LTH

Lund has had an institute of technology for 40 years – LTH – which is now part of Lund University, constituting its Faculty of Engineering. LTH has more than 5,000 undergraduates studying programmes leading to various degrees.
Among the 4 ½-year engineering programmes are subjects such as engineering physics, civil engineering, chemical engineering, electrical engineering, computer science and engineering, mechanical engineering, surveying, engineering nano-science, engineering mathematics, information and communication engineering, industrial management and engineering, environmental engineering, biotechnology and risk management.
LTH has about 540 postgraduate students whose goal is to obtain a doctoral degree in engineering after five year's study.

LTH International Office

The International Office at LTH, Kårhuset is open for students between 8.30 and 16.30. If you have any questions or problems, please feel welcome to visit. Turn to Anna Carlqvist and if you want to be sure that she is there just send an e-mail and make an appointment
anna.carlqvist@kansli.lth.se

Academic Year

The academic year is divided into two terms. At LTH each term is divided into two study periods. Each study period consists of seven weeks. Usually you study at least two courses in parallel during each period.

Autumn term 2005, August 30 – January 15
Spring term 2006 (preliminary) January 17 – June 3

Christmas vacation: December 22, 2005 - - January 6, 2006
Easter vacation: April 10, 2006 - - April 17, 2006 (preliminary)

Credit System

Academic studies in Sweden are organized according to a credit system. One Swedish credit is equivalent to one week of full-time studies, and during the course of a normal academic year students should aim at obtaining 40 credits.

Degree

The international master's programmes in

- Bio- and Food Technology
- System-on-Chip
- Water Resources

all lead to the Swedish degree of "Magisterexamen" which is translated into English as "Degree of Master in...". This degree is awarded by LTH.

Degree projects in engineering programmes

Aim

In the project paper the student should display an ability to apply and compile knowledge and skills acquired on various central and qualified courses of the relevant educational programme. Through the project the student should demonstrate an ability to identify, analyse and solve a technical or scientific problem and evaluate the solution, and to present and document the result. The project should be an in-depth study of a topic, showing that the student can apply the methods of science and engineering.
The paper should be the result of independent work, carried out individually or in a group of two. If the paper is produced jointly there should be a clear statement of who contributed what. The paper should be written on one of the topics stated in the study programme syllabus unless the education committee permits an exception in individual cases.
A pass on the project is compulsory if a student it to obtain a degree in engineering.

Content

The work on the project includes:
• A written report in Swedish or English with a summary in English
• A separate summary which may be popular in character or take the form of a scientific article
• A presentation at a public seminar at LTH
• Acting as opponent at a seminar where another student's paper is presented
All of the above points must be approved if the project is to receive a pass grade.
The report should be available in a version for examination at least one week before the seminar. The department takes responsibility for producing the required number of copies of the report. It is desirable but not compulsory that the report should be scrutinized by another project candidate at the seminar. The same report can be scrutinized by more than one candidate. The seminar may be scheduled outside term time if the student, supervisor and examiner are in agreement.
The report is public and no part of it may be kept confidential. The examiner may not take into account any confidential information when assessing the report. The department must file the report.

Assessment and supervision

For each project topic the head of department appoints one or more teachers with research training at Lund University as examiner. This means, among other things, that the project is to be examined at Lund University even in the case of exchange students. The examiner decides the grade to be awarded to the paper. Before work on the project begins, the examiner must approve the choice of topic and appoint a supervisor to provide the candidate with continuous supervision. The aim of the supervision includes making it possible to complete the project within 20 weeks of full-time study. The student cannot expect supervision for more than 15 months. The examiner may appoint as supervisor anyone deemed suitable. The supervisor need not be a teacher at LTH. No one may act as examiner on a paper which he or she has supervised. The grades awarded are either pass or fail.

Scope

The degree project is worth 20 credits.

Eligibility and registration

Work on the project may begin when the student has at least 140 credits (30 credits for Master's

students) which may count towards the degree. Dispensation from this can only be granted by the education committee and only if there are special grounds.
To be allowed to start work on the project the student should also have acquired sufficient knowledge in the subject field of the project. It is up to the examiner to determine whether this requirement has been met before the work begins.

Examination

There is always one week of examinations at the end of each study period prior to the start of the next study period. It is not unusual for a course to run over two study periods and be followed by an examination at the end of the course. Written examinations at the end of a course are the most common form of evaluation, however, written reports, which may be presented orally to the lecturer or to a group, are also a common means of evaluating the performance of students.
There are always three periods of re-examination every year: in August, just prior to the start of the new academic year, in the beginning of January and just after the Easter holidays.

