



Fachausschuss
Maschinenbau/
Verfahrenstechnik



SUBJECT-SPECIFIC CRITERIA

Relating to the accreditation of Bachelor's and Master's degree programmes in mechanical engineering, process engineering and chemical engineering

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The following specifications complement the "ASIIN General Criteria for the Accreditation of Degree Programmes".

1 Classification

1.1 Function

The Subject-Specific Criteria (SSC) of the Technical Committee for Mechanical Engineering and Process Engineering have the premise that the intended learning outcomes framed by Higher Education Institutions in their own responsibility and according to their academic profile concerning the programmes submitted for accreditation build the main scale for their curricular review.

Above this the Subject-Specific Criteria of all ASIIN Technical Committees meet a number of important functions:

The SSC are the result of an assessment, regularly performed by ASIIN Technical Committees, which summarize what is considered as good practice by a professional community formed equally by academics and professional practitioners in higher education and is required as future-oriented quality of training in the labour market. The expectations outlined in the SSC for the achievement of study objectives, learning outcomes and competency profiles are not developed statically. They are rather subject to constant review in close cooperation with organizations of the professional community, such as associations of faculties and university departments, professional societies and federations relating professional practice. Applicant universities are asked to study critically the interaction between the intended learning outcomes they strive for, the curricula and their relating quality expectations by using SSC and to position themselves in the light of their own higher education goals.

In their role in the accreditation process the SSC also provide a professionally elaborated basis for discussion among experts, Higher Education Institutions and bodies of ASIIN. By this they make an important contribution to the comparability of national and international accreditation procedures, since it should not be left to chance of the characters of the individual evaluators which technical parameters find their way into discussion and individual assessment. Simulta-

neously the SSC enumerate those abilities, skills and competencies which may typically be considered as state of the art of a discipline, but which can always be exceeded and varied, and also should be in accordance with the objectives of the university.

For inter- and multidisciplinary studies the SSC of ASIIN can provide orientation for presentation and evaluation. However, they are basically aligned on the core subjects of particular disciplines.

The SSC of the ASIIN are positioned and coordinated internationally and thus contribute to the achievement of the unified European Higher Education Area. They act on requirements of the "Bologna 2020" European strategy to formulate subject specialized, discipline-oriented learning outcomes as one of the most important means for the promotion of academic and professional mobility in Europe as quality requirement. The SSC consider, among others, the many preparations in the context of European projects (e.g. "Tuning") and professional networks.

1.2 Collaboration of the Technical Committees

The Technical Committee 01 – Mechanical Engineering/Process Engineering works together with the other Technical Committees of ASIIN, mostly to give consideration to the requirements of interdisciplinary study programmes. The universities are called upon to submit their assessment of the assignment of one or several Technical Committees in the course of the application for an accreditation procedure.

Degree programmes with a proportion of more than 50 percent of mechanical engineering and/or process engineering contents are overseen by the Technical Committee Mechanical Engineering/Process Engineering. The latter is, as a rule, in charge of the accreditation procedure and seeks advice of auditors from other areas, if needed. When it comes to interdisciplinary study programmes with a weighted share of mechanical engineering and/or process engineering contents (below and up to and including 50%) the Technical Committee Mechanical Engineering/Process Engineering and the disciplines involved are jointly responsible or simply provide auditors.

2 Educational Objectives and Learning Outcomes

The educational objectives are outlined by the description of the learning outcomes required by the graduates for practising their profession or for post-graduate studies. The outcomes vary in extent and intensity in accordance with the differing objectives of Bachelor's and Master's programmes.

In line with the Europe-wide comparability of different profiles of degree programmes as intended by the so-called Bologna process – "in order to accommodate a diversity of individual, academic and labour market needs"¹ – the Technical Committee supposes the existence of at least two typical general profiles in mechanical engineering, process engineering and chemical engineering with relevance for the labour market, education and research: one profile stressing the scientific fundamentals and research and one profile stressing the scientifically-based application; to be designated in the following for short as research-oriented and application-oriented. The Technical Committee recognizes that both profiles overlap and include common characteristics.

