Chapter 1

Introduction

A large pipe break in primary heat transport system (PHT) in CANDU-9 nuclear power plant can cause a severe accident. As soon as the break occurs, the reactor power increases rapidly because of positive void reactivity. This increase during blowdown period is arrested by fast reactor trip[1]. However, the heat buildup after reactor trip still continues. Due to loss of coolant in heat transport system, the fuel sheath temperature rises. Ultimately, it would induce core meltdown in the reactor. To refill the fuel channels, and remove residual heat from the reactor fuel, Emergency Core Cooling System (ECCS), one of four safety systems in a CANDU-9 nuclear power plant, will be initiated after receiving Loss Of Coolant Accident (LOCA) signal. Mistakes made by human error or equipment failure in any stages of ECCS may trigger huge disaster in nuclear power plant. For example, if gas isolation valves cannot be open when LOCA signal is generated, the differential pressure between ECC and PHT is not adequate to burst rupture disks. Therefore, there is no flow to refill fuel channels.

To evaluate ECC operating procedure, to observe the response of the parameters, and to improve the operator skill solving the unexpected problems, the simulation of the Emergency Core Cooling System (ECCS) in CANDU-9 nuclear power plant has been developed by using a simulation development system, CASSIM.

Chapter 2 shows the description of ECCS. This chapter describes the operation, control description, and component control and monitoring of ECCS. Chapter 3 explains how to develop the simulation models by using CASSIM. Chapter 4 deals with the results of the simulation due to a large break pipe in PHT. The responses of flow rate, pressure, temperature during the large break happened will be observed. Discussion will be made to analyze the results from the simulation. Chapter 5 concludes the results from chapter 4. Suggestions to improve the model are also described..

1.1 Objectives

To develop the model for the Emergency Core Cooling System of the CANDU-9 nuclear power plant on a microcomputer.

1.2 Scope of work

1.2.1 To simulate hydraulic system for the Emergency Core Cooling System of the CANDU-9 nuclear power plant.

1.2.2 To simulate the operation of the Emergency Core Cooling System of the CANDU-9 nuclear power plant in case of low pressure at Reactor Outlet Header2 (ROH2) and sustained low pressure at Reactor Outlet Header1 (ROH1)

1.3 Procedure of work

1.3.1 Study Fortran language to write the algorithm.

1.3.2 Study CASSIM and LabVIEW programs.

1.3.3 Study and conduct the data search for necessary for development of the ECCS model including main components, steps and procedures to control equipment, specifications for each components, automatic control for the system, monitoring and alarming parameters.

1.3.4 Develop the models for ECCS.

1.3.5 Test the model of ECCS.

1.3.6 Build graphical user interface screens using LabVIEW program.

1.3.7 Conclude and write the papers.

1.4 Benefit expected from this work

With this simulation, the operation of the Emergency Core Cooling System of the CANDU-9 nuclear power plant can be studied. The operator can simulate LOCA accident in the CANDU-9 nuclear power plant and improve the skills to cope with unexpected problems by using this simulation.

1.5 Background

CANDU-9 is a 900 MW nuclear power plant which is used natural uranium as a fuel and pressurized heavy water as coolant and moderator. The CANDU reactor is contained in a cylindrical, horizontal vessel called the calandria, which provides containment for the heavy water moderator. Heat produced in the reactor core is propagated by heavy water coolant in the calandria to steam generators via heat transport pumps in Heat Transport System (HTS) or Primary Heat Transport system (PHT). PHT main circuit of a CANDU-9 is shown in Figure 1.1.

