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COMPETENT AUTHORITY APPROVED FISSILE EXCEPTIONS UK EXPERIENCE

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ABSTRACT

The IAEA transport regulations contain criteria for excluding some shipments of uranium and/or plutonium from the requirements pertaining to fissile material. The new 2012 edition (SSR-6) has completely overhauled these criteria which have been developed since the IAEA regulations were first introduced.

One provision in the revised fissile exception criteria is for a material to be certified by a Competent Authority as posing no criticality safety concern and consequently able safely to be transported as non fissile. Such an approval would be given only following the successful assessment of a safety case justifying that the material would remain subcritical under normal and accident conditions.

At PATRAM 2010 the author presented a paper giving a view of the type of material that might be approved under this scheme, the criteria against which an application for approval may be assessed and the type of arguments that an applicant would be expected to present. It particular, however, this paper stressed the radical change in approach that needs to be adopted if benefit is to be gained from this new criterion.

This paper follows on from the 2010 paper and describes the Technical Assessment Guide produced by the UK Office for Nuclear Regulation and the types of material that have been presented to the UK Competent Authority as possible candidates for fissile exception.

This paper is the personal view of the author and does not represent UK Competent Authority policy.

INTRODUCTION

The IAEA transport regulations have always contained criteria to exclude from those requirements pertaining to fissile material packages containing small quantities of fissile nuclides or fissile nuclides in a form in which criticality was considered (at the time) impossible. These “fissile exceptions” permit packages or material meeting them to be transported as if there were no fissile nuclides present.

The fissile exception criteria have changed with successive revisions and the latest version of the regulations [3] introduced in 2012 contain the most significant changes to date.

WASTE EXCEPTION

Prior to 1996 the transport regulations [1] contained a fissile exception based on there being no more than 5g of fissile nuclides in any 10 litre volume. This exception was introduced to cover waste materials where non-fissile material is contaminated by small quantities of fissile isotopes.

The shortcomings of this exception had long been noted [4] and when TS-R-1 [2] was introduced in 1996 a consignment limit of approximately half a minimum critical mass was "bolted" onto this exception. This changed the nature of the exception from one based only on material properties to one based primarily on mass limits. The author's PATRAM 2010 paper [5] discussed in detail why this is an inadequate control and consequently why the latest IAEA regulations [3] no longer include this exception.

With the withdrawal of the 5g in 10 litre exception there remains a need to exclude from the fissile requirements packages containing materials which could not conceivably go critical but nevertheless could contain significant quantities of fissile nuclides. Such exception(s) would be intended to cover waste products but would not be explicitly limited to them.

The weakness in the 5g in 10 litre exception is that it was based on a non-fissile volume rather than mass. It was intended that its replacement(s) would be similar in nature but strengthened by being based on a fissile/non-fissile mass ratio with additional specification as to the extent of mixing and requirements for this arrangement to survive an accident.

The provision in the USA regulations [6] to except material with 1g fissile nuclides in any 2000g of non-fissile material was an obvious candidate. However, international agreement could not be obtained as to how the extent of fissile/non-fissile mixing was to be specified and what the post-accident requirements should be.

COMPETANT AUTHORITY APPROVED FISSILE EXCEPTIONS

Rather than explicitly include replacement(s) for the 5g in 10 litre exception in the revised IAEA regulations it was decided to include a provision for an individual Competent Authority (CA) to approve its own.

The provision for CA approved fissile exceptions is in paragraph 417(f) of the revised regulations [3] and in the UK this is increasingly becoming known as a "417(f) exception".

An operator will apply to their CA to have a material approved as being fissile excepted. Following a detailed assessment the CA will issue a certificate approving the material and specifying what requirements need to be met. Once approval has been given then this material may be transported in any package subject only to its suitability for its radiological and any other dangerous properties.

CRITICALITY SAFETY CASE CONSIDERATIONS

The author's PATRAM 2010 paper [5] discusses in detail what it would mean for a material to be fissile excepted and how this might be demonstrated. However, in general terms a fissile excepted material must be safe in any quantity without any further controls and the only way this can really occur is if the fissile nuclides present are swamped by non-fissile material.

It is considerations of how well the fissile nuclides are distributed throughout the non-fissile material, the extent to which this mixing can be guaranteed and how this might change following an accident which are at the heart of any application for fissile exception.

