Ibrahim Kar / Michael Berz

Scheduling in Plant Construction

VOGEL COMMUNICATIONS GROUP

Dipl.-Ing., Dipl.-Kfm. **Ibrahim Kar**
Born in 1970
After training as a technical draughtsman and completing his studies, he worked as a development engineer, research assistant, project manager and project service engineer. His current main areas of activity at Royal Dutch Shell include finance, in particular cost estimates, scheduling, controlling and physical progress (construction site progress).

Dipl.-Wirt.-Ing. (FH) **Michael Berz**
Born in 1986
is a senior cost engineer at Evonik responsible for the preparation of first cost ranges and validation of Study, Conceptual & Basic Cost Estimations.

Templates and accompanying documents are available for scheduling, which can be downloaded can be purchased separately as Word or Excel files from the publisher (download): www.vogel-fachbuch.de

Vogel Communications Group GmbH & Co.KG
Max-Planck-Straße 7/9
97082 Würzburg
Tel.: +49 931 418-0

Further information:
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Preface

This technical book on scheduling is intended for anyone seeking a detailed overview of the scheduling area of expertise in plant construction, particularly in the area of process plant construction. Such plants are often complex systems for the production of chemical and petrochemical products and require careful planning to be completed on time and within budget. Accurate and comprehensive scheduling is therefore essential.

The book provides readers with a detailed overview of the structure of schedules, as well as the procedure for preparing the necessary supporting documents, such as Schedule Plan, which summarises the procedure for schedule preparation, Basis of Schedule, which describes the assumption of the schedule planning and Schedule Templates.

It is divided into the following main chapters:

- Basis of Scheduling,
- Engineering (planning services),
- Procurement (equipment and material purchasing and procurement) and
- Construction (erection, assembly and installation) as well as
- Commissioning (testing and pre-commissioning).

The authors would like to thank the publisher and their supporters who have contributed to the success of this book.

Cologne, November 2023

Ibrahim Kar
Michael Berz

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Scheduling in the Project Process

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This chapter introduces the tasks and objectives of schedule planning in the project process. It also explains the supporting documents such as Schedule Plan (summarises the procedure for schedule preparation) and Basis of Schedule (documents the assumptions of schedule planning) and presents the structure of schedules and the schedule types in detail.

3.1 Scheduling Process

The focus of scheduling is to develop, summarise, as well as document the timing of the individual working steps and activities (also called tasks) in the individual project phases. This process ensures:

- that "nothing" is forgotten,
- a structured processing of the individual activities and
- the measurement of the project performance. Project performance is defined as the comparison of the current status with the original or target planning, which was released after the gate reviews at the decision gates.

Other questions that can be answered using scheduling include:

a) Are business boundary conditions being met, such as the RFSU (Ready for Start-up) deadline?
b) Are the contracts with the EPC (Engineering, Procurement, Construction) partners finalised?
c) Which activities constitute the critical path? The critical path is the longest project path formed by formally lining up the activities to be worked on with zero buffer (see chapter 8.9).
d) What does the critical path look like?

Basically, scheduling should not be confused with a to-do list. Scheduling documents and addresses items that are significant for the project, for example, the activity "Piping MTO (Material Take Off)" with the piping resource. This is an extensive item, which essentially describes the scope of work in the project for the piping department. The piping engineer knows all the details, reviews and initiates all the sub-activities of this item, such as:

- Are all boundary conditions for the preparation of the Piping MTO in place?
- Is the MTO recorded in a list and or multiple lists as appropriate (e.g. separately for pipes and valves)?
- Are different lists prepared for different materials?

Schedule development is not the sole responsibility of the scheduler. The schedule is developed jointly in the project with all participants in a so-called Interactive Planning Meeting (IAP). For this meeting, the scheduler prepares the basics and, in the meeting:

- the missing activities are added,
- plausibility is checked and
- the interfaces between the departments and with other projects and/or other areas are coordinated.

