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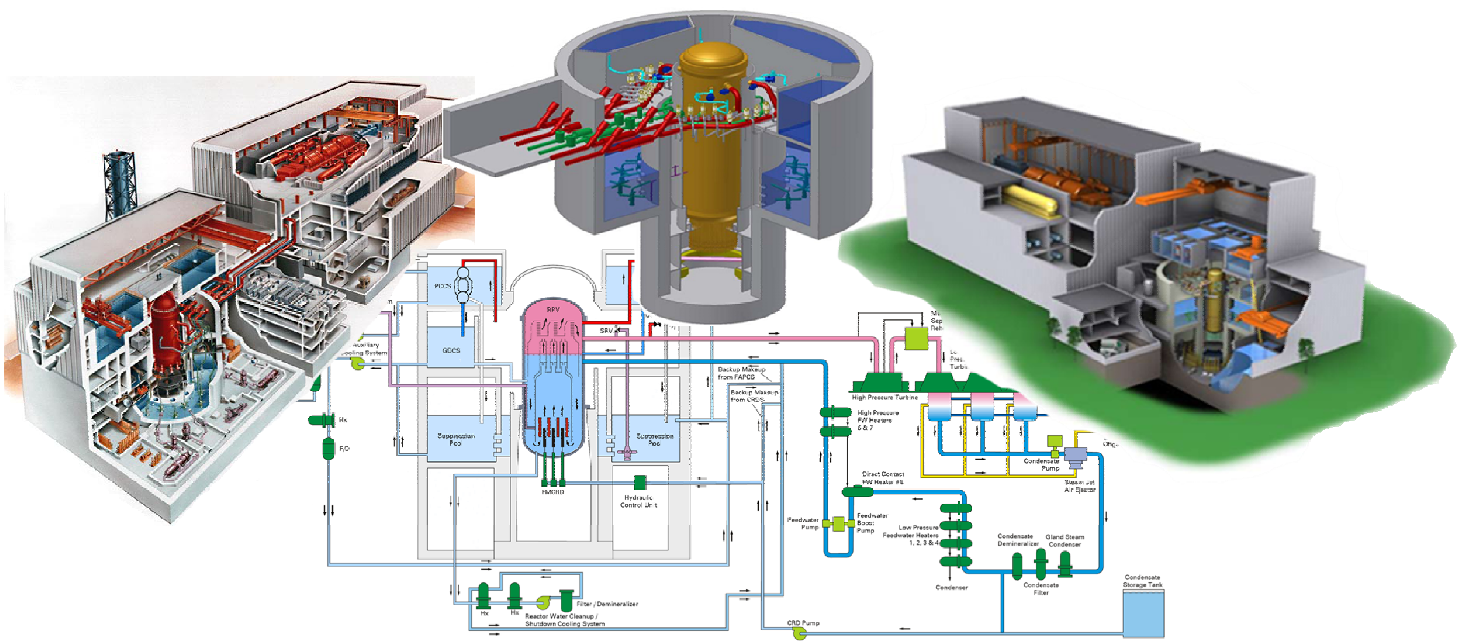

Part II
Introduction to Reactor Technology - BWR

Chapter 6.0, Standby Liquid Control System

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HUMAN RESOURCES TRAINING & DEVELOPMENT

Introduction to Reactor Technology

This manual is a text and reference document for the Introduction to Reactor Technology for the media briefing. It should be used by students as a study guide during attendance at this course. This manual was compiled by staff members from the Human Resources Training & Development in the Office of Human Resources.

The information in this manual was compiled for NRC personnel in support of internal training and qualification programs. No assumptions should be made as to its applicability for any other purpose. Information or statements contained in this manual should not be interpreted as setting official policy. The data provided are not necessarily specific to any particular nuclear power plant, but can be considered to be representative of the vendor design.

The Introduction to Reactor Technology – BWR briefing manual outlines the differences between the Boiling Water Reactors (BWR), Advanced Boiling Water Reactor (ABWR), and Economic Simplified Boiling Water Reactor (ESBWR). The course is broken down into discussions on design features, facility and plant layout, containment systems, nuclear steam supply systems, control and instrumentation, safety systems, balance of plant systems, normal, abnormal, and emergency operations.