In transport criticality safety assessments, unless the disposition of the fissile nuclides is specified precisely (e.g. by reference to a drawing) and there is no doubt concerning the post-accident condition (via evidence from package tests), the worst case is assumed. For waste materials this approach had traditionally lead to modelling an optimally moderated and reflected sphere of pure fissile material in the corner of a package. Such pessimism may be appropriate if a package design is being approved to transport unspecified waste where there are no constraints at all on the disposition of the fissile nuclides. However, when it is known that a particular waste stream consists of very large quantities of non-fissile material contaminated by small quantities of fissile nuclides this approach is unnecessarily limiting.

The ability to claim credit for the known, but not necessarily 110% guaranteed disposition of the fissile nuclides, lies at the heart of CA approved fissile exception concept.

CA assessors must be prepared to be pragmatic and not expect to receive technical justifications based on precise tests as would be expected for fissile package designs. It should be stressed that CA approved fissile exceptions are for materials that are clearly safe even allowing for uncertainties in specification and behaviour in an accident. If there is any concern that an unsafe situation could arise, except by deliberate action a fissile exception would not be given.

Because accepting arguments concerning the disposition of fissile material that is not as precise as has traditionally been expected consideration must be given to sensitivity analysis. There must be no "cliff-edges" where a small departure from the specified arrangement could lead to an unsafe situation.

ONR GUIDENCE DOCUMENT

UK industry has been requesting that ONR provide guidance as to what would be an acceptable application for fissile exception.

A draft guidance document is being produced which attempts to provide useful guidance without being too prescriptive. It will be very much a discussion document that looks at the issues rather than a hard set of rules which must be observed.

Currently the document is in the form of a draft Office for Nuclear Regulation (ONR)Technical Assessment Guide (TAG). TAGs are guides for ONR assessors, however, the information contained would equally act as a guide to operators as to what would constitute an acceptable application.

The document describes the attributes of a fissile excepted material and uses the existing uranium enrichment based exceptions as examples. It is explained that these exceptions, even though their adequacy has not been challenged, can too be "broken".

The main thrust of the advice to assessors is that the current totally deterministic approach to transport criticality safety cases must not be taken. Candidate materials for fissile exception would be "clearly safe", however, an applicant must have demonstrated that this is the case.

Many applications will be for existing material currently being stored prior to transport to a final disposal site. Such material is being safely stored in far larger quantities than would be transported. The stating point for an application is likely to be the current criticality safety case covering storage and on-site handling from the current storage location to where it is placed in a transport package. Transport considerations will impose additional challenges above those in the on-site criticality cases as the material will be in the public domain and the severity of an accident that must be considered is informed by the IAEA test regime rather than the more controlled environment of a nuclear licensed site.

An assessor should ensure himself that an application has provided evidence that the operator understands to the maximum reasonable extent the nature of the material he wishes to except.

A draft outline of an application would be:

1. The specification of the material on which the criticality case will be based. For an existing waste this must include evidence that the material in question meets this specification.
2. A justification that this specification would not give rise to a criticality hazard. Generally this means showing that $k_{\infty}<1$ but if the mass of amount of material required to give $k_{eff}>1$ is clearly so large as to not be feasible in transport this could also be acceptable.
3. Evidence of how the specification might alter if a package transporting it were to be involved in an accident.
4. An assessment that the assessed post-accident changes would not affect criticality safety

Factors that would prevent a successful application would be:

- The need to place controls on the amount of fissile material placed into a package.
- The need to make claims on a package to protect the material (eg from water).
- The need to control accumulations of packages.
- The need for processing prior to transport (eg removal or arrangement of items prior to loading). However, processing prior to the point the material can be considered fissile excepted.

TRIAL APPLICATIONS RECEIVED

Prior to SSR-6 being formally adopted into UK law the ONR has encouraged industry to present "test applications" whereby potential waste streams are presented for consideration together with the type arguments that might be used. These applications have proved useful for both parties as it gives the opportunity for:

- ONR to gauge the type of candidate materials.
- Operators to consider the type of argument that might be advance in support of an application.
- Applicants to receive feedback from ONR.
- ONR to develop guidance material.

Several of these trial applications have been received and some aspects of these are described (in general terms) below as they exhibit different features that might be considered in future formal applications.

1. Sludge

An existing waste facility holds material contaminated with small quantities of fissile material which over the year has corroded to form a sludge. This sludge would seem an ideal candidate for exception as there is likely to be a high degree of homogeneity of fissile/non-fissile mixing.

