

## Reactor, Boiler &amp; Auxiliaries - Course 233

MODERATOR D<sub>2</sub>O COLLECTION

---

I. PURPOSE OF SYSTEM

The main purpose of the moderator D<sub>2</sub>O collection system is to collect, by gravity drainage, normal leakage from moderator equipment collection points via a closed piping system. The system also pumps the collected D<sub>2</sub>O back to the main moderator system.

As the main collection points are from equipment that leaks during normal operation, the use of this system minimizes:

- (a) Direct leakage of moderator D<sub>2</sub>O into moderator equipment room atmosphere. If this leakage were collected via an open drainage system the leaked D<sub>2</sub>O would suffer downgrading due to mixing with H<sub>2</sub>O vapour present in the atmosphere. In addition the load on the D<sub>2</sub>O vapour recovery system would be increased as also would stack D<sub>2</sub>O losses.
- (b) Tritium concentrations around moderator equipment. This is particularly important for moderator D<sub>2</sub>O as moderator tritium activity is much larger than HT D<sub>2</sub>O tritium activity. The operating target of 1% DEL (Derived Emission Limit) and the license limit of 100% DEL for tritium release in air would be more difficult to achieve without a closed collection system.

II. SYSTEM DESCRIPTION

Typical main collection points used to take off moderator D<sub>2</sub>O are:

- moderator pump seals
- moderator He cover gas compressor ring seal and mechanical seal.
- moderator isolating and control valves.

Valve leakoff points are not usually used on all moderator valves however. The number used depends on the station and the type of valves installed. Generally speaking the moderator D<sub>2</sub>O collection system will have a lot fewer collection lines than the corresponding HT collection system as the moderator and auxiliary systems have fewer

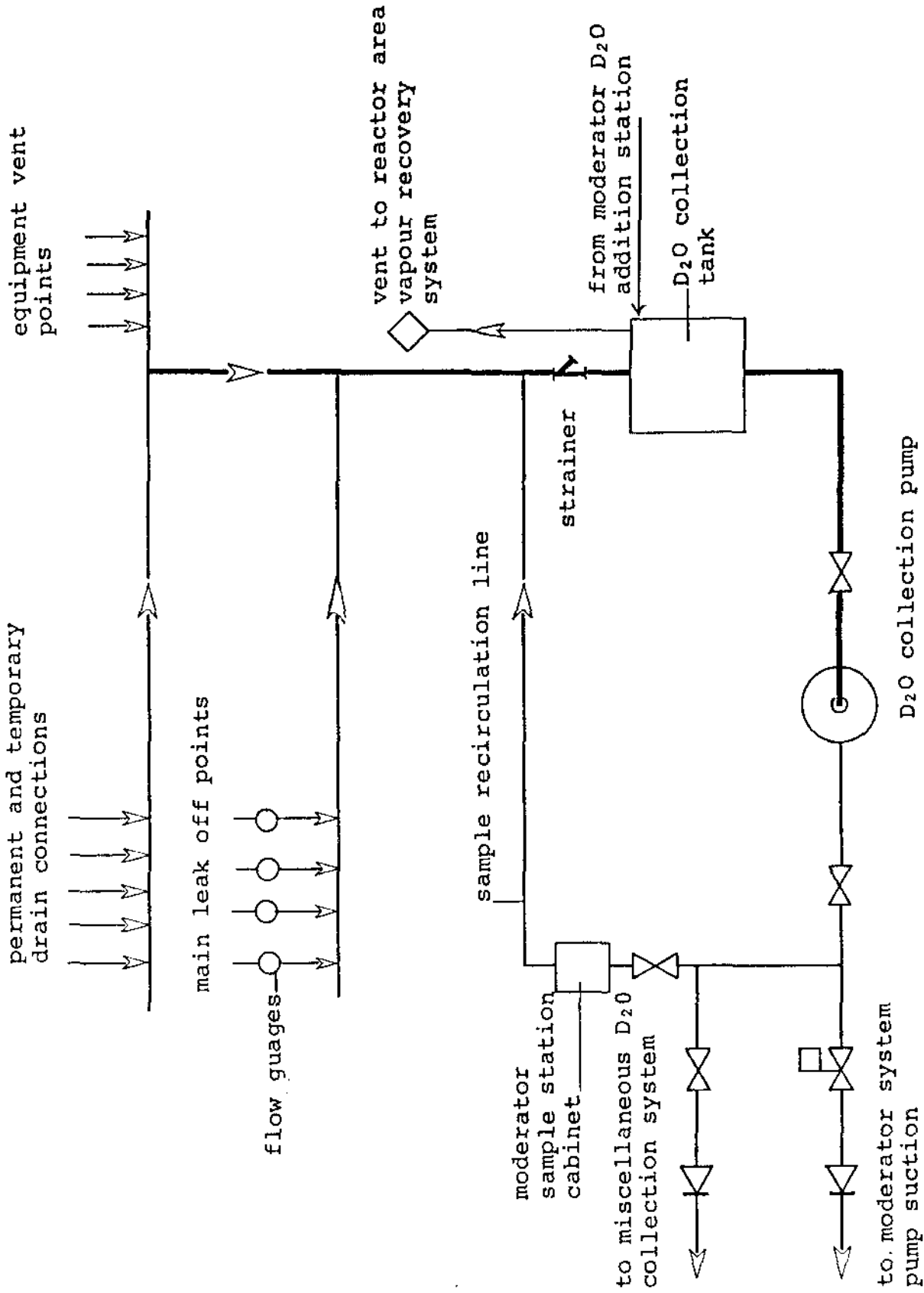


Figure 1

Typical Moderator D<sub>2</sub>O Collection System

1  
2  
1

components than the HT and HT auxiliary components. As a result of this and also because of the lower moderator system pressure, the leakage rate to moderator collection will be smaller than that to the HT D<sub>2</sub>O collection system.

