LINER INSULATION FOR GAS-COOLED REACTORS

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I. INTRODUCTION

A. Advantages of Concrete Pressure Vessels

In his formal closing of the Conference on Prestressed Concrete Pressure Vessels organized by the Institution of Civil Engineers in London in March, 1967, Lord Hinton of Bankside gave a brief history of the evolution of the design of pressure vessels for gas-cooled reactors (1).

Soon after World War II, designers in both the United Kingdom, France, the United States and elsewhere realized that the roles of the welded steel pressure vessel and the concrete biological shield could be combined in a prestressed concrete pressure vessel. However, cost studies in the United Kingdom did not show the concrete vessels to be cheaper, and the first gas-cooled reactor designed to produce plutonium for the military program with electrical energy as a byproduct used a steel pressure vessel, and was commissioned at Calder Hall in 1956.

At the same time, several similar designs aimed at a civil nuclear program were nearing completion, and contracts were placed by the Central Electricity Generating Board for twin reactor stations at Berkeley (275 (MW(e)) and Bradwell (300 MW(e)). As the Magnox reactor program evolved, gas pressures and vessel sizes increased. Problems arose with the site fabrication and inspection of the steel vessels, and in 1959 the concept of an integral design of concrete pressure vessel was being considered by Sir Robert McAlpine.
and Sons Ltd. In this design, the reactor core and boilers were contained within one vessel, the failure of which was considered to be incredible (Figure 1). The safety problems of the steel vessels, boilers, duct work and bellows units were thereby eliminated and replaced by the relatively minor problems associated with the inevitable penetrations of the concrete vessel required for circulators, water, steam and fuel access.

The first power station incorporating these features was a twin reactor design of 660 (MW(e)) built by The Nuclear Power Group Ltd, at Oldbury on Severn (Figure 1) and commissioned in 1967. A foil and mesh insulation developed in conjunction with Darchem Ltd was used (Figure 5). The last of the U. K. Magnox Stations, which was built at Wylfa (1200 MW(e)), used two internally spherical concrete vessels. Insulation also included the element style developed in conjunction with Darchem Ltd (Figure 8).

The Magnox Stations were followed by Advanced Gas-cooled Reactors (AGR), all of which use concrete pressure vessels. Hinkley 'B' and Hunterston 'B' (1250 MW(e), seen in Figure 2), were commissioned in 1976 and used a fibre insulation developed with Delaney Galley Ltd (Figure 7). Very similar designs using similar insulation are proposed for the AGR stations approved by the government in 1978. The podded boiler layouts of Hartlepool and Heysham, shown in Figure 3, use element insulation.

It is interesting to note that presented with similar problems, the French designers came to different conclusions, and their first concrete pressure vessel contained only the core. The G2 and G3 (40 MW(e)) reactors were built at Marcoule and commissioned in 1960. After reverting to steel vessels for the Chinon Power Station EDF1 (70 MW(e)) and EDF2 (200 MW(e)), a concrete vessel was again used to contain the core only in EDF3 (480 MW(e)), and this station was commissioned in 1967. However, an integral design was chosen for EDF4 (480 MW(e) commissioned in 1969) and subsequent gas-cooled reactor stations(2).

In the French integral design, the vessel diameter is kept to a minimum by positioning the boilers below the core. The flow through the core is downward, thereby reducing the surface area exposed to gas at the core outlet temperature.