Grades

The grades usually awarded at LTH are:
5 - Excellent
4 - Very good
3 - Pass
Some courses are graded simply as Pass or Fail. NB! The only grade available for a Master's thesis is a Pass.
There will be no ranking of the students enrolled in the master's programmes.

Individual written exams

The length of the exam can vary from 1 to 6 hours. Normally the students should register in advance in order to participate in the exam.
The student should bring the following to an exam: Valid ID, the original “Letter of Acceptance” and permissible accessories such as pencil, ruler and eraser.
During the written exam, invigilators will answer any general questions and ensure a controlled environment. The responsible lecturer is normally available during parts of the exam to answer more specified questions. Students may bring drinks or snacks to the exam. The student should enquire as to which accessories are allowed during the exams. It is forbidden to bring accessories such as, notes, books, calculators, mobile phones, tape recorders etc., unless approved by the responsible lecturer. It is considered cheating if forbidden accessories are used or found during the exam. Communication between examining students is also considered cheating. Also note, that cheating is not socially accepted among students! Any incidence occurred where cheating is suspected will be reported to the Board of Discipline and may lead to that the student will be expelled, if he is found guilty.

Graduation Day

Graduation will be celebrated once a year by a ceremony in the University building in December.

Student Counselling

Are you having trouble concentrating on your studies, perhaps because of personal problems? Are you going through difficulties as a result of studying abroad or because of a culture change? Are you in a crisis situation and need to talk to someone or get help?

At LTH we have student councellors who are trained social workers and are there to help you. Please be assured that all your dealings with these counsellors are strictly confidential. You can call or e-mail to make an appointment at:
046-222 71 91, LTH, Kårhuset, Lund Ulla.Bergman@kansli.lth.se

Students´ Health Care

Studenthälsan/student health care centre provides care and counselling for all students at Lund University/LTH. They can help you with physical, personal or social problems, which may hamper your capacity to succeed with your studies. You may consult a general practitioner or psychiatrist, a social worker, psychologist or nurse. The centre can also provide support groups and the possibility to discuss focus issues like alcohol, eating disorders, stress reactions and examination anxiety.

Visiting address: Gerdagatan 7a, Lund
Postal address: Box 117, 221 00 Lund
Phone: 046-222 4377 (reception 222 0000)
Fax: 046-222 4386
E-mail: studhals@stu.lu.se
www.lu.se/stud/studh.htm

Time booking: Mon-Thur 9-00 - 12-00, 13.00 – 15.00, Fri 9.00 – 12.00, 13.00 – 14.00

Timetables

The schedule generator is only available in Swedish. Here is a short instruction how to generate your timetable:

1) Go to the schedule generator Http://klth4d.kansli.lth.se/start.html, and choose the appropriate study period.
2) Enter the course code in the form field and click “Sök” (Search)
3) The search has one result. Mark the box and click “Lägg till” (Add).
4) If you have successfully added a course, you will see a list of the courses that you have chosen. You can use the form field to add more courses
5) When your list is complete, click “Generera schema” (Generate schedule)

The complete course name and/or code are not mentioned in the schedule. Instead, each course is given another abbreviation in Swedish. To know what the various courses are called in Swedish you should consult the Swedish student’s handbook,
http://www.lth.se/for_student/studiehandbok.html , and choose “Läro- och timplan med tentaschemat”.

This all may seem rather complicated, but you’ll soon get the hang of it, so don’t give up.

STUDY PLAN

WATER RESOURCES

Master's Programme in Water Resources

1 Aim and purpose

1.1

The programme comprises 60 credit points and leads to a master's degree *with broad competence* in Water Resources.

1.2 Overall aim

According to the Higher Education Act, a university education is supposed to give students, besides knowledge and skills, a capacity for independent and critical judgement, an ability to solve problems independently, and an ability to follow the development of knowledge in the fields covered by the education. The education should also develop the students' ability to exchange knowledge at a scientific level.

1.3 General content of the programme

The programme consists of compulsory courses, optional courses, and a degree project. Tuition is provided in different forms and with various types of examination. Students are given practice in identifying, formulating, and solving problems, and in presenting solutions.