Some plants provide vent connections from equipment containing moderator D<sub>2</sub>O such as:

- moderator D<sub>2</sub>O addition station drums.
- moderator IX columns.
- resin drying system.

These connections help to enclose the D<sub>2</sub>O vapour. However, as the moderator D<sub>2</sub>O collection tank which has an air cover gas is normally vented to the reactor area vapour recovery system, this feature is not in every plant. The collection tank is vented to prevent the tank from being overpressurized and also to ensure it is not underpressurized when pumped out. Underpressurization could lead to tank collapse.

Drain connections from various locations may also be tied into the D<sub>2</sub>O collection tank and used when required prior to equipment maintenance, or following equipment testing; examples are:

- moderator cover gas helium tank drains.
- emergency injection system (if moderator D<sub>2</sub>O used) drain lines.
- additional connections available to connect flexible hoses to moderator equipment for maintenance purposes.

A typical moderator D<sub>2</sub>O collection system is shown in Figure 1. The collection points (leakoffs, vents and drains) drain down into the D<sub>2</sub>O collection tank which is usually situated at a low level in the reactor building to facilitate good gravity drainage.

A D<sub>2</sub>O collection pump is connected to the tank to pump the D<sub>2</sub>O from the tank back to the main moderator system. A sample recirculation line is provided to recirculate tank D<sub>2</sub>O through the moderator D<sub>2</sub>O sample station cabinet to provide good mixing, enabling a representative sample to be obtained at the sample station.

An additional use of the collection system is to use the collection pump to provide moderator D<sub>2</sub>O make up, using moderator transferred from the moderator D<sub>2</sub>O addition system into the moderator D<sub>2</sub>O collection tank.

### III. OPERATING FEATURES

During normal operation the main leakage points will provide typically a few kg/hr, enough to fill the collection tank once every few days. Increases in the tank fill up rate will usually indicate deterioration in the pump/compressor seals. An increased flow rate indicated in individual flow gauges in each collection line will enable the particular deteriorating pump seal to be traced.

When the collection tank is almost full, a high level alarm annunciation will come in and the tank D<sub>2</sub>O should then be recirculated using the D<sub>2</sub>O collection pump to obtain a representative sample. It is then important to check the isotopic of the D<sub>2</sub>O sample before pumping the tank returns back to the system. The isotopic of the returns is usually specified to be within 0.1% of the current unit moderator isotopic before it can be returned, after authorization by the control room operator who checks the sample isotopic value with the current system isotopic quoted by the chemical unit. If the isotopic is within 0.1% the collection tank D<sub>2</sub>O is returned to the main moderator D<sub>2</sub>O system via the moderator pump suction.

This check is particularly important for moderator collection returns as adding downgraded D<sub>2</sub>O will immediately result in a decrease of reactivity and contribute to downgrading the bulk moderator. The reactivity will change by about  $\pm 3.6$  mk for each  $\pm 0.1\%$  change in the bulk moderator isotopic. This is a much larger reactivity change than an equivalent HT isotopic change would produce. As an illustration, if one collection tank full of H<sub>2</sub>O were added to the moderator, the typical downgrading would be about 0.1%. The short and long term consequences of this can be seen from Table 2, section 20-1.

The D<sub>2</sub>O in the collection tank will be very slightly downgraded due to H<sub>2</sub>O ingress in the saturated air atmosphere above the D<sub>2</sub>O in the tank. This will result in a very small continual moderator downgrading. Use of a helium cover gas would reduce this downgrading but may not justify the cost of the helium gas.

If visual inspection of a moderator collection sample indicates the presence of insolubles, or if the isotopic is unacceptable, the returns should be pumped to drums where it can be collected ready for chemical clean up and/or upgrading. Oil can enter the moderator collection tank in some plants especially via various drain lines. Return of oil contaminated water to the main system would result in increased moderator radiolysis and very likely a cover gas D<sub>2</sub> excursion as only small amounts of oil are required to cause extra D<sub>2</sub> gas production. If no routine tests are made for

organics in the collection tank then the presence of oil may be noticed by oily foam in the water sample taken for the isotopic check.

ASSIGNMENT

1. What are the main moderator D<sub>2</sub>O leak off collection points?
2. What is the most important check done before the moderator D<sub>2</sub>O collection tank is pumped out? Can you think of any circumstances where this may not be done?
3. Why is a helium cover gas not usually designed for this system as it is in the main moderator system for example?
4. Calculate the resulting isotopic of the moderator D<sub>2</sub>O if the contents of the moderator D<sub>2</sub>O collection tank are completely pumped back into the moderator in the following cases. (A calculator is necessary to do this accurately.)

(a) moderator collection isotopic is 99.75%.

(b) moderator collection isotopic is 99.65%.

(c) moderator collection isotopic is 99.00%.

(d) moderator collection tank is full of H<sub>2</sub>O.

State the immediate and long term consequences of (a), (b), (c) and (d). Assume:

(i) initial moderator isotopic is 99.750%.

(ii) total moderator mass = 300 Mg.

(iii) mass of water in full collection tank = 220 kg.

5. In your own station find out:
  - (a) how often the moderator D<sub>2</sub>O collection tank is normally pumped out.
  - (b) how often an isotopic check of the collection tank D<sub>2</sub>O is made.
  - (c) which equipment has the largest normal leak rate.
  - (d) any ways in which H<sub>2</sub>O may get into the collection system.

D.J. Winfield