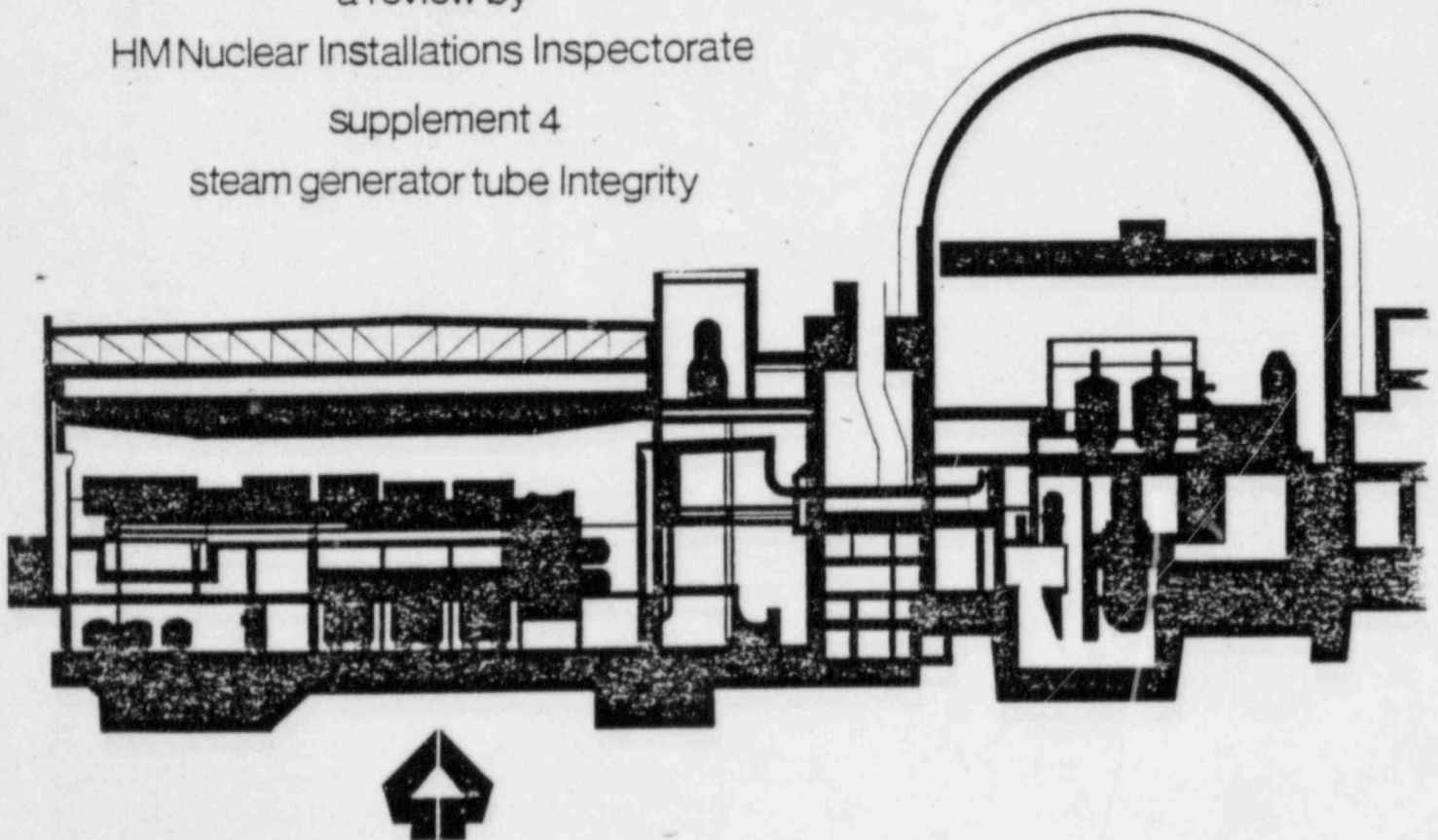


MAR 17 1983

# NII 01 (SUPP 4)

## Sizewell B

a review by  
HM Nuclear Installations Inspectorate  
supplement 4  
steam generator tube Integrity



**Sizewell B**

A review by HM Nuclear Installations Inspectorate  
Supplement 4: Steam generator tube integrity. NII 01 (SUPP 4)

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## INTRODUCTION

1 In its Review of the CEBG's Pre-Construction Safety Report (PCSR) for Sizewell B (ref 1), paragraphs 10.21 to 10.28, the Inspectorate indicated that its main concerns in regard to steam generator tube integrity arose from the possibility of multiple tube failures arising from circumferentially-orientated intergranular attack (IGA) in the residual crevice at the top of the tube-plate. The concerns encompassed the need for assurance that the thermal treatment applied to the tubes would not sensitise the material, and that the hydraulic expansion of the tubes would not produce a significant degree of cold work and residual stress in the expanded tube. The concerns were enhanced by the apparent unreliability of currently-proven non-destructive examination (NDE) techniques, based usually on multi-frequency eddy current testing (ECT) in detecting IGA in those steam generators where its presence has been undetected until tubes have been cut out for other reasons.