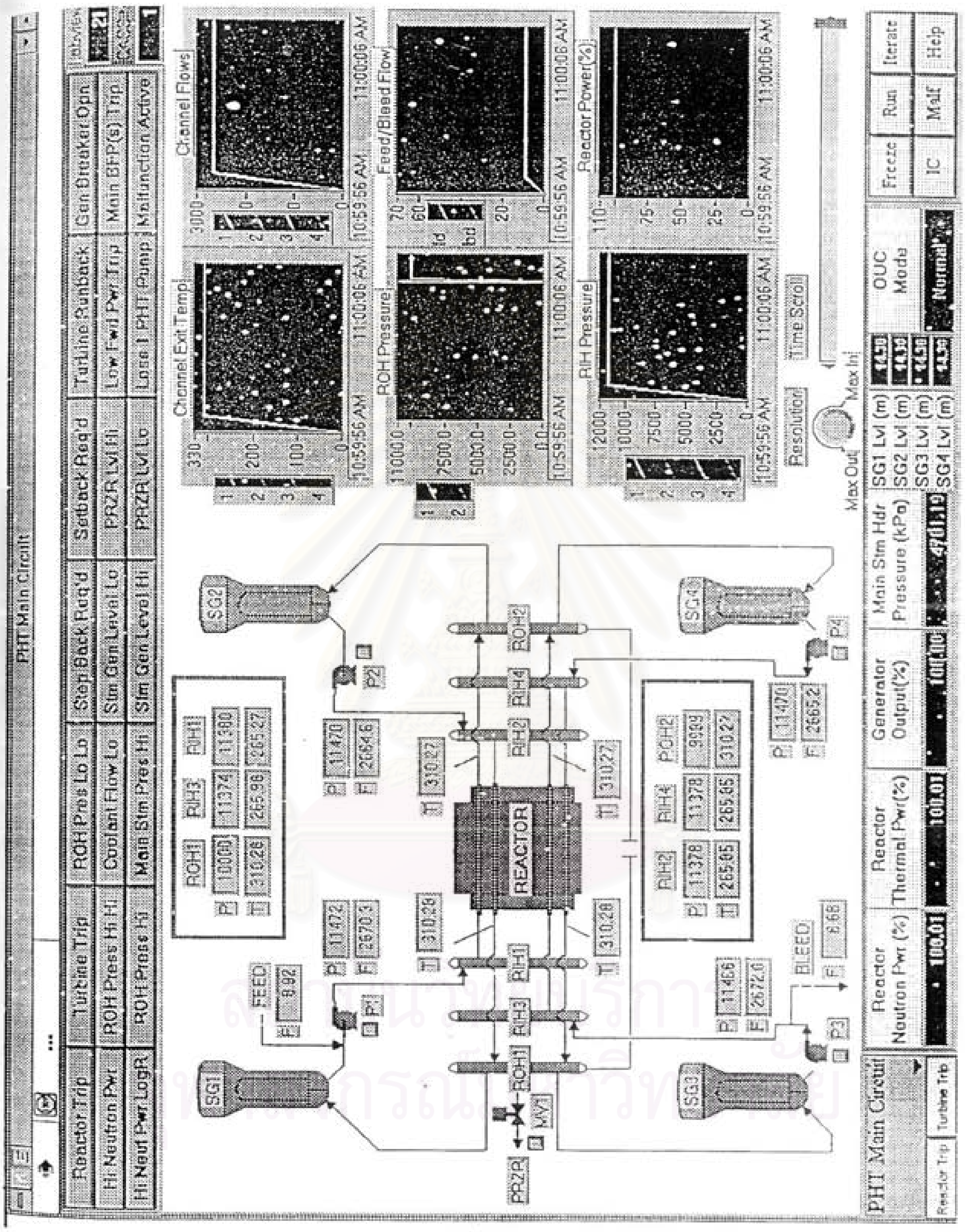

Figure 1.1 PHT main circuit for CANDU-9[2]

Accidents in which cooling of the core is impaired have the potential for very serious consequences to the reactor and staff, and possibly the public[3]. Safety systems are designed to mitigate that consequence. There are four safety systems in a CANDU nuclear power plant; Shut Down System 1 (SDS1), Shut Down System 2 (SDS2), Emergency Core Cooling System (ECCS), and Containment system.

