Department Geoenergy

Syllabus of Applied Geoenergy Resources Engineering

Pipeline Engineering

2025-2026

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DEPARTMENT
GEO ENERGY

MONTAN
UNIVERSITÄT
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Contents

Module 1: Basics of Pipeline Engineering & Design Fundamentals

1. Introduction to Pipeline Engineering (4 ECTS)

Course Description

This introductory course provides a comprehensive overview of pipeline engineering, focusing on its historical development, technological advancements, and industry standards. Participants will explore the evolution of pipeline technology, recent innovations, and the core principles that guide the construction, operation, and maintenance of modern pipeline systems. The course covers different pipeline types—such as transmission, distribution, and flow lines—and the classification of pipelines based on fluid type, operational conditions, and specific mechanical and material considerations.

The economic and strategic significance of pipelines within global energy infrastructure will be addressed, and alternatives to transportation methods will be compared. Participants will also gain insight into the various fluids transported through pipelines, including oil, natural gas, water, Hydrogen, and CO_2, and understand the basic design considerations, operational parameters, and construction techniques. Ethics and responsibilities in engineering will be emphasized, focusing on sustainable, safe, and environmentally conscious solutions. This introductory knowledge, paired with practical insights, provides an essential foundation for anyone new to the field of pipeline engineering.

Course Content

1. **Overview of Pipeline Systems**
    - **Historical Context and Evolution**
        - Development of pipeline technology through the ages
        - Key innovations and milestones in pipeline engineering
    - **Technological Advancements**
        - Recent breakthroughs and modern advancements
        - Emerging technologies and future trends
    - **Current Practices and Industry Standards**
        - Modern construction methods
        - Best practices in pipeline operation and maintenance
2. **Core Concepts of Pipeline Engineering**
    - **Pipeline Types and Functions**
        - Transmission, distribution, and flow lines
        - Characteristics and applications of each pipeline type
    - **Components and Classifications**
        - Essential components: pipeline (liner part), stations, terminals, and supervisory & control system
        - Pipeline classification based on fluid type and operational parameters
3. **Economic and Strategic Importance**
    - **Pipelines as Critical Infrastructure**
        - Economic impact and role in global and local economies
        - Integration with other transportation and energy systems
    - **Comparative Analysis**
        - Pipelines versus rail, road, and maritime transport

        - Comparison of transportation cost
        - Benefits and challenges associated with pipelines
4. **Fluids and Pipeline Design**
    - **Types of Fluids Transported**
        - Overview of fluids: oil, natural gas, water, Hydrogen, CO_2, Ammonia
        - Specific requirements and handling considerations for each fluid
    - **Design Considerations**
        - Factors influencing pipeline design: fluid characteristics, environmental conditions
        - System optimization
    - **Materials and Mechanical Design**
        - Selection of materials based on corrosion resistance, strength, and operational demands
        - Mechanical aspects of pipeline design to ensure safety and longevity
5. **System and Route Design**
    - **System Design (Hydraulics and Stations)**
        - Hydraulic calculations, pressure requirements, and station placement
        - Design of pump stations, compressor stations, and storage facilities
        - Introduction to the system optimization process
    - **Route Design (Environmental and Structural Aspects)**
        - Route selection, crossing methods, and environmental impact assessments
        - Considerations for terrain, habitats, and infrastructure crossings
6. **Engineer's Ethics and Responsibilities**
    - **Professional Standards in Pipeline Engineering**
        - Ethical responsibilities in design and decision-making
        - Commitment to safe, sustainable, and environmentally responsible solutions

Learning Outcomes:

By the end of this course, participants will be able to:

- Describe the development of pipeline systems, emphasizing key technological advancements and the importance of following current construction and maintenance standards.
- Differentiate between pipeline types and components, linking their design principles to operational needs.
- Analyze pipelines' economic and strategic value, comparing them with other transport methods and assessing their broader economic impact.
- Evaluate fluid properties and apply appropriate design and material choices to ensure safe, efficient pipeline operation.
- Develop hydraulic design strategies and address environmental and structural considerations in route planning.
- Promote ethical engineering practices, prioritizing safety, sustainability, and responsible project management.

Module 2: Pipeline Materials and Mechanical Design

2.1 Pipeline Materials and Corrosion Protection (3.5 ECTS)

Course Description

This course comprehensively introduces essential materials and corrosion protection strategies in pipeline engineering. Participants will acquire fundamental knowledge of key construction materials, including steel, polymers, plastics, concrete, and advanced composites. Emphasis is placed on these materials' properties, applications, and selection criteria, such as strength, durability, corrosion resistance, and cost-effectiveness. The course also covers manufacturing techniques, joining technologies, and factors influencing material selection for optimal pipeline performance.

In addition, the course addresses the core principles of corrosion mechanisms and the methods used to protect pipelines from corrosion damage, including selecting adequate line pipe material. Various corrosion protection methods—such as protective coatings, cathodic protection, and corrosion inhibitors—are explored, along with practical approaches to corrosion surveillance, inspection techniques, and management strategies.

Course Content

1. **Introduction to Pipeline Materials**
    - Overview of materials used in pipeline engineering
    - Key considerations for material selection: strength, durability, corrosion resistance, cost, and environmental impact
2. **Types of Pipeline Materials**
    - Steel Pipelines: Types of steel (carbon steel, stainless steel, alloy steel), properties, advantages, and limitations
    - Plastic Pipelines: Types of plastics (PVC, HDPE, PP), suitability for various applications (water, gas, chemicals)
    - Concrete Pipelines: Types, properties, applications, and maintenance considerations
    - Advanced and Composite Materials: Overview of modern materials (fiberglass, composites), their applications, and benefits
3. **Manufacturing Technologies for Pipeline Materials**
    - Steel Pipe Manufacturing: Seamless and welded pipe production, rolling processes, quality control
    - Plastic and Concrete Pipe Manufacturing: Extrusion, molding, casting techniques, durability considerations
4. **Joining Technologies in Pipeline Construction**
    - Welding: Types (butt welding, arc welding), procedures, and quality assurance
    - Mechanical Joints: Flanges, couplings, and their applications for different materials
    - Adhesive Bonding: Techniques for plastic and composite pipelines, including solvent welding
5. **Introduction to Corrosion in Pipeline Systems**
    - Overview of corrosion and its impact on pipeline integrity

- Importance of corrosion management in ensuring pipeline safety

6. **Corrosion Mechanisms**
   - Chemical and electrochemical processes causing corrosion
   - Types of corrosion relevant to pipelines: uniform, pitting, crevice corrosion, and stress corrosion cracking
7. **Corrosion Protection Techniques**
   - Protective Coatings: Types (fusion-bonded epoxy, polyethylene), application methods, selection criteria, and joint coating methods.
   - Cathodic Protection (CP): Principles, types (sacrificial anode, impressed current), design, and maintenance
   - Corrosion Inhibitors: Types, mechanisms, application methods, and environmental considerations
8. **Surveillance and Inspection Basics**
   - Overview of corrosion surveillance and inspection methods
   - In-line inspection (ILI) tools and pigging for corrosion detection
   - Basic principles of corrosion monitoring and data analysis

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the properties, applications, and selection criteria of different pipeline materials.
- Recognize key manufacturing and joining techniques for pipeline materials and their impact on quality and performance.
- Explain the fundamental mechanisms of corrosion and their effects on pipeline integrity.
- Identify and apply various corrosion protection techniques, including protective coatings, cathodic protection, and corrosion inhibitors.
- Utilize surveillance and inspection methods to detect and manage corrosion in pipeline systems.
- Integrate material selection with corrosion management strategies to ensure long-term pipeline safety and performance.

2.2 Pipeline Structural Design (3 ECTS)

Course Description

This course covers the fundamental principles of pipeline structural design, emphasizing critical concepts such as design pressures, Maximum Allowable Operating Pressure (MAOP), wall thickness determination, and stress and flexibility analysis. Participants will learn to calculate and evaluate design pressures, considering fluid types, operational conditions, and safety margins. The course also explores MAOP calculations, which are essential for maintaining safe pipeline operations across diverse pressures and environments.

