Module 10

HEAT TRANSPORT SYSTEM AUXILIARIES

OBJECTIVES:

After completing this module you will be able to:

10.1 a) For the heat transport purification system inlet temperature, explain three reasons why it is important and describe how it is maintained for: *⇔ Page 4*

- i) Purification systems operating at reduced pressures,
- ii) Purification systems operating at full HTS pressure.

b) For the heat transport purification system flow, explain two reasons why it is important and describe how it is maintained for: *⇔ Pages 4-6*

- i) Purification systems operating at reduced pressures,
- ii) Purification systems operating at full HTS pressure.

c) For the heat transport purification system ΔP across the IX column, explain the reason why it is important and describe how it is maintained. *⇔ Page 6*

d) For the heat transport purification system inlet pressure, explain three reasons why it is important and describe two methods how high pressures are controlled. *⇔ Page 7*

10.2 a) Give two examples of heat transport system conditions that require an increase in the rate of removal of heat transport impurities. *⇔ Page 8*

b) Describe how this increased removal rate is achieved. *⇔ Page 8*

10.3 Explain the purpose of hydrogen addition to the heat transport system and identify when it is required. *⇔ Page 9, 10*

10.4 Explain the major concern associated with each of the following conditions:

Page 9 ⇔ a) Unavailability of the hydrogen gas addition system.

Page 9 ⇔ b) A high rate of hydrogen addition.

Page 10 ⇔ c) H_2, D_2, and O_2 coming out of solution in:

- i) The D_2O storage tank,
- ii) The bleed condenser.

Page 11 ⇔ 10.5 a) State the reason why the gland seal supply system should be available at all times (HT pumps ON or OFF) and,

Page 12 ⇔ b) State the two major purposes of the gland seal supply system.

10.6 Explain why D_2O supplied for gland sealing must be:

Page 12 ⇔ a) Filtered,

Page 12 ⇔ b) Pressurized,

Page 13 ⇔ c) Cooled.

Page 13 ⇔ 10.7 a) State where the back up gland sealing supply comes from and explain how this supply is initiated.

Page 13 ⇔ b) Explain why additional cooling and purification is required for this supply.

Page 13 ⇔ 10.8 State four parameters that are monitored to verify seal problems.

Page 14 ⇔ 10.9 Explain the purpose of the gland return bottle-up valve.

* * *

INSTRUCTIONAL TEXT

INTRODUCTION

This module deals with a number of auxiliary systems essential for ensuring the reliable and prolonged operation of the Heat Transport System (HTS).

The systems described are:

1) HTS Purification,
2) HTS Hydrogen Addition,
3) HTS Main Pump Gland Seal Supply.

HEAT TRANSPORT PURIFICATION SYSTEM

Your previous R&A courses have already described the equipment, ie. filters, strainers, and ion exchange columns, required to effect purification of the HTS coolant.

Basically, the purification process has two main purposes:

a) To maintain HTS chemical parameters at specified levels.

b) To remove impurities (crud) from the HTS.

The method of providing the flow to the purification system is site specific. In most stations, purification occurs at a reduced pressure (300-1000 KPa). In other stations, purification occurs at full HTS pressure (9-10MPa). However, some general common parameters exist. A typical purification system arrangement is shown in Figure 10.1.