SDS1 is the primary method of quickly shutting down the reactor when certain operating parameters show potentially unsafe operation. Shutdown rods drop under gravity with spring assistance SDS2 provides a second method quickly shutting down the reactor under accident conditions. This is a rapid injection of a concentrated gadolinium nitrate solution into the moderator[4]. Figure 1.2 show SDS1 and SDS2. ECCS, which is shown in Figure 1.3, is the means to remove the heat from the core after the accident. ECCS will be discussed in detail in the next chapter. Containment system is an envelope around the nuclear components of the heat transport system designed to prevent significant amounts of radioactivity from being released to the environment. The containment system consists of the basic containment structure with an epoxy liner on the inner surface, a dousing system, air coolers and an isolation system in Figure 1.4.

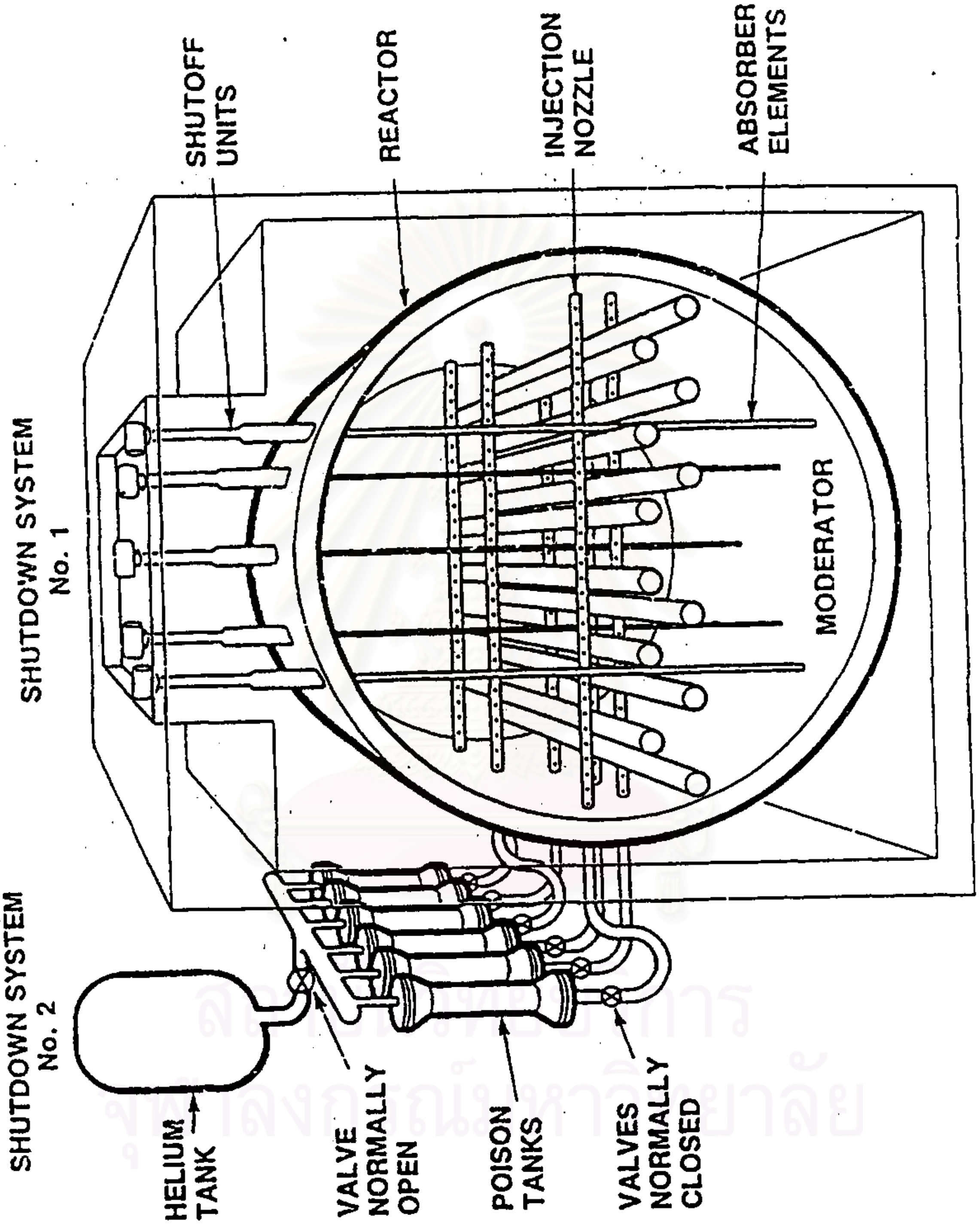

Figure 1.2 Shut Down System1 and Shut Down System2[4]