2 The problem had been identified as an important area of concern in paragraph 19.5 of the Review because it represented, in the Inspectorate's view, a potentially serious problem for which no demonstrable remedy existed at the time of writing; that is to say, it was concluded that some development work or design changes might be necessary to resolve the issue.

3 The CEBG responded to the Review with a paragraph by paragraph response, in Report No FWR/R685\*, (ref 2). This report by the Inspectorate considers the responses in R685 in the context of the appropriate paragraphs of the Review. Information given in sections 2, 3 and 5 of R685 is taken into consideration, as appropriate, in the commentary under each paragraph.

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PARAGRAPH 10.22

4 In paragraph 10.22 of the Review, the Inspectorate was concerned that there had been incidents affecting PWRs in the USA in which the design basis for tube leakage, i.e. double-ended rupture of a single steam generator tube, had been exceeded. The information about the causes of tube failures provided in R685 is welcomed, and supports the Inspectorate in its conclusion, as indicated in paragraph 10.23, that the features incorporated in the Westinghouse Model F steam generator and the secondary plant provisions on Sizewell B should alleviate if not eliminate the mechanisms which gave rise to the failures at Surry 2, Point Beach 1 and Doel 2.

5 The Inspectorate also welcomes the commitment to provide loose parts monitoring for the shell side of the steam generators in addition to that which will be provided in the reactor pressure vessel. This provision, should also overcome loose parts problems of the kind which have been reported on Ringhals 3 (ref 3).

PARAGRAPH 10.23

6 No further comment required.

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7 The Inspectorate's concern in this paragraph of the Review related to the possibility of circumferentially orientated defects arising in the crevice at the top of the tube plate. The Inspectorate accepts that the mean depth of the crevice will be about 3.56mm, and not 6mm as stated in the Review. However, this does not affect the concern, which remains.

8 In discussing this problem with the CEGB, the Inspectorate has also indicated that in its view the thermal treatment proposed for steam generator tubes to improve resistance to IGA and stress corrosion cracking might produce detrimental effects, which might even include sensitisation (denudation of chromium in the grains adjacent to the grain boundaries). This was reinforced by a review of the literature conducted by Weldon (ref 4) on behalf of the Inspectorate.

The CEEB has quoted a substantial body of information which supports its view that both the temperature and duration of the thermal treatment process have been carefully selected to minimise precipitation of the higher carbides ( $\text{Cr}_{23}\text{C}_6$ ) at the grain boundaries, to minimise denudation of chromium in the grains adjacent to the grain boundaries, to reduce residual stresses and to maximise the resistance of the material to laboratory-induced corrosion in aggressive media.

9 The CEEB has provided additional information, all of it proprietary to Westinghouse, which indicates that the process controls applied to the production, thermal treatment and fabrication of the tubes should ensure that the tubes are in optimum condition when installed in the steam generator.

10 The CEEB has also described to the Inspectorate an extensive programme of corrosion testing. Though the bulk of this is directed to the resolution of problems other than IGA in the tube-plate crevice, it is accepted that the proposed short-term work directed to various aspects of IGA will provide information on, and perhaps enhance understanding of, some aspects of the problem.

11 In R685 the CEEB objects to the Inspectorate's reference to the inadequacies of short-term corrosion test data. The Inspectorate's concern was not only related to the breakaway corrosion phenomenon in the 9% Cr ferritic steels in the context of the Advanced Gas-Cooled Reactor but also to the breakaway corrosion behaviour in carbon steels in Magnox reactors. In both cases, short-term corrosion tests failed to reveal the accelerated corrosion which it was subsequently found could occur after a lengthy incubation period.

12 In these circumstances, it is the Inspectorate's view that the work to date validates only the short-term resistance of thermally-treated tubing to stress-corrosion in concentrated aggressive solutions, and the model boiler tests discussed will demonstrate only the short-term endurance of the material within the water chemistry limits laid down by the Steam Generator Owners' Group (SGOG) (see Appendix 1 of R685). The Inspectorate accepts that it should be possible to hold Sizewell B chemistry generally within tighter limits

than SGOG chemistry, and it is further accepted that the model boiler tests should reasonably reproduce the short-term behaviour of Sizewell B, but they will not give adequate assurance of the long term behaviour.