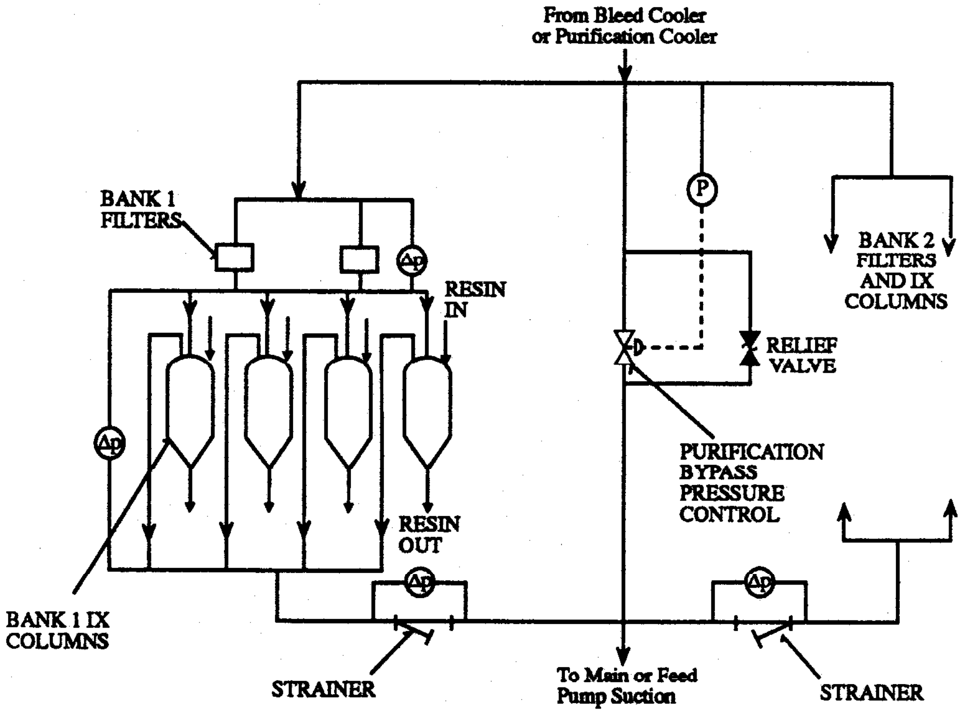

Figure 10.1: Typical HT Purification System

To ensure proper operation of this system, the following parameters must be maintained within limits:

a) Inlet temperature,

b) Flow,

c) ΔP across the system,

d) Inlet pressure.

Each of these parameters is discussed in detail below.

Inlet Temperature

Obj. 10.1 a) ⇔

The temperature of the D_2O coolant feed to the IX columns is **limited to about 65°C** to protect the IX resins from damage. A high temperature in D_2O feed to the IX columns can have the following possible consequences:

a) **Reduction in** ion exchange **efficiency** (particularly anion).

b) Risk of IX bead **melting** and subsequent **migration** into the HTS.

c) **Release** of any residual **chemicals** (eg. chlorides, fluorides) that may exist in the resin. This increases the risk of stress corrosion problems with zircaloy and stainless steel components.

To prevent these consequences, the HTS purification flow must be cooled from reactor operating temperature (~250°C) when the unit is at power. At most stations, a combination of a **bleed condenser and bleed cooler** provide the necessary temperature (and pressure) reduction. At the other stations, where purification occurs at full HTS pressure, the cooling is achieved by **two interchangers and a cooler**. In both cases, the D_2O is partially cooled by D_2O being returned to the HTS, and partially cooled by cooling water. Figure 10.2 shows the purification system arrangement for systems operating at reduced pressure. Figure 10.3 shows the purification system arrangement for systems operating at full HTS pressure.

Flow

Obj. 10.1 b) ⇔

In stations where the purification is performed at a reduced pressure, the flow rate is **adjusted** by varying the **bias on the bleed valves**. A typical maximum attainable flow is 40 kg/s. Assuming IX column performance is normal, this will result in a cleanup half-life of about 60 minutes. (This is the time taken to reduce impurity levels to one half of the original value, assuming no further impurity addition.)

Under normal operating conditions the flow rate will be close to 10 kg/s. Increased flow rates can be selected, for example, to reduce levels of I^{131} in the HTS or to reduce the effects of crud releases*.

* causes of crud releases will be discussed later in this module.

