Sizewell B
A review by HM Nuclear Installations Inspectorate
Supplement 3: External hazards – aircraft crash NII 01 (SUPP 3)

Health and Safety Executive
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CONTENTS

INTRODUCTION

1 In the CEGB's Pre-Construction Safety Report (PCSR) for Sizewell B (ref 1) it was claimed that the probability of an aircraft crash on the station leading to a significant release of radioactivity was so low that no further measures to protect the station against this contingency were necessary. The Inspectorate took the view that the claim was insufficiently substantiated and in paragraph 5.20 of the Review of the PCSR (ref 2) requested further work by the CEGB.

2 This supplement to the Review presents the Inspectorate's current view on the status of the CEGB's safety case for aircraft crash in the light of the CEGB's supplement to the PCSR on "External Hazards - Aircraft Crash", report N/403 (ref 3). In arriving at its view, the Inspectorate has not only assessed the case as provided but has also held discussions with the Civil Aviation Authority (CAA) and the Ministry of Defence (Air) with regard to such matters as the data on aircraft crashes and their geographical location and the factors which can affect aircraft crashes.

ASSESSMENT OF AIRCRAFT CRASH

3 There exists a possibility, however unlikely, that an aircraft may crash on the proposed Sizewell B site, and in so doing it may initiate a chain of events culminating in an uncontrolled release of radioactivity to the atmosphere. The aircraft considered are all types of civil and military fixed wing aircraft and helicopters.

4 The approach adopted by the CEGB in assessing the probability of this event is outlined below:-

(i) A statistical evaluation of the probability of an aircraft crash occurring per unit horizontal area in England and Wales based on relevant crash data for the 13 year period 1968 to 1980 inclusive for civil aircraft and for the period January 1969 to April 1982 (partial data only available for 1974) for military aircraft.

(ii) The identification of those buildings and equipment on the Sizewell B site which if struck by an aircraft might lead to an uncontrolled release of radioactivity; described by the CEGB as the "potentially vulnerable areas".

(iii) The projection of a "shadow" area of those buildings on to the ground to determine the "effective target" area for the site, taking into account variations in the angle of approach of impacting aircraft.

(iv) The matching of this "effective target" area to the aircraft crash probability per unit area (for England and Wales) to quantify the probability of an aircraft crashing on to the potentially vulnerable areas.

(v) The identification of other ameliorating factors which cannot be quantified but which, in practice, should reduce the probability of the occurrence, mitigate the immediate consequences of an impact and reduce the chances of ensuing events leading to a release.

5 Following the approach outlined in paragraph 4 above, it is concluded by the CEGB in N/403 that the expected frequency of an aircraft crash on the buildings of Sizewell B leading to an uncontrolled release of radioactivity is less than 7×10^{-7} per reactor year for all aircraft and well below 4×10^{-7} per reactor year if the contribution of light* aircraft can be discounted, and that the risk is therefore acceptably low in relation to the CEGB Design Safety Guidelines.

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*The terms 'light', 'medium' and 'heavy' aircraft used in this report refer to the three categories used by the CEGB in N/403. These categories are specified by the CEGB as: less than 2.3 tonnes, 2.3 to 5.7 tonnes, and greater than 5.7 tonnes. The CEGB has not specified which of several possible weights applicable to an aircraft these figures refer to, but the Inspectorate understands them to refer to the all-up-weight as defined on page 2 of the Civil Aviation Report, "A review of aircraft accidents between 1971 and 1977 relating to Public Safety Zones", DORA Communication 8103 (March 1981)

DATA BASE

6 The statistical evaluation in N/403 examines the available data on both civil and military aircraft crashes in Britain over the periods specified in paragraph 4(i) above. Those crashes which occurred within five nautical miles of an airfield have been eliminated from consideration. This is in accordance with the well-documented view that the effect of airfield-associated crashes cannot be distinguished from a random crash pattern beyond a distance of five nautical miles from the airfield. This is in accordance with international opinion, and is accepted by the Inspectorate .