Schedule terminology is discussed in detail in chapter 8. For better comprehensibility, two terms are already used in this section: on the one hand, the term activity or task and the term milestone. An activity is defined by a start time, an action, and an end time, see figure 3.1. Additional characteristics such as resources, costs, etc. can be defined for the activity.

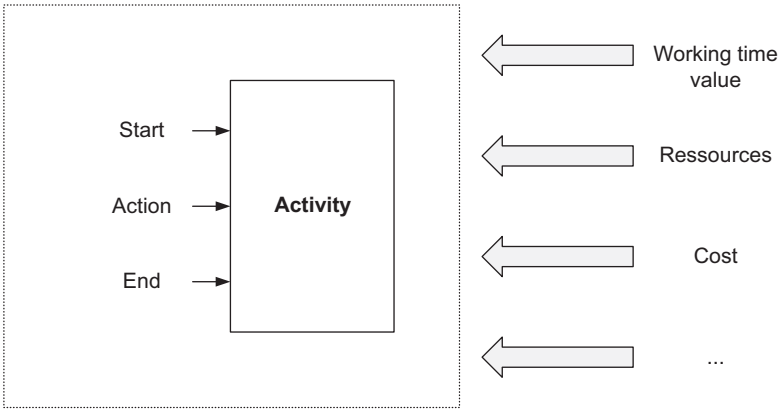

Figure 3.1: *Activity*

A milestone, on the other hand, is a activity with a duration of zero. The duration is the difference between the end time and the start time, see also [THEP23].

3.2 Schedule Plan

The Schedule Plan lists for each department individually which planning documents are to be prepared for the schedule and at what level of detail. In addition, it must be described which sources are to be used for which content, e.g., in-house data and/or delivery times for pipe material (pipes, fittings, and flanges, etc.). Further, the Schedule Plan must specify a timeline, as shown in table 3.1 as an example.

It is important that the Schedule Plan is coordinated with the project team and approved. In addition, the Schedule Plan should be prepared and released at the beginning of each project phase so that all participants can prepare.

A template for a Schedule Plan can be found in Appendix A.2.

Table 3.1: *Example of a Schedule Plan*

Description	Competence	End date	Comment
Approval of the Schedule Plan by the project team	Project manager	11.01.2018	
Scope lists, such as: - equipment list - line list - tie-in point list - piping and instrument flow diagrams, - block flow diagram	Process engineering	20.02.2018	With project release
Layout plan	Plant and pipeline construction	20.02.2018	With project release
Circuit diagram	Electrical engineering	20.02.2018	With project release
Instrument index	Instrumentation, control and automation	20.02.2018	With project release
Start of the schedule		20.02.2018	
Sending the material take-offs (MTOs) or quantities to scheduling, such as: - pipeline construction - civil engineering - electrical engineering - instrumentation, control and automation - crane & scaffolding construction	Technical department & project manager	20.02.2018	With project release
Deadline for receipt of all offers according to Estimating Plan	Technical department & project manager	05.03.2018	With technical review of the disciplines
Inclusion of the assembly/dismantling or installation hours according to the cost estimate (up to and including Define; in Execute, the assembly/dismantling or installation hours are based on information from the executing companies (based on AFC documents)).	Estimation / scheduler / CM	05.03.2018	
Handover of the hourly estimates of the engineering departments	Technical department & project manager	07.03.2018	With project release
Interactive Planning Session	Technical department & project manager	15.03.2018	With project release
Project Team Review	Scheduling	22.03.2018	With project release
Schedule review with internal management	Scheduling	23.03.2018	With project release
Sending the schedule to all parties involved	Scheduling	26.03.2018	After receiving management approval

3.3 Basis of Schedule

The Basis of Schedule (BoS) or Schedule Premises essentially serves the following tasks:

- brief presentation of the project content and the project objective,
- description of the planning documents used, and
- description of the assumptions and exclusions made in the schedule.