The possibility of localised increases in concentration was considered by showing that the fissile/non-fissile concentration could increase by a factor 10 without compromising criticality safety

2. Grouting

Several of the applications involve grouting waste prior to transport. This involves placing the grouted waste into concrete containers to form a large (~3m^3) monolithic solid. Care should be taken to confine assessment to the grouted material placed into the package and not the package itself, otherwise the application will move away from a fissile exception into that of a fissile package design. In one application the fissile/non-fissile ratio was estimated before grouting and in another the grout itself was included in the non-fissile inventory. Neither application made any claim on the composition of the grout but if this was done the approval would have to specify the relevant grout parameters and it would have to be ensured that the operators had adequate systems in place to control this.

Grouting is intended to immobilise the waste. If the presence of grout is claimed it must be confirmed than in an accident (in particular a fire) there would remain a sufficient fissile/no-fissile ratio to ensure safety. For example consideration would have to be given to the extent of grout destruction that would take place if grouted waste were to be exposed to the IAEA fire test.

3. Presence of discrete fissile items

One application was for waste held in a facility into which there are records of there having been disposed cans containing significant quantities (~100g) of fissile nuclides. The cans themselves clearly could never be candidates for fissile exception and they could potentially cause a criticality hazard if they were to accumulate. Any criticality safety case for a material containing some of these cans "somewhere" within it must be based on probabilistic considerations. The argument presented in the application claimed significant accumulation was highly unlikely. ONR feedback was that such an approach would not be rejected (although the word "unlikely" is traditionally an anathema in the transport community), however, improbability arguments should be strengthened. Some attempt should be made to quantify the statement that accumulation of cans is improbable so that this may be compared with what would acceptable on-site.

Any attempts to control how many cans were put into a transport container would fail due to the difficulty identifying which cans contain fissile material and the fact that this will involve special criticality operations during loading of a transport package.

It is believed that these cans are currently intact, however, the material is to be processed prior to loading and this may cause some cans to break and spread their contents throughout the non-fissile waste. Making claims on this happening is unlikely to succeed, conversely though the criticality effects of release of material must be considered.

4. Very low fissile content

An existing waste facility has been estimated to contain no more than a minimum critical mass of fissile material even under optimum geometry and moderation. No claim is made for the reality that the small amount of fissile material in the facility is swamped by non-fissile material. From a neutronic viewpoint this would not appear to be a fissile exception application as no attempt has been made to demonstrate the safety of the material in unlimited quantities.

However, from an operational viewpoint it may be treated as fissile excepted as no account need be taken of how much material may be loaded into a package, nor how many packages may be transported. This material can be safely handled and transported as if there were no fissile material present, just like a fissile excepted material. The fact that the fissile material is spread among loads of other non-fissile material is an extra safety margin, albeit unquantified in this case.

Any fissile exception granted for this material would be limited to the particular facility involved and it must be ensured that no further fissile nuclides are added to it.

At a first look therefore this would not seem anything like a fissile exception, however, it is premature to reject it on this basis.

Approval of this case would involve ensuring that the estimate of total fissile content bounds what is actually present.

CONCLUSIONS

CA fissile exceptions have been introduced in paragraph 417(f) of the revised IAEA regulations to provide a replacement for the 5g in 10 litre exception.

Trial applications received by the ONR indicate that there is an interest in using the provisions of 417(f). These applications are all for existing wastes that have been in storage for many years. There are aspects of these applications that were not anticipated might apply when considering fissile excepted material.

Guidance to applications for fissile exception is being developed based on theoretical considerations but heavily informed by trial applications. The development of ONR guidance will be a cooperative process with industry to derive a set of rules that will be useful and practicable for industry and acceptable to the ONR. The provision of very prescriptive advice at an earlier stage could inhibit applications that the advice might indicate would be rejected but which on further consideration could safely be transported as if there were no fissile material present. This concern has been borne out by the trial applications received.

In assessing applications for fissile exception CAs will have to step back from traditional assumptions. In this respect fissile exception applications will have more in common with the way criticality safety is assessed for plant, including perhaps the use of probabilistic arguments. The recent move of the CA function in the UK from the Department for Transport into the ONR could assist the development of this approach.

REFERENCES

1. IAEA Regulations for the Safe Transport of Radioactive Material
   Safety Series 6, 1985 Edition (As amended 1990)
2. IAEA Regulations for the Safe Transport of Radioactive Material, TS-R-1, 2009 Edition
3. IAEA Regulations for the Safe Transport of Radioactive Material, SSR-6, 2012 Edition
4. A Review of the Fissile Exceptions Criteria , Barton & Wilson - ICNC 95
5. Competent Authority Approved Fissile Exceptions - One Regulator's View, N J Barton, PATRAM 2010, London
6. 10 CFR 71.15