Additionally, the program delves into the methodologies for determining appropriate wall thickness, considering design codes, material properties, and safety factors to ensure the integrity and reliability of pipelines. By integrating stress and flexibility considerations, this course equips participants to manage structural demands due to thermal expansion, external loads, and pressure variations. Through theoretical knowledge and practical applications, participants gain foundational skills to design structurally sound and safe pipelines.

Course Content

1. **Introduction to Pipeline Structural Design**
    - Overview of pipeline structural design principles
    - Importance of structural integrity in pipeline engineering
    - Key design codes and standards (e.g., ASME, API, ISO)
2. **Design Pressures in Pipeline Systems**
    - Definition and types of design pressures (internal, external)
    - Calculating design pressure based on fluid type, temperature, and flow conditions
    - Selection of the most suitable design pressure level as part of the system optimization process
    - Considerations for transient pressures (e.g., surges, water hammer)
    - Safety factors and margins in design pressure determination
3. **Maximum Allowable Operating Pressure (MAOP)**
    - Definition and significance of MAOP in pipeline design
    - Regulatory requirements and standards for determining MAOP
    - Factors affecting MAOP: material strength, pipe dimensions, temperature, and environmental conditions
    - Calculating MAOP for various pipeline systems
    - Impact of MAOP on pipeline safety and operational efficiency
4. **Wall Thickness Determination**
    - Principles of wall thickness design for pipelines
    - Factors influencing wall thickness: design pressure, diameter, material grade, corrosion allowance, and external loads
    - Calculation methods for wall thickness based on design codes (e.g., ASME B31.4, ASME B31.8)
    - Designing for internal and external pressures, bending, and buckling
    - Considerations for buried and above-ground pipelines
5. **Pipeline Material Strength and Properties**
    - Material properties affecting pipeline structural design (yield strength, tensile strength, toughness)
    - Selection of appropriate materials based on design requirements
    - Relationship between material strength, design pressure, and wall thickness
6. **Load Analysis, Stress, and Flexibility**
    - Types of loads affecting pipelines (internal pressure, external pressure, thermal expansion, soil loads)
    - Stress analysis and flexibility for different loading conditions
    - Methods for analyzing stress concentrations, fatigue, and fracture mechanics
7. **Safety, Reliability, and Compliance**

- Ensuring compliance with safety regulations and industry standards
- Approaches to designing safe and reliable pipelines
- Incorporating safety factors and redundancy into structural design

Learning Outcomes

By the end of this course, participants will be able to:

- Understand and apply the fundamental principles of pipeline structural design.
- Calculate and assess design pressures for various pipeline applications based on operational parameters.
- Determine Maximum Allowable Operating Pressure (MAOP) in compliance with regulatory standards and safety considerations.
- Consider design codes, safety factors, and environmental conditions to determine appropriate pipeline wall thickness.
- Analyze load and combined stresses affecting pipelines and apply stress and flexibility analysis techniques to ensure structural integrity.
- Evaluate and ensure compliance with industry codes and standards, integrating safety factors into structural design.
- Develop and apply best pipeline safety, reliability, and integrity management practices.

Module 3: Pipeline Routing and Civil Design

3.1 Pipeline Routing and Alignment Design (2 ECTS)

Course Description

This course provides a thorough overview of the principles and methodologies involved in pipeline routing and alignment design. Participants will learn to strategically plan pipeline routes, considering environmental, geographical, and infrastructural considerations. Emphasis is placed on optimizing route selection to reduce environmental disruption and construction challenges while ensuring compliance with regulatory standards. Through integrating civil design concepts and case study analysis, participants will gain practical skills in designing efficient and sustainable pipeline routes.

Course Content

1. **Introduction to Pipeline Routing and Alignment Design**
    - Overview of routing and alignment principles
    - Importance of alignment in pipeline engineering
2. **Route Selection Criteria**
    - Environmental, topographical, and socio-economic factors
    - Methods for assessing and mitigating environmental impact
    - Navigating geographical constraints (e.g., mountains, rivers, urban areas)
    - Longitudinal profile on the hydraulic location of stations (Effect on system design)
3. **Alignment Design Techniques**
    - Principles of optimal alignment for pipeline efficiency
    - Minimizing construction challenges and environmental impact
    - Use of Geographic Information Systems (GIS) in planning
4. **Crossings and Interactions with Infrastructure**
    - Design considerations for crossings (roads, railways, waterways), including open-cut and trenchless construction methods (horizontal direction drilling, micro tunnels, and tunnels)
    - Coordinating pipeline routes with existing infrastructure
    - Strategies for mitigating conflicts and disruptions
5. **Regulatory Compliance and Standards**
    - Overview of relevant regulatory requirements and standards
    - Ensuring adherence to regulations
    - Documentation and reporting practices
    - Documentation of the Route, Maps, and Alignment Sheets
6. **Acquiring the pipelines, the Routes**
    - Permit Engineering
    - Stakeholder Management
    - Right of Way Acquisition

Learning Outcomes

By the end of this course, participants will be able to:

- Apply principles of pipeline routing and alignment design to optimize installation and operational efficiency.
- Evaluate and address environmental, geographical, and infrastructural factors impacting pipeline routing.
- Implement alignment design techniques and utilize GIS tools for efficient route planning.
- Design safe infrastructure crossings and coordinate with existing infrastructure to minimize conflicts.
- Ensure adherence to regulatory standards and best practices in pipeline routing.

3.2 Civil Design and Infrastructure for Pipelines (2ECTS)

Course Description

This course focuses on the geotechnical aspects critical to pipeline engineering, covering the interaction between pipelines as well as related facilities (like tanks) and the ground on which they are placed or in which they are buried. Participants will study soil and rock mechanics, site investigation techniques, and the impact of geotechnical factors on pipeline stability and performance. The course highlights methods for assessing ground conditions, designing foundations and supports, and mitigating geotechnical risks. Emphasis is placed on practical applications and regulatory considerations to ensure safe and effective pipeline construction and operation.

Course Content

1. **Introduction to Geotechnical Considerations for Pipelines**
    - Overview of geotechnical engineering in pipeline projects
    - Importance of understanding soil and rock properties
    - Integration of pipeline design with construction ability (steep slopes, swamps, sand dunes, etc.)
2. **Soil and Rock Mechanics**
    - Properties of soils and rocks relevant to pipeline engineering
    - Methods for soil and rock testing
    - Analysis of soil behavior and load-bearing capacity
3. **Site Investigation and Assessment**
    - Techniques for site investigation and ground condition assessment
    - Use of geotechnical data in pipeline design
    - Analyzing ground conditions and their impact on pipeline stability, especially in side hill sections
    - Checking groundwater level

- Checking the suitability of the ground/soil for bedding of the pipelines

4. **Foundation and Support Design**
    - Design principles for pipeline foundations and supports
    - Types of foundations (e.g., spread footings, piles, mat foundations)
    - Techniques for improving soil conditions and supporting pipelines
5. **Geotechnical Risks and Mitigation**
    - Identifying and assessing geotechnical risks in geohazards (e.g., faults/ earthquakes, settlement, soil liquefaction)
    - Methods for mitigating risks and ensuring pipeline stability
    - Design and construction techniques to address challenging ground conditions
6. **Regulatory Compliance and Standards**
    - Overview of geotechnical regulations and standards for pipelines
    - Ensuring compliance with local, national, and international guidelines
    - Documentation and reporting requirements
7. **Civil Design Part of Pipeline Engineering**
    - Civil design for tank farms, tank foundations
    - Civil design for jetties and marine facilities
    - Civil design for pipeline crossings, including open cut, HDD (horizontal directional drilling), micro tunnels, tunnels
    - Civil design for stations, including buildings and shelters
    - Equipment foundations
    - Piling
    - Protective measures for pipelines against erosion

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the critical geotechnical considerations in pipeline engineering and their impact on design and construction.
- Assess soil and rock properties using various testing methods and analyze their implications for pipeline stability.
- Conduct site investigations and incorporated geotechnical data into pipeline design and construction plans.
- Identify and mitigate geotechnical risks to ensure the stability and safety of pipeline systems.
- Ensure compliance with geotechnical regulations and standards and effectively document and report findings.
- Understand and apply the knowledge for the civil design part of pipeline projects.