The content of this course was based on the content provided in the following references:

- General Electric Systems Manual
- Introduction to ABWR Manual
- Introduction to ESBWR Course Manual
- Economic Simplified Boiling Water Reactor Plant General Description; June 2006, General Electric Company
- NUREG-1503, Final Safety Evaluation Report Related to the Certification of the Advanced Boiling Water Reactor Design and Appendices, U.S. Nuclear Regulatory Commission Office of Nuclear Reactor Regulation, July 1994
- ABWR, Advanced Boiling Water Reactor Plant General Description, “First of the Next Generation,” GE Nuclear Energy, June 2000
- Nuclear News, World List of Nuclear Power Plants, American Nuclear Society, March 2007
- J. Alan Beard & L.E. Fennern, General Electric presentation to DOE et.al, April 13th 2007, Germantown Md.

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6.0 STANDBY LIQUID CONTROL SYSTEM

The purpose of the Standby Liquid Control (SLC) system is to shutdown the reactor by chemical poisoning in the event of failure of the control rod drive system.

The functional classification of the SLC system is that of a safety related system.

6.1 System Description

The SLC system, Figure 6.0-1, consists of a heated storage tank, two positive displacement pumps, two explosive actuated injection valves and piping necessary to inject the neutron absorber solution into the reactor vessel. The system contains a sufficient quantity and concentration of neutron absorbing solution to shut down the reactor any time in core life without the use of control rods.

The SLC system provides the operator with a relatively slow method of achieving reactor shutdown conditions. The SLC system was never designed to serve as a backup for the reactor scram function of the Reactor Protection system.

6.2 Component Description

The major components of this system are discussed in the paragraphs which follow and are illustrated in Figure 6.0-1.

6.2.1 Storage Tank

The standby liquid control storage tank is a stainless steel tank with a capacity of 4,850 gallons. The tank provides the means for storage and mixing of the neutron absorber solution. To prevent the neutron absorber solution, sodium pentaborate, from precipitating out of solution, the storage tank is equipped with immersion heaters. The heaters are automatically controlled to regulate the solution temperature at 80+5°F.

6.2.2 Standby Liquid Control Pumps

The sodium pentaborate solution is pumped into the reactor vessel by either of two 100% capacity positive displacement pumps. At a minimum, each pump will have a capacity greater than 39 gpm.

6.2.3 Explosive Valves

The explosive actuated valves used to control the flow path of sodium pentaborate solution to the reactor vessel, are zero leakage valves. Unless the valves have been fired, no solution will enter the reactor vessel. Each explosive valve consists of two firing circuits, a ram, and shear plug. When the firing circuits are actuated, the ram drives forward and shears off the integral cap (shear plug) on the valve inlet fitting. The extended ram prevents the sheared cap from obstructing the passage of sodium pentaborate solution into the reactor vessel.

6.2.4 Test Tank

The test tank is provided for pump capacity and relief valve testing.

6.2.5 Vessel Injection Line

The vessel injection line serves a dual function within the reactor vessel. It provides an injection path for the sodium pentaborate solution and a tap for vessel instrumentation. The line penetrates the reactor vessel through a pipe in the bottom section of the vessel. This external pipe minimizes thermal shock to the vessel penetration welds. Inside the reactor vessel the injection line has circumferential holes drilled throughout its entire length. Injection beneath the core plate into the region of turbulent flow from jet pump diffuser outlets ensures proper mixing.

6.3 System Features

A short discussion of system features is given in the paragraphs which follow.

6.3.1 System Operation

System actuation is accomplished with the use of a key lock switch located in the control room. When a decision is made to inject sodium pentaborate into the reactor, a key must be inserted into the key lock switch and the switch turned to System 1 or System 2 position. Turning the switch to either position starts a single pump, fires both explosive valves and isolates the Reactor Water Cleanup system. While reactor power is decreasing from poison addition, the control room operators conduct a normal plant shutdown and cooldown. Because of the one to two hour shutdown time required to reduce reactor power to zero percent, it should be obvious that the SLC system was not designed to serve as a backup for the reactor scram function of the Reactor Protection system.

6.3.2 Neutron Absorber Solution

The neutron absorber solution is made by dissolving measured amounts of boric acid and borax in demineralized water in the storage tank, forming a sodium pentaborate solution. Following chemical additions, the solution is thoroughly mixed and a sample is taken to ensure the concentration complies with that required to meet the purpose of the system.

As a result of the 10CFR50.62 requirement, BWRs must have a SLC system with the capability of injecting 86 gpm of 13 weight percent sodium pentaborate decahydrate solution at the natural boron-10 isotope.