7 For civil aircraft, the data suggest that there may be a slight upward trend in the rate of aircraft crashes over the last decade, but this is so small that the Inspectorate considers it to be reasonable to use an average annual crash rate in view of the comparatively large year-to-year fluctuations in the number of crashes. Inspection of the locations of aircraft crashes also indicates that the assumption that Sizewell is an average area for this purpose is not unreasonable and may be somewhat conservative.

8 In the case of military aircraft, the data on the total numbers of crashes given in Table IV of N/403 show a downward trend between 1969 and 1981 although for crashes more than five miles from airfields the trend is not so apparent because of year-to-year fluctuations. However, the Inspectorate accepts that it is reasonable to use an average value of the annual crash rate. Military aircraft crashes have been divided into two groups geographically, one based on those areas associated with military flying, and the rest. The average crash rate appropriate to the former group has been used by the CEGB for Sizewell and the inclusion of crashes resulting from certain types of more hazardous flying activity than that practised in the Sizewell area implies that this may be somewhat conservative. The Inspectorate's examination of the distribution of military aircraft crash locations also indicates that this is the case.

POTENTIAL SOURCE BUILDINGS

9 The buildings which have been identified by the CEGB as those which could give rise to an uncontrolled release of radioactivity if struck by an aircraft are in a central block and consist of:-

- the fuel storage building;
- the primary containment;
- the steam and feed cell;
- the auxiliary building;
- the control building.

The reasons for excluding other buildings, such as the radwaste building and turbine hall, from further consideration are given in section 7 of the CEGB report. This selection is acceptable to the Inspectorate so far as the effects of aircraft impacts directly onto buildings are concerned, subject to the results of further work to be carried out to support it, as discussed below.

10 It is claimed by the CEGB in sections 7.8 and 7.9 of N/403 that crashes on buildings other than the above would not lead to an uncontrolled release of radioactivity taking into account such factors as site layout, the improbability of combined events, segregation and redundancy of equipment. However, as is discussed in paragraphs 5.13 to 5.17 of the Review, the Inspectorate is not yet satisfied with the safety case in relation to layout and segregation. Hence the CEGB's claim needs to be justified by extending the present analysis to the other plant and buildings on the site to show, to the extent necessary, that crashes outside the potentially vulnerable areas are unlikely to initiate an interaction which will lead to unacceptable consequences.

11 The CEGB argues in section 7.10 of N/403 that transmitted effects of impacts adjacent to, but not directly on, potentially vulnerable buildings will not contribute significantly to the risk of an uncontrolled release. The Inspectorate has asked the CEGB to provide additional evidence in support of its judgement on this point.

EFFECTIVE TARGET AREA

12 The potential source buildings partially shield each other from impacting aircraft where they overlap as viewed from the direction of approach, and they are also shielded by other adjacent buildings which it is claimed by the CEGB can suffer an aircraft strike without giving rise to an uncontrolled release of activity. This shielding factor was taken into account by the CEGB in estimating the effective target area in section 9 of its report (see also Appendix 1 of the report). This factor may need to be modified as a result of the further work requested from the CEGB in paragraphs 10 and 11 above.

13 An important consideration in the calculation of the effective target area is the determination of the angles of approach for aircraft impacting on the plant since the effective target area is calculated as a projection on to the horizontal plane. The CEGB has carried out an examination of those crash reports which it considers to be relevant to a site like Sizewell. From such an examination of military aircraft crash records for the period 1977 to 1982, it was assumed by the CEGB that roughly one-third of the aircraft crashed at low angles (5^{o}-15^{o}) of impact and that in only 10% of these cases would the pilot have been unable to avoid the potentially vulnerable buildings through loss of control.