Module 4: Pipeline System Design

4.1 Pipeline Thermodynamics, Energy Efficiency, and System Optimization (3 ECTS)

Course Description

This course concisely introduces the principles of thermodynamics, energy efficiency, and system optimization specifically tailored for pipeline systems. It aims to equip participants with the essential knowledge and skills to analyze pipeline performance, minimize energy consumption, and optimize system operations. Key topics include fluid flow dynamics, heat transfer, pressure management, and practical approaches to optimizing pipeline systems for energy efficiency. This course suits professionals and participants who need a foundational understanding of thermodynamics and optimization in pipeline system design.

Course Content

1. **Introduction to Thermodynamics in Pipeline Systems**
    - Basic principles: First and second laws of thermodynamics
    - Application of thermodynamic principles to fluid flow in pipelines
2. **Fundamentals of Fluid Flow in Pipelines/ Hydraulics**
    - Overview of fluid flow types: laminar and turbulent
    - Key factors affecting fluid flow in pipelines, including pressure and velocity
    - Simplified Bernoulli's equation for pipeline design
3. **Heat Transfer and Energy Loss in Pipelines**
    - Basics of heat transfer mechanisms (conduction and convection) relevant to pipelines
    - Strategies to minimize heat loss, including insulation techniques
    - Impact of Temperature on fluid properties and flow efficiency
4. **Pressure Management and Energy Efficiency**
    - Calculating pressure drops due to friction and fittings
    - Basic techniques for managing pressure within operational limits
    - Introduction to energy efficiency in pipeline operation, focusing on pump and compressor optimization
5. **Introduction to Pipeline Design**
    - Basic operation covering preselection of diameter, modeling, sensitivity analysis, considering the imponderables, selection of the optimum solution
    - Introduction to software tools and models for pipeline optimization

Learning Outcomes

By the end of this course, participants will be able to:

- Understand fundamental thermodynamic principles relevant to pipeline systems.
- Analyze basic fluid flow and heat transfer dynamics in pipelines.
- Perform hydraulic calculations
- Understand the basic approach to pipeline system optimization

4.2 Pipeline System Modeling (Hydraulic, Thermal, Dynamic) (3 ECTS)

Course Description

This course introduces the fundamentals of modeling pipeline systems, focusing on hydraulic, thermal, and dynamic aspects. Participants will learn essential concepts and techniques for creating and analyzing models that represent the behavior and performance of pipeline systems under various operating conditions. The course covers steady-state and transient flow modeling, thermal modeling for heat transfer analysis, and dynamic modeling for understanding fluid behavior under different pressures and flow rates. The goal is to provide participants with practical skills in using simulation tools and interpreting modeling results to optimize pipeline design and operation.

Course Content

1. **Introduction to Pipeline System Modeling**
    - Overview of modeling in pipeline system design
    - Importance of hydraulic, thermal, and dynamic modeling
    - Key assumptions and limitations in modeling approaches
2. **Fundamentals of Hydraulic Modeling**
    - Basics of fluid mechanics applied to pipeline systems
    - Steady-state hydraulic modeling: Bernoulli's equation and Darcy-Weisbach equation
    - Pressure loss calculations and flow rate analysis in pipelines
    - Introduction to hydraulic simulation tools
3. **Thermal Modeling of Pipelines**
    - Basics of heat transfer (conduction, convection) in pipeline systems
    - Thermal gradients and their impact on fluid properties and pipeline integrity
    - Simple thermal modeling techniques for steady-state heat transfer
    - Thermal insulation and its effect on energy efficiency
4. **Dynamic Modeling of Pipeline Systems**
    - Understanding transient flow conditions: surge, water hammer, and slugging
    - Introduction to dynamic modeling and analysis of transient phenomena
    - Tools and software for dynamic simulation
    - Basic case studies of dynamic events in pipeline systems
5. **Integration of Hydraulic, Thermal, and Dynamic Models**
    - Combining hydraulic, thermal, and dynamic aspects for comprehensive modeling
    - Introduction to coupled simulations and multi-physics modeling
    - Applications of integrated modeling for system optimization

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the fundamental principles of hydraulic, thermal, and dynamic modeling for pipeline systems.

- Apply basic hydraulic models to analyze flow rates, pressure losses, and pipeline efficiency.
- Use introductory thermal modeling techniques to assess pipeline heat transfer and temperature distribution.
- Conduct simple dynamic modeling to evaluate transient flow phenomena and their effects on pipeline operations.
- Integrate different modeling approaches to develop a comprehensive understanding of pipeline system behavior.
- Understand and apply cost modeling.

4.3 Optimal Pipeline System Design: Safety, Risk, Economics, and Sustainability (2.5 ECTS)

Course Description

This course explores optimal pipeline system design in-depth, focusing on creating safe, economically viable, and sustainable solutions. Using an integrated approach, participants will learn to balance critical factors—safety, risk, economic considerations, and environmental impact. The course covers industry standards and regulatory frameworks that shape pipeline design and highlights essential methods for hazard identification, risk management, and economic analysis. Emphasis is placed on sustainable practices, including material selection, energy efficiency, and environmental impact assessments. Mastering these multidisciplinary concepts will equip participants to design pipeline systems prioritizing safety, cost-effectiveness, and environmental responsibility.

Course Content

1. **Introduction to Optimal Pipeline System Design**
    - Key principles of optimal pipeline design, definition of the extended optimum
    - Balancing safety, risk, economics, and sustainability in selecting the optimum solution
2. **Safety and Risk Assessment in Pipeline Design**
    - Identification and assessment of potential hazards in pipeline systems
    - Risk of innovative solutions
    - Risk connected to constructability
    - Risk management techniques (qualitative and quantitative risk assessment)
    - Integrating safety considerations into the design phase, performing HAZID and HAZOP studies
    - Introduction to software tools for risk analysis and safety simulation
3. **Economic Evaluation of Pipeline Systems**
    - Fundamentals of economic analysis, including cost estimation, lifecycle cost analysis, and cost-benefit analysis specific to pipeline systems.
    - Application of cost modeling techniques to compute and evaluate pipeline project expenses, including capital, operational, and maintenance costs.

    - Conducting sensitivity analysis to assess the impact of various factors (e.g., market conditions, regulatory changes) on the economic viability of pipeline projects.
    - Case studies on economic decision-making in pipeline projects
4. **Sustainability in Pipeline Design**
    - Understanding environmental impact: emissions, leaks, and land use
    - Sustainable design practices: material selection, energy efficiency, and waste management
    - Introduction to environmental impact assessments (EIA) for pipeline projects
    - Incorporating renewable energy and green technologies in pipeline systems
5. **Integrated Design Approach: Safety, Risk, Economics, and Sustainability**
    - Multi-criteria decision analysis for balancing safety, risk, economics, and sustainability
    - Optimizing pipeline design for minimal environmental footprint and maximum safety
    - Best practices for sustainable and resilient pipeline systems
    - Tools and frameworks for integrated design evaluation

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the key principles and considerations for optimal pipeline system design.
- Understand the meaning of the extended optimum and how to balance the various criteria.
- Perform basic safety and risk assessments and incorporate them into the design process.
- Conduct economic evaluations of pipeline systems to determine cost-effective design solutions.
- Apply sustainable practices in pipeline design to minimize environmental impact.
- Integrate safety, risk, economic, and sustainability aspects into a holistic design approach.