1.4 Special objective of master's education in Water Resources

The Master's in Water Resources is intended to give students a good foundation of knowledge, based on research in science/engineering, to be able to analyse and develop human activities in the sphere of water. Special importance is attached both to environmental sustainability and to appropriate technical systems.

2 The main content and arrangement of the programme

The compulsory courses comprise 25 credit points, the optional ones 15 credit points, and the degree project 20 credit points. The introductory set of compulsory courses in the first term contains basic courses about water resources. In the second and third terms the student, by choosing optional courses and a degree project, can acquire advanced and specialized education in the field of water resources.

3 Special prior knowledge required for admission

A first Swedish degree in engineering (minimum 120 credit points) or a B.Sc. in civil or environmental engineering, environmental science, or equivalent from a foreign university corresponding to at least 3 years' study. Special requirements for eligibility: From their first degree, students must have prior knowledge in mathematics (calculus and linear algebra), hydraulics/fluid mechanics, and geology. Participation in the master's programme requires a good knowledge of English. Students from Nordic countries must have basic university eligibility. Students from other countries who are not native speakers of English or who have not had previous education in English must satisfy the following requirements: TOEFL at level 550 (213 for computer-based TOEFL) or more, IELTS 6.0, or Cambridge Certificate of Proficiency.

4 Grading

Grades are awarded for whole courses and tests as stated in the respective syllabus. Whole courses are graded as fail, pass (3), credit (4), and distinction (5). Grades for tests are either fail or pass. The syllabus may, however, contain instructions that a particular whole course shall be graded as either fail or pass. For degree projects the grade is passed. In addition, the syllabus may contain

rules about different grade scales for the constituent tests. Courses and tests which a student has failed are not included in the course certificate or degree certificate. *Note that, in the grade system used at LTH, grades are absolute and directly linked to the target knowledge and not based on ranking of the students.*

5 Degree certificate and qualification

When the requirements for the degree are satisfied, students receive a degree certificate as Master in Water Resources. The certificate is accompanied by a Diploma Supplement in English, describing the content and scope of the education. This is intended to facilitate the acknowledgment of university qualifications throughout Europe and in other parts of the world.

6 Examination requirements

6.1 Required courses

The programme is divided into courses. Section 8 shows which courses must (compulsory courses) or may (optional courses) be part of the qualification if a student is to be considered to have followed and passed the programme. All the courses listed in section 8 are given in English. To obtain a degree, students, besides the basic eligibility stated in section 3, must have passed compulsory and optional courses and completed a degree project, all to a total value of at least 60 credit points. At least 45 credit points, including the degree project, must be obtained at LTH. Students who wish to count towards the degree a course which is not listed in section 8 below must apply to the education committee for permission to do so. Courses from other faculties at Lund University may be counted after application to the education committee; further information is available from the study counsellor. A course from outside the programme will only be counted towards the degree if it is relevant for a Master's in Water Resources.

6.2 Degree project

The aim of the degree project in water resources is to develop the student's competence in independently identifying, analysing, and solving technical and/or scientific problems in a subject area of central relevance to the programme. The degree project comprises 20 credit points and corresponds to a full term's work. The degree project may be commenced when the student has a maximum of 30 credit points left to the requirements for a degree and may – if supervision resources can be offered – be done outside term time. The degree project is carried out by an individual student or a group of no more than three students in collaboration.

The degree project must be examined at LTH. If a student wishes to do the degree project in collaboration with another university or company inside or outside Sweden, this must be discussed in advance with the education committee. *If the degree project is to be published by a company, it must be designed in consultation between the contact person at the company and the supervisor/examiner on the master's programme. Only the supervisor/examiner on the master's programme can give the go-ahead to commence a degree project.*

The degree project must be presented in a written report and ventilated at a public seminar. The report must be written in English.

7 Special regulations

7.1 Prior knowledge

For some optional courses it is necessary to specify certain requirements of prior knowledge alongside the general eligibility requirements for the master's programme in water resources.

7.2 Laboratory exercises and excursions

All laboratory exercises and excursions in the master's programme in water resources are compulsory unless otherwise stated in the syllabus.

7.3 Course evaluations

All courses on the programme must be evaluated.

