# Preface

A pipeline network, which is by far the most efficient way to transport fluids despite the expense of appropriate maintenance, is a complex system with many types of components and consumers. Therefore, pipeline networks have reached high levels of importance for transportation all over the world.

It is crucial for industries and societies that networks operate properly by considering the growing need for efficient interconnecting fluid systems. This task is not easy, because one must concurrently ensure a safe fluid supply and the fulfillment of the varying demands of consumers. This task becomes more complicated with the emergence of leaks blockage and the defects in sensors, actuators, which can generate the deterioration and malfunction of the whole network.

Network breakdowns induce high economic losses and environmental damage, which make the design and implementation of monitoring systems essential for the opportune detection and localization of faults to safeguard the network.

The monitoring of networks is a concern normally tackled by interdisciplinary groups comprising scientists, researchers, and industrial engineers from diverse knowledge fields. These include fluid mechanics, instrumentation, automatic control, signal processing, computing, and civil engineering. The main problems that these interdisciplinary groups find in the design of automatic supervision systems for pipeline networks are the following.

- The imprecise knowledge about the network parameters that significantly changes from their design values because of the manufacturing execution, the installation process and the aging deterioration.
- The reduced number of available sensors with high sensitivity and wide bandwidth that allows the monitoring in real time of every network component.
- The high number of fault scenarios which could occur in a real network.
- The deterioration of the components during the life cycle of the installations.
- The occurrence of unpredictable natural phenomena such as earthquakes, tornadoes, and hurricanes which can damage the whole system.

- The changing structure of the network caused by either scheduled or unplanned events.
- The varying demand of fluid during time intervals.

For the safety of pipeline networks, specific software tools have been developed over the past three decades which are complementary to the traditional supervisory control and data acquisition systems (SCADA). Commonly, such tools are comprised of fault detection and location (FDI) algorithms, based on mathematical models of the fluid or routines for processing signals, and they take into account a limited number of available variables from the pipeline.

Note that some faults to be detected require active detection, i.e., by demanding that supervision systems act upon the pipeline network in periodical intervals or at critical times by using test signals to generate, for instance, transient responses of the fluid for detecting abnormal events. Thus, there are a considerable number of research groups around the world with different backgrounds who are dedicating efforts to propose feasible automatic monitoring and supervision systems for networks.

Diverse abnormal conditions have been studied, specific sensors have been developed, and some maneuvers have been proposed to look for abnormal conditions. The most common fault scenarios are leaks, blockages, sequential faults over time, and illegal extractions.

This monograph presents some tools for improving the automatic monitoring and supervision of networks, and it could be suitable for a wide variety of users who are interested in the new technology for the monitoring of pipelines.

The main goals of the monograph are the following:

- To introduce fault detection techniques in pipelines to a new audience;
- To present new algorithms to manage the monitoring of pipeline networks for more general fault scenarios;
- To present techniques for designing auxiliary signals to improve the identification of parameters and faults in pipelines;
- To present fault detection techniques in pipelines that have been validated in real applications;
- To integrate results developed by the civil engineers and the safe process communities.

The monograph is a compiled summary of research topics and applications studies done by international experts in the field of automatic monitoring for pipelines' networks. The content has been organized in 12 chapters related to leak detection and location, modeling of networks, auxiliary signals for parameter identification, design of monitoring systems, adequate placement of sensors in water demand networks, and related issues. The authors are civil engineers and diagnosis researchers from institutions of different countries such as France, Spain, Portugal, Venezuela, Mexico, Poland, Canada, Cuba, and Colombia.

The monograph was designed to provide key knowledge, useful techniques and tools to mathematicians, computer scientists, and engineers concerned with the issues of design, as well as the adjustment and operation of robust monitoring systems for pipeline networks through software. It is hoped that the content will be helpful reference text for newcomers to the field of computational pipeline monitoring (CPM) by using advanced automatic technologies as well as those with some knowledge of the subject.

This monograph was possible through the effort of the authors to present the topics in a clear and uniform manner. Our purpose during the preparation was that readers could follow the content even if they have different backgrounds. Furthermore, chapters can be read independently despite being arranged in a natural sequence. First, the issue of ad hoc models for fault detection in a pipeline and the problems' formulation are discussed. As the second group of contributions, specific leaks' diagnosis systems are introduced for a single pipeline, and finally some solutions to the complex problem of leak location in pipeline networks with multiple leaks and uncertain demand are suggested. This facilitates the understanding according to the interest of the reader.

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