Reactor, Boiler & Auxiliares - Course 233

HEAT TRANSPORT D_2O RECOVERY

I. PURPOSE OF SYSTEM

The purpose of the HT D_2O recovery system is to return enough HT D_2O escaping from the HT system in the event of a moderate piping rupture to provide for adequate coolant flow in the fuel channels until the HT system can be cooled down and depressurized.

A "moderate" leak here is defined as one that does not allow the HT system pressure to fall below the saturation pressure. In other words, the rate at which coolant escapes from the leak is less than the rate at which it can be returned to the main system, at normal system pressure.

This system is then designed to avoid the need for ECI (ECC or EI) system operation during moderate HT leaks. The ECI system is intended for use in the event of a major break in the HT system, and its use involves serious consequences. ECIS operation would result in a large downgrading of moderator D_2O if moderator injection were used, or a large downgrading of HT D_2O if H_2O were used. Hence substantial upgrading costs would be incurred. Furthermore, in the case of a moderate coolant leak crash cooling of the HT system would likely be required in order to reduce system pressure to ECIS injection pressure quickly enough to prevent fuel damage. However, HT components might be damaged due to the severe thermal stresses associated with the crash cooldown.

In contrast, the use of the HT D_2O recovery system for moderate leaks allows an orderly reactor shutdown and HT cooldown and depressurization. This will then reduce the leakage rate and bring the system to a state where the leak can be eventually isolated and then repaired.

II. SYSTEM DESCRIPTION

The system (see Figure 1) consists of a D_2O recovery tank located at a low point in the reactor building. Water from a break drains via gravity into this tank.

A HT D_2O recovery pump, usually attached to the top of the tank via a flange, is provided to pump recovered D_2O back to the suction of the HT feed pumps (or HT D_2O storage tank) via a check valve and a motorized isolating valve. The recovered D_2O is then pressurized and returned to the system by the feed pumps. The motorized isolating valve opens when the recovery pump starts, and closes when the pump shuts down.