¹ See. "Realising the European Higher Education Area", Communiqué of the Conference of Ministers responsible for Higher Education in Berlin on 19 September 2003, p. 4.

This differentiation also underlies the following presentation of ideal learning outcomes for Bachelor's and Master's degree in mechanical engineering, in process engineering and in chemical engineering. These are to be understood as an orientation guideline for higher education institutions in the writing of educational objectives and learning outcomes.

2.1 Requirements on Bachelor's Degree Programmes

Successfully completed Bachelor's degree programmes in mechanical engineering / process engineering / chemical engineering are to facilitate early professional careers (professional qualification) as well as qualify the graduates for advanced scientific degree programmes or additional degree programmes other than in engineering sciences.

1. Knowledge and Understanding

Graduates of **more research-oriented Bachelor's degree programmes** have in particular:

- gained a broad and sound knowledge in mathematics, science and engineering, enabling them to understand the complex phenomena peculiar to mechanical engineering / process engineering / chemical engineering;
- gained an understanding for the broader multi-disciplinary context of Engineering Sciences.

Graduates of **more practice-oriented Bachelor's degree programmes** have in particular:

- gained extensive technical knowledge as to engineering, mathematics and natural science with a view to mechanical engineering / process engineering / chemical engineering, enabling them to carry out scientifically substantiated work and act responsibly in their professional activities;
- gained an understanding of the multi-disciplinary context of Engineering Sciences.

2. Engineering Analysis

Graduates of **more research-oriented Bachelor's degree programmes** are in particular qualified to:

- identify, abstract, formulate and holistically solve problems peculiar to mechanical engineering / process engineering / chemical engineering in their complexity with an orientation on the fundamentals;
- penetrate, analyse and assess products, processes and methods forming part of their discipline on the basis of system technology;
- choose, apply and (further) develop suitable methods of analysing, modelling, simulating and optimising.

Graduates of **more practice-oriented Bachelor's degree programmes** are in particular qualified to:

- identify, formulate and solve problems peculiar to mechanical engineering / process engineering / chemical engineering based on the application of established scientific methods;
- analyse and assess products, processes and methods used in their discipline based

on scientific facts;

- choose suitable methods of analysing, modelling, simulating and optimising and apply them with a high degree of competence.

3. Engineering Design

Graduates of **more research-oriented Bachelor's degree programmes** have in particular:

- the ability to conceive the design of complex machinery, devices, EDP programmes or processes correspondent to the status of their knowledge and understanding and according to specified requirements;
- a well-founded understanding of design methods and the ability to apply and (further) develop them.

Graduates of **more practice-oriented Bachelor's degree programmes** have in particular:

- the ability to conceive designs for machinery, devices, EDP programmes or processes correspondent to the status of their knowledge and to develop them according to specified requirements;
- a practically orientated understanding of design methods and the ability to apply them in a competent manner.

4. Investigations and Assessment

Graduates of **Bachelor's degree programmes** are in particular able to:

- carry out literature research in accordance with the status of their knowledge and understanding and to use data bases and other sources of information for their work;
- plan and carry out suitable experiments correspondent to the status of their knowledge and understanding, to interpret the data and draw suitable conclusions.

5. Engineering Practice

Graduates of **more research-oriented Bachelor's degree programmes** have in particular:

- the ability to combine theory and practice with the aim to analyse and solve problems peculiar to engineering sciences with an orientation on methods and fundamentals;
- an understanding of applicable techniques and methods and their limits;
- the ability to responsibly apply and independently consolidate their knowledge in different fields under consideration of economic, ecologic and safety requirements as well as sustainability and environmental compatibility;
- an awareness of the non-technical effects of engineering activities.

Graduates of **more practice-oriented Bachelor's degree programmes** are in particular:

- able to transfer new findings in engineering and natural sciences to industrial and commercial production under consideration of economic, ecologic and safety

requirements as well as sustainability and environmental compatibility;

- able to plan, control and monitor processes and to develop and operate systems and equipment;
- able to independently consolidate the knowledge gained;
- aware of the non-technical effects of engineering activities.

