# INDUSTRIAL PROJECTS' IMPLEMENTATION AND ORGANIZATION BY THE MAIN CONTRACTOR

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Master's thesis

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Teknologiaosaamisen johtaminen — Tiivistelmä

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| Ohjaajat | Katja Rönkkönen | |


TIIVISTELMÄ

Tämä opinnäytetyö on Andritz OY: n tilaama, ja sen tarkoituksena on tarkastella tapaa, jolla alihankkijan työ on suoritettu yrityksen projekteissa, jotta voidaan tuoda esiin keskeiset tekijät, jotka vaikuttavat projektin suorituskykyyn ja onnistumiseen. Tämä aihe on tärkeä, koska urakoitsijoilla on määrittelevä rooli töiden toteuttamisessa, ja optimoimalla heidän suorituksensa voidaan vaikuttaa myönteisesti projektin budjettiin ja aikatauluun, varmistaa, että niitä ei ylitetä ja virheitä ei tapahdu. Opinnäytetyön aluksi annetaan taustatietoa Andritz Oy:sta teollisuusrakennusyrityksenä, jatkuen projektin aloittamisen periaatteisiin sekä osapuolten välillä solmittuihin erilaisiin työsopimuksiin. Se kattaa myös työmaan organisaation ja antaa tietoa siitä, miten urakoitsijat vaikuttavat projektiin. Opinnäytetyön lopussa tarkastellaan kolmen työmaapäällikön haastattelujen tuloksia korostamalla avainkohtia ja antamalla esimerkkejä Andritzin urakoitsijoiden hallintakäytännöistä teollisuusprojektien toteuttamisessa ja järjestämisessä pääurakoitsijan toimesta.



Avainsanat Urakoitsija, Viivästyminen, Kommunikaatio

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Strategic Leading of Technology-based Business Abstract

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ABSTRACT

This thesis project is commissioned by Andritz OY and is aiming to review the way subcontractors' work has been executed in company's projects in order to highlight the key factors affecting a project's performance and successfulness. This topic is important, because contractors play a defining role in carrying out the works, and by optimizing their performance it is possible to positively affect the project's budget and schedule, ensure that they are not exceeded and mistakes do not happen. The thesis starts by giving background information on Andritz as an industrial construction company, delves into the principles of initiating a project, as well as the different kinds of working agreements that are established between the parties. It also covers the issue of worksite organization and provides insight into the way contractors affect the project. The thesis concludes by reviewing the results of interviews with three construction site managers by highlighting the key points, and giving a set of Andritz's best management practices in industrial projects' implementation and organization.

Keywords Contractors, Delays, Communications

Pages 69 pages and appendices 5 pages

## Contents

# 1 INTRODUCTION

Big industrial projects require an immense amount of human labor. Thousands of different people can be involved in one project, each of them performing a specific, unique task. It takes a vast amount of cooperation and communication in order to ensure that people that play different roles are able to accomplish a bigger joint task. Naturally, organizing big groups of people comes with its share of problems. From misunderstanding, to human and external factors, project work progress is influenced by many things, and it can be extremely challenging maintaining a certain pre-defined work pace and following a schedule. Thus, developing client's work with contractors and sub-contractors is a vital task within the frame of any big project.

This Master's thesis aims to analyze the management of the Andritz Oy installation project and the different project type agreements used at work to monitor contractors' work, ensure effective collaboration and to prevent work delays. By doing so, the author of the thesis is hoping to find a way to increase long-term profitability of the company's projects.

Project cost optimization is one of the responsibilities of a competent project team. Exploring the nature of communication with contractors and sub-contractors can help highlights problems and bottlenecks that lead to delays and extra project costs. A deeper understanding of these processes will allow to foresee similar problems in future projects and to plan accordingly, with more precision.

This thesis project is research-based, and will rely on information from different professional sources such as technical literature, commissioning company's former project material, contractors' agreements, magazine articles, as well as interviews with site and project managers. The latter is important to highlight past problems that have been experienced with contractors. In addition to the above mentioned sources, the author will rely on his own experience of working in an industrial setting and will convey his personal views and opinions.

The author of the thesis will utilize both quantitative and qualitative research methods. The breakdown can be found below:

- Qualitative – work agreements between parties, site organization chart
- Quantitative – progress curve, supplying materials plan, cost breakdowns, PI diagram, data collected using secondary sources (existing data)

This project's research stages are explained in the next paragraph.

### 1.1 **Research stages of thesis**

The methodology of this thesis's research abides by the canonic rules of a research project, as described by Jyväskylän yliopisto among others. (University of Jyväskylä, 2010)

First, a research aim is derived, and questions that need to be answered formulated.

Secondly, a literature review will be conducted. At this stage, a wide range of secondary sources mentioned above will be collected, compared, and analyzed. Processing a sufficient quantity of data to complete this project will most likely be the most time-intensive activity of the whole endeavor.

Thirdly, conclusions will be generated. The conclusions will be relevant to the research aim and objectives, will be based on the research literature used and will suggest grounds for future research. Thus, the project will be completed.

### 1.2 **Research aim and project questions**

Optimizing project costs and precise beforehand planning are important ways to make construction projects more affordable. Predicting problems and costs beforehand allows for high levels of customer satisfaction and helps maintain the reputation of the main contractor company as that of a reliable player in construction business sector.

The main goal of this thesis is to produce a description of how industry projects are organized and realized on the example of Andritz Oy. The information is presented in a

way that allows the reader to understand what is happening on the site, what kind of challenges the project may have, the different types of working agreements between parties and how they cooperate. The thesis produces recommendations for monitoring the work of contractors and for collaboration that can be applied to use as its outcome.

Exploring this issue is important, as it may help improve the long-term profitability of construction projects and highlight hidden bottlenecks. Making construction projects more affordable and efficient will positively affect the company's competitiveness level on the market, meanwhile lowering the number of project delays will positively impact Andritz Oy's business image as that of a reliable player on the market of industrial construction.

Questions relevant within the frame of the project:

- How have industrial projects been realized and implemented on-site?
- What are the costs of a project?
- What kinds of work agreements between different parties exist?
- How can work delays be prevented?

### 1.3 **The project's boundaries**

Thesis will be limited to the mechanics of the main-contractor-subcontractor relationship and ways to improve it, and will focus on utilizing previous experiences and results to produce new work strategies and develop communication. The effectiveness of these methods will not be tested on practice for the sake of this research project, and will therefore not be included into the thesis.

### 1.4 **Author's professional credibility as an information source**

The author of this Thesis has a Bachelor's Degree in Construction engineering, and 4 years of industrial work experience in different positions. His career began as an assistant to the supervisor at a Finnish process piping installation company. The first project was in Sweden and there the author did pipeline inspections, as well as work

management. In the following projects, he acted in the position of a piping supervisor and a quality supervisor. The last two years he has been working as a piping installation advisor at a technology company Andritz Oy, which is one of the world's leading suppliers of pulp and paper industry systems, equipment and services. At the time of writing this thesis, the author is still working on different international projects.

### 1.5 **The main concepts of the project**

| Theoretical term | Theoretical definition |
|---|---|
| Project | "A unique set of co-ordinated activities with definite starting and finishing points, undertaken by an individual or organisation to meet *specific objectives* within defined schedule, cost and performance parameters (BSI, 2000)." |
| Project management | "The overall planning, co-ordination and control of a project from inception to completion, aimed at meeting a client's requirements in order to produce a functionally and financially viable project that will be completed on time, within authorised cost and to the required quality standards (CIOB, 2002)." |
| Client | 'Entity, individual<br>or organisation commissioning and funding the project, directly or indirectly (ICE, 2020).' |
| Contractor | An organization or a person that is hired by the client to execute a specific task required for the completion of a project (ICE, 2020) |
| Sub-contractor | An organization or a person that is hired by the contractor to perform a part of the task necessary for the completion of a project (ICE, 2020) |

## 2 **ANDRITZ OY**

The international technology group Andritz - is one of the world's leading suppliers of plants, equipment and services to the hydropower industry, the pulp and paper industry, the metal and steel industry, and municipal and industrial separation technology solutions, as well as the production of animal feed and biomass pellets.

Andritz employs approximately 12,300 people worldwide. The Group manufactures and sells its products and services worldwide. Andritz's Pulp & Paper business area is among the top leading suppliers of facilities, systems, machinery and comprehensive service solutions for the manufacturing and treatment of various kinds of pulp, paper, board and tissue products. The technology solutions are used in the processing of logs, fibers and waste paper, in the production of chemical pulp, groundwood and recycled fibers, in the recovery and reuse of chemicals, in the supply of paper machines, in the production of paper, board and tissue paper, in gluing, polishing and coating. The range of services covers system and machine modernization, reconstruction, spare and consumable parts, on-site and factory services, process performance optimization, maintenance and automation solutions, as well as machine relocations and used equipment. The business also includes biomass, steam and recovery boilers for energy production, gasification plants and flue gas cleaning plants, production systems and plants for nonwovens, soluble pulp and fibreboard (MDF), and solutions for shredding various waste materials. (Andritz Oy, 2021)

Andritz has a subsidiary in Finland, Andritz Oy, which is one of the world's leading suppliers of systems, equipment and services to the pulp and paper industry. Its product areas include wood processing, fiber processes, chemical recovery and pulp processing. In addition, ANDRITZ Oy builds a variety of biomass boilers and gasification plants for electricity generation. In Finland, the Andritz companies have about 1,300 employees. The centers of expertise are in Kotka, Lahti, Lappeenranta, Savonlinna, Varkaus and Tampere. The company’s headquarters are located in Helsinki. (Andritz Oy, 2021)

# 3 INDUSTRIAL PROJECT MANAGEMENT

Industrial project management is a discipline that aims to meet the requirements of an industrial project by applying a set of specific skills, tools, techniques and knowledge in project-related work. To be more specific, it is a methodology for organizing, planning, leading, coordinating human and material resources throughout the life cycle of such a project, which is aimed at effectively achieving goals in terms of scope of work, cost, time, and quality. (Project Management Institute, 2013, ss. 5-6)

Project management practices are known to improve the chances of success in a project, if applied appropriately. Since every project is unique, picking the appropriate techniques and strategies is left at the discretion of the project manager who is in charge of the work.

To effectively manage industrial projects, the work system must be well structured. The essence of structuring comes down to breaking down the project and its management system into subsystems and components that can be controlled. Project structuring can consist of a set of different:

- components of the project's product;
- stages of the life cycle;
- elements of the organizational structure.

To provide a more specific example of this, one way to break down a project is to present it as a set of processes:

- initiating
- planning
- executing
- monitoring and controlling
- closing. (Project Management Institute, 2013, ss. 5-6)

These processes are further broken down into sub-processes and constituent tasks, to create a scheme of product-oriented components (equipment, works, services, information), and organize the links and relationships between different elements of the project.

Structuring the project this way allows to distribute the total volume of work in the project into manageable independent blocks, which can be completed one at a time. The way project activities are connected to each other is called “the logical structure”, as it determines the way work will progress.

Structuring helps to solve the following tasks:

- division of the object into manageable blocks;
- adequate distribution of responsibility;
- assessment of the required expenditures of funds, time, material resources;
- making a unified system for planning, budgeting and cost control;
- linking the work on the project with the accounting system;
- transition from general goals to specific tasks.

The project is carried out under a set of specific conditions that are defined by economic, political, social, technological, regulatory, cultural and other factors. All of these factors influence the project constraints in one way or another, creating a dynamic environment where everything is intertwined. For instance factors leading to the schedule being shortened, would by extent affect the budget and workforce, leading to the increase of the latter two. If that cannot be done, the task or the desired quality level can be altered, to suit the new timeline. Overall, it is a game of prioritising and balancing, and therefore a project's plan is continuously reforming and evolving over the course of the endeavour, at the same pace as more precise and detailed estimates become clear. (Project Management Institute, 2013, ss. 5-6)

The large scale and diversity of the industrial construction process means that a large number of participants are involved. The main parties are:

- customers
- stakeholders
- design organizations
- contractors and subcontractors for construction companies
- suppliers
- transport organizations
- state organizations.

All of these parties influence the project, and need to be managed in one way or another in order for the project to succeed. In order to be able to do so, meticulous

planning of the project's subsystems is necessary. Industrial project management subsystems are formed depending on the project elements. Elements within a project can include: timing, labor, costs, revenues, procurement and supply of resources and services, project changes, project risks, information and communication, quality, and others. Depending on the particular project in question, more or fewer subsystems can be present. (Project Management Institute, 2013, ss. 47-49)

Also, the following elements are included in the scope of industrial project management: planning, project control, analysis, decision-making, preparation and maintenance of the project budget, organization of implementation, monitoring, evaluation, reporting, expertise, verification and acceptance, accounting, administration and so on. They can be respectfully achieved by using project management methods, such as network planning and management, scheduling, logistics, standard planning, structural planning, resource planning, and others. (Project Management Institute, 2013, ss. 47-49)

# 4 PROJECT START

Any project begins with meticulous planning and cost estimation. The client together with the developer carries out detailed planning for the future implementation of the project in construction, defines and clarifies the goals and objectives, develops the sequence of actions required for their subsequent achievement, and determines the overall content of the work. On the basis of design estimates, business correspondence, minutes of meetings, meetings with the author and the audience of the project, volume and cost indicators, specifics of work, production methods, the project specific financial, technical, time and other restrictions and assumptions are determined. Here, the project is compared with the company's strategy, its policy, current workload and the available resource base. All information is collected, summarized and analyzed by the project team. The project management plan in construction is the main document in the planning and implementation of the project, its management and control, as well as the conditions for commissioning and the formal completion of the project. (DTU, 2019)

## 4.1 **Project categorization**

Project management methods depend on many factors, including the scale of the project, timing of implementation, quality, resource constraints, etc. Carefully classifying the project can allow to choose the most effective management strategies and ensure that the following planning is done appropriately for the project's special needs.

The following factors should be taken into consideration when classifying a project:

1. Scale. A project can be categorised as a small project, a medium project and a megaproject:

   Small projects are simple, and their scope and scale are minimal. Thus, in American practice, small projects are associated with an investment volume of $ 10–15 million. A typical example of a small project is the modernization of existing production facilities. The specificity of small projects is that they allow for some simplification in the design and implementation procedure (simple schedule, the leader is one person, it is not necessary to create a project team, etc.).

