Editor Per-Erik Petersson

Research & Development
in the field of
Building and Property Management
at SP Swedish National Testing and Research Institute

Report to the Formas scientific evaluation of Swedish building research
Dnr 10.9/2003 - 0174
RESEARCH & DEVELOPMENT
in the field of
BUILDING AND PROPERTY MANAGEMENT
at
SP
SWEDISH NATIONAL TESTING AND
RESEARCH INSTITUTE

SP-Report 2004:03

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Dnr 10.9/2003 - 0174

Borås
2003-09-11
Research & Development at SP in the field of Building and Property management
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SUMMARY

The research institute SP

SP (the Swedish National Testing and Research Institute) is one of the biggest research institutes in Sweden. With a multi-disciplinary approach the aim is to contribute significantly to innovation and growth in industry and to a sustainable development in the society as a whole.

SP is a national institute with a comprehensive competence in a number of profile areas such as: Building, Energy, Fire and fire protection, Materials, Transport, Electronics, Measurement techniques.

We co-operate with all sectors, universities, institutes, industry, users and organisations of society and politics. This is essential to contribute efficiently to growth in the innovation system. In particular we co-operate with universities for synergy of aspects in performing research. We prioritize international co-operation, e.g. in EU-projects. This is important for exchange of knowledge, influence and creation of confidence and networks facilitating trade and increasing competitiveness.

SP is a private company (like Chalmers) with all shares held by the Swedish state. The organisation is flat with a high degree of delegation, which enhances flexibility and multi-disciplinarily. The technical departments have overall responsibility for economy, personnel, equipment, research, marketing etc according to an annual plan and following the common strategies and policies.

Many of the R&D activities at SP are co-financed and SP receive grants from around 20 of the Swedish research councils, funds and authorities in competition. This financing has increased considerably during the last decade, while the government grants for development of new knowledge through R&D have decreased slowly. The governmental grants were about 9 % of SP's total turnover in 2002.

The staff's comprises 550 persons (man years). Of these 97 have a Ph D (72) or a licentiate degree (25). A further 140 persons have a masters degree, and there are also a number with a B Sc. This means that the technical areas/environments at the departments in general have a sustainable research competence and capacity for tutoring of Ph D students.

There are 35 Ph D students at SP, generally employees of SP with a project in co-operation with a technical university, for courses and formal exam requirements, and with supervision from SP's researchers.

SP has co-operation in around 90 projects with a large number of departments at Swedish universities and university colleges, with a concentration to Chalmers, KTH and LTH. There is also co-operation with 15 of the Swedish research institutes and program boards (as Brandforsk, Elforsk and Värme forsk). Internationally, SP co-operates with 90 institutes, mostly Nordic and European, and to a large extent in the 5th Framework program. In this program SP participated in 43 projects and as co-ordinator in 6.

All in all SP has a wide co-operation in research and a strong international network. Not least should be mentioned organisations as Eurolab, Euromet, EGOLF (fire), ENBRI, RILEM, IABSE, CIB (building), Eurachem, ENCRESS (software), ADLNBE (telecommunication), EMCIT/EMCEL (electronics), CEEES (environment), IEA (energy), ESIS (mechanics) and VAMAS (materials).

In 2002 SP researchers published 233 reports, papers etc. A total of 169 of the publications were in external journals, conference proceedings, and theses. Of these 94 were published after peer review. The other 64 publications were handbooks, methods and final project reports and they were published in the SP report series. SP staff also made 270 presentations at conferences, workshops and seminars.
SP arranged or co-arranged 150 courses, seminars or conferences in 2002. This includes international meetings regarding standardisation and other expert issues.

**Organisation of research on Building and Property management at SP**

Research and development related to Building and Property management is one of SP's key areas of activity. SP's work in the field is characterised by a wide technical span including sustainable development, indoor environment, building acoustics, efficient production and use of energy, materials and construction technique, wood and wood technology, fire, productivity and operation and maintenance.

The research activities become more and more international. SP participates normally in about 20 projects dealing with construction and buildings within the European frame programmes and co-ordinates some of them.

SP is a polytechnic institute organised in eight technical departments. The building competence is mainly found in four of these: Building Technology and Mechanics, Energy Technology, Fire Technology and Chemistry and Materials Technology. These four departments are shortly presented in the report.

In order to co-ordinate the activities related to construction there is an internal network, the SP Strategic Group for Building and Property management.

**Important research areas in the field of Building and Property management at SP**

In the report 12 important research areas in the field of Building and Property management at SP are presented:

1. Concrete and concrete technology
2. Wood materials and structures
3. Geological materials
4. Thermal insulation and air tightness in the building envelope
5. Moisture control and indoor environment
6. Acoustics
7. Fire response of building materials and structures
8. Spread of fire effluents and environmental impacts
9. Polymeric materials
10. Service life prediction of solar thermal components
11. Coatings and surface protection
12. Building materials and indoor air quality

Detailed facts about each of the research areas are presented in the report and these facts can be summarized as follows.

There are today 11 Ph D students active in the 12 research areas, which are employees of SP with a project in co-operation with a technical university. During the last ten years 9 persons have got their licentiate and 6 persons their Ph D at SP in the field of Building and Property management. In addition to this, 13 students from several European universities have carried out their master thesis work at SP, all of them in the field of wood technology. These figures are strong for a research institute, as most of the research at institutes in Sweden normally is performed by senior researchers. This shows a fruitful co-operation with universities.
CVs for 40 senior researchers, 34 Ph D and 6 licentiates are included in the report. Most of them are active as supervisors for doctoral students, in close co-operation with universities.

SP participates/has participated in 38 European projects in the field of construction during the last ten years period and has been co-ordinator for four of these. SP has also participated in more than 80 Nordic construction projects, often financed by Nordtest or Nordic Industrial Fund, and, of course, in a large number of national projects.

The publication list since 1992 in the field of Building and Property management is extensive and comprises the numbers of publications for different categories shown in the table below.

**TABLE** Number of publications in the field of Building and Property management at SP during the period 1993-2002.

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of publications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peer reviewed papers</td>
<td>246</td>
</tr>
<tr>
<td>Other international scientific publ.</td>
<td>194</td>
</tr>
<tr>
<td>Swedish reports</td>
<td>204</td>
</tr>
<tr>
<td>Popular scientific reports</td>
<td>76</td>
</tr>
<tr>
<td>Others</td>
<td>31</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>751</strong></td>
</tr>
</tbody>
</table>

The total financing of the 12 research areas during the last three years is presented in the table below. The total research turnover for the 12 areas is about 34-38 MSEK/year. As can be seen, the financing comes from many sources. Formas contributes, as an average, with about 13 % of the total turnover and is, consequently, an important financing source. International financing (EU, Nordtest) becomes more and more important and stands today for almost 20 % of the total research turnover.

**TABLE** Financing of the research in the field of Building and Property management at SP during the period 2001-2003.

<table>
<thead>
<tr>
<th>Financing partner</th>
<th>Amount (MSEK)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2001</td>
</tr>
<tr>
<td>EU</td>
<td>4.2</td>
</tr>
<tr>
<td>Nordtest</td>
<td>1.1</td>
</tr>
<tr>
<td>Nordic Industrial Fund</td>
<td>0.3</td>
</tr>
<tr>
<td>Formas</td>
<td>2.8</td>
</tr>
<tr>
<td>Swedish Agency for Innov. Syst. (Vinnova)</td>
<td>1.5</td>
</tr>
<tr>
<td>Research Foundations (MISTRA, SSF)</td>
<td>0.8</td>
</tr>
<tr>
<td>Swedish Board for Fire Research</td>
<td>1.4</td>
</tr>
<tr>
<td>SBUF</td>
<td>0.3</td>
</tr>
<tr>
<td>National authorities</td>
<td>2.8</td>
</tr>
<tr>
<td>Industry</td>
<td>4.5</td>
</tr>
<tr>
<td>Others</td>
<td>4.1</td>
</tr>
<tr>
<td>Government grant</td>
<td>10.5</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>34.3</strong></td>
</tr>
</tbody>
</table>
1 The research institute SP
1.1 Aim and profile

SP (The Swedish National Testing and Research Institute) is one of the biggest research institutes in Sweden. With a multi-disciplinary approach the aim is to contribute significantly to innovation and growth in industry and to a sustainable development in the society as a whole.

This is achieved by research in experimental and measurement techniques, and in the development and evaluation of new products and processes by the use of experiments, computations and analysis.

SP is a national institute with a comprehensive competence in a number of profile areas:

- Building
- Energy
- Fire and fire protection
- Materials
- Transport
- Electronics
- Measurement techniques*)

with broad aspects on environment, sustainability, health and safety. SP is the main Swedish institute also with respect to international co-operation in its field, considered as a competent and attractive partner by the main international R&D players. Particularly in the building, energy, fire, and measurement areas SP have essential national competence and resources.

*) SP is appointed by the government as the National Metrology Institute in Sweden

1.2 Strategies

We use the three steps development, application, and dissemination of knowledge in a systematic way, for interaction, influence and feed-back concerning all parties involved. This also means that we participate in all the steps from research to industrial applications which enhance efficiency of knowledge transfer.

We adjust our scientific development work to strategic needs appearing in society and industry, through broad and continuing contacts, and based on an organisation in terms of long term sustainable R&D environments.

We use our multi-disciplinarily actively to combine competencies for attacking new problem areas in industrial branches or societal areas. Examples can be found in the building and energy areas, where e.g. materials science and chemical analyses are combined with knowledge in thermodynamics, building physics and structural mechanics etc.

We co-operate with all sectors, as universities, institutes, industry, users, and organisations of society and politics, i.e. we make use of the "Triple Helix" concept in practise. This is essential to contribute efficiently to growth in the innovation system. In particular we co-operate with universities for synergy of aspects in performing research. We want to see this not as links in a chain as much as the two rails of a railroad, running in parallel and both necessary for success.

We prioritise international co-operation, e.g. in EU-projects. This is important for exchange of knowledge, influence and creation of confidence and networks facilitating trade and increasing competitiveness.
1.3 Organisation

SP is a private company (like Chalmers) with all shares held by the Swedish state. The organisation is flat with a high degree of delegation, which enhances flexibility and multi-disciplinarity. With a board, and a management consisting of a managing director, a planning and marketing director and a technical director there are eight technical and one administrative department. The technical departments have overall responsibility for economy, personnel, equipment, research, marketing etc according to an annual plan and following the common strategies and policies. Each department consists of a head of department, a deputy head of department and three to five sections/divisions. The departments and divisions/sections are shown in Figure 1.

SP has two subsidiary companies SMP (The Swedish Machinery Testing Institute) and SITAC (The Swedish Institute for Technical Approval and Certification).

<table>
<thead>
<tr>
<th>Fire Technology</th>
<th>Building Technology and Mechanics</th>
<th>Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>- fire resistance</td>
<td>- transport and vehicle technology</td>
<td>- products</td>
</tr>
<tr>
<td>- reaction to fire</td>
<td>- solid mechanics and structures</td>
<td>- management systems</td>
</tr>
<tr>
<td>- fire protection</td>
<td>- wood materials and structures</td>
<td></td>
</tr>
<tr>
<td>- research</td>
<td>- building materials</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Gothenburg</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electronics</th>
<th>Energy Technology</th>
<th>Chemistry and Materials Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>- electronics</td>
<td>- building physics</td>
<td>- chemical analysis</td>
</tr>
<tr>
<td>- EMC</td>
<td>- HVAC technology</td>
<td>- information storage systems</td>
</tr>
<tr>
<td>- product safety</td>
<td>- acoustics</td>
<td>- polymer technology</td>
</tr>
<tr>
<td>- software</td>
<td></td>
<td>- surface protection &amp; corrosion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- functional materials</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measurement Technology</th>
<th>Weight and Measures</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- electricity and time</td>
<td>- assay office</td>
<td></td>
</tr>
<tr>
<td>- electrical power</td>
<td>- verification office</td>
<td></td>
</tr>
<tr>
<td>- optoelectronics, length, and geometry</td>
<td>- field calibration</td>
<td></td>
</tr>
<tr>
<td>- mass, force and pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- volume, flow and temperature</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Departments and sections. The discipline oriented organisational parts co-operate in strategic project to work according to the profile areas.

1.4 Work principles

Many staff members have specialist or area responsibility and market contacts. SP has around 8000 customers and other contacts annually, mostly small and medium sized enterprises. This results in many networks and in competent and experienced project leaders.

The development of personnel is made systematically and followed up for all kinds of personnel, as well in Ph D-, graduate and under-graduate courses as in special courses and in planned participation in R&D.
SP has a management system integrating requirements for laboratory work (ISO 17025) and environmental management (ISO 14000). There are special routines for the planning, performance, reporting and evaluation of R&D.

SP uses the technique with so called balanced score cards in order to run a complex organisation with multi-dimensional goals successfully. Aims and vision are made measurable in terms of aims in four “dimensions” (economy, customers, competence, and processes), which balance each other.

SP is project oriented and all activities are run as projects supported by a modern business/economy system. All personnel declare time spent on projects. This means that all costs and incomes can be related to the performance of a project.

SP has an integrated plan and a policy for equality between sexes and for non-discrimination according to Swedish law.

1.5 Financing

The financing of SP 2002 is shown in Figure 2 in terms of the activity areas R&D, technical services and dissemination of knowledge. Many of the R&D activities are co-financed and SP receives grants from around 20 of the Swedish research councils, funds and authorities in competition. This financing has increased considerably during the last decade, while the government grants for development of new knowledge through R&D have decreased slowly.

Technical services includes as well large projects of a qualified nature as many smaller assignments of value for SME:s and their development. Dissemination of knowledge includes expert services to authorities in connection to rules and standards, standardisation and courses. Financing through the 5th framework program is 10 MSEK.

SP has been growing by around 5% annually for several years and with a profit margin of 3-4%.

Essential problems are connected to the Swedish co-financing of EU-projects, particularly in the 6th framework program with its requirements for large projects. SP is well suited for this kind of tasks and is presently coordinator for 6 projects of which two are large, in the sense of the 5th framework program. Another problem is the under-financing of Ph D students, which is common to that in universities but more accentuated.

<table>
<thead>
<tr>
<th>R&amp;D financing</th>
<th>142,9</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Industry (full financing)</td>
<td>39,0</td>
</tr>
<tr>
<td>- Industry (co-financing)</td>
<td>6,6</td>
</tr>
<tr>
<td>- R&amp;D councils and authorities (Formas, Vinnova, KK etc)</td>
<td>24,2</td>
</tr>
<tr>
<td>- Authorities (Vägverket, STEM etc)</td>
<td>17,4</td>
</tr>
<tr>
<td>- International financing</td>
<td>16,0</td>
</tr>
<tr>
<td>- Government grant</td>
<td>39,7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Income from technical services</th>
<th>268,3</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Industry and private organisations</td>
<td>255,5</td>
</tr>
<tr>
<td>- Government, keeping of metrology standards</td>
<td>12,8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dissemination of knowledge</th>
<th>16,0</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Industry (including courses)</td>
<td>10,3</td>
</tr>
<tr>
<td>- Government grant for (expert services)</td>
<td>5,7</td>
</tr>
</tbody>
</table>

*Figure 2. Financing of SP 2002.*
1.6 Personnel, education

The staff comprises 550 persons. Of these 97 have a Ph D (72) or a licentiate (25) degree. A further 140 persons have a masters degree, and there are also a number with a B Sc. This means that the technical areas/environments at the departments in general have a sustainable research competence and capacity for tutoring of Ph D students.

SP has 8 staff members working as so called adjungated professors, and a further 45 who have assignments as teachers at the technical universities or university colleges.

There are 35 Ph D students at SP, generally employees of SP with a project in co-operation with a technical university, for courses and formal exam requirements, and with supervision from SP:s researchers. There are also a few persons connected to Ph D programs at the research foundations, some foreign research students and returning post docs.

This activity has been successful. Since 1988 over 50 persons have got their licentiate or/and Ph D at SP with 4-6 exams per year. There have been no failures so far, although the rate of study has, of course, varied in a planned way. It could be mentioned that two of the SP trained Ph Ds have achieved professoriate’s.

During 2002 33 so called exam works (one semester projects at the end of a master’s or bachelor’s exam) were performed at SP.

1.7 Equipment

SP’s profile as national resource in experimental techniques and measurements means that there is unique equipment for experiments in several areas. Some of these are the following ones.

- The most modern and extensive fire research facility in Scandinavia
- The biggest and most varied EMC research facility in Scandinavia
- National metrology institute with primary standards for most physical entities, as length, mass, time and electrical entities.
- In co-operation with Chalmers a very qualified set of equipment for materials and surface analysis.
- Servo-hydraulic equipment for shock, vibration and fatigue investigations in building and mechanical applications with high capacity in the force and frequency ranges.

It should be mentioned that the value of qualified equipment lies in the fact that there is a sustainable personal competence in a research environment connected to it, so that it can be continuously and meaningfully used. This is the case at SP.

SP also has a group for advanced numerical calculations (FEM, CFD and electromagnetic). The combination with experiment gives unique possibilities to verify calculation models with regard to e.g. material models or boundary conditions.

SP’s annual investment in equipment is 35-40 MSEK.

1.8 Co-operation

SP has co-operation in around 90 projects (teaching, research, representation, equipment) with a large number of departments at Swedish (mostly technical) universities and university colleges, with a concentration to Chalmers, KTH and LTH. This includes participation in the so called Competence centra (by NUTEK/Vinnova).
There is also co-operation with 15 of the Swedish research institutes and program boards (as Brandforsk, Elforsk and Värme forsk). An important part is the co-operation with IVL, SIK and Trätek in United Competence, representing 40% of the Swedish institute volume.

Internationally, SP co-operates with 90 institutes, mostly Nordic and European, and to a large extent in the 5th Framework program. In this program SP participated in 43 projects and as co-ordinator in 6, of which 2 are bigger. Several activities are small and connected to inter comparisons.

All in all SP has a wide co-operation in research and a strong international network. Not least should be mentioned organisations as Eurolab, Euromet, EGOLF (fire), ENBRI, RILEM, IABSE, CIB (building), Eurachem, ENCRESS (software), ADLNB (telecommunication), EMCIT/EMCEL (electronics), CEEES (environment), IEA (energy), ESIS (mechanics) and VAMAS (materials).

1.9 Publications, dissemination of knowledge

In 2002 SP researchers published 233 reports, papers etc. A total of 169 of the publications were in external journals, conference proceedings, and theses. Of these 94 were published after peer review.

The other 64 publications were handbooks, methods and final project reports and they were published in the SP report series. These reports are distributed to branches of industry according to their scope, and they are also available through the SP web site.
SP staff also made 270 presentations at conferences, workshops and seminars, which means that around 10 000 – 15 000 persons were reached.

SP arranged or co-arranged 150 courses, seminars or conferences in 2002. This includes international meetings regarding standardisation and other expert issues.

1.10 Strengths

In conclusion SP could be seen as a major research performer in Sweden with particular strengths regarding

- use of multi-disciplinarily for broad problem areas,
- arena for all sorts of interests, as science, industry and society,
- broad contact networks with industry and research, nationally and internationally,
- national resource for advanced equipment in some areas,
- nationally strong research environments in e.g building, energy, materials and measurements,
- high capacity for project management, research by senior researchers, and thus continuity in keeping research environments, and
- effective dissemination and use of results.
2 Organisation of research on Building and Property management at SP

2.1 The network for Building and Property management at SP

Research and development related to Building and Property management is one of SP’s key areas of activity. SP’s work in the field is characterised by a wide technical span including sustainable development, indoor environment, building acoustics, efficient production and use of energy, materials and construction technique, wood and wood technology, fire, productivity and operation and maintenance.

The research activities become more and more international. SP participates normally in about 20 projects dealing with construction and buildings within the European frame programmes and coordinates some of them.

SP forms a part of an extensive network of national and international contacts, as well as being a member of organisations such as RILEM, CIB, EGOLF and ENBRI. In the last-mentioned network, the European Network of Building Research Institutes, participates the main building research institute in most of the member states and associated states of EU and also in Norway, Iceland and Switzerland. International standardisation is a working area of importance as well, and we are actively engaged in the work of CEN and ISO.

SP is a polytechnic institute organised in eight technical departments. The building competence is mainly found in four of these: Building Technology and Mechanics, Energy Technology, Fire Technology and Chemistry and Materials Technology. These four departments are shortly described below.

In order to coordinate the activities related to construction and buildings there is an internal network, the SP Strategic Group for Building and Property management. The group consists of one representative from each of the relevant departments, one representative from the market section and the planning and marketing director. The group meets about 6-8 times per year.

2.2 Departments active in the field of Building and Property management

2.2.1 Building Technology and Mechanics

Building Technology and Mechanics has a staff of about 110 persons of which about 65 works with activities related to the construction sector. The activities are focused on strength and stability, durability and environmental aspects of building structures, components and materials. Mostly we work with wood and wood based products, concrete and concrete constituents, rock materials and steel but also with masonry, brickwork, polymers and some other materials.

Computational calculations and simulations become more and more important, not least in combination with full scale testing. The combination calculation + testing have been successfully used, for example, for evaluation of temporary structures such as scaffolds, pall rackets, etc.

Another speciality for the department is field exposure experiments where components and materials are exposed for real climatic exposure. Three exposure sites are running today: one in a marine environment on the Swedish west-coast, one in a high-way environment between Borås and Gothenburg and one on the premises of SP.

Three research areas of importance for the department are presented in detail in chapter three of this report: a) Concrete and concrete technology, b) Wood materials and structures and c) Rock materials.
2.2.2 Energy Technology

Energy Technology has a staff of about 80 persons with activities in the areas HVAC, Combustion Technology, Building Physics and Acoustics. The department is playing an important part in the work of moving Sweden towards sustainability through its involvement in many research projects, often in conjunction with industry, universities or international research institutions. Our applied R&D provides a link between university research and practical application, creating new knowledge and giving birth to new ideas, which in turn develop new tools and incentives for further technical development.

Examples of current research areas include:

- **The indoor environment.** Problems are occurring in indoor environments. Special effort is needed in interdisciplinary research, incorporating both environmental medicine and technical aspects.
- **Energy conservation and efficient use of energy.** The need for improved energy conservation is obvious and it is becoming increasingly closely linked to the environmental impact.
- **Combustion and the environment.** Combustion processes increase the burden on the external environment, while the move towards renewable energy sources can bring new problems with it.
- **Wind and solar energy.** We have been engaged in research and development of solar energy for many years, and have the country's most comprehensive development and testing facilities in this field.
- **Acoustics.** During the last 10 years the research focus has been on environmental noise. Some projects on sound insulation and building acoustical test methods have also been carried out.

Three research areas of importance for the department and within the scope of the evaluation are presented in detail in chapter three of this report: a) Thermal insulation and air tightness in the building envelope, b) Moisture control and indoor environment and c) Acoustics.

2.2.3 Fire Technology

The Department of Fire Technology has a staff of about 50 persons. About two thirds of them are engaged in research and testing related to the building and construction sector. Ten of the staff members have academic doctors’ degrees. About two thirds of the activities are ordered and paid for abroad. Three of the academic researchers originate from outside the Nordic countries, five from outside Sweden.

The research is focused on developing small scale and full scale test for evaluating building products. A lot of effort is spent on interpreting small scale tests so that the results correspond to the behaviour in full scale fires. Several theoretical calculation models have been developed and verified whereby full scale fire behaviour can be predicted based on small scale test results. Thus the fire behaviour of products can be evaluated by relatively cheap and convenient tests and behaviour in real fires can be estimated with good precision and confidence. These techniques are now used in practice for our clients to facilitate the evaluation procedure and reduce costs.