6. Transferable Skills

Transferable skills required for practical engineering activities and beyond are developed and extended within the study programme.

Graduates of **Bachelor's degree programmes** are able to

- function effectively as an individual and as a member of a team, including where relevant coordination of the team;
- use diverse methods to communicate effectively with the engineering community and with society at large;
- demonstrate awareness of the health, safety and legal issues and responsibilities of engineering practice, the impact of engineering solutions in a societal and environmental context, and commit to professional ethics, responsibilities and norms of engineering practice;
- demonstrate an awareness of project management and business practices, such as risk and change management, and understand their limitations;
- recognise the need for, and have the ability to engage in independent, life-long learning;
- work and communicate in national and international contexts.

2.2 Requirements on Master's degree programmes

As a continuation of an initial university degree the Master's degree programmes lead to the acquisition of advanced analytic-methodical and technical competences with a view to mechanical engineering / process engineering / chemical engineering.

The educational objectives of Master's degree programmes ought to integrate the specific strengths in the field of R&D of the respective university offering the programme.

1. Knowledge and understanding

Graduates of **more research-oriented Master's degree programmes** have in particular:

- extensive advanced knowledge of mathematic-scientific and engineering principles of mechanical engineering / process engineering / chemical engineering and their interdisciplinary expansion;
- as well as a critical awareness of the latest findings in their discipline.

Graduates of **more practice-oriented Master's degree programmes** have in particular:

- consolidated knowledge of mathematic-scientific and engineering principles of mechanical engineering / process engineering / chemical engineering as well as

deepened practice-oriented knowledge in special subjects;

- a critical awareness of the newer findings in their discipline.

2. Engineering Analysis

Graduates of **more research-oriented Master's degree programmes** are particularly qualified to:

- analyse and solve problems scientifically, which are unusual and/or incompletely defined and show competing specifications;
- abstract and formulate complex problems arising from a new or emerging field of their discipline;
- apply innovative methods to problem-solving based on fundamentals and to develop new scientific methods.

Graduates of **more practice-oriented Master's degree programmes** are particularly qualified to:

- analyse and solve problems scientifically, which are incompletely defined and show competing specifications;
- formulate practice-oriented problems arising from a new or emerging field of their specialised subject,
- use innovative methods for practice-oriented problem-solving (*EUR-ACE*).

3. Engineering Design

Graduates of **more research-oriented Master's degree programmes** are particularly qualified to:

- develop concepts and solutions for fundamentally orientated and partially unusual problems under broad consideration of other disciplines;
- use their creativity to develop new and inventive products, processes and methods;
- apply their scientific ability to judge in order to work with complex, technologically impure or incomplete information.

Graduates of **more practice-oriented Master's degree programmes** are particularly qualified to:

- develop solutions for practice-oriented and partially unusual problems also under consideration of other disciplines;
- use their creativity to develop new and inventive practical solutions;
- apply their scientific ability to judge in order to work with complex, technologically impure or incomplete information.

4. Investigations and Assessment

Graduates of **Master's degree programmes** are in particular qualified to:

- identify, find and procure necessary information;
- plan and carry out analytic, model and experimental investigations;

- critically assess data and draw conclusions;
- investigate and assess the application of new and emerging technologies in their discipline.

5. Engineering Practice

Graduates of **more research-oriented Master's degree programmes** are in particular able to:

- classify and systematically combine knowledge of different fields and handle complexity;
- familiarise themselves speedily, methodically and systematically with the new and unknown;
- assess applicable methods and their limits;
- reflect non-technical effects of engineering activities systematically and to integrate them into their actions in a responsible manner.

Graduates of **more practice-oriented Master's degree programmes** are in particular able to:

- combine knowledge in different fields for fast realisation and to handle complexity;
- familiarise themselves in a fast and targeted way with the new and unknown;
- assess applicable techniques on the basis of their imminent knowledge and to assess their limits;
- recognise non-technical effects of engineering activities systematically and to integrate them into their actions in a responsible manner.

