Inservice Behaviour of Irradiated Fuel Transport Flasks

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INTRODUCTION

The AIEA Regulations for the Safe Transport of Radioactive Material foresee some strong requirements regarding flask maintenance and associated Quality Assurance ; it is especially mentioned that the "packagings must continue to comply with all relevant requirements and specifications, even after repeated use".

This instruction is rather imprecise and hard because it does not give any indication regarding a possible deviation in comparison with manufacture.

Nevertheless, in Service, the notion of Maintenance has been implemented with the following definition : "All operations carried out on flask in view to recover its manufacture characteristics, or, beyond a certain amount of tolerable wear, to measure the margin with regards to these".

In practice, the Responsible for the Maintenance is concerned with the following considerations :

- the nature of detrimental effects which may occur on flask components,
- the adaptation of maintenance criteria to these effects,
- the maximum admissible associated defects,
- the evaluation of every defect behaviour, especially its increase versus time or other parameter.

The present document intends to give one practical approach of the answer to the questions raised above. This approach is gained from experience relevant to the maintenance of Irradiated Fuel Transport Flasks carried out by the COGEMA Company for many years in a special Facility located in the LA HAGUE REPROCESSING PLANT.

GENERAL CONSIDERATION

Cogema and associated companies (I.E. Nuclear Transport Limited and Pacific Nuclear Transport Limited) own a fleet of about 90 flasks. Some characteristics of these flasks are as follows :

Age : at the present date (mid 89), their age is in the range 1 - 20 years. The figure 1 shows the distribution in time, ; the figure 2, the distribution versus the number of transports carried out.

This fleet of flasks can be divided in two parts :

. The most important one (77) made with standardized flasks designed by TRANSNUCLEAIRE ; their age is less than 10 years. They are used for transport in dry condition ;

. The other part, the older, is made with non-standardized ones ; their age is up to 20. They are used for both transport in wet or dry condition.

Transport conditions : there are also two different kinds :

. The flasks used for European market : they perform about 10 transports per year,

. The flasks used for Japanese market : they only perform 2 or less transports per year.

Maintenance : The experience gained by Cogema is especially relevant to the work carried out in the AMEC facility for more than five years, associated with other previous inspections made since 1979.

- It is reminded that the present status of flask maintenance frequencies is as follows :

  Inspection at every turn round (Nuclear and Reprocessing plants)
  Basic maintenance every 10 transports or 2 years
  Main maintenance every 40 transports or 4 years

- The figures 3 and 4 respectively show the total number of flasks maintained and the corresponding labour time from 1984 to 1988. In total, about 215 maintenances have been performed and more than 200 000 man hours have been allocated to the works.

ASSESSMENT OF POSSIBLE CAUSES WHICH MAY INVOLVE DEFECTS ON FLASK COMPONENTS

The maintenance of flask components and associated tests for the whole flask involve the necessity to establish full QA procedures for inspection and repair. The corresponding NDT methods to be applied needs to define the knowledge of possible causes of trouble. These causes may be devided in two kinds :

The first one is relevant to the Safety Analysis report of the flask. This document especially takes into account all stresses applied to the different parts of the flasks including in transient or accidental situation.

The second kind involves the "In Service" conditions, especially all detrimental effects as corrosion, for example. Of course, these effects are more difficult to assess because all environmental parameters are not necessarily well known, particularly during the design period.

The table 1 gives the inventory of both kinds of foreseen (SAR) or recognized (inspection) causes of possible defects on major flask components.

SCRUTINY OF MAINTENANCE CRITERIA

The maintenance procedures involve the definition of acceptance criteria. As mentioned above, these criteria have to be as closed as possible to the Manufacture values. In practice, (and also to take into account the "in service conditions"), some of them may be different or have to be completely re-defined.

As an example, the table 2 gives the criteria presently applied on the "Standardized" flasks concerning the following functions :

Tightness
Closing systems
Handling
Subcriticality

PRACTICAL CONSIDERATIONS

General attitude during flask component inspection : When a defect is noticed or suspected on a flask component, two possibilities are commonly used :

The small removable items are generally replaced without complementary scrutiny. This especially involves the cost of the operation, but may also lead to revise the inspection frequency.

The bigger "fixed" items are inspected in more details to evaluate if they can be re-used with or without repair. Besides, it is necessary to try to understand the behaviour of the defect.

The figure 5 intends to explain the geneal philosophy to be applied to follow the general evolution of a defined criterion / parameter versus the flask life.

