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POTENTIAL RADIOLOGICAL IMPACT AND CONSEQUENCES ARISING FROM INCIDENTS INVOLVING A CONSIGNMENT OF PLUTONIUM DIOXIDE UNDER TRANSIT FROM COGEMA LA HAGUE TO MARCOULE/CADARACHE

AP

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POTENTIAL RADIOLOGICAL IMPACT – LOCALITIES OF PARIS AND LYON

SUMMARY

This analysis considers the road haulage of consignments of plutonium dioxide from the COGEMA reprocessing plant at la Hague near Cherbourg to the mixed oxide fuel fabrication plants at Cadarache and Marcoule in southeast France.

Until August of 2003, consignments of about 150kg of plutonium dioxide (PuO_2) were carried in a single vehicle, but since that time the number of consignments per convoy have been doubled to a total of about 280 to 300kg PuO_2 being carried by two vehicles making up a convoy that regularly passes south of Paris on the A6 and to the east of Lyon where the A6/A7 crosses the River Rhône. The consequences of these vehicles being involved in i) a severely damaging road accident, iii) a tunnel fire, and iii) a well planned and executed terrorist attack, are assessed in terms of the radiological and potential health consequences arising from a release of plutonium dioxide are summarised as follows:

Plutonium Dioxide Release to Atmosphere: The analysis considers only a release to atmosphere, its passing and subsequent dispersion and ground deposition, omitting any consequences of the plutonium run-off into watercourses. The fraction of plutonium dioxide released in either accident or terrorist scenario, is taken directly from the authoritative United States Department of Energy (DOE) environmental impact study relating to the Eurofab project that is to involve the movement of US-sourced weapons-grade plutonium to France for conversion to mixed oxide fuel (MOX). In its study, the US DOE assumes that a severely damaging accident could result in a release of respirable-sized aerosol of 595g from the *weapons-grade* plutonium dioxide of one of three FS47 flasks carried in a single, armoured road vehicle.

For this analysis, the same US defined release conditions and fraction are applied to French-sourced consignments of *reactor-grade* plutonium dioxide carried in the unarmoured trailer compartment of each of the two vehicles making up the convoy, but with each vehicle carrying 9 full FS47 flasks compared to the 3 identical FS47 flasks per vehicle in the United States example.

These release fractions are applied to the more radiotoxic *reactor-grade* consignment for i) a severely damaging road accident in which one FS47 flask is breached, ii) a similar road accident where the same proportion of FS47 flasks fail in a single vehicle (ie 1:3 so 3 of 9 flask failures); iii) a road incident in which both vehicles of the convoy are caught in a road tunnel fire in which all flasks fail, and vi) a well planned and executed terrorist attack centred on one of the vehicles of the convoy.

INCIDENT TYPE	i) SEVERE ROAD ACCIDENT – 1 VEHICLE	ii) SEVERE ROAD ACCIDENT - 1 VEHICLE	iii) SEVERE TUNNEL ACCIDENT – 2 VEHICLES	iv) TERRORIST ATTACK 1 VEHICLE
Nº FS 47 FLASKS BREACHED	1	3	18	9
RESPIRABLE-SIZED PuO_2 RELEASED	0.595kg	1.785kg	10.71kg & 25.22kg	5.355kg

Risk and Probability: For the French consignments of plutonium dioxide considered here, unlike the projected single US road shipment evaluated by the US DOE, the road transfers of French-sourced plutonium from the COGEMA plant at la Hague to the MOX are frequent (on average, 2 vehicles each carrying about 138 to 153kg every seven to ten or so days), geared to the commercial operation of the MOX fuel plant at Marcoule (and Dessel in Belgium).

The probability of a severe road accident, say a major pile-up involving impact and subsequent fire then, setting aside that heavy vehicle road accident rates between the US and France differ (but which are generally higher in France), but taking account of the shorter distances travelled in France, the risk of accident on the French roads is significantly higher than that determined for the US DOE study, being about 0.5E-06, 1E-06 and 0.5E-09 for rural, suburban and urban situations respectively (2.5E-07 overall) for each year of future operation.

Again based on data compiled in the United States, the probability of a collision-with-truck-or-bus event at a velocity of, say, 80kph followed by impact with an unyielding object (ie a bridge abutment) and then a high-

temperature engulfing fire of 2.0 to 3.0 hours duration is 6.06E-07. For such an accident to occur within the confines of a road tunnel is even more remote, although not that remote to be dismissed to be incredible, as shown by the separate Gotthard and Mount Blanc road tunnel fires, of 1999 and 2001 respectively.

On the other hand, terrorist acts are intentionally driven by, amongst other things, behavioural factors and the taking of opportunity that are, all in all, beyond the bounds of probability. Put another way, one and then two aircraft flying into the World Trade Center was unthinkable, but on September 11, 2001 the unthinkable happened.

INCIDENT TYPE	SEVERE ROAD ACCIDENT	SEVERE TUNNEL ACCIDENT	TERRORIST ATTACK
PROBABILITY	0.5E-06/1E-06/0.5E-09 rural/suburban/urban	6E-07 once initiated in tunnel	Not Applicable

Consequences: The results of this analysis indicate that the consequences of a radiological release during the road transit of plutonium dioxide in quantities that are potentially available, from both terrorist attack and road accident, are mainly long-term in nature, giving rise to increased cancer incidence, particularly lung, bone, and liver cancer. Apart for the short-term risk to those individuals engaged in the transport activity (drivers, guards, etc) and emergency personnel attending at the scene of the incident, exposure levels are unlikely to produce early effects of radiation sickness and mortality.