6. Transferable Skills

Transferable skills required for practical engineering activities and beyond are developed and extended within the study programme.

Graduates of Master's degree programmes are able to:

- fulfil all the Transferable Skill requirements of a First Cycle graduate at the more demanding level of Second Cycle;
- function effectively as leader of a team that may be composed of different disciplines and levels;
- work and communicate effectively in national and international contexts.

3 Curriculum

3.1 Practical Education (industrial placements)

Carrying out a practical activity is an essential element of engineering education and is preferably completed on the basis of realistic problems prior to and during the study period in the form of industrial placements.

The aim of a **pre-study industrial placement** is the familiarisation with the industry from a technical perspective prior to studies in a Bachelor's Degree Programme. Preferable activities

are i. a. the work on and processing of metallic and non-metallic materials, assembly and maintenance, laboratorial and pilot plant work in the industrial environment. In accordance with this aim, the qualified pre-study industrial placement is ideally completed prior to studies and thus constitutes an admission requirement. As it does not form part of the curriculum and is not supervised by the university, no credit points are awarded.

In **an industry placement** forming part of the degree programme, the technical and methodical competences gained at university level are to be applied to, extended and deepened in an industrial environment within the framework of typical engineering activities. Preferred fields are i. a. development, construction, planning and application technology. Technical laboratories are supervised by the universities as part of the curriculum, are completed by colloquia and are awarded credit points.

3.2 Compulsory Elective Subjects, Fields of Studies and Focal Subjects

In the field of **compulsory elective subjects** there is a clear target orientation for the students for the creation of focal points of studies, which is documented through the stipulation of educational goals. Correspondent exemplary study schedules facilitate the students' orientation. If the students are free to prepare individual study schedules, the university employs means for ensuring a technically sensible composition of the individual schedules in line with the level and intended competence profile of the relevant degree.

The above paragraph applies correspondingly, if **fields of studies or focal subjects** or similar can be chosen.

3.3 Master's degree programmes

The curricula of Master's degree programmes reflect the specific R&D competence of the respective university and consistently operate on Master's level.

Appendix – Exemplary curricular contents

The appendix relating subject-specific criteria (SSC) of the Technical Committee 01 – Mechanical Engineering/Process Engineering takes up learning outcomes and educational objectives for graduates of bachelor and master degree programmes, specified in SSC outlined concerning mechanical, process and chemical engineering. The appendix comprises an exemplary list of curricular contents and possible education and training forms. The following summary should be regarded as orientation for the composition of degree programmes. Its intention is to support higher education institutions in their endeavour to create self-responsibly concrete programme objectives, profile types and forms of particular degree programmes, to underline them with curricular contents and types of adequate education, training and examination. The Technical Committee 01 – Mechanical Engineering/Process Engineering welcomes any innovative development of contents or didactic concepts. Ideally, any chosen forms of learning and teaching aim at cultivating intrinsic motivation of students.

1 General Mechanical Engineering

1.1 Bachelor's degree programmes: mechanical engineering

Subject-related competences	Exemplary curricular contents
Broad and sound knowledge in mathematics and natural sciences applicable to engineering	Mathematical and natural sciences fundamentals, e.g. mathematics, physics, computer science
Advanced knowledge and methodological competence of sub-disciplines of engineering	Engineering fundamentals, e.g. technical mechanics, machine dynamics, vibration theory, fluid mechanics, technical thermodynamics including heat and material transfer, electrical engineering and electronics, materials science, measurement and control engineering
Ability to apply methodological competence of engineering to specific machines and equipment	Engineering applications, e.g. machine engineering, construction/ product development, manufacturing/ production technology
Acquisition and enhancement of specific knowledge in special disciplines of engineering	Advanced subject, focal subject:– electives oriented on fundamentals or application
Transferable competences	Exemplary curricular contents
Ability to evaluate technical products and procedures relating e.g. their economic and ecologic effects	Interdisciplinary content: Economics, non-technical electives (if not integrated already in the curriculum)
Ability to work in national and international teams	Self-, time- and project management, team development, communication, languages (if not integrated already in the curriculum)
Competences in work methodology	Exemplary curricular contents
Knowledge and skill to work independently on scientific tasks in engineering and to present work results	Study projects, bachelor's thesis
Ability of autonomous processing of practical engineering tasks within a professional environment	practical training, professional training