Results obtained during maintenance in COGEMA FACILITY :

- *Tightness* :

The figure 6 gives the evolution of a so called "Safety factor" versus the number of transports carried out ; this safety factor is defined as :

$$\left(\frac{\text{Total flask leak rate measured during maintenance}}{\text{Total leak rate allowed during transport}} \right)^{-1}$$

It can be observed that the safety factor is always at a very high level (more than one thousand).

Closure systems

The figure 7 gives a typical summary of numerous checks made on lid closure tapped holes of a standardized TN MK1 flask during its present life. A certain amount of wear is detectable on lid tapped holes but is sensitive only on a small number of those. This wear seems significant above 50 - 60 transports.

For the same time, practically no wear has been noticed on trunnion settling holes.

Trunnions

The "direct" wear arising by careless handling has been detected from the beginning of the trunnion life. Nevertheless, this wear has now a slow kinetics and is not seriously concerning.

The careful dye penetrant tests carried out on some trunnion surfaces revealed a typical "pitting corrosion". Some complementary investigation and tests have been performed and show an important difference in "incubation time" between the materials used as recorded on figure 8. Although the kinetics of the phenomenon seems slow (I.E. pit depth propagation), conservation measures have been taken and future machining is foreseen as necessary.

Subcriticality (baskets)

The neutron flux attenuation measurements do not show any decrease of absorber presence versus time (see figure 9). However, it must be noted that the accuracy and the sensitivity of the method used has to be improved.

The neutron flux survey has also to be completed by a camera or a fiberscope examination of the basket walls associated with a mandrel compartment check. These operations, already started on some flasks, will be generalized in a short future.

Special events

During maintenance, some flasks among the oldest ones, have shown "special important defects" which are more probably relevant to their age and low QA level used during manufacture. For example :

- Stainless steel cladding defect on a lid,
- Weld defect on stainless steel cavity layer,
- High internal contamination and corrosion levels.

Cost

The maintenance costs observed vary from one year to another and also with the flask type. Nevertheless, it is possible to assume as a simple rule that this yearly maintenance cost per flask is about 5 to 10 % of the investment for a new one.

COMMENTS

. The maintenance criteria applied to check the soundness of the fundamental flask functions are presently acceptable. This is especially true and conservative for the removable components, and others as the flask body, the tightness and the shielding. For some other functions, the experience shows that a higher accuracy is necessary (closure systems, handling, ...), at once to avoid too high conservative values and also to improve the knowledge of the phenomenon considered.

In the same feeling, it would be desirable that the possibility to revise the SAR could sometimes be more flexible for adaptation to the experience.

It has also to be considered that during an assumed life in the range 30 - 40 years, the improvement in studies and associated NDT technics may lead to modify the criteria values.

. The most frequent detrimental effects presently observed on flask components are relevant to the different kinds of corrosion for which pitting or SCC are worrying. The corrosion may also induce some unexpected consequences lying with deposits, etc...

. Following the present low age of standardized flasks, it is difficult to look to the end of their life only with the knowledge of the evolution of wear, corrosion, reminded contamination level etc...

. Considering the fact that special events have been noticed on old "non standardized" flasks, it seems possible that a major problem may happen around 20 years old. In this case, the repair problem concerns both technics and especially the cost. This lies with the big difficulty to manage an important work on a large component heavily contaminated. On the other hand, the flask decommisioning (also under study in Cogema) may be very costly.

. The experience shows that the maintenance operations would be more efficient if a complementary set of flasks (about 10%) would be available (to avoid a lack in transport operations).

. Although flasks are apparently heavy "static" and simple items, it must be emphasized that, if an important part of the maintenance work is made with routine duties, it is with those that a statistical data can be recorded in view to carry out a "predictive" or conditional maintenance. Of course, there is an important human factor to be considered : to keep in place the same people during long years with a permanent "critical mind".

. Most of the non conformances have been detected during the flask maintenance and in due time. This confirms the necessity of such preventive operations associated with a high QA level.