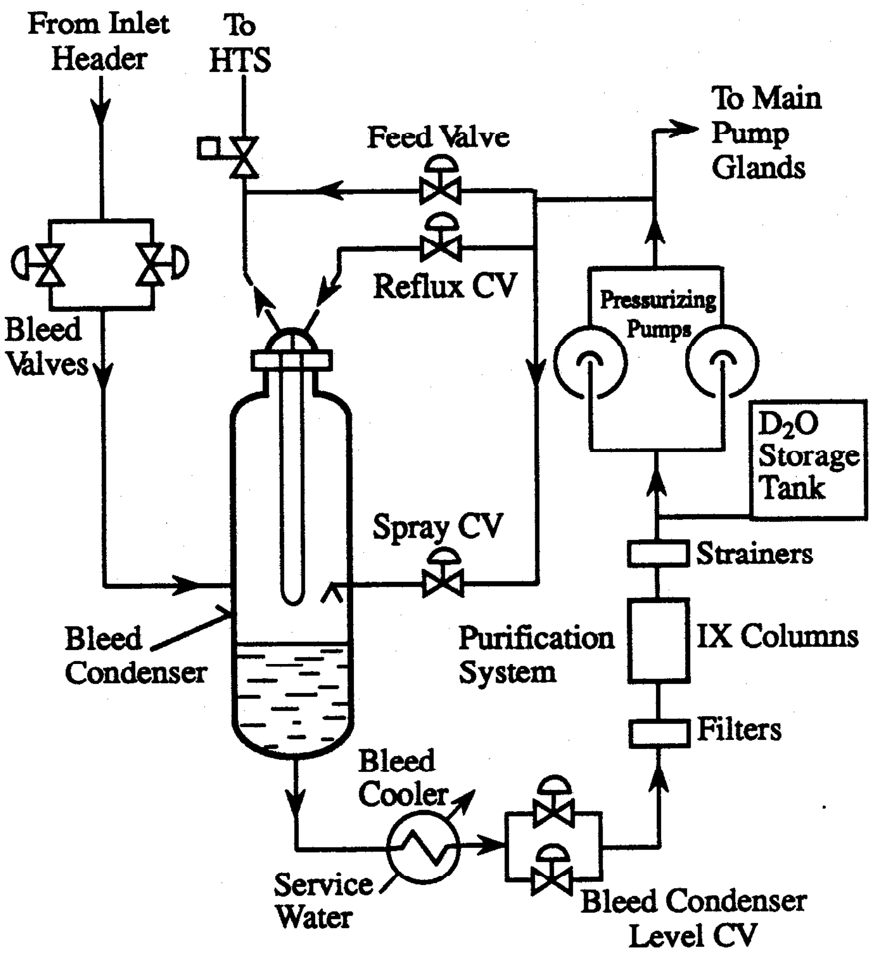

Figure 10.2
Purification System Requiring Pressure Reduction

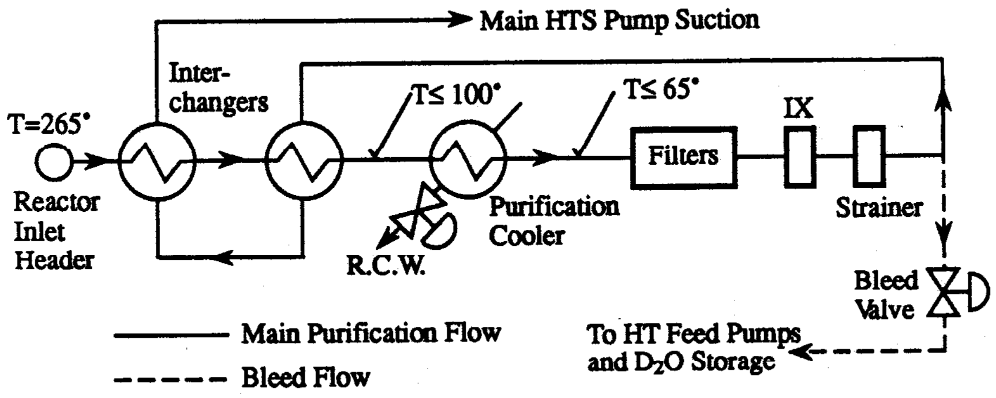

Figure 10.3
Purification System Using Full System Pressure

If this circulating **crud is not removed** from the HTS, subsequent neutron **activation and re-deposition** will create radiological problems in the HTS (increased man-rem). An increased purification flow will remove much or all of these products. But, the removal of these materials in the purification circuit will result in high radiation fields around the filters, strainers and IX columns.

However, purification flows that are **too high** will **reduce IX column efficiency** (ie. coolant does not have enough time in the column to effectively exchange ions).

