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4.2 BORON THERMAL REGENERATION SYSTEM

4.2.1 Introduction

The Boron Thermal Regeneration System (BTRS) varies the reactor coolant system (RCS) boron concentration to compensate for xenon transients and other reactivity changes which occur when power is changed. The BTRS is installed to allow for maximum load following while minimizing the liquid radioactive effluents from boron concentration changes. The design load follow capability for the BTRS is 12 hours at 100% power, 3 hour ramp to 50% power, 6 hours at 50% power, and a 3 hour ramp to 100% power. The operation of the BTRS is described below.

4.2.2 System Operation

Downstream of the mixed bed demineralizers in the chemical and volume control system (CVCS), the letdown flow can be diverted to the BTRS. The letdown flow, all or in part, may be treated when boron concentration changes are desired for load follow operations. After processing, this fluid is returned to a point upstream of the reactor coolant filter in the CVCS letdown line. Storage and release of boron during load follow operations are determined by the temperature of the fluid entering the thermal regeneration demineralizers. A chiller, which is cooled by a separate refrigeration system, and a group of heat exchangers are employed to provide the desired fluid temperatures to the demineralizers for either storage or release operation of the system.

4.2.2.1 Dilution Mode

The flow path through the BTRS is different for the boron storage and release operations. During boron storage (dilution - Figure 4.2-1), the letdown stream enters the moderating heat exchanger tube side and from there it passes through the letdown chiller heat exchanger tube side.

These two heat exchangers cool the letdown stream prior to entering the BTRS demineralizers. The letdown reheat heat exchanger is valved out on the tube side and performs no function during boron storage operations. The temperature of the letdown stream at the point of entry to the demineralizers is maintained automatically by the temperature control valve which regulates the shell side flow to the letdown chiller heat exchanger. After passing through the BTRS demineralizers, the letdown enters the moderating heat exchanger shell side, where it is heated by the incoming letdown stream.

The letdown flow then enters the normal letdown flowpath upstream of the RCS filter before going to the volume control tank. Therefore, for boron storage, a decrease in the boric acid concentration in the reactor coolant is accomplished by sending the letdown flow at relatively low temperatures to the thermal regeneration demineralizers. The resin, which was depleted of boron at high temperature during a prior boron release operation (borate), is capable of storing boron from the low temperature letdown stream. Letdown flow with a decreased concentration of boric acid leaves the demineralizers and is directed to the RCS via the CVCS normal charging flowpath.

4.2.2.2 Boration Mode

During the boron release operation (boration - Figure 4.2-2), the letdown stream enters the moderating heat exchanger tube side, bypasses the letdown chiller heat exchanger, and passes through the shell side of the letdown reheat heat exchanger. The moderating and letdown reheat heat exchangers heat the letdown stream prior to its entering the resin beds. The temperature of the letdown at the point of entry to the demineralizers is maintained automatically by the temperature control valve which regulates the flow rate on the tube side of the letdown reheat heat exchanger. After passing through the demineralizers, the letdown stream enters the shell side of the moderating heat exchanger, passes through the tube side of the letdown chiller heat exchanger.

An increase in the boric acid concentration in the reactor coolant is accomplished by sending the letdown flow at relatively high temperatures through the thermal regeneration demineralizers. The higher temperature water flowing through the demineralizers releases boron which was stored by the resin at low temperature during a previous boron storage (dilution) operation. The boron enriched letdown is returned to the RCS via the CVCS normal charging flowpath.

Although the BTRS is primarily designed to compensate for xenon transients occurring during load follow operations, it can also be used to handle boron swings far in excess of the design capacity of the demineralizers.

For dilution during a reactor start-up and power escalation for example, the resin beds are first saturated with boron, then washed off to the boron recovery system, then again saturated and washed off. This operation continues until the desired dilution in the RCS is obtained.

As an additional function, a thermal regeneration demineralizer can be used as a deborating demineralizer, which would be used to dilute the reactor coolant when it has very low boron concentrations at the end of the core cycle. To make such an operation effective, the boron concentration of the effluent from the resin bed must be kept very low, close to zero ppm. This low effluent concentration can be achieved by using fresh resin. The use of fresh resin can be coupled with the normal replacement cycle of the resin; one resin bed being replaced during each core cycle.