Health Impact - Projected Mortality: The numbers of individuals projected to suffer late mortality are:

LOCATION	SCENARIO WITH COUNTERMEASURES	MEAN – MAX MORTALITY	
Paris Outskirts	Road Accident – 0.595kg release	**68**	**523**
Paris Outskirts	Road Accident – 1.785kg release	**204**	**1,572**
Paris Outskirts	Tunnel Fire – 10.71kg release	**613**	**4,879**
Paris Outskirts	Tunnel Fire – 25.200kg release	**1,323**	**11,520**
Paris Outskirts	Terrorist Attack – 5.250kg release	**467**	**4,691**
Lyon Outskirts	Road Accident – 0.595kg release	**34**	**141**
Lyon Outskirts	Road Accident – 1.785kg release	**103**	**424**
Lyon Outskirts	Terrorist Attack – 5.250kg release	**163**	**845**

These projections are of increased incidence of mortality arising as a direct result of the releases, with the range of the forecast being determined by weather conditions and for the two different localities (Paris and Lyon) by population density. The tunnel fire scenario applies only to Paris with the incident occurring in the cut and cover road tunnel at Versailles.

The increased (over existing from other causes) incidence of cancers would be expected to peak after a delay of 15 to 30 years, with a shorter determination for leukaemia of, perhaps, 5 years from the date of exposure. Because the populations exposed for the two sample localities are so large, not only would the impact of the health detriment and fatalities remain hidden for several decades, but the significance of the numbers directly attributable to any of the earlier plutonium releases might be masked by the high 'natural' incidence, particularly of lung cancers in smokers, in the population.

Effectiveness of Countermeasures: Countermeasures, essentially sheltering and evacuation, have little effect because, first, the main exposure route is via respiration and, second, even small delays in implementation of the most common sense precautions results in over-exposure of nearby populations.

For the terrorist triggered incident, the numbers of public requiring to shelter, around Paris for example, ranges from some 40,000 to several million individuals over an area of up to 900km^2 depending on the prevailing weather conditions and the particular incident scenario. Of course, such projections are hypothetical particularly because advice from the authorities to shelter might, in fact, itself prompt a mass self-evacuation. The model assumption is that, at any time, 90% of the public are indoors and thus are already sheltering at a 50% reduction in dose uptake, so the additional benefit of implementing the organised sheltering countermeasure only applies to 10% of the potentially exposed population. Self-evacuation is likely to result in more individuals coming onto the streets without much protection and, indeed, some may unknowingly move into contaminated areas and/or become trapped for hours in the jams and traffic chaos that is almost bound to arise. The conundrum for the authorities being that the introduction of countermeasures might (indeed is likely to) increase the exposure and, hence, health detriment to many more members of public.

Again for Paris as example, relocation patterns for the longer term (1 to 2 years) extend out to 15km from the centre of the incident, although such projections should be treated with caution because of the difficulties and inaccuracies of modelling dispersion over urban areas (as demonstrated by the very patchy ground and surface contamination levels in the town of Pripyat, nearby Chernobyl).

Other than not to transport such hazardous nuclear material, the next best pre-emptive countermeasure is to separate and distance large numbers of public from the hazard. Routing the plutonium carrying convoy nearby large urban conurbations, such as Paris and Lyon, introduces the potential for high (numbers of individuals) consequences – this could be avoided by relatively straightforward route changes avoiding medium and large centres of population. On the other hand, routing the convoys to lesser roads might, in turn, result in an increased frequency of accident and a greater vulnerability to terrorist attack.

Economic and Social Impact

It is also possible to model aspects of the economic impact. However, the modelling is somewhat mechanistic, giving account to the costs of relocation, sheltering and late health effects, agricultural loss, etc., but it does not, nor could it be expected to, evaluate impacts arising from negative perceptions gained and held by the public in France and, particularly, abroad.

For example, a release into or nearby Paris would undoubtedly have a very severe impact on world tourism to this World Heritage City and, at the other example location nominated for this study, the contamination of a relatively small area of the Rhône would, no doubt, blight tourism to and the export of wines from, and perhaps, throughout the valley and entire region. These economic detriments might be expected to persist for many years, irrespective of the degree of decontamination achieved in the aftermath of the release.

It is recommended that assessment of the economic and social impact be subject of a separate study and report.

In conclusion

Recent evaluation of the safety case for the transportation of plutonium dioxide in the United Sates has led to a number of harsh constraints being imposed upon such transits.

Using the same transport flask (FS47), the US restricts the number of flasks per vehicle to 3, whereas the French transport up to 9 fully loaded flasks per vehicle. The US road convoy comprises custom-built Safe Secure Transport (SST) trucks that are fully armoured and equipped with at least two systems that automatically prevent the removal of the flasks and armoured personnel carriers accompany the convoy throughout is transit, whereas the French vehicle seem to be little more that a commercial tractor unit hauling a standard trailer with an ISO container attached, with the two consignment trucks making up the convoy being accompanied by 6 to 8 Gendarmerie travelling in what seem to be a standard and unarmoured minibus and a car. Most oddly, the US analysis reaches the conclusion that the FS47 flask could fail in a road accident and that there is a potential for 595g release from each flask in transit which compares to the utter confidence of the French that the FS47 flask is failsafe, so much so that the worst credible accident would only result in a 0.07g release.

Because the French authorities do not concede that in a real incident an amount of plutonium greater than the 0.07g could be released, a maximum dose of 10mSv is assumed for any member of the public located within the immediate vicinity, and that no emergency actions will be required further than a few hundred metres from the point of release. This contrasts to the consequences of real incidents in which realistic amounts of plutonium are released, where sheltering distances extend from 1km to 110km depending on the incident severity and, even with this countermeasure being deployed, the long-term radiation dose to the lung, for example, could be several hundred milliSieverts.

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