In the harmonisation process of fire testing and evaluation in Europe SP has solved many crucial technical problems decisive for the progress. One example is the so called Plate Thermometer which is crucial for the harmonization of furnace testing; another is the interpretation rules for the new test method named SBI where the concepts of FIGRA and SMOGRA were introduced by SP. SP has made important contributions to the development of the fire parts of the Eurocodes. All these contributions have been made possible by the knowledge and experience obtained from the extensive research that has been carried out over many years.
Fire Technology has also made decisive contributions in the field of CFD (Computational Fluid Dynamics). Such computer codes are used to predict fire and smoke spread in e.g. buildings and tunnels among other things for computing times available for escape. SP has contributed in particular with algorithms on how to predict generations of various gas species. Several mathematical formula have been developed.

2.2.4 Chemistry and Materials Technology

The department of Chemistry and Materials Technology has a staff of about 70 persons of which 20 have postgraduate studies. The department carries out basic and applied research in the following program areas:

1. Lifetime Technology of Materials and Products
2. Sustainable Development and Life Cycle Management
3. Indoor Environment; Air Quality and Chemical Emissions from Materials
4. Surfaces and Interfaces in Materials, Products and Production Processes
5. International Aspects of Measurement Quality and Quality Assurance

The activities related to the construction sector are focused on performance, durability, weather ability and environmental aspects of building components and materials. The majority of work concerns performance, durability, weather ability and recycling of plastic and rubber materials. Performance characteristics of paints, metallic materials and organic and inorganic coatings, temporary corrosion protection agents and advanced ceramics are also included as well as technical service life related to outdoor durability of products.

Another speciality for the department is chemical analyses of building materials such as concrete, wood, and polymeric materials. Volatile compounds may affect the indoor air quality where building materials can be considered as one of the major emission sources for formaldehyde and VOC's. We can determine either emission factors for specific compounds (e.g. formaldehyde) or for a series of compounds (e.g. VOCs, aldehydes). Material emission measurements on site in buildings are also performed.

Six research areas of importance for the department are presented in detail:

- a) Recycling and durability of polymeric materials as wastes from buildings
- b) Long-term durability and performance of polymeric materials in various environments
- c) Service life prediction of solar thermal components
- d) Coatings for corrosion protection
- e) Painting of exterior wood
- f) Building materials and indoor air quality.
Research & Development at SP in the field of Building and Property management
3 Presentations of some important research areas in the field of Building and Property management at SP

3.1 Concrete and concrete technology
3.1.1 Ongoing and recently completed research

From SP research to European standard
In the early eighties it was found that there was an urgent need to repair many of the Swedish concrete bridges. The reason for this was poor frost resistance. There was, therefore, a need to develop a reliable method for freeze/thaw testing for classifying suitable concrete qualities for concrete bridges.

Based on earlier Swedish and Austrian experience SP then developed the method that in 1988 became Swedish Standard SS 13 72 44. This method is since then used for testing all bridge concrete in Sweden. This has, together with the development of a new cement type and new admixtures, led to significantly improved quality of new concrete bridges in Sweden. Very few freeze/thaw damages have been reported during the last 20 years.

In the early nineties work was started to standardize a European method for scaling resistance testing. The Swedish method SS 13 72 44 was one of three candidates. The two others were German methods.

The three methods were carefully compared in the European research project *Standard test methods for testing the resistance of concrete to freezing and thawing*. The Swedish method was found to be the most suitable and was suggested to be the European reference method. Now, after another 5 years, the method will be a European pre-standard (ENV). After another couple of years, when more countries have acquired more experience of the method, it will be established as an EN-standard. SP-research in the eighties thus will result in a European standard 20 years later. Research sometimes is trying!

References: 17, 25, 33, 37, 41, 46, 47, 50, 53, 54, 59, 96, 104, 105-109

Field exposure sites
Around 1990 the decision about the construction of the Öresund link was taken. As a preparation for this SP established a field exposure site in seawater at the Swedish west coast.

The research work at the exposure site was carried out together with universities, institutes and industry. Chloride penetration, reinforcement corrosion and freeze/thaw resistance were studied. Many different concrete qualities were tested under realistic exposure conditions to find a suitable concrete composition for the Öresund link. The mistakes from the Öland bridge should not be repeated!

The work at the field site was successful and led to valuable new knowledge, a number of doctoral theses and, not least, to a reliable concrete mixture for the Öresund link.

Encouraged by the success with the field exposure site in sea, SP established a new one in 1996 in a road environment along highway 40 between Borås and Gothenburg. Hundreds of concrete qualities are exposed and freeze/thaw resistance and reinforcement corrosion are studied.

The field exposure sites continue to produce important information and new projects. A few of these are presented below.

References: 7, 10, 11, 16, 29, 34, 45, 56-58, 60-67, 72-74, 78-89, 92, 97, 100

Internal frost damage
Concrete is, traditionally, protected against freeze/thaw damage by using air-entraining agents. Modern concrete technology allows the use of very low water/cement-ratios. Sometimes it is questioned if entrained air is needed to obtain frost resistance in such very dense concrete qualities.
Experience from the field exposure sites shows that the scaling strongly reduces with decreasing water-cement-ratios, also for concrete without entrained air. There is, however, a risk for internal frost damage also for low water/cement-ratios, especially for concrete with micro-silica but without air-entraining agents.

SS 13 72 44 has in two Nordtest-projects been developed to measure also the internal damage simultaneously with the scaling resistance testing. The internal damages are measured by registering the change of the ultra-sonic pulse velocity or length change after different number of freeze/thaw-cycles.

The method is now a RILEM recommendation: Slab Test – Freeze/Thaw Resistance of Concrete – Internal deterioration and efforts are taken to make it to a European Standard.

References: 4, 6, 19, 32, 36, 43

The influence of ageing on the freeze/thaw resistance
Testing of concrete normally takes place at an age of 28 days. Buildings, on the other hand, are dimensioned for a service life of 50 or 100 years. It is, therefore, often difficult to interpret the test results, not least for durability testing.

Peter Utgenannt runs a postgraduate project where he studies The influence of ageing on the frost resistance of concrete. Experience from field exposure sites is combined with laboratory studies.

Peter has found that carbonation is very positive for Portland cement concrete. Uncarbonated concrete shows up to 100 times higher scaling compared with carbonated concrete! This is completely new knowledge, which means that one, in principle, has to question much of the results from earlier performed research in the field of frost resistance. Wrong conclusions will be drawn if the effects of carbonation are not considered.

For other types of concrete, for example with high slag contents, the effect becomes completely different and carbonation leads to more severe scaling. Different types of concrete, for example with different binder qualities, show various types of degradation mechanisms. This must be considered in test methods, standards and norms.

References: 18, 20, 27, 30

Reinforcement corrosion
Chloride initiated reinforcement corrosion is probably the most important degradation process for concrete structures. Today, however, there exists no test methods or requirements in the European standards.

The European project Resistance of concrete to chloride ingress. From laboratory tests to in-field performance aims at developing accelerated test methods suitable for the European standardisation, and to evaluate these and calibrate them against field exposure. The project started in January 2003. SP is through associate professor Tang Luping coordinator for the project.

References: 1, 3, 5, 8, 9, 12, 14, 15, 21, 31, 35, 39, 42, 44, 77

Aggregate for concrete
SP participates through dr Björn Schouenborg in the European project Alkali silica reactions (PARTNER). The project is a direct continuation of the earlier EU-project Standard test of alkali reactive rocks, which was completed in 1998.
In the Nordtest-project *Frost resistance testing of aggregate with salt* a new test method is developed. The aim is to develop a method that reflects real exposure conditions in a better way than the existing EN-standard does.

References: 52

**Environmentally friendly concrete**
The sustainable society is built of concrete. Concrete dams for hydro power stations are the basis for the production of renewable energy. Concrete for harbours, tunnels, railways, etc. contributes to efficient and environmentally friendly transport. Waste water treatment plants can hardly be built without using concrete, and so on. The list of examples is very long.

However, the production and use of concrete and concrete structures has an environmentally impact, as do all other kinds of building materials as well. The national research programme *Advanced material and construction technique for sustainable concrete construction* aims at reduce the environmental impact when concrete is used. Three doctor’s project within the programme have started so far: at SP, Chalmers and Lund Institute of Technology respectively. The projects, which are run in close cooperation, all deals with *The use of industrial by-products and filler for concrete construction*. Prof Per-Erik Petersson from SP is supervisor for all the three projects.

Monica Lundgren leads the project at SP. This deals with *The early strength development with special focus on winter conditions*. The project aims at increasing the knowledge of the early age properties of concrete containing industrial by-products, i.e. during the first week after production. Slag, silica fume and lime-stone filler are included in the investigation.

The project in Lund is led by Dimitrios Boubitsas who is an industrial doctoral student from SP. He is investigating long-time properties/durability of concrete with industrial by-products.

SP also participates in the Nordic network project *Concrete for the environment*, which is financed by Nordic Industrial Fund.

References: 26, 28, 38, 68, 69, 98

**Inspection of concrete structures**
In the project *Mapping of reinforcement corrosion*, financed by the Swedish National Road Administration, dr Tang Luping has developed a rapid, non-destructive technique for mapping of ongoing reinforcement corrosion in existing structures. The method is based on electro-chemical principles and mathematical modelling. Conventional technique means that a single individual measurement takes several minutes to carry out. With the new technique a corresponding measurement can be carried out in 5 seconds with similar precision. This is important as a complete mapping includes a very great number of individual measurements.

SP also participates in the European research project *Development of two new measurement and inspection methods to improve the quality and maintainability of large concrete structures*. New equipment for ultra sonic pulse velocity measurements, including sensors, will, among other things, be developed.

References: 2, 24, 90, 94, 101

**Self compacting concrete (SCC)**
SCC does not need compaction when it is filled into the form. However, practical and reliable test methods for SCC are often still missing.
The EU-project *Measurement of properties of fresh self-compacting concrete* started at the end of 2001 and SP participates in the project. The project aims at evaluating and developing test methods for fresh self-compacting concrete. The result will be recommended test methods, which can form the basis for European standardisation.

SP is coordinator for the Nordic project *Nordic evaluation of test methods for self-compacting concrete*. This project can be seen as a complement to the European project.

In a project financed by Vinnova, experiments have been carried out in order to study the form pressure when SCC is used. The use of SCC led to higher pressure compared with the case where traditional concrete was used. For SCC the form pressure sometimes were very close to the hydraulic pressure.

*References: 13, 55, 95*

### 3.1.2 C.V. for researchers

The C.Vs for Professor Per-Erik Petersson and dr Tang Luping are shown in appendix CONCRETE 1. The C.V. for dr Björn Schouenborg is shown elsewhere in this document.

### 3.1.3 Doctoral students

SP has doctoral students in its staff, in cooperation with Building Materials at the Lund institute of Technology, in the field of concrete and concrete technology since about 1997:

<table>
<thead>
<tr>
<th>Name</th>
<th>Project</th>
<th>Examination</th>
<th>Financing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peter Utgenannt</td>
<td>Influence of ageing on the frost resistance of concrete</td>
<td>2003 (dr)</td>
<td>Formas, Cementa, SBUF, SP</td>
</tr>
<tr>
<td>Monica Lundgren</td>
<td>Use of industrial by-products and filler in concrete construction. Early strength development with special focus on winter conditions.</td>
<td>2004 (lic)</td>
<td>SBUF, Vinnova, Cementa, SP</td>
</tr>
<tr>
<td>Dimitrios Boubitsas (Lund Institute of Technology+SP)</td>
<td>Use of industrial by-products and filler in concrete construction. Long term properties/durability.</td>
<td>2004 (lic) 2006 (dr)</td>
<td>Formas, Cementa, KK</td>
</tr>
</tbody>
</table>

### 3.1.4 Financing

The financing of the research in the field of Concrete and concrete technology during the last three years are presented in the table below.

<table>
<thead>
<tr>
<th>Financing partner</th>
<th>Amount (kkr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2001</td>
</tr>
<tr>
<td>EU</td>
<td>204</td>
</tr>
<tr>
<td>SBUF</td>
<td>300</td>
</tr>
<tr>
<td>Industry</td>
<td>552</td>
</tr>
<tr>
<td>Nordtest</td>
<td>371</td>
</tr>
<tr>
<td>Swedish Agency for Innovation Systems (Vinnova)</td>
<td>446</td>
</tr>
<tr>
<td>Project</td>
<td>Period</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Resistance of concrete to chloride ingress – From laboratory tests to in-field performance</td>
<td>03-05</td>
</tr>
<tr>
<td>Alkali silica reactions (PARTNER)</td>
<td>02-04</td>
</tr>
<tr>
<td>Measurement of properties of fresh self-compacting concrete</td>
<td>01-04</td>
</tr>
<tr>
<td>Development of two new measurement and inspection methods to improve the quality and maintainability of large concrete structures</td>
<td>02-05</td>
</tr>
<tr>
<td>Life time prediction of high performance concrete with respect to durability</td>
<td>01-03</td>
</tr>
<tr>
<td>Standard test of alkali reactive rocks (STAR)</td>
<td>97-98</td>
</tr>
<tr>
<td>Standard methods for testing the resistance of concrete to freezing and thawing</td>
<td>95-98</td>
</tr>
<tr>
<td>Standard test methods for testing the permeability of concrete</td>
<td>94-98</td>
</tr>
</tbody>
</table>

### Nordic projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>Financing</th>
<th>Partners*</th>
<th>Contact at SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision of NT BUILD 361 – Concrete hardened, Water/cement-ratio</td>
<td>95</td>
<td>Nordtest</td>
<td>NBI, DTI, SP, VTT, Rb</td>
<td>Anders Andalen</td>
</tr>
<tr>
<td>Revision of NT BUILD 208 – Concrete hardened, Chloride content</td>
<td>95</td>
<td>Nordtest</td>
<td>NBI, SP, DTI, VTT, Rb</td>
<td>Anders Andalen</td>
</tr>
<tr>
<td>Frost resistance test on aggregates: Intercomparison of a new Nordtest method</td>
<td>95-96</td>
<td>Nordtest</td>
<td>Rb, SP, NBI, VTT</td>
<td>Björn Schouenborg</td>
</tr>
</tbody>
</table>

Research & Development at SP in the field of Building and Property management
### Frost resistance of concrete pavement blocks

Frost resistance of concrete pavement blocks was studied in 1995. The research was conducted by Nordtest, with SP, NBI, Aalborg Portland, and SP, NBI, Aalborg Portland, Aalborg Portland, VTT, and SP, NBI, Aalborg Portland, Aalborg Portland, VTT as partners. Anders Andalen was the coordinator.

### Frost resistance testing of mortar

Frost resistance testing of mortar was studied in 1996. The research was conducted by Nordtest, with SP, DTI, NBI, LTH, and SP, Aalborg Portland, NBI, SP, Aalborg Portland, VTT, SP, Aalborg Portland, VTT, and SP, Aalborg Portland, VTT as partners. Matz Sandström was the coordinator.

### Methods for water-tightening of specimens used for the freeze/thaw scaling test – Evaluation and suggestions

Methods for water-tightening of specimens used for the freeze/thaw scaling test were studied in 1996. The research was conducted by Nordtest, with SP, Aalborg Portland, VTT, and SP, Aalborg Portland, VTT as partners. Tang Luping was the coordinator.

### Chloride penetration resistance of paint on concrete

Chloride penetration resistance of paint on concrete was studied from 1996 to 1997. The research was conducted by Nordtest, with AEC, SP, SINTEF, and AEC, SP, SINTEF as partners. Tang Luping was the coordinator.

### Determination of the fracture energy of concrete: A comparison of the three-point bend test on notched beam and the wedge –splitting test

Determination of the fracture energy of concrete was studied from 1997 to 1998. The research was conducted by Nordtest, with SP, DTU, SINTEF, and SP, DTU, SINTEF as partners. Per-Erik Petersson was the coordinator.

### Evaluation of the ultrasonic method for detecting the freeze/thaw cracking in concrete

Evaluation of the ultrasonic method for detecting the freeze/thaw cracking in concrete was studied in 1997. The research was conducted by Nordtest, with SP, NBI, Aalborg Portland, and SP, NBI, Aalborg Portland as partners. Tang Luping was the coordinator.

### Measurement of volumetric frost degradation according to SS 13 72 44

Measurement of volumetric frost degradation according to SS 13 72 44 was studied in 1998. The research was conducted by Nordtest, with NBI, SP, VTT, Aalborg Portland, VTT, SP, Aalborg Portland, and VTT as partners. Tang Luping was the coordinator.

### Measurement of chloride content in concrete with blended cement – An evaluation of repeatability and reproducability of the commonly used test methods

Measurement of chloride content in concrete with blended cement was studied in 1998. The research was conducted by Nordtest, with SP, AEC, Ramböll, Chalmers, CBI, NBI, SINTEF, VTT, and SP, AEC, Ramböll, Chalmers, CBI, NBI, SINTEF, VTT as partners. Tang Luping was the coordinator.

### Calibration of the electrochemical methods for the corrosion rate measurement of steel in concrete

Calibration of the electrochemical methods for the corrosion rate measurement of steel in concrete was studied from 2001 to 2002. The research was conducted by Nordtest, with SP, NBI, VTT, Aalborg Portland, and SP, NBI, VTT, Aalborg Portland as partners. Tang Luping was the coordinator.

### Isothermal calorimetry for the study of cement hydration

Isothermal calorimetry for the study of cement hydration was studied from 2001 to 2002. The research was conducted by Nordtest, with LTH, SP, NBI, Grace (US), and LTH, SP, NBI, Grace (US) as partners. Monica Lundgren was the coordinator.

### Estimation of cement/binder profile parallel to the chloride determination

Estimation of cement/binder profile parallel to the chloride determination was studied from 2002 to 2003. The research was conducted by Nordtest, with SP, FORCE, CBI, Elkem, and SP, FORCE, CBI, Elkem as partners. Tang Luping was the coordinator.

### Influence of freezing media on the frost resistance of concrete

Influence of freezing media on the frost resistance of concrete was studied from 2001 to 2002. The research was conducted by Nordtest, with SP, Aalborg Portland, NBI, Rb, Vtt, and SP, Aalborg Portland, NBI, Rb, Vtt as partners. Peter Utgenannt was the coordinator.

### Concrete for the environment

Concrete for the environment was studied from 2001 to 2003. The research was conducted by Nordic Industrial Fund, with DTI, SP, CBI, RBI, FORCE, NBI, SINTEF, Industry, and Nordic Industrial Fund, DTI, SP, CBI, RBI, FORCE, NBI, SINTEF, Industry as partners. Per-Erik Petersson was the coordinator.

### National projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>Financing</th>
<th>Partners*</th>
<th>Contact at SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride and moisture profiles in concrete exposed to a marine climate</td>
<td>02-03</td>
<td>National Swedish Road Administration</td>
<td>SP, Chalmers</td>
<td>Tang Luping</td>
</tr>
<tr>
<td>Mapping of reinforcement corrosion</td>
<td>01-02</td>
<td>National Swedish Road Administration</td>
<td>SP</td>
<td>Tang Luping</td>
</tr>
<tr>
<td>Use of industrial by-products and filler in concrete construction. Early strength development with special focus on winter conditions.</td>
<td>02-04</td>
<td>SBUF, Cementa, Vinnova</td>
<td>SP</td>
<td>Monica Lundgren</td>
</tr>
</tbody>
</table>
Influence of ageing on the frost resistance of concrete  
97-03  
Formas, Cementa, SBUF  
SP  
Peter Utgenannt

Use of industrial by-products and filler in concrete construction. Long term properties/durability. (together with Lund Institute of Technology)  
02-06  
Formas, Cementa, KK  
SP, Lund Institute of Technology  
Dimitrios Boubitsas

Aspects on working environment when using self-compacting concrete  
00-01  
Swedish Council for Work Life Research  
SP  
Erica Waller

Safety at concrete working site – Development of the bearing capacity of the reinforced concrete structures  
97-98  
Swedish Council for Work Life Research  
SP  
Per-Erik Petersson

* Partner in bold = co-ordinator

### 3.1.6 International and national cooperation

Beside the cooperation in the research projects SP also participates/has participated in the following activities in the field of concrete and concrete technology. These activities are important for an efficient dissemination of the results from the research projects.

#### International

<table>
<thead>
<tr>
<th>Activity</th>
<th>Contact at SP</th>
<th>Period</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>RILEM TC 176 Internal damage of concrete</td>
<td>Per-Erik Petersson</td>
<td>00-</td>
<td></td>
</tr>
<tr>
<td>RILEM TC 117 Freeze/thaw</td>
<td>Per-Erik Petersson</td>
<td>93-00</td>
<td></td>
</tr>
<tr>
<td>RILEM TC 116 Permeability</td>
<td>Per-Erik Petersson</td>
<td>93-00</td>
<td></td>
</tr>
<tr>
<td>RILEM TC 106 Alkali silica reactions</td>
<td>Björn Schouemborg</td>
<td>97-02</td>
<td></td>
</tr>
<tr>
<td>RILEM TC,…. Chloride permeability</td>
<td>Tang Luping</td>
<td>99-</td>
<td></td>
</tr>
<tr>
<td>CEN/TC51/WG12/TG4 Frost resistance</td>
<td>Per-Erik Petersson</td>
<td>94-</td>
<td></td>
</tr>
<tr>
<td>CEN TC104 SC3 Admixtures</td>
<td>Kent Malmström</td>
<td>93-01</td>
<td></td>
</tr>
<tr>
<td>CEN TC104 SC1 TG7 Curing</td>
<td>Per-Erik Petersson</td>
<td>94-98</td>
<td></td>
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<tr>
<td>CEN TC104 SC1 TG8, Test methods</td>
<td>Anders Andalen</td>
<td>96-00</td>
<td></td>
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<tr>
<td>CEN/TC104/SC/WG3 Electro-chemical test methods</td>
<td>Tang Luping</td>
<td>99-</td>
<td></td>
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<tr>
<td>The Nordic concrete research committee</td>
<td>Per-Erik Petersson</td>
<td>01-</td>
<td></td>
</tr>
</tbody>
</table>

#### National

<table>
<thead>
<tr>
<th>Activity</th>
<th>Contact at SP</th>
<th>Period</th>
<th>Comments</th>
</tr>
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<tbody>
<tr>
<td>The Swedish Concrete Association’s Council of Concrete Research</td>
<td>Per-Erik Pettersson</td>
<td>88-</td>
<td></td>
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<tr>
<td>Nordcert AB (Certification authority for concrete and steel in building structures)</td>
<td>Per-Erik Pettersson (board member)</td>
<td>02-</td>
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<tr>
<td>”Stiftelsen Betong- och Ballastindustrins Kvalitetsutveckling, SBBK”</td>
<td>Per-Erik Petersson (Chairman of board)</td>
<td>99-</td>
<td></td>
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<tr>
<td>SIS TK 185 Cement and lime</td>
<td>Mats Sandström</td>
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<td>SIS TK 190 Concrete</td>
<td>Per-Erik Petersson</td>
<td>88-</td>
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<td>“Boverkets konstruktionsråd”</td>
<td>Carl-Johan Johansson</td>
<td>02-</td>
<td></td>
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<tr>
<td>“Föreningen ackrediterade betonglaboratorier” FAB</td>
<td>Cathrine Ewertson</td>
<td>99-</td>
<td></td>
</tr>
</tbody>
</table>
### Relevant publications 1993-2003

#### Peer reviewed papers

1. **TANG, Luping, NILSSON, Lars-Olof.** "On relationships between different chloride diffusion and/or migration coefficient in concrete". Proceedings of the 3rd International RILEM Workshop on Testing and Modelling the Chloride Ingress into Concrete, September 2002, Madrid, Spanien.