For stations where the purification operates at full HTS pressure, the purification circuit flow rate is independent of the bleed valve. Purification is achieved via a bypass flow around the main HTS circulating pumps (refer back to Figure 10.3). The operator **manually controls the flow rate** through the purification system by means of a flow control valve. Flow is controlled at an upper limit of ~25 kg/s, equivalent to a purification half life of ~60 minutes.

Note that for the stations where the purification system operates at full HTS pressure, ΔP across the purification system is fixed by the HT system and circulating pump characteristics. Maximum flows are determined by pipe sizes and orifice plates, and are monitored by ΔP transmitters.

The purification flow control can be overriden by any high temperature situation, which may cause resin damage. This was discussed in the last section of Module 7.

ΔP Across Purification

Obj. 10.1 c) ⇔

The filters, IX columns, and strainers are each provided with a differential pressure indicator (as shown in Figure 10.1). Any **increase in ΔP** across the components will result in a **reduction of purification flow**. This could impair the effectiveness of the purification system. For this reason it is important that any increase in ΔP **above specification be corrected.**

For the filters, ΔP indicates the degree of crud accumulation and the need for filter replacement.

A high ΔP across the IX columns indicates an accumulation of solid impurities in the column or compaction of resin fines such that resin replacement may be required.

The strainers which are downstream of the IX columns will collect any IX resin which escapes. A high ΔP across the strainers indicates that strainer cleaning is required.

Pressure At Inlet

⇔ *Obj. 10.1 d)*

Design flow through the purification circuit is achieved by setting a predetermined inlet pressure to cover all expected pressure drops in the system. Inlet pressure that is **too high** will result in **increased** purification **flow** through the IX column with a probable **reduction in IX column efficiency**. In addition, **component overpressure** may result (for systems operating at reduced pressures). This situation may be corrected by either:

a) **Bypassing the purification system** and flowing directly to D_2O storage, or,

b) **Pressure relief valves** on the individual components. These will relieve to D_2O storage.

An inlet pressure that is **too low will reduce purification flow**. Again, this poses a risk of insufficient quantity of HTS D_2O being cleaned.

SUMMARY OF THE KEY CONCEPTS

- The HTS Purification System is designed to maintain HTS chemical parameters within specification and remove impurities from the HTS.
- Purification system temperatures are maintained ≤ 65°C to:
  - Ensure IX column resins do not release chemicals that could cause stress corrosion cracking of reactor components,
  - Prevent resin bead melting and migration into the HTS,
  - Prevent a reduction in IX resin efficiency.
- The purification temperature is controlled by proper cooling of the bleed flow. In the typical purification system, pressure and temperature reduction occurs in the bleed condenser and the bleed cooler. For the stations where the purification system operates at full HTS pressure, the cooling is performed by two interchangers and a purification cooler.
- Purification flow must be maintained at an optimum rate to ensure crud and fission products (I^{131}) are removed. Without purification, this crud could be activated and could re-deposit within the HTS.
- The flow through purification is controlled by the bleed bias. In stations where the purification system operates at full HTS pressure, the flow is manually controlled.
- High ΔP in the purification components would indicate that:
  - Filters are plugged and require replacement or,
  - Strainers are plugged and require cleaning or,
  - Resins are compacted or contaminated with impurities and will possibly require replacement.

- The pressure at the inlet is set to overcome all expected loses in the purification system. An inlet pressure that is too high will result in an excess purification flow and a corresponding decrease in resin efficiency. An inlet pressure that is too low will result in an insufficient purification flow for HTS cleanup.
- The purification inlet pressure is controlled by bypassing purification flow and ultimately by pressure relief valves on individual components.

ABNORMAL OPERATING CONDITIONS

Obj. 10.2 a) ⇔

We have already mentioned in passing that some situations require an **increased purification flow**, ie. reducing radioiodines and reducing effects of crud releases. They will now be explained.

Removal Of Radioiodines

The station licence sets limits for the quantity of radioiodine which may be present in the HTS with the unit at power. The reason for the limit is to protect the public and our employees from exceeding regulatory dose limits, should a release from the HTS occur. The presence of radioiodines in the HTS indicates fuel has failed in the reactor. Purification flow is increased to remove the radioiodine. If the levels exceed those stated in the licence, the unit must be shutdown. Even in the shutdown state, the purification flow will be maintained at a high level to facilitate the removal process. Note that the release of radioiodines from failed fuel may continue even after shutdown, depending on the severity of the fuel failure.