   Medium projects are the most common in practice. they have a relatively short duration - 2–5 years, require a more thorough study of all subsystems of the project and involve more significant investments.

   Megaprojects are targeted programs containing many interrelated projects united by a common goal, dedicated resources, allotted time. Megaprojects have a high cost - up to 1 billion dollars, duration of implementation - 5-7 years. (MosaicProjects, n.d.)

2. Complexity. A project can be categorised as a simple, organizationally complex, technically complex, resource complex, structurally complex. (MosaicProjects, n.d.)

3. Implementation. A project can be categorised as one with a short-term, medium and long-term implementation. Short-term projects require 1-2 years for their implementation. Short-term projects are usually implemented at enterprises producing new products of various kinds, pilot installations, and executing restoration projects. Medium-term projects are completed in 3-5 years. The duration of the implementation of long-term projects can be 10-15 years. (MosaicProjects, n.d.)

4. Level of participation. A project can be categorised as international, domestic, state, territorial or local, depending on the extent of geographical diversity of its components involvement. (MosaicProjects, n.d.)

5. Nature of the projected changes. A construction project can be categorised as an innovative project, or a supporting project. Supportive projects are further broken down into resuscitation and restoration projects. The task of innovative projects is to introduce fundamentally new developments. (MosaicProjects, n.d.)

6. Financing. A project can be categorised as an investment project (the main motive of the investor is making a profit), a sponsorship project (the sponsor provides funds to support the project, if this can become a form of its advertising or presentation, to form the image of the company), a credit project (obtaining funds is possible only if guarantees are provided to the credit institution, therefore the credit project involves a detailed financial and economic justification), a budget project (funding sources - budgets of various levels), a charitable project (as a rule, these are non-profitable and costly projects, financing of such projects has the form of patronage, grant form). (MosaicProjects, n.d.)

7. Ownership and profitability. A project can be categorised as a commercial one (making a profit) or a social one (achieving social goals). Social projects are owned by the state or municipality. (MosaicProjects, n.d.)

## 4.2 **Tendering process**

Tendering is a term that refers to the process of getting a contractor and agreeing on a price for a construction project. Contractors are invited to place bids for the work to be performed and make a price offer that can later be accepted by the client. For the purpose of bid calculation the client's preliminary project documentation is needed. The candidate whose offer best suits the client's interests becomes a contractor, and signs an agreement that is legally binding to both parties. Tender documents become a part of the final contract, which is based on the scope of work provided in them. (Futurelearn, n.d.)

From the client's standpoint, the idea is to find a contractor that would be right for the job and for the right price, while for the contractor the idea is to enter a profitable arrangement. It is equally important that both parties are satisfied, as the client needs the contractor as much as the contractor needs the client. (Futurelearn, n.d.)

## 4.3 **Determining key performance indicators and project results**

Key performance indicators and project results indicate the effectiveness of the implementation of the entire project and its individual parts. If they are not defined, it is impossible to know whether the project has actually been completed. The following criteria can be used as performance indicators:

- the project is completed on time, within budget
- the required quality of the object has been achieved
- project resources are allocated as efficiently as possible
- the project is in line with the business plan. (Institution of Civil Engineers, 2021)

Key performance indicators for each project are developed by the project manager together with the investor. (Institution of Civil Engineers, 2021)

## 4.4 **Communication planning**

Communication planning and subsequent management includes facilitating the timely and high-quality exchange of information when making decisions, making changes,

collecting and distributing initial data, drawings and other documentation, followed by archiving and the ability to quickly retrieve it. A key factor in the successful implementation of a project in construction is the provision of an up-to-date database, documentation and reporting for all project participants in construction. (Taylor, 2019)

## 4.5 **Project changes work planning**

Projects in construction are most often subject to changes, both in design and in the construction process, often not only for reasons of the need to adjust the initial decisions, but also under the influence of external uncontrollable factors, such as changes in legislation and others. For the purpose of managing changes and minimizing their likely negative effect, it is necessary to determine the procedure for dealing with them.

Within the framework of project management, the results of the change management process are the definition and documentation of the process of working with changes in the project, namely:

- identifying changes
- determining the magnitude of the impact on the timing
- budget or quality of the project
- agreeing and approving changes
- organizing the accounting of versions and products of the project
- communicating information about changes to interested parties (Hao, Shen, Neelamkavil, & Thomas, 2008)

## 4.6 **Economic viability**

It is necessary to determine the effectiveness of a project at the initial stage of planning. The information that should be gathered includes:

- formation of the investment concept of the project
- study of investment opportunities and their justification

- feasibility study for the construction of the project (Mazur, Shapiro, & Olderogge, 2004, pp. 48-50)

The client can utilize the data to their advantage for the purpose of:

- Conducting further research, public opinion polls
- Negotiating with executive authorities on granting subsidies, tax and other benefits
- Negotiating with potential investors (Mazur, Shapiro, & Olderogge, 2004, pp. 48-50)

This step is performed under the guidance of the client, a project organization or a specialized consulting firm. The result is an assessment of the viability of the project options, conclusions based on the justification materials and documents for making a preliminary investment decision. (Mazur, Shapiro, & Olderogge, 2004, pp. 48-50)

### 4.7 **Project costs**

The cost of a project is determined by the resources required to complete the work, including:

- Design ( civil, equipment, pressure part, piping, etc.)
- Equipment (purchase, renting, leasing)
- Fixtures, devices and production facilities
- Labor (staff members hired under contract)
- Subcontractors (installation companies, etc.)
- Consumables (stationery, etc.)
- Materials
- Training, seminars, conferences
- Transportation (Hendrickson, 2008, p. Chapter 12)

Financial planning and budget management of a construction project includes:

- calculating the cost of planned works and services

- bringing together all the elements and operations for planning the project budget, as well as determining the sources of its financing
- verifying documents submitted for payment by organizations for work performed, products supplied and services rendered
- providing timely financing and timely payment for work according to contracts with contractors
- determining the cost of the necessary changes, proposals for budget optimization
- providing reports to the investor on the use of financial resources, the need for financial resources for the next period, and sometimes operational information on the implementation of the investment and construction project (Hendrickson, 2008, p. Chapter 12)

Based on the budget calculations, an additional check of the financial indicators determined at the stage of business planning is carried out. Accounting, operational and statistical accounting are usually carried out by the investor.

### 4.8 **Timetables**

Time planning begins from the moment the scope of work (content) of the project is determined. The result of planning is a detailed project implementation schedule, which includes:

- a schedule for the development of project documentation
- calendar and network construction schedule (installation and commissioning works)
- financing schedule and others (Institution of Civil Engineers, 2020)

In the process of implementing an investment into a construction project, the project manager constantly monitors the schedule and, if necessary, makes adjustments and changes. The schedule should display the previous and subsequent work, performers (workers, teams) and people responsible, as well as all the necessary resources, and the method and timing of their delivery. When the project schedule is so precise, and

weekly updates regarding the work completed are available, the manager receives objective information about the state of the project as a whole. That alone allows to optimize the construction process, in the conditions of limited financial, labor and material resources. (Institution of Civil Engineers, 2020)

The main task of scheduling integrates the achievement of three conditions:

- minimization of project duration in the conditions of limited resources
- minimization of project costs
- equalization of the distribution of resources (Institution of Civil Engineers, 2020)

### 4.9 **Choice of subcontractors**

At the construction stage, the project manager takes part in the selection of the general contracting and contractor organizations, mainly based on the results of tenders, assesses the conditions for the construction of the facility specified in the tender proposal, the technology of construction and installation works implemented by the contractor, the availability of the necessary approvals of self-regulatory organizations, internal quality management systems, reputation, financial state of the contractor and other aspects. (Vatin & Kalashnikov, 2010)

The project manager participates in the conclusion of an agreement for capital construction, reconstruction or overhaul of enterprises, buildings and structures. When concluding a contract, the project team, on the basis of the approved project management plan, establishes the requirements for the construction time, the quality of the constructed object, considers, in accordance with the design documentation, the composition and range of building materials, structures, technological equipment and other types of material resources supplied by the contractor, the procedure for carrying out commissioning works, specifies the contractual price of work, conditions for insurance of risks associated with construction, requirements for labor protection and safety during construction and installation works, property liability of the parties

for non-fulfillment of contractual obligations, confidentiality conditions for the fulfillment of the contract and other conditions. (Vatin & Kalashnikov, 2010)

### 4.10 **Resources**

Assigning resources, i.e. determining the workload and the amount of required resources, is a crucial aspect of any project. Resources can be:

- intellectual (having the required level of project work knowledge)
- material (having the needed spaces, tools, machines, etc.)
- financial (having the necessary funds to execute the project)
- professional (having the needed quantity of qualified personnel to undertake the work)
- legal (having the needed licenses and certifications)
- informational (having the needed information / sources)
- technological (having the required performance) (Mazur, Shapiro, & Olderogge, 2004)

Mainly, the project resource planning algorithm includes the following steps:

- Resource definition (description of the resource and determination of the maximum available amount of this resource)
- Assigning resources to tasks
- Analysis of the schedule and resolution of conflicts that have arisen between the required amount of resources and the amount available (Mazur, Shapiro, & Olderogge, 2004)

Since the availability of the necessary resources to complete the work is often a key factor in project management, the manager can develop a realistic plan only if a set of available resources is described. This information also enables the project manager to more reasonably negotiate completion dates and resources with senior management, client management, and functional managers.

The main tasks of resource management are:

- optimal resource planning
- resource procurement management
- supply management
- resource supply management
- resource stock management
- managing the allocation of resources for the work of the project

(Mazur, Shapiro, & Olderogge, 2004)

### 4.10.1 Purchase planning

One of project resource management tools is procurement planning of materials, equipment, work and services to optimize the cost of purchased products and the timing of their delivery.

Purchasing management includes:

- Planning of supplies
- Organization of accounting
- Delivery, acceptance and storage of goods
- Accounting and control of delivery

The project team has to base their decisions on how competitive the selected product is, what are the preferred materials, structures, products and equipment. These things influence the development of technical specifications, preparation of contracts for the supply of equipment and materials and technological processes. (Vatin & Kalashnikov, 2010)

## 4.11 **Risk analysis**

A likely risk in a project is an event or series of events and conditions that can affect the successful implementation of a project. Project work and projects are always related to a certain degree of uncertainty, and therefore are always subject to a certain amount of risk. Uncertainty can stem from:

- lack of information
- the presence of an element of chance
- counteraction (when there are other parties with diverging interests involved) (Boronina & Senuk, 2015, pp. 75-91)

In accordance with the general provisions of risk management, the main points are:

- risk identification
- risk assessment
- risk treatment (including the development of measures to reduce or eliminate its impact)
- research and monitoring of risk
- exchange of information on risk issues (Boronina & Senuk, 2015, pp. 75-91)

The necessary documents for planning and managing risks are a risk management plan and a project risk register. Every risk requires a strategic plan, or a combination thereof, according to what might be the best way of tackling it. Upon creating one, it is then necessary to facilitate the development of measures for the integration of the chosen tactics. (Boronina & Senuk, 2015, pp. 75-91)

Risk control and management should be continuously implemented over the course of a project lifecycle.

# 5 SITE ORGANIZATION

## 5.1 Working site organization

Effectively organizing a construction site is a cornerstone pillar of any successful project. Organizational aspects strongly affect project costs, duration, etc. A construction site has to be meticulously organized in order to work effectively and flawlessly. Any operational failures of a single element can lead to considerable drawbacks for the entire project. Therefore, it is among the primary responsibilities of a successful construction manager to ensure that a site is running smoothly. (CPDcources, n.d.)

The total amount of subcontractors on-site is very big. Taking into consideration the construction of power boilers, there can be different companies working at the same time on a site for following installations:

- Boiler installation company
- Process piping installation company
- Steel structures installation company
- AEI (Automation, Electrification, Instrumentation) installation company
- Scaffolding installation company
- Flue gas condensation equipment installation company
- Insulation company
- Concrete installation company
- Roof cladding installation company
- Firefighting systems installation company
- Elevator installation company
- HVAC systems installation company
- Company providing mobile cranes

That's why well thought-out project planning by the main contractor is required to ensure an appropriate execution of construction works'. On the construction site each subcontractor is following their own time schedule and it is included in the general project schedule. An excerpt from project schedule is presented in Figure 1.