11. TANG, Luping, UTGENANNT, Peter. Characterization of chloride environment along a highway. 5th International Conference on Durability of Concrete, Barcelona, June 2000.


21. TANG, Luping. Chloride penetration into the concrete exposed under different conditions. 7th International Conference on the Durability of Building Materials and Components, Stockholm May 1996.


Other international scientific publications


26. LUNDGREN, Monica. Strength development at low temperatures in young concrete with mineral additives. Proceedings Nordic Concrete Research Meeting, Helsingör, Denmark 2002


29. BOUBITSA, Dimitrios. Chloride profiles in concrete specimens exposed to a high-way environment for five years. Proceedings from mini-seminar i Hirtshals, Denmark.


34. UTGENANNT, Peter. Salt-frost resistance of concrete in highway environment. 3rd Nordic research seminar on frost resistance of building materials. Lund 31 August – 1 September 1999.


44. TANG, Luping. Chloride profiles in concrete treated with different coating systems. SP AR 1997:32.


Swedish reports


57. UTGENANNT, Peter. Register över utplacerade provkroppar – hösten 2002. BTB-rapport nr 34.


60. NILSSON, Lars-Olof, ANDERSSON, Alf, TANG, Luping, UTGENANNT, Peter. Chloride ingress data from field exposure in a Swedish road environment. BTB-rapport nr 21.


69. UTGENANNT, Peter, PETERSSON, Per-Erik. Provning av ”byggcem” i laboratorium och i fält – jämförelse mellan Slite std. och ”byggcem”. SP AR 1999:32 1999


91. STENBERG, Fredrik. Cements värmeutveckling - mätning med semadiabatisk kalorimeter. SP AR 1996:20


**Popular scientific publications**


100. UTGENANNT, Peter, PETERSSON, Per-Erik, MALMSTRÖM, Kent. Fältexponering av betong - två nationella projekt. Bygg & teknik 7/96. Article 1996


103. ÅGÅRDH, Lennart. Icke förstörande provningsmetoder för betongkonstruktioner – ny teknik under utveckling i Canada och USA. Bygg och Teknik nr 7/94. Article 1994


Others


Appendix CONCRETE 1

CV Per-Erik Petersson

Name: Per-Erik Petersson

Address, residence: Akvilejagången 25, 507 52 Borås, Sweden

Telephone, residence: 033-152008

Family: Married, three children

Present position: Head of the Department of Building and Mechanics at SP Swedish National Testing and Research Institute

Assistant Professor (20%) at the Division of Building Materials, Lund Institute of Technology

Telephone number, SP: 033-165000 (direct: 033-165217)

E-mail address: pererik.petersson@sp.se

Education and degrees:

Upper secondary school degree ("Studentexamen"), Falkenberg 1968

Master of Science in Civil engineer (V), Lund Institute of Technology, 1973

Doctor’s degree, Division of Building Materials, Lund Institute of Technology, 1981

Other courses:

“Betongkurs I”, 1977

Leadership development and techniques, 1991

Professional quality assurance lead auditor, 1993

Training course on EC research and technological development programmes, 1994

Pricing and business communication, 1994

SP Leadership development (1999-2000)

University positions:

Various positions at Lund Institute of Technology during the period 1971-1982, see the enclosed certificate of service

Assistant Professor (20%) at the Division of Building Materials at Lund Institute of Technology, 1999-

Other positions:

At SP Swedish National Testing and Research Institute I have held the following positions since 1983:
Research Engineer 1983-1986 at the section of Building materials
Head of the section of Building Materials 1986-1991
Head of the department of Building Technology 1987- 2002
Head of department of Building and Mechanics 2003-

Language skills: Swedish (mothers tongue), English, German (reading)

Current assignments:

International organisations

- European Network for Building Research institutes (ENBRI) Board member
- ENBRI WG on Research Technical Development and prenormative research Member
- RILEM General Council Sweden’s representative
- NBS (“Nordisk byggsamverkan”) Board member
- NORDTEST expert group in construction Chairman
- RILEM TC 176 Internal damage of concrete Member
- The Nordic concrete research committee Member
- CEN/TC51/WG12/TG4 Frost resistance Member

Swedish organisations

- The Swedish Concrete Association’s Council of Concrete Research Member
- Certification Authority for Steel in Building Structures ltd (“SBS AB”) Board member
- ”Stiftelsen Betong- och Ballastindustrins Kvalitetutveckling, SBBK” Chairman of board
- Concrete and Aggregate Certification (“ Betong och Ballast Certifiering AB”) Board Member
- “KTH Byggnaskap” SPs representative
- ”Föreningen Svensk Kvalitet” SPs representative
- “BST/TK45 Betong” Member
- ”Boverkets Konstruktionsråd” SPs representative
- ”Institutionssstyrelsen för Ingenjörshögskolan vid Högskolan i Borås från jän 2002” Chairman

Publications

Available on request.
Curriculum Vitae

Full Name: TANG, Luping
Address: Tvärgäten 2
SE-518 30 SANDARED
Sweden
Telephone: Work: +46 33 165000 (direct +46 33 16 51 38)
Home: +46 33 25 82 96
E-mail: tang_luping@sp.se

Personal Information
Marital Status: Married since 1984
Birth Day: January 28, 1956
Place of Birth: Sichuan, China
Nationality: Swedish
Children: Two girls

Summary of Qualifications

2002.4 - Present
Building and Mechanics, SP Swedish National Testing and Research Institute
Borås, Sweden
Research scientist (80% of full time).

Building Materials, Chalmers University of Technology (CTH)
Göteborg, Sweden
Associate professor (Oavslutad docent, 20% of full time).

1997.1 – 2002.3
Dept. of Building Technology, Swedish National Testing and Research Institute
Borås, Sweden
Research scientist.

1990.1 - 1995.8
Dept. of Building Materials, Chalmers University of Technology
Göteborg, Sweden
Research assistant and Doctoral student.

Dept. of Building Materials, Chongqing Institute of Architecture & Engineering
Chongqing, China
Research and teaching assistant.

Education

1993 - 1996
Dept. of Building Materials, Chalmers University of Technology
Göteborg, Sweden
Technology Doctor (PhD).

1990 - 1993
Dept. of Building Materials, Chalmers University of Technology
Göteborg, Sweden
Technology Licentiate.
1978 - 1982 | **Dept. of Building Materials, Chongqing Institute of Architecture & Engineering**
*Chongqing, China*
Bachelor of Engineering

**Languages**

Chinese (mother tongue), English and Swedish

**Participating in international technical organisations**

1998 - Member of RILEM TC 178 Testing and Modelling Chloride Ingress in Concrete
1998 - Member of CEN/TC104/SC3/WG3 Electrochemical methods for testing corrosion

**Publications**

(A list available on request)
3.2 Wood materials and structures
3.2.1 Ongoing and recently completed research

Non-destructive testing/grading of structural timber

A pre-requisite for the use of timber in load-bearing constructions is that the strength and stiffness properties are known and can be controlled to stay within desirable limits. This can not be achieved in the same way as for man-made products such as steel, concrete, plastics and wood fibre board where a certain material quality is obtained by changing the composition of the raw materials or by changing some of the environmental conditions (temperature, pressure etc). As far as the mechanical properties of wood are concerned the only realistic way of obtaining quality within desired limits is grading. There are presently two types of strength grading systems:

- **Visual strength grading** which is based on visual inspection to ensure that the pieces do not have visible defects in excess of the limits specified in the relevant grading rule.
- **Machine strength grading** where the pieces are passed through a machine, which measures one or several parameters non-destructively. Based on these measurements strength and stiffness are predicted.

SP has focused on improving existing machine grading systems. Research in this area requires extensive testing of timber. This has resulted in a “structural timber database” at SP, where test results from around 5000 timber pieces are collected (grading data, raw material data, strength and stiffness etc.). One strategy has been to combine strength prediction by means of bending stiffness with knot measurements. This has proved to be successful in the sense that it has been shown that only the knots on the timber edge need to be measured. Rune Ziethén in his postgraduate project has another strategy. He studies different aspects of proof-loading as a grading technique. This technique is used for example in USA, but not yet in Europe. Other ongoing projects deal with settings for different types of grading machines. Optimum settings of the machines is decisive for the economy of grading. This work is carried out on a Nordic basis together with the industry and is used in the European standardization activities within CEN/TC124/WG2/TG2.

Presently, projects on “Visual grading by using scanner technique” and “Better prediction methods for timber properties by combining grading methods” are planned.

References:1, 5, 10, 11, 17, 18, 19, 20, 24, 25, 26, 27, 28, 29, 30, 31, 32, 37, 45, 47, 57, 64, 65, 67, 69, 71, 72, 76, 87, 99, 101, 102

Wood durability and environment

Since the mid 1990s SP has been more actively involved in wood durability and wood protection research. Focus has been on the following themes:

- performance studies (testing durability and technical properties)
- quality assurance (QA) in the wood preserving industry.

The performance studies have been focused on arsenic and chromium free preservative treatments, chemically modified wood, in particular heat-treated wood, and different wood species claimed to have a high natural durability, such as larch, pine and oak heartwood. These studies, conducted as laboratory, field and service tests, have increased the knowledge of various alternative wood materials to “traditionally preservative-treated “ wood. SP has a field exposure site in Borås.

SP has also conducted an extensive study with the primary aim to investigate Swedish private home owners’ expectations of the service life for outdoor wooden constructions (i.e. decking, fencing, garden timbers, carports). A majority of the home owners favoured a service life of more than 20 years but a substantial part was content with a service life of less than 10 years.

Wood protection by design is another area of interest for SP. In a recent study SP has carried out a literature study on building codes and guidelines on wood protection by design as well as an inventory...
of failures related to poor design. It was concluded that a key issue to avoid failures (decay damages) is to make the building sector aware of and to apply existing knowledge.

The QA system in the Nordic wood preserving industry is based on European Standards (EN 351-1 and EN 351-2). In recent years SP has taken initiatives to studies with the aim to improve the QA system.

**Waste wood**

Recycling of building materials is an important area of research at SP. With respect to wood SP has been involved in a number of projects.

The first study related to waste wood was to prepare a guideline for sorting demolition wood with particular reference to re-cycling of constructional timbers.

With the aim of providing a basis for scenarios for waste management options with treated wood as well as realistic risk assessments for the use of treated wood a study was recently carried out. The purpose was to get an overview of the use of wood preservatives and their active substances in Sweden since the beginning of the 20th century. The inventory revealed, for example, that approximately 14 000 tons of arsenic and 9000 tons each of copper and chromium had been used so far for wood preservation in Sweden.

The most recent project has been focused on problems related to incineration of waste wood. This is increasingly used as fuel in Sweden. Analyses of waste wood fuel chips have shown that the major chemical contaminants are surface treatments (paints etc) and wood preservatives. The surface treatments contribute in particular to contaminants of zinc and lead. In some cases, there are strong indications that these metals can cause severe deposit formation in the furnaces. Preservative-treated wood is the most important source of increased levels of copper, chromium and arsenic in the waste wood.

Chemical analyses indicate that the distribution in levels of impurities varies considerably between deliveries of waste wood.

*References: 13, 14, 35, 36, 39, 40, 42, 43, 52, 53, 54, 55, 56, 60, 75, 77, 78, 80, 81, 82, 83, 84, 85, 86, 90, 92, 93, 94, 95, 96, 97*

**Adhesive bonding**

Adhesive bonding is a pre-requisite for development of engineered wood products (EWP) with good, predictable and well-defined mechanical properties. Adhesives for such products need to have a good creep rupture behaviour. For most of the traditional structural wood adhesives creep has not been an issue. The adhesive types that are now being introduced, for example the one component polyurethane, are however prone to creep, in particular at elevated temperatures. Based on an ASTM – standard SP has developed a creep rupture test method, in which time to failure in shear is measured. Small specimens are loaded at different levels. An aluminium tube is used and load is applied by means of springs. The tubes can easily be placed in large numbers in different climate cabinets. This test method is included in European standards prepared by CEN/TC193/SC1/WG4.

Glued-in rods are means of transferring forces within a structure, and of providing local reinforcement to critical zones of timber members. They also provide an important technology for the repair and upgrading of historically important timber structures which exist throughout Europe. SP has coordinated a European project dealing with design-rules, test methods for suitable adhesives and production control methods for glued-in rods. The project has resulted in design rules for glued-in rods to be included in Eurocode 5 and a basis for standards, which are now being drafted in CEN/TC193/SC1 and in CEN/TC124.
For development of efficient adhesive bonds multidisciplinary knowledge is needed (adhesive chemistry, surface properties and properties of the glued product). At SP such an interdisciplinary approach has been initiated for studying wood adhesive (polyurethane based) joints. Cross sections and fracture surfaces of the joints have been studied with electron microscopy. Differences in the mechanical performance of the joints studied in the project show a clear correlation with the microstructure of the joints. In the same project, methods are also being developed for chemical analysis of adhesives by mass spectrometric techniques. Results obtained so far show that by using proper sample preparation procedures, detailed information about the molecular composition of adhesives can be obtained.

Future activities dealing with gluing wet wood and optimization of glued wood products are planned.

References: 2, 3, 4, 6, 8, 9, 12, 16, 34, 44, 50, 61, 63, 89, 103

Wood drying
Drying, together with grading, is the most important process in a sawmill. The work at SP concentrates on properties of the wood material after different drying processes. Recently a large study on the influence of high temperature drying on strength and stiffness of spruce timber was carried out. It was shown that the stiffness was not affected by temperatures up to 125 degrees but the strength was, on the average, 5% lower compared to conventionally dried timber. This is important knowledge as most of the grading methods are based on the relationship between strength and stiffness and indicates that the machine settings may have to be corrected for the effect of the drying.

In coming projects it is planned to study how the drying affects the treatment by wood preservatives.

References: 7, 15, 38, 48, 51, 66, 79, 91, 100

Components and systems
Since the 1980’s SP has been involved in developing design and test methods for light weight wood based I-joists. This work played an important role when European guidelines for such products were elaborated in the late 1990’s. These products will be among the first wood based products to obtain CE-marking.

In an on-going project components and systems for multi-storey timber framed houses are developed. Five prefab house manufacturers are involved and the aim is to use their technique to build multi-storey residential houses. The projects contains a number of challenges such as

- Development of a competitive floor element with acceptable sound insulation using a traditional structure with 22 mm particleboard on beams spaced 600 mm.
- Finding on-site building methods that minimises the effect of moisture.
- Development of wall to floor connections that allow easy assembly without jeopardising the stability of the building or causing excessive flank transmission of sound.
- Wood based beams for long spans.

The project also involves planning of three four-storey residential houses near Gothenburg, which will be erected during the autumn of 2003.

References: 21, 23, 41, 46, 49, 58, 59, 68, 70, 74, 88, 98

Furniture
Design of furniture is usually based on experience from already existing furniture. Evaluation is then carried out by testing prototypes. This is expensive and time-consuming work. By using existing tools for calculation it is possible to simplify the process from idea to a new furniture. However, furniture is complex structures consisting of different materials and geometries. Usually, connections are the most critical points. Work on finite element modelling of furniture and parts of furniture has started at SP.
3.2.2 C.V. for researchers

The C.Vs for Professor Carl-Johan Johansson, Dr Charlotte Bengtsson, Dr Erik Serrano, Tech Lic Björn Källander and Dr Marie-Louise Edlund are shown in appendix WOOD 1.

3.2.3 Doctoral students and international diploma thesis works

SP has a doctoral students on its staff, in cooperation with Växjö University in the field of strength grading of timber as well as a researcher that recently got his Licentiate degree in wood drying.

<table>
<thead>
<tr>
<th>Name</th>
<th>Project</th>
<th>Examination</th>
<th>Financing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rune Ziethén</td>
<td>Proof-loading – a new principle for machine strength grading of timber</td>
<td>2003 (lic) exp</td>
<td>Wood Technology Program, SP</td>
</tr>
<tr>
<td>Björn Källander</td>
<td>Vacuum drying of wood – climate control and drying quality.</td>
<td>2000</td>
<td>Industry</td>
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</table>

In addition to this, students from several European universities have carried out their master thesis work at SP.

<table>
<thead>
<tr>
<th>Name</th>
<th>Project</th>
<th>Examination</th>
<th>University</th>
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<tbody>
<tr>
<td>Ernst-Werner Wormuth</td>
<td>Untersuchung des Verhältnisses von flachkant zu hochkant ermitteltem Elastizitätsmodul von Schnittholz zur Verbesserung der maschinellen Festigkeitssortierung.</td>
<td>1993</td>
<td>Universität Hamburg</td>
</tr>
<tr>
<td>Martin Kemmsies</td>
<td>Einfluss des Klebstoffes und der Klebetechnik auf die Festigkeit von geklebten Brettschichtholz-Stahlplatten verbindingen</td>
<td>1994</td>
<td>Universität Hamburg</td>
</tr>
<tr>
<td>Ralph Streicher</td>
<td>Einflüsse wechselnder Temperatur und Luftfeuchtigkeit auf geklebte Brettschichtholz-Stahlplatten-Verbindungen in tragenden Konstruktionen</td>
<td>1994</td>
<td>Universität Hamburg</td>
</tr>
<tr>
<td>Henning Duwe</td>
<td>Faktoren, die die Nageltragfähigkeit von nagelplatten in Fichtenholz (Picea abies (L.) Karst) beeinflussen</td>
<td>1995</td>
<td>Universität Hamburg</td>
</tr>
<tr>
<td>Hauke Chrestin</td>
<td>Elasto-mechanischen Eigenschaften und maschinelle Festigkeitssortierung von Fichtenschnittholz aus verschiedenen Regionen Schwedens</td>
<td>1996</td>
<td>Universität Hamburg</td>
</tr>
<tr>
<td>Daniel Betzhold</td>
<td>Maschinelle Festigkeitssortierung – Einfluss der Hochtemperatur-Trocknung auf die elasto-mechanischen Eigenschaften des Schnittholzes</td>
<td>1999</td>
<td>Fachhochschule Eberswalde</td>
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<tr>
<td>Katharina Hausmann, Nicole Reil</td>
<td>Herstellungskontrolle für eingeleimte Bolzen in Holzkonstruktionen</td>
<td>1999</td>
<td>Universität Karlsruhe</td>
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<tr>
<td>Sabine Ott</td>
<td>Machine Strength Grading – An investigation on Timber with Single Large Effects</td>
<td>2000</td>
<td>Universität Karlsruhe</td>
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<tr>
<td>Arnoud Vink</td>
<td>Technical feasibility study for screw gluing of composite wood structures</td>
<td>2000</td>
<td>Delft University of Technology</td>
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</table>
### 3.2.4 Financing

The financing of the research in the field of Wood Materials and Structures during the last three years is presented in the table below.

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<th>Financing partner</th>
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<td>2001</td>
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<td>EU</td>
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<td>Swedish Wood Association (Arbio AB)</td>
<td>1445</td>
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<td>Sågverkens Forskningsstiftelse</td>
<td>365</td>
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<tr>
<td>Strategiska Forskningsstiftelsen SSF</td>
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<td>Industry</td>
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<td>Nordtest</td>
<td>182</td>
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<td>Swedish Agency for Innovation Systems (Vinnova)</td>
<td>652</td>
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<td>Nordic Industrial Fund</td>
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<td>Others</td>
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<td>Government grant</td>
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### 3.2.5 International and national research projects

#### European projects

<table>
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<th>Project</th>
<th>Period</th>
<th>Partners*</th>
<th>Contact at SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIROD - Glued-in rods for timber structures</td>
<td>98-01</td>
<td>SP, Lund University, TRADA (UK), Karlsruhe University (DE), FMPA (DE) + industry</td>
<td>Carl-Johan Johansson (coordinator)</td>
</tr>
<tr>
<td>CONGRAD - Control of Timber Strength Grading Machines</td>
<td>97-00</td>
<td>SP, BRE (UK), CTBA (FR), VTT (FI), Ludwig Maximilian University (DE)</td>
<td>Lars Boström (coordinator)</td>
</tr>
<tr>
<td>Improving grading methods for structural timber by non-destructive techniques</td>
<td>94-97</td>
<td>SP, CTBA (F), BRE (UK) + industry</td>
<td>Lars Boström</td>
</tr>
<tr>
<td>SHEAR - Extending markets for wood based panels by developing a better understanding of shear test methods and board shear properties</td>
<td>96 – 99</td>
<td>TRADA (UK), BRE (UK), VTT (FI), DTI (DK), SP (S)</td>
<td>Rune Ziethén</td>
</tr>
</tbody>
</table>
### Nordic projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>Financing</th>
<th>Partners*</th>
<th>Contact at SP</th>
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<tr>
<td>Dimensionering av träkonstruktioner genom provning</td>
<td>92-94</td>
<td>Nordtest</td>
<td>SP, NTI, VTT</td>
<td>Carl-Johan Johansson</td>
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<tr>
<td>Bestämning av skjuvhållfasthet hos träbaserade skivmaterial till bärande konstruktioner</td>
<td>92-94</td>
<td>Nordtest</td>
<td>SP</td>
<td>Rune Ziethén</td>
</tr>
<tr>
<td>Limträkonstruktioner i större byggnader och anläggningar</td>
<td>92-94</td>
<td>NUTEK</td>
<td>SP, Moelven Limtre-gruppen, Euro-Tre, Norbuild, NILU, NTI</td>
<td>Carl-Johan Johansson</td>
</tr>
<tr>
<td>Provningsmetoder för bestämning av spånsvivors beständighet - ringtest</td>
<td>93-94</td>
<td>Nordtest</td>
<td>SP, NTI, DTI</td>
<td>Carl-Johan Johansson</td>
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<tr>
<td>Provning av limfogar i limträ – ringtest</td>
<td>93-95</td>
<td>Nordtest</td>
<td>SP, NTI, RB, DTI, VTT</td>
<td>Carl-Johan Johansson</td>
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<tr>
<td>Fuktberoende dimensioneringsändringar i träbaserade skivmaterial</td>
<td>94-95</td>
<td>Nordtest</td>
<td>SP, NTI, DTI</td>
<td>Carl-Johan Johansson</td>
</tr>
<tr>
<td>Styrkesortering ger mervärde</td>
<td>94-95</td>
<td>Nordisk Industrifond</td>
<td>SP, VTT, DTU, NTI, Trätek</td>
<td>Carl-Johan Johansson</td>
</tr>
<tr>
<td>Trä för återvinning</td>
<td>96-07</td>
<td>Nordtest</td>
<td>SP, DTI, rivningsföretag</td>
<td>Charlotta Holmqvist</td>
</tr>
<tr>
<td>Mätning av elasticitetsmodulen hos trä</td>
<td>97-98</td>
<td>Nordtest</td>
<td>SP, VTT, NTI, Trätek</td>
<td>Lars Boström</td>
</tr>
<tr>
<td>Hållfasthetsklasser för limträlameller</td>
<td>97-99</td>
<td>Nordisk Industrifond</td>
<td>SP, DTU, NTI, LTH, Trätek, VTT</td>
<td>Carl-Johan Johansson</td>
</tr>
<tr>
<td>Träbaserade lättbalkar – ringtest</td>
<td>99-00</td>
<td>Nordtest</td>
<td>SP, NTI, VTT, industrin</td>
<td>Carl-Johan Johansson</td>
</tr>
<tr>
<td>Nordic test method to classify the performance of adhesives for load-bearing timber structures after fire exposure</td>
<td>99-01</td>
<td>Nordtest</td>
<td>SP, NTI</td>
<td>Björn Källander</td>
</tr>
<tr>
<td>Icke-förstörande provningsteknik baserad på mätning av resonanta vibrationer – tillämpning på träbaserade material.</td>
<td>99-01</td>
<td>Nordtest</td>
<td>SP, DTI, VTT</td>
<td>Carl-Johan Johansson</td>
</tr>
<tr>
<td>Träkonstruktioners pålitlighet</td>
<td>00</td>
<td>DTU</td>
<td>SP</td>
<td>Charlotte Bengtsson</td>
</tr>
<tr>
<td>Produktionsprocess- och hållbarhetsdokumentation för krom- och arsenikfria impregneringsmedel</td>
<td>00-??</td>
<td>Vinnova</td>
<td>SP, SLU, Svenska Träskyddsföreningen</td>
<td>Jöran Jermer</td>
</tr>
<tr>
<td>Fungicid från räkor</td>
<td>01-02</td>
<td>Vinnova</td>
<td>NTI, SP</td>
<td>Jöran Jermer</td>
</tr>
</tbody>
</table>