Removal Of Crud

Crud releases ("crud-bursts") can occur during certain reactor operating conditions resulting in thermal or chemical transients, such as HTS warmup and cooldown, reactor power manoeuvering or during normal reactor operation when chemical parameters stray from specification.

Obj. 10.2 b) ⇔

In these instances, primary removal will be by filters and increased purification flow. The **increase in purification** will usually be achieved by either or a combination of:

i) **Increased purification flow**, but recall that there are limits to this,

ii) Place **more purification equipment in-service**. This would increase the time spent in the IX columns by the coolant (ie. for a given flow, the flow would move slower through a larger number of flow paths).

HEAT TRANSPORT HYDROGEN ADDITION SYSTEM

Radiolysis of the HTS coolant while in the reactor core occurs with the resultant formation of D_2 and O_2 gases. These gases will remain in solution under normal HTS operating temperatures and pressures.

The radiolysis reaction is, fortunately, reversible and recombination can be promoted by the addition of H_2 or D_2 gas. D_2 and H_2 will behave identically as far as the reaction is concerned. Either could be used to scavenge the oxygen; the only difference being the end product: D_2O or H_2O.

The choice of gas is mainly economic. In terms of product (gas) cost, hydrogen is much cheaper than deuterium. However, the additional expense of D_2O downgrading must be considered since the addition of H_2 forms H_2O. At the moment hydrogen is used exclusively.

⇔ ***Obj. 10.3***

Hydrogen is added to the HTS to **maintain the deuterium/hydrogen concentration**; and hence the **oxygen concentration**, within station **specified limits.**

The hydrogen concentration is monitored (as opposed to oxygen) because of the ease of measuring H_2. This ensures that an optimum amount of H_2 is injected into the system.

Inappropriate addition of hydrogen can result in the following adverse consequences:

⇔ ***Obj. 10.4 a)***

a) Insufficient addition of hydrogen will result in the presence of an excess of O_2. Excess O_2 will promote **corrosion** with subsequent component wastage and activated crud (corrosion product) formation.

⇔ ***Obj. 10.4 b)***

b) **Excessive addition of hydrogen** is also undesirable since it **promotes embrittlement of the pressure tubes***. Note also that any corrosion would result in some excess of D_2 (H_2) **.

* This is discussed in the Materials 228 course.

** This is discussed in the Chemistry 224 course.

Recall from Module 7 that there is a danger of H_2 coming out of solution at reduced HTS pressure, termed degassing.

Under normal operating conditions, degassing will be generally confined to two areas:

- The D_2O Storage Tank,
- The Bleed Condenser (or Degasser Condenser, depending on the station).

Both have D_2O liquid in thermal equilibrium with the D_2O vapour above.

Obj. 10.4 c) i) ⇔

In the **D_2O storage tank** the cover gas is helium. But H_2/D_2 gas will also be present due to degassing of the radiolysis gases. A concentration of more than about 4% H_2/D_2 gas will require purging to reduce the possibility of an **H_2/D_2 explosion.**

Obj. 10.4 c) ii) ⇔

In the **bleed condenser** the cover gas is saturated D_2O vapour with some O_2, D_2/H_2 and fission product gases (such as Xe and Kr). These gases come out of solution from the HT D_2O when it flashes to steam upon entering the bleed condenser. Being non-condensible at the bleed condenser temperature, these gases accumulate gradually in the bleed condenser atmosphere. They concentrate mainly in the vicinity of the reflux cooling coils because that's where the vapour condenses and leaves the gases behind (a process referred to as tube blanketing). This collection of gases **inhibits reflux cooling** in the bleed condenser.

Compared with areas of the bleed condenser that are more remote from the cooling coils, the partial pressure of vapour around the coils is decreased. Therefore, the condensed liquid that is formed on the cooling coils is cooler than the vapour at the D_2O inlet to the bleed condenser * (where gas concentration is lower). Thus, the ΔT between the vapour at the condenser top and the liquid at the bottom is indicative of accumulation of gases. If the ΔT becomes excessive, the gases are removed through the off gas system. This degassing will remove fission product gases as well as any D_2 and O_2 produced by radiolysis.