| Task Name | Delay | % Work Complete | Planned % | Start | Finish | Baseline Start | Baseline Finish |
|---|---|---|---|---|---|---|---|
| Boiler building roof membrane final layer installation | | 0% | 0% | 19.10.20 | 20.11.20 | 21.9.20 | 30.10.20 |
| Day fuel silo building intermediate paroc walls and ceiling | | 100% | 100% | 27.3.20 | 29.5.20 | 24.3.20 | 24.4.20 |
| Day fuel silo building roof sheets: Installation | | 100% | 100% | 25.5.20 | 29.5.20 | 18.5.20 | 22.5.20 |
| FW pump room intermediate paroc walls | | 100% | 100% | 24.3.20 | 24.7.20 | 24.3.20 | 1.5.20 |
| Day fuel silo building roofing works | | 0% | 100% | 31.8.20 | 18.9.20 | 29.6.20 | 10.7.20 |
| Roof for fly ash silo building | | 20% | 0% | 20.7.20 | 4.9.20 | 27.7.20 | 14.8.20 |
| Engineering station room and electrical room roof installation | | 90% | 100% | 13.7.20 | 31.7.20 | 29.6.20 | 8.7.20 |
| Media bridge cladding installation | | 0% | 0% | 27.8.20 | 2.10.20 | 27.8.20 | 18.11.20 |
| Walls finalization works | | 9% | 0% | 13.4.20 | 20.11.20 | 1.10.20 | 20.11.20 |
| Roofs finalization works | | 0% | 0% | 2.11.20 | 20.11.20 | 2.11.20 | 20.11.20 |
| Door installations | | 0% | 0% | 3.8.20 | 2.10.20 | 3.8.20 | 2.10.20 |
| **Engineering station room building works** | | **0%** | **0%** | **3.8.20** | **28.8.20** | **3.8.20** | **28.8.20** |
| Engineering station room and electrical room building works | | 0% | 0% | 3.8.20 | 28.8.20 | 3.8.20 | 28.8.20 |
| **Erection and installation** | | **35%** | **38%** | **9.12.19** | **4.2.22** | **2.12.19** | **14.1.22** |
| **Common** | | **26%** | **28%** | **9.12.19** | **4.2.22** | **2.12.19** | **14.1.22** |
| **Contractual milestones for Installation companies and major rental eq** | | **26%** | **28%** | **9.12.19** | **30.11.21** | **2.12.19** | **31.12.21** |
| **Scaffolding company milestones** | | **50%** | **50%** | **28.1.20** | **28.5.21** | **3.1.20** | **28.5.21** |
| Scaffolding: Mobilization of the site | | 100% | 100% | 28.1.20 | 28.1.20 | 3.1.20 | 3.1.20 |
| Scaffolding: Demobilization (estimated date) | | 0% | 0% | 28.5.21 | 28.5.21 | 28.5.21 | 28.5.21 |
| **Container milestones** | | **100%** | **100%** | **9.12.19** | **7.1.20** | **2.12.19** | **2.1.20** |
| Containers released | | 100% | 100% | 7.1.20 | 7.1.20 | 2.1.20 | 2.1.20 |
| **Steel structure installation company milestones for boiler area** | | **44%** | **44%** | **20.1.20** | **30.10.20** | **20.1.20** | **2.11.20** |
| Steel structure installation: Mobilization of the Site | | 100% | 100% | 20.1.20 | 20.1.20 | 20.1.20 | 20.1.20 |
| Steel structure installation: Start of erection of Power boiler | | 100% | 100% | 23.1.20 | 23.1.20 | 27.1.20 | 27.1.20 |
| Steel structure installation: Steel structures ready from 1st and 2 | | 100% | 100% | 9.4.20 | 9.4.20 | 27.3.20 | 27.3.20 |
| Steel structure installation: Steel structures ready at Boiler buildi | | 100% | 100% | 3.7.20 | 3.7.20 | 12.6.20 | 12.6.20 |
| Steel structure installation: Mechanical completion of Power boil | | 0% | 0% | 31.7.20 | 31.7.20 | 31.7.20 | 31.7.20 |
| Steel structure installation: Demobilization | | 0% | 0% | 30.10.20 | 30.10.20 | 30.10.20 | 30.10.20 |
| Steel structure installation: Punch list works have been complete | | 0% | 0% | 5.10.20 | 5.10.20 | 30.10.20 | 30.10.20 |
| Steel structure installation: Red pen drawings (for As-built) | | 0% | 0% | 5.10.20 | 5.10.20 | 7.10.20 | 7.10.20 |
| Steel structure installation: Quality documentation completed | | 0% | 0% | 6.10.20 | 6.10.20 | 2.11.20 | 2.11.20 |
| **HVAC installation company milestones** | | **20%** | **20%** | **1.6.20** | **30.11.20** | **15.6.20** | **30.11.20** |

Figure 1. Project schedule (Andritz Oy, n.d.)

Project schedule contains a set of all activities to be done with the start and the end of a day. It is very important to accomplish the scope according to the given timeframe since otherwise it can hinder other companies' activities.

Daily coordination and technical supervision of the above mentioned subcontractors is needed to implement the project according to the planned schedule and achieve goals in time. For that Andritz has its own organizational chart as is shown in Figure 2.

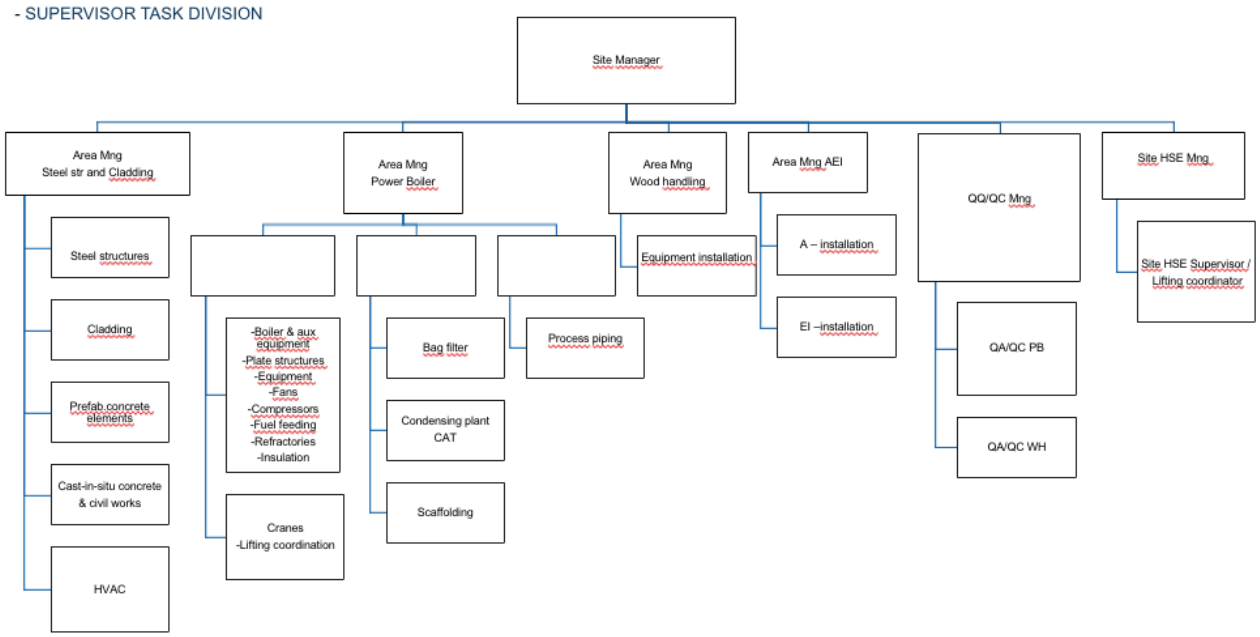



Figure 2. Responsibility/site organization chart (Andritz Oy, n.d.)

There are many works and they are different, therefore construction control is carried out by a wide range of highly qualified specialists of various profiles. The head of the whole construction site is called the site manager. The rest of Andritz's personnel is divided into several main areas based on their respective responsibilities as follows:

- Civil works: steel structure and cladding installations, concrete works, HVAC
- Power boiler: boiler, equipment and filter installation
- Process piping: high pressure and low pressure piping
- Wood handling: equipment installation
- AEI: all automation, electrification and instrumentation related installations
- Quality assurance and control at the whole site

Each technical advisor is following the subcontractors that are performing works under his/her area of responsibility. That's why a clear and understandable delineation of areas of responsibility before starting work is a most important point for building a productive relationship between the project participants.

Technical supervision is aimed at achieving compliance with the quality and project characteristics in accordance with the design. The range of works performed by

Andritz's technical supervisors is extensive, it includes a full cycle of control of the site preliminary work that goes before the start of the construction itself. Further, the entire construction process is subject to controlling. Technical supervision tasks can be broken down into following points:

- Quality assurance and control of executed works, material used and compliance with design.
- Works aimed at reducing the cost and duration of construction by finding the most optimal design solutions and efficient labor organization.
- Control of not exceeding the planned and estimated working costs. Supervision of all necessary documentation.
- Subcontractors' daily coordination.

## 5.2 **Cost tracking/WBS**

A Work Breakdown Structure WBS is, as its name states, a flow chart where project deliverables are featured. The aim of a WBS chart is to simplify project objectives by breaking them down into smaller working steps which are manageable. It is one of the most powerful tools for controlling, monitoring and executing a project. Every work stage included in a flow chart like that has to be identified, estimated, scheduled, and budgeted. (Visual paradigm, 2021)

In the course of building a WBS, the project is sequentially decomposed into subprojects, work packages of various levels, and separate detailed work tasks. Decomposition is the division of project deliverables into smaller, more manageable components down to the work package level. Work packages usually correspond to the lowest level of detail and are composed of individual activities. The decomposition must be correct, i.e. elements of any WBS level must be necessary and sufficient to create a corresponding top-level element. (Visual paradigm, 2021)

A WBS's development mode can be either top-down, bottom-up, or both. Usually a so-called "wave" mode is used - the more distant in time an element is, the lesser the

depth of its decomposition (e.g. the most urgent elements are at the bottom). (Systems management college, 2001, pp. 85-90)

As a result of building a WBS, all the goals of the project must be taken into account and all the necessary prerequisites for its successful implementation must be created. The following things can serve as starting points for decomposing a project:

- components of the product (services, areas of activity) obtained as a result of the project;
- processes or functional activities done by the organization executing the project;
- stages of the project life cycle, main phases;
- subdivisions of the organizational structure;
- geographic location for spatially distributed projects. (Systems management college, 2001, pp. 85-90)

For the purposes of project decomposition, it is necessary to agree on the basic structures of the project, which include:

- the Organization Breakdown Structure
- the Account Breakdown Structure
- the Resource Breakdown Structure
- the functional structure
- the information structure
- the structure of time intervals. (Systems management college, 2001, pp. 85-90)

As mentioned before, the hierarchical structure of work should reflect the structure of the object by starting with more complex structures and transitioning into structures that characterize specific works of the lower levels. The tasks of the lower level (separate work tasks) are included in the work schedule, based on which the project execution time and project costs are estimated. At the same time, for each level, there should be a procedure for determining responsible managers and a procedure for

resolving specific situations which would be taking into account the priorities of the next higher WBS level. (Systems management college, 2001, pp. 85-90)

The set of work at the lower level must be necessary and sufficient to complete the project, and decomposition is one of the most important tasks of the project manager. Since the implementation of the project scope is tracked by the WBS, and the content of the project product is compared with the requirements for it, the WBS should be built in such a way that the result of the design work is the creation of the specified project scope of the project. (Systems management college, 2001, pp. 85-90)

Benefits of the WBS structure for managers:

1) Strengthening communication in the project team. The work breakdown structure includes communication acts every step of the way.
2) Focus on ultimate goals. WBS helps keep the entire team focused on the ultimate goal. This minimizes the likelihood of unnecessary work being done.
3) Detailing. Every detail is carefully considered, so nothing is lost in the project.
4) Anticipating problems. When the project is ready, unexpected problems may arise. The work breakdown helps to reduce the number of work, as all the details are considered before execution.
5) Planning issues. WBS makes it easy to identify which scheduled tasks are behind schedule.
6) Risk management. Using WBS helps reduce and manage risks from the start. This allows to allocate resources (such as money, time and labor) more efficiently.
7) Distribution of tasks. Once a project has been structured, it becomes easier to assign tasks to specific people.
8) Flexibility for different teams. The work breakdown structure is used in various fields. It doesn't matter how many people are on the team, WBS system supports progress regardless of the project’s size. It can also be a great tool for attracting customers, as it shows the processes from the inside and helps to understand them better. (Systems management college, 2001, pp. 85-90)

It is very important to keep track of the projects' money flow to know exactly where the money goes to. That's why Andritz is also implementing WBS system. For every project a list of all activities to be done during the whole project phase with own numbers is created. This helps to later analyze the final costs of works. An example of projects' WBS structure is presented in the Figure 3.

| WBS element | WBS element description |
|---|---|
| C-00-000000-000-0001 | Project Management |
| C-00-000000-000-0002 | Project Purchasing |
| C-00-000000-000-0003 | Project Engineering |
| C-00-000000-000-0004 | Civil & structural project management |
| C-00-000000-000-0005 | Product Management |
| C-00-000000-000-0006 | Global project management/coordination |
| C-00-000000-000-0007 | Steering and review, divisional |
| C-00-000000-000-0008 | Health and Safety |
| C-00-000000-000-0009 | Project Management, Sweden |
| C-00-000000-000-0010 | Warranty reservation |
| C-00-000000-000-0011 | Contingencies |
| C-00-000000-000-0012 | Insurances |
| C-00-000000-000-0013 | Licences |
| C-00-000000-000-0014 | Commissions |
| C-00-000000-000-0015 | Financing costs |
| C-00-000000-000-0016 | Permanent estab. or branch office cost |
| C-00-000000-000-0017 | IT Setup |
| C-00-000000-000-0018 | Legal fees |
| C-00-000000-000-0019 | Project Cost Savings |
| C-00-000000-000-0020 | Process Engineering |
| C-00-000000-000-0021 | Layout Engineering |
| C-00-000000-000-0022 | Pressure part engineering |
| C-00-000000-000-0023 | Piping Engineering |
| C-00-000000-000-0024 | Civil Engineering |
| C-00-000000-000-0025 | Assistant / Secretary Work |
| C-00-000000-000-0026 | Project documentation |

Figure 3. WBS structure (Andritz Oy, n.d.)