4.4 Pipeline Project Management (3 ECTS)

Course Description

This course introduces the fundamental principles and practices of project management specifically tailored for pipeline projects. It covers critical aspects from initiation to closure, including planning, scheduling, cost management, risk analysis, quality control, and stakeholder management. In addition, the course addresses key execution and control aspects, ensuring that projects are completed on time, within budget, and meet the required quality standards. Special emphasis is placed on the unique challenges of pipeline projects, such as regulatory compliance, environmental considerations, and cross-disciplinary coordination.

Course Content

1. **Introduction to Pipeline Project Management**
    - Overview of project management in the context of pipeline projects
    - Key phases of the pipeline project lifecycle: initiation, planning, execution, monitoring, and closure
    - Importance of integrating technical, financial, and environmental considerations in project management
    - Establish a Project Management organization
2. **Project Planning and Scheduling for Pipeline Projects**
    - Development of project scope and objectives
    - Work Breakdown Structure (WBS) and Gantt charts for pipeline project scheduling
    - Critical Path Method (CPM) and Program Evaluation and Review Technique for pipeline projects
    - Resource allocation and management in pipeline projects
3. **Cost Management and Budgeting**
    - Cost estimation techniques for pipeline projects: direct and indirect costs
    - Budgeting and financial planning for pipeline project phases
    - Cost control techniques: Earned Value Management (EVM) and cost variance analysis
    - Case studies on budget overruns and cost optimization strategies
4. **Risk Management in Pipeline Projects**
    - Identifying potential risks in pipeline projects: technical, environmental, and financial risks
    - Qualitative and quantitative risk analysis methods
    - Risk mitigation and contingency planning
    - Application of risk management tools and software
5. **Quality Management and Compliance**
    - Quality assurance and quality control (QA/QC) in pipeline projects
    - Design vetting
    - Regulatory compliance and standards for pipeline construction and operation
    - Inspection, testing, and auditing processes to ensure quality
    - Case studies on quality failures and lessons learned
6. **Stakeholder Management and Communication**
    - Identifying and managing stakeholders: internal and external stakeholders
    - Effective communication strategies and conflict resolution
    - Collaboration and coordination across multidisciplinary teams
    - Managing community relations and public perception in pipeline projects
7. **Project Execution, Control, and Reporting**
    - Strategies for effective control during the project execution phase
    - Frameworks and best practices for regular reporting and decision-making
    - Methods to measure progress, including the application of PoC AWP techniques
    - Approaches for managing plant and operational data efficiently
    - Document Management: Best practices for maintaining and controlling project documentation

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the fundamental principles and processes of project management in pipeline projects.
- Develop and manage project schedules, budgets, and resources effectively.
- Perform risk assessments and implement risk management strategies for pipeline projects.
- Ensure quality management and regulatory compliance in all phases of pipeline projects.
- Manage stakeholders and communicate effectively to achieve project objectives.
- Effectively apply execution control, reporting, and progress measurement techniques while managing plant data and project documentation efficiently.

Module 5: Pipeline Station Design and Equipment Selection

5.1 Pipeline Pumping & Compressor Stations Design (3 ECTS)

Course Description

This course offers a comprehensive overview of the design, equipment selection, and operation of pumping and compressor stations within pipeline systems. It focuses on key components, including pumps, compressors, and drivers, such as electric motors, gas turbines, and diesel engines. Participants will explore hydraulic and compressor station design principles for natural gas and Hydrogen, performance optimization, and system integration.

Participants will gain foundational knowledge of pump and compressor types, selection criteria based on fluid or gas properties, and engineering considerations for ensuring system reliability and efficiency. The course emphasizes real-world applications, covering pipeline station design, operation, maintenance, and strategies for addressing operational challenges.

Course Content

1. **Introduction to Pumping Stations and Hydraulic Design**
    - Overview of pumping stations and their role in pipeline systems.
    - Components of a pumping station: pumps, drivers, piping, valves, and controls.
    - Design considerations for various pipeline types (oil, gas, water, CO2, H2, etc.).
    - Principles of fluid dynamics and hydraulics relevant to pumping station design.
    - Calculating head loss, flow rates, and pressure requirements.

2. **Pumps: Types, Selection, and Performance**
    - Overview of pump types used in pipeline systems: centrifugal, reciprocating, screw, and diaphragm pumps.
    - Selection criteria based on fluid type, flow rate, pressure, and efficiency requirements.
    - Understanding pump performance curves and their implications for system design.
    - Considerations for pump sizing, cavitation, and net positive suction head (NPSH).

3. **Pump Drivers and Auxiliary Equipment**
    - Types of pump drivers: electric motors, gas turbines, and diesel engines.
    - Selection criteria based on operational requirements, fuel availability, and cost.
    - Overview of control and relief valves, SLOP systems, pigging facilities, and flowmeters.
    - Integration of pumps and drivers for optimal performance and reliability.
    - Energy supply system (electrical and Natural gas)

4. **Operation, Maintenance, and Design Documentation**
    - Basics of control systems and instrumentation for pumping stations.

- Common operational challenges: pressure surges, pipeline pigging, and leak detection.
- Maintenance strategies to ensure reliability and extend equipment life.
- Energy efficiency optimization and performance monitoring of pumps and drivers.
- Design documentation, including process and instrument diagrams (P&ID), plot plans, single-line diagrams, and equipment specifications.

5. **Introduction to Compressor Stations and Design Principles**
   - Role and importance of compressor stations in gas pipeline networks.
   - Key components: compressors, drivers, coolers, piping, and control systems.
   - Basic design considerations: pressure requirements, station layout, and environmental factors.
   - Overview of compressor types: centrifugal, reciprocating, screw, and axial compressors.

6. **Compressor Selection and Drivers**
   - Selection criteria based on gas type, flow rate, pressure ratio, and energy efficiency.
   - Understanding compressor performance curves and maps.
   - Types of drivers for compressors: gas turbines, electric motors, and diesel engines.
   - Criteria for selecting drivers: operational flexibility, fuel availability, efficiency, and cost.
   - Energy supply system (electrical power, natural gas, Hydrogen)

7. **Operation, Maintenance, and Auxiliary Equipment**
   - Basic compressor station operation principles include safety, control, and instrumentation.
   - Key operational challenges: pressure management, noise reduction, vibration control, and leak detection (methane).
   - Maintenance strategies for different types of compressors and drivers.
   - Overview of auxiliary equipment: filter separators and coolers.

8. **Design Documentation and Reliability**
   - Design documentation includes process and instrument diagrams (P&ID), plot plans, equipment specifications, and single-line diagrams.
   - Reliability-centered maintenance (RCM) and condition-based monitoring.
   - Common failure modes and troubleshooting techniques.
   - Ensuring safe operation and compliance with industry standards.

Learning Outcomes

By the end of the course, participants will be able to:

- Understand the design principles and operational requirements of pumping stations within pipeline systems.

- Select and specify pumps and drivers based on hydraulic, operational, and economic criteria.
- Analyze pump performance curves and assess their implications for system design.
- Develop strategies for efficiently operating, controlling, and maintaining pumping stations.
- Comprehend compressor station design principles and operational requirements in gas pipeline systems.
- Choose appropriate compressors and drivers based on gas properties, operational needs, and economic factors.
- Interpret compressor performance curves and apply this knowledge to system design and optimization.
- Formulate strategies for the safe and efficient operation and maintenance of compressor stations.

5.2 Pipeline Station and Terminal Design: Tanks, Loading Facilities, Pressure Management, and Metering (3 ECTS)

Course Description

This course explores pipeline stations and terminals' design, operation, and management, focusing on storage tanks, loading facilities, pressure management, and metering systems. It covers essential principles of tank farm design, including safety and environmental considerations, and specialized pipeline stations such as pressure reduction, pressure relief, and branch-off stations. The course provides a comprehensive understanding of equipment selection, safety standards, automation, and integration of these systems into a functioning pipeline network. It is tailored for pipeline engineering participants and professionals designing, operating, and managing tank farms and specialized pipeline stations.

