SPRINGER BRIEFS IN
APPLIED SCIENCES AND TECHNOLOGY

Alireza Bahadori · Malcolm Clark
Bill Boyd

Essentials of Water Systems Design in the Oil, Gas, and Chemical Processing Industries

Springer

SpringerBriefs in Applied Sciences and Technology

For further volumes:
http://www.springer.com/series/8884

Alireza Bahadori · Malcolm Clark
Bill Boyd

Essentials of Water Systems Design in the Oil, Gas, and Chemical Processing Industries

Springer

Alireza Bahadori
Malcolm Clark
Bill Boyd
School of Environment,
Science and Engineering
Southern Cross University
Lismore, NSW
Australia

ISSN 2191-530X ISSN 2191-5318 (electronic)
ISBN 978-1-4614-6515-7 ISBN 978-1-4614-6516-4 (eBook)
DOI 10.1007/978-1-4614-6516-4
Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2013932784

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

Water supply systems are crucial in supporting industrial oil, gas, and other chemical processing systems. Reliability of supply and cost of water to such industries is important for both the sustainable management of such industries and for the provision of a supply market. This book, therefore, overviews and introduces the technical matters related to the process design and selection of water supply systems used in such industries. In doing so, it provides an introduction to the field of industrial processing water supply management, and a frame for further engagement in the detailed literature of this field.

Both process design and process selection of the many water supply systems used in oil, gas, and chemical processing industries are crucial for the maintenance of existing facilities and the design of next-generation processing industries. Simply put, oil, gas, and most chemical processing plants cannot function without water-based utility systems. Although the importance of these systems is not usually contested, expansion or upgrade expenditures of these operations are often avoided, because no direct payback can be assigned to any utility capital expenditures.

The cost of supplying water for steam, cooling, and processing varies greatly, depending on the water source. Water typically comes from sources such as on-site groundwater wells, surface water, or off-site providers. These supplies often have flow limit restrictions, and the purchasing water can be expensive. There may also be additional regulations enforced when demand exceeds permitted limits. Moreover, the cost for raw water treatment (chemical additives, softeners, and flocculants), sludge disposal, pumping, and other processing, rises with increased water demand.

Water use at a plant can increase for many reasons; hence plant expansions and unit conversions can impact utility systems by boosting flows and contaminant loading. In addition, new and modified units may contribute to increased storm water runoff, and more stringent quality specifications may also increase water demand from increased washing/treatment steps.

The aim of this book is to provide an overview of the main technical points related to the process design and selection of water supply systems used in the oil, gas, and chemical processing industries. This overview is framed around four systems that, together, provide an integrated industrial water management system.

- Water treatment system
- Raw water and plant water system
- Water pollution
- Fire water distribution and storage facilities

There is a direct relationship between water demand and flows to water treatment. Consequently, many water treatment and wastewater units are designed for peak flows only experienced during storm conditions. Treatment costs during these peak flow conditions can climb exponentially from increased pumping, aeration demands, sludge management, and solids disposal requirements. Most importantly, additional water use reduces treatment capacity during peak flows often resulting in the need for additional storage capacity to dampen these peaks.

The field of process water design is broad, and contains a wide range of subjects, each of paramount importance including raw water treatment and recovery systems. The treatment of both water and wastewater involves a sequence of treatment steps. All water and wastewater treatment processes involve the separation of solids from water in at least some part of the operation and removal of biochemical oxygen demand (BOD) to some extent. The end of pipe treatment sequence can be divided into the following elements: primary or pretreatment; intermediate treatment; secondary treatment; and tertiary treatment plus ancillary, sludge dewatering, and disposal operations.

Optimizing the performance of individual unit operations, such as gravity separator, dissolved air flotation, biological treatment, etc., can best be achieved if:

- the properties of influent streams are considered;
- the chemical principles that are used in solids pretreatment are understood;
- the variety of chemicals available for solids treatment is recognized;
- the properties of effluent water are established based on the local environmental regulations and final disposal; and
- the protocols for quantifying results are identified.

Effluent wastewaters are a combination of the liquid and water-carried wastes from buildings, industrial plants, plus groundwater, surface water, or storm water. Wastewater may be grouped into the following classes [5–8]:

Class 1 Effluents that are non-toxic, and not directly polluting but liable to disturb the physical nature of the receiving water, may be improved by physical means.

Class 2 Effluents that are non-toxic, but polluting because they have an organic content with high oxygen demand, may be treated for removal of objectionable characteristics by biological methods.

Class 3 Effluents that contain toxic materials, and therefore are polluting, may be treated by chemical methods.