## 5.3 **Additional works**

Additional Works are the acute parts of all projects. Variations are inevitable in every project, since it is impossible to precisely estimate all tasks and work steps even when the most meticulous of plannings is done. The alterations come in a variety of forms:

- the addition of extra project steps
- the omission of certain steps, or even
- the replacement of a certain task with another (Institution of Civil Engineers, 2020)

Also, alterations might have various impacts on the project overall as follows:

- beneficial variations improve the quality standard, simplify the project, diminish costs, etc.
- negative variations cause value loss from the client's standpoint. This can be extra costs, schedule delays, quality decrease, etc. (Ndihokubwayo, 2008, pp. 15-17)

Alterations do not extend only to the work itself. In general, they can arise in respect to:

- quantities
- quality
- design
- working conditions
- sequence of work
- nature of work (as mentioned before) (Institution of Civil Engineers, 2020)

The fundamental difference that sets a variation from another possible change is that a variation will not:

- change the principle nature of the work in question
- be issued after the completion of work to which it applies
- delegate responsibility for a task
- alter the contractual agreements (Institution of Civil Engineers, 2020)

The frequency with which variations may occur depends on the following factors:

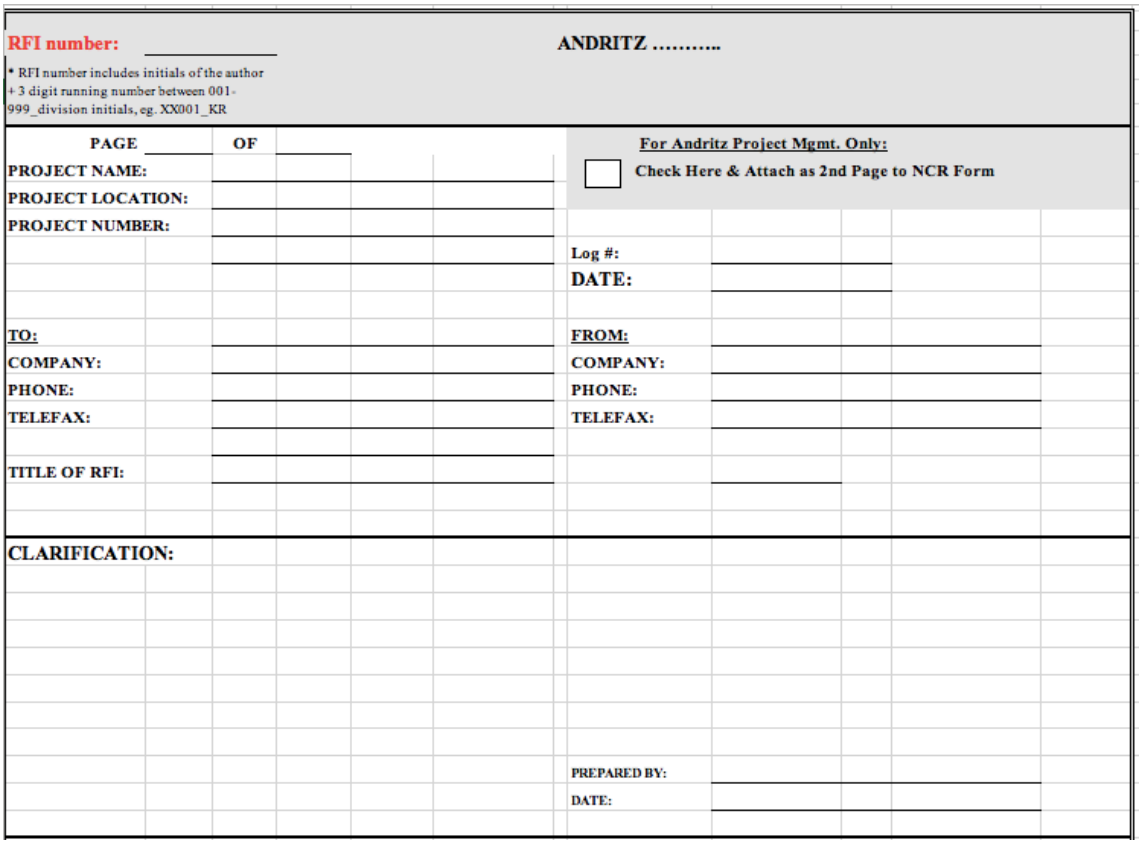
- the project's nature. Some project may involve a higher number of causes of uncertainty due to their specifics. This in particular can be triggered by weather and natural conditions, among other things.
- the project's complexity. This term in turn can be sub-divided into organizational or management complexity and technological or technical complexity. If the project, for instance, has too many parties involved, or

requires the use of advanced technologies, these can negatively affect the uncertainty factor and be the cause of a lot of causes for variations.

- the procurement methods. Based on whether the procurement for the project's needs is done according to a traditional or non-traditional method can vastly impact the uncertainty related to it. For example, some projects do not follow the typical established linearity of work (namely, commissioning a team of designers to prepare drawings on the basis of which a bid price is created)and abandon them in favour of other systems (involving the contractor during the design phase of the project as opposed to the previous example). (Ndihokubwayo, 2008, pp. 28-33)

Like any sort of a legal agreement, variations have to be included in the working agreement, otherwise they are not binding and the contractor can refuse executing them. Including room for 'contractual clauses' in an agreement in practice means that a new agreement is not made every time a variation is requested, simplifying the legal aspect of the client-contractor communication and allowing a certain degree of reasonable flexibility. Variations are issued in the form of contract instructions by the consultant who represents the client to the contractor in writing. The process, however, can also happen backwards, with the contractor being the initiator of variations. If a variation is not accepted, then a claim is filed. (Ndihokubwayo, 2008, pp. 21-22)

In order to handle variations on site, Andritz has its own procedure. If in subcontractors' opinion some activity which must be done does not belong to their scope of work, they send to Andritz a fulfilled RFI (request for information) form (Figure 4).



RFI number: _____ ANDRITZ .....

* RFI number includes initials of the author + 3 digit running number between 001-999_division initials, eg. XX001_KR

PAGE _____ OF _____

For Andritz Project Mgmt. Only:

☐ Check Here & Attach as 2nd Page to NCR Form

PROJECT NAME:

PROJECT LOCATION:

PROJECT NUMBER:

Log #:

DATE:

TO: FROM:

COMPANY: COMPANY:

PHONE: PHONE:

TELEFAX: TELEFAX:

TITLE OF RFI:

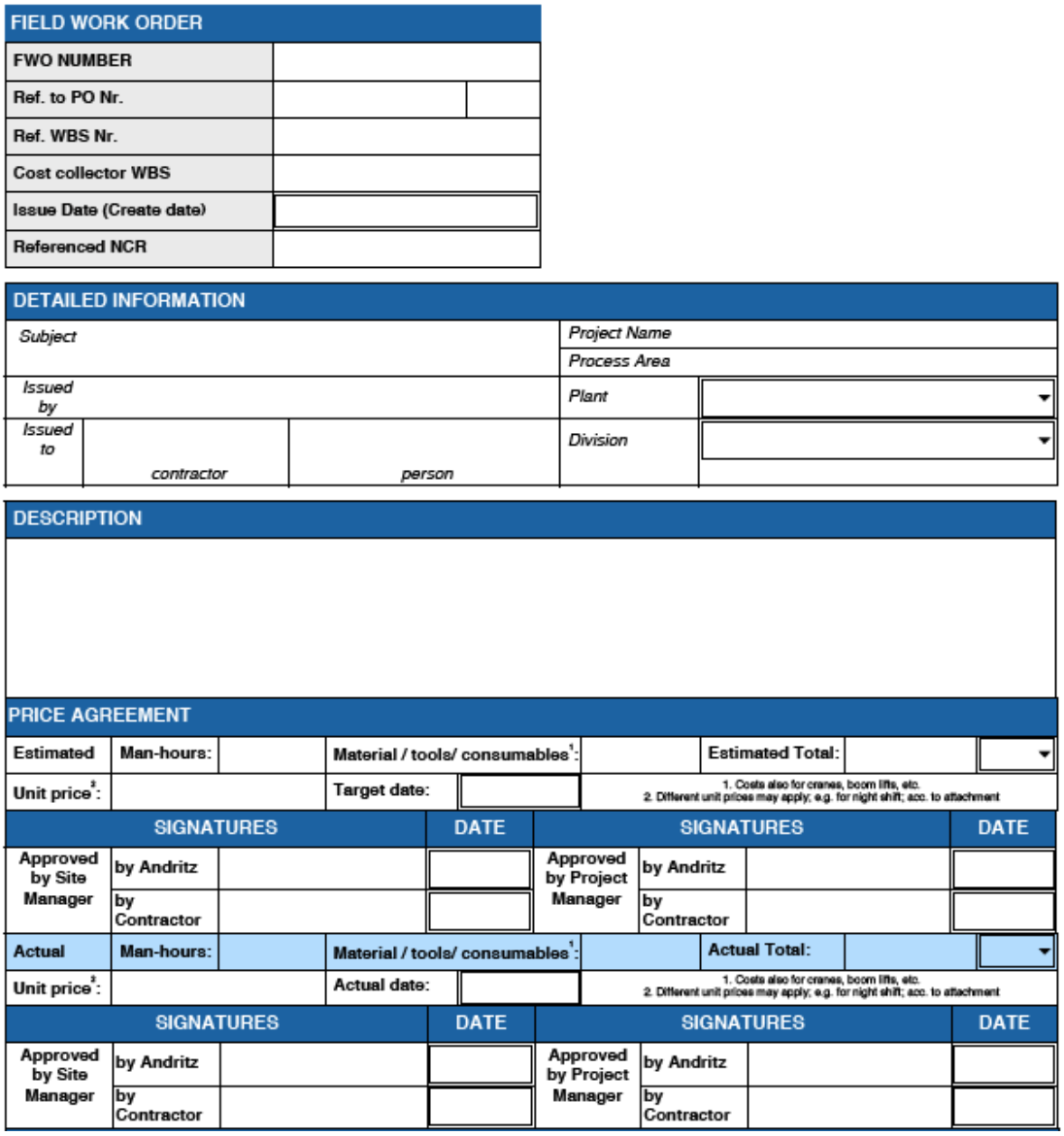
CLARIFICATION:

PREPARED BY:

DATE:

Figure 4. RFI example (Andritz Oy, n.d.)

As can be seen from Figure 4, an RFI should contain an explanation of additional work to be done, as well as an estimation of the needed manhours and materials. If Andritz accepts the request, then work is normally started. After that Andritz prepares an FWO (Field Work Order). An example of a FWO is featured in Figure 5.



| FIELD WORK ORDER | |
|---|---|
| FWO NUMBER | |
| Ref. to PO Nr. | |
| Ref. WBS Nr. | |
| Cost collector WBS | |
| Issue Date (Create date) | |
| Referenced NCR | |

| DETAILED INFORMATION | | | | |
|---|---|---|---|---|
| *Subject* | | | *Project Name* | |
| | | | *Process Area* | |
| *Issued by* | | | *Plant* | |
| *Issued to* | *contractor* | *person* | *Division* | |

| DESCRIPTION |
|---|
| |

| PRICE AGREEMENT | | | | | | |
|---|---|---|---|---|---|---|
| Estimated | Man-hours: | | Material / tools/ consumables[1]: | | Estimated Total: | |
| Unit price[2]: | | | Target date: | | 1. Costs also for cranes, boom lifts, etc.<br>2. Different unit prices may apply; e.g. for night shift; acc. to attachment | |

| SIGNATURES | | | DATE | SIGNATURES | | | DATE |
|---|---|---|---|---|---|---|---|
| Approved by Site Manager | by Andritz | | | Approved by Project Manager | by Andritz | | |
| | by Contractor | | | | by Contractor | | |

| Actual | Man-hours: | | Material / tools/ consumables[1]: | | Actual Total: | |
|---|---|---|---|---|---|---|
| Unit price[2]: | | | Actual date: | | 1. Costs also for cranes, boom lifts, etc.<br>2. Different unit prices may apply; e.g. for night shift; acc. to attachment | |

| SIGNATURES | | | DATE | SIGNATURES | | | DATE |
|---|---|---|---|---|---|---|---|
| Approved by Site Manager | by Andritz | | | Approved by Project Manager | by Andritz | | |
| | by Contractor | | | | by Contractor | | |

Figure 5. An example of an FWO (Andritz Oy, n.d.)

An FWO form contains information about the work performed, the amount of hours and money spent, as well as the root cause of additional works. This document is signed by contractors and Andritz management. The signed document is scanned and a copy is sent to contractors. On the basis of this document a subcontractor can later bill Andritz their work. All scanned RFI and FWO's are stored in the project documentation system ADMS, so that this information can be retrieved upon need (to settle claims or for accounting purposes, among other things).

The amount of subcontractors on site varies from site to site, and can be quite big, as well as the amount of extra works. That's why it is important for the site manager to

maintain an up-to-date Excel file with all FWO's per company. This file is called "An FWO index". That list is kept in ADMS and is freely available to all Andritz project members.

## 5.4 **Work tracking**

Communication is one of the main driving forces behind construction projects. The success of a project can be attributed to many things, however effective communication is arguably the cornerstone quality that a project team might have. It, in turn, stems from early and often sharing of information, usually though meetings. This form of communication somehow established itself in the construction sector, and it is maintained over the entire course of the project cycle. The direction in which the project will move is defined during such meetings at every stage of the project: from planning to client handover. (Ludwig)

Weekly site meetings play a crucial role in the successful management of a construction project. They are used as a way to report work advancement, while also giving an opportunity to enable the discussion of engineering or quality issues, and allowing the proposal of solutions. (Institution of Civil Enginers, 2020)

The meetings are held regularly, at the same time and on the same day each week at the site office, starting from the beginning of the construction work until the completion of all work (including punch list work and final documentation release). The attendees should include representatives from Andritz side: site manager and a responsible advisor, as well as from the subcontractors' side: a site manager and a foreman. After every meeting, a memo is distributed.

Also every subcontractor is obliged to provide Andritz with an updated "Profure" once a week. A "Profure" is an Excel document, which contains all tasks included in the contractor's agreement and prepared by Andritz. For every working task there is a specified amount of needed working hours.  Based on the reported figures in the input sheet, a Profure automatically generates the progress curves. One example is reflected in Figure 6.

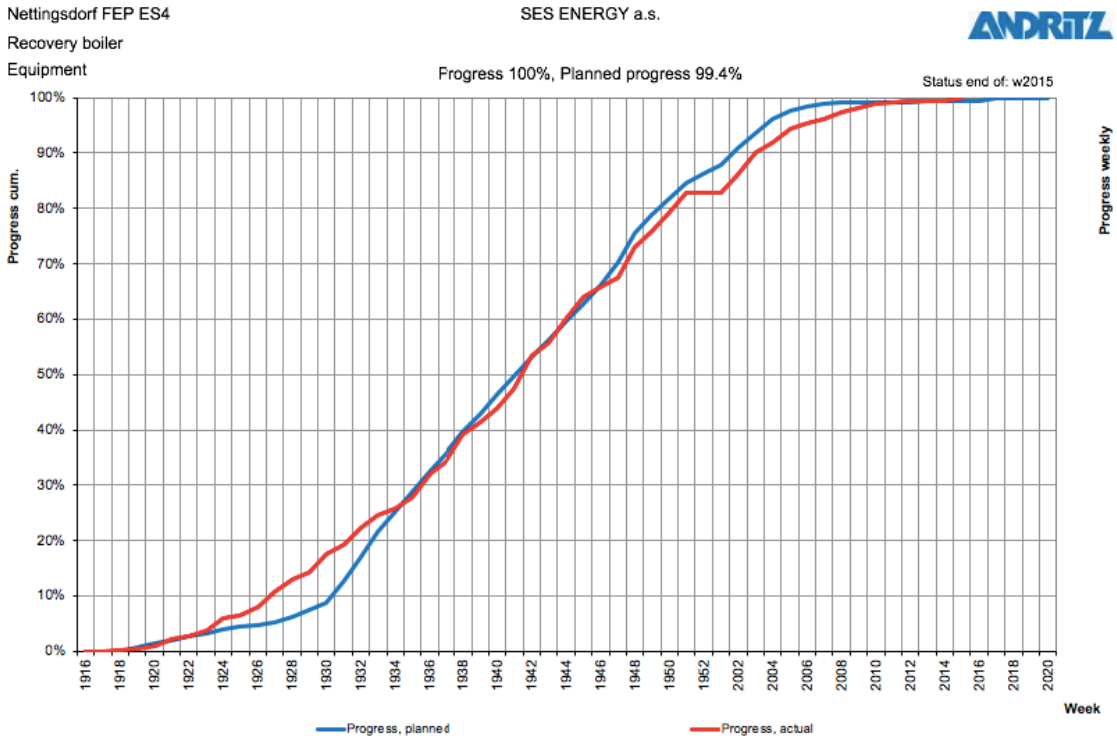



Figure 6. Profure progress curve example (Andritz Oy, n.d.)