13 However, the Inspectorate also accepts that the long lead experience of replacement steam generators with thermally-treated tubes illustrated in Table 2, the substantial lead times of many US and overseas plants illustrated in Table 1, the long lead times of French steam generators of types similar to Model F illustrated in Table 3 and the arguments in Appendix 1 of R685 should give adequate assurance against problems on Sizewell B, provided always that a validated NDE technique is employed in inspection of the crevice region. Even if problems of this kind were to arise after Sizewell B were commissioned, these long lead times give assurance that a response could be developed before the problem became acute for Sizewell B.

#### PARAGRAPH 10.25

14 In paragraph 10.25 of the Review, the Inspectorate cites two independent inspections of steam generators which suggest that most modern multi-frequency eddy current testing (ECT) techniques are not capable of identifying IGA in the crevice. The Inspectorate does not accept the CEB's interpretation of the statement quoted from reference 39 of the Review. It is understood that the signals recorded during the field inspection were below the reporting level and hence no report was made. After tubes, which were originally given a clean bill of health in terms of the crevice region, were removed from the steam generator for other reasons it was discovered that they had suffered IGA to such an extent that they were cracked up to 70% of the wall thickness. Only when this IGA had been detected visually were the ECT records re-examined. The signals recorded were reinterpreted as indicating 3-10% wall thinning. The Inspectorate regards this as a failure even after reinterpretation to detect IGA even when the cracking was up to 70% through the wall in extent.

15 Much of the development work on ECT in the United States is directed towards resolving problems other than the detection of IGA in the crevice region. Nevertheless, it is accepted that much improved understanding of the capabilities and limitations of ECT will be likely to arise from this work. Again, it is accepted that the CEBB and Babcock Power Limited programmes should extend the capabilities of ECT, but it is by no means certain that it will succeed in the case of the difficult crack morphology associated with field IGA and the complex specimen geometry of the crevice region. The Inspectorate is not as optimistic about the successful outcome of this development work as the CEBB appears to be.

16 The Inspectorate is more optimistic that the proposed development programme on ultrasonics described in R685 will yield a valid NDE method. This optimism is tempered by the problems of access in such small tubes and the complex geometry of the crevice region.

17 All of these factors, taken together with the realisation that certainty with regard to the absence of IGA in operating plants can only be assured if a reliable NDE technique exists, leads the Inspectorate to reiterate that an NDE technique should be demonstrated as feasible prior to a decision on licensing. The Inspectorate would expect this to be followed by a programme of inspection using this technique as a part of the maintenance schedule for Sizewell B, should it be licensed.

#### PARAGRAPH 10.26

18 Assuming that a demonstration is provided that an NDE technique exists which can reliably detect IGA in the crevice, the Inspectorate would then be able to accept the CEBB's argument regarding the burst strength of tubing. It would then be reasonable to assume that only rogue tubes are susceptible to failure and that the USNRC criteria for tube inspection and plugging (refs 5 and 6) can be satisfied. Accordingly, it seems reasonable to require that a flow cross-section equivalent to a double-ended guillotine fracture of a single tube should be assumed for safety analyses. The Inspectorate considers that a safety case based on these assumptions is acceptable for licensing purposes. However, the Inspectorate expects the consequences

of rupture area corresponding to that of two tubes with double-ended guillotine fractures to be examined, to provide some further margin of assurance.

19 In regard to failed tubes propagating, the CEGB states in R685 that work has been initiated by NNC to demonstrate that failure of one tube will have a sufficiently low probability of causing further tubes to fail (so that the possibility of such consequential multiple failures may be discounted). The Inspectorate awaits receipt of the preliminary results of this work shortly.

#### PAPAGRAPH 10.27

20 In response to the Inspectorate's point that multiple tube failures have occurred, the CEGB advances arguments to suggest that, even in the event of such failures, the likelihood of radioactivity releases which would give doses exceeding 1 emergency reference level (ERL) is extremely small. A number of reservations about these arguments have been conveyed to the CEGB, and a response has recently been received but has not yet been assessed.

#### PARAGRAPHS 10.28, 10.58

21 See the conclusions set out below.

#### CHAPTER 12 CONCERNS

22 The remaining responses made in R685 are to the steam generator secondary side chemistry issues in paragraph 12.23-12.26 of the Review. They are not essential to the safety case required to remove steam generator tube integrity from the Inspectorate's list of major issues and will be considered separately.

