

DRAWINGS ATTACHED

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(19)



(54) IMPROVEMENTS IN METHODS OF TESTING FOR FUEL ELEMENT SHEATHING FAILURES

(71) We, UNITED KINGDOM ATOMIC ENERGY AUTHORITY, London, a British Authority, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to testing for fuel element sheathing failures in a nuclear reactor cooled by a flow of liquid coolant by detecting gas escape from the fuel elements into the coolant.

In UK Patent No. 1,108,137 a method and various apparatus of testing for such occurrences are disclosed. The method of that patent relates to the testing for fuel element sheathing failures in a nuclear reactor cooled by a flow of liquid coolant and is characterised by the steps of localising in a collector zone within the coolant any gaseous substance derived from the fuel, and detecting whether gaseous substance or coolant is present in the collector zone. Should the presence of gaseous substance be detected it is presumed that a release is taking place, since the amount of gas necessary to replace coolant by gas can only be presumed to come from a release. One exception to this is the case of vented fuel, where a sheathing failure will result in collected gas being replaced by coolant. In this case, should the presence of coolant be detected where gaseous substance is normally present, it is presumed that a release is taking place.

The present invention provides apparatus for testing for fuel element sheathing failures in a nuclear reactor cooled by a flow of liquid coolant by detecting gas-escape from the fuel elements into the coolant, said apparatus comprising:

- (a) a duct defining a constrained flow path for liquid coolant,
- (b) means for imparting a vortex motion to coolant entering said duct,

- (c) means for imparting a straightening motion to coolant leaving said duct,
- (d) a duct having an opening in the axial region of the duct (a) and between the means (b) and (c), and
- (e) means connected with said duct to detect the pressure of gas at the opening of the duct (d).

The present invention also provides a method of testing for fuel element sheathing failures, the method being applicable to control of the operation of nuclear reactors.

Apparatus embodying the invention will now be described with reference to the drawing accompanying the provisional specification of which:

Figure 1 is a sectional elevation,

Figure 2 is a graph.

Figure 1 shows a circular section tube 11 through which flows reactor coolant in the direction of the arrow 12. A first boss 13 of diameter D is provided in the tube the boss having vanes 14 mounted around it to impart a rotary component of velocity to the coolant. A second boss 15 of smaller diameter than D is provided downstream of the first boss 13 so defining between the bosses an axial region 17. The second boss 15 has mounted around it a second set of vanes 18 serving to straighten the flow of coolant caused to rotate by the vanes 14.

A duct 20 has an opening 19 which opens into the region 17 and faces in the downstream direction. The duct is connected to a differential pressure transducer (not shown) of known type to measure pressure at the opening 19. The pressure transducer may be connected across a flow restrictor in the duct 20 with the end of the duct remote from the opening 19 connected to the tube 11 downstream of the second set of vanes 18 so that the pressure measured is the difference between the pressure at the opening 19 and the pressure downstream of vanes 18.

In the event of coolant flowing through the tube in the direction of arrow 12 carrying gas bubbles they are caused to congregate in the shaded part of the axial region 5 17 by the vortex caused in the coolant by vanes 14. The arrival of the bubbles causes an increase in pressure to be sensed at the opening 19. As the bubbles clear away or decay the pressure at opening 19 falls.

10 The relationship between the pressure differential and the time the bubbles take to decay away is shown in Figure 2 for various values of S (which is the distance between the downstream edges of vanes 14 and the upstream edges of the second set of vanes 18). From this it will be apparent that the bubble system tends to clear itself (or decay) after a given bubble congregation has occurred. This enables the system to be used to detect a rapid fuel element burst — as distinct from a slow leak — since the relatively large volume of gas released in a fast burst causes a readily detectable increase in pressure in the axial region 17 which subsequently decays away resulting, effectively, in a resetting of the detection system in a short time.

WHAT WE CLAIM IS:—

1. Apparatus for testing for fuel element sheathing failures in a nuclear reactor cooled by a flow of liquid coolant by detecting gas-escape from the fuel elements into the coolant, said apparatus comprising:
 30 (a) a duct defining a constrained flow path for liquid coolant,
 35 (b) means for imparting a vortex motion to coolant entering said duct,
 (c) means for imparting a straightening motion to coolant leaving said duct,
 40 (d) a duct having an opening in the axial region of the duct (a) and between the means (b) and (c), and
 45 (e) means connected with said duct to detect the pressure of gas at the opening of the duct (d).

2. Apparatus as claimed in claim 1 in which the means (b) comprises a central boss of diameter D having vortex imparting vanes and in which the means (c) comprises a central boss of diameter less than 50 D having straightening vanes and in which the duct (d) has its opening facing in the downstream direction of the duct (a).

3. Apparatus according to claim 1 or 2 in which the means (e) comprises a differential pressure transducer. 55

4. Apparatus according to claim 3 in which said pressure transducer is connected across a flow restrictor in the duct (d) and the end of that duct remote from the opening in the axial region of the duct (a) is connected to a duct on the downstream side of the means (c). 60

5. Apparatus for testing for fuel element sheathing failures substantially as hereinbefore described with reference to the drawings accompanying the Provisional Specification. 65

6. In a nuclear reactor having, in channels, sheathed fuel elements cooled by flow of liquid coolant, apparatus according to any preceding claim provided on the coolant outlet end of said channels. 70

7. A method of testing for the presence of gas, in a flow of nuclear reactor coolant liquid, escaping from a sheathing failure in fuel elements in the reactor said method comprising the steps of: 75

- (a) creating a vortex in said flow confined between a vortex imparting means and a flow straightening means to separate the gas from the liquid in the flow, and
 80 (b) measuring the pressure of separated gas and relating it with time. 85

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FIG.1

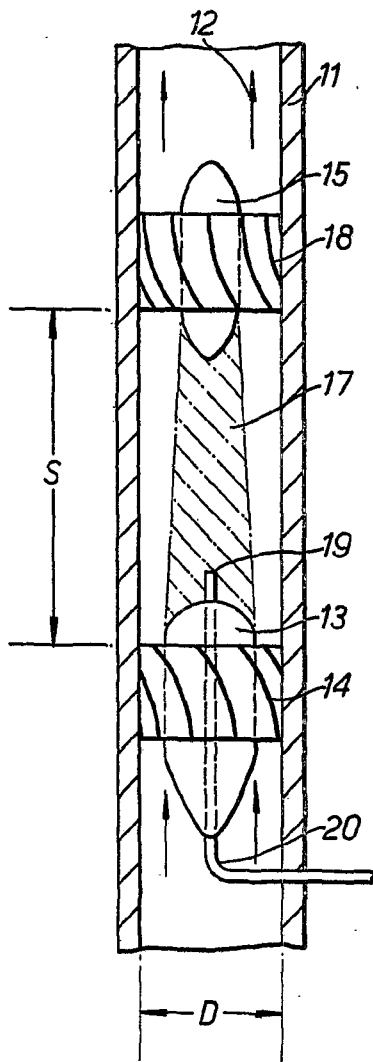


FIG. 2.