Course Content

1. **Introduction to Tank Farms, Terminals, and Specialized Pipeline Stations**
    - Overview of tank farms and terminals in pipeline operations.
    - Functions of specialized stations: pressure reduction, pressure relief, metering, and branch-off.
    - Key design challenges and considerations for integration into pipeline systems.
2. **Storage Tanks: Types and Design Principles**
    - Types of storage tanks: fixed roof, floating roof, bullet, and sphere tanks.
    - Selection criteria based on the stored product (e.g., crude oil, chemicals).
    - Design considerations: capacity, material selection, safety features, and structural integrity.
    - Design of the tank foundation
3. **Loading and Unloading Facilities Design**
    - Design of loading/unloading systems: truck, rail, ship, and pipeline connections.

    - Integration of loading facilities with tank farms for seamless operations.
    - Safety and control devices for loading/unloading processes, including metering and vapor recovery systems.
4. **Pressure Reduction and Pressure Relief Station Design**
    - Principles of pressure reduction and overpressure protection in pipeline systems.
    - Design of pressure reduction stations: control valves, regulators, and surge protection.
    - Pressure relief devices: safety valves, rupture discs, and design standards for set pressure and relief capacity.
5. **Metering Stations: Accuracy and Design Considerations**
    - Types of flow meters: ultrasonic, turbine, Coriolis, and differential pressure meters.
    - Design criteria for metering stations: accuracy, repeatability, and calibration.
    - Integration of metering data with SCADA systems for real-time monitoring and control.
6. **Branch-Off Stations: Design and Integration**
    - Function of branch-off stations: connection to lateral pipelines and distribution points.
    - Design considerations: valve selection, flow control, and hydraulic analysis.
    - Operational challenges: flow balancing, pigging, and maintenance access.
7. **Safety, Environmental, and Automation Systems**
    - Risk assessment and hazard analysis in tank farms and specialized stations.
    - Compliance with industry safety standards (API, NFPA) and environmental regulations.
    - Automation and control systems: SCADA, DCS, and inventory management for operational efficiency.

Learning Outcomes

By the end of the course, participants will be able to:

- Understand the design and operational principles of tank farms, terminals, and specialized pipeline stations.
- Select and specify appropriate storage tanks, loading facilities, and specialized pipeline equipment.
- Design pressure reduction, pressure relief, and metering stations, incorporating safety and regulatory standards.
- Integrate automation and control systems to efficiently manage and monitor pipeline stations and terminals.
- Apply environmental and safety considerations to the design and operation of tank farms and specialized stations.

5.3 Stations for Underground Storage: Design and Equipment (2 ECTS)

Course Description

This course provides an in-depth understanding of the design, operation, and equipment used in stations for underground storage, such as those used for natural gas, oil, or other fluids like Hydrogen and CO2. It covers underground storage facility design principles, including storage cavern construction, pressure management, and the selection of associated equipment. The course also explores the safety, operational, and environmental considerations essential for effectively managing underground storage stations. This course is tailored for participants and professionals in pipeline and storage engineering who seek to understand the complexities of underground storage systems.

Course Content

1. **Introduction to Underground Storage Stations**
    - Overview of underground storage facilities and their role in energy and fluid management
    - Types of underground storage: depleted oil and gas fields, salt caverns, rock caverns (lined and unlined)and aquifers
    - Key design considerations: geological, hydrological, and environmental factors
2. **Design Principles for Underground Storage Facilities**
    - Geological and geotechnical considerations for selecting storage sites
    - Design of storage caverns: construction methods, stability analysis, and sealing techniques
    - Pressure management and control systems for maintaining storage integrity
    - Integration of storage facilities with surface infrastructure
3. **Design of the stations (above-ground facilities (PSIDs)**
    - For crude oil, Hydrogen, natural gas, and CO2
4. **Equipment for Underground Storage Stations**
    - Overview of equipment used in underground storage: compressors, pumps, and wellheads
    - Selection criteria for equipment based on storage type and operational requirements
    - Safety and control systems: monitoring, pressure relief, and emergency shutdown mechanisms
    - Maintenance and reliability considerations for underground storage equipment
5. **Safety and Environmental Considerations**
    - Safety standards and regulatory requirements for underground storage facilities
    - Risk assessment and hazard analysis: potential leaks, pressure management, and environmental impacts
    - Environmental impact mitigation strategies: leak detection systems, groundwater protection, and emission controls
    - Emergency response planning and crisis management
6. **Operational Management and Optimization**
    - Best practices for the operation of underground storage stations: operational procedures, monitoring, and control
    - Optimization of storage cycles: injection and withdrawal strategies

- Data management and integration with pipeline systems for efficient storage management
- Case studies on successful and challenging underground storage operations

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the fundamental principles and design considerations for underground storage stations.
- Select and integrate equipment for underground storage, ensuring safety and operational efficiency.
- Address safety, environmental, and regulatory requirements in the design and operation of storage stations.

Module 6: Pipeline Instrumentation, Automation, and Control Systems

6.1 Fundamentals of Pipeline Instrumentation (3 ECTS)

Course Description

This course comprehensively introduces pipeline instrumentation principles, technologies, and applications. It covers the essential concepts and components of pipeline monitoring and control systems, including sensors, transmitters, and control devices. The course explores the fundamentals of instrumentation, automation, and control systems used in pipeline operations, emphasizing practical applications, accuracy, and reliability. Designed for participants and professionals in pipeline engineering, this course aims to equip learners with the knowledge and skills required for effective instrumentation and automation, including safeguarding equipment in pipeline systems.

Course Content

1. **Introduction to Pipeline Instrumentation**
    - Overview of pipeline instrumentation and its role in pipeline systems
    - Types of instrumentation used in pipelines: sensors, transmitters, controllers, and actuators
    - Basic principles of measurement and control in pipeline operations
2. **Sensors and Transmitters**
    - Types of sensors used in pipelines: pressure, temperature, flow, media/product quality analyzer, and level sensors
    - Working principles of different types of sensors and their applications
    - Calibration, installation, and maintenance of sensors
    - Transmitters: signal conditioning, transmission protocols, and integration with control systems
3. **Control Devices and Automation Systems**
    - Overview of control devices: control valves, actuators, and relays
    - Introduction to automation systems: PLCs (Programmable Logic Controllers), DCS (Distributed Control Systems), and SIS (safety instrumented Systems)
    - Control strategies: PID control, on/off control, and feedforward control
    - Integration of control devices and automation systems in pipeline operations
4. **Data Acquisition and Monitoring**
    - Fundamentals of data acquisition systems and their role in pipeline instrumentation
    - Data logging, visualization, and analysis techniques
    - Real-time monitoring and alarms for operational safety and efficiency
    - Use of SCADA (Supervisory Control and Data Acquisition) systems in pipeline management
5. **Instrumentation for Pipeline Safety and Efficiency**
    - Safety instrumentation: emergency shutdown systems, overpressure protection, and leak detection

- Enhancing pipeline efficiency through instrumentation: flow optimization, leak detection, and energy management
- Best practices for instrumentation design and implementation to ensure reliability and accuracy

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the fundamental principles and components of pipeline instrumentation.
- Select and implement appropriate sensors, transmitters, and control devices for pipeline monitoring and control.
- Design and configure automation systems, including PLCs and DCS, for pipeline operations.
- Utilize data acquisition and monitoring techniques to enhance pipeline safety and efficiency.

6.2 Automation and Control Systems (2 ECTS)

Course Description

This course provides an essential introduction to automation and control systems specifically tailored for pipeline engineering applications. It covers the fundamental concepts and technologies used in the automation of pipeline operations, including Programmable Logic Controllers (PLCs), Distributed Control Systems (DCS), and other control technologies. Participants will learn about designing, implementing, and optimizing control systems for managing pipeline processes, such as flow control, pressure regulation, and safety monitoring. This course will equip pipeline engineers with the practical skills and knowledge necessary for effective automation and control in pipeline systems.