Some utilities have opted to change the enrichment of the boron-10 in the storage tank rather than to increase the pumping rate. It is the boric acid constituent that is enriched. This approach maintains the SLC system redundancy of having two pumps capable of independent operation. It also permits the sodium pentaborate concentration within the tank to be reduced form 13.4% by weight to less than 9.2% by weight, which lowers the saturation temperature to 40^0F and thereby eliminates the requirement for monitoring and maintaining the solution temperature.

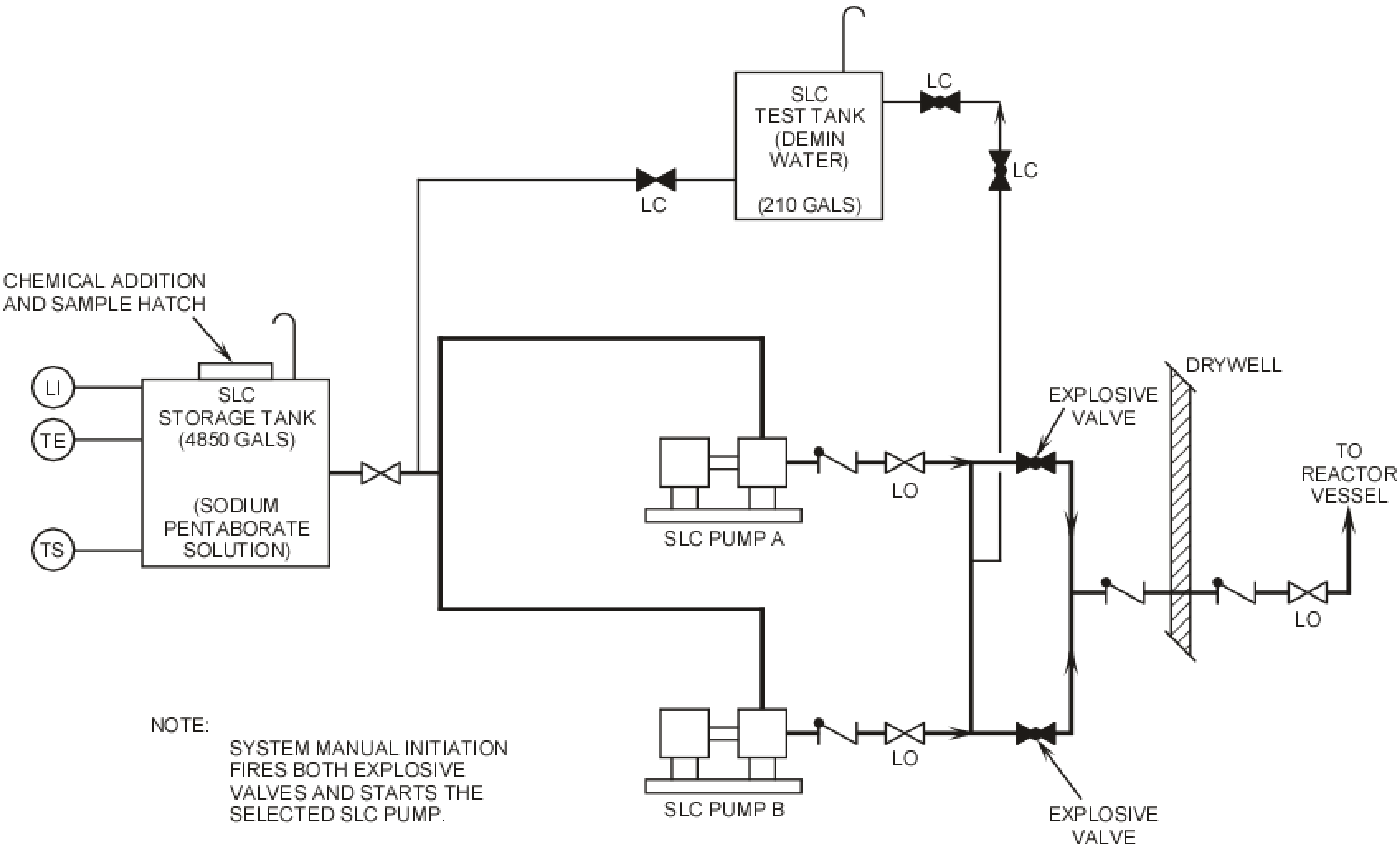

Figure 6.0-1, Standby Liquid Control System