1.2 Master's degree programmes: mechanical engineering, research-oriented

Subject-related competences	Exemplary curricular contents
Advanced knowledge in mathematics, sciences and engineering for the solution of complex tasks	In-depth mathematical, sciences and engineering: mathematical methods, higher mechanics, heat and mass transfer, technical computer science, higher construction theory, tech. physics
Knowledge, skills and methodical competence in engineering for analysis and synthesis of products and systems	in-depth engineering applications: machine theory, production technology, energy technology, process technology, handling technology, materials science, laboratory practicals
Specific knowledge and competence of methods to enhance or broaden topics of engineering science	Advanced subject, focal subject: fundamental electives
Transferable competences	Exemplary curricular contents
Ability to judge and evaluate how engineering problems are dealt with	Interdisciplinary contents: Subjects in the area of economics, non-technical elective subjects, (if not integrated in curriculum in an other way)
Ability to work and communicate confidently in national and international teams	Project management, team development, leadership and facilitation, communication, languages (if not integrated in the curriculum in other way)
Competences in work methodology	Exemplary curricular contents
Knowledge and capacity to work on autonomously research and development tasks using scientific engineering methods, to document them and to present work results	Scientific projects, master thesis
Ability to work practically on demanding engineering tasks in the field of research	Engineering practice: professional placement, if not accomplished already during previous studies

1.3 Master's degree programmes: mechanical engineering, application oriented

Subject-related competences	Exemplary curricular contents
In-depth knowledge in mathematical and scientific areas and in the field of engineering sciences for the solution of complex tasks	In-depths mathematics, sciences and engineering and engineering applications: mathematical methods, higher mechanics, heat and mass transfer, technical computer science, higher construction theory
Knowledge, skills and methodical competence in engineering for analysis and synthesis of products and systems	In-depth engineering application: Motors and machines, laboratory practicals, application oriented elective subject (power engineering, conveyor engineering, logistics, etc.)
Specific knowledge and engineering methods to enhance or broaden topics of engineering science	Advanced subject, focal subject: application oriented electives
Transferable competences	Exemplary curricular contents
Ability to judge and evaluate how engineering problems are dealt with	Interdisciplinary contents: Subjects in the area of economics, non-technical elective subjects, (if not integrated in curriculum in an other way)
Ability to work and communicate confidently in national and international teams	Projekt management, team development, control and moderation, communication, languages (if not integrated in the curriculum in other way)
Competences in work methodology	Exemplary curricular contents
Knowledge and skills to work independently with methods of engineering on application oriented research and development tasks, to document them and to present work results	Scientific projects, master thesis
Knowledge and skills to operate practically on demanding engineering tasks in the professional environment of industry, research institutions or university	Engineering practice: professional placement, if not comprised already in previous studies