*Contact at SP* indicates the contact person at SP for each project.
### National projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>Financing</th>
<th>Partners*</th>
<th>Contact at SP</th>
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<tbody>
<tr>
<td>Drift- and skötselinstruktion för ett småhus</td>
<td>92-94</td>
<td>BFR</td>
<td>SP</td>
<td>Roger Anneling</td>
</tr>
<tr>
<td>Kalibreringsbräda för sorteringsmaskiner</td>
<td>92</td>
<td>Trätek</td>
<td>SP, Trätek</td>
<td>Carl-Johan Johansson</td>
</tr>
<tr>
<td>Fältförsök impregnering</td>
<td>96-06</td>
<td>SVTF Service AB</td>
<td>SP</td>
<td>Carl-Johan Johansson</td>
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<tr>
<td>Höghållfast konstruktionsvirke</td>
<td>97</td>
<td>CTH</td>
<td>SP, CTH, LuTH</td>
<td>Lars Boström</td>
</tr>
<tr>
<td>Godkännanderegler för träbaserade lättbalkar</td>
<td>98-00</td>
<td>NUTEK</td>
<td>SP, NTI, VTT</td>
<td>Carl-Johan Johansson</td>
</tr>
<tr>
<td>Gran med ytligt skydd för utomhusbruk</td>
<td>99</td>
<td>ARBIO AB</td>
<td>SP</td>
<td>Carl-Johan Johansson</td>
</tr>
<tr>
<td>LVL en engineered wood product</td>
<td>99-01</td>
<td>NUTEK</td>
<td>SP, Mälarpy, Dynalyse, CTH</td>
<td>Carl-Johan Johansson</td>
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<td>Industriella lösningar för produktion av formbeständigt virke</td>
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<td>Trätek</td>
<td>SP</td>
<td>Charlotte Bengtsson</td>
</tr>
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<td>Machine strength grading by means of proof loading</td>
<td>00-03</td>
<td>LuTH</td>
<td>SP</td>
<td>Rune Ziethén</td>
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<tr>
<td>Maskinsorterat virke till USA</td>
<td>00-</td>
<td>Sågv. Forskningsstiftelse</td>
<td>SP, sorterande företag</td>
<td>Charlotte Bengtsson</td>
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<td>Brukarkrav om träkonstruktioners beständighet/livslängd</td>
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<td>ARBIO AB</td>
<td>SP</td>
<td>Jöran Jermer</td>
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<td>SP</td>
<td>Björn Källander</td>
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<td>Värmebehandlat trä – kunskapsläget</td>
<td>00-01</td>
<td>Vinnova</td>
<td>SP</td>
<td>Jöran Jermer</td>
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<td>Inventering av innehållet i RT-flis</td>
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<td>Värme-forsk</td>
<td>SP</td>
<td>Jöran Jermer</td>
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<td>Nya konstruktionslim för trä – värdering av beständighet och långtidshållfasthet</td>
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<td>Flervånings trähus med prefab-teknik</td>
<td>01-03</td>
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<td>Beständighet virke</td>
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<td>SP</td>
<td>M-L Edlund</td>
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<tr>
<td>Beständighet hos miljöanpassat träskydd</td>
<td>01-03</td>
<td>ARBIO AB</td>
<td>SP</td>
<td>Marie-Louise Edlund</td>
</tr>
</tbody>
</table>

* Partners refer to the organizations involved in the project.
3.2.6 International and national cooperation

Beside the cooperation in the research projects SP also participates/has participated in the following activities in the field of wood materials and structures. These activities are important for an efficient dissemination of the results from the research projects.

### International

<table>
<thead>
<tr>
<th>Activity</th>
<th>Contact at SP</th>
<th>Period</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>COST E13 Wood Adhesion and glued Products</td>
<td>Carl-Johan Johansson</td>
<td>99-02</td>
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<tr>
<td>COST E34 Gluing of wood</td>
<td>Björn Källander</td>
<td>03-</td>
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<tr>
<td>COST E22 Environmental optimization of wood protection</td>
<td>Jöran Jermer</td>
<td>01-04</td>
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<tr>
<td>CEN/TC124/WG2/TG2 Machine Strength Grading of Timber</td>
<td>Charlotte Bengtsson</td>
<td>01-</td>
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<tr>
<td>CEN/TC193/SC1/WG4 Test methods, classification and performance requirements for adhesives other than phenolic and aminoplastic, for load bearing timber structures</td>
<td>Björn Källander (convenor)</td>
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<tr>
<td>CEN/TC193/SC1/WG6 Adhesives for glued in rods</td>
<td>Björn Källander (convenor)</td>
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<tr>
<td>CEN/TC193/SC1/WG11 Adhesives for on-site assembling or restoration of timber structures</td>
<td>Björn Källander</td>
<td>01-</td>
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<tr>
<td>CEN/TC112/WG4 Wood-based panels General test methods</td>
<td>Rune Ziethén</td>
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<td>CEN/TC38/WG26 Wood protection</td>
<td>Jöran Jermer</td>
<td>88-</td>
<td>Convenor</td>
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<tr>
<td>ISO/TC165/SC1 Durability and preservation</td>
<td>Jöran Jermer</td>
<td>96-</td>
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<tr>
<td>SG 18, Sector Group, Timber Structures</td>
<td>Carl-Johan Johansson (convenor)</td>
<td>01-</td>
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<tr>
<td>SG 20, Sector Group, Wood based panels</td>
<td>Rune Ziethén</td>
<td>01-</td>
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<tr>
<td>Innova wood</td>
<td>Charlotte Bengtsson</td>
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### National

<table>
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<tr>
<td>SIS/TK 182 Wood</td>
<td>Charlotte Bengtsson</td>
<td>01-</td>
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<tr>
<td>SIS/TK 162 Adhesives and gluingtechniques</td>
<td>Björn Källander</td>
<td>00-</td>
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<tr>
<td>SIS/TK 195 Wood-based panels</td>
<td>Rune Ziethén</td>
<td>80-</td>
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<tr>
<td>SIS/TK 205 Wood protection/Durability</td>
<td>Jöran Jermer</td>
<td>89-</td>
<td>Chairman</td>
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<tr>
<td>STG TK 18 Furnitures</td>
<td>Mikael Calestam</td>
<td>95-</td>
<td></td>
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<tr>
<td>Contactgroup, Glulam industry</td>
<td>Carl-Johan Johansson</td>
<td>78-</td>
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Contactgroup, Furniture industry  Mikael Calestam  03-
Contactgroup, Graded timber producers  Bertil Stenman  96-
Contactgroup, Wood-based panels  Rune Ziethén  80-
Contactgroup, Wood protection industry  Ingvar Johansson  96-
Contactgroup, Timber house industry  Carl-Johan Johansson  00-

### 3.2.7 Relevant publications 1993-2003

#### Peer reviewed papers

1. **BENGTSSON C, FONSELIUS M.** 2003 Settings for strength grading machines – evaluation of the procedure according to prEN 14081 part 52, paper 36-5-1 in proceedings of CIB-W18, 11-14/8 2003, Estes Park, Colorado, USA.  
   Proceedings 2003

   Proceedings 2002

   Proceedings 2002

   Proceedings 2002

   Proceedings 2002

   Proceedings 2002

   Proceedings 2001

   Proceedings 2001

   Proceedings 2001

    Proceedings 2000


31. BOSTRÖM, Lars, ORMARSSON, S, DAHLBOM, O. On determination of modulus of elasticity in bending. CIB W18, Bordeaux August 1996.

32. JOHANSSON, Carl-Johan, STEFFEN, Andreas, WORMUTH, Ernst. Relation of moduli of elasticity in flatwise and edgewise bending of solid timber. CIB W18, Bordeaux August 1996.

33. BOSTRÖM, Lars. The tapered end-notched flexure (TENF) specimen for measurement of fracture energy in Mode II. COST 508 conference 14-17 May 1996, Stuttgart.


Other international scientific publications


48. TJÄDER, H. Fracture properties of high temperature dried timber, Diploma work, SP Swedish National Testing and Research Institute, Borås, 2002.


51. KÄLLANDER, Björn, BENGTSSON, Charlotte, DAHLBERG, Jonas. Reduction of strength but not stiffness of Norway spruce planks dried at 125°C as compared to 70°C. Proceeding of the COST E15 wood drying conference, June 2001, Finland.


Swedish reports

78. JOHANSSON, Pernilla, JERMER, Jöran, JOHANSSON, Ingvar.  


82. JERMER, Jöran, EDLUND, Marie-Louise, EVANS, Fred G, HENRIKSEN, Keld, SYRJÄNEN, T. Träskyddsbehandling enligt 351 – Utvärdering och erfarenhetsåterföring. NTR. Nordiska Träskyddsrådets Information nr 37/01.

83. JOHANSSON, Pernilla, JERMER, Jöran, JOHANSSON, Ingvar.  


85. SIGFRID, Lotta, JERMER, Jöran, ERLANDSSON, Martin.  


87. BOSTRÖM, Lars. Årsringsbreddens inverkan på mekaniska egenskaper hos sydsvenskt virke. SP AR 1997:11.


**Popular scientific publications**


Others


CV for Carl-Johan Johansson

Personal information

Full name: Carl-Johan Johansson  
Date of birth: 3 March 1948  
Place of birth: Varberg, Sweden  
Nationality: Swedish  
Position: Head of Wood Materials and Structure Section and Dep. Head of Building Technology Department at SP Swedish National Testing and Research Institute, P.O. Box 857, 501 15 BORÅS, Sweden  
Languages: Swedish, English, German

Academic qualifications

1973 Master of science in civil engineering, Chalmers University of Technology  
1987 Licentiate’s degree in civil engineering, Chalmers University of Technology  
1993-1997 Adjunct professor, Structural Mechanics and Structural Engineering Dept., Lund University (LTH)  
1997 Adjunct professor, Wood Design and Technology, Växjö University

Main research fields

Timber engineering, wood based materials, wood adhesive bonding, timber strength grading

Employment record

1973-1976 Chalmers University of Technology  
1976- Swedish National Testing and Research Institute  
1985 and 1987 Chalmers University of Technology  
1993-1997 Lund technical University  
1997- Växjö University  
Researcher  
Head of Section, Deputy head of department 1984-  
Research supervisor  
Adjunct professor  
Adjunct professor

Selected assignments (last ten years only)

Committees

1990- Swedish Glulam Control Board  
1990-1991 Nordic Glulam Control Board  
1999-2001 Swedish Wood Panel industry consultation group with SP and others  
1999- COST E13 Adhesive bonding and glued products  
1998-2001 EU-project SMT4-CT97-2199. Glued-in-rods in timber structures  
Technical Secretary  
Secretary General  
Chairman  
Member of management committee and chairman of WG 2 on Glued products  
Project co-ordinator
Research & Development at SP in the field of Building and Property management

2000- Swedish prefabricated house manufacturers – Grup of technicians Secretary
2000- European Commission Sector Group SG18 - Timber structures Chairman

Standardization

1988- CEN/TC124/WG3- Glued Laminated Timber Member
1990-1996 CEN/TC112/WG3 - Fibre Boards Member
1990-1996 Joint working group of CEN/TC124 and CEN/TC112 Member
1990-1991 CEN/TC193 - Adhesives for wood and derived products Member

Doctoral dissertations – Member of jury

T. Bekele, Marie-Louise Edlund, Mikael Stehr, Henrik Berglind, Christina Foley

Major projects

1999-2001 Glued-in rods for timber structures. EU Contract number SMT4-CT97-219 Project co-ordinator
2000- Multi-storey timber framed houses using prefab. technique. NUTEK. Project number P14395 Project co-ordinator

A list of publications is available on request.
CV Charlotte Bengtsson

Name: Charlotte Karolina Helen Bengtsson

Born: April 13 1971 in Sölvesborg, Sweden

Nationality: Swedish

Profession, affiliation: Ph. D, Group leader at Building Technology and Mechanics, Wood Materials and Structures and Building Materials, SP Swedish National Testing and Research Institute, Box 857, 501 15 Borås, Sweden
Head of department, School of Engineering, Högskolan i Borås, 501 90 Borås, Sweden

Home: Graneliden 2B, 430 63 Hindås

Family: Per Mattsson (married)

Language: Swedish (native speaker), English (fluent), German (good knowledge) and French (basic knowledge)

ACADEMIC QUALIFICATIONS
PhD in Steel and Timber Structures, Chalmers University of Technology 1997-1999
Post Graduate School “Wood and Wood fibres” 1994-1999
Licentiate of Engineering, Steel and Timber Structures, Chalmers University of Technology 1994-1997
MSc in Civil Engineering, Chalmers University of Technology 1990-1994

OTHER COURSES
SP Leadership development programme 2003-

TEACHING EXPERIENCE
Teacher (lectures) “Steel and Timber Structures advanced course”, Chalmers University of Technology 2001
Supervisor for diploma works at SP, Wood Materials and Structures 2000-
Assistant supervisor for PhD-student, Steel and Timber Structures 2000-
Teacher (lectures), Post Graduate school “Wood Technology” 2000
Teacher (lectures), Post Graduate school “Wood and Wood fibres” 1998
Supervisor for diploma works in Steel and Timber Structures, Chalmers University of Technology 1996, 1998

Teacher for calculation and design exercises, Steel and Timber Structures (master’s programme), Chalmers University of Technology 1994-1999

Teacher for calculation exercises, Building and Civil Engineering (bachelor level), Chalmers University of Technology 1995-1998

**EMPLOYMENTS**

Head of department (prefekt), School of Engineering, Högskolan i Borås 2003-

Group leader R&D, Building Technology, Wood Materials and Structures, SP Swedish National Testing and Research Institute 2001-

Assistant Professor, Steel and Timber Structures, Chalmers University of Technology 2001

Researcher, Building Technology, Wood Materials and Structures, SP Swedish National Testing and Research Institute 1999-2000

Researcher, Steel and Timber Structures, Chalmers University of Technology 1999-2000

Research assistant, Steel and Timber Structures, Chalmers University of Technology 1994-1999

**ASSIGNMENTS**

Secretary of Commission Sector Group SG18 – Timber Structures 2000-

Member of CEN/TC124/WG2/TG2 2001-

**PUBLICATIONS**

Refereed journal papers

4. Bengtsson C. 1999 Mechano-sorptive tension and compression creep of spruce wood. Accepted for publication in Wood Science and Technology.
7. Kliger R., Bengtsson C., Johansson M. 2002 Distortion and material properties of high-temperature dried spruce timber, manuscript to be submitted.

A complete list of publications is available on request.
CV Erik Serrano

**Personal information**

Name: Erik Alfonso Serrano  
Date and place of birth: November 7, 1968, Málaga (Spain)  
Home address: Nöbbelövs kyrkoväg 57, SE-226 53 Lund, Sweden  
Home tel. and fax: +46 46 188763  
Present employment: Researcher, SP Swedish National Testing and Research Institute (50%)  
Acting senior lecturer, Structural Mechanics, Lund University (50%)  
Office street address: John Ericssons väg 1, Lund, Sweden  
Office postal address: Division of Structural Mechanics, Lund Institute of Technology, Lund University, Box 118, SE-221 00 Lund, Sweden  
Office telephone: +46 46 222 95 88  
Office fax: +46 46 222 44 20  
Office e-mail address: erik.serrano@byggmek.lth.se

**Languages**

Swedish, English, Spanish

**PhD**

PhD-degree obtained 2001-02-01  
Subject: Structural Mechanics  
Title: Adhesive Joints in Timber Engineering- Modelling and Testing of Fracture Properties  
Supervisor: Prof. Per Johan Gustafsson, Prof. Hans Petersson (part of the work)

**Education and Appointments and Courses**

Higher School Certificate, the engineering programme Hässleholms Tekniska Skola, 1987  
Master of Science in Civil Engineering, Lund University, 1993  
Licentiate in Engineering, Structural Mechanics, Lund University, 1997  
Doctor in Engineering, Structural Mechanics, Lund University, 2001  
Coordinating teacher for 3rd –year Industrial-design students, 2002  
“Pedagogisk Inspirationskurs”, LTH 2002  
Docentkurs, LTH 2003

**Employments**

Research engineer, Structural Mechanics, Lund University, 1993  
PhD-student, Structural Mechanics, Lund University, 1994-1997  
Structural engineer, Valeo Engine Cooling AB, Mjällby, 1997-1998  
PhD-student, Structural Mechanics, Lund University, 1998-2001  
Project assistant, Structural Mechanics, Lund University, 2001-2003  
Acting senior lecturer (vik. lektor), Structural Mechanics, Lund University, 2003-  
Researcher, SP-Swedish National Testing and Research Institute, 2003-

**Research Achievements**

Dr. Serrano obtained his degree in early 2001. His thesis, presented in late 2000, related to experimental and numerical methods for wood-adhesive bonds. He has done significant research on finger-joints and laminated products and also on glued timber connections based on glued-in rods. He has carried out both basic theoretical work within constitutive modelling of wood adhesive bonds, and advanced applied finite element strength analysis. He has also experience within the experimental work. Early work relates to the determination of fracture properties on solid wood, and later work...
relates to the determination of fracture properties of wood-adhesive bonds. His complete list of publication includes 6 papers in journals, 22 conference papers and 17 reports and chapters in books. He has also reviewed several papers for possible publication in the International Journal of Adhesion and Adhesives (Elsevier).

Teaching and Supervision

Responsible for course creation and development and lecturer for the course “Material, shape and force”. This course is on mechanics of materials, and computer-aided visualisation and analysis methods for students in the Industrial design curriculum.

General participation in teaching in courses on: mechanics, mechanics of materials, frame and truss analysis, finite element method, beam theory.

Supervisor of 3 Master’s dissertations.

Miscellaneous

- Responsible for coordination of Master’s thesis at the Division of Structural Mechanics.
- Coordinating teacher for the 3rd year of the Industrial design curriculum (2002).
- Member of the “Library committee”.
- Member of jury during Admittance Tests for the Industrial Design programme (2003)

A list of publications is available on request.
CV for Björn Källander

Personal information

Full name: Björn Arne Källander
Date of birth: 9 May 1960
Place of birth: Korpilombolo
Nationality: Swedish
Languages: Swedish, English. Basic knowledge in French and German.

Academic qualifications:

1984 Master of science in mechanical engineering, Royal Institute of Technology
2000 Licentiate of Engineering, Royal Institute of Technology

Main research fields

Wood drying, wood adhesives and glued structures.

Employment record

1984 - 1990 SP Swedish National Testing and Research Institute, Borås
1990 - 1997 Stora Corporate Research AB, Falun
1997 - 1999 AssiDomän Timber AB, Stockholm
2000 - SP Swedish National Testing and Research Institute, Borås

Assignments

2000 - CEN TC193 / SC1 / WG6 Convenor
2002 - CEN TC193 / SC1 / WG4 Convenor

A list of publications is available on request.
Curriculum vitae, Marie-Louise Edlund

Name: Marie-Louise Edlund

Present position: PhD

Date of birth: November 4, 1943

Present work address: SP Swedish National Testing and Research Institute
Box 5609
S-114 86 Stockholm
Sweden

Nationality: Swedish

Residence: Sweden

Educational background: B.Sc at University of Stockholm 1968, PhD at Swedish University of Agricultural Sciences 1998

Employment: At Swedish Forest Products Research Laboratory, as laboratory assistant 1966-1968, and researcher 1968-1984

At Swedish Wood Preservation Institute 1984-1993, responsible for research at the institute, education at universities and other schools. Working with standardization and information.

PhD-studies at Swedish University of Agricultural Sciences 1994-1998.

Researcher at Swedish University of Agricultural Sciences, department of Wood Sciences 1998-2003

40 % employment at SP Swedish National Testing and Research Institute since 2000-02-14.

Main scope of research: Durability of wood and wood preservation. Degradation of wood by micro-organisms


A list of publications is available on request.
3.3 Geological materials

Photo “Ulf Lonäs/Svensk Bergs- och Brukstidning”

Research & Development at SP in the field of Building and Property management
3.3.1 Ongoing and recently completed research

Short background
SP has a very long tradition of research in the field of geological materials, especially aggregates (both hydraulically bound and unbound) and natural stones. A comprehensive description of commonly used building stone types, relevant tests methods and stone characteristics were compiled in the nineteen thirties. However, it lasted until the mid sixties until a new set of methods (SP Methods) were drafted and came into force for this area. In the beginning of the nineties, the activities of the Swedish natural stone industry increased largely on both national and international basis. In addition, the harmonization of European standards started (CEN 246 Natural stones and TC 154 Aggregates). Hence, SP decided to make a large effort in both the aggregate and the natural stone areas. Two researchers were employed and several research projects started. SP also took over the chairmanship of the Swedish mirror group to TC 154 Aggregates during this period of time. In the late nineties SP intensified the collaboration with universities and technical high schools and supervision of several doctoral students, two of them are now employed at SP. In 2000, the activities on alternative materials increased and two researchers are now working with materials such as slag and foundry sand for civil engineering purposes as well as sludge and digestate as soil improvers. SP is represented in CEN/TC 223 Soil improvers and growing media and CEN/TC 308 Characterisation of sludges through the joint Swedish committee TK 428. This report covers activities from 1990 and onwards.

General
Our main focus in this field is on “bedrock materials” (aggregates, natural stones and industrial minerals), recycled construction materials and materials from secondary sources for the construction area. Development and validation of new test methods (including the organisation of precision trials) is of multidisciplinary importance. Our work spans from part materials to the finished construction and its function and maintenance. It is mainly driven by the need for integrating new materials and solutions in society, the demand for sustainable use of natural resources and a rapid change of the European market. SP’s extensive contacts with the industry and community in this field are crucial in order to identify relevant problems for research.

Durability
Research on the durability aspects of geological materials has focused on frost resistance. Similar as for concrete, it has proven necessary to develop and perform accelerated laboratory freeze-thaw test on aggregates and natural stones by including a small percentage of NaCl in order to get a good correlation with the frost resistance in structures. In the Nordtest-project Frost resistance testing of aggregate with salt (FRAS) a new test method is developed. The aim is to develop a method that reflects real exposure conditions in a better way than the existing EN-standard does. SPs outdoor filed exposure sites are now in use also for aggregates and natural stones.

Chemical attack on geological materials, e.g. atmospheric corrosion of natural stones and alkali-silica reactivity of concrete aggregates is also of major concern. SP participates through dr Björn Schouenborg in the European project Alkali silica reactions (PARTNER). The project is a direct continuation of the earlier EU-project Standard test of alkali reactive rocks (STAR) which was completed in 1998. SP is also Swedens representative in RILEM TC ARP (Alkali Reactive Products).

Durability also concerns esthetical aspects such as shape and colour. A closely related subject that has been in our focus the last 10 years is surface protection, cleaning and maintenance of building components. Our engagement in this field covers most external building components and lately, also indoor floorings and wall covering of natural stones, e.g. as expert advisors for the new Danish Opera building in Copenhagen. Concerning shape, the expansion of natural stone claddings is crucial for the dimensioning of the dilatation joints. SP has therefore developed a Nordic method for this purpose and recently also performed research on the special case of marble and limestone materials.