8 List of courses

8.1 Compulsory courses, year 1

Code	Course	Credits	Study period
VVA030	Urban Waters	10	1 – 2 Autumn
VVR140	Rural Waters	5	1 Autumn
VTG070	Groundwater and Environment	10	2 Autumn – 1 Spring

8.2 Optional courses, year 1

Code	Course	Credits	Study period
VVR090	Hydromechanics	5	1 Spring
TNV080	River Restoration	5	1 – 2 Spring
TNV070	Unsteady Water Flow	5	1 - 2 Spring
VVR040	Coastal Hydraulics	5	2 Spring
VVR130	International Water Issues	5	2 Spring
TEK	Limnology	10	2 Spring

8.3 Special subjects

Within the framework of the optional courses, the student is recommended to choose one of the following advanced special subjects, each of which is worth 15 credit points.

Water Technology

Code	Course	Credits
VVR090	Hydromechanics	5
TNV070	Unsteady Water Flow	5
VVR040	Coastal Hydraulics	5

Water Resources

Code	Course	Credits
TNV080	River Restoration	5
VVR040	Coastal Hydraulics	5
VVR130	International Water Issues	5

Ecology

Code	Course	Credit Points
TNV080	River Restoration	5
TEK	Limnology	10

COURSES

WATER RESOURCES

LIMNOLOGY TEK

Credit Points: 10 **Grading:** UV. **Lecturer:** Karin Rengefors, Karin.Rengefors@limnol.lu.se. **Prerequisites:** Elementary course in Ecology. **Examination:** Participation in seminars and laboratory experiments. Excursion is compulsory. Project work. Written examination.

Aim

To provide understanding of basic features of structure and function of inland waters, training in limnological laboratory and field methods and limnological synthesis, understanding of man's impact on inland water systems, conservation and restoration methods.

Description

Physical properties of water. Cycling of nutrients and other ions and relations with organism populations. Effects of man on lake ecosystems, lake restoration, eutrophication and acidification. Lake types. Analysis of phyto- and zooplankton, bacteria, benthic invertebrates, fish, macrophyt and the chemistry of water and sediment.

Literature

C. Brönmark och L-A. Hansson: The biology of lakes and ponds, Oxford Univ. Press, 2nd ed., 2005

GROUNDWATER AND ENVIRONMENT VTG070

Credit Points: 10. **Grading:** TH. **Lecturer:** Engineering Geology. **Prerequisites:** Geology corresponding to 3 ECTS, VTG011 or VTG060. **Examination:** Written examination 5 hours. Two compulsory supervised projects. Written report and oral presentation at a seminar. **Notes:** If less than 15 participants the course can be cancelled.

Aim

To give a thorough understanding of groundwater and soil water occurrence, flow, chemical and physical properties. The environment part of the course provides thorough understanding of how handling and management of waste and remnants can cause soil and groundwater contamination, in particular by leaching of contaminants.

Description

Hydrogeology: groundwater occurrence and behaviour in various kinds of aquifers. Soil water and soil water movement. Fluctuations in groundwater level on various time-scales and in various formations. Temperature and age of groundwater. Groundwater quality: water analyses, chemical composition, equilibrium, chemical processes and pollution. Drilling and well technology. Hydraulic properties of aquifers and wells. Groundwater withdrawal and test pumpings. Analysis of data by graphical methods. Hydraulic boundaries. Projects: two compulsory projects in which students use their theoretical and practical knowledge to solve a complex groundwater-engineering problem emphasizing risk of contamination. Projects are tackled in small groups with a supervisor. The results are presented in written form and in a seminar. The environmental part of the course includes general descriptions of handling of waste and remnants in the society as well as characterization of waste. Contaminated soil and waste deposits and also other sources of pollutants are treated. Treatment and cleaning-up of contaminated soils. Leaching of contaminants are emphasized as well as simulation of chemical reactions and contaminant transport by the computer code PHREEQC.

Literature

Fetter, C W: Applied Hydrogeology Fourth edition. Prentice Hall 2001
Svensson, C: Groundwater chemistry. Teknisk geologi, LTH 2004.
Exercises. Additional books and off-prints for the environmental part.

URBAN WATERS VVA030

Credit Points: 10. **Grading:** TH. **Lecturer:** Jes la Cour Jansen, Water and Environmental Engineering. **Prerequisites:** VVR015 or VVR120. **Examination:** Participation in seminars, laboratory experiments, computer exercises. Excursion is compulsory. Written examination.

Aim

Design and operation of water and wastewater treatment plants and storm water systems in urban areas.

Description

Survey of water resources, water consumption and water quality. Treatment processes for potable water. Storage and distribution of fresh water. Waste water systems. Characterization of waste water. Physical, biological and chemical treatment processes. Computer modelling of activated sludge systems. Sludge treatment. Re-use of treated waste water. Urban hydrology. Storm water modelling

Literature

Kompendium.