4.2.3 Summary

The BTRS provides a means of varying the boron concentration of the reactor coolant. This system reduces the operational demands on the boron recovery system thereby generating less liquid radioactive waste. The BTRS makes use of a temperature dependent ion exchange process in order to both remove boron from (dilute) and release boron to (borate) the CVCS letdown stream.

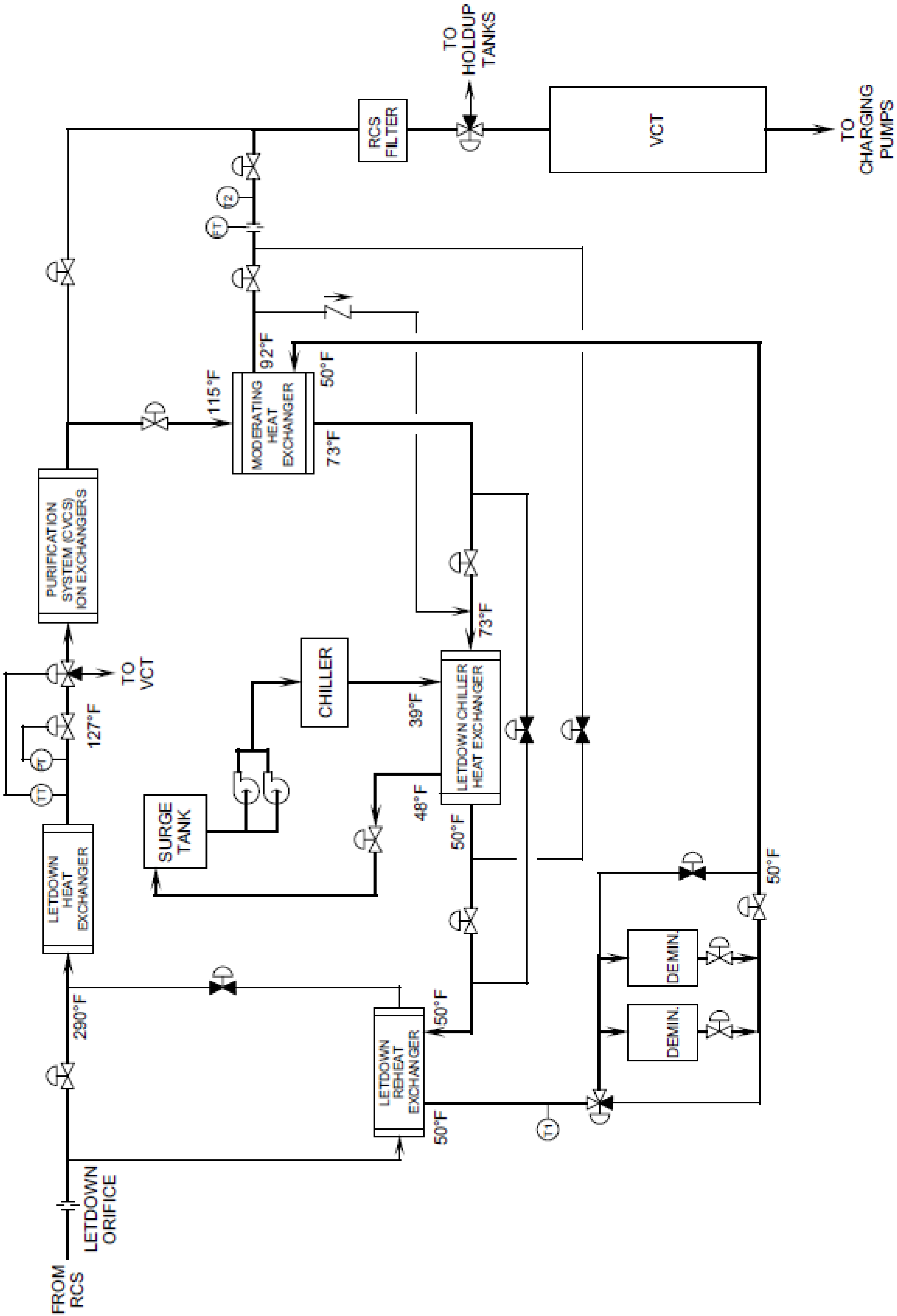

Figure 4.2-1 Boron Thermal Regeneration System (Dilution)