The BoS must contain at least the following elements to make the schedule plausible and transparent:

- brief presentation of the project content and objective,
- short tabular summary of the changes compared to the preliminary phase (if available) or revision, with the classification into the following categories:
  - re-evaluation (new offers, new material take-offs (Bill of Materials), but all with the same scope),
  - project scope reduction,
  - project scope extension as well as and
  - service transfer to another project;
- Reference to the planning documents that served as the basis (depending on the project phase), such as:
  - layout plans,
  - piping and instrument flow diagrams,
  - isometrics,
  - foundation drawings,
  - offers,
  - equipment lists,
  - material extracts of the trades and
  - scaffolding and crane erection plans incl. service life and requirements calculation for a stand-by team for scaffolding construction;
- start of purchasing activities,
- start and end of construction,
- list of key quantities (key quantities of the individual trades),
- key milestones,
- organigram,
- risks and
- project-specific information.

Appendix A.3 summarises a template of the Basis of Schedule

3.4 Project Duration

Before setting up a schedule, it is important to know or derive the approximate project duration or project term. As a rule, this is determined by the projects boundary conditions as, for example by:

- business goals,
- critical equipment delivery times and,
- adherence to turnaround deadlines.

The project term derived from the project boundary conditions as must be checked for plausibility in order to derive the rough project phase classification. To provide orientation table 3.2 documents the project duration in relation to the project budget. [Resc15] describes project terms of three to four years for project budgets of 100 M€ to 700 M€. [Buch13] deals with project terms of one to four years for project budgets of 5 M€ to 1200 M€. Further information on project terms can be found in [Fing90]. Here project budgets of about 3.5 M€ to about 15 M€ for project durations of 27 months to 48 months are documented.

Table 3.2: *Typical project durations depending on project budgets (literature values, serve as rough orientation)*

Project budget	Project duration	Comment
Up to 1 M€	12 Months	
1 M€ to 10 M€	24 Months	
10 M € to 50 M€	36 Months	
50 M€ to 150 M€	48 Months	
More than 150 M€	> 48 Months	

Project durations are significantly dependent on the company, the project scope, and the current company infrastructure. Large companies with excellent infrastructure, framework contract suppliers for equipment and bulk material, as well as framework contract companies and contractors, can implement a project scope more efficiently than companies that do not have these advantages. These conditions then result in significantly shorter project durations for almost the same scope.

The project durations can be roughly divided among the individual project phases as follows:

- FEL phase: $\frac{1}{3}$ project duration and
- Execute phase $\frac{2}{3}$ of the project duration.

The division of the FEL phase into Select and Define phases can be made roughly in the same proportion.

With a given project duration of approx. 36 months, this results in the following project phases:

a) Select: approx. 4 months ($\frac{1}{3}$ of the combined Select and Define runtime)
b) Define: approx. 8 months ($\frac{2}{3}$ of the combined Select and Define-runtime)
c) Execute: approx. 24 months ($\frac{2}{3}$ of the combined Select, Define, and Execute runtime).

The Appraise phase is usually not counted as part of the project duration, since conceptual questions must be answered here, e.g. possible patent applications. This can last from several months to years.

3.5 Schedule Types

In the literature, there is no generally valid classification of which schedule elements and characteristics are to be considered in the individual schedule types or levels. Therefore, the authors of this technical book have made a possible classification that has proven itself in practice.

Table 3.3: *Schedule types see among references in [KALF14]*

Schedule designation	Schedule type	Schedule detail basis	Schedule update	Schedule feature
Level 1	Milestone Plan (basic schedule, management schedule)	Years / months / weeks (depending on project duration)	Is created at the beginning of the project and is always updated as soon as the milestones change due to the project activities.	- Represents the project life cycle, - is intended for senior management to coordinate the project(s) and/or the project portfolio, - represents the key contract dates, - presents the milestones (e.g. kick-off meeting) and - focuses on the total duration for engineering, procurement, construction as well as testing and pre-commissioning.
Level 2	Overall schedule at department level (schedule for middle management)	Months / weeks / days (depending on project duration)	Is created at the beginning of the project and is always updated as soon as the mapped activities change due to the project activities.	- Represents the project life cycle, - is intended for middle management, - represents higher-level scheduling activities at the departmental level and - forms the basis for the schedule model, e.g. to carry out cost schedule risk analysis (CSRA).
Level 3	Detailed schedule (classic schedule with the focus on engineering, procurement, construction, represents the activities for controlling the project at department level).	Weeks / days (depending on project duration)	Monthly / weekly	- Represents the project life cycle: the current phase in Level 3 and the next phases in Level 2 and - is intended for the project management as well as for the technical engineers.