Class 4 Effluents that are polluting because of organic content with high oxygen demand and, in addition are toxic, may require a combination of chemical, physical, and biological processes.

The final release of effluents and surface water drainage to the broader environment is subject to the approval of environmental scientists and experts, a factor that must be borne in mind in the early stages of design. In general, the aim of any drainage/effluent disposal system should be to segregate uncontaminated water from contaminated water or effluents and to segregate different types of effluents in order to reduce the size, complexity, and costs of any treatment units which may be required for handling the contaminated water and effluents before they are discharged from oil, gas, and chemical processing plants.

Dr. Alireza Bahadori
Dr. Malcolm Clark
Prof. Bill Boyd

Contents

Chapter 1
Water Treatment Systems

Keywords Source water · Water treatment · Treatment process selection · Water quality · Boiler water · Total suspended solids · Total dissolved solids · Silica · Deposits in water systems

1.1 Introduction

The increasing energy demand over the last decades has resulted in a corresponding growth and expansion in the processing of crude petroleum, natural gas and other hydrocarbon resources. Water treatment or the purification of water varies as to the source and kinds of water. Type of water treatment depends on the quality of the source water and the quality desired in the finished water. Adequate information on the source water is thus a prerequisite for design. This includes analysis of the water and, where the supply is non-uniform, the ranges of the various characteristics.

The proliferation of oil, gas, petrochemical and chemical plants, combined with increasingly stringent discharge limit requirements for effluents from these facilities, underscores the need for improving existing pollution control technologies or developing new and improved approaches for minimizing the pollution potential in the oil, gas, petrochemical and chemical sector [1, 2].

For example, in petroleum industry, nearly all crude oils contain some basic sediment and water (BS&W), which is generally composed of a mixture of water, iron rust, iron sulfides, clay, sand and particulate contaminates produced with the crude oil or picked up in transit. Part of the BS&W is charged to the crude oil unit and may settle out in the desalter, entering the oily water sewer system along with the desalter effluent. Similarly, water in contact with process streams, originating from steam stripping, crude oil washing, some chemical oil treatment processes etc., may contain variable amounts of oil [3, 4].

Suspended solids, biodegradable organics, nutrients, refractory organics, heavy metals, dissolved inorganic solids, pathogens, soluble material such as ammonium sulfide, phenols, thiophenols, organic acids and inorganic salts such as sodium

A. Bahadori et al., *Essentials of Water Systems Design in the Oil, Gas, and Chemical Processing Industries*, SpringerBriefs in Applied Sciences and Technology,
DOI: 10.1007/978-1-4614-6516-4_1, © The Author(s) 2013

chloride are the important contaminants which may be found in the oil, gas and chemical processing industry's utility waters and wastewaters [5, 6].

Relevant to the above-mentioned facts, these five categories of water may need different treatments, and for this reason, water streams are often kept segregated in a modern refinery to reduce the cost of water treatment facilities.

Water treatment requirements for oil, gas, chemical processing industries and/or plant services depend upon [5, 6].

- the quality of the source of makeup water;
- the manner in which the water is used;
- environmental regulations; and
- Site climatic conditions governing wastewater disposal.

In wastewater treatment systems, suspended solids can be removed by physical treatment to some extent. The removal of biodegradable organics, suspended solids and pathogens is achieved through the secondary treatment operation units. The more stringent standards are dealt with the removal of nutrients and priority pollutants.

When wastewater is to be reused, regulations normally include requirements for the removal of refractory organics, heavy metals and, in some cases, dissolved inorganic solids [7–10].

Process waters and all other special drainages throughout the plant/refinery shall be isolated from surface runoff. The surface drainage shall be collected in a dedicated and separate clean stormwater sewer system. Extensive efforts shall be made to segregate the surface drainages and to avoid the contamination or mixing with the oily water sewers.

In oil, gas and chemical industries, water is the most commonly used agent for controlling and fighting a fire, by cooling adjacent equipment, and for controlling and/or extinguishing the fire either by itself or combined as a foam. It can also provide protection for firefighters and other personnel in the event of fire. Water shall therefore be readily available at all the appropriate locations, at the correct pressure and in the required quantity [7–10].

These factors should be considered in selecting the overall plant process and utility systems.

1.2 Quality of Source Waters

The quality of many water sources will change little over the lifetime of treatment plant except for the seasonal changes that should be anticipated in advance. In some instances, it is best arrived at by judgment based on past trends in quality, a survey of the source and evaluation of future developments relating to the supply. Other sources can be expected to deteriorate substantially as a result of an increase