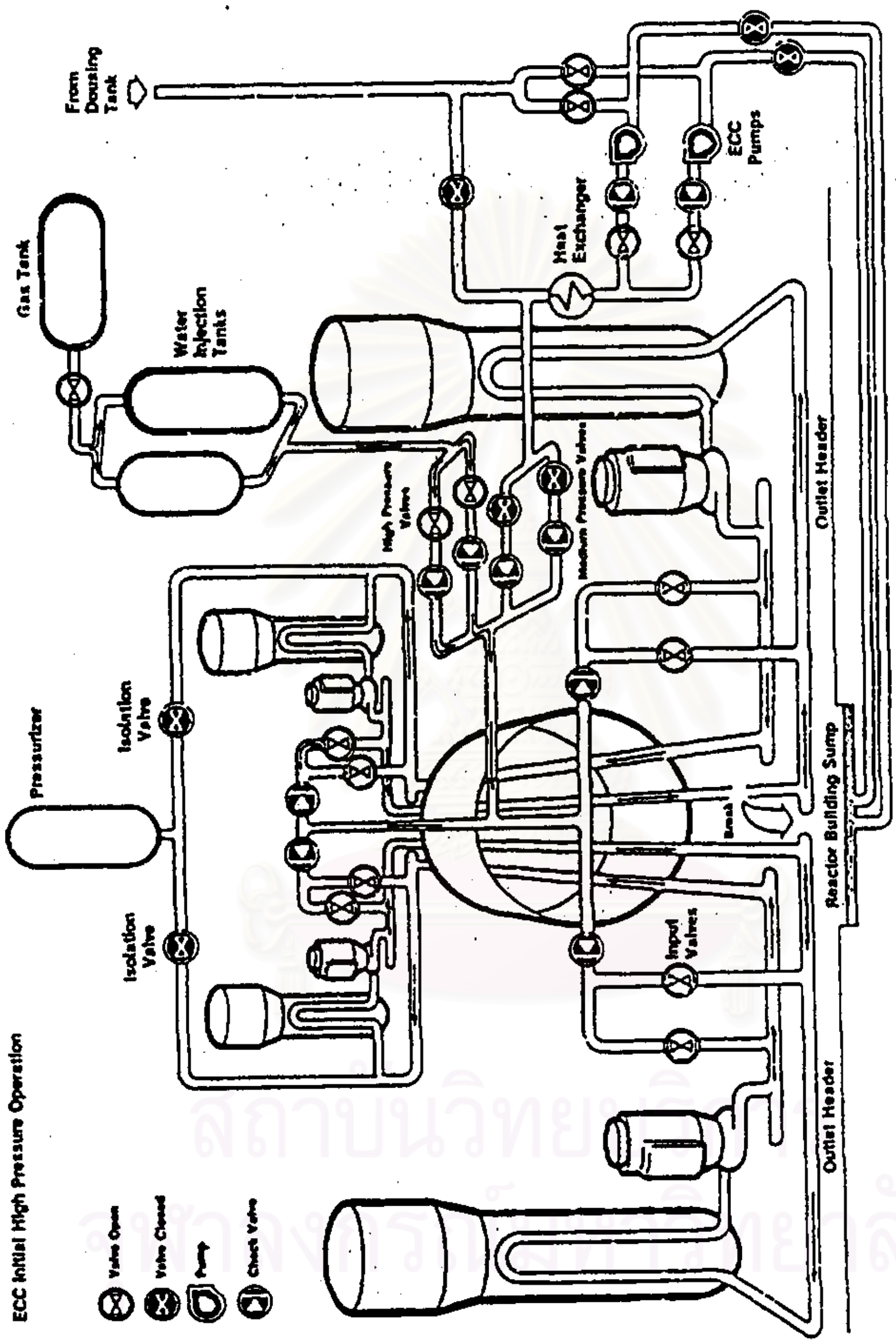

Figure 1.3 Emergency Core Cooling System[4]