Course Content

1. **Introduction to Pipeline Automation and Control Systems**
   - Overview of automation and control systems in pipeline engineering
   - Key components: sensors, actuators, controllers, and communication systems
   - Principles of pipeline process control and automation
2. **Programmable Logic Controllers (PLCs) for Pipeline Systems**
   - Introduction to PLCs: structure, operation, and programming specific to pipelines
   - PLC programming languages: Ladder Logic, Function Block Diagram, and Structured Text
   - Design and implementation of PLC-based control systems for pipeline operations
   - Troubleshooting and maintenance of PLCs in pipeline contexts

3. **Distributed Control Systems (DCS) in Pipeline Applications**
    - Overview of DCS: architecture, components, and functionalities relevant to pipelines
    - Comparison between PLCs and DCS for pipeline control
    - Configuration and programming of DCS for pipeline process control
    - Integration of DCS with field devices and monitoring systems
4. **Control Strategies and Techniques for Pipelines**
    - Basic and advanced control strategies: On/Off, Proportional-Integral-Derivative (PID), and Model Predictive Control (MPC)
    - Application of control strategies in managing pipeline flow, pressure, and temperature
    - Optimization and tuning of control loops specific to pipeline systems
5. **Automation Systems Integration and Communication**
    - Integration of control systems with pipeline management systems: SCADA and telemetry
    - Communication protocols and networks used in pipeline automation: Modbus, Profibus, and Ethernet
    - Data acquisition, visualization, and monitoring for pipeline operations
    - Best practices for system integration and ensuring reliable communication
    - Safety Integreity Lever (SIL) rating and its implantation.

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the principles and components of automation and control systems specific to pipeline engineering.
- Design, program, and implement PLC-based control systems for pipeline operations.
- Configure and use DCS for complex pipeline process control and monitoring.
- Apply various control strategies and techniques to optimize pipeline system performance.
- Integrate automation systems with pipeline management and communication networks effectively.

Module 7: Applied Pipeline Engineering

7.1 Crude Oil and Natural Gas Product Pipeline Systems (3ECTS)

Course Description

This course provides a comprehensive overview of the design, operation, and management of crude oil, refined products, and natural gas pipeline systems. It covers essential principles and practices for transporting crude oil, petroleum products, and natural gas, focusing on pipeline design, material selection, compression, storage, and operational safety. Participants will gain practical insights into the challenges and solutions associated with liquid and gas pipeline systems. This course is designed for pipeline engineering participants and professionals, equipping them with the fundamental knowledge needed for effective pipeline system management.

Course Content

1. **Introduction to Crude Oil and Product Pipelines**
    - Overview of crude oil and product pipelines: Purpose and significance in the energy sector.
    - Types of pipelines: Crude oil pipelines and refined product pipelines.
    - Key components of pipeline systems: Pipeline segments, stations, tank farms, and terminals.
2. **Pipeline Design for Crude Oil and Products**
    - Design considerations: Flow rates, pressure requirements, and temperature management.
    - Materials selection for pipelines: Corrosion resistance, strength, and durability.
    - Pipeline sizing and hydraulic analysis: Calculating flow capacity, pressure drops, and surge management.
    - Design of pipeline components: Pump stations, pressure relief stations, tank farms, and marine facilities for loading and unloading.
    - Special considerations for multi-product pipelines and terminals (batch separation, batch tracking, and truck loading facilities).
3. **Operational and Maintenance Practices for Crude Oil and Product Pipelines**
    - Best practices for operating crude oil and product pipelines: Start-up, shutdown, and normal operation.
    - Maintenance strategies: Routine inspections, preventive maintenance, and condition-based monitoring.
    - Common operational challenges: Blockages, leaks, pressure fluctuations.
    - Use of pipeline inspection tools and technologies: Smart pigs, ultrasonic testing, and hydrostatic testing.
4. **Safety and Environmental Considerations for Crude Oil and Product Pipelines**
    - Safety regulations and standards: Pipeline integrity, leak prevention, and emergency response.
    - Environmental impact mitigation: Spill prevention, environmental monitoring, and remediation strategies.

    - Safety management systems and compliance with industry regulations.
5. **Introduction to Natural Gas Pipelines and Storage**
    - Overview of natural gas pipeline systems: Purpose and significance in the energy sector.
    - Types of natural gas pipelines: Transmission pipelines, distribution pipelines, and gathering systems.
    - Natural gas storage systems: Underground storage (depleted reservoirs, salt caverns, aquifers) and above-ground storage.
6. **Pipeline Design for Natural Gas**
    - Design considerations: Flow rates, pressure requirements, and temperature management.
    - Materials selection for natural gas pipelines: Corrosion resistance, strength, and flexibility.
    - Pipeline sizing and hydraulic analysis: Calculating flow capacity, pressure drops, and surge management.
    - Design of pipeline components: Compressors, valves, regulators, and metering stations.
7. **Compressor Stations for Natural Gas Pipelines**
    - The role of compressors in natural gas pipelines: Types (centrifugal, reciprocating) and operational principles.
    - Compressor station design: Sizing, layout, and integration with pipelines.
    - Maintenance and operational challenges of compression systems.
8. **Natural Gas and NLG Storage Technologies**
    - Overview of storage technologies: Underground vs. above-ground storage for natural gas.
    - Above-ground storage: Pressure vessels and tanks for gas storage.
    - NLG (Natural Liquefied Gas) transportation and storage.
9. **Safety and Environmental Considerations for Natural Gas Pipelines**
    - Safety regulations and standards for natural gas pipelines and storage: Pipeline integrity, leak detection, and emergency response.
    - Environmental impact mitigation: Spill prevention, emissions control, and land use management.
    - Safety management systems and compliance with industry regulations.

Learning Outcomes

By the end of this course, students will be able to:

- Understand the fundamental principles and components in designing and operating crude oil, product, and natural gas pipeline systems and their associated storage systems.
- Apply design considerations and materials selection to create effective pipeline systems for crude oil, refined products, and natural gas.
- Implement compression, storage, and operational technologies to manage pipeline transportation and storage.
- Address safety and environmental concerns associated with the operation and management of pipeline systems.

7.2 CO_2 and H_2 Transportation & Storage (3 ECTS)

Course Description

This course examines the transportation and storage of CO2 and H2, focusing on subsurface storage technologies. It covers the principles, technologies, and challenges associated with the pipeline transportation and underground storage of these critical substances, emphasizing their roles in carbon capture and storage (CCS) and the hydrogen economy. Participants will learn about pipeline design, geological storage options, subsurface storage methods, enhanced oil recovery (EOR), monitoring and verification methods, safety considerations, potential risks and mitigation strategies, and technical challenges. The course equips participants and professionals in the pipeline engineering and energy sectors with essential skills and knowledge to effectively manage CO2 and H2 transportation and storage systems, aiming to reduce greenhouse gas emissions and enhance oil recovery operations.