14 In their examination of civil aircraft crashes in section 9.1 of N/403 the CEGB has classified aircraft into two categories, light plus medium (below 5.7 tonnes), and heavy (greater than 5.7 tonnes). It is understood that this stems from CAA practice in data collection and handling. For the light and medium weight aircraft category the CEGB claims from its examination that certain kinds of crash eg those associated with forced landings of light aircraft and with crop spraying, need not be considered and that from the remainder low angle impacts will be negligible since they will be controlled descents and the pilots will take avoiding action. The 'effective target area' for light and medium civil aircraft crashes was therefore calculated on the basis that only high angle descents would occur, and in the

absence of relevant data the angular distribution for these descents was assumed by the CEGB to be the same as that derived for military aircraft (see Table XI of N/403).

15 A similar lack of information for heavy civil aircraft crashes led to the assumption that the distribution of impact angles for this class of aircraft would be the same as that for military aircraft ie one-third at low angles, two-thirds at high angles. It was further assumed by the CEGB that in 90% of the low angle cases the pilot would be able to take avoiding action.

16 The Inspectorate has noted that the importance of these assumptions for civil aircraft is diminished either because for light aircraft the effect of impact is likely to be small or because the crash frequencies for medium and heavy aircraft are low.

17 Although based on available records, these assumptions necessarily involved a degree of judgement by the CEGB and consequently it has examined the sensitivity of the results to these assumptions. This has been done in N/403, where the CEGB conclude that increasing the conservatism of the assumptions does not increase the estimated crash frequencies so greatly that the overall conclusions become invalid. As has been discussed in paragraphs 10 and 11, above, the Inspectorate expects to see further work carried out before it can comment on this conclusion.

CALCULATION OF CRASH FREQUENCIES

18 The estimate of crash frequencies has been based on the superficial land area of England and Wales. The crash data include crashes into the sea out to a distance of two miles, which is slightly conservative, since the sea area is not included in the total. However this is balanced by the inclusion in the land area of the area within 5 miles radius of each airfield for which the crash data have been eliminated, which is slightly non-conservative. These two areas are approximately equal in size. Once the effective target areas have been derived, the calculation of the frequency of impact on the potential source buildings is then merely a matter of arithmetic.

19 The frequency of a random aircraft crash on the potentially vulnerable buildings of Sizewell 'B' is thus estimated by the CEGB to be around 7×10^{-7} per year, of which aircraft greater than 2.3 tonnes in take-off weight contribute around 4×10^{-7} per year. It should be noted that the value calculated for the crash frequency is a 'best estimate' and an examination has been made by the CEGB of the values which could be calculated for 95% confidence limits. The Inspectorate considers that the results indicate that the range of uncertainty is acceptable for a statistical evaluation of a rare event of this nature.

20 Factors which should be taken into further account in considering the possibility of an uncontrolled release of radioactivity resulting from such a crash are dealt with below.

FIRE

21 The possibility of fire following an aircraft crash should be taken into account. To evaluate the effects of aircraft fuel spillage, the CEGB has, in essence divided crashes into two categories depending on whether or not the crash itself is likely to have penetrated a potentially vulnerable building.

22 For light aircraft (whether fixed wing or helicopter) which crash on or near the potentially vulunerable buildings for which it is claimed by the CEGB in section 10.2 of N/403 that impact would not lead to any release, and for other aircraft which crash near to these buildings, it is stated in N/403 that the possibility of fire and its consequences are dealt with in a separate submission on fire accidents on the station (ref 4). The consideration of fires resulting from crashes of these aircraft should be one of the inputs to this safety case. Since this assessment requires consideration of fire protection measures in addition to aircraft crash probabilities, it will be treated separately from the review of aircraft impact in this Supplement and will be included in the Inspectorate's review of the hazard from fire (NII 01 (Supp 8)).