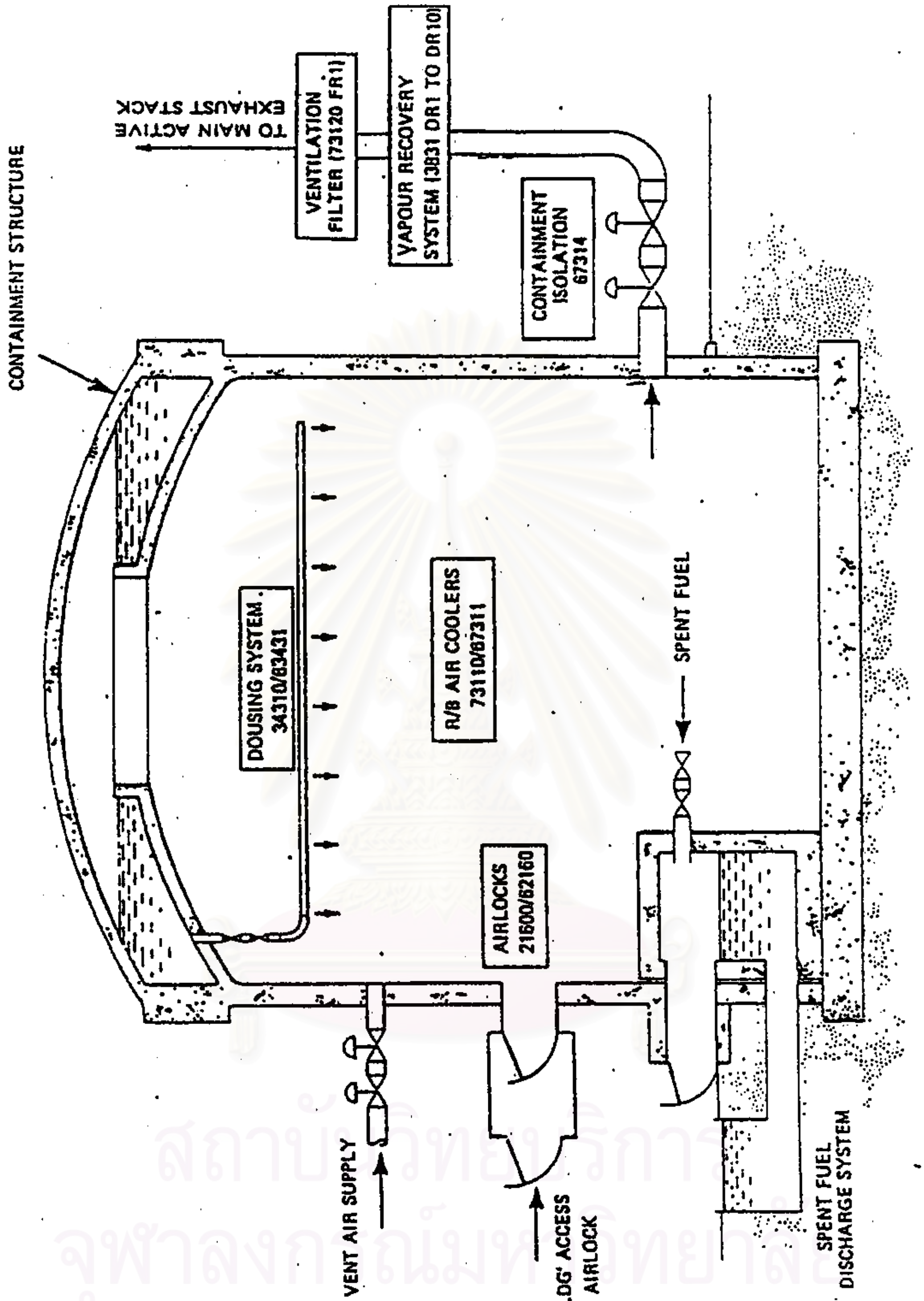

Figure 1.4 Containment System[4]