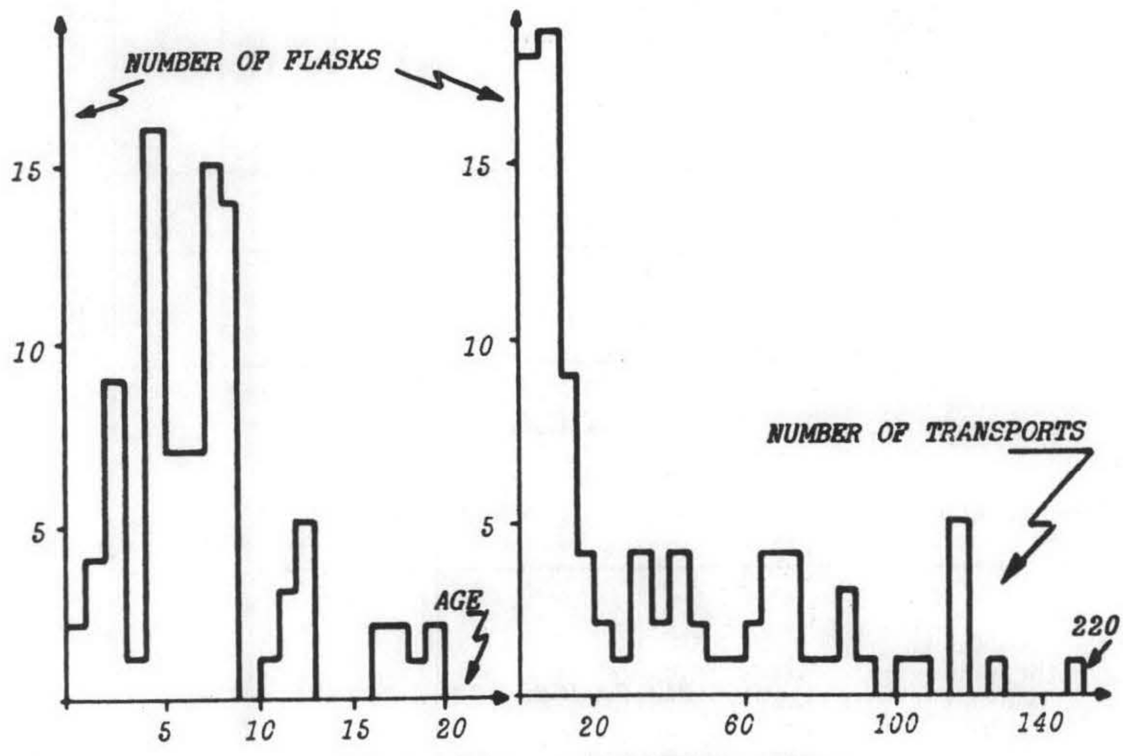

FIG.1 AND 2 : FLASK DISTRIBUTION

NATURE	FLASK COMPONENT						
	Cavity (body)	Basket	Trunnions	Lid	Screws and tapped holes	External surfaces	Orifices
Mechanical stresses (including shocks)	×	×	×	×	×		×
Thermal stress	×	×		×	×		×
Fatigue		×	×		×		
Embrittlement	×		×		×		
Wear	×	×	×		×	×	×
Corrosion							
. generalised	×	×					
. pitting	×		×	×	×	×	×
. S.C.C.			×		×		
Aging		×	×	×		×	
Contamination and dose rate	×	×	×	×	×	×	×
New fuel (higher Burn up)	These new contingencies may occur defective functions on flasks						
New regulations							

TABLE 1 : POSSIBLE CAUSES OF DEFECTS

FUNCTION	MANUFACTURE	MAINTENANCE
TIGHTNESS	10^{-1} lusec (Transport 10 lusec)	10^{-1} lusec
CLOSURE AND SETTLING SYSTEMS SCREWS TAPPED HOLES	"Go - no Go gauge" principle 6G / 6g or 6H / 6g	- Deformation : Go gauge - Wear : 6H - 6G - 8H - 8G max 8G < 3 turns - Corrosion scrutiny
HANDLING (TRUNNIONS)	- Diameters $\phi \pm 0.1$ - Ra = - No flaws (ASME code)	- Wear : diameter - 0,1 expected -2 Bearing surface ≥ 80 % - Corrosion Pit depth ≤ 0.7 on radii - Flaw evolution recorded
SUBCRITICALITY (BASKET)	- Neutron poison checked . Density of plates . B / B10 content . Homogeneity - Compartment dimensions checked	- Check by neutron flux attenuation measurement - Corrosion - defects followed by visual / video recording - Deformation checked with mandrel