This progress chart includes two curves: a planned progress curve and an actual progress curve. The graphical output they produce gives a good opportunity to easily analyze and report the situation on site. Also it is one of the key elements in defining the efficiency of the work in question. These files are collected once a week to guarantee the optimum response time for site management in case of deviations. Reported figures are stored into the ADMS system for any future needs.

## 5.5 **Start-up**

Prior to the start-up of a new plant, a set of commissioning activities is initiated. At this stage, the commissioning manager with engineers take responsibility for those tasks. They are executing commissioning on group systems.

The first activity for the commissioning group to accomplish on site is PI-Diagram checking. A piping and instrumentation diagram (PI-Diagram) is a detailed diagram used in the process industry, and created with the purpose of reflecting the piping and process equipment together with the instrumentation and control devices. PI-Diagrams contain process flow sheet data, elements of the mechanical process

equipment design, as well as the instrumentation engineering design. The diagrams are created during the design stage of the project. (Lucidchart, 2021)

An example of a PI-Diagram is presented in the Figure 7 located below:

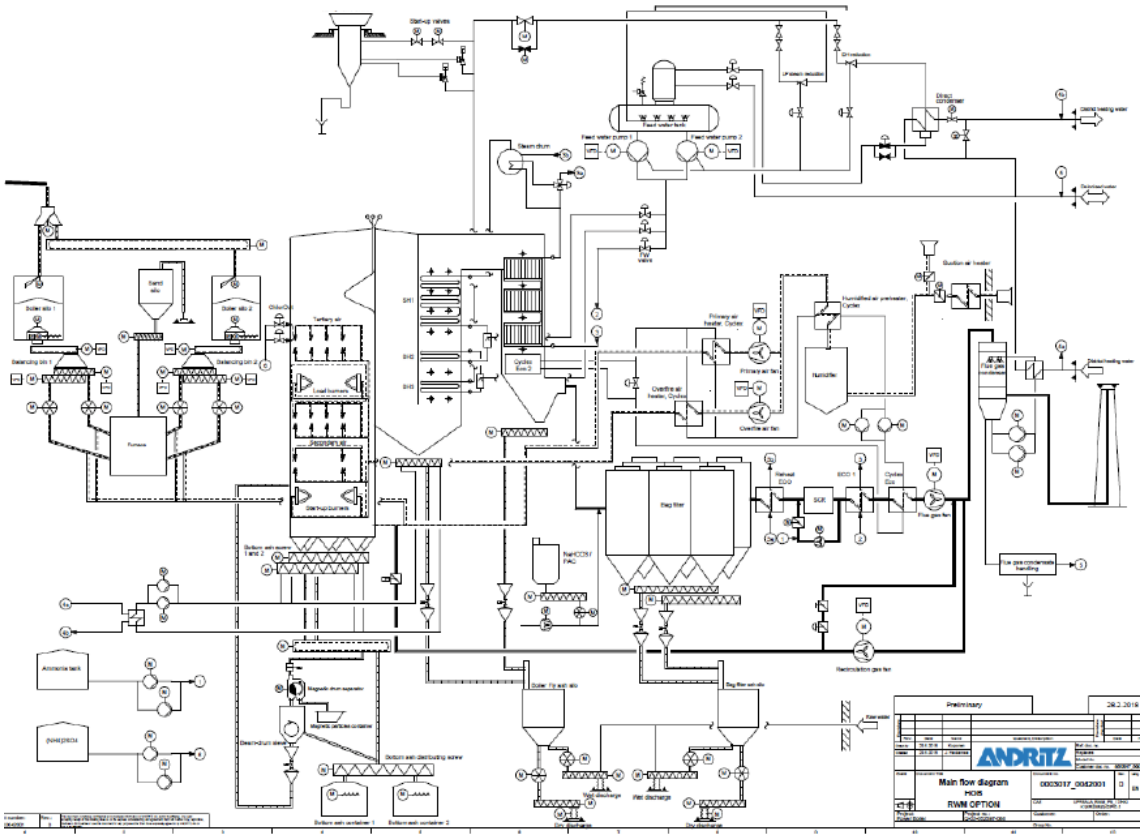



Figure 7. PI-diagram example (Andritz Oy, n.d.)

PI-Diagrams are checked by the commissioning engineers to ensure one more time that the installations are done in full compliance with them. Sometimes there can be errors in design, for example where pipe routing or equipment location is not done precisely as on a PI-Diagram.

After that cold commissioning starts. During this period systems are flushed with water or air, filled with water or air instead of the right media to simulate processes, installed instruments and pumps are checked as well. In order to start cold commissioning a certain group, an erection completion certificate should be signed. A document is signed per each testing system by the final customer and Andritz commissioning team. This kind of certificate includes the following documents:

- Erection inspection report
- Hydro test report
- Punch list
- System commissioning PID
- System commissioning action list
- Electrification inspection test sheet

The presence of all of the above mentioned documents shows that the system is mechanically ready.

Successfully performed cold commissioning is followed by hot commissioning. During this period designated fluids are introduced into the separate systems. After all systems are tested separately, the start-up of the plant can be initiated. During this phase the entire plant is taken into operation.

# 6 CONTRACTORS' INFLUENCE ON PROJECT EXECUTION

In this chapter the way contractors may affect the projects they are working on will be discussed. As the contractors are the ones that are actually carrying out the works, their influence on project execution and outcome cannot be underestimated. As Andritz technical supervisors cannot physically supervise the work of every person at any given moment, contractors are trusted to do the right thing and supervise themselves. Every minute they have to make small decisions which can have wide-reaching effects. It is a big responsibility to carry, and its effects can be traced in the project performance dynamics.

## 6.1 **Design companies**

Industrial construction projects are extremely complex and continuous endeavours, where design plays a crucial role. Therefore, the following expression is often used: "Well designed is half done". Professionally designed projects save money by decreasing installation hours. That's why it is very important to not underestimate it.

Poor design can result in the following effects, among other things:

- Project delays
- Project cost change
- Project termination
- Material misuse and utilization
- Conflicts between parties (Suleiman & Luvara, 2016)

Among other things, the need for design changes may arise. Design changes cause rework, which in turn causes delays, cost overruns and productivity losses. In order to diminish the negative impacts that design changes have on the schedule, costs, etc., the root causes of the changes have to be addressed at earlier stages of the project's life cycle. The later in the project any changes are implemented, and the bigger these changes are, the more exponentially burdensome these additions will be. (Rahman, Yap, & Wang, 2015)

Some of the things that can lead to change of design:

- Owner's desire to modify the design
- Addition of new works
- Change in regulations
- Change in the project's budgeting
- Unrealistic execution schedule
- Unavailability of resources
- Miscommunication between parties, etc. (Suleiman & Luvara, 2016)

In order to eliminate problems with design, Andritz has its own professional designers who are capable of designing pulp and paper factories according to Andritz's own proven technologies and techniques. Their main engineering office is located in India and supervised from Finland by the head of designers during the whole project's length. The investment to the Indian market has allowed to reduce the costs of design and the whole project respectively.

However, the amount of running projects at the same time can be high and this fact creates a need for hiring extra designing companies. In this situation it is important to hire experienced companies, who can present the references and make an offer adequately.

## 6.2 **Logistic companies**

The logistics of a construction project significantly affect its time and cost. Logistic service suppliers typically act as separate links in the supply chain that provide the project with products, services, information and finance. Supply chains in construction projects have proven to be complicated to manage and optimize. The difficulty is due to the presence of the various factors mentioned below:

- Project diversification (various materials, procedures and places of every project require a new network of supply chain)
- Technical complexity of the project;
- Amount of those involved in a project;
- Prevalence of the contract acquisition bidding system;
- Need to integrate every member of the supply chain in the project's logistic system. (Sobotka, Czarnigowska, & Stefaniak, 2005)

A logistics plan that is carefully designed reflects every possible arrangement between the project players the project owner and management, designers, contractors, suppliers of services and products, insurance companies, financial institutions and regulatory bodies. However usually, each contractor utilizes and manages their own supply chain. For big projects that means that problems are unavoidable due to a high number of contractors involved, mismatched systems of logistics and a general absence of means of cooperation. As the result, disruptions in material and information flows are experiences. (Sobotka, Czarnigowska, & Stefaniak, 2005)

In Andritz company a shipping engineer is responsible for all material logistics related issues. Over the course of a construction project, a plan of supplying materials to the construction site is developed. Two people are responsible for creating the plan: a

shipping engineer and a project planner. Together, they create an Excel chart which lists all needed material and equipment. An example of such a table can be seen in Figure 8.

PROJECT: UPPSALA VATTENFALL(CARPE FUTURUM)
WBS: C-02-833287-088
Contract Number 1 002 905 367
Issued by / Date: M.Kosunen/ 29.03.2021

**Preliminary Shipping Plan**

1 002 905 367

HIDE
Internal

| Division | Shipment # | Package # | ITEM Number | Equip. Descr. | Equipment number | Main Equipment (as per Ap1.) | Content of Package ("Spefication") | "Type" of package | Standard, Oversize, Courier |
|---|---|---|---|---|---|---|---|---|---|
| KRP | 1100589655 | CF-PB/4502447139/0001 | 1100 | 101 | 1100 | Steam drum | include manhole gasket 8 pcs | unpacked | oversize |
| KRP | | | 1100 | 103 | 1100 | Steam drum internals (cyclones) | | | |
| KRP | | | 1100 | 103 | 1100 | Steam drum internals (demisters) | | | |
| KRP | | CF-PB/4502932934/0001 | 1110 | 111 | 1110 | Plate | | pallette | standard |
| KRP | 1100572767/2 | CF-PB/4502524325/0047 | 1100 | 111 | 1100 | Furnace sections with headers | Furnace rear wall | steel frame | oversize |
| KRP | 1100572767/2 | CF-PB/4502524325/0048 | 1100 | 111 | 1100 | Furnace sections with headers | Furnace front wall | steel frame | oversize |
| KRP | 1100572767/1 | CF-PB/4502524325/0046 | 1100 | 111 | 1100 | Furnace sections with headers | Furnace right wall | steel frame | oversize |
| KRP | 1100572767/1 | CF-PB/4502524325/0043 | 1100 | 111 | 1100 | Furnace sections with headers | Furnace left wall | steel frame | oversize |
| KRP | 1100572767/3 | CF-PB/4502524325/0018 | 1100 | 111 | 1100 | Furnace sections with headers | Furnace roof | steel frame | oversize |
| KRP | 1100604644 | CF-PB/4503042722/0001 | 1100 | 111 | 1100 | Refractory box | | pallette | standard |
| KRP | 1100604644 | CF-PB/4503044206/0001 | 1100 | 111 | 1100 | By pass tubes 2 pcs + 3 x FIN | C02STDDRW088_1110111_4103122 | pallette | standard |
| KRP | | | 1100 | 112 | 1100 | Water cooled grid | Air nozzles for Fluidizing grid: Transportation to workshop | | |
| KRP | 1100557924/30 | CF-PB/4502617264/0083 | 1100 | 112 | 1100 | Fluidizing grid ash hoppers | C02833287088_1110112_0308040/1K | loose | standard |
| KRP | 1100557924/30 | CF-PB/4502617264/0084 | 1100 | 112 | 1100 | Fluidizing grid ash hoppers | C02833287088_1110112_0308040/2K | loose | standard |

Figure 8. Supplying materials plan (Andritz Oy, n.d.)

This list contains delivery times, which correlate with the installation plan. However, during the installation phase of a project, a site manager can modify the delivery times if it is possible, since installation plans can change or because of a limited storage space.

Sometimes the goods can get stuck and delays occur due to unforeseen situations, such as bad weather conditions, traffic line jams, etc. This is especially important in regards to goods that are supplied from abroad, as their timely delivery is influenced by a great multitude of factors. For example, in spring 2020, equipment delivery times increased twofold due to the coronavirus border restrictions. Force major situations have also been known to occur, one example of which was a fire on a shipping liner that led to extended waiting times. All of these things have a severe impact on the installation and manpower schedule. Andritz is always choosing only proven logistic companies to minimize risks as much as possible.

## 6.3 **Equipment suppliers**

During the whole length of the company's lifespan it has obtained its own trusted equipment and material suppliers who match the needed requirements. These

companies have proven their service levels many times. However, a human factor should be remembered. That's why in order to minimize the risk of defective equipment delivery, Andritz's quality team is doing inspections during different phases of manufacturing. Suppliers are located all over the world, so the quality team has to travel periodically to the workshops. During inspections, the following things are investigated:

- Welding quality
- Installation quality
- Installation correspondence to design
- Working personnel quality
- Supervisory during different type of tests (hydrotest, pneumatic test)
- Manufacturing schedule
- Documentation

Deviations from any of the above mentioned things can have dramatic impacts, as because of project's complexity overlooked mistakes can require sometimes twice more time for repair. In some cases they can affect significantly the project's time schedule and budget. Andritz has also faced manufacturing mistakes and had to act fast and accordingly to minimize consequences.