* You may recall from 225 and 234 courses that similar apparent subcooling occurs in the turbine condenser if non-condensibles accumulate there.

In units without bleed condensers, degassing is performed in the degasser condenser. A degassing flow is established to the degasser condenser from the HTS or by pressurizer steam bleed flow. The vapour/gas mixture is directed to a vent condenser, then to vapour recovery. Hence, the problem of reflux cooling capacity reduction is eliminated (Note also that only spray cooling is performed in the degasser condenser).

Reactor Shutdown

Obj. 10.3 ⇔

Radiolysis under **shutdown** conditions, is very much reduced and **hydrogen addition is discontinued.** This also reduces the risk of H_2 buildup in the HTS, especially during maintenance, when H_2 could create an explosion hazard.

Hydrogen Supplies

The hydrogen injection supply is from standard hydrogen cylinders. In most stations, the hydrogen addition is located at the HT feed pump suction. Cylinders are declared "spent" when their pressure falls to suction pressure at the feed pumps. Since pumps can become gas locked, the hydrogen supplies must be isolated when the pumps are shut down.

Note also that conventional hazards exist due to handling of pressurized gas cylinders and because H_2 can create an explosive mixture in air.

SUMMARY OF THE KEY CONCEPTS

- HTS warmup/cooldown, reactor power manoeuvres and normal operation with chemical excursions can cause crud bursts. Increased purification is required and will be performed by increased purification flows or valving more purification equipment into service.
- The addition of hydrogen to the HTS through the hydrogen addition system reverses the radiolysis reaction and recombines O_2 (to form H_2O) thus reducing risk of corrosion in the HT system. This system is not required during shutdowns, when radiolysis is much less.
- Increased amounts of non condensible gases (mainly O_2, D_2 or H_2 and noble gases) in the bleed cooler cause reduced efficiency of reflux cooling. Increased concentrations of O_2 with D_2 or H_2 in the D_2O storage tank could result in an explosion hazard.
- Excess hydrogen addition to the HTS increases the risk of hydrogen embrittlement of pressure tubes.

HEAT TRANSPORT GLAND SEAL SUPPLY SYSTEM

⇔ Obj. 10.5 a)

The main HTS pumps circulate **hot** (300°C), pressurized (~8-10 MPa) D_2O continuously, while the reactor is at power. Remember this D_2O contains **radioactive materials.** It is important that this **D_2O be contained within the pump** body and gland (which are part of the HTS boundary) **at all times.** To achieve this containment, the pump is sealed along its shaft through a gland.

This gland incorporates a number of mechanical seals (two or three depending on station). This seal arrangement allows a gradual pressure drop (from HTS pressure to atmospheric) in steps across the seals, hence reducing the pressure drop across individual seals. By allowing a gradual pressure drop across the seals (ie. causing some fluid to pass through each seal), a cooling and lubricating D_2O supply is available for the seal. It must also be noted that each of the seals is capable of holding full HTS pressure, but if one fails, redundancy has been lost.

For efficient operation these seals must be continuously supplied with cool, pure, high pressure D_2O. This is accomplished by the gland seal supply system.

This supply system has two main purposes:

Obj. 10.5 b) ⇔

a) To provide a flow of **cool** (~40°C), **filtered D_2O** to the gland for **cooling and lubrication** of the mechanical seals.

b) To provide **high pressure** (~12 MPa) D_2O to the seal cavities, and **thus prevent hot, unfiltered HT D_2O from entering the gland.**

A representative gland seal and supply system is shown in Figure 10.4 (at the end of the module, which can be unfolded and kept in sight for your reference).

The **normal supply** of D_2O for the gland seal supply system is the D_2O storage tank. This D_2O has already passed through the HTS purification system. It is **fed by the HTS feed pumps**, via a filter system, to a gland supply header.

