Self Evaluation

MODULE B.1

REACTOR

1. The major reason that channel blockage presents a serious problem in the reactor is that the rate of flow of coolant to the fuel is decreased.

   If we briefly explain the equation for power in the channel, we can see the effect of changing mass flow.

   $\mathring{Q}$ = mass flowrate x (Enthalpy In - Enthalpy Out).

   In this expression, the channel power will remain sensibly constant so $\mathring{Q}$ will not alter. The channel inlet enthalpy will remain constant. If the mass flowrate now decreases, the exit enthalpy must increase to compensate, keeping $\mathring{Q}$ constant.

   The increased enthalpy is seen by a rise in Channel outlet temperature. This is the first indication of possible channel blockage, provided it does not appear in other adjacent fuel channels.

   The rise in temperature of the heat transport D_2O will cause an increase in the fuel sheath temperatures which will not be a problem provided that voiding does not occur. A channel high temperature trip is the expected result from this event.

   The danger lies in the situation where channel voiding occurs and the heat transport pressure is low enough that voiding occurs at a temperature below the high temperature trip setting on the channel.

   The channel blockage may be confirmed by monitoring the channel pressure drop using the fuelling machines.

2. The two problems that may result from a low heat transport system pressure are both related to the production of vapour.

   The two problems concern the fuel bundles and the heat transport pumps.

   If the system pressure falls to the saturation pressure, large scale vapour production will occur in the channel and voiding will result. The major concern in now of loss of heat transfer from the fuel. Instead of forced convection with liquid, the heat transfer is taking place with vapour which has a far inferior ability to transfer heat.

Under normal conditions, the centre temperature of the fuel is around 2300°C when the melting point is around 2800°C. As the fuel temperature rises, the possibility of fuel sheath failure increases and is likely to occur.

When the fuel sheath temperature has risen from around 350°C and has reached a range of 800 - 1100°C, sheath failure is accelerated by the release of fission product gases from the fuel grain boundaries at high temperatures, causing high pressure between the fuel and the sheath.

If the system pressure falls below the value to establish the required positive suction head for the heat transport pumps, then cavitation will result. The effect of cavitation will be pump damage and loss of coolant flow.

3. If the heat transport system pressure control program cannot maintain the pressure because of loss of coolant, this is a serious condition.

As soon as the system pressure reaches the saturation value, large scale vapour production will begin and it may appear as though the problem was over because the system pressure has stabilized. In fact, from the moment the saturation pressure was reached and channel voiding commenced, the fuel was beginning to overheat.

The object of the exercise is to reduce the fuel overheating to a minimum and re-establish fuel cooling as soon as possible. This cooling can only be achieved when liquid is again in contact with the fuel bundles.

By crash cooling, the heat transport circuit is cooled and depressurized rapidly in a few minutes to a point where the heat transport fluid can restore cooling. If there is not enough heat transport D_2O left in the circuit, emergency core injection may commence as soon as the heat transport pressure has fallen below the maximum possible injection pressure.

The main difference between a small loss of coolant and a major LOCA is that in a small loss of coolant situation, it may not be obvious to the operator that channel voiding has occurred. The large quantities of vapour generated stabilize the system pressure and may disguise the real problem. In a major LOCA, the operator is left in no doubt as to what has happened!

4. A loss of coolant from the heat transport system may not appear in the immediate environment and may not necessarily result in a high boiler room pressure trip or a Beetle alarm.

The D_2O could leak into the steam generator, for example. In this situation, we would have to look elsewhere for pointers indicating a loss of coolant.

A reducing level in the D_2O storage vessel, ie, the D_2O storage tank may be some indication.

A loss of heat transport system pressure may be a further indication of loss of D_2O.

If the D_2O was leaking into the boiler room, then a high boiler room pressure trip and Beetle alarms would confirm this event. A steam leak could produce the same effect!

If the loss of coolant created voiding, the resultant positive reactivity would produce the Linear Rate Trip, Hi Log Rate Trip, Hi Power Trip.

5. The immediate effect of losing the feedwater supply is to lose around 17% of the heat sink because no heat is being removed from the PHT to increase the sensible heat of the feedwater. There is now a mismatch of thermal power and the PHT temperature starts to rise.

As the level in the steam generator falls below the tubes, heat transfer is further lost due to the reduction of heat transfer area and the rate of temperature rise of the PHT increases.

6. The onset of bulk boiling occurs at constant temperature which means that channel ΔT can no longer be used as an indication of channel power.

The production of vapour increases the "steam quality" along the remaining section of the fuel channel but gives no external indication of whether 10% or 80% of the liquid has become vapour.

7. The reactor is at a lower elevation than the steam generator. This arrangement permits the less dense hot D_2O to rise up to the steam generator by convection and equally causes the cooler D_2O to return to the reactor. This mechanism establishes flow round the PHT circuit, with no pump running, by thermosyphon.

   The thermosyphon can only be maintained provided no vapour or gases collect in the tubes in the steam generator.

   ROH temperature is monitored to ensure that no vapour is produced in the PHT circuit and that sufficient temperature difference exists between the steam generator and the PHT system for adequate heat transfer. This ΔT may be controlled by the steam generator pressure.

* * * * *

When you have compared these notes with your own answers, have the Course Manager review them. When you are both satisfied with your answers, have the Manager sign off the test sheet.

* * * * *

Before you finish, please complete the course evaluation form and let us know what we can do to make this course more suited to your needs, in format <u>and</u> content.

* * * * *

Well Done!