COASTAL HYDRAULICS VVR040

Credit Points: 5. **Grading:** TH. **Lecturer:** Hans Hanson, Water Resources Engineering. **Prerequisites:** Water Resources Engineering (VVR015). **Examination:** To qualify for a final grade, students must have submitted the compulsory exercises. The final grade equals the grade obtained in the examination. **Web page:** aqua.tvrl.lth.se/course/Undergraduate.html.

Aim

The course provides knowledge on how to solve flow problems in the areas of coastal and receiving water hydraulics. Coastal hydraulics focuses on wind-generated waves and the forces such waves create in the coastal area. Receiving water hydraulics involves discharge of polluted water in different recipients such as coastal areas, lakes, and rivers. The main objectives of the course are to provide basic knowledge about the governing physical processes and to develop the participants' skill in formulating quantitative models for the analysis of important flow problems in coastal and receiving water hydraulics.

Description

Coastal engineering problems: Wave theory including phenomena such as shoaling, refraction, diffraction, reflection, and wave breaking. Statistical wave theory and estimation of waves generated by wind. Nearshore currents and water level variations together with their causes. Forces on structures due to breaking and non-breaking waves. Planning and design of nearshore structures.

Receiving water hydraulics problems: Different types of recipients. Transport processes such as diffusion and dispersion. Equations to describe the transport and spreading of pollutants in coastal and inland waters. Jet theory in the near- and far-field zones. Lateral spreading of polluted water in a density-stratified ambient. Heat and oxygen exchange in rivers. Measurement techniques.

Literature

US Army Corps of Engineers: Shore Protection Manual Jönsson, L.: Recipienthydraulik Hanson, H. & Jönsson, L.: Exempelsamling Handouts.

HYDROMECHANICS VVR090

Credit Points: 5. **Grading:** TH. **Lecturer:** Lennart Jönsson, Water Resources Engineering. **Prerequisites:** VVR150 or VVR120 or a corresponding course in basic hydraulics/fluid mechanics. **Examination:** Written examination, assignments and a laboratory exercise. **Web page:** aqua.tvrl.lth.se/course/Undergraduate.html.

Aim

This course is a continuation and enhancement of the hydraulics part of the basic course in Water Resources Engineering. The aim is to convey a physical understanding of technically important hydraulic phenomena as well as to describe computational methods. Significant emphasis is placed on free surface flow - mainly concerning channel flow. Some other areas - such as boundary layer theory, similitude and dimensional analysis, drag, flow measurement methods - are also treated.

Description

Hydraulic models, similitude, dimensionless numbers such as the Reynolds number and the Froude number. Dimensional analysis with Buckingham's pi-theorem. Boundary layer theory. Surface drag and form drag. Open channel flow in general. The energy principle with specific energy, flow controls, critical flow, Froude number. The momentum principle with the hydraulic jump. Uniform channel flow with Manning's formula and methods of calculation. Theory and analysis of gradually varying channel flow. Water surface profiles and numerical methods for the calculation of water depths. Spatial change of flow in channels. Practical views on channel design. Discharge measurements in channels. Weirs and flumes. Flow measurements in pipelines. Rapidly varying channel flow - bridge piers, control of the hydraulic jump.

Literature

French, R.: Open Channel Hydraulics, McGraw-Hill, 1994 Vennard, J. & Street, R.: Elementary Fluid Mechanics, John Wiley & Sons, 6th edition, 1982 (two chapters)

INTERNATIONAL WATER ISSUES VVR130

Credit Points: 5. **Grading:** TH. **Lecturer:** Linus Zhang, Water Resources Engineering. **Recommended prerequisites:** VVR015 or VVR110 or equivalent. **Examination:** Written examine plus one project. **Comments:** The course will be based to a large extent on recent or ongoing international research projects at the department. Also one or more projects from departments of Water and Wastewater Engineering, Technical Geology and Limnology.

Aim

The aim of the course is to prepare the students for international water related jobs (mainly in the developing countries).

After completing the course the student is expected to

- have good knowledge about the main international water issues,

- have a good understanding of the importance of non-technical aspects of water issues,

- know the special problems of the developing countries and their most common problems related to water and the environment.