## 6.4 **Construction companies**

### 6.4.1 Boiler and process piping installation companies

Boilers play a critical role in keeping industrial plants running and ensuring that the production process is smooth. They are utilized in many industries where the main product is steam. Multiple product variations can be manufactured in order to custom-tailor them for the specific purpose they are needed to serve, and in the specific geographic region they will be operating. Their classification ranges too, from hot water boilers to steam boilers. The most widely used in an industrial setting are steam boilers, whereas hot water boilers are applied for residential or commercial purposes to generate heat or hot water. Also, a distinction is made based on the kind of fuel the boilers are using, as it strongly affects the exact boiler modification that will be used,

for the particular purpose/industry/area they are intended for. Thus, the best possible solution can be provided, which will be reflected in lower operational costs. (STI group, 2013)

An example of Andritz power boilers used in the pulp and paper industry is displayed in Figure 9.

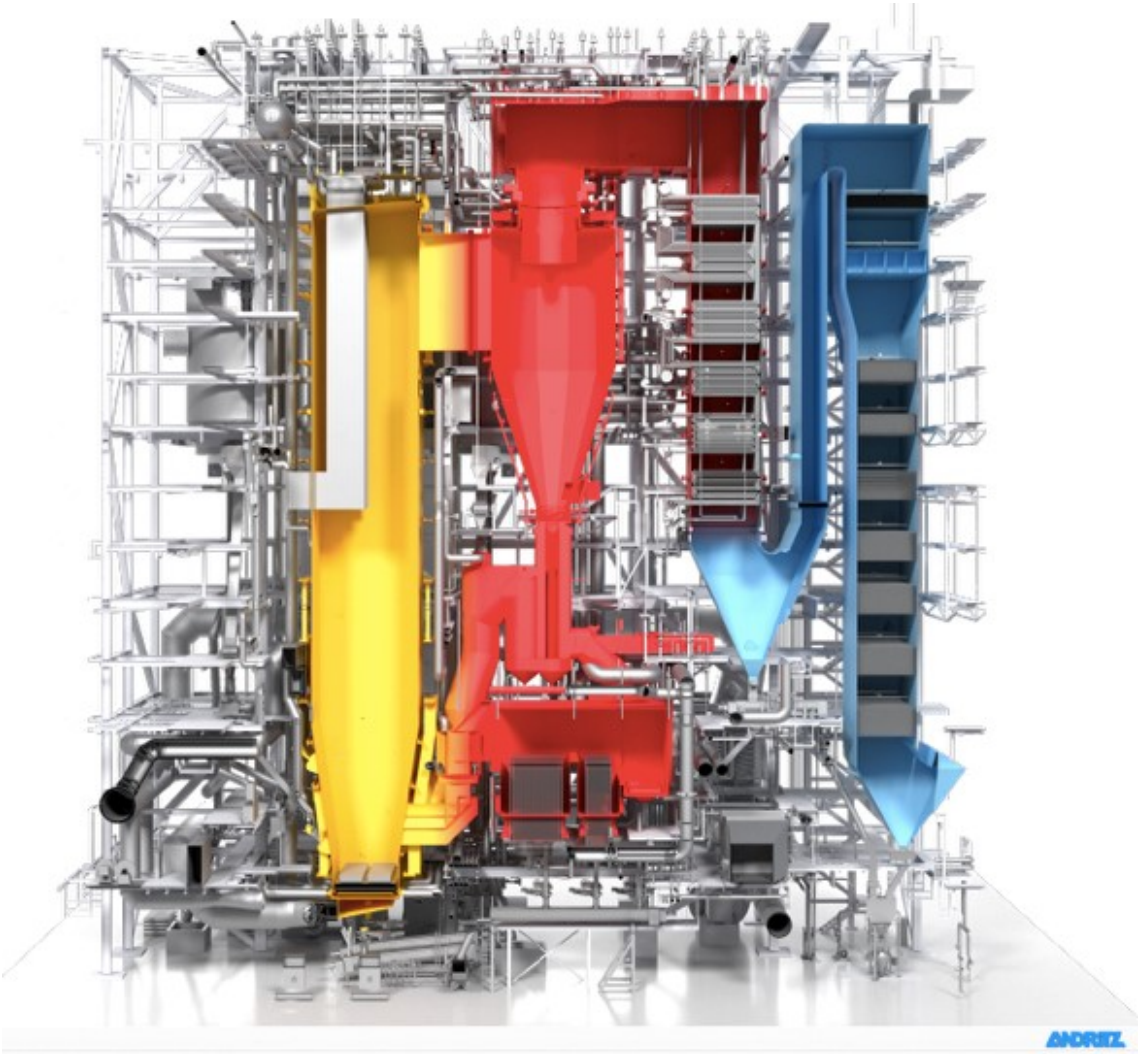



Figure 9. Boiler type example used by Andritz (Andritz Oy, n.d.)

An intrinsic part of any boiler is process piping, which transports liquids, gases, slurries or fine particles. A piping system is normally compiled of the complete interconnection of pipes, including in-line components such as pipe fittings and flanges. Pumps, heat exchanges, valves and tanks are also deemed to be parts of a piping system, all of which are essential parts of any industrial process. They comprise a vast share of the total plant cost, sometimes up to 30% of the total investment. Piping systems arranged

within a very confined area can present extra challenges to piping and support engineers as well as installation companies. (The Process piping, n.d.)

An example of a process piping part can be seen in Figure 10:

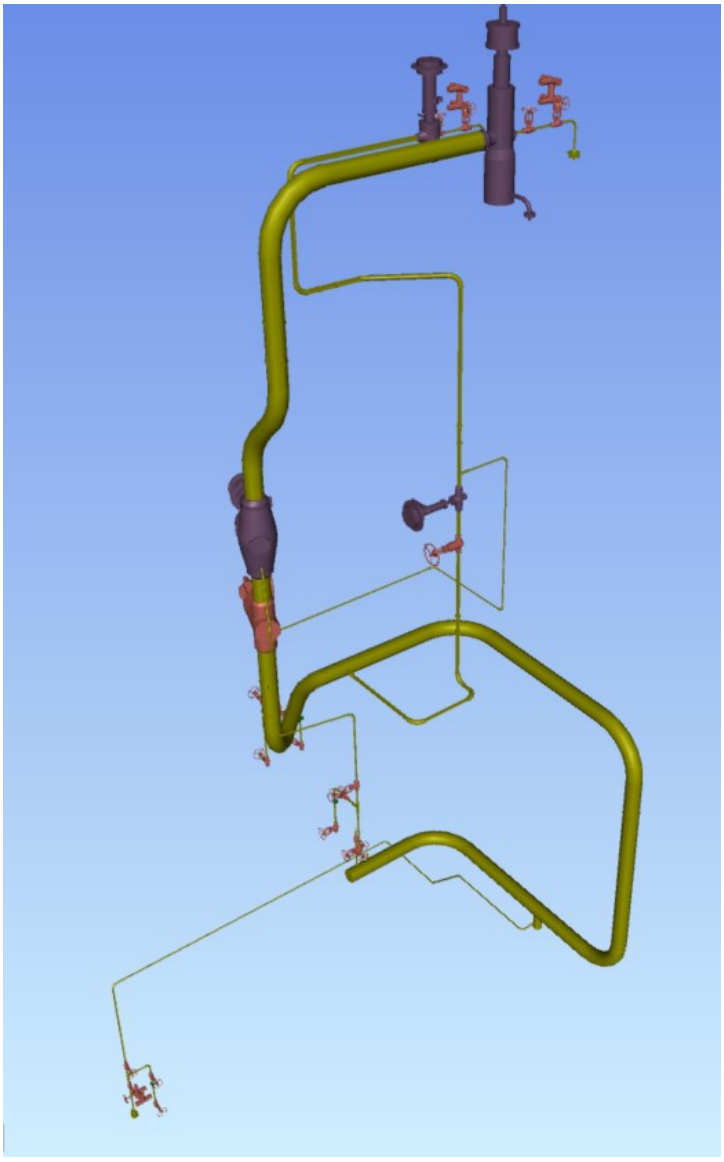


Figure 10. An example of the process piping (Andritz Oy, n.d.)

High level installations can be achieved only with the competent contractors. That's why leading installation companies are chosen, who have years of experience in the industry.

Process piping, boiler and equipment installations are very complex. Installation errors and deviation from design can have serious consequences for the project. The following errors are most common among non-professional companies:

- Lack of experienced personnel
- Irresponsible attitude toward general installation rules of boiler and piping systems
- Installation of inappropriate piping material
- Use of a wrong filler material during welding or wrong welding procedures
- Poor welding quality
- Inapplicable handling of welding consumables and storage of piping material
- Inability to assess current situation and set priorities

The above mentioned factors can cause serious problems during the operation of the plant and at a later stage can even lead to extreme emergencies. That's why it is critical to select a company that has the experience, the knowledge, and the professionals to perform the installation according to the design, within the given time frame and budget, and while complying with quality requirements.

### 6.4.2 Scaffolding companies

Scaffolding - an auxiliary structure, which is used when performing installations and finishing building works. A scaffolding consists of a rigid frame assembled from a variety of precast modules, repeating the contours of the building. Safety in installation and operation is regulated by provisions on the safety of labor, construction standards and other documents. High requirements are defined regarding the material and the installation process. Strictly following the rules ensures the security of employees and comfortable working conditions. (TheConstructor.org, n.d.)

The benefits of using a scaffolding include:

- A highly secure environment for the personnel
- Universality. Scaffolding can be used on any worksite regardless of the topography. In order for the model to fully comply with expectations, it is important to select an option the technical specifications of which are suitable, and the installation is carried out in compliance with the instructions.

- Compactness. There are multiple people and building materials at the same time at the site.
- Efficiency. Convenient transportation to the object and storage until the start of work reduces the associated costs.
- High levels of deformation resistance.
- Decorativeness. Many solutions are equipped with a protective grid, which helps to shield and protect the working site, as well as retain an aesthetically pleasing appearance of the project. (Up-Scaffolding, 2018)

An important aspect of safety regulations is the right installation of a scaffolding. It must be carried out by qualified employees or a third-party company with the relevant certificates. When installing scaffolding, it is important to take into account the sequence of work. The design should be stable and securely fixed vertically and horizontally. The following elements are absolutely essential: railing, visors, solid flooring and stairs. (ACE, n.d.)

Workers' safety is of paramount importance, and the company should have any permits required by the local authorities to perform installation works, and be up-to-date in regards to the latest safety regulations in the country where the project is being implemented. Also, selecting a local contractor for executing this share of the project can allow to cut costs related to equipment shipping. Finding the right ratio of safety to cost is also important, as either way the excessive costs will be likely to strain the budget unnecessarily. (ACE, n.d.)

A big number of worksite accident related to scaffolding are due to a human error and not the structure itself. It is important that the subcontractor taking care of scaffolding takes into consideration the height of the building when choosing a system, to make sure that it is of suitable height, and without the danger of overstretching the structure thus potentially causing an accident. (ACE, n.d.)

When a contractor for scaffolding is being selected, it is important to ensure that they have the necessary qualifications to perform this kind of work, the necessary means

appropriate for the size of your project, and that they can perform the work within the financial limit that you have dedicated to that task. (ACE, n.d.)

Also it is very important to check scaffolding company's previous references to ensure that they have enough of right experience to handle the selected project. Pulp and paper sphere as any other industry sphere is unique. A scaffolding company which worked mainly before in a real estate business, will not be appropriate at an industrial construction site.

Andritz is targeting to choose only professional, experienced and reliable companies. However, Andritz has also faced with inappropriate scaffolding companies. For example, at one construction site, where the selection of the contractor was done by the owner of the plant. As a result, the installation of scaffoldings was pretty slow and incongruous. This has affected the construction company's efficiency, project budget and the entire time schedule.

# 7 OBLIGATIONS OF SUBCONTRACTORS AND WORK ARRANGEMENTS

In this section of the thesis the different kinds of contractual agreements will be discussed, as well as their pros and cons. In addition, this chapter will delve into the different operating methods related to the distribution of responsibility over the duration of the project, and discuss logistics-related arrangements, all of which are inherently related to the topic of contracts and working agreements.

## 7.1 **Construction contracts**

A construction contract is concluded for the construction or reconstruction of a building (including residential buildings), facilities or another object, as well as the implementation of installation works and other related works. (Institution of Civil Engineers, 2020)

Under the terms of a construction contract, the contractor undertakes to build a specific object or perform other construction work upon the request of the commissioner, and the commissioner, in turn, is bound to create for the contractor the

necessary conditions for work, as well as to take their result and pay the due price. (Institution of Civil Engineers, 2020)

A construction contract is a very specific kind of agreement, due to the fact that its subjects are architectural objects, which are required to meet certain local established requirements and specifications. On the contractor lies great responsibility for the quality of the work performed, since the failure to comply with the requirements and conditions of the contract can lead not just to the customer's losses, but also to more serious consequences, such as the destruction of the building, the threat to life and health, ecological dangers, etc. That is why there are increased demands in terms of technical documentation, estimates, materials, etc. related to construction contracts.

Construction contracts are quite complicated in nature. In addition to the description of the essence of works, the prices of work, the term of execution, they often include the obligations of the customer for the preparation of the contractor's site, questions concerning the risks of loss or damage to the object, the obligations of one of the parties to supply the building materials, and others. The annexes of the contract can contain detailed information such as the technical task, the project description, the calendar work plan, the estimations, the list of building materials. (Institution of Civil Engineers, 2020)

It is recommended to include procedures regarding the definition of additional works. For example, specify which correspondence is recognized as a change in the contract: an agreement on paper, a file with an electronic signature of the organization or a certain person, etc. (Institution of Civil Engineers, 2020)

There are several main types of contracts in construction. They differ in price- and cost-related arrangements, as well as the methods of payment to the contractor. The contract types are as follows:

1) Lump-sum Contract

   The most common type is the lump sum contract, which supposes the implementation of the project for some predetermined price, regardless of the

actual costs which the contractor had to pay for the construction of the facility. This type of contract requires the existence of a set of complete design documentation for the object under construction and guarantees to the customer to implement the project within a given timeframe. However, it is characterized by a high degree of risk for a contractor, since it is impossible to predict all possible difficulties in the project implementation process. As a result, the contractor seeks to increase the contract price of the project. (TheConstructor.org, n.d.)

