*Frank Peter Helmus*

# Process Plant Design

Project Management from Inquiry to Acceptance

*Translated by Christine Ahner*


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*This book is dedicated to my three daughters Svenja, Tabea and Merle.*

## Contents

# Preface

Undertaking the design, erection and commissioning of process engineering plants requires a whole host of knowledge areas. Moreover, apart from this knowledge, project engineers also need to be in command of a range of so-called "soft skills" in order to communicate with engineers involved in the project in multi-disciplinary ways. Furthermore, project engineers are under enormous pressures of time and cost due to the strong international competition. Finally, a lot of experience is required in the business of plant engineering and construction. Some companies' tendency towards early retirement entails great loss in experience values. To make matters worse, sometimes those "old hands" are not given the opportunity to transfer their knowledge to young engineers. Thus, the mistakes of former generations continue to be repeated.

This flood of demands, however, should by no means act as a deterrent. On the contrary: The fascination of process plant engineering needs to be conveyed. Try imagining how it feels if after two or three years of hard project-related team work, a process plant, planned and erected with consideration having been given to the latest process-engineering, environmental and safety-engineering insights is finally realized. This is something you can show your kids and say: "I had a share in it!"

Of course, mistakes are sometimes made during the execution of a project. The crucial point, however, is how to avoid *big* and thus really expensive mistakes. Therefore, in this book, with the help of examples, many possibilities for error that may arise during the execution of a project will be described.

This book is intended to address beginners and to give them an overview of the activity flow involved in process plant engineering. The technical details are not exhaustive, but are rather intended to give a broad coherent view. Process engineers are also required to have a certain basic knowledge of economics, and this is given in Chapter 3, "Contract", in terminology which, I hope, will be comprehensible to engineers.

In general, more importance is attached to clear and understandable rather than technical and dry language. Therefore, many terms are derived from industry terms and jargon.

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# 1
# Introduction

## 1.1
## General remarks on process plant design

In process plants, source materials (reactants) are converted into merchantable products. Source materials and products may be gaseous, liquid or solid substances or even mixtures of these different states (suspensions, particulates etc.) Products may be intermediate or end products which are being processed step by step. The result is a whole host of possible problems or types of plants that solve these problems. The following list shows at least some typical products of process plants and their lines of business:

- chemistry: paints, plastics, fibres, fertilizers etc.
- pharmaceutics: drugs
- cosmetics: creams, lotions, cosmetic products etc.
- refineries: fuels, basic products for chemistry, lubricants etc.
- building materials: cement, sand, gravel etc.
- food industry: fats, oils, cereals, sugar etc.
- coal: mining and processing of coal

This book deals with the activities arising during the phase of design, construction and start-up of process plants. Here, the emphasis is on *process* plants, since, in comparison with production plants, totally different planning instruments (e.g. CAD-systems) and steps (e.g. pipe design) are required. The activities are, as far as possible, described chronologically, beginning with the product idea up to the acceptance of a successfully commissioned plant. In order to keep the scope of this book within reasonable limits it cannot go into each and every detail, but instead refers to secondary literature. Importance is attached to practical orientation. Since, depending on the company, procedures regarding project management are often very different not all procedural methods can be taken into account. The focus is rather on the imparting the understanding of basic structures.

The book has mainly been written for students of process engineering and chemical engineering as well as professional newcomers of these disciplines working in the field of process plant engineering.

Nowadays, process plant engineering is characterized by globalization. Engineers are increasingly required to dispose of so-called "soft skills" apart from their respective expertise. In the field of plant engineering, this includes mainly team-building qualities, communicational and language skills. Against the background of the strictly interdisciplinary character of procedural projects, the ability to communicate between the disciplines involved in the project (process engineers, chemists, civil engineers, architects, electrical engineers, control engineers, business administrators and jurists) is of special importance. Thus, the different "languages" and aims of the individual disciplines will be addressed with an attempt to develop mutual understanding.

Apart from the technical aspects, and in order to take account of the enormous price erosion created by international competition in the field of plant engineering, the commercial aspects of project engineering will be discussed. Engineers may often aim to achieve excellent or best-quality technology, but the costs arising from this may not adequately be taken into consideration. Moreover, young project engineers, may sometimes execute disadvantageous sale contracts out of ignorance. Unfortunately it sometimes happens that even dubious requirements such as liability towards consequential loss or damage or horrendous percentages for penalties are accepted by young project engineers due to a lack of knowledge, and their sense of commercial matters therefore needs to be sharpened. This includes, inter alia, a comprehensible and simplified introduction to claims management and the basics of contract making.

Owing to increasingly strict environmental requirements, technology for environmental protection is gaining more and more importance. Processes for the purification of exhaust gases, waste water and solid waste have to be integrated into process plants in such a way that the accruing residual materials – provided they cannot be completely avoided or converted into recyclable material – are at least minimized or rendered as harmless as possible. This effort is subsumed under the term "Production-Integrated Environmental Protection" /1.1/. Depending on the country-specific legislation, environmentally relevant measures can cause the environmental-engineering components of a process plant to exceed actual production plants both in volume and in required investment. Here, the expenses for the flue gas cleaning of a garbage incineration plant have to be mentioned as an example. In addition, the expenses for so-called "authority engineering" have to be taken into account, the main goal of which is the achievement of official authorisation for the construction and operation of the designed plant.