Obj. 10.6 a) ⇔

This bank of filters, under normal conditions, is a precautionary measure. It further reduces the possibility of abrasive particulates entering the gland. Note that the seal faces (carbon and tungsten carbide) are lapped to a high degree of flatness (thousandths of a millimetre) and even the most minute **particles are capable of inflicting damage** and, therefore, causing additional leakage through the seal faces.

A minimal amount of D_2O passes through each seal itself providing lubrication. This **lubrication flow reduces** any **heat** generated by **friction.** This flow will typically be a few cc/minute.

About 10% of the total gland supply D_2O flows between the various seal cavities via seal throttles (or breakdown cells) arranged in parallel with the seal faces. This results in a progressive lowering of D_2O pressure in successive seal cavities. The flow of this cool D_2O from cavity to cavity, via the breakdown cells, will also remove heat from the seal.

Obj. 10.6 b) ⇔

The remainder of the flow is handled in one of two ways, depending on the seal design. In some seals, all of the remaining flow (~90% of total flow) will enter the HTS through the restriction (throttle) bushing. **This flow is the major factor preventing hot D_2O** from the HTS entering the gland and also represents a **constant addition** of D_2O to the HTS **inventory** (ie. bleed valve opening required). In other seal designs, only ~10% of the flow enters the HTS via the restriction bushing (serving the same purpose as mentioned above) and the rest of the flow goes into the recirculation flow in the seal. Note that a majority of this recirculation flow will bypass the seal through ports in the seal housing (not shown in Figure 10.4).

Gland return flow is taken from the final seal cavity. Any leakage across the final seal will be contained by the backup seal and will be directed to D_2O collection.

As previously mentioned, the gland seal requires a supply of cool pressurized D_2O at all times when the HTS is at pressure. The **loss of this supply** would cause rapid **overheating** of the seal because of:

⇔ ***Obj. 10.6 c)***

a) The loss of cool D_2O flowing through the seals.

b) The entry of hot D_2O from HTS through the restriction bushing.

This overheating can fail seals in a very short time period, typically minutes (if the gland seal return valve is not closed *). To guard against this, a **backup** gland seal **supply** is provided. It is taken from the main **HTS pump discharge (or RIH) and/or the fuelling machine D_2O supply pumps** ** (only in some stations). This will usually be at a **high temperature** (>250°C) and a some cooling must be provided to cool the D_2O to ~40°C. This cooling is accomplished by the either the recirculation cooler or by the backup gland cooler, depending on the seal design. This D_2O also has a higher level of **impurities**. The in-line **gland filters** are used to clean up the D_2O.

⇔ ***Obj. 10.7 a)***

* This will be discussed later in the module.

⇔ ***Obj. 10.7 b)***

** Due to limited capacity of these pumps, fuelling cannot continue when this feed is required.

Note that the provision of **check valves** ensures that the backup supply **becomes available immediately** on loss of normal supply. The cooling water to the backup coolers or recirculation coolers (depending on the station) is always in-service. The check valves also prevent interaction between the backup and normal supply under normal conditions.

⇔ ***Obj. 10.7 a)***

Since a total loss of seal supply can cause seals to fail in a very short time, it is important to provide control room staff with indications of gland supply problems. These indications include:

⇔ ***Obj. 10.8***

a) Individual pump gland **seal flow.**

b) Gland **return temperature.**

c) Gland **interseal temperatures (and recirculation temperature,** where used).

d) Gland **interseal pressures.**

Note that gland filter differential pressure can also be monitored, which may indicate impending flow problems due to filter blockage. This could prevent potential seal damage.

No reactor or HT pump trips are directly initiated from these parameters. Manual intervention by the operator is required to trip the pump or adjust parameter values on alarms which require action.

Gland Return

The return lines from each gland return the D_2O to the feed pump suction. Seal cavity pressure can often be adjusted by manual operation of a valve in the return line.

Obj. 10.9 ⇔

The motorized "**bottle up**" valve can be closed automatically on low gland supply flow. This may be necessary if, for example, feed pumps are lost and backup supplies are not available. This prevents the **much hotter and impure HTS D_2O from entering the gland through the throttle bushing.**

When bottled-up, cooling of gland seal water is now limited to that provided by the recirculation cooler (where installed) or by the cooling water jacket which surrounds the gland (not shown on diagram). Normal gland flow must be restored as soon as possible to avoid seal damage.