2) Unit Price Contract

The contractor defines its pricing on the basis of the estimated cost of the person-hour of each employee, worker, car and each type of mechanism. The information is then reported and the customer is billed based on that sum. This option is utilized when the contract is made at the stage when it is impossible to accurately assess the scope of work. (TheConstructor.org, n.d.)

3) Cost-plus Contract

Cost Plus contract eliminates the main disadvantage of the lump sum contract, since it ensures that the customer is responsible for all additional costs, not the contractor. With this type of contracts, the entire risk associated with the rise in the cost of construction is shifted to the customer. In accordance with the terms of the Cost-Plus contract, the construction of an object begins before the final design and estimate documentation are accepted, which reduces the duration of the project. (TheConstructor.org, n.d.)

4) Target cost contract

This contract type combines the traits of both lump sum and cost-plus contracts. The actual costs in addition to a fee (either fixed or a percentage of total costs) make the basis of what the contractor is paid. The contractor is given a financial incentive to save any possible project costs by means of rewarding them a percentage of the difference between target and actual budget costs. The Finnish contract law is mostly free of any compulsory form requirements. Contracts can be concluded in any form that is deemed suitable

or convenient by the parties. A specific feature of the Finnish contracting practice is the widespread use of standardized contract terms, which are frequently drafted by groups of interested parties in the relevant industry, with the sole goal of creating a balanced framework that could later be applied to the vast majority of the applicable contracts. (Jaspers, 2019)

## 7.2 **Project delivery methods**

The project delivery method is a system used by a company for the purpose of facilitating and funding the design, construction, operation and upkeep services for a structure or an object by entering into legal agreements with one party or more.

### 7.2.1 Design-Bid-Build (Traditional Building)

A method of project implementation when the agency or the owner concludes an agreement with private organizations for the design and construction of the project. Design-Bid-Build is a traditional method for implementing a project, and one of the most widely used too. There are three main consecutive stages to this method:

1) Design phase

   At this stage, the owner hires an architect (or an infrastructure consultant engineer) for the development and preparation of tender documentation, including building drawings and technical specifications for which various general contractors, in turn, will make bids for the construction of the project. The architect will work with the owner to determine the project needs, develop a written program documenting these needs, and then develop a conceptual and / or schematic project. Then the architect usually attracts other design specialists, including construction engineers, mechanical engineers, electricians and plumbers, fire safety engineers, etc. to develop the initial concept and fill in building drawings and technical specifications. The ready-made tender documents are approved by the architect and the owner in order to issue them to the prospective general contractors at the bidding stage. The design fee is usually 5-10% of the total cost of the project. (Gordian, 2019)

2) Bidding (tender) phase

The bidding can be "open", meaning that any qualified party can participate in it, or "selective", when only a limited number of pre-selected contractors is invited to participate in the auction. Various general contractors participating in the auction receive copies of tender documents, and then send them to several subcontractors to participate in auctions on project subcomponents. Subcomponents can include elements such as concrete works, steel frame, electrical systems, HVAC and landscape design. Based on this information the contractor creates a bid and submits it by the due date of the auction closure. After receiving offers, the architect checks them, requests any clarification in case they are needed, examines the qualifications of the contractors, checks whether all the documentation is in order, and informs the owner about the ranking of applications. If the cost rates fall into the range acceptable for the owner, the owner and the architect discuss the suitability of various applicants and their proposals. As a rule, the project is awarded to the general contractor, who suggested the lowest price. (Gordian, 2019)

3) Construction stage

After the contractor received the right to build a project, tender documents (for example, approved building drawings and technical specifications) cannot be changed. Required permits (for example, a building permit) must be obtained so that the construction process can be initiated. The general contractor can perform work on its own, but usually the general contractor restricts its role mainly by the management of the construction process and everyday activity at the construction site. Therefore, in most cases, almost every project component is supplied and established by subcontractors. (Gordian, 2019)

### 7.2.2 Design-Build

This project system is used in the construction industry when both design and construction are carried out by one organization. Unlike the Design-Bid-Build scheme, in this scheme, all contract responsibility is assigned to one company, thus minimizing the risks for the customer/investor and reducing the delivery time due to simultaneous

design, production, supply and installation of the building. Due to the concentration of full responsibility on one party, the Design-Buid scheme provides the client with a transparent contractual environment, obliging the contractor to bear full responsibility for the project, regardless of the nature of the identified faults. (Gordian, 2019)

### 7.2.3 Build-Operate-Transfer

This is a form of project implementation that is usually reserved for large-scale infrastructure projects, when a private enterprise receives a concession from the public sector (or another company in the private sector in rare cases) for financing, designing, construction, ownership and operation of a facility in question. This allows the project initiator to recover the money invested, as well as operational costs. Build–operate–transfer is usually a model used in public-private partnership. According to this delivery method scheme, a third party, such as the government of a state, requests from an enterprise of the private sector to design and build a piece of infrastructure, as well as to operate and maintain the object for a certain specified period of time. The building company is responsible for raising the funding for the project and has the right to withhold any profits the project will generate. The company is also considered to be the owner of the object in question. The object will then be transferred to the state at the end of the aforementioned period of time, without any financial reimbursement. (Hayes, 2020)

### 7.2.4 Integrated project delivery

This is a method of construction project implementation that seeks to reach maximum efficiency and involve all participants (people, systems, business structures and practices) during all stages of design, manufacturing and construction. Integrated project delivery combines ideas of integrated practice and lean construction. The goals of this method are to increase productivity, reduce waste (waste is described as resources spent on activities that do not increase the value of the final product), avoid time overuse, improv the quality of the final product and reduce conflicts between owners, architects and contractors during construction. This project method focuses on improving communication among the entities involved in the construction process, and relies on technologies to do so. Unlike the "Design - Construction" method, in

which the Contractor usually plays the leading role in the construction project, Integrated Project Delivery causes the entire construction team, including owner, architect, general contractor, builder engineers, manufacturers and subcontractors to work together throughout the entire process. (KPMG, 2013)

## 7.3 **Supply chains-related agreement in construction projects**

An essential challenge for logistics in the construction sector is the uniqueness of each construction object, the supply chain for which needs to be tailor-planned to suit the needs of each project separately. In turn, this does not allow to establish long-term relationships with suppliers. Also, construction projects are characterized by a wide variety of materials used, all of which differ in form, size, manufacturing time, storage period, etc. As a result, the problems of material overuse arise, as well as unnecessary time expenditures. The constantly changing environment of construction projects is explained by the complexity and the diversity of components related to both the project itself and logistics and supply activities around it. (Al-Werikat, 2017)

Logistics tasks at the stage of early planning are reduced to the following:

- the development of detailed supply plans
- the selection of suppliers offering the best conditions for the price and quality
- signing long-term contracts (Al-Werikat, 2017)

At the implementation stage, there is a need for materials and, consequently, the need for their purchase and delivery. At this point, the purpose of logistics is to ensure the timely delivery of materials according to the plans formed earlier. This stage is characterized by the execution of typical operations related to order placing, material delivery and billing. The construction process is characterized by a highly intense level of consumption of building materials, which means a high frequency of deliveries, which in turn makes it necessary to carefully track the states of the delivered materials as well as their allocation. In addition, it is necessary to standardize delivery, unloading and storage of supplies. (Al-Werikat, 2017)

Regarding the project logistics modes, four base models of supply systems are usually distinguished:

- An independent supply chain for individual contractors, in which the choice of suppliers as well as the planning of demand is the responsibility of each contractor
- A centralized supply chain, which is managed by the general contractor or another party, which controls the whole project through their own logistics departments
- A centralized supply chain, which is managed by an external logistics company
- A combination of the aforementioned chains (Lee, 2018)

Supply systems based on independent supply chains or services of an external logistics company are possible to implement together with any of the project delivery methods. However, an integrated logistics system in a project means the possibility of optimizing supply chains and coordinating supplies, which is essential for large construction projects involving many contractors working in limited space. Unclear division of responsibilities for deliveries among many subcontractors can lead to technology and materials accumulating on the construction site, as well as excessive costs and delays in the performance of work. (Al-Werikat, 2017)

Organizations offering logistics services can exist in the form of independent companies or be created directly for the needs of the construction project. According to their volume of operations, they can take all logistic processes within the project's life cycle or focus only on some functions, such as delivering supplies, or controlling transport and warehousing. (Lee, 2018)

## 7.4 **Contracts used by Andritz with subcontractors**

In contracts definitions are used to simplify the interpretation of the contract. Usually in Andritz contracts there are definitions for following terms:

- Andritz – hereinafter referred as the Buyer
- Subcontractor – hereinafter referred as the Seller.

- Mechanical Completion Day 1 and 2 – days on which the Buyer receives a written report from the Seller, to the effect that contractual requirement on completion of mentioned milestones is achieved.
- Day of Takeover – the day on which the Owner receives a well-founded written report from the Buyer to the effect that a trouble-free test run with the Total Buyer's Delivery has been carried out in the specified manner.
- Punch list – the specification for remedial work to be carried out.
- Scope of Supply – design, engineering, documentation, procurement, manufacturing, construction, as well as the achievement of Take-over and all other work or tasks to be done or performed by the Seller.

### 7.4.1 Equipment and Erection Services

After signing a contract, the Seller undertakes to deliver everything ready for operation in accordance with the terms and conditions of the Contract, including unloading, handling, storage and erection of all equipment and materials at the site. If a part, device, special tool or accessory necessary for the Scope of Supply is lacking, it shall be considered to be included in the Scope of Supply at no extra cost to Andritz even if the part is not specially mentioned in the technical specification.

Contractors shall perform all work under the Contract in a professional manner, applying sound engineering and design practices and meticulous supervisory procedures, in accordance with the highest standards of care employed, as applied by leading international sellers and operators in the industry.

### 7.4.2 Project management

The Seller's project personnel shall participate in negotiations, site meetings and other meetings with the Owner, the Buyer or their consultants and other advisors at no cost to the Owner or the Buyer. The language in any such meetings shall be English, and the participating personnel of the Seller shall be required to possess sufficient English skills in order to conduct the work in the required professional manner.

### 7.4.3 Changes

During project execution there can be a need for modification or change. This procedure is regulated in the way that Andritz may at any time require changes (additions or deductions) to the work to be performed under contract and may, under the terms of the contract, require the Seller to furnish any extra work, which may be necessary for carrying out such changes.

Changes shall be authorized only by a written FWO duly approved by Andritz. An FWO shall specify the price of the change as well as the impact on delivery time and guaranteed performance. Each FWO shall be supported with required back up documentation.

If there is a difference in the interpretation, whether an FWO is needed or not, the Seller is under no circumstances allowed to stop any work or threaten to do so. The final interpretation of open issues will be mutually made in Project closing meeting.

Extra work, in the amounts to be paid to the Seller by reason of any such order, is determined by unit prices mentioned in the contract.

### 7.4.4 Terms of payments

Andritz is using different payment options with subcontractors. Contract price for mechanical installations such as boiler, process piping or insulation, is generally paid in following instalments:

- X% of the contract price after
    - signing the contract
    - completion of agreed construction plans
    - delivery of insurance certificates
    - mobilization at the site
- X% of the contract price after the monthly progress according to the progress and/or after a specific milestone
- X% of the contract price after mechanical completion day 1

- X% of the contract price after mechanical completion day 2
- X% of contract price after all the work at the punch list have been done and demobilization of the site and all extra works have been agreed, approved documentation delivered.

If the installation company causes some damage or expenses to the Buyer, then Andritz has a right to make a deduction from any monies payable to the Seller.

### 7.4.5 Mechanical warranty

The mechanical warranty period is typically 24 months from the provisional acceptance of the buyer's total delivery. Any defects or mistakes, which are found after mechanical completion day 1 but before start of the warranty period, will be corrected and handled by the seller. The seller is still liable even after the expiry of the warranty period for faults and defects which have appeared later.

The installation company warrants that the equipment, materials and workmanship supplied are of the best quality, free of defects, completely new and unused.

### 7.4.6 Insurance

The installation company should have an insurance coverage in accordance to following requirements:

- Liability insurance policy 2.000.000 – 5.000.000 EUR covering professional liability
- Liability insurance policy 2.000.000 – 5.000.000 EUR covering third party liability

### 7.4.7 Commissioning

Commissioning, which is made by Andritz, is following Mechanical completion 1 and 2. That's why the Seller is obliged to plan and perform works in such a manner that it will not interfere or disturb the commissioning and by all means assist in commissioning.

This clause reminds about the importance of following the commissioning schedule.

### 7.4.8 Delay of the delivery and liquidated damages

If the plant is not completed according to the contract, then the installation company has to pay to Andritz Liquidated Damages for a delay in the following ways:

- For every commenced week of delay of the Mechanical completion 1, the Seller is to pay liquidated damages for delay in the amount of X percent of the estimated contract price.
- For every commenced week of delay of the Mechanical completion 2, the Seller needs to pay for delay in the amount of X Eur per week.
- For every commenced day of delay of the Take-over until X days, installation company is to pay Liquidated Damages for delay in the amount of X percent of the Contract price, and for every commenced day of delay of beyond X days of the Takeover, the Seller is to pay Liquidated Damages for delay in the amount of X percent of Contract price.

The accumulated total liquidated damages for late equipment delivery and late document delivery shall not, however, exceed X percent of the estimated contract price.

### 7.4.9 Termination

Andritz can terminate the contract, entirely or partially, on written notice to the seller in the event of any of the following defaults:

- Declaration of bankruptcy
- Disregard or violation of provisions of the applicable laws or provisions of the contract, when the Seller did not take remedial action within five working days after a written notice
- In case of total delay to the schedule exceeding five weeks
- Failure to provide a qualified superintendent, competent workmen, or subcontractor, or proper material.

This clause allows Andritz to terminate contracts and, in the worst case scenario, take another subcontractor. Such extreme measures are rarely taken.