TABLE 2 : CRITERIA FOR SOME STANDARDIZED FLASK FUNCTIONS

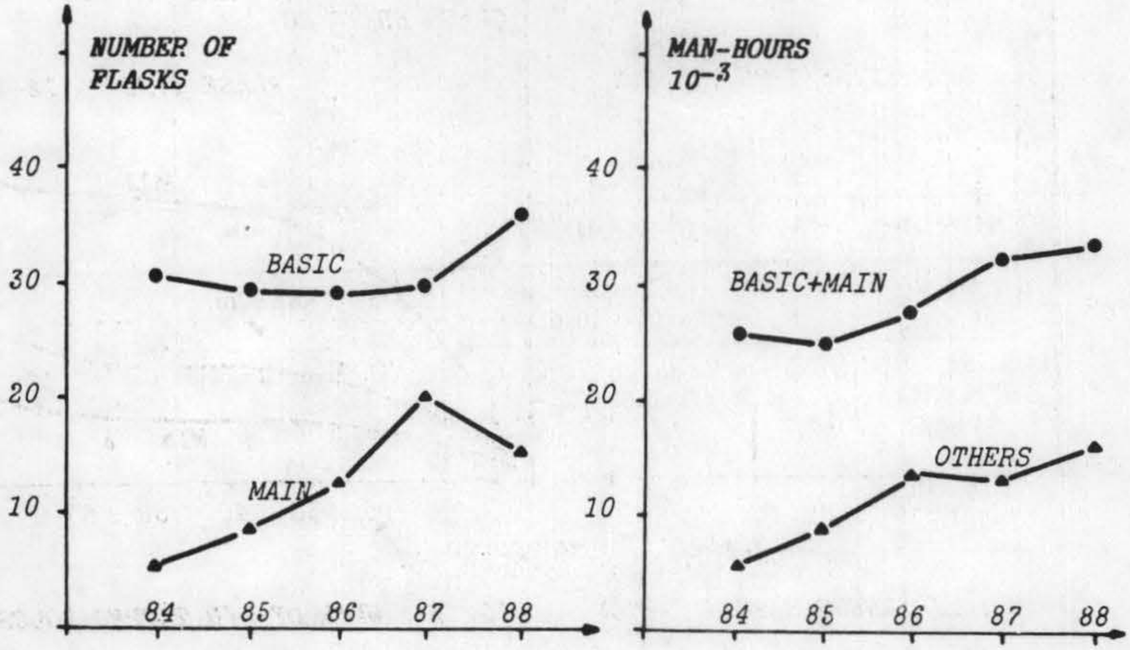

FIG.3 AND 4 : MAINTENANCE DATA (NUMBER AND LABOUR)

