

Chemistry - PI 24

MODERATOR WATER CHEMISTRY

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Objectives

1. List four chemical conditions maintained in the moderator system. Briefly annotate the reasons for these conditions. (See the summary at the end of the text).
  2. List three impurities that may appear in the moderator, give a source and a problem for each.
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If you were to consider the moderator from a chemical objective's point of view, you would most likely arrive at a list of items to prevent:

- corrosion
- erosion
- deposition
- neutron absorption
- radiolysis.

To prevent corrosion, we must consider protection of the calandria and auxiliary equipment material of construction which is usually stainless steel (or aluminum at NPD). The method employed for moderator water is to:

- (a) Maintain corrosive substances (eg, chloride) at a very low concentration.
- (b) Maintain low dissolved oxygen.
- (c) Maintain optimum system pH. For moderator water this is pH 7.

The main corrosive impurities are:

- (a) Chlorides - These cause stress corrosion cracking of stainless steels and zircalloys. The main source is from breakdown of overheated resin in the purification system. A possible secondary source is impure make-up water.

- (b) Fluorides - Same problems as chlorides, a possible source is from teflon gasket material although this is no longer used by NGD in heavy water systems.
- (c) Oxygen from radiolysis of D<sub>2</sub>O (Radiolysis will be discussed in Module 22-4). Oxygen is a general corrosive agent. Another source of oxygen is air inleakage.
- (d) Deuterium Peroxide from radiolysis of D<sub>2</sub>O. This has effects similar to oxygen but D<sub>2</sub>O<sub>2</sub> is extremely reactive.
- (e) Nitric and Nitrous acids from radiolysis products of tramp N<sub>2</sub> and O<sub>2</sub> in the cover gas.

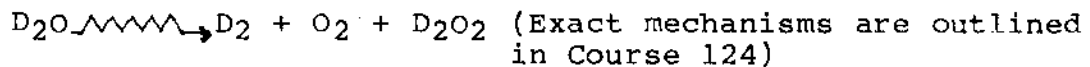
The main sources of erosive and deposit forming substances are system corrosion products and suspended solids in impure make-up water.

The effects of corrosion, erosion and deposition are shorter equipment life and high maintenance and outage time.

Impurities in the moderator will also pose a problem by absorbing neutrons. You will recall that the CANDU system operation is highly dependent on the low neutron absorption cross-section of heavy water and any neutron absorption by impurities will simply defeat the purpose of using heavy water.

Radiolysis means radiolytic decomposition - the breaking of chemical bonds by radiation. All 4 types of radiation, but especially gamma, may cause radiolysis.

Radiolysis of heavy water results in the formation of deuterium (a gas), oxygen (a gas) and deuterium peroxide (a water-soluble un-ionized liquid):



The squiggly arrow means "this reaction requires radiation".

Oxygen and the peroxide are undesirable because they are corrosive. In the moderator, the two gases bubble out into the helium cover gas; if the D<sub>2</sub> + O<sub>2</sub> achieve a high enough concentration, an explosion hazard will exist.

The presence of dissolved and suspended solids enhance the possibility of radiolysis.

A summary of Moderator Water Chemistry is as follows:

<u>Condition</u>	<u>Reasons</u>
1. pH 7	- neutral for low radiolysis - satisfactory corrosion rates
2. Very low dissolved solids.	- low neutron absorption - low radiolysis
3. Very low suspended solids.	- low neutron absorption - low radiolysis - low erosion
4. Low oxygen.	- low corrosion. - reduce explosion with D <sub>2</sub> in cover gas (see 22-4)

Practice Exercise

Consider the objectives as questions. From memory, note down your answers and compare to the data in the text.

P.D. Dodgson