Table 3.3: *Schedule types see among references in [KALF14] – Continuation*

Schedule designation	Schedule type	Schedule detail basis	Schedule update	Schedule feature
Level 4	Construction and erection (erection, assembly and installation) schedule (for classic construction sites without project standstill activities)	Days / hours	Weekly / daily / hourly	- Presents the construction and erection (erection, assembly and installation) activities, - is intended for construction and project management as well as specialist site managers and - is intended for the classic construction site without project turnaround activities.
Level 5	Construction and assembly (erection, assembly and installation) schedule (for classic construction site with project standstill activities)	Hours	Daily / hourly	- Presents the construction and erection activities, - is intended for construction and project management as well as specialist site managers and - is intended for the classic construction site with project turnaround activities.

Table 3.3 summarises the schedule types. A distinction is made between five different schedule types.

The schedule name column specifies the schedule levels. The other columns document more details and characteristics of the individual schedules.

The Schedule Level 1 Schedule (Milestone Plan) documents the project milestones for senior management, whereas Schedule Level 2 is aimed at middle management and summarises the activities at the department level, which is a kind of "summary bar for the heads of disciplines". The classic project schedule with all its activities is set up in Schedule Level 3. This schedule is aimed to the engineering disciplines. The Level 3 Schedule then forms the basis from which Level 2 and Level 1 are derived. Since the accuracy (schedule detail basis) of the construction activities in the Level 3 Schedule is too low, a Level 4 or Level 5 Schedule for the construction activities is set up in the Execute phase of the project, a so-called construction and erection (erection, assembly and installation) schedule. These schedules can also be achieved by extending the Level 3 Schedule beyond the construction activities with the relevant information, boundary conditions, and the current project status or according to the project progress.

The basis for the construction and assembly (erection, assembly and installation) schedules are in turn the corresponding schedules of the construction and assembly partners (contractors, execution partners, or framework contract partners). These can only prepare their construction and assembly (erection, assembly and installation) schedules after completion of the detailed engineering package, which is usually processed

by the engineering partner. Intensive coordination meetings between the project participants and the construction and assembly partners are therefore important, especially with the construction management and the scheduler.

As a rule, construction and assembly (erection, assembly and installation) schedules are only required in the execute phase, especially in the construction and assembly phase. In some projects, the construction phase may start earlier, e.g. in projects for dismantling facilities or site preparation.

The distinction between Levels 4 and 5 is based on whether there are turnaround activities in the project. Level 4 schedules are usually used for projects without turnaround activities (revision turnarounds or TÜV (Technical Supervisory Association) turnarounds). For projects with turnaround activities, Level 5 schedules are favored due to their accuracy. For the Level 4 Schedule, see also the definition in [THEP15].

Table 3.4: *Schedule Types – Decision Gate*

Project phases	Decision Gate	Comments
Schedule Level 1	DG1, DG2 and DG3	
Schedule Level 2	In consultation	
Schedule Level 3	DG1, DG2 and DG3	- The Level 3 Schedule shall be prepared with Level 3 accuracy (schedule detail basis) for the project phase and review. - Level 2 accuracy is sufficient for the subsequent project phase. - The critical path schedule shall also be prepared.
Schedule Level 4	after DG3	Before start of construction
Schedule Level 5	after DG3	Before start of construction

At the decision gates, certain types of schedules are critically reviewed and approved. These are given in table 3.4.

