3 Case-Studies

3.1 Piping and Equipment

The studied design process for pipes and pressure vessels for chemical plants was a case of normal design: the operational principles and normal configurations were known and used.

After disasters like Bhopal, Seveso and recently the severe contamination of a Chinese river with benzene following an explosion in a chemical installation, it is not difficult to support the idea that safety in chemical installations is an ethical issue. In the case studied, the decisions regarding safety that engineers made during the design process ranged from decisions about safety valves, load scenarios, required material properties, to safety distances between pressure vessels. The engineers used the existing regulative framework to help them make decisions concerning safety, and believed that designing according to the regulative framework produced safe installations.

The regulative framework for pipes and pressure vessels used in the Netherlands is based on the European Pressure Equipment Directive (PED) (European directive 97/23/EC). Certification organizations, called Notified Bodies, are appointed in each EU country to check whether new designs and refurbishments comply with PED regulations. Approved designs obtain a CE mark.

Other regulations that are part of the regulative framework are those encompassing environmental regulations and regulations regarding noise and smell. Such regulations are commonly used to regulate the outcome of the design process: an installation should perform within the limits of allowed noise levels and emissions.

The relevant legislation and regulations make references to standards, which are therefore also part of the regulative framework. The organizations that formulate standards differ in different countries. Standards can be formulated by professional organizations, e.g., the American Society of Mechanical Engineers (ASME), industry, e.g., *Regels* in the Netherlands or by governmental institutions, e.g., British Standards. Standards are usually written rules for good design practice that, if used correctly, should protect the health and safety of persons and protect the environment. Standards are often prescriptive; they prescribe the use of certain hardware and calculations. In some countries, the application of a certain standards is required by law. In many states of the United States, the application of the ASME standards for pressure vessels and piping is required by law. In the EU, the use of EU standards during the design process of pipelines and pressure vessels leads to an assumption that the design conforms to the PED.

Despite the existence of an extensive regulative framework for pipes and pressurize vessels some elements of choice remain for the design engineers and for their customers. Due to the existence of a variety of safety standards for pipes and pressurize vessels the design engineers and their customers need to choose which of the standards to apply. Additionally the regulative framework does not cover all the safety choices that need to be made during the early phases of the design

process. Where such choices are not mandated safety becomes the responsibility of the design engineers and their customers. For example, the design engineers in the case study mentioned that accident and load scenarios are not defined in the European standards and legislation for pipes and pressure vessels, even if the PED requires that a risk analysis is carried out. According to the engineers they usually referred to company standards for load and accident scenarios in such cases, or, if these are not available, discussed the issue with their customer or asked advice from the national notified body.

3.2 Bridge

Our second case concerned the preliminary construction design phase for an arched bridge over the Amsterdam-Rijncanal in Amsterdam. This case was an instance of normal design because the operational principle and normal configuration of arched bridges are well-known and were used when designing this bridge.

Several ethical questions about the safety and sustainability of the bridge were encountered by the engineers. The collapse of a bridge can cause deaths and injuries so decisions that influence the chances of the bridge collapsing are ethically relevant. Moreover, the construction industry is prone to accidents in which people are killed or seriously injured on the construction site, and the Netherlands is no exception. During the design process of a bridge decisions are made that influence construction site safety and risks that workers face during construction. Safety of the bridge covered several different aspects: safety during use, safety during construction, and safety for ships passing under the bridge.[6]

Most of the decisions concerning safety during use of the bridge were made using a regulative framework for bridge building that is based on the Dutch building decree. The building decree is detailed and contains prescriptions for, for example, strength calculations. The building decree refers to standards, for example, the Dutch standard for concrete and steel bridges (NEN 6723, 1995 and NEN 6788, 1995, respectively). Although the bridge regulative framework covers most of the decisions that need to be made concerning bridge safety and sustainability of the construction, it does not cover all decisions. An example of a safety issue that is not covered is misuse. In the case of the Amsterdam bridge people could climb onto the arches of the bridge because the arches were not very steep. The design engineers had to decide whether or not to do something to prevent people from climbing onto and walking on the bridge arches.

The regulative framework concerning safety during bridge construction is based on two European directives: 89/391/EC (working conditions) and 92/57/EC (health and safety on construction sites). The European directives are incorporated in

[6] We will not focus on obstructing ships on the canal, an elaboration of this can be found in Van Gorp (2005).