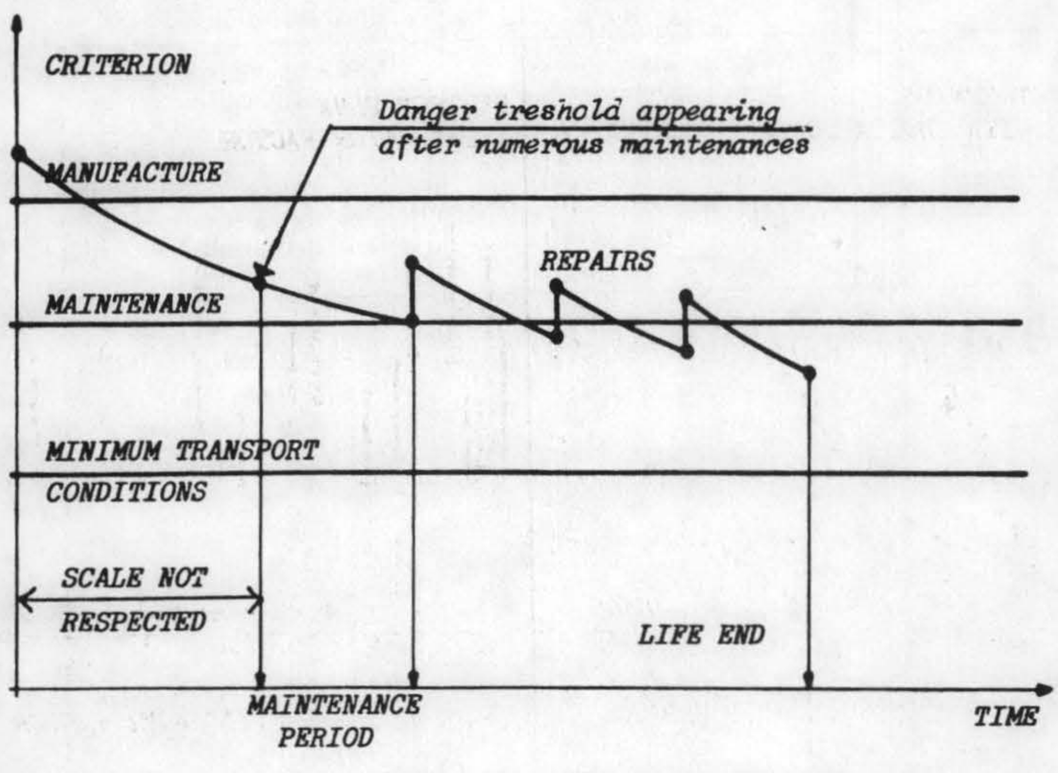

FIG. 5 : GENERAL MAINTENANCE APPROACH

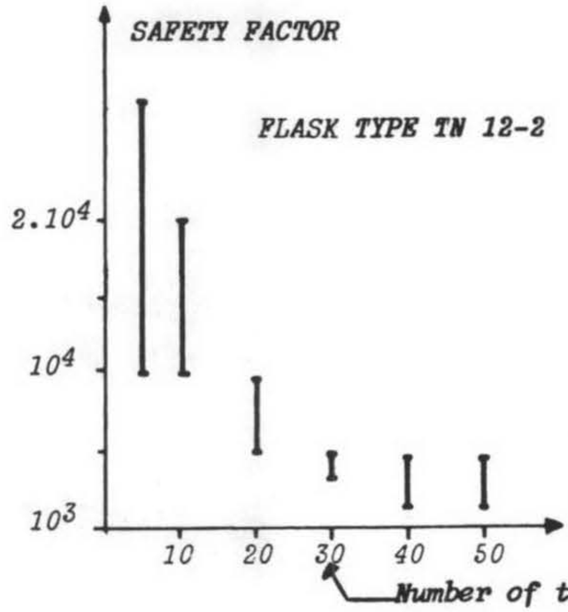

FIG. 6 : TIGHTNESS SAFETY FACTOR

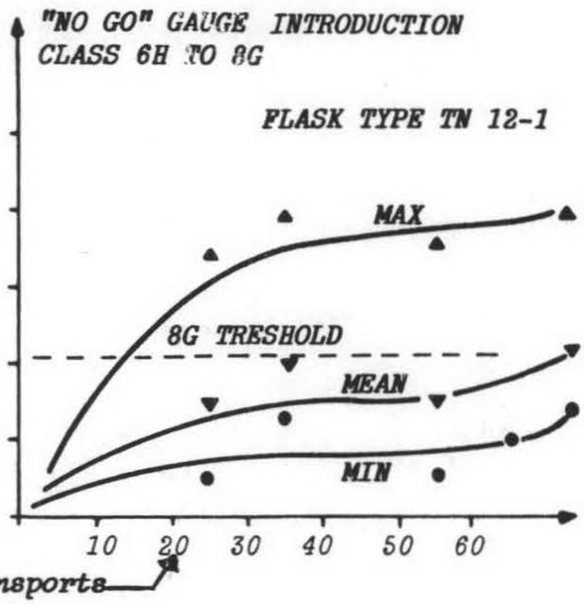

FIG. 7 : WEAR OF LID TAPPED HOLES

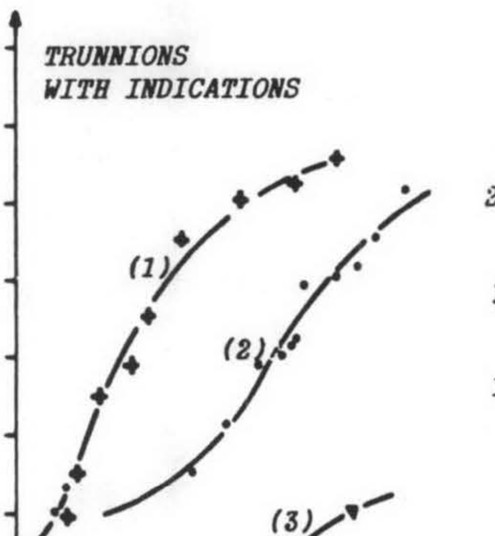

FIG. 8 : PITTING ON TRUNNION MATERIAL

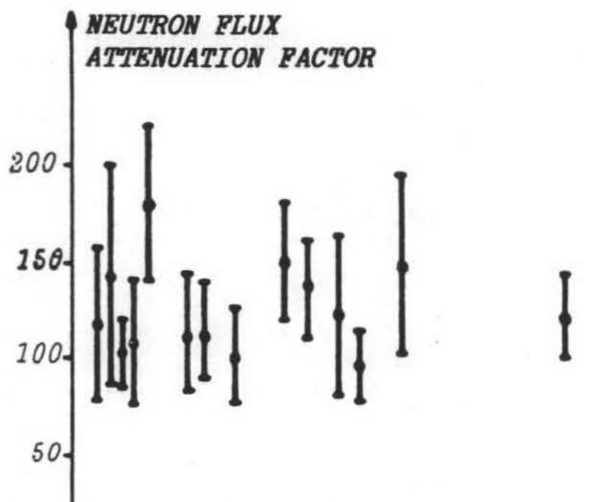

FIG. 9 : SUBCRITICALITY FACTOR

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Planning