Course Content

1. **Introduction to CO2 Transportation and Storage**
    - Overview of carbon dioxide as a critical substance in the energy sector.
    - Significance in carbon capture and storage (CCS).
2. **Pipeline Transportation of CO2**
    - Principles of pipeline transportation for CO2.
    - Design considerations for CO2 pipelines.
    - Safety and regulatory considerations specific to CO2.
    - Challenges in transporting CO2 via pipelines.
3. **Geological Storage Options for CO2**
    - Types of geological storage: saline aquifers, depleted oil and gas reservoirs, unmineable coal seams, etc.
    - Selection criteria and site characterization for geological storage.
    - Principles of enhanced oil recovery (EOR) using CO2.
    - Integration of CO2 EOR with carbon storage strategies.
4. **Monitoring and Verification of CO2 Storage**
    - Techniques for monitoring subsurface CO2 storage sites.
    - Verification methods to ensure containment and effectiveness.
    - Regulatory and reporting requirements for CO2 storage.
5. **Introduction to H2 Transportation and Storage**
    - Overview of Hydrogen as a critical substance in the energy sector.
    - Significance in the hydrogen economy.
6. **Pipeline Transportation of H2**
    - Principles of pipeline transportation for H2.
    - Design considerations for H2 pipelines.
    - Safety and regulatory considerations specific to H2.
    - Challenges in transporting H2 via pipelines.
7. **Geological Storage Options for H2**
    - Overview of geological storage methods suitable for H2.
    - Selection criteria and site characterization for H2 storage.
8. **Monitoring and Verification of H2 Storage**

- Techniques for monitoring subsurface H2 storage sites.
- Verification methods to ensure containment and effectiveness.
- Regulatory and reporting requirements for H2 storage.

9. **Risk Assessment and Mitigation Strategies**
   - Identification of potential risks in CO2 and H2 storage.
   - Development of mitigation strategies to address identified risks.
   - Emergency response planning.
10. **Technical Challenges and Solutions in CO2 and H2 Storage**
    - Challenges related to injection, pressure management, and storage integrity for both CO2 and H2.
    - Technological advancements and emerging solutions.

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the principles and technologies in CO_2 and H_2 pipeline transportation and subsurface storage.
- Evaluate different geological storage options and select appropriate sites based on technical and safety criteria.
- Explain the role of enhanced oil recovery (EOR) in CO_2 storage and its application in the energy sector.
- Apply various subsurface storage methods and injection technologies for CO_2 and H_2.
- Utilize monitoring and verification techniques to assess the safety and effectiveness of CO_2 and H_2 storage sites.
- Identify potential CO_2 and H_2 storage risks and develop appropriate mitigation strategies.
- Analyze technical challenges related to CO_2 and H_2 storage and propose effective solutions.

7.3 Specialized Pipeline Systems: Waste Water, Slurry, Liquid Sulfur, etc. (3 ECTS)

Course Description

This course offers an in-depth exploration of specialized pipeline systems for transporting wastewater, slurry, liquid sulfur, and Ammonia. It covers the design, operation, and management of these systems, emphasizing the unique considerations for each type of pipeline. Participants will gain practical insights into materials selection, hydraulic analysis, and safety practices necessary for effective management. Designed for pipeline engineering participants and professionals, this course equips learners with essential skills to address the specific needs and challenges associated with various specialized pipeline systems.

Course Content

1. **Introduction to Specialized Pipeline Systems**
   - Overview and significance of specialized pipelines in various industries.

- Types of pipelines: wastewater, slurry, liquid sulfur, and Ammonia.
- Key components: pipeline segments, pumps, valves, and storage systems.

2. **Pipeline Design for Water Systems**
   - Design principles: hydraulic calculations, pipeline sizing, and pressure management.
   - Materials selection: pipes (PVC, ductile iron, steel), joints, and fittings.
   - Hydraulic analysis: friction losses, surge management, and system balancing.
   - Design of pipeline components: pump stations, control valves, and metering systems.
3. **Pipeline Design for Waste Water**
   - Design considerations: flow rates, pressure management, and materials selection.
   - Hydraulic analysis: friction losses and pressure management.
   - Corrosion and erosion control: materials and coatings to prevent degradation.
4. **Pipeline Design for Slurry Transport**
   - Characteristics of slurry pipelines: composition and flow behavior.
   - Design considerations: pipeline sizing and wear-resistant materials.
   - Hydraulic design: pressure drop calculations and pump selection.
   - Maintenance practices: handling blockages and sediment management.
5. **Pipeline Design for Liquid Sulfur**
   - Properties of liquid sulfur: temperature control and flow characteristics.
   - Design considerations: materials selection and thermal management.
   - Pipeline heating and insulation techniques to prevent solidification.
6. **Pipeline Design for Ammonia**
   - Properties of Ammonia
   - Hydraulic design.
   - Design considerations concerning pressure and temperature level.
   - Pump station design
7. **Water Storage Technologies**
   - Types of water storage: above-ground tanks, underground reservoirs, and cisterns.
   - Design and construction of storage facilities: capacity, structural integrity, and safety considerations.
   - Operational management of storage facilities: water levels, quality control, and maintenance.
   - Integration of storage systems with pipeline networks for efficient water distribution.
8. **Pumping and Control Systems**
   - Overview of pumping systems: types (centrifugal, positive displacement), selection, and operation.
   - Design and optimization of pump stations: layout, control systems, and energy efficiency.
   - Control strategies for water distribution: pressure regulation, flow control, and SCADA systems.

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the principles and challenges of wastewater, slurry, liquid sulfur, and water pipeline systems.
- Design pipelines considering material and safety requirements for each specialized fluid.
- Implement and manage specialized pipelines effectively, addressing operational and environmental challenges.
- Apply best practices in designing, operating, and maintaining water and specialized pipeline systems.

7.4 Offshore Pipeline Design and Engineering (2 ECTS)

Course Description

This course examines offshore pipeline design and engineering, covering the unique challenges and considerations of transporting fluids (mainly natural gas, Hydrogen, and CO2) across marine environments. It addresses the principles of offshore pipeline design, including materials selection, structural analysis, and installation techniques. Participants will learn about the engineering practices and safety measures necessary for successful offshore pipeline projects. Designed for participants and professionals in pipeline engineering, this course equips learners with essential skills for managing offshore pipeline projects.

Course Content

1. **Introduction to Offshore Pipelines**
    - Overview of offshore pipelines: purpose, significance, and types (transmission lines and flowlines upstream)
    - Key components Upstream: risers, subsea flowlines, and umbilicals
    - Offshore pipeline project phases: design, installation, and operation
2. **Pipeline Design Considerations**
    - Design principles: flow rates, pressure requirements, and temperature management
    - Materials selection: corrosion resistance, flexibility, and strength under marine conditions
    - Structural analysis: assessing stresses due to environmental loads (waves, currents, and seabed conditions) and load cases during construction and operation.
    - Pipeline routing: considerations for minimizing environmental impact and optimizing constructability.
    - Scope and methods of offshore survey
3. **Installation Techniques and Challenges**
    - Installation methods: S-lay, J-lay, reel-lay, and trenching
    - Equipment and technologies: pipelay vessels, ROVs (Remotely Operated Vehicles), and support structures

    - Challenges: deepwater installation, subsea interventions, and risk management
4. **Compressor Stations**
    - P&ID and layout
    - Equipment
5. **Safety and Environmental Considerations**
    - Safety regulations and standards for offshore pipelines: integrity management, inspection, and maintenance
    - Environmental impact: mitigation strategies, pollution prevention, and habitat protection
    - Emergency response: contingency planning and spill response

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the principles and challenges associated with offshore pipeline design and engineering.
- Apply design considerations and materials selection for offshore pipeline systems.
- Understand installation techniques and the challenges specific to offshore environments.
- Address safety and environmental concerns associated with offshore pipelines.

Module 8: Pipeline Construction

8.1 Onshore Pipeline Construction and Facility Engineering (2 ECTS)

Course Description

This course provides an in-depth exploration of onshore pipeline construction, covering the essential aspects of building pipelines and associated facilities. Topics include the construction of new pipelines, stations, and tank farms, as well as brownfield rehabilitation and conversion projects. Emphasis is placed on practical construction practices, safety, and operational considerations. Designed for participants and professionals in pipeline engineering, this course equips learners with the necessary skills and knowledge for effective onshore pipeline construction.