SUMMARY OF THE KEY CONCEPTS

- The HTS Gland Seal Supply System must be available at all times to keep the potentially contaminated HTS D_2O within the main pumps (hence within the HTS boundary).
- The HTS Gland Seal Supply System provides clean, cool, high pressure D_2O to the HTS pump glands. This provides cooling and lubrication for the mechanical seals and prevents leakage of the hot, impure HTS D_2O from the main HTS pump bodies from entering the gland. Filtering is required to ensure seal faces are not damaged by foreign particles.
- The backup gland seal supply is supplied from the discharge of the HTS circulating pumps (or RIH) and/or the fuelling machine D_2O supply pumps. This water is hot and impure, hence it requires cooling and filtering before it is supplied to the gland.
- The seal flows, return temperatures, interseal temperatures (and also recirculation temperature) and interseal pressures can be monitored to determine seal condition.
- The bottle-up valve automatically closes on loss of seal flow. This prevents the hotter and impure HTS D_2O from entering the seal.

Page 15 ⇔

You can now **work on the assignment questions.**

ASSIGNMENT

1. a) The temperature of the purification flow must be controlled because:

   i) ____

   ____

   ii) ____

   ____

   iii) ____

   ____

   b) For stations using purification systems at reduced pressure, cooling is provided by the ____________________ and the ______________________. For stations using purification systems at full HTS pressure, cooling is provided by ____________________________ and ____________ ______________________________.

2. a) Purification flow is controlled by ____________________ in systems operating at reduced pressures. For stations using purification systems at full HTS pressure, purification flow is controlled by _____________________________.

   b) High purification flow rates are a problem because _________

   ____

   ____.

   c) Low purification flow rates are a problem because _________

   ____

   ____.

3. ΔP in the purification components is monitored because _________

   ____.

   ΔP is controlled by ____________________________________

   ____.

4. a) The pressure at the purification inlet is set to:

   i) ______________________________

   ____

   ii) ______________________________

   ____

   iii) ______________________________

   ____

   b) High pressures in the purification system are controlled by:

   i) ______________________________

   ____

   ii) ______________________________

   ____

5. Two examples of heat transport system conditions that require an increase in the rate of removal of heat transport impurities are:

   a) ______________________________.

   b) ______________________________.

6. Two methods of increasing the rate of impurity removal are:

   a) ______________________________.

   b) ______________________________.

7. The purpose of hydrogen addition system ____________________

   ______________________________. It

   is required (at all times / never / intermittently) when the reactor is

   operating because ______________________________

   ______________________________.

8. a) The major concern associated with the unavailability of the hydrogen gas addition system is ______________________.

   b) An excess of hydrogen in the HTS could cause ____________

      ______________________________.

   c) H_2, D_2, and O_2 coming out of solution in the bleed condenser will cause ______________________________________.

   d) H_2, D_2, and O_2 coming out of solution in the D_2O storage tank could cause ______________________________________.

9. a) The two major purposes of the gland sealing supply system are:

      i) ______________________________________

         ____

      ii) ______________________________________

         ____

   b) The gland sealing supply system should be available at all times because

      ____

      ______________________________________.

10. a) The D_2O used for gland sealing must be cooled because

      ____

      ______________________________________.

    b) The D_2O used for gland sealing must be filtered because

      ____

      ______________________________________.

    c) The D_2O used for gland sealing must be pressurized because

      ____

      ______________________________________.

11. The back up gland sealing supply comes from either ____________ ________________________ or ________________________ ____________________, depending on the station. It is placed in service by opening of ________________________________ ____. This supply requires additional ____________________ and ____________________ because damage to the seals could from ________________________ or ________________________.

12. Four parameters monitored to verify seal problems are:
    a) ____
    b) ____
    c) ____
    d) ____

13. The purpose of the gland bottle-up valve is to ________________ ____ ____.

Before you move on, **review the objectives** and make sure that you can meet their requirements.

Prepared by:	D. Tennant, N. Ritter, WNTD
Revised by:	P. Bird, WNTD
Revision date:	June, 1992