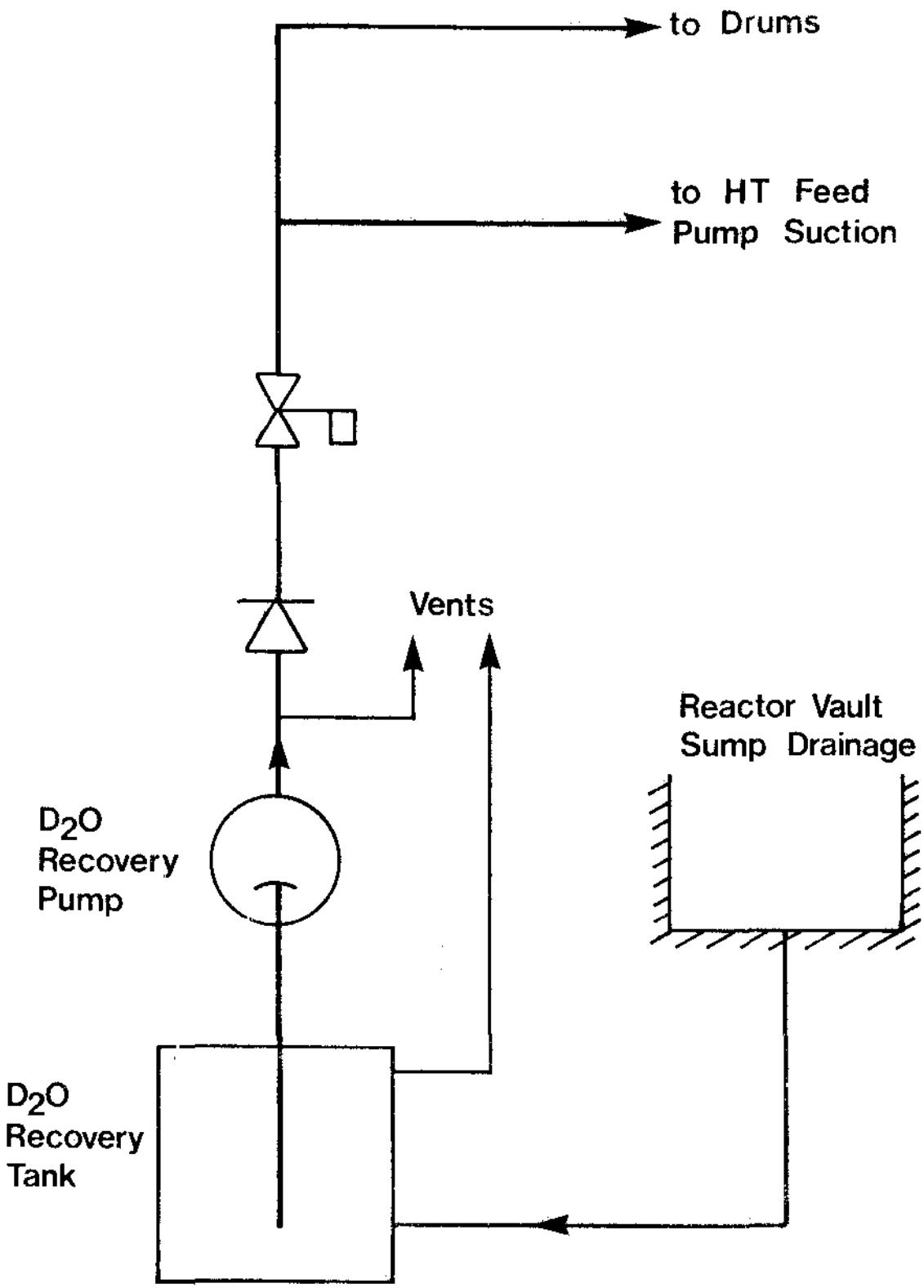

Figure 1: Simplified HT D_2O Recovery System

If the HT leak rate is small, then the recovered water can be pumped to drums for chemical cleanup and/or upgrading. The D_2O storage tank inventory would then be used to supply HT D_2O until the leak could be isolated. Such action would prevent any downgrading and contamination with insolubles of the HT D_2O, which would occur to some extent if recovered D_2O were returned directly to the HT system.

III. OPERATING FEATURES OF SYSTEM

From a HT system break at power, two phase (ie, liquid and vapour) fluid will be ejected. Initially $\sim$60% will be liquid and $\sim$40% will be vapour (steam). As the HT D_2O cools down in the main system, the liquid percentage of ejected fluid will increase. The steam buildup results in a pressure rise inside containment. Containment (vacuum building or reactor building dousing) operation will be triggered if this pressure rise is large enough. However, for leaks small enough to be handled via the recovery system, containment is not likely to be triggered.

Although the liquid draining into the recovery tank is hot ($\sim$80°C - 100°C) typically, the drainage system is designed to provide adequate suction head for the recovery pump.

Vent lines on the recovery tank and pump discharge allow air to be vented from these components prior to pump back of recovered coolant. Thus the probability of air-locking is minimized. These lines, shown in Figure 1, vent into containment.

IV. DETECTION OF HT D_2O LEAKS

Whether or not the HT D_2O recovery system is used it is useful to summarize the range of HT D_2O leaks, from small to large, and to describe how they are detected and which system(s) would be necessary to cope with the problem.

(a) Small Leaks

Small HT D_2O leaks due to bad seals on channel closure plugs, or on other equipment such as valves or pumps, will be indicated by an increased collection rate from the HT vapour recovery driers. Decrease in HT D_2O inventory will also indicate a leak: HT D_2O storage tank level falling will indicate this. (Closure plug leaks can be traced directly by using the ultrasonic leak scanner on the fuelling machine). Leaks of this nature will not require recovery system operation.

(b) Moderate leaks

These will be leaks from ruptured instrument lines up around 1 cm in diameter. They will likely require recovery system operation varying from intermittent pumping to drums to continual recirculation back to the main system. Indication of leaks of this nature may be one or more of the following:

- low storage tank level
- high vault pressure alarm
- beetle alarms in drainage sumps
- reactor building liquid recovery system tank high level alarm
- increased collection rate in D_2O vapour recovery collection tank
- high inlet dewpoint to D_2O vapour recovery driers

Whether the recovery system is used to pump to drums or to the main system will depend on whether adequate HT coolant inventory is available in the storage tank (or can be transferred from other units) to allow for HT cooldown, a procedure lasting about one hour. Drumming is preferred, because it prevents contamination with foreign matter and downgrading of the HT D_2O remaining in the HT system. However, if adequate inventory is unavailable to compensate for the leakage, the recovery system would be used to return the D_2O to the feed pumps. If the feed capacity is then adequate to maintain the HT pressure at the control setpoint and to maintain pressurizer tank level then the recovery system operation will be adequate to cope with the leak.

To confirm whether pressure control has stabilized, one should check HT pressure/temperature readings with saturation values in steam tables. Note that an indicated constant pressure does not necessarily mean pressure is being controlled - it may simply mean that the water is boiling, which is to be avoided.

(c) Large Leaks

For large breaks, the above indicators will all still be evident, with the additional triggering of containment and ECIS. Large leakage rates are discussed under ECIS operation, section 30-11.

ASSIGNMENT

1. Define as precisely as possible, the type of leak that will require the recovery system operation.

2. Give two reasons why it is desirable to avoid ECC system operation on a HT leak if possible.

3. For your own plant, state exactly where the HT D_2O recovery drainage paths are located, and what specific lines are available for recovery system air venting prior to operation.

4. Are there any other indications of the leaks (a), (b) or (c) discussed in section IV you can think of which are not mentioned?

5. If a small LOCA occurred, the leakage rate could be monitored by the rate of fall of the HT D_2O storage tank level. If a HT D_2O cooldown were initiated after the LOCA began, explain why the rate of fall of storage tank level would appear to increase.

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