2 Process engineering, biological and chemical engineering

2.1 Bachelor's degree programmes: process engineering, biological and chemical engineering

Subject-related competences	Exemplary curricular contents
Broad and sound knowledge in mathematics and natural sciences applicable to engineering	Mathematical and scientific fundamentals, e.g. mathematics, chemistry/biology, physics, computer science
In-depth knowledge and methodological competence of sub-disciplines of engineering	Engineering fundamentals, e.g. technical mechanics, fluid mechanics, technical thermodynamics including caloric and mass transfer, electrical engineering and electronics, materials science, system dynamic range and control engineering
Knowledge and skills in process operations	Subjects of process engineering: reaction technology, fluid and solid materials process engineering, biotechnology, and other topics according to the technical orientation
Ability to apply engineering methods to specific machines and equipment	Engineering applications, e.g. production, process and plant technology, safety engineering, environmental engineering, construction and apparatus engineering, supply and waste technology, CAD/CAE-systems
Acquisition and enhancement of specific knowledge in special disciplines of engineering	Advanced subject, focal subject: basis or application oriented electives
Interdisciplinary competences	Exemplary curricular contents
Ability to evaluate technical products and procedures relating e.g. their economic and ecologic effects	Interdisciplinary contents: Subjects in the area of economics, non-technical elective subjects, (if not already integrated by subjects mentioned before)
Ability to work and communicate in national and international teams	Self-, time- and project management, team development, communication, languages (if not integrated otherwise in the curriculum)
Competences in work methodology	Exemplary curricular contents
Knowledge and skill to work independently on scientific tasks in engineering sciences and to present work results	Studies projects, bachelor's thesis
Ability of autonomous processing of practice tasks in engineering within a professional environment	practical placement, professional practice

2.2 Master's degree programmes: Process engineering, biological and chemical engineering, research oriented

Subject-related competences	Exemplary curricular contents
In-depth knowledge in mathematical and scientific areas and in the field of engineering sciences for the solution of complex tasks	In-depth mathematical, natural and engineering sciences: mathematical methods, heat and mass transfer, technical chemistry/ biology/ physics, technical computer science
Enhanced knowledge, skills and methodical competence in engineering science for analysis and synthesis of process technological products and processes	in-depth engineering applications: separation processing, production technology, energy engineering, process engineering, instruments technology, materials science, laboratory practicals
Specific knowledge and competence of methods to enhance or broaden topics of engineering science	Advanced subject, focal subject: fundamental electives
Transferable competences	Exemplary curricular contents
Ability to judge and evaluate how engineering problems are dealt with	Interdisciplinary education contents: Subjects in the area of economics, non-technical elective subjects, (if not already educated by subjects mentioned before)
Ability to work in national and international teams	Project management, team development, control and moderation, communication, languages (if not integrated in the curriculum in other way)
Competences in work methodology	Exemplary curricular contents
Knowledge and skills to work independently with methods of engineering on research and development tasks, to document them and to present work results	Scientific projects, master thesis
Ability to work practically on demanding engineering tasks in the fields of research	Engineering practice: professional placement, if not comprised already in previous studies

2.3 Master's degree programmes: Process engineering, biological and chemical engineering, practical orientation

Subject related competences	Exemplary curricular contents
In-depth knowledge in mathematical and scientific areas and in the field of engineering sciences for the solution of complex tasks	In-depth mathematical, natural and engineering sciences and applications: mathematical methods, fluid mechanics, technical chemistry/ biology/ physics, caloric and mass transfer, automation and process control, technical computer science
Specific knowledge and skills to apply operations in process engineering	In-depth and broadened process engineering: Unit Operations of chemical, biological, mechanical and thermal process engineering
Knowledge, skills and methodical competence in engineering for analysis and synthesis of products and systems	In-depth engineering applications: system technology, environment and safety engineering, CAD/CAE-systems, process simulation technology, construction and apparatus engineering, plant construction
Specific knowledge and competence of methods to enhance or broaden topics of engineering	Advanced subject, focal subject: application oriented electives
Transferable competences	Exemplary curricular contents
Ability to judge and evaluate how engineering problems are dealt with	Interdisciplinary contents: Subjects in the area of economics, non-technical elective subjects, (if not already educated by subjects mentioned before)
Ability to work and communicate confidently in national and international teams	Project management, team development, control and moderation, communication, languages (if not otherwise integrated in the curriculum)
Competences in work methodology	Exemplary curricular contents
Knowledge and skills to work independently with scientific engineering methods on application oriented research and development tasks, to document them and to present work results	Scientific projects, master thesis
Knowledge and skills to work practically on demanding engineering tasks in professional fields of industry, research institutions or universities	Engineering practice: professional placement, if not comprised already in previous studies