References: 69
Microstructures versus material properties
The laboratory is working with light and electron microscopy using image analysis. The work includes research, calibration, quality control (large part of the QA control for the Öresund Bridge project was done at this laboratory) and damage investigations. This mix is important in order identify practical problems were knowledge about the microstructure can provide a part of the solution. Although the activities are focused on geological, cement and lime based materials it also overlaps several areas. Examples of recent project in other fields are fracture mechanics in heat treated wood, bacteria in compost and quality of LDC-screens. The damage investigations covers the fields of concrete, masonry, natural stones and aggregates and include micro structural analysis and verdicts related to these fields.

Katarina Malaga has been a doctoral student working on the connection between microstructure and durability of natural stone as building materials. She took her Dr exam in May 2003. The project was carried out in co-operation with the Department of Inorganic Chemistry, University of Gothenburg.

Urban Åkesson is a doctoral student working on a project financed by the Swedish Geological Survey treating the relation between microstructure and resistance to fragmentation for unbound aggregate gives results that compares with mechanical testing and gives information on the crucial parameters.

Research focused on assessment of the condition and analysis of type of materials in the built historic heritage is one area were SP has expertise competence and has performed research projects in cooperation with the National Heritage Board (RAÄ) and universities and also through participation in the RILEM TC-COM (characterisation of historical mortars). It also includes being assistant supervisor for Sölve Johansson at the Department of Conservation at the University of Gothenburg. Developed techniques and obtained experience are applied in consultant commissions for conservators and architects.


Research in support of standardisation
Many research projects have been initiated through our participation in standardisation activities. The Swedish “Studded Tyre Test” once developed by VTI is now a European standard. SP performed the necessary precision trial to complete the method with this information. SP acted as the national co-ordinator of the European project “Testing of Industrial Products – Aggregates for Construction”, focussing on determining the precision of the new European standards, New sampling methods and finding the best method for Determination of the mechanical strength of aggregates. We now offer to organize inter-comparison trials for both Precision and Proficiency Testing.

Both STAR, PARTNER and FRAS (see above) were initiated through our standardisation activities.

SP has also prepared educational material about European standardisation in general and Aggregates in particular for Swedish authorities and is presently engaged in providing information for the new Swedish specification of Railway Ballast. SP has also participated in the preparation of a common European information package to be used in the present implementation phase of the new European standards of aggregates.

References: 36, 37, 42, 56, 58, 64
Quality classification of bedrock
Traditionally customers have turned to SP and asked if their rock material can be used for a specific purpose, roads, concrete etc. In collaboration with the Swedish Geological Survey (SGU) SP has successfully developed the concept of quality classification of bedrock for civil engineering purposes since 1992. Research student Urban Åkesson (now employed at SP) started on a spin off project, initiated by SP, emanating from this concept. All bedrock materials expected to be exploited in Stockholm during the construction of Ringen have been examined and classified by SP, SGU in collaboration with consultants. Today SGU regularly produces bedrock maps of parts of Sweden with an extensive infrastructural activity (see www.sgu.se). SP and SGU have also gained a deep knowledge of sampling and sample preparation techniques through this collaboration. Knowledge that the Swedish industry now benefits from.

Applied projects directly for the industry, especially SMEs
Results from research and international standardisation have been transferred to SMEs through a number of applied projects and commissions to SMEs. The projects are in many cases co-operation projects with universities, other research institutes and private consultants. Even if the problems for SMEs are market oriented, it is not unusual that new technology must be developed in order to solve the problem for SME. One example is development of a method for impregnation of natural stones (Techstone). As spin off Torgny Sahlin started a research project towards licentiate degree which was completed in 2002.

References: 5, 11, 12, 19, 22, 51, 54, 55, 57, 68

Leight-weight aggregates
The research on light weight aggregates at BMm has been focused on mechanical and physical properties and how to estimate the long term behaviour. Most of the traditional standards has been developed for natural aggregate

References: 30, 33, 41, 48

Recycled and alternative materials
The research and development activities at BMm concern four areas: waste in general, waste wood, organic waste materials and alternative aggregate materials.

Trying to define suitable, new test procedures (validation) for recycled materials and aggregates from secondary sources are of increasing importance. Most standardized test methods are unsuitable for such materials. SP has initiated three Nordic and one national project on this subject.

The largest of these areas of research is alternative aggregate materials for civil engineering purposes, mostly road construction. Another project AIS-32, aims to develop a system of quality criteria concerning functional and environmental aspects of foundry sand and ashes from pulp and paper industry. Other investigated materials suitable for road construction are steel slag, BF-stone and bottom ash. Quality criteria and certification rules for all these are currently developed. A natural development of the above mentioned research and development activities is the participation in the Nordic joint project Gjenbruksmaterialer i vegbygging (Recycled materials for road construction).

SP has finished two projects on waste wood quality and the coupling between this and slagging, fouling and corrosion in the furnace. A third part where suggested solutions are implemented is planned for 2004. BMm also has two projects about waste quality together with ET. The scope of both projects is to match waste of the right quality with a combustion plant suitable for that kind of waste. SP has developed certification rules for sewage sludge, compost and digested sludge from biogas production. The development of quality criteria for soil will result in certification rules shortly.

References: 43, 47, 52, 65, 66
**Priorities for the near future and in the long run**

Our collaboration with several producers federations has lately been intensified. SP's “task” is hence widened to give guidance about the correct choice of material and construction for a certain application and in a certain environment/climate. In this context, the international collaboration has been largely extended through the European Natural Stones Network (OSNET) and the proposed Integrated Project I-STONE. SP’s field exposure sites are more and more used also for geological materials. The knowledge between performance in a structure, accelerated lab. tests and field exposure sites needs to be deepened.

Concerning the alternative aggregate materials, we now focus on their durability, environmental influence and the integration in society (logistics etc.)

### 3.3.2 C.V. for researchers

The C.Vs for Ph. Lic. Urban Åkesson, Techn. Lic. Bo von Bahr, Dr Annika Ekvall, Dr Katarina Malaga, Dr Jan Erik Lindqvist, Dr Björn Schouenborg and Civ. Eng. Mining Matz Sandström are shown in appendix GEOLOGICAL MATERIALS 1.

### 3.3.3 Doctoral students

SP has doctoral students in its staff, in cooperation with The University of Gothenburg and The Royal Institute of Technology (KTH) in Stockholm.

<table>
<thead>
<tr>
<th>Name</th>
<th>Project</th>
<th>Examination</th>
<th>Financing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Åkesson</td>
<td>Micro-structural characteristics of aggregates versus their mechanical properties</td>
<td>2002 (lic)</td>
<td>Geological survey of Sweden, SP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2004 (dr) exp.</td>
<td></td>
</tr>
<tr>
<td>Katarina Malaga</td>
<td>Atmospheric corrosion of natural stones</td>
<td>2000 (lic)</td>
<td>KK stiftelsen, SP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2003 (dr)</td>
<td></td>
</tr>
<tr>
<td>Torgny Sahlin*)</td>
<td>Production of ultrathin slabs of natural stones and their durability</td>
<td>2002 (lic)</td>
<td>Industry, University of Gothenburgh, SP</td>
</tr>
<tr>
<td>Anna Klingberg**)</td>
<td>Process control in the aggregate industry</td>
<td>2002 (lic)</td>
<td>Industry, SP, SBMI, SBUF</td>
</tr>
</tbody>
</table>

*) Student at The University of Gothenburg. Supervision by Björn Schouenborg.
**) Student at The Royal Institute of Technology. Supervision by Björn Schouenborg.
3.3.4 Financing

The financing of the research in the field of Geological Materials during the last three years are presented in the table below.

<table>
<thead>
<tr>
<th>Financing partner</th>
<th>2001</th>
<th>2002</th>
<th>2003 (expected)</th>
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<tbody>
<tr>
<td>SGU</td>
<td>500</td>
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<tr>
<td>EU</td>
<td>1482</td>
<td>1629</td>
<td>2619</td>
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<tr>
<td>Nordtest</td>
<td>19</td>
<td>142</td>
<td>102</td>
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<td>Betong och Ballastadmn</td>
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<td>Swedish National Board for Industrial and Technical Development (Nutek)</td>
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<td>Cultural Heritage Management (RAÄ)</td>
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<td>Government grant</td>
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<td><strong>Sum</strong></td>
<td><strong>3102</strong></td>
<td><strong>1997</strong></td>
<td><strong>3522</strong></td>
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3.3.5 International and national research projects

**European projects**

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<tr>
<th>Project</th>
<th>Period</th>
<th>Partners*</th>
<th>Contact at SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing of Industrial Products Aggregates for Construction</td>
<td>93-97</td>
<td>6 +</td>
<td>Björn Schouenborg</td>
</tr>
<tr>
<td>Testing and Assessment of Marble and Limestone (TEAM)</td>
<td>01-05</td>
<td>9</td>
<td>Björn Schouenborg (co-ordinator)</td>
</tr>
<tr>
<td>Alkali silica reactions (PARTNER)</td>
<td>02-04</td>
<td>24</td>
<td>Björn Schouenborg</td>
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<tr>
<td>Ornamental Stones Network (OSNET)</td>
<td>01-04</td>
<td>Ca. 100</td>
<td>Björn Schouenborg</td>
</tr>
<tr>
<td>Standard test of alkali reactive rocks (STAR)</td>
<td>97-98</td>
<td>6</td>
<td>Björn Schouenborg</td>
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</table>

**Nordic projects**

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>Financing</th>
<th>Partners*</th>
<th>Contact at SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retningslinjer for petrografisk mikroanalyse av betongtilslag</td>
<td>89-90</td>
<td>Nordtest</td>
<td>DTI, SP, VTT, SINTEF</td>
<td>Björn Schouenborg</td>
</tr>
<tr>
<td>Testing of Nordic Natural Stones</td>
<td>91-93</td>
<td>Nordtest</td>
<td>SP, DTI, VTT, SINTEF</td>
<td>Björn Schouenborg</td>
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<tr>
<td>Petrografisk mikroanalys av ballast</td>
<td>91-93</td>
<td>Nordtest</td>
<td>DTI, SP</td>
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<tr>
<td>Kvalitativ analys av luftporstruktur i betong – Bildatlas</td>
<td>93-95</td>
<td>Nordtest</td>
<td>SP, DTI, NBI</td>
<td>Björn Schouenborg</td>
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<tr>
<td>Research &amp; Development at SP in the field of Building and Property management</td>
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<tr>
<td><strong>Frost resistance test on aggregates:</strong> Inter-comparison of a new Nordtest method</td>
<td>95-96</td>
<td>Nordtest</td>
<td><strong>RB, SP, NBI, VTT</strong></td>
<td>Björn Schouenborg</td>
</tr>
<tr>
<td>Standardpreparat för kalibrering vid mätning av storleksfördelning med bildanalyser</td>
<td>95-97</td>
<td>Nordtest</td>
<td><strong>SP, DTI, RB</strong></td>
<td>Jan Erik Lindqvist</td>
</tr>
<tr>
<td>Återanvändning av byggprodukter. Anpassad siktning av restprodukter för bättre kretsloppsanpassning.</td>
<td>95-97</td>
<td>Nordtest</td>
<td><strong>SP, DTI, GFC, Aros Grusförädling</strong></td>
<td>Björn Schouenborg</td>
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<tr>
<td>Provningsmetoder anpassade för återvinningsmaterial - Kornstorleksfördelning</td>
<td>96-97</td>
<td>Nordtest</td>
<td><strong>SP, DTI, SiAB, Lohja Rudus</strong></td>
<td>Björn Schouenborg</td>
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<tr>
<td>Hållfasthet och deformationsegenskaper hos material för grundläggning</td>
<td>97-98</td>
<td>Banverket</td>
<td><strong>SP, Banverket, Vägverket, Neste, Svensk Leca</strong></td>
<td>Matz Sandström</td>
</tr>
<tr>
<td>Provningsmetoder anpassade för återvinningsmaterial-Del 2 Sprödhet</td>
<td>97-99</td>
<td>Nordtest</td>
<td><strong>SP, SINTEF</strong></td>
<td>Björn Schouenborg</td>
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<tr>
<td>Lättballast och återvunnen ballast – Bestämning av hållfasthets- och kompressibilitet</td>
<td>97-99</td>
<td>Nordtest</td>
<td><strong>SP, NBI, Svensk Leca</strong></td>
<td>Matz Sandström</td>
</tr>
<tr>
<td>Reliable frost testing of porous and recycled aggregates – revision.</td>
<td>98-99</td>
<td>Nordtest</td>
<td><strong>NBI, RB, VTT, SP</strong></td>
<td>Björn Schouenborg</td>
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<tr>
<td>Buktningsprovning av marmor för fasadbeklädnad</td>
<td>99-00</td>
<td>Nordtest</td>
<td><strong>SP, Ramboll, SINTEF, JAC</strong></td>
<td>Björn Schouenborg</td>
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<tr>
<td>Provningsmetoder anpassade för återvinningsmaterial – Del 3 Vattenabsorption</td>
<td>00-02</td>
<td>Nordtest</td>
<td><strong>SP, RBI, SINTEF</strong></td>
<td>Björn Schouenborg</td>
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<tr>
<td>Frost resistance test on aggregates with/without salt</td>
<td>03-04</td>
<td>Nordtest</td>
<td><strong>RB, SP, NBT, TUT, DTI, RWTH, HOLCIM, FEHS, LRPC, KOAC, Univ Ulster</strong></td>
<td>Björn Schouenborg</td>
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</tbody>
</table>

**National projects**

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>Financing</th>
<th>Partners*</th>
<th>Contact at SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kvalitetsklassning av bergarter, N Stockholm</td>
<td>93-95</td>
<td>SGU</td>
<td><strong>SP, SGU</strong></td>
<td>Björn Schouenborg</td>
</tr>
<tr>
<td>Ballasthandboken – Europastandardisering av ballast och järnvägsmakadam</td>
<td>97-98</td>
<td>Banverket</td>
<td><strong>SP, Banverket</strong></td>
<td>Björn Schouenborg</td>
</tr>
<tr>
<td>Alternativa material till vägunderbyggnad</td>
<td>97-98</td>
<td>Vägverket</td>
<td><strong>SP, Vägverket</strong></td>
<td>Björn Schouenborg</td>
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<tr>
<td>Natursten – byggnadsmaterial med ekologiskt mervärde</td>
<td>99-01</td>
<td>Nutek</td>
<td><strong>SFI, SP, Stenindustri, Kemiföretag, Städbolag m fl</strong></td>
<td>Björn Schouenborg</td>
</tr>
<tr>
<td>Kvantifiering av kvarts i bergmaterial</td>
<td>98-01</td>
<td>RALF</td>
<td><strong>SP, SGU, Geovetarcentrum, MINPRO</strong></td>
<td>Björn Schouenborg</td>
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<tr>
<td>Provtagning inom ballastindustrin</td>
<td>98-01</td>
<td>BBA</td>
<td><strong>SP, BBA</strong></td>
<td>Björn Schouenborg</td>
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<tr>
<td>Provning av marmor för projektet HERMES</td>
<td>00-01</td>
<td>RAÄ</td>
<td><strong>SP, RAÄ</strong></td>
<td>Björn Schouenborg</td>
</tr>
</tbody>
</table>
3.3.6 International and national cooperation

Beside the cooperation in the research projects SP also participates/has participated in the following activities in the field of geological materials. These activities are important for e.g. an efficient dissemination of the results from the research projects.

### International

<table>
<thead>
<tr>
<th>Activity</th>
<th>Contact at SP</th>
<th>Period</th>
<th>Comments</th>
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<tbody>
<tr>
<td>RILEM TC 106 Alkali silica reactions</td>
<td>Björn Schouenborg</td>
<td>97-01</td>
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<td>RILEM TC ARP Alkali silica reactions</td>
<td>Björn Schouenborg</td>
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<td>CENT C 154 Aggregates TG 5 Precision</td>
<td>Björn Schouenborg</td>
<td>02 - 98</td>
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<tr>
<td>CENT C 154 SC 6 Aggregates Test methods</td>
<td>Björn Schouenborg</td>
<td>92 -</td>
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<tr>
<td>CENT C 154 Ad hoc RAC (recycled agr)</td>
<td>Björn Schouenborg</td>
<td>95-98</td>
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<tr>
<td>CEN TC 154 SC 4 WG 2 Rail ballast group</td>
<td>Björn Schouenborg</td>
<td>95 -</td>
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<tr>
<td>IAEG C 17 Aggregates</td>
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<td>98-</td>
<td>Secr.</td>
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<td>ENBRI WG R&amp;D Projects</td>
<td>Björn Schouenborg</td>
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<td>CEN 154 TC 4 Requirem. for chem. properties</td>
<td>Jan Erik Lindqvist</td>
<td>93-97</td>
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<td>CEN 154 TC 8 Test methods for chem. properties</td>
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<td>CEN 125 WG 4 Test methods masonry</td>
<td>Matz Sandström</td>
<td>92-98</td>
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<td>CEN TC 125 Masonry</td>
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<td>CEN TC 154 Aggregates</td>
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<td>CEN TC 154 SC 1 Aggregates for mortar</td>
<td>Matz Sandström</td>
<td>92-98</td>
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<td>CEN TC 51 Cement</td>
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<tr>
<td>RILEM TC COM Characterisation of old mortars</td>
<td>Jan Erik Lindqvist</td>
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### National

<table>
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<tr>
<th>Activity</th>
<th>Contact at SP</th>
<th>Period</th>
<th>Comments</th>
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<tr>
<td>SIS TK 187 Ballast</td>
<td>Björn Schouenborg</td>
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<tr>
<td>SIS TK 428 Characterisation of sewage sludge and soil improvers</td>
<td>Bo von Bahr Annika Ekvall</td>
<td>03-</td>
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<td>SIS STG 105 Industrial liming</td>
<td>Björn Schouenborg Annika Ekvall</td>
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<td>SIS STG 107 Liming and fertilizer</td>
<td>Annika Ekvall Björn Schouenborg</td>
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<td>SIS STG 106 Soil and soil improvers</td>
<td>Annika Ekvall</td>
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<td>SIS STG TK 48 Characterisation of sewage sludge</td>
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<td>SIS TK 185 Cement</td>
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<td>SIS TK 180 Masonry</td>
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<td>SIS TK 187 Aggregates</td>
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<td>94-98</td>
<td>Chairman</td>
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</tbody>
</table>
3.3.7 Relevant publications 1993-2003

Peer reviewed papers


11. SCHOUENBORG, Björn, KLINGBERG, Anna. The influence of different sample reduction techniques on the aggregate test result – One cause of observed variation in the production. Proceedings of the IAEG-Aggregate 2001 meeting in Helsinki.


24. MALAGA-STARZEC, Katarina, PANAS, I. & LINDQVIST, O., Efflorescence on thin sections of calcareous stones. Accepted for publication in Journal of Cultural Heritage. Article


26. MALAGA-STARZEC, Katarina., PANAS, I. & LINDQVIST, O., Model study of initial adsorption of SO₂ on calcite and dolomite. Accepted for publication in Applied Surface Science. Article

Other international scientific publications


33. SANDSTRÖM, Matz, LUNDGREN, Monica, MALMQVIST, Göran, HAGNESTÅL, Lennart. Provning av mekaniska egenskaper hos lättballast. SP AR 1999: 18 Nordtest project no 1391-98 1999


Swedish reports

41. HAGNESTÅL, Lennart. Jämförelseprovning, skrymdensitet och siktningsanalys hos lättklinker för väg och järnväg. SP AR 2001:05 2001

42. ALVHAGE, Bengt, LYDÉN, Carina, SANDSTRÖM, Matz. SP Småföretag – Tekniköverföring under år 2000. SP AR 2001:07 2001


45. SCHOUENBORG, Björn, ARM, M, CARLING, M, ANDERSSON, H. Provningsmetoder för alternativa material till vägunderbyggnad – Undersökning av rostereldad kolbottenaska, slaggrus och krossad betong. Vägverksrapport 1999


47. Återvunna byggnadsmaterial. BÅ 99. Boverkets handbok om användning av återvunna byggnadsmaterial. Medförfattare/deltagare i arbetsgruppen för betong/ballast 1999


58. LINDQVIST, Jan Erik. Kommande europeiska gränsvärden för lättklinkerballast i betong. SP AR 1993:43.

Popular scientific publications


60. SCHOUENBORG, Björn. Classification of aggregates with respect to ASR. Abstract 2000


62. SCHOUENBORG, Björn, m fl. Infoartikel om TEAM. Bygg & Teknik, nr 8, 2000. Article 2000


<table>
<thead>
<tr>
<th></th>
<th>Author</th>
<th>Title</th>
<th>Publication Details</th>
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<tbody>
<tr>
<td>69</td>
<td>SCHOUENBORG, Björn.</td>
<td>&quot;SP RAPPORTEN&quot; – en återkommande sida i Svensk Bergs- &amp; Bruktidning.</td>
<td>Article 1994-</td>
</tr>
</tbody>
</table>
CV Björn Schouenborg

Title and present job description
- Dr in Mineralogy and Petrology, exam 1989
- Responsible co-ordinator for EU-projects and other international RTD projects

Main work tasks:
Lead and develop the work at Building Materials
Initiate and co-ordinate R&D projects
Main responsibility for R&D and standardisation within the areas:
Aggregate, Natural stone and Industrial Minerals

Present research projects (International)
Co-ordinator for TEAM (Testing and Assessment of Marble and Limestone); EU-project for 5 years, 4,2 M EURO, 9 countries, 16 partners. See www.sp.se/building/team. Within the project, for example research on the bowing and strength loss potential, permeability of stone materials, porosity, water absorption, capillarity, thermal dilatation etc.
Principal contractor in the European network for natural stones; OSNET, See www.osent.ntua.gr
Main participant in the EU-project PARTNER about alkali reactivity of aggregates for concrete, (http://www.partner.eu.com)
Main actor in the application on Integrated project for natural stones (I-STONE)
National and Nordic project led by undersigned or where SP is the leading part:
Nordtest project about Frost durability of aggregates
Nordtest project about development of new testing methods for alternative aggregate materials
Gjenbruksmaterial i veg (“Recycled materials in road construction”) (Nordic Industrial Fund)

National projects
New European standard for railway ballast (project for National Railway Authority: Basis for the new Swedish directives)
Introduce the Swedish stone industry in the European standardisation; testing and education/seminars
A number of projects about the use of recycling products, such as ashes, slag, crushed concrete etc.

Representaton in standardisation and working groups
SP's representative in ENBRI (European Network for Building Research Institutes) RTD group

Natural Stone
Swedish delegate/technical expert in CEN TC 246 Natural Stones WG 2 Analyse methods
Member of TK 87 Natural stone (Swedish mirror group to TC 246)
Member of TK 72 Paving products made of concrete, brick and natural stone

Aggregate
- Secretary in IAEG Commission 17 (International Association of Engineering Geologists)
- Swedish expert in RILEM TC ARP Methods for ASR in aggregate for concrete
- Swedish delegate in CEN TC 154 Aggregates, SC 6 Analysis methods
- Swedish expert in TC 154 SC 4 WG 2 Rail ballast group
- Swedish co-ordinator for inter-comparison tests within the frame for M & T projekt 134: “Testing of Industrial products - Aggregates for Construction”

Telephone. +46 33 165433, Mobile +46 70 520 2551
E-post: bjorn.schouenborg@sp.se A list of publications is available on request.
CV for Jan Erik Lindqvist

**Personal information**

Name: Jan Erik Lindqvist  
Date and place of birth: June 5, 1952, Eskilstuna  
Home address: Värmlandsg 3B, SE-504 39 Borås, Sweden  
Home: +46 33 136756  
Present employment: Senior researcher at Building and Mechanics at SP  
Office street address: Brinellgatan 4, Borås, Sweden  
Office postal address: SP Swedish National Testing and Research Institute  
Office telephone: +46 33 16 51 43  
Office fax: +46 33 13 45 16  
Office e-mail address: janerik.lindqvist@sp.se  

**Education**

Fil kand, Lund University, 1979  
Doctors Exam in Mineralogy and Petrology, Lund University, 1988  
1988-1989 University lektor at the department of Geology, University of Lund

**Employments**

1989-1990 Project employment at the laboratory of Chemistry at the Department of Geology, University of Lund  
1991-1992 Project employment at Swedish National Testing Institute  
1993- Researcher at the Department of Building Materials at the Swedish National Testing and Research Institute.