Description

International water issues: Floods, droughts, drinking water, sanitation, pollution, water resources planning. These issues will be studied with an emphasis on technical aspects and natural sciences, but also taking other aspects into account.

Non-technical aspects: International organisations, water related international aid, politics and administration related to water.

Project work/Case-studies relating to ongoing international research projects.

Literature

Principles of Water Resources: History, Development Management and Policy. By Cech, Thomas V.Wiley, UK, 2002 (ISBN 0471438618)

RURAL WATERS VVR140

Credit Points: 5. **Grading:** TH. **Lecturer:** Rolf Larsson, Water Resources Engineering. **Recommended prerequisites:** Mathematical Statistics. **Examination:** Written examination, compulsory assignments.

Aim

The main objectives are that the students should reach an advanced understanding of the hydrological processes and that the students should acquire an ability to compute precipitation generated flows in rivers. The students should learn to use mathematical models as tools for river runoff computations and for design of hydraulic works and structures.

Description

Run-off modelling in rural areas. Hands-on exercises using computer models. Associated topics; rain characteristics, snow melt, melt water movement, water movement in the unsaturated zone, surface run-off, linear reservoir theory, conceptual modelling. Thermo- and hydrodynamics of lakes. Assignments include an essay, rainfall-runoff modelling and lake routing.

Literature

Ward & Robinson: Principles of Hydrology, McGrawHill.

RIVER RESTORATION VVR171

Credit Points: 5. **Grading**: UG. **Lecturer:** Dr Rolf Larsson, Rolf Larsson@tvrl.lth.se, Water Resources Engineering. **Prerequisites:** Hydrology and Hydraulics as VVR150 or VVR015 or VVR111 + VVV120 or corresponding. **Recommended prerequisites:** VVR090 **Examination:** Written exam, mandatory assignments and excursions. **Notes:** The course is delivered in cooperation with the Limnology Department. Class scheduled for evenings.

Aim

After completing the course each student should:

- have enough knowledge of the physical/biological processes involved in river related problems to be able to communicate with other specialists;
- have a clear overall picture of river restoration/management approaches;
- have good knowledge concerning key rules and regulations related to river management (focused on Sweden);
- know where to find relevant information concerning river restoration/management;
- have good knowledge of existing problems and management methods in Europe

Description

Review of basic concepts in hydrology, hydraulics, sediment transport and lotic ecology. Introduction to river management / restoration goals and approaches. Overview of recent advances in river restoration methodology and techniques.Overview of key legal and administrative aspects of river restoration in Europe (EU), with focus on Sweden. Overview of experiences from around the world.

UNSTEADY WATER FLOW VVR175

Credit Points: 5 **Lecturer:** Dr Lennart Jönsson, Lennart.Jonsson@tvrl.lth.se
Prerequisites: VVR150 or VVR120 or a corresponding course on basic hydraulics/fluid mechanics. **Examination:** Written examination and assignments

Aim

This course could be regarded as a natural continuation of the basic course in hydraulics, especially regarding steady state pipe flow. The course will focus on two types of technically important unsteady water flows – mass oscillation and hydraulic transients in pressurized conduits for water conveyance. The emphasis is put on hydraulic transients. Mass oscillation occurs in conduits with surge chambers or air vessels. Hydraulic transients occur at rapid flow changes due to actions such as pump stop or valve operation and are accompanied by strong pressure waves. Knowledge of these flow types is essential in order to secure the function of pipeline systems and to avoid physical damage. The overall aim is to give a physically based understanding of the flow types, to give a thorough background for the mathematical description, to provide methods for the computation of the flows and for giving an insight into measurements of hydraulic transients.

Description

Repetition of basic hydraulics. Examples of unsteady flows in practice. Mathematical description of mass oscillation – equations of continuity and energy. Surge shafts and air vessels. Analytical solution for a frictionless case. Numerical method. General properties of hydraulic transients. Basic equations considering the elasticity of water and pipeline. Physical interpretation of the equations. Pressure wave velocities. Rules of thumb for pressure change. Time scales. Hydraulic description of valves, reservoirs, branches etc. as boundary values for unsteady flow. The method of characteristics as a solution method, graphically and numerically. Pump as a boundary value. Pump types and pump characteristics. Hydraulic transients at valve operation and pump stop. Cavitation at steady and unsteady flow. Methods for counteracting hydraulic transients. Demonstration of the measurement of transients in the laboratory and in the field.

Literature

Jönsson, L and Larsson, R.: Kompendium i instationär strömning