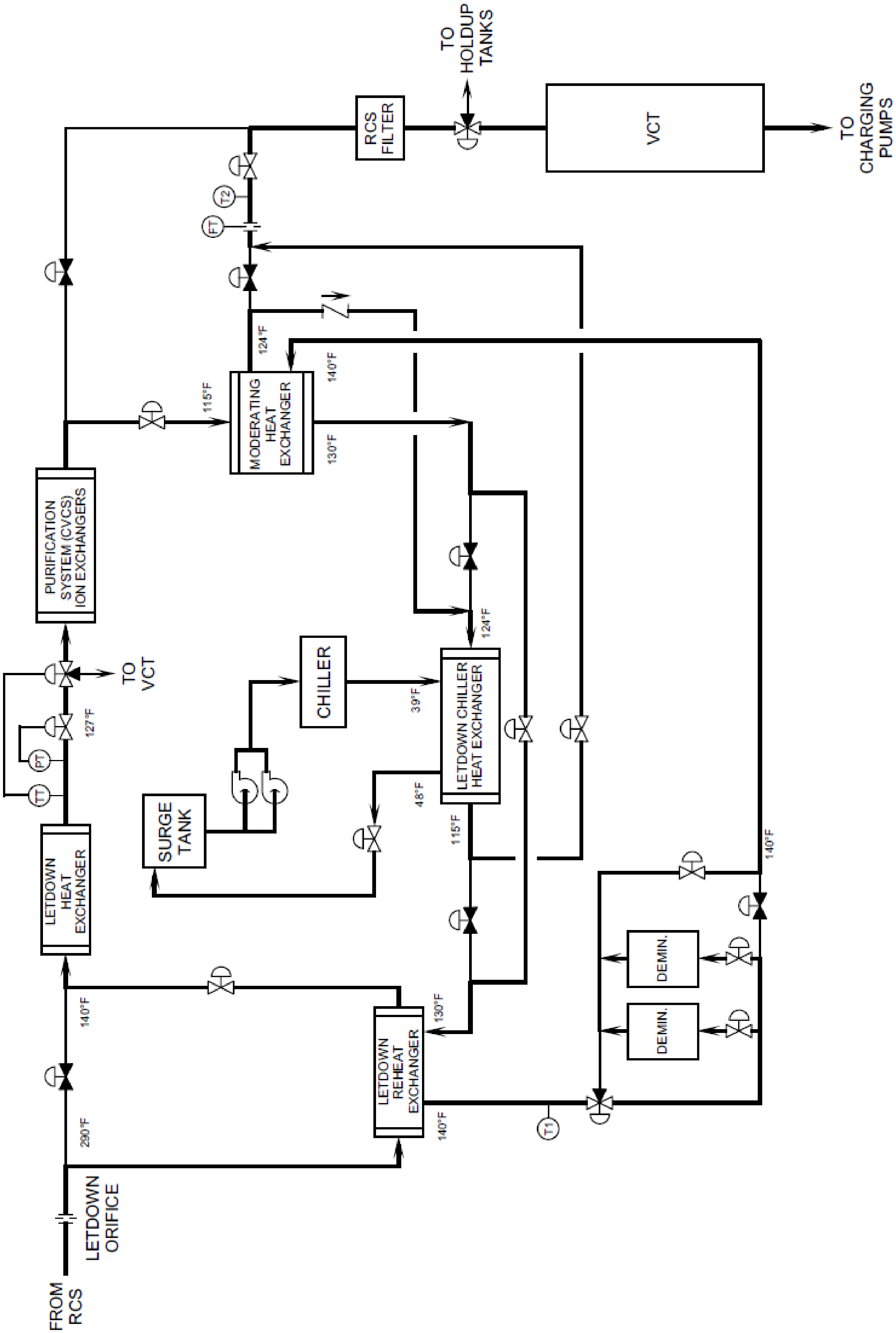

Figure 4.2-2 Boron Thermal Regeneration System (Boration)