. Transport should not commence until all relevant data on concentrations is available
3. Data needed for: Th-232, Ra-228, Th-228 and U-238, Th-230, Ra-226, Pb-210, Po-210 (option 1)
4. If data for Po-210 is not available - use option 2

1. Po-210 value available

Type in values for all radionuclides in Bq/g
DO NOT over-write figures in black font

	Th-232	Ra-228	Th-228	U-238	U-234	Th-230	Ra-226	Pb-210	Po-210	SUM
	4.35	7.13	4.01	2.04	2.04	2.74	6.80	8.13	9.18	46.42
fraction	0.094	0.154	0.086	0.044	0.044	0.059	0.146	0.175	0.198	
X(i)	100	100	10	100	100	10	100	100	100	
limit for THIS mixture									43.31	

X(i) values from Table 2 of SSR-6 corrected by "*

Is this material radioactive?
YES

2. Po-210 value not available

Type in values for all radionuclides in Bq/g
DO NOT over-write figures in black font

	Th-232	Ra-228	Th-228	U-238	U-234	Th-230	Ra-226	Pb-210	SUM
	4.35	7.13	4.01	2.04	2.04	2.74	6.80	8.13	37.24
fraction	0.117	0.191	0.108	0.055	0.055	0.074	0.183	0.218	
X(i)	100	100	10	100	100	10	100	100	
limit for THIS mixture								38.00	

X(i) values from Table 2 of SSR-6 corrected by "*10" for NORM

Is this material radioactive?
NO

IAEA
International Atomic Energy Agency

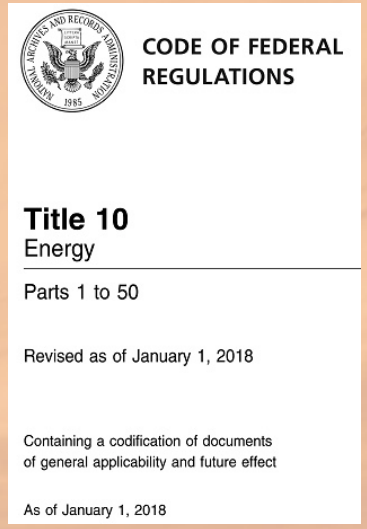
Transport Safety Standards Committee

WORKING GROUP ON NORM

The reference note and an excel file for calculations are available on request: nick@calytrix.biz

The myth of 500 ppm U+Th

The value of 500 ppm U+Th has no relevance to transport whatsoever


CODE OF FEDERAL REGULATIONS

Title 10
Energy

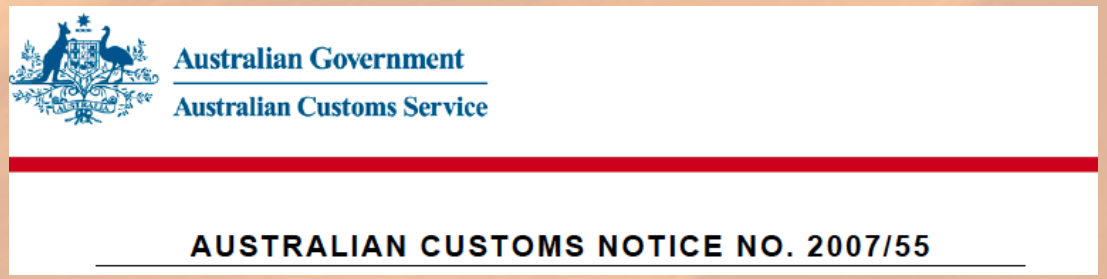
Parts 1 to 50

Revised as of January 1, 2018

Containing a codification of documents of general applicability and future effect

As of January 1, 2018

Source Material *means (1) Uranium or thorium, or any combination thereof, in any physical or chemical form or (2) ores which contain by weight one twentieth of one percent (0.05%) or more of: (i) Uranium, (ii) thorium or (iii) any combination thereof.*


Australian Government
Australian Customs Service

AUSTRALIAN CUSTOMS NOTICE NO. 2007/55

Provides an exemption for any ore or concentrate containing less than 0.05% by weight of the identified types of uranium or thorium ***source materials****.*

The threshold of 0.05% is a technology-related value and is not based on any potential radiation risk from these materials.

Thus, all it means is that if your material has more than 500 ppm U+Th – you will need to have additional export and/or import licenses for your product.

Associated legal issues

The companies and government departments may become involved in legal challenges without actually transporting radioactive material or exposing workers and/or general public to any levels of radiation.

Case 1 – Reduction in property values:

"If people will not purchase property because they fear living or working on or near a …[radioactive material transport] *route, or if a buyer can be found, but only at a reduced price, a loss of value exists. If this loss can be proven to the jury, the landowner should be compensated."*

Associated legal issues

Case 2 – Compensable injury from fear of radiation:

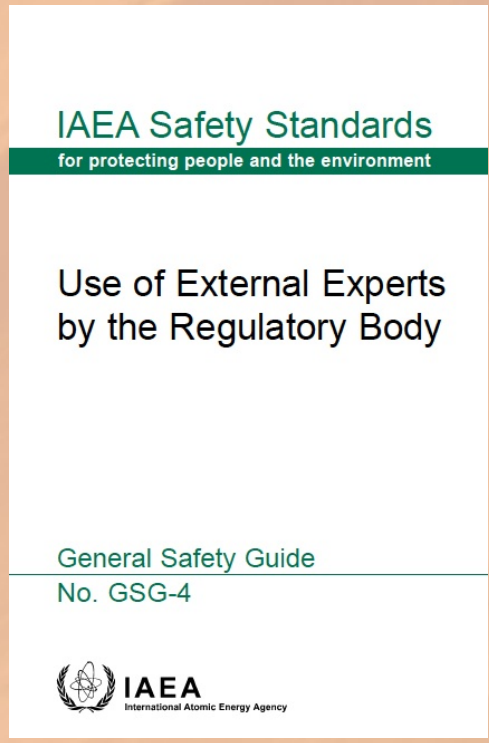
A truck driver's contact with a leaking container that was mistakenly labeled as radioactive waste.

Although the driver suffered no physical injuries and was not actually exposed to radiation, the court determined that the driver's post traumatic stress disorder, depression, fatigue and anxiety were rationally connected to his contact with the hazardous material; and are, therefore, compensable under Tennessee's Law.

Conclusions

- The transport of NORM is usually a very complex issue. It is hoped that the examples and the information provided will be useful both for the companies involved in this process, and for the relevant government departments administering transport safety regulations.

- It is expected that the specialist advice will often be required to ensure compliance with all relevant regulations and guidelines.




Thank you for your attention!