**International activities**

Active within the EUREKA-projects EUROLIME and EUROPLASTER.  
Member of the Nordic Lime Seminar 1992 - 1996.  
Member of RILEM TC-COM 167 (Characterisation of historical mortars).  
Member of CEN TC 154 Aggregate TC 4 Chemical properties, Requirements & TC 8 Chemical properties, Test methods 1993-1997.

**Languages**

Swedish, English

Jan Erik Lindqvist is responsible for microscopy and structural analysis and damage investigations. Responsible for the microstructural concrete quality control in the Öresund Bridge Project.

Assistant supervisor for Urban Åkesson at Earth Sciences Centre, University of Gothenburg licentiat exam December 2002 and for Katarina Malaga Department of Inorganic Chemistry, University of Gothenburg, doctoral exam Maj 2003 and for Sölve Johansson Department of Environmental Science/Conservation, University of Gothenburg, licentiate exam planed to November 2003.

A list of publications is available on request.
CV Urban Åkesson

Name: Urban Åkesson

Born: 1972 05 08-3251

Address: Skogsbovägen 1 428 34 Kållered
Telephone
Residence: 031-18 43 63
Mobile: 0705-76 51 48
Work: 033-16 51 48

E-mail: urban.akesson@sp.se

Education and degrees
1998-06: BSc Mineralogy & Petrology, Göteborg University
1998-06: Master course Petroleum geology, Chalmers tekniska högskola
2002-01: Fil. Lic Mineralogy & Petrology, Göteborg University

Employments
1999- PhD student, Göteborgs Universitet
2003- Researcher, SP Swedish National Testing and Research Institute
Building Technology and Mechanics

A list of publications is available on request.
CV Bo von Bahr

Background, title and work

- Master Degree of Science in Mechanical Engineering, Energy and Fluid Mechanics, 1996
- Development Engineer at OKG nuclear power plant
- PhD student at Civil Engineering Departement at Chalmers University of Technology, Technical licentiate in Environmental Systems Analysis
- Researcher at SP, Building Technology and Mechanics

Main work tasks:
To work in research projects about improved use of rest materials from different industrial sectors in society, especially with the aim of recycling rest materials for use in the sector of civil construction. Research projects in the organic sector of recycling (sewage sludge, soil production etc) are also among the work tasks.

Ongoing research projects

VINNOVA-funded project for improve use of foundry sand and ashes to civil construction. Time period 2002-2003. Responsibility for the environmental part of the analyses of the rest products

Quality criteria for soil for civil construction. The aim of the project is to reach common and widely accepted requirements for the characeristics of soil

Product certification of blast furnace slag. The aim of the project is to develop quality criteria (certification rules) for blast furnace slag as a road building material

Product certification of steel slag. The aim of the project is to develop quality criteria (certification rules) for a large number of different use of steel slag.

Quality criteria for ashes for civil construction. The aim of the project is to develop quality criteria for ashes to reduce the uncertainty about ashes as a material for civil construction.

Representation in standardisation groups

TK 428, Characterisation of sewage sludge and soil improvers

Tel. 033 – 16 51 23, Mobile 070 - 516 51 43
E-mail: bo.vonbahr@sp.se

A list of publications is available on request.
CV Annika Ekvall

Name: Carin Eva Annika Ekvall, née Carlson
Date and place of birth: February 12, 1964, Solna
Home address: Smeagatan 10, SE-434 35 Kungsbacka, Sweden
Home tel: +46 300 131 81
Present employment: Researcher and project manager, Building Materials, SP
Office street address: Brinellgatan 4, Borås, Sweden
Office postal address: SP Swedish National Testing and Research Institute
Building material and mechanics
Box 857, SE-501 15 Borås, Sweden
Office telephone: +46 33 16 52 85
Office fax: +46 33 13 45 16
Office e-mail address: annika.ekvall@sp.se
Family Married, three children

Education and degree:
Higher school certificate, Science, Munkebäcksgymnasiet, Göteborg, 1982
M Sc in Chemical Engineering, Chalmers University of Technology, 1988
Licentiate of Technology in Sanitary Engineering, Chalmers University of Technology, 1992
Ph D in Sanitary Engineering, Chalmers University of Technology, 1995
Environmental Management 20 p Chalmers University of Technology 1999

Employments
Research Engineer, IVL Swedish Environmental Research Institute, 1988-89
Doctoral student, Dept of Sanitary Engineering, Chalmers University of Technology, 1989-95
Course coordinator Applied Environmental Measurement Techniques, Chalmers University of Technology, 1995-96,
Researcher, project manager, SP Chemistry and Materials Technology, 1996-1999
Researcher, project manager, SP Building Technology and Mechanics, 2000-

Languages
Swedish, English (German, French)

Main work tasks
Responsible for research and development projects concerning waste materials, including alternative road construction materials (foundry sand, BF stone, steel slag, ashes) and assessment of factory production control of organic waste materials such as sewage sludge, compost, digestate from biogas production and soil.

List of publications available on request
A list of publications is available on request.
CV Katarina Malaga

Born: 660625

Education

- MSc in Quaternary Geology at Gothenburg University, Sweden. Master thesis in restoration of industrial waste disposal and numerical simulation of contaminates transport in porous media (1996).

- Master’s thesis at Chalmers University in Technical geology in Gothenburg, Sweden. The subject of the thesis is a numerical soil modelling applying Bayesian approach implemented by GIS and BayMar computer tools. The outcome of these studies is to be applied for road building planning as well as for groundwater vulnerability assessment when considering roads as a potential pollution source (1997).

- International Master of Science and Civil Engineering Program in Applied Environmental Measurement Techniques at Chalmers University in Gothenburg, Sweden (1998).


- Philosophy Doctor in Inorganic Chemistry: Microscopic and macroscopic studies of initial weathering of stones used as building materials (2003).

Research and Work experience

The mechanisms and chemistry of weathering of fresh and impregnated natural stones; environmental impact on the mechanical and chemical weathering of rock.

1996-1997 Teaching Assistant/Lecturer, Geology Dept. Chalmers University, Gothenburg, Sweden. Conducted research on technical geology and taught contaminant hydrogeology, soil remediation, geological site description, well logging and geostatistics.

1998-2003 PhD student at Inorganic Chemistry Department. Conduct research on air pollution impact on natural stone surface; do research about porosity changes due to deterioration (pollution and heat) and impregnation; evaluate efficacy of impregnation/consolidation materials.

2001-2003 Part time employee at SP Swedish National Testing and Research Institute

2003-09-01 Full time employee at SP Swedish National Testing and Research Institute

Languages

Swedish, Polish, English, Spanish, Russian

A list of publications is available on request.
CV Matz Sandström

**Name:** Matz Sandström

**Address, residence:** Viltstigen 6 518 41 Sjömarken, Sweden

**Telephone, residence:** 033-25 46 72

**Family:** Married, five children

**Present position:** Head of the section for Building Materials at the Department of Building and Mechanics at SP Swedish National Testing and Research Institute

**Telephone number, SP:** 033-165000 (direct: 033-165126)

**E-mail address:** matz.sandstrom@sp.se

**Education and degrees:**
Upper secondary school degree, Lycksele, 1972
Master of Science in Geotechnical engineering (B), Luleå University of Technology, 1977.

**Other courses:**
Leadership development and techniques, 1991
Professional quality assurance lead auditor, 1993
Pricing and business communication, 1994
Professional environment assurance lead auditor, 1993
SP Leadership development (1999-2000)
Authorised technology Broker, 2000

**Employment:**
At SP Swedish National Testing and Research Institute I have held the following positions since 1977:

- Research Engineer 1977 - 1988 at the section of Building materials
- Head of the section of Building Materials 1989-1997
- Projectleader, Technology transfer to small and medium sized enterprises, 1998 -
- Head of the section of Building Materials, 2000 -

**Language skills:** Swedish (mothers tongue), English

**Publications:** Available on request.
3.4 Thermal insulation and air tightness in the building envelope
3.4.1 Ongoing and completed research

Introduction
This research program is closely related to energy use in buildings. Since energy research is excluded from the evaluation we have limited this report to describe only parts related to the physical processes of heat and air transfer in the building envelope – parts that are normally considered to belong to the area of Building Physics.

The research spans from materials to components and whole buildings and from theoretical parts (such as moisture effects on heat transfer) to applied parts (such as workmanship to achieve good air tightness in building elements). Since SP is also a testing institute, there is always work going on to develop new test methods and to improve existing methods.

Moisture effects on heat transfer in thermal insulation materials
This area is important both because moisture effects play an important role in energy conservation and because older test methods have been inadequate. The coupled phenomena of heat and moisture transfer is complicated and it has been necessary to acquire a good understanding of the phenomena to develop reliable test methods. The research has comprised both theoretical work and laboratory experiments. SP has been responsible for the development of an ISO standard (ISO 10051) on tests of moist materials. SP has also been participating in research projects with the responsibility to handle the interaction between heat and moisture transfer. The results from the research have also been used in developing CEN standards and in drafting the Swedish Building Code.

References: 1, 2, 3, 4, 17, 18, 19

Development of test equipment and test methods
With the energy crisis in the 70’s came a growing interest in thermal measurements and improved test methods. In particular the producers required more accurate and reliable test methods. Over the years a number of laboratory and in situ methods were developed and improved. Most of the results of our research have resulted in or been input to international standards (Nordtest, CEN and ISO).

References: 5, 6, 7, 8, 9, 20, 26

Material properties of thermal insulation materials and components
One of the tasks of our institute is to compile, arrange and disseminate information from our tests in the laboratory and in situ. The results are reported at symposia, in journals and at lectures in different situations.

References: 10, 11, 21, 22, 27, 28, 29, 34, 35

Windows and external condensation on windows
Windows constitute the thermally weakest link in the building envelope. At the same time the window has to perform well in a number of aspects: being able to be opened for airing and evacuation and still be airtight, being transparent etc. Therefore new types of windows and window panes with coatings and gas filling etc have been developed during recent years. These new window constructions have required modified test methods. Thermal tests of windows are complicated, expensive and time consuming and therefore combinations of calculations and tests have become frequent. Our research has been used as input into a number of new test and calculation methods for thermal properties of windows.

A specific problem with very energy efficient windows is the risk of external condensation. This problem has been studied and methods to calculate the extent and duration of condensation in different situations have been developed.

References: 12, 13, 14, 15, 30, 31, 32, 36, 37
Air tightness in the building envelope

The understanding that air tightness is important not only for energy efficiency, but also for moisture control, thermal comfort and performance of the ventilation system has resulted in a growing interest for better air tightness in the building envelope. Some of our findings are reported in different symposia.

In the debate in Sweden on so called “ecological” buildings some parties have asserted that a plastic foil vapour barrier is not necessary for the good performance of the building. Research and investigations we have done demonstrates that buildings without plastic foil may perform well with an accurate workmanship and suitable building materials.

References: 16, 23, 24, 25, 33, 38

3.4.2 C.V. for researchers

C.V.s for senior researchers (Bertil Jonsson, Per Ingvar Sandberg and Agneta Olsson-Jonsson) are enclosed in appendix THERMAL INSULATION 1.

3.4.3 Financing

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3.4.4 International and national research projects

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<td>96-99</td>
<td>EU-proj</td>
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<td>Replacemant of CRM064</td>
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<td>Moist Masonry</td>
<td>Per Ingvar Sandberg</td>
<td>98-01</td>
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<td>Windat; Network on window data</td>
<td>Bertil Jonsson</td>
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<td>Bertil Jonsson</td>
<td>97-98</td>
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<tr>
<td>Nordtest: Round Robin HotBox</td>
<td>Bertil Jonsson</td>
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In addition to these international projects, a large number of smaller projects have been carried out; see references in publication lists.

3.4.5 International and national cooperation

<table>
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<td>CEN/TC89/WG8</td>
<td>Per Ingvar Sandberg</td>
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</table>
3.4.6 Relevant publications 1993-2003

Peer reviewed papers


Other international scientific publications


19 SANDBERG, Per Ingvar and JONSSON, Bertil. Determination of the thermal resistance of walls (masonry) in dry and moist state and a conversion procedure to get the appropriate design value. Responsible for WP5 Modelling. EU-project CONTRACT N° : SMT4-CT98-2211 (DG 12 - HIAS). Final report November 2001.


22 JONSSON, Bertil. Participation in EU-projekt Thermal properties of building materials. Contract SMT4-CT96-2050.


Swedish reports


28 JONSSON, Bertil. Värme- och fuktteknisk funktion för lösfyllnadsisolering på vindsbjälklag. SP AR 1996:38

29 JONSSON, Bertil. Värme- och fuktteknisk funktion för rörisolering. SP AR 1997:49


32 JONSSON, Bertil. Beräkning av förekomst av utvändig kondens på energieffektiva fönster. SP AR 1999:40

33 SIKANDER, Eva, OLSSON-JONSSON, Agneta. Lufttäthet i hus med träregelstomme och utan plastfolie. 85 s. SP Rapport 1997, nr 34. ISBN 91-7848-694-7
### Popular scientific publications

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<th>No.</th>
<th>Author(s)</th>
<th>Title and Details</th>
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<td>34</td>
<td>JONSSON, Bertil</td>
<td>Bestämning av U-värdet på fönster. Artikel i Bygg &amp; teknik nr 8, 1999</td>
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<td>35</td>
<td>OLSSON, Lars</td>
<td>Cellulosaisoleringens fukttegenskaper. Artikel i Bygg &amp; Teknik nr 2, 2001</td>
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<td>36</td>
<td>JONSSON, Bertil</td>
<td>Utvändig kondens på fönster. Artikel i Bygg &amp; Teknik nr 8, 2000</td>
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<td>37</td>
<td>BROLIN, Hans</td>
<td>Europeiskt regn tuffare för fönster? Artikel i Bygg &amp; Teknik nr 8, 2000</td>
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<td>38</td>
<td>SIKANDER, Eva, OLSSON-JONSSON, Agneta</td>
<td>Lufttäthet i hus utan plastfölje. Artikel i Bygg &amp; Teknik nr 5 1998</td>
</tr>
</tbody>
</table>
Appendix THERMAL INSULATION 1

CV for Bertil Jonsson

Personal information

Full name: Nils Ivar Bertil Jonsson
Date of birth: 1945-01-28
Place of birth: Nordmaling, Sweden
Nationality: Swedish
Position: Technical manager of Department of Energy Technology at SP Swedish National Testing and Research Institute, P.O. Box 857, SE-501 15 BORÅS, Sweden

Languages: Swedish, English

Academic qualifications

1970 M.Sc. in Civil Engineering, Lund University (LTH), Lund
1985 Ph.D. in Civil Engineering, dept. of Building Science, Lund University (LTH)
Thesis: Heat transfer through windows during the hours of darkness with the effect of infiltration ignored

Employments

1970 - 1971 Building Constructor, Nils Centerlöf AB, Malmö
1971 -1987 Researcher at the Department of Building Science, Lund University (LTH)
1987 - Section head of Building Component, Building Physics at SP Swedish National Testing and Research Institute

Main research fields

Heat transfer in building components

International Committees

CEN Key Mark for thermal insulation products, Expert group

Standardization

ISO/TC163/WG2 Thermal transmission properties of windows
ISO/TC163/SC1/WG14 Hot box method for door and windows
CEN/TC89/WG7 Thermal properties of doors and windows
CV for Per Ingvar Sandberg

Personal information

Full name: Per Ingvar Harry Sandberg
Date of birth: 1942-04-14
Place of birth: Kalmar, Sweden
Nationality: Swedish
Position: Assistant Head of Department of Energy Technology at SP Swedish National Testing and Research Institute, P.O. Box 857, SE-501 15 BORÅS, Sweden
Languages: Swedish, English, German

Academic qualifications

1966 M.Sc. in Civil Engineering, Royal Institute of Technology (KTH), Stockholm
1973 Ph.D. in Civil Engineering, dept. of Building Technology, Lund University (LTH)
1982 Associated professor (docent) in Building Technology, Lund University (LTH)
1988-1999 Adjunct professor (adjungerad professor) in Building Technology/Building Physics, Lund University (LTH)

Employments

1966 - 1973 Doctoral student, research engineer, acting professor at the Department of Building Technology, Lund University (LTH)
1973 -1975 Researcher at the Department of Building Technology, Lund University (LTH)
1975 - Responsible for Building Physics, head of Laboratory for Building Physics and later head of Department of Energy Technology at SP Swedish National Testing and Research Institute

Main research fields

Heat and moisture transfer in building materials and components
Effects of moisture on heat transfer
Roofs and roofing materials
Influence of climatic conditions on moisture conditions in building envelopes

International Committees

Participated in committees/working groups, among others:
CIB W40 Heat and Moisture Transfer in Buildings
RILEM 31 PMC
IABSE Building Physics
IEA Annex 24
Nordtest, Expert group and Strategy group Civil Engineering
Standardization

Participated in committees/working groups, among others:
ISO TC 163/SC1 WG 8, WG9 Moisture, Moisture effect on heat transfer
CEN TC 89 WG 8, WG10, Thermal test methods, Moisture
CEN TC 88 WG1 Test methods
SIS/ TK 189 Värmeisolering

Doctoral dissertations – Opponent or member of jury

Lars-Olof Nilsson, Jan Isberg, Mårten Hjorslev-Hansen, Stefan Hjort, Bengt Svennerstedt, Petter Wallentén, Krystyna Pietrzyk, Fredrik Gränne, Hülya Kus

Supervision of PhD students

Eva Harderup (PhD 1998)

A list of publications is available on request.
CV for Agneta Olsson-Jonsson

Full name: Agneta Helena Olsson-Jonsson  
Date of birth: 1946-09-23  
Place of birth: Malmö, Sweden  
Nationality: Swedish

Education
B.Sc. in mathematics, theoretical physics and mathematical statistics, Lund University, Lund. 1969. 
Ph. D in Architecture, Department of Building Science, Lund Institute of Technology, Lund University. 1988. 
Tutors: professor Bo Adamson, Department of Building Science and professor Rikard Küller, Environmental Psychology, Lund Institute of Technology, Lund University.

Environmental investigator of buildings, certificate from SSC, 2000-12-31.

Employments
Research engineer at the Department of Building Science, Lund Institute of Technology, Lund University, 1974 - 1987.  
Project manager of several research project financed by BFR (The National Swedish Council for Building Research).  

Research engineer at Energy Technology, SP Swedish National Testing and Research Institute, Borås since 1987. 
Working with testing, investigation and research of windows, doors and sealed glazing units. Do environmental investigations of buildings. Participate in conferences and seminars of building physics, building components and environment.

Participation in research and development project
Energy saving in existing blocks of flats by building technical measures. BFR. Project manager. 1975-79. 
Replacement of windows – Perception of window replacements. BFR. Project manager. 1982-84. 
Improvement of thermal insulation performance of windows. BFR. Project manager. 1984-88. 
Airtightness of timber frame buildings not having a plastic film vapour barrier. BFR, SBUF och FoU-Väst. Responsible for the laboratory tests. 1996-97.
Environmental criteria in P-marking system of windows and doors. SP-project. Project manager. 1997-99.


A list of publications is available on request.
3.5 Moisture control and indoor environment
3.5.1 Ongoing and recently completed research

Introduction
Indoor environment includes many parameters. Thermal comfort, indoor air quality, ventilation, emissions, lighting, acoustics and health aspects are some of the relevant factors for indoor environment. Our investigations in moisture damaged buildings and “sick houses” for many years and testing of moisture properties and emissions from different materials have given focus on moisture control and quality assurance of the indoor environment for healthy buildings.

This presentation includes moisture research, thermal comfort, indoor environmental investigations, research on quality assurance and health aspects. Aspects concerning materials emissions and their impacts on indoor air quality are described under the heading Building materials and indoor air quality research in 3.12.

Design for Moisture Control
Moisture causes deterioration of building materials and increases the risk of gaseous emissions from materials. Its presence is also necessary for the growth of micro-organisms. In order to avoid moisture and mildew damage in new buildings, or when renovating existing buildings, the design must be such that all elements, including connections and penetrations, are designed and constructed in such a way as to remain dry during normal moisture loadings. In addition, they must be able to withstand occasional water loading without serious damage occurring. Over and above this, materials on building sites must be protected against precipitation and dirt.

Moisture design covers all the steps intended to create dry buildings, not suffering from moisture or mildew damage. This means that structures must be built so that they remain dry, regardless of normal external conditions. Under extreme conditions, e.g. in connection with a leak, the structures must be such that they can dry out within a reasonable period of time without serious problems occurring. This applies both to the building component as such, and to connections between different parts of the building, both in detailing and for penetrations. All parts must be thermally insulated, airtight and protected against moisture as necessary. The building work must be carried out under cover, materials must be stored under cover, and the site and stores must be kept clean, with particular attention to preventing the ingress of earth or other dirt. In order to achieve a properly dry building, it is necessary for everyone involved in it to understand the objectives and to work towards the same ends.

References: 2-9, 62, 63, 82-84

Moisture Conditions in Materials and Components
The widespread nature of moisture damage indicates that there is a need for further knowledge. Damage still occurs, despite the fact that research into moisture has been conducted intensely over the last few decades. Research needs to continue, but perhaps with a slightly different emphasis than hitherto. Research is needed, not only to describe moisture conditions in structures as a function of varying external conditions, to improve measurements of actual conditions, and to be able to specify criteria for various materials more accurately, but also in order to be able to verify health risks associated with moisture damage.

A difficult task is to implement knowledge to the building sector. Many research projects have resulted in reports but not in practical use. One thing is to do the research, another is to make the market use the results.

SP has been a member of CIB W40 “Heat and Moisture Transfer in Buildings” for a long time and Ingemar Samuelson has been the coordinator of the working commission since 1993.
Peter Roots and Per Ingvar Sandberg have studied thermal and moisture properties in heated floors. This knowledge has been used by the producers to write guidelines for the use and installation of floor heating.

Claes Bankvall has studied the thermal behaviour of loose fill insulations and Ingemar Samuelson has studied moisture balance in well-insulated attics.

Agneta Olsson-Jonsson studies the long-time behaviour of different types of windows exposed in an office building at SP.

References: 10-25, 64, 85-87

Moisture Damages – Investigation Methodology
Any investigation of damage needs to show:
- where the seat of the damage is, whether it is due to moisture, and its extent;
- in addition, the cause of the problem needs to be determined.

With this information, the type and extent of appropriate countermeasures can be decided.

First of all, therefore, the investigation needs to show whether moisture is the cause of the damage, i.e. if the relative humidity exceeds, or has exceeded, critical values. This part of the investigation is concerned with the measurement of moisture content or relative humidity, which is normally done using electrical instruments. Further assistance is provided by various types of analyses; for example, of microbiological activity, moisture contents, air quality or emissions.