3.5.1 Level 1-Schedule (Milestone Plan)

Figure 3.2 is a schematic representation of a Level 1 Schedule (Milestone Plan). In such a Level 1, the main activities of the project are presented in the individual project phases.

From Appraise to Define, these main activities are usually: engineering, scheduling, cost estimating, and the milestone decision gate. In Execute, the activities of procurement and construction are added for classical planning, followed by the milestone handover after the performance test. After the handover, the project is completed, and the operation unit takes over the project or the plant.

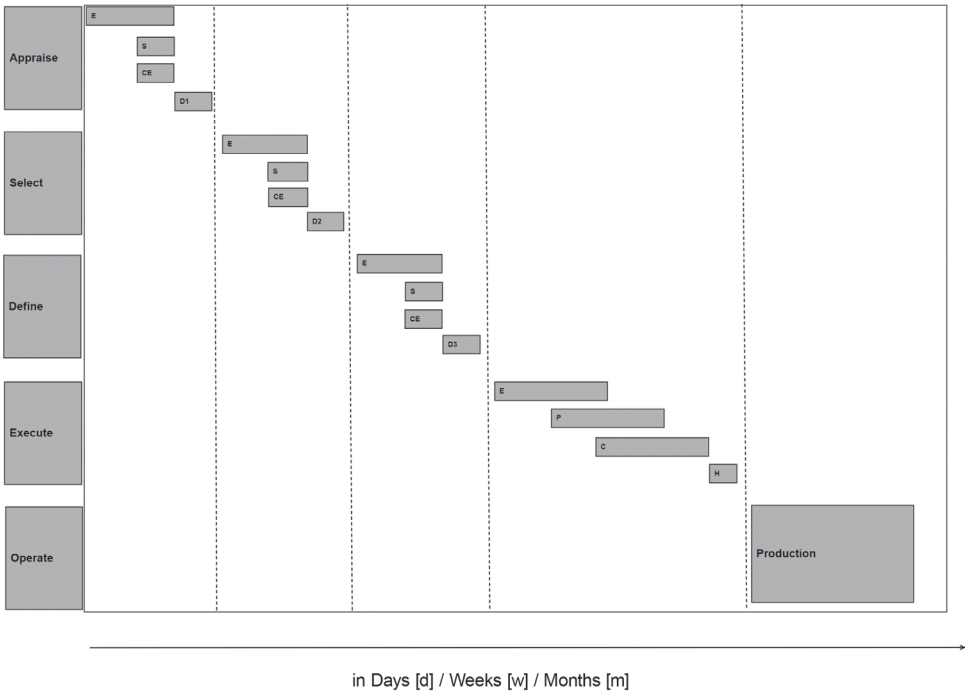

Figure 3.2: *Level 1-Schedule (Milestone Plan)*
E: Engineering (planning)
S: Schedule
CE: Cost estimation
D: Decision gate
P: Procurement (equipment and material procurement)
C: Construction (assembly and installation)
H: Handover (handover to operation)

3.5.2 Level 2-Schedule (Overall Schedule at Departmental Level)

The Level 2 Schedule is more detailed than the Level 1. Figure 3.3 shows an example of such a Level 2 Schedule. As can be seen, the most important activity areas are shown here. More precise are the detailed schedules, such as the Level 3 schedule. For clarity, only the engineering of one phase, the Select phase, is shown in Figure 3.3. The other project phases, such as Appraise or Define, are to be set up in the same structure.

Here, the key areas of engineering are portrayed "zoomed". The process department starts by drawing up a heat and mass balance, for example. Once the corresponding partial results are available, the other specialist departments such as piping, equipment, ICA (instrumentation, control and automation), electrical, or civil can also start with their design services. The information exchange is not shown in the schedules. In regular meetings, the results are presented and the required deliverables are exchanged. For example, civil needs the weights of the equipment. The engineering activity in Figure 3.3 can be seen as a "collection bar". The beginning of this collection bar is linked to the start of the first engineering activity and the end to the end of its last activity. This collective bar thus represents the complete duration of engineering in Select.