CHAPTER I
INTRODUCTION

Thinning of a pipe wall caused by the Flow Accelerated Corrosion (FAC) is possible for all carbon steel pipes exposed to high temperature water or wet steam. It is well known that when ferrous metals are exposed to water the metal is corroded and becomes covered with a protective oxide film on the surface. Exposure of the oxide layer to fast flowing water leads to dissolving or erosion of the protecting oxide surface in the solution. The underlying metal continues to corrode to re-create the oxide film, and thus the metal loss continues which results in the ultimate degradation of the pipe.

During the corrosion process, hydrogen atoms are produced electrochemically as iron is lost into solution as a consequence of FAC. The atomic hydrogen enters the metallic lattice interstitially and permeates throughout the metal due to the high diffusivity of hydrogen in the carbon steel. The through-wall hydrogen emerges at the outer surface of the pipe where the atoms combine to form hydrogen gas. Thus, the rate of FAC-generated hydrogen diffusing through the pipe wall is proportional to the FAC rate on the wall inside the pipe.

Many endeavors have been made to monitor such corrosion rates. One of the conventional corrosion rate monitors is by using an ultrasonic signal to measure the reduction in the wall thickness. Unfortunately, data from this device have a low signal-to-noise ratio and respond sluggishly to local changes in thinning rate. In order to obtain a more reliable and accurate measurement of the corrosion rate, the Center for Nuclear Energy Research (CNER) has developed the Hydrogen Effusion Probe (HEP) which provides an on-line, real-time, non-intrusive corrosion monitoring of the corrosion rate. Data from the HEP were expected to give a high signal-to-noise ratio, and respond quickly to local changes in thinning rate.

The HEP device is attached to the exterior surface of a pipe and is capable of containing and measuring the increase in hydrogen pressure associated with the diffusion of hydrogen atoms through the carbon steel pipe. This atomic hydrogen is produced by the corrosion reaction at the inner surface of the pipe. The rate of pressure rise measured by the HEP can be converted to a rate of metal loss due to the corrosion of the inner wall of the pipe. The HEP has a significant commercial potential, and can be use for industrial applications where pipe wall loss due to corrosion is a concern. The on-line HEP measurement is expected to be sensitive enough to show the rate of pipe wall thinning under upset conditions.

The purpose of this work focused primarily on studying the performance of the HEPs to monitor FAC. An experimental test loop at CNER has been used to study the performance of the HEP to monitor the FAC. The effects of operating temperature on the corrosion rate and the hydrogen diffusion were investigated. HEPs have also been installed on an outlet feeder pipe of a CANDU reactor at the Point Lepreau Generating Station and on a water-wall tube of a boiler at the Coleson Cove Generating Station to better assess the operation of an HEP in various industrial applications.

The hydrogen flux depends not only on the corrosion kinetics but also on the hydrogen transport through the steel. The coefficient of hydrogen diffusion in carbon steel pipe is a basic parameter that should be known in order to predict response times for an HEP. Thus the basic background related to the hydrogen transport through metals was reviewed and summarized. The information provided in this work is intended to support the data analysis and the prediction of the experimental results related to the HEP.