The investigation also needs to determine where the moisture is coming from or has come from. It is at this stage that the skills of the investigator are put to the test. Moisture migration is controlled by various mechanisms: diffusion, air currents, capillary attraction or simply by water flowing down through the structure. This means that it is necessary to know what type of moisture transport we are looking for.

SP wrote a handbook ten years ago how to investigate indoor environment and how to handle problems in “sick buildings”. This handbook is in practical use by investigators and is also used in education.

References: 26, 65-68, 88

Microbiology and Mould
The tendency for mould growth to occur varies between building materials. Wood and wood-based materials are easily attacked if they are not kept dry or not protected by fungicides. Other materials, such as mineral wool, plastic film and concrete, can also be attacked if conditions are favourable. There is a continuously ongoing discussion whether growth on different materials can result in different risks, e.g. from a health viewpoint.

In damp buildings there are often a mouldy odour, associated with the presence of actinomycetes. Soil is a natural environment for these microorganisms. It is therefore of greatest importance to protect building materials and the building site from soil, thereby reducing the risk for odour.

During the last ten years there has been a tendency to reuse materials from old buildings. If microorganisms have affected these materials and they later on will be wetted in the new building, there is a risk for new growth and also for mould odour. Moisture control in planning, construction, erection and maintenance of a building is an effective tool to avoid mould and mould odour.

References: 27-29, 69-73
Indoor Environment
A considerable amount of energy is used for heating and ventilating buildings: in Sweden, about 40% of the country's total energy use is for these purposes. This use must be reduced, which can be done only by constructing new buildings so that they have a low energy requirement and by upgrading existing buildings.

Many improvements to buildings and ventilation systems reduce energy consumption. More insulation in walls, floors and roofs, together with improved windows and doors, reduce transmission losses, while reduced ventilation air change rates reduce the energy demand, and heat exchangers, heat pumps etc. can help to improve the energy balance. All these measures can be applied in various ways, and can result in both improvements and deteriorations in the indoor climate conditions in the building.

Incorrectly applied energy conservation measures have resulted in the breakdown of materials, mildew formation, staining, odour, poor indoor conditions and so on. A common factor in many of these faults is that, in one way or another, moisture has contributed to the processes resulting in breakdown of materials, microbiological growth or chemical emissions.

Many of these faults can be avoided by applying appropriate knowledge of building physics.

The International Society for Indoor Air Quality and Climate, ISIAQ, has a Swedish chapter SWESIAQ, the chairman of which is Carl Gustaf Bornehag. SWESIAQ's intention is to bring researchers together nationally and internationally for the exchange of information and to stimulate interdisciplinary research.

During the last 10-15 years there has been a strong movement towards ecological buildings and “green houses” in Sweden. In some cases this has lead to bad technical design and also to moisture damages and bad indoor air quality in these houses. SP has studied both design and the choice of materials for walls and roofs with no vapour barriers and the design of “natural” ventilated houses. “Natural” ventilation, or “Hybrid” ventilation may give insufficient airflow thus creating bad indoor air quality and a risk for moisture damages especially in roofs and upper parts of walls.

The need for proper cleaning in dwellings, offices, schools and day care centres has continuously been questioned. Both cleaning methods and materials used for cleaning have to be investigated if a good indoor environment shall be assured. SP has given rules for a quality system for cleaning (P-märkning).

References: 30-42, 74-78, 89-96

Thermal Comfort
Different heat distributing systems in dwellings will generate different thermal comfort. During the 1980s airborne distribution systems were used in many one family houses. These systems were questioned with regard to both air quality and thermal comfort.

In this project both theoretical investigations and practical measurements have been carried out.

References: 1, 61

Damp Buildings and Health
Allergy and other hypersensitivity reactions are large public health issues. Among other factors the indoor environment is suspected of playing a considerable role both for the development of allergic diseases and for symptoms of allergic people. In an interdisciplinary scientific review of the entire literature on “dampness” in buildings and health (NORDDAMP) it is concluded that living or working...
in buildings that are “damp” appears to increase the risk for a number of illnesses and symptoms such as cough, wheeze, and asthma. However, it is not known what agents in indoor air due to “dampness” that are responsible for the health effects but there are hypothesis on both chemical and microbiological dampness related exposures.

With the over aiming aim to identify health relevant exposures in damp buildings an interdisciplinary epidemiological study started in Sweden 1999, Damp Buildings and Health (DBH).

The study is divided into three steps. The first step (carried out during spring 2000) included a cross-sectional study on 14 000 children (1-6 years) with focus on their health and their home environmental conditions (investigated by questionnaires), (DBH-step 1). Questions on allergic symptoms followed the ISAAC questionnaire.

In the next step (DBH step 2) including a case-control study of 400 dwellings the main purpose was to identify exposure differences (chemical and microbiological agents) in indoor air between buildings with and without dampness indications identified in DBH-step 1. This part of the study included inspections of the dwellings, exposure measurements in air and on dust and clinical investigations of the children. Step 2 was done during the winter season 2001-2002.

In the final step (DBH-step 3) findings (eg. dampness related exposures) from step 1 and 2 will be tested in controlled chamber studies.

To end the study, a follow-up questionnaire will be done five years after the first one in order to check the health status of the children. The questionnaire will include mainly the same questions and subjects as the first one.

The DBH-study arises very much international attention and 4 papers originated from the study were presented at the Indoor Air Conference in Monterrey 2002.

References: 43-60, 79-81, 97

3.5.2 C.V. for researchers

C.V.s for Carl-Gustaf Bornehag, Anker Nielsen and Ingemar Samuelson are enclosed in appendix MOISTURE CONTENT 1. CV for Per Ingvar Sandberg is given elsewhere in this document.

3.5.3 Doctoral students

<table>
<thead>
<tr>
<th>Name</th>
<th>Project</th>
<th>Examination</th>
<th>Financing</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-G Bornehag</td>
<td>Mönsteranalys av inomhusluft. (Pattern analysis of VOC in indoor air)</td>
<td>1994 (dr)</td>
<td>BFR, SP</td>
</tr>
<tr>
<td>Annika Ekstrand-Tobin</td>
<td>Samband mellan astma och inomhusmiljö</td>
<td>1993(lic)</td>
<td>BFR, SP</td>
</tr>
<tr>
<td>Christer Johansson</td>
<td>Thermal comfort in detached houses</td>
<td>1993(lic)</td>
<td>BFR, Nordtest, SP</td>
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<td>Linda Hägerhed</td>
<td>Damp Buildings and Health</td>
<td>2004 (dr) exp</td>
<td>Formas, Vårdfonden, KK-stiftelsen, SP, Landstinget i Värmland</td>
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<tr>
<td>Annika Ekstrand-Tobin</td>
<td>Remedial actions in allergic peoples homes</td>
<td>2004 (dr) exp</td>
<td>Formas, Småhusskadefonden, Vårdsstiftelsen</td>
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<tr>
<td>Carolina Hiller</td>
<td>Sustainable Energy Savings</td>
<td>2003 (lic) exp 2006 (dr)</td>
<td>Formas, SP</td>
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3.5.4 Financing

Estimated sums for the whole period 1993 – 2002

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<td>SBUF</td>
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<td>Others</td>
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<td>Government grant</td>
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<tr>
<td><strong>Sum</strong></td>
<td><strong>25,000</strong></td>
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In addition to these international tasks cooperation on a national level has taken place with several national authorities, standardization bodies, industry groups etc.

3.5.5. International and national research projects

<table>
<thead>
<tr>
<th>Activity</th>
<th>Contact at SP</th>
<th>Period</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORDDAMP</td>
<td>Carl Gustaf Bornehag, Anker Nielsen</td>
<td>96-00</td>
<td>Associations between exposure to “dampness” and health effects, Nordic perspective</td>
</tr>
<tr>
<td>EUROEXPO</td>
<td>Carl Gustaf Bornehag</td>
<td>00-02</td>
<td>Associations between exposure to “dampness” and health effects, European perspective</td>
</tr>
<tr>
<td>DBH/DTU</td>
<td>Carl Gustaf Bornehag</td>
<td>99-02</td>
<td>In cooperation with University of Karlstad, University of Linköping, Sahlgrenska universitetssjukhuset, University of Stockholm, Folkhelsa N, University of Aarhus DK, Vejle County hospital DK, Harward school of public health USA, University of Iowa USA, NILU N, Mycoteam N, Teknologiskt institut DK, Arbetsmiljöinstitutet DK</td>
</tr>
</tbody>
</table>

In addition to these international projects, a large number of smaller projects have been carried out; see references in publication lists.

3.5.6. International and national cooperation

<table>
<thead>
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<th>Activity</th>
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<th>Period</th>
<th>Comments</th>
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<tr>
<td>CIB W40</td>
<td>Ingemar Samuelson, Per Ingvar Sandberg</td>
<td>93-00</td>
<td>Coordinator</td>
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</tbody>
</table>
In addition to these international tasks co-operation on a national level has taken place with several national authorities, standardisation bodies, industry group etc.

3.5.7 Relevant publications 1993-2003

Peer reviewed papers


53b BORNEHAG, C-G, SUNDELL, J, HÄGERHED, L, JANSON, S. Pet-keeping in early childhood and airway, nose and skin symptoms later in life. Allergy 58 (9), 939-944, 2003

54. BORNEHAG, CG, SUNDELL, J. Differences in possible risk factors for allergic diseases between children living on farms and other children. Proceedings for International Society for Environment Epidemiology, Vancouver, 2002

55. BORNEHAG, C-G. The burden of asthma – as reflected by the prevalence defined by doctor’s diagnosis and the use of health care services by pre-school children in a Swedish region. Acta Paediatr. 2002:91(11):1246-50

Other international publications

57. SUNDAHL, Mikael, SIKANDER, Eva, TORNEVALL, Mats m fl. Determinations of PCB within a project to develop cleanup methods for PCB-containing elastic sealant used in outdoor joints between concrete blocks in buildings. J. Environment Monit. 1999 No 1, p. 383-387


59. NIELSEN, Anker. Planning of Class Rooms in Schools for better Cleaning. Third international congress on professional cleaning. Helsinki, Finland, 2001-09-30--10-01

60. BORNEHAG, C-G. Housing and Health. WHO's annual report (World Health Report) for 2002. Accepted

Swedish Reports

62. SIKANDER, Eva. Fuktsäkerhet hos några typer av byggnadskonstruktioner. 72 s. SP Rapport 1996, nr 34.
ISBN 91-7848-639-4


73. JOHANSSON, Pernilla. Nedsmutsning av virke under byggtiden och betydelsen för utveckling av elak lukt. En fältstudie. SP AR 1999:22


75. SIKANDER, Eva, SUNDAHL, Mikael m fl. Utveckling och utvärdering av metoder för utbyte av PCB-haltiga fogmassor. 63 s. SP Rapport 1999, nr 07. ISBN91-7848-763-3


Popular Scientific Publications

82. SANDBERG, Per Ingvar, ELMROTH, Arne, HARDERUP, Eva. Räkna med fukt. Ökad säkerhet med fuktdimensionering. Byggforskning nr 2 1996

83. SANDBERG, Per Ingvar. Fuktssäkerhet i ekologiskt byggande. Byggforskning nr 2 1996

84. SAMUELSON, Ingemar m fl. Går det att bygga fuktssäkra krypgrunder. Artikel i Bygg & Teknik nr 5, 2002

85. SAMUELSON, Ingemar. Fuktbalans i kalla vindar - betydelsen av ventilation och valet av isoleringsmaterial. Artikel i Bygg och Teknik nr 2, 1995
86. SIKANDER, Eva. Fukt i "ekologiskt" byggande. Artikel i Bygg och Teknik nr 4, 1996

87. SAMUELSON, Ingemar. Tak utan ventilationsspalt – en risikkonstruktion. Artikel i Bygg & Teknik nr 2, 2000

88. SAMUELSON, Ingemar, WÅNGREN, Bengt. Fukt- och mögelskador, Hammarby Sjöstad. Bygg & Teknik nr 2, 2002

89. SAMUELSON, Ingemar. Har byggranschen brist på kunskap? Byggforskning nr 1, 1997

90. BORNEHAG, C-G. Flerbostadshus för allergiker. Byggforskning nr 1, 1997

91. BORNEHAG, C-G. En gång fukt - alltid problem? Byggforskning nr 1, 1997

92. EKSTRAND-TOBIN, Annika. Detaljstudier i bostäder ringar in samband mellan allergiker och fukt. Byggforskning nr 1, 1997


95. BORNEHAG, C-G, SAMUELSON, Ingemar m fl. Dags att rikta fokus mot innemiljöns betydelse för hälsan. Artikel i VVS-forum nr 8


97. BORNEHAG, Carl-Gustaf. Sambandet mellan fukt i byggnader och hälsa: Nordisk tvärvetenskaplig granskning av den samlade litteraturen. Artikel i Bygg & Teknik nr 5 1998
Appendix MOISTURE CONTENT 1

CV for Carl-Gustaf Bornehag

Name  Jan Carl-Gustaf Bornehag

Home address  S:a Grimstad, S-665 93 Kil, Sweden
               Tel/fax: +46 (0)554 204 20
               e-post: carl-gustaf.bornehag@kau.se

Born  25 mars 1957, Karlstad, Sweden


Education  M.Sc.Eng. Chalmers University of Technology (CTH) 1984
            National economy (20 p), University of Karlstad 1985
            Swedish language (20 p), University of Stockholm 1986
            Theoretical philosophy (10 p), University of Stockholm 1987
            PhD.Eng. Lund Institute of Technology (LTH) 1994

          Swedish National Testing and Research Institute, Borås (1994-)
          International Centre for Indoor Environment and Energy, Technical University of Denmark,
          Copenhagen (1998-)
          Karlstad University (2001-)

Selected Projects

- Responsible for technical measurements in multifamily houses with floor- and humidity problems in
  Enskededalen, Stockholm. Measurements of indoor temperature, relative humidity indoor and outdoor,
  ventilation, volatile organic compounds (VOC), formaldehyde, particles, etc in 90 apartments with different
  Occupational and Environmental Medicine, Örebro Medical Centre Hospital.

- Responsible for technical measurements in evaluation of a multiapartment building for allergic people
  in Stockholm. Responsible for multidisciplinary report including techniques, medicine and social science.

- Responsible for the indoor environmental part of an asthma study in northern Sweden (OLIN V). The
  study is an epidemiological investigation of the impact from occupational, resident and outdoor
  environments on the incidence of asthma. Cooperation with National Institute for Working Life in Umeå
  and Umeå University. (1997-2000)

- Leader of a project with regard to suspected hypersensitivity to electric fields. Evaluation of indoor
  climate with regard to electric fields and from a health point of view. Cooperation with Karolinska Hospital.
  (1996-1999)

- Leader of a project, which is a part of the national ELIB-study in Sweden. In the study the co variation
  between Volatile Organic Compounds (VOC:s) in indoor air and Sick Building Syndrome symptoms is
  investigated. Single VOC-compounds have been identified in 200 randomly sampled apartments from the
  Swedish housing stock. Cooperation with Department of Occupational and Environmental Medicine, Örebro
  Medical Centre Hospital. (1995-2000)

- Leader of a project dealing with evaluation of health effects from damp problems in concrete floors and
  evaluation of technical measures to get better indoor climate. Cooperation with Department of Occupational
  and Environmental Medicine, Örebro Medical Centre Hospital. (1995-1998)
- Leader of an epidemiological study on Damp Buildings and Health (DBH) among children (n=14,000) in Sweden. Cooperation between Swedish National Testing and Research Institute, International Center for Indoor Environment and Energy (DTU), Karlstad University, Sahlgrenska University Hospital, County council of Värmland and 20 other international institutions. (1999-)

- Leader of a field intervention experiment on self-cleaning electrostatic air cleaners in school classrooms. Cooperation between Swedish National Testing and Research Institute and International Center for Indoor Environment and Energy (DTU). (2001-)

- Scientific secretary in consensus works on indoor environment and health, NORDWORKS and EUROWORKS.

**Professional Committees**

The 8th International Conference on Indoor Air Quality and Climate, INDOOR AIR ‘99 International advisor.


Nordic Scientific Consensus Group on TVOC and Health (NORDVOC), (1996-), scientific secretary.


European Scientific Consensus Group on Dampness, Mites, Pets and Health (EUROEXPO), (2000-), scientific secretary.


International Society of Indoor Air Quality and Climate (ISIAQ), Task Force XI on VOC in indoor air and health, chairman.

Allergistämma 1996. Advisory committee.

Allergistämma 1998. Advisory committee and chairman for two workshops, (ecological buildings and health; energy-saving and health).


ISIAQ-CIB Task Force, TG28 Dissemination of Indoor Air Sciences.

President of SWESIAQ. Swedish chapter of International Society of Indoor Air Quality and Climate, (ISIAQ). 2000-

Allergistämma 2003: Advisory committee.

**Teaching**

About 75 lectures per year at universities in Sweden and Denmark on indoor environment and health.

A list of publications is available on request.
CV for Anker Nielsen

Personal information:
Full name: Anker Frank Nielsen
Birth: May 19, 1945 in København, Denmark.
Nationality: Danish
Living in:
Denmark to 1981
Norway 1981-2000
Sweden from 2000

Employment:
80% Energy Technology, Ete
SP – Swedish National Testing and Research Institute
Box 857, 501 15 BORÅS

20% Professor i Integret Bygningsteknologi
Integret Bygningsteknologi (Building Science)
Højskolen i Narvik (Narvik Institute of Technology)
Box 385, N-8505 Narvik, Norway

DENMARK
From 1964 to 1969 engineering student at the Danish Technical University.
In 1969 civil engineer with diploma work at the Thermal Insulation Laboratory.
1969-71 compulsory military service in special technical service.
In 1971 starting as Ph.D. student at the Thermal Insulation Laboratory with the topic:
Measurements of moisture distributions in cellular concrete during moisture transfer.
From 1974 to 1981 employed as researcher on different projects at the Thermal Insulation Laboratory. The main
topics have been: Moisture Research, Low Energy Houses, Calculations of Energy Consumption and Heat
Accumulation in Materials.

NORWAY
From 1981 living in Trondheim, Norway. Employed as researcher at The Norwegian Building Research
Institute, Trondheim Division. The main topics has been: Energy Balances (special windows and glass),
Measurements of heat transfer, Calculations of Energy Consumption, Moisture Dimensioning with Statistics,
Use of Computers for Building Physics calculations, Information systems on CD for Building Details Sheets,
Snow loads on glass roofs, thermal insulation and inverted roofs.
Head of group for Building Physics and Climate (8 persons).
Technical secretary for the Norwegian Association of Insulation Materials Producers - control of thermal
insulation of products.
Member of the Trondheim Glass Yard Group for research on glass and glazed areas.
In 1985 judged to be qualified as professor in Building Technology.
Has participated as teacher at in-service courses for different Norwegian Organisations in Moisture Theory,
Glass Roofs and Energy Savings.
From 1988 censor at 2 institutes at the Norwegian Institute of Technology in Trondheim.

In 1990 employed as Professor in Building Science at the new Narvik Institute of Technology (SIN –
Sivilingeniørutdanningen i Narvik). Copy of Professor appointment included. Responsible for all technical
courses at the two year M.Sc. study in Building Science (Integret Bygningsteknologi). Started research in
simulation of wind and snow around buildings in 1992. This is a special research area for SIN.
Member of the board (all administrative and professional matters) for SIN from 1990 to 1994.
Elected as Co-Vice Chancellor (prorektor) and member of the board from the start of HIN (Højskolen i Narvik)
from 1994 to 1997 with a special responsibility for research. Elected as member of the advisory board
1997-1998 research year at Aalborg University, Indoor Environment Engineering, Denmark and at UNIS (The
university studies in Svalbard), Longyearbyen, Norway.
SWEDEN
In 2000 employed as researcher at SP – Swedish National Testing and Research Institute, Department of Energy Technology. Working with moisture problems information technology and productivity in the building sector, evaluation of a building project (European Village)

Web page with information on publications: http://www.hin.no/ansatte/an/

Member of:
- Research group CIB W40 Heat and Moisture Transfer in Buildings
- ISIAQ - International society of indoor air quality and climate
- ASHRAE - American society of Heating, Refrigerating and Air-Conditioning Engineers
- DANVAK - Dansk selskab for Varme og Klimateknik (Danish society for Heat- and Climate Technology)
- Norsk VVS Energi- og Miljøteknisk Forening (Norwegian Society for Energy and Environment)

Assessor for DANAK (Danish Accreditation Board) in technical evaluation of laboratories in the Building Physic area after DS/EN 45000 and DS/EN ISO 17025.

A list of publications is available on request.
CV for Ingemar Samuelson

Home address  Dillgatan 16
              SE 507 52  BORÅS, Sweden
              Tel +46 33 15 24 38

Born 1944

Family  Widower. Three children

Education  M.Sc.Eng Lund Institute of Technology (LTH) 1968
           PhD Eng Lund Institute of Technology (LTH) 1976

Employer  Lund Institute of Technology (LTH) 1976-77
           Swedish National Testing and Research Institute 1977-

Telephone SP +46 33 16 51 59

E-mail address ingemar.samuelson@sp.se

Teaching  Associate Professor at Lund Institute of Technology 1997
           About 25 lectures per year at universities in Sweden on building physics and indoor air
           quality.
           Associate Professor at Högskolan i Borås 2000

Member of  Coordinator of the working commission CIB W40 Heat and Moisture Transfer in
           Buildings
           ISIAQ - International society of indoor air quality and climate
           SWESIAQ – Swedish chapter of ISIAQ

A list of publications is available on request.
3.6 Acoustics

Traffic noise barrier
3.6.1 Ongoing and completed research

Introduction
Within the field of building acoustics the main research areas during the last 10 years have been within environmental noise, sound insulation and test methods.

Environmental noise
Between 1996-2001 SP was the Swedish partner in a Nordic project, Nord 2000, to develop improved prediction methods for environmental noise. Within this project new sound propagation models and source models were developed. SP focused on determination of the acoustic impedance of ground, screening by barriers, acoustic modelling of road and rail vehicles and the complete models combining source models with propagation theory. Since 2001 SP is one of the key partners of a corresponding European project, Harmonoise. This project involves 19 partners from all over Europe.

References: 2-5, 7,10, 11, 13, 15-18, 20, 21, 23-25, 31, 34, 35, 39-43, 45, 46

Sound insulation
Most of the research in this field has been carried out as diploma works. The most basic research involves the fundamental resonance frequency of double constructions and the interaction of leaves in multiple leaf constructions. Some practical studies on the sound insulation of facades and windows have also been carried out.

References: 6, 14, 19, 26, 27, 29, 43, 44, 47

Test methods
SP has a long record of developing acoustic test methods later adopted by ISO/CEN. Most of the projects have been supported by Nordtest. During the period 1993-2002 methods for measurement of low frequency sound in rooms, the acoustic impedance of ground surfaces, radiator valves and floor coverings on light-weight floors have been developed.

References: 1, 8, 9, 12, 15, 28, 30, 32, 33, 36, 37, 38, 43, 44

3.6.2 C.V. for researchers

C.V. for senior researcher (Hans Jonasson) is enclosed in appendix ACOUSTICS 1.

3.6.3 Financing

<table>
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<tr>
<th>Financing partner</th>
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<td>EU</td>
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<td>Government grant</td>
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3.6.4. International and national research projects

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<th>Period</th>
<th>Comments</th>
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</thead>
</table>
Nordtest projects on noise and sound insulation | Hans Jonasson | 1993-2003

In addition to these international projects, a number of smaller projects have been carried out; see references in publication lists.