#### CONCLUSIONS

23 The CEGB are now committed to an R & D programme to extend the work in the USA and elsewhere on NDE development applied to steam generator tubes to develop a validated method capable of detecting IGA and sizing IGA in the crevice region. Providing such a programme is

successful, the Inspectorate would then accept the experimental programmes and the Model F operating lead times quoted in R685 as giving adequate assurance against the likelihood of multiple steam generator tube failures. However, demonstration to the Inspectorate's satisfaction that an NDE technique exists which is likely to be reliable thus becomes a prerequisite of licensing. With this proviso it is concluded that the safety case for steam generator tube integrity is now satisfactory for licensing.

HMNII,  
March 1983

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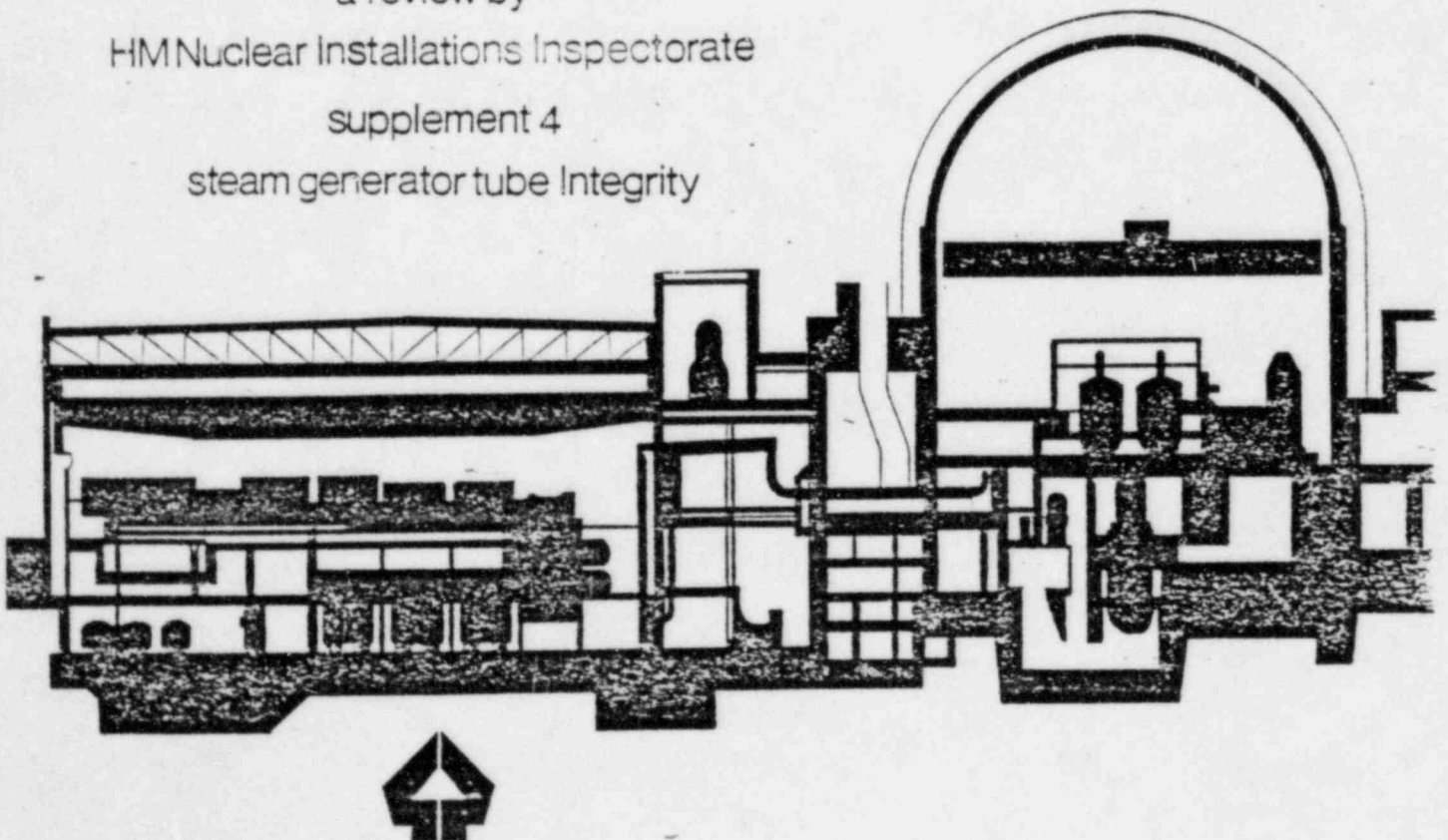
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