23 The Inspectorate understands that the CEGB's case against fires arising from crashes of heavy aircraft on the potentially vulnerable buildings is primarily based on the low probability of occurrence of the event, estimated at around 4 x 10^{-7} per year (see paragraph 19 above). Other ameliorating factors are adduced (see section 10.3 of N/403) which the CEGB claims will in practice reduce this value even further. In addition the CEGB claims that those design measures and safeguarding systems specifically intended to protect the plant against fires from other sources will act to reduce the overall probability of an uncontrolled release of radioactivity from such an initiating event. Hence it concludes that the risk from heavy aircraft crash is not significantly affected by fire considerations. The Inspectorate considers this overall argument to be acceptable subject to the results of the further work the CEGB is to do on fire and impacts outside the potentially vulnerable areas.

ADDITIONAL FACTORS

24 The CEGB has presented a case which purports to demonstrate that an aircraft crash is either of so small a probability, or for light aircraft, of no account, that there is no need to undertake significant additional precautions against this event.

25 The estimated frequency of aircraft crashes and the risk from such crashes is dominated by the value for military aircraft if it is accepted that light aircraft can be eliminated from consideration. The CEGB has undertaken to provide evidence to substantiate this latter claim.

26 For military aircraft the CEGB claims that the existence of "Provost Marshal's Prohibited Zones" over the site and the neighbouring bird sanctuary will reduce the possibility of an aircraft crash though the statistical data are too sparse to permit such a reduction to be quantified. This argument does not seem unreasonable.

27 Further ameliorating factors presented by the CEGB are that not all aircraft strikes will be such as to cause maximum damage, (for

example, some would only be glancing blows), and that following an impact to a potentially vulnerable building, spatial separation and segregation of essential plant provided for other purposes will act to protect such plant so that it will be available to reduce the possibility of a release. In other words the probability of a release following a collision must be less than one.

28 Taking into account the factors discussed above and other conservatisms such as the strength of construction of the buildings the Inspectorate accepts that the probability of an uncontrolled release of radioactivity will be less than the "best estimate" frequency of aircraft crash.

CONCLUSIONS

29 The Inspectorate finds the CEGB's general approach to the safety case for aircraft crash acceptable but requires confirmation that the treatment of potentially vulnerable areas is satisfactory. Additional evidence should be provided in support of the CEGB's judgement that:

(i) the effects of crashes on other buildings and equipment on the site (ie excluding the potentially vulnerable buildings),

(ii) the effects of impact of medium and heavy military aircraft adjacent to but not directly on the potentially vulnerable buildings, and

(iii) crashes of light aircraft directly onto the potentially vulnerable buildings,

will not contribute significantly to the risk of an uncontrolled release. This information should be provided to the Inspectorate's satisfaction before a decision on licensing is made.

30 The potential effects of fire following an aircraft crash have yet to be shown to be acceptable, but since this requires consideration of fire protection measures it will be dealt with elsewhere.

31 Assuming that these reservations can be answered satisfactorily by the further analysis which is to be provided, the Inspectorate takes the view that the possibility of an aircraft crash on Sizewell B leading to an uncontrolled release of radioactivity is sufficiently remote that no substantial modifications to the design of the plant will be required.

HM NII,
March 1983

REFERENCES

1. Central Electricity Generating Board, Sizewell B PWR Pre-Construction Safety Report No CEGB 10, April 1982, CEGB 02.

2. Health and Safety Executive, Sizewell B: A review by HM Nuclear Installations Inspectorate of the Pre-Construction Safety Report, Report No HA3, HMSO, July 1982, NII 01.

3. Central Electricity Generating Board, Sizewell 'B' PWR, Supplement to the Pre-Construction Safety Report on External Hazards - Aircraft Crash, Report No. GD/PE-N/403, December 1982, CEGB/S/724.

4. M H Goldemund. Response to NII Review of the PCSR July 1982 - Safety Aspects of Fire Protection. National Nuclear Corporation, Report No. PWR/R 684 Issue B, December 1982.