## 1.2 Project

The goal of plant design is the realization of process plants within the framework of *projects*. /1.2/. Here, as a rule, two parties have to be distinguished: first the *plant operator* who wants to procure and operate a process plant, and secondly the *plant constructor* who, according to the agreed scope of delivery and service, takes

on the planning, delivery, assembly and start-up. Exceptions are some large-scale enterprises which utilise their own departments for plant design, so that both parties are represented in one company.

The two parties mentioned above follow completely different objectives: The plant operator wants to make as much profit as possible by producing and selling a certain quantity of a product in a defined quality. For this purpose, the relevant process plant has to be acquired at the lowest price possible and erected and put into operation as quickly as possible. These efforts come up against limiting factors both regarding acquisition costs and time scheduling. This point is dealt with in more detail in Chapter 2, section 2.1.3, "Costs" and Chapter 4, section 4.1.4, "Time scheduling/deadline control".

The aim of the plant manufacturer is to keep the expenses for planning and erection of the plant as low as possible. However, restrictions are placed on this effort as well. For example, the procurement of the equipment does not allow of discretionary savings, since it has to meet the quality requirements guaranteed in the contract. The difference between the selling price achieved and the actual costs represents the profit or even the loss for the plant manufacturing company. How to keep the actual costs low is shown essentially in Chapter 4, "Project Execution".

These different targets evidently provoke a certain conflict of interests between the parties involved. Considering the selling price of the designed process plant which is to be stipulated, this becomes clear. In order to avoid disputes that may arise from this conflict situation, comprehensive *contracts* binding for both sides are executed in the majority of cases. Since a lot of technical aspects are treated in a sales contract, too, Chapter 3, "Contract", deals with this topic in a way that is designed to be comprehensible to engineers.

As already mentioned, the manifold procedural tasks entail a similar number of different plant versions. Apart from the kind of process plant, there are large differences with regard to size in respect to *plant capacity*. This usually refers to the annual quantity of manufactured products. According to the plant size, different planning activities and, above all, different project structures are required. For the sake of clarity, the following types of plants are going to be distinguished.

**Small plants**: Here, plants with a production volume of up to €500,000 are concerned. The entire planning and erection regarding assembly of these smaller plants are from one hand. Frequently they are still transportable and thus can be kept in stock. The duration of the project is rather short, i.e. up to a maximum of one year. The engineer primarily in charge of such a project, the so-called "project manager", can carry out several such projects at the same time, often being responsible not only for the organization but also for the technical handling. There is a multitude of suppliers for such small plants, both small and large enterprises. Examples for smaller plants are more complex systems such as redundant vacuum pump units together with the respective periphery, silo plants, spray

driers with equipment or, as shown in Figure 1.1, complex metering systems (LEWA company).

**Medium-sized plants**: Under this category process plants with order volumes of single or double digit amounts in millions are subsumed. The term of a project has to be estimated as one to three years. The transaction is carried out by a project team under the leadership of a project manager. The tasks of the project manager are focussed on organisational matters. Depending on the agreed scope of delivery and service, the transaction comprises the handling of all steps of plant design. Such systems are supplied by medium-sized and large-scale enterprises within a certain range of plant types. Individual assembly sections, such as pipelines or E/MC-technology, can be subcontracted. Medium-sized plants often include several smaller plants integrated as components. Thus, medium-sized plants might include, for example, individual chemical plants, food production plants, sewage plants, pharmaceutical plants etc. Figure 1.2 shows the example of the Strobilurin plant of the BASF Schwarzheide GmbH with a contract value of €14.9 m. Figure 1.3 shows a photo of a combined heat and power plant of the G.A.S. Energietechnologie GmbH with a contract value of approx. €3 m.

**Large-scale plants**: The order volumes of such large-scale plants are approximately a billion. At any rate, the project term exceeds two years. The handling is controlled by

**Figure 1.1** LEWA dosing and mixing plant for the continuous fabrication of sulphuric acid in different concentrations, e.g. for battery manufacturing.

**Figure 1.2** Strobilurin plant for BASF Schwarzheide GmbH with an order value of 14.9 million €.

**Figure 1.3** Combined heat and power plant in Dortmund/Derne with four modules for G.A.S. Energietechnologie GmbH (order value approx. 3 million €).

large project teams headed by several project managers. The general project manager takes on the overall responsibility which involves organisational labour only. In many cases, one or two staff members are solely entrusted with the time scheduling for which special planning tools, such as network analysis, are applied /1.3, 1.4, 1.5/. Suppliers of the process-engineering part of such large-scale plants are a few groups active in the field of process engineering. The handling is often carried out in cooperation with one or more syndicate partners with