Course Content

1. **Construction of Onshore Pipelines**
    - **Construction Planning:** Site assessment, logistical, and environmental considerations
    - **Construction Techniques:** Right-of-way (Row) clearing, trenching, bedding, welding, lowering in backfilling, and clean up.
    - **Materials and Equipment:** Selection and use of materials and equipment, setting up a construction spread.
    - **Quality Assurance:** Inspection, testing, and documentation
    - **Non-destructive testing (NDT) techniques**: ultrasonic, magnetic flux leakage, radiography
2. **Construction of Stations, Tank Farms, and Marine Facilities**
    - Pump and compressor, other stations, and valve stations.
    - Tank Farm
    - Marine facilities for loading and unloading
    - Construction of crossings like roads, railway lines, creeks, rivers
3. **Brownfield and Rehabilitation Works**
    - **Assessment and Evaluation:** Condition assessment of existing pipelines
    - **Rehabilitation Techniques:** Repair methods, pipeline relining, corrosion control, hot tapping, and stopple operation
    - **Upgrades and Enhancements:** Improving performance and capacity
4. **Conversion of Natural Gas Pipelines for Hydrogen Service**
    - **Challenges and Considerations:** Differences in properties and requirements for Hydrogen
    - **Material and System Adjustments:** Assessing and modifying existing infrastructure
    - **Safety and Risk Management:** Addressing risks associated with Hydrogen
5. **Health & Safety During Construction**
    - **Safety Regulations:** Compliance with safety standards and regulations
    - **Risk Management:** Identifying hazards and implementing safety measures
    - **Emergency Procedures:** Safety protocols and response planning
6. **Testing and Commissioning**

- **Testing Methods:** Hydrostatic and pneumatic testing procedures
- **Commissioning Procedures:** Bringing pipelines and facilities into operational status
- **Documentation and Compliance:** Ensuring all standards are met

Learning Outcomes

By the end of this course, participants will be able to:

- Understand how to construct onshore pipelines, stations, tank farms, and marine facilities.
- Implement rehabilitation techniques and manage pipeline conversions.
- Apply health and safety practices during construction and ensure effective testing and commissioning.

8.2 Offshore Pipeline Engineering: Construction, Safety, and Testing (3 ECTS)

Course Description

This course focuses on offshore pipeline construction, safety, and testing aspects specific to marine environments. Participants will learn about offshore pipeline design, installation methods, safety regulations, and testing procedures. Emphasis is placed on the unique challenges of offshore environments, including deepwater installation and subsea interventions. This course provides participants and professionals with the knowledge and skills to manage offshore pipeline projects effectively and ensure safety and operational integrity.

Course Content

1. **Construction of Offshore Pipelines**
   - **Design Considerations:** Subsea pipeline design, environmental factors, and materials
   - **Installation Techniques:** S-lay, J-lay, reel-lay, and trenching methods
   - **Equipment and Technologies:** Offshore pipelay vessels, ROVs (Remotely Operated Vehicles), and support structures
   - **Challenges and Solutions:** Deepwater installation, subsea interventions, and risk management
2. **Health & Safety During Offshore Construction**
   - **Safety Regulations:** Compliance with offshore safety standards and regulations
   - **Risk Management:** Identifying hazards specific to offshore construction
   - **Emergency Response:** Developing and implementing safety and response plans
3. **Testing and Commissioning of Offshore Pipelines**
   - **Testing Procedures:** Hydrostatic and pneumatic testing adapted for offshore environments
   - **Commissioning:** Procedures for bringing offshore pipelines into operation

- **Final Inspections:** Ensuring compliance with standards and operational readiness

Learning Outcomes

By the end of this course, participants will be able to:

- Understand the principles and techniques involved in offshore pipeline construction and installation.
- Implement health and safety practices tailored to offshore environments.
- Conduct testing and commissioning procedures for offshore pipelines.
- Analyze and apply lessons learned from real-world offshore pipeline projects.

Module 9: Pipeline Operation and Maintenance

9.1 Pipeline Operation and Integrity Management (2.5 ECTS)

Course Description

This course provides a comprehensive understanding of pipeline operation and integrity management. It covers the principles and practices essential for ensuring pipeline systems' safe and efficient operation. Topics include monitoring, maintenance strategies, and integrity management techniques aimed at prolonging the lifespan and reliability of pipelines. Tailored for participants and professionals in pipeline engineering, this course provides learners with the essential skills to effectively manage pipeline systems and maintain operational integrity.

Course Content

1. **Pipeline Operation Fundamentals**
    - **Operational Procedures:** Standard operating procedures for pipeline systems
    - **Monitoring Systems:** Technologies and techniques for real-time pipeline monitoring
    - **Flow Management:** Control of flow rates, pressure, and temperature in pipelines
    - **Operational Challenges:** Common issues and solutions in pipeline operation
    - **Organizational Setup for Operation:** Best practices for organizing a pipeline operation team, including staffing, training, and resource management.
2. **Integrity Management Strategies**
    - **Integrity Assessment:** Methods for assessing pipeline condition and performance
    - **Inspection Techniques:** Use of smart pigs, ultrasonic testing, and other inspection technologies
    - **Corrosion Management:** Corrosion control methods, including coatings and cathodic protection
    - **Risk Management:** Identifying and mitigating risks to pipeline integrity
3. **Regulatory and Safety Considerations**
    - **Regulatory Requirements:** Compliance with industry standards and regulations
    - **Safety Protocols:** Implementing safety measures and procedures to protect personnel and the environment
    - **Emergency response planning**: Development of emergency response plans for managing pipeline incidents, such as spills, ruptures, and leaks.
    - **Documentation:** Keeping accurate records of pipeline operation, maintenance, and inspections

Learning Outcomes

By the end of this course, participants will be able to:

- Understand and apply principles of pipeline operation and integrity management.
- Implement effective monitoring and maintenance strategies to ensure pipeline performance.

- Manage risks and respond to emergencies associated with pipeline systems.
- Comply with regulatory requirements and safety protocols in pipeline operation.

9.2 Pipeline Maintenance and Repair Techniques (2.5 ECTS)

Course Description

This course focuses on the techniques and methodologies for maintaining and repairing pipeline systems. It covers a range of maintenance strategies, repair methods, and technologies used to address pipeline issues and extend the service life of infrastructure. Tailored for participants and professionals in pipeline engineering, this course provides practical knowledge and skills for effective pipeline maintenance and repair.

Course Content

1. **Maintenance Strategies**
    - **Preventive Maintenance:** Scheduled maintenance activities to prevent issues
    - **Predictive Maintenance:** Techniques for predicting potential failures using data analysis
    - **Risk-**Based Maintenance
    - **Condition-Based Maintenance:** Maintenance based on the actual condition of the pipeline
    - **Organizational Setup for Maintenance:** Structuring an organization to handle pipeline maintenance, including staffing, training, and resource allocation.
    - **Surveillance & inspection:** Techniques for pipeline surveillance and inspection, including In-line Inspection (ILI) tools and pigging for corrosion detection.
2. **Maintenance Practices**
    - **Routine Maintenance:** Regular maintenance activities to ensure optimal performance
    - **Predictive Maintenance:** Techniques for predicting and preventing pipeline failures
    - **Emergency Response:** Procedures for responding to pipeline emergencies and leaks
3. **Technology and Equipment**
    - **Repair Tools and Technologies:** Equipment used in pipeline repair, including clamps, sleeves, and welding equipment
    - **Innovative Solutions:** Emerging technologies and methods in pipeline maintenance and repair
4. **Health and Safety Considerations**
    - **Safety Measures:** Ensuring safety during maintenance and repair activities
    - **Hazard Identification:** Identifying and mitigating risks associated with pipeline repair work
    - **Compliance:** Adhering to safety standards and regulatory requirements

Learning Outcomes

By the end of this course, participants will be able to:

- Apply maintenance strategies to ensure the reliability and longevity of pipeline systems.
- Implement effective repair techniques to address pipeline issues and restore functionality.
- Utilize technology and equipment for pipeline maintenance and repair.
- Adhere to safety protocols and regulatory requirements during maintenance and repair activities.