# 8 INTERVIEW ROUNDS

For the purposes of gathering actual, hands-on experience of working with subcontractors rounds of interviews were held with experienced site managers from Andritz and other companies. The full interview can be found in Appendix 1, in which the interview questions are answered respectively by each respondent. The questions are as follows:

- What qualities do you look for in subcontractors before hiring them?
- How do you monitor your subcontractors?
- Which practical steps did you take when subcontractor start falling behind?
- How to keep your subcontractors motivated?
- How do you approach scheduling?
- Which practical steps would you take if a project starts falling behind or exceeds budget?
- In your experience, what is the key to ensure that subcontractor will deliver everything in time?
- What do you find is the most challenging aspect about managing budgets?
- How to avoid a delay in project?
- What was your the most successful project and why?
- What was your least successful project and why?
- What would you say are the key elements to ensuring effective communication with the contractor?
- Would you say that good communication is the most important thing?
- What kind of problems have you encountered most frequently in working with contractors? How did you solve them?

On the basis of the answers of the respondents it is clear that site managers find contractor monitoring and regular keeping in touch vital for smooth project work experience and timely result. Daily coordination meetings with the contractors have

been found to work well to ensure that there is no miscommunication and that both parties are on the same page, and still more meetings are scheduled if there are pressing problems with the work.

Every respondent was of the opinion that if a contractor is starting to fall behind, they need to be provided assistance as soon as possible, and should not be left to deal with the problem on their own. Also, every respondent made a point out of taking especial care to create a well-defined and realistic project execution plan, as it was noted to have a dramatic impact on the presence of delays in a project. Continuously monitoring a project plan while the works are ongoing was also recommended as a good way to prevent delays, as well as beforehand preparation of the worksite.

# 9 CONCLUSIONS

## 9.1 In conclusion

Now some of the features that have been deduced to be shared among Andritz's successful projects from the management perspective will be discussed.

All Andritz contracts contain contractor roles and responsibilities, as well as clear premeditated conditions of the scope of works, schedule, price, allowable room for contract changes, details of deliverables, work hierarchy, etc. This leaves no room for ambiguity, and allows to eliminate the most extreme cases of miscommunication during the project. Subcontractors are also provided with any relevant information regarding the project in advance, and are notified of the changes at the soonest opportunity. This is especially important to stay continuously in touch with the subcontractors and avoid delays in communication, both to continuously monitor their performance and be able to fix any setbacks at an early stage, and to keep them updated in return. By doing so, Andritz's managers have been able to ensure that the project is handed over or time or even ahead of the schedule.

Staying on the topic of communication, the most efficient form of it has been deduced to be holding frequent and regular meetings with contractors. This allows for effective two-way communication, during which subcontractors can express their concerns, and

managers theirs. Keeping meetings' tabs and records is another practice used in Andritz, that allows to further prevent any disputes, as human memory is prone to lapses, and physical proof is needed for any agreements or changes made.

Another important issue to tackle when dealing with contractors is payments. It has been a part of Andritz's best practices to pay subcontractors according to the time in the agreement, even when the customer payments have been delayed. It is needed to ensure that contractors can complete the work and manage their job.

To reiterate, producing excellent project work requires a lot of pre-planning, communication and a good relationship between sub-contractors and the general contractor. Subcontractors need to be managed continuously by the main contractor, and a failure to do so with great likelihood will lead to project delays, substandard work, disputes, etc. Any problems that subcontractors face during work by extension also affect the main contractor in terms of financial and reputation damage. It is a partnership that is aimed at satisfying the wishes of the work commissioner in a timely and smooth manners that is a mutually positive experience. Making sure that all parties are involved during every stage of the project is crucial to facilitating the aforementioned result.

## 9.2 **Recommendations for technical advisors on subcontractors' supervisory**

Subcontractors' supervision requires a great deal of effort from the main contractors' technical advisors. Here will be listed some recommendations for technical advisors based on the author's own experience and interviews:

- Content of the contract. The technical advisor should be familiar with the subcontractors' contracts, since they contain answers to many questions and help to settle many disputes. It is important to read the contract in the beginning of the project and build working relationships accordingly.
- Installation and commissioning time schedules matching. Subcontractors are mainly following the installation time schedule included into the contract. However, for the technical advisor it is important to review the commissioning

time schedule on site as well as to make the installation planning properly and guide the subcontractor in the right way. Water run groups must be double checked in order to have the installation and the release sequences right. A review should be done at least once in the beginning of the project to set correct priorities. Later during project, time schedules should be checked for the presence of revisions.

- Subcontractors' manpower on site. In order to adequately determine the current and the future manpower on site, the following aspects should be considered: installation schedule, subcontractor's professional integrity, upcoming events. Personal experience can be of great help in determining the proper manpower flows. Manpower follow-ups should be reviewed on a weekly basis.
- Correctness of installation. Project technical documentation should be thoroughly studied, and Installation drawings must be checked by advisors prior to installation. Having this knowledge will help to discover imperfections on site at the early stage and minimize economical and time schedule effects. Site inspections should be done on a daily basis.
- Correctness of used welding materials and procedures. It is important to keep an eye on welding works. Project's special welding requirements should be investigated. Monitoring should be done on the daily basis.
- Weekly meetings. Minutes of weekly meetings should contain all found technical or contractual deviations, disputes, upcoming events. It helps to avoid controversial situations later, as sometimes something can be forgotten. In the worst scenario meetings' memo can be used in the court. That's why it is important to put on paper every piece of information.

### 9.3 **Recommendations for collaboration with subcontractors on site**

Maintaining collaborative relationships with subcontractors on site is definitely the key to success and a major factor leading to on-time project delivery and higher profits. Since industrial projects are complexly regulated and require a lot of effort from both the main contractor and subcontractors, improving working relationships helps achieve common goals more effectively. Below, a summary of highlights and

takeaways relevant to the topic is presented, extracted from Andritz Oy's and the author's industrial experiences.

- Clear rules and expectations. For successful collaborations, contracts should include each party's roles and responsibilities, as they are the basis of the working relationships. This helps to eliminate future conflicts. Contract conditions should be defined including project standards, requirements, time schedules and a precisely defined delivery scope. Contracts should also include procedures for additional works handover. The implementation of the above mentioned factors ensures the facilitation of productive relationships on site. The expectations of the main contractor should match the goals and desires of subcontractors.
- Trust. The relationship between parties must be supported by not only the contract, but also honest and benevolent relationship. People should be honest, as it is the foundation for a good collaboration. It is important to give the right information when it is needed. If information is not delivered in a timely manner to the main contractor, this can have serious consequences. In the presence of a trusting relationship, subcontractors will be able to more effectively meet expectations and needed requirements for ensuring a better delivery of the project.
- Reward. Rewarding subcontractors for good performance makes them more goal oriented. In this case, people are more likely to put more effort into the project and reaching goals, since it improves the overall motivation. Offering bonuses for work delivery ahead of deadlines is one way of doing so.
- Two-way communication. A good communication is essential for an effective collaboration. Daily coordination and weekly meetings on site help subcontractors to avoid mistakes, obtain technical advice in a timely manner and solve problems effectively as they appear. Daily and weekly progress reporting is very important for the main contractor too, as it allows to be up to date on the state of progress, and if any delays are identified, address them immediately before they impact the project timeline significantly.

## 9.4 **Reflection on reliability**

Reliability and validity are by definition the consistency of results under a set of varying circumstances and the adequate representation of the underlying phenomena respectively. These two notions are essential parts of a scientific work, as they assure that the research is relevant to the field of study and its results have been achieved in a way that can be trusted. Among other things, this includes using sources that are reliable, such as acknowledged topical literature. One reason why it is important to clarify the means of reasoning, is that if the study is repeated by another researcher, results can be cross-compared in a meaningful and comprehensive way. (Edwin, 2019)

Within the context of this study, both the research results and the interview results point toward the same outcomes, namely they highlight the importance of the same elements in project management work. Both the source of theoretical information and the respondents can be considered as reliable, the former due to the fact that professional literature and examples of real-life successful projects have been used, and the latter due to the fact that experienced and successful site managers have been interviewed, ones that have a history of consistently being able to provide high rates of successful project work. The same reasoning applies to validity, as since the recommendations provided were based upon a big number of both successful and unsuccessful projects, their adequacy is at high level.

As mentioned before, every project is unique and is influenced by many factors simultaneously. This makes it difficult to give a number to how effective the highlighted techniques are, as it would be impossible to create two identical situations in which different management practices are used, just in order to be able to measure their efficiency.

By following the recommendations provided in this thesis, it is possible to avoid a lot of delays and mistakes that would negatively affect a project's progress and budget. However, a lot of success in managing projects comes down to bare experience, which can only be accumulated naturally with time. It still would be interesting to interview the same managers in several years once their industrial work experience becomes

even more diverse, to see if they are still guided by the same principles in their work as ones that they mentioned to the author of this thesis.

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# APPENDIXES

INTERVIEW QUESTIONS Appendix 1

- What qualities do you look for in subcontractors before hiring them?

    1) Professional references, to ensure that it is a trustworthy player; company size, to ensure that it has enough resources to support the working needs; how long the company has been in business for, to ensure enough working experience;
    2) Good credit history, e.g. no debts; References from other companies; the amount of personnel; technical capabilities of the organization (tools and machines); price range; certificated and accredited accordingly to the project's needs;
    3) References; how the offer is calculated and explained; how they have understood the scope;

- How do you monitor your subcontractors?

    1) Daily managing; weekly meetings; quality checks; schedule and progress monitoring.
    2) Directly; periodical audits and quality checks; welding checks; daily checks; weekly meetings;
    3) Audits before mobilization to site and even before signing the contract; following minimum weekly progress

- Which practical steps did you take when subcontractor start falling behind?

    1) Working out the root cause of the problem, e.g. clarifying what can be done to rectify the situation, maybe adding more personnel or using services of another contractor can help?

2) Extra meetings; helping with coordinating works; increasing personnel amount, working equipment and working hours to avoid fining the contractor.
3) Pushing them to increase the qualified manpower; sometimes part of scope have been taken out to another contractor; not release payments until progress is better; offering acceleration bonus;

- How to keep your subcontractors motivated?

1) Maintaining a good teamwork spirit; Encouragement and guidance; Give responsibility to the contractor for their performance and freedom to solve problems, to make them feel like they are important.
2) A good contractor is already motivated and doesn't need prodding.
3) Keep your own scope correctly: deliveries on time on promised time, documentation is in order, site arrangements are in order (facilities, storages, HSE); good cooperation.

- How do you approach scheduling?

1) Daily and weekly checks, pre-planning for 2 weeks
2) Rely on work experience, it gives an opportunity to estimate how much work is left to be done.
3) Daily and weekly checks

- Which practical steps would you take if a project starts falling behind or exceeds budget?

1) Clarify the reasons why this has happened; Increasing working hours or even two shift work; If delay is due to subcontractor, then customer don't bear extra expenses.

2) Clarify the reason; Apply sanctions according to the agreement with the contractor; extra meeting to rectify the situations;
3) Clarify the reason why a delay has happened; Adding reasonable manpower accordingly; try to share the costs with contractors or suppliers and client if possible.

- In your experience, what is the key to ensure that subcontractors will deliver everything in time?

1) Actively monitoring the schedule and the progress
2) Works are happening ahead of the schedule; Contractor's professional attitude; If more time is assigned to complete the works to have some room for delays.
3) Monitoring the schedule and progress; make sure that own deliveries and engineering are in schedule.

- What do you find is the most challenging aspect about managing budgets?

1) Having a deficient budget plan from the start. However, if the contractors' contract are also in deficit, they just get more work.
2) Having a complex project that requires to divide the budget into many parts.
3) To keep site costs within planned budget;

- How to avoid a delay in project?

1) The execution of a project that is well-prepared and planned from the start diminishes the risk of it being delayed. Plans should be thoroughly checked before the start of the project.
2) It is important to be more pedantic when composing a project and the schedule of works. Ensuring effective communications and logistics channels among contractors, fine-tuning working systems,

starting preparing for on-site works well in advance (creating arrangements with all personnel involved) are all good ways of ensuring that project delays are minimized

3) Project plans have to be carefully prepared and monitored during the whole project. Deviations can appear at different stages and it is important to solve them at early phase to minimize costs and time losses.

- What was your most successful project and why?

1) It was a 28 flat apartment complex in Porvoo. Good contractors which the respondent was able to choose himself. Enough time was given to get acquainted with the project, as well as sufficient funds were allocated. The level of safety made the site YIT's best worksite in South Finland. The project was ready 2 months ahead of the schedule.
2) It was an installation project of a waste-heat boiler for a VKG oil station. The project's profitability was 60% higher than had been expected. A lot of cost savings on machinery and installation processes by using modern technological processes.
3) Boiler and main equipment delivery and installation at Uppsala Power boiler construction site 2020-2021. Main contractor was very professional and cooperative. All works were completed even ahead the schedule, which happens quite seldom. Even the pricing of extra works done by the contractor was reasonable and still completed in schedule.

- What was your least successful project and why?

1) A terraced house project, the respondent was involved in the project starting from the middle stage. Basis data was wrong at the beginning of the project. The budget was exceeded considerably and the project handover was delayed by 4 months.

2) All completed projects have been handed over in time and in accordance with the budget.
3) Evaporation plant in Sweden. Complex layout due to old building, subcontracted engineering was a disaster, open book contractor chosen by client did not understand the scope they have offered.

- What would you say are the key elements to ensuring effective communication with the contractor? Would you say that good communication is the most important thing?

1) Everyday communication with the contractor.
2) Open communication from both sides, to ensure that the necessary information comes on time. Openness, honesty, timeliness, respect.
3) Regular meetings with records; daily communications and discussions;

- What kind of problems have you encountered most frequently in working with contractors? How did you solve them?

1) Finance- and schedule-related differences in opinions. Solution: Holding a meeting as early as possible during which the problems are discussed and efforts to resolve them are made.
2) Violation of the safety regulations, technical and technological issues, bad performance, inability to complete the works in due time. Solution: Holding meetings and communicating the needed changes. Fixing mistakes. In extreme cases contractor is changed.
3) Daily HSE approach; differences in working culture; understanding of what is extra work and its pricing; Solution: toolbox talks and monitoring, knowing the contract to demand agreed obligations, monitoring and understanding what exactly was done as claimed extra work.