3.6.5. International and national cooperation

<table>
<thead>
<tr>
<th>Activity</th>
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<tr>
<td>CEN/TC211</td>
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<td>93-02</td>
<td>Acoustics</td>
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<td>ISO/TC43</td>
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<tr>
<td>Nordtest</td>
<td>Hans Jonasson</td>
<td>93-02</td>
<td>Expert group Acoustics</td>
</tr>
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</table>

In addition to these international tasks cooperation on a national level has taken place with several national authorities, standardization bodies, industry groups etc.

3.6.6 Relevant publications 1993-2003

Peer reviewed papers


SP Reports


Other reports

Conference proceedings
31. STRÖM, Tomas. Spot measurements on sound sources using a highly directional microphone with parabolic reflector – Applications on vehicle noise and screen insertion loss measurement. NAM 1996 i Helsingfors.
32. JONASSON, Hans. Some applications of sound intensity in building acoustics, Invited paper, Inter-noise 96 i Liverpool.
34. JONASSON, Hans. Sound reduction of low railway barriers. Inter-noise 97, Budapest.
35. ÖGREN, Mikael. JONASSON, Hans (samt KLEINER, Mendel, CTH). Design and use of array microphones. Inter-noise 97, Budapest.
37. JONASSON, Hans. Some problems associated with sound intensity measurements of sound insulation, (with Machimbarrena,González and Sánchez), paper presented at Inter-noise 98, Nov 16-18, Christchurch, New Zealand
39. JONASSON, Hans & Ögren, Mikael, Measurement of ground impedance paper presented at ASA/DAGA meeting, March 16-19, Berlin
45. ZHANG, Xuetao. Time history investigation of train pass-by. Intenose 2002, Dearborn, 
Appendix ACOUSTICS 1

CV for Hans Jonasson

CV
Hans G Jonasson
420607-4355

Head Acoustics Section

Telephone: +46 33 16 54 20

Committees:
Nordtest Technical Group Acoustics and Noise
SIS TK 197-Building Acoustics (chairman)
SIS TK 110 Noise Noise (chairman)
ISO TC43/SC2 Building acoustics
ISO TC43/SC2/WG18
ISO TC43/SC2/WG23 (convener) Sound reduction index with intensity
ISO TC43/SC1 Acoustics including its Advisory panel
ISO TC43/SC1/WG28 Sound power measurements
ISO TC 43/SC1/WG 45 Environmental noise
CEN TC 126 Acoustical properties of building products
CEN TC 126/WG 1 Sound insulation
CEN TC 211 Acoustics including its Advisory panel

Work:
Assistant in building acoustics at the University of Lund 1966-71
Research assistant 1971-1974

Education:
Tekn dr in building acoustics (LTH); exam: 71;
"Civilingenjör", technical physics; exam: 66;
Business German, 0-10p, 1995; 10-20 p 1996

Languages:
English: Excellent
German: Very good
French: Good
Italian and Spanish: Some
3.7 Fire response of building materials and structures
3.7.1 Ongoing and recently completed research

Fire initiation and growth
During the last 10 year-period a large number of projects and research activities have taken place. They have mostly been of an international character and in a number of cases the results have been used directly in legislation or by the market actors. The building products directive and the process of harmonisation of requirements in the fire area have lead to a number of projects where SP had a leading role. The European commission, DG enterprise, has given us tasks to develop test methods and evaluation technologies for building products such as linings, cables and pipe insulation. These projects have often found a direct application as they have been used for European legislation.

Estimations on time available for egress are based on the assumption of how the initial fire will grow, the so-called design fire. SP –Fire Technology has contributed in this area by developing calculation tools on flame spread, ignition and generally on fire dynamics. SP has very much focused on interpreting results form small scale test in terms of full scale fire behaviour. Thus several mathematical algorithms have been developed on how to predict the burning behaviour of linings in a small room based on test results from the so called Cone Calorimeter ISO 5660. These algorithms are now used commercially in practice to facilitate and speed up the evaluation of products.

References:
2,6,7,8,11,12,13,14,17,19,20,21,26,32,33,34,35,36,38,39,40,44,45,52,56,64,65,66,74,79,80,83,85,86,89,90,95,100,101,103,106,107,108,111,112,115,123,124,127,130,137,140,142,145,147,148,151

Fire containment
Building fire safety requires that fires shall not spread form one fire cell to another. Fires shall be contained in one part of a building, e.g. in one compartment. Therefore products like walls, floor slabs, doors, penetrations etc. are tested to verify that they can withstand a severe fire for a given time depending by not letting flames or high temperature develop on the unexposed side. Tests are carried out in large scale fire resistance furnaces heated by oil or gas according to a specified time-temperature curve. However, the furnaces have various characteristics, i.e. they used to be more or less severe until it was decided to use so called Plate Thermocouples for controlling the furnace temperature. This device was invented and developed at SP based on research on heat transfer in fires. These thermocouples are now introduced in the European standards as well as in international ISO standards.

SP has also developed several algorithms for calculating temperature in fire exposed steel as well as concrete structures which have been introduced in the Eurocodes.
In the last few years SP has carried out several research projects on the susceptibility of concrete to explosive spalling when exposed to fire. This is of particular interest for tunnels where failures are devastating.
This year a new apparatus TPS has been installed for measuring thermal properties of materials needed as input to our finite element code TASEF for theoretical calculations of e.g. fire resistance.

References:
3,4,5,15,16,18,27,28,29,30,50,51,55,69,70,76,81,82,91,98,105,110,118,122,129,132,133,134,135,136,138,141,143,144,146,149,152,155,156,157

3.7.2 C.V. for researchers
The C.Vs for researchers in this field (Ulf Wickström, Björn Sundström, Lars Bostrom, Patrick Van Hees, Bijan Adl-Zarrabi, Haukur Ingason) can be found in appendix FIRE RESPONSE 1.
3.7.3 Doctoral students

SP has doctoral students in its staff, in cooperation with Lund institute of Technology, Department of fire technology since about 1990. Two current employees finished their PhD during the nineties at LTH, namely Dr. Haukur Ingason and Dr. Heimo Tuovinen. At the moment the following PhD student is active in the field of fire response of building materials and structures:

<table>
<thead>
<tr>
<th>Name</th>
<th>Project</th>
<th>Examination</th>
<th>Financing</th>
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<tbody>
<tr>
<td>Robert Jansson</td>
<td>Material properties of concrete at high temperatures</td>
<td>2004 (lic) exp 2006 (dr) exp</td>
<td>SBUF (Development Fund of the Swedish Construction Industry), Brandforsk (Swedish Board For Fire Research)</td>
</tr>
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</table>

Two other PhD students are active in the area of spread of fire and effluents and environmental impact, see 3.8.3.

3.7.4 Financing

The financing of the research in the field of fire response of building materials and structures are presented in the table below for the last three years.

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<thead>
<tr>
<th>Financing partner</th>
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<td>Swedish Foundation for Strategic Research</td>
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<td>Swedish National Railway Administration</td>
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<td>Nutek/Vinnova (Swedish Agency for Innovation Systems)</td>
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<td>Industry</td>
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<td>Trätek (Swedish Wood Institute)</td>
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<td>SRV (Swedish Rescue Services)</td>
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<td>Vägverket (Swedish National Road Administration)</td>
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<td>CECOST (Centre For Combustion Technology)</td>
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<td>Formas (Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning)</td>
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<td>Others</td>
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<td>Government grant</td>
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### 3.7.5 International and national research projects

#### International and European projects

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<th>Period</th>
<th>Partners</th>
<th>Contact at SP</th>
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<tr>
<td>EU project Development of calibration methods for fire resistance furnaces- Calibration of vertical furnaces</td>
<td>1994-1997</td>
<td>Different European laboratories</td>
<td>L Boström</td>
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<tr>
<td>EU project Development of calibration methods for fire resistance furnaces- Calibration of horizontal fire resistance furnaces – EGOLF/CEN TC 127 ad hoc 14</td>
<td>1996-1997</td>
<td>EGOLF Laboratories</td>
<td>L Boström</td>
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<tr>
<td>EU project FIPEC – Fire Performance of Electrical Cables</td>
<td>1996-1999</td>
<td>Interscience Communications, Centro Elettrotecnico Sperimentale Italiano, Institut Scientifique de Service Public, SP</td>
<td>P Van Hees</td>
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<tr>
<td>RR for CEN flooring method</td>
<td>1997</td>
<td>Official European Fire Laboratories</td>
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<tr>
<td>Calibration of vertical furnaces – Verification of plate thermometer and calibration elements- Calibration according to prEN 1363-3 - CEN TC 127 EGOLF project</td>
<td>1997-1998</td>
<td>Official European Fire Laboratories</td>
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<td>EU-project FIRESCAL, CEN TC 127 ad hoc 7 testing of plate thermometer</td>
<td>1997-1998</td>
<td>Official European Fire Laboratories</td>
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<td>CEN TC 127 modification of plate thermometer</td>
<td>1997-1998</td>
<td>Official European Fire Laboratories</td>
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<td>RR for non combustibility and calorific value</td>
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<td>Official European Fire Laboratories</td>
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<td>EU project Insulating materials for fire safety cables (PHOENIX) Brite Euram project 4962</td>
<td>1998-2003</td>
<td>Industry</td>
<td>B Adl-Zarrabi</td>
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<tr>
<td>Industry project Fire properties of insulated concrete blocks</td>
<td>2001-2003</td>
<td>Canadian Cement Industry</td>
<td>Patrick Van Hees</td>
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<tr>
<td>EU project HFCAL on heat flux meters</td>
<td>1998-1999</td>
<td>VTT, SP, LNE, TNO</td>
<td>B Persson</td>
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<td>Euroclasses for pipe insulations</td>
<td>2000-2002</td>
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<td>B Sundström</td>
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<td>Intermediate scale test for insulated roof-decks</td>
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<td>Euroclasses for cables</td>
<td>02-04</td>
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<td>J Axelsson</td>
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<td><strong>Nordic projects</strong></td>
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<td>Aging effect of materials with respect to fire</td>
<td>92-94</td>
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<td>Comparative study on the fire testing of insulated steel structures</td>
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<td>Fire Testing of wall linings – Comparison between NT FIRE04 and cone</td>
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<td>calorimeter ISO 5660</td>
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<td>Fire test method for cables</td>
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<td>Test method for determination of thermo stability of insulating</td>
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<td>materials at high temperatures</td>
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<td>Fire Simulation Codes – Round Robin validation under CIB W14</td>
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<td>Calibration Horizontal fire test furnaces</td>
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<td>Consequences for different products when introducing the plate</td>
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<td>Fire Simulation code – Round robin validation under CIB W14, phase II</td>
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<td>Comparison of the Nordic classification system for wall and ceiling</td>
<td>97-98</td>
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<td>Revision of NT FIRE 031 towards the ISO standard</td>
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<td>Development of an evaluation scheme for computer codes for calculating</td>
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<td>Development of a test method for sandwich panels based on NT FIRE</td>
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<td>NT FIRE 006 and the European harmonisation</td>
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<td>Measuring Uncertainty NT FIRE 050</td>
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<td>Test methods for sandwich panels</td>
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<td>Development of a screening method for the SBI method</td>
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<td>Improvement of NT FIRE 006 for the European harmonisation,</td>
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<td>National projects</td>
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<td>Effect of wind on the fire development</td>
<td>91-95</td>
<td>Brandforsk</td>
<td>H Ingason</td>
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<td>Fire testing of cables – New test methods based on modern techniques</td>
<td>94-95</td>
<td>Brandforsk</td>
<td>B Sundström</td>
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<td>Fire tests in Märstatunnel</td>
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<td>Shear effects on fire exposed Concrete</td>
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<td>L Boström</td>
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<td>Under-ventilated fires</td>
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<td>H Tuovinen</td>
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<td>Tunnelproject</td>
<td>95-96</td>
<td>SRV</td>
<td>M Arvidsson</td>
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<td>Pre study of the fire safety in a sawing mill</td>
<td>95-96</td>
<td>Brandforsk</td>
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<td>Fire performance based design</td>
<td>96-97</td>
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<td>Full-scale tests in Cardington</td>
<td>96-97</td>
<td>Brandforsk</td>
<td>B Persson</td>
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<td>Fire safety in underground facilities</td>
<td>96-98</td>
<td>Brandforsk</td>
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<td>Fire containment by means of water shields</td>
<td>96-98</td>
<td>Brandforsk</td>
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<tr>
<td>Literature survey of residential sprinklers</td>
<td>97-98</td>
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<td>Fire compartments in industrial buildings</td>
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<td>Sprinklers and Fire ventilation</td>
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<td>Fire spread in industrial buildings</td>
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<td>Effects of the new EUROCLASSES</td>
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<td>Influence of thermal radiation on the functional performance of cables</td>
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<td>P Van Hees</td>
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<td>Fire safety in prisons</td>
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<td>RALF</td>
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<td>Design Fires</td>
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<td>Cable fires in difficult accessible areas</td>
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<td>Brandforsk</td>
<td>P Van Hees</td>
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<td>Spalling of concrete</td>
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<td>Pre-study on aging effects with respect to the fire resistance</td>
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<td>L Boström</td>
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<td>Influence of temperature on functional performance of cables</td>
<td>01-02</td>
<td>Brandforsk</td>
<td>P Andersson</td>
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<td>Self compacting concrete</td>
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<td>Study on aging effect with respect to the fire study</td>
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### 3.7.6 International and national cooperation

#### International

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<th>Contact at SP</th>
<th>Period</th>
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<tr>
<td>ISO TC 92 – Fire Safety</td>
<td>Björn Sundström (convenor)</td>
<td>93-03</td>
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<tr>
<td>ISO TC 92 SC1 Fire initiation and growth</td>
<td>Björn Sundström (convenor), Patrick Van Hees (convenor WG7), Ingrid Wetterlund (convenor WG 10)</td>
<td>93-03</td>
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<tr>
<td>ISO TC 92 SC2 – Fire Containment</td>
<td>Ulf Wickström</td>
<td>93-03</td>
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<tr>
<td>ISO TC 92 SC3 – Fire Effluents</td>
<td>Margaret Simonson</td>
<td>01-03</td>
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<tr>
<td>CEN TC 127 - Fire Safety in buildings</td>
<td>Ulf Wickström</td>
<td>93-03</td>
<td></td>
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<tr>
<td>EGOLF (European Group of Official Fire Laboratories)</td>
<td>Ulf Wickström (board member)</td>
<td>93-03</td>
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<td>Nordtest Expert group Fire</td>
<td>Ulf Wickström</td>
<td>93-02</td>
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<tr>
<td>CEN/TC250/SC1 - Project team, horizontal group fire</td>
<td>Ulf Wickström</td>
<td>93-03</td>
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<td>CEN/TC250/SC1 - Project team, PT1 Actions</td>
<td>Ulf Wickström</td>
<td>93-03</td>
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<tr>
<td>NASFM (National Association of State Fire Marshals, USA) Science Advisory Council</td>
<td>Margaret Simonson</td>
<td>00-03</td>
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<td>CIB W14</td>
<td>Ulf Wickström</td>
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<td>ASTM E15 Fire committee</td>
<td>Björn Sundström</td>
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<td>EU-commission - Fire Sector group for notified bodies and Fire Regulators Group</td>
<td>Björn Sundström</td>
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#### National

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<td>Brandforsk – mirror committees</td>
<td>All researchers</td>
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<td>Brandforsk – Board</td>
<td>Ulf Wickström</td>
<td>93-02</td>
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<td>Boverket - EUROCLASS-group</td>
<td>Ulf Wickström, Björn Sundström</td>
<td>93-03</td>
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</tbody>
</table>

### 3.7.7 Relevant publications 1993-2003

See 3.8.7.
Appendix FIRE RESPONSE 1

CV for professor Ulf Wickström

Professor Ulf Wickström is heading the department of fire technology at the Swedish National Testing and Research Institute (SP). The department has now in the year of 2003 a staff of about 50 involved in fire testing and research.

Professor Wickström has a PhD from the Lund University of Technology (1979) in fire technology, a masters of science from University of California (1977), Berkeley, and Master of Science in civil engineering from the above Lund University of Technology (1974). In his research for obtaining his theses he developed a computer code Tasef for calculating temperature in fire exposed concrete and steel structures.

Professor Wickström was given the name ”professor” in 1988 by the Department of Industry of the Swedish Government. His special scientific interest lies in heat transfer analysis of structures exposed to fire where he has published several scientific papers.

Professor Wickström joined the Department of Fire Technology of SP in 1979 and has been leading it since 1986. The laboratory is one of the leading of its kind in the world. It is active in international research as well as direct services to industry in the field of fire safety testing and evaluation. The staff of specialists from various engineering fields is experienced well educated, over ten have obtained academic PhDs.

A list of publications is available on request.
Curriculum Vitae, Björn Sundström

Personal information
Name: Björn Sundström
Date and place of birth: April 16, 1951, Kiruna, Sweden
Home address: Romansgatan 30, 504 71 Borås
Home tel. and fax: +46 33 107968
Present employment: Manager, section for Fire Dynamics, Fire Technology SP
Office street address: Brinellgatan 4, Borås, Sweden
Office postal address: SP Swedish National Testing and Research Institute
Fire Technology
Box 857, SE-501 15 Borås, Sweden
Office telephone: +46 33 16 50 86
Office fax: +46 33 41 77 59
Office e-mail address: bjorn.sundstrom@sp.se

Education
Technical Licentiate in Fire Technology Lund University of Technology 1990. (Fire calorimetry and the development of large-scale tests using oxygen consumption calorimetry).

Present position
Manager, section for Fire Dynamics, 1976-
Deputy Director, Fire Technology, 1991-

Other information
Ongoing international activities

<table>
<thead>
<tr>
<th>Name of group</th>
<th>Main activity</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU, Fire Regulators Group</td>
<td>Development of EU legislation in support of the building directive</td>
<td>Swedish expert</td>
</tr>
<tr>
<td>Cables for EU, Fire Regulators Group</td>
<td>Proposal for evaluation and classification system</td>
<td>Leader</td>
</tr>
<tr>
<td>ISO/TC92 Fire Safety</td>
<td>Development of international standards regarding fire safety engineering, fire initiation and growth, fire containment and fire effluents</td>
<td>Chairman</td>
</tr>
<tr>
<td>ISO/TC92/SC1 Fire Initiation and Growth</td>
<td>Development of international standards for fire initiation and growth</td>
<td>Chairman</td>
</tr>
<tr>
<td>CEN/TC127</td>
<td>Development of European standards in support of the building directive</td>
<td>Swedish expert</td>
</tr>
<tr>
<td>CEN/TC 127/ad hoc 36 Fire Sector group of notified bodies</td>
<td>Development of Room/Corner Test as EN-standard</td>
<td>Chair</td>
</tr>
<tr>
<td></td>
<td>Develop praxis for the implementation of the building directive in the group of bodies notified to the European commission</td>
<td>SP representative</td>
</tr>
</tbody>
</table>

Also Swedish expert in, CEN/TC 207/WG 6 furniture, IMO Sub-Committee on Fire Protection and other international groups.
Leader of research projects:

<table>
<thead>
<tr>
<th>Name of project</th>
<th>Type</th>
<th>Role</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUREFIC</td>
<td>Fire growth in linings</td>
<td>Nordic project. Project leader for the Swedish part</td>
<td>1989-92</td>
</tr>
<tr>
<td>Furniture fire modelling</td>
<td>Fire growth in furniture</td>
<td>EU BCR project. Project leader</td>
<td>1992</td>
</tr>
<tr>
<td>Furniture calorimeter RR CBUF</td>
<td>Development of furniture calorimeter</td>
<td>EU BCR project. Project leader</td>
<td>1992</td>
</tr>
<tr>
<td>SBI-project</td>
<td>Development of large-scale reference scenario and development of evaluation system.</td>
<td>EU DG Enterprise. Project leader for mentioned activities</td>
<td>1997-98</td>
</tr>
<tr>
<td>Pipe insulation</td>
<td>Development of large-scale reference scenario and development of evaluation system.</td>
<td>Industry group</td>
<td>1999-2002</td>
</tr>
</tbody>
</table>

Received the Interflam trophy 1996 for work in the technical leadership of the Combustion Behaviour of Upholstered Furniture project.

A list of publications is available on request.
Curriculum Vitae, Lars Boström

**Personal information**
Name: Lars Boström  
Date and place of birth: January 22, 1957, Smedjebacken  
Home address: Sonatgatan 20B, SE-504 71 Borås, Sweden  
Home tel. and fax: +46 33 412039  
Present employment: Head of department of Fire Resistance at SP  
Office street address: Brinellgatan 4, Borås, Sweden  
Office postal address: SP Swedish National Testing and Research Institute  
Fire Resistance  
Box 857, SE-501 15 Borås, Sweden  
Office telephone: +46 33 16 56 08  
Office fax: +46 33 41 77 59  
Office e-mail address: lars.bostrom@sp.se

**Education and appointments**
Higher School Certificate, the Engineering Programme, Ålvkullegymnasiet, Karlstad, 1978  
Master of Science in Civil Engineering, Lund University, 1984  
Doctors Exam in Building Materials, Lund University, 1992

**Short time employments 1975-1983**
Industrial work at SKF iron factory, Häleofors 1975-1976  
Industrial work at SKF iron factory, Häleofors 1980  
Industrial work at Åkerlund&Rausing, Lund, spring 1982

**Employments**
Research assistant, Building Materials, Lund University, 1984-1991  
Researcher, SP Wood Technology 1991-1999  
Head of department, SP Fire Resistance, 1999-

**Languages**
Swedish, English

Lars Boström has been working with development and analysis of different test methods ranging from small scale bench tests for measurement of material properties up to test programs for complete machinery systems such as strength grading systems for the timber industry. He has during the last years been leading projects on determination of spalling of concrete when exposed to fire.

A list of publications is available on request.
Curriculum Vitae, Patrick van Hees

Personal information
Name: Patrick van Hees
Date and place of birth: February 4, 1962, Essen Belgium
Home address: Fjällgatan 55 D, SE-504 61 Borås, Sweden
Home tel. and fax: +46 33 417012
Present employment: Research Manager Fire Technology SP
Office street address: Brinellgatan 4, Borås, Sweden
Office postal address: SP Swedish National Testing and Research Institute
                     Fire Technology
                     Box 857, SE-501 15 Borås, Sweden
Office telephone: +46 33 16 50 93
Office fax: +46 33 41 77 59
Office e-mail address: Patrick.van.hees@sp.se

Education
Electrical Engineer, KIHA Technical University Antwerp, Belgium, 1983 (Bachelors degree in Engineering)
Electromechanical Engineer, Power electricity, Gent University, Belgium, 1986 (Master Degree in engineering)
Doctors Exam in Fire Technology within the Department of Combustion Technology and Heat Transfer of the University of Gent Belgium, 1995

Employments
Assistant Professor, University of Gent, Belgium 1986-1995
Senior Research Scientist at material section of SP Fire Technology 1995-2002
Research Manager, SP Fire Technology 2002-

Languages
Swedish, English, Dutch, French, German

Other Information
Asssociate Editor of scientific Journal: Fire and Materials Journal  (Wiley Editors)
Swedish Delegate for ISO TC 92 SC 1
Convenor of ISO TC 92 SC 1 Large and intermediate Scale Fire tests

A list of publications is available on request.
Curriculum Vitae, Bijan Adl-Zarrabi

Tech. Dr. Bijan Adl-Zarrabi has been working in the field of building physics and especially focused on temperature analysis of building structures. He is currently leading projects for international concrete industries developing concrete/sandwich elements with high fire resistance. He is also active in the development of small scale test methods, such as the TPS-method, for determination of thermal properties at high temperatures

Personal information

Name: Bijan Adl-Zarrabi
Date of birth: 1959-03-03
Swedish citizen
Present position: Researcher, Swedish National Testing and Research Institute (SP)
Telephone number, place of employment: +46 33 16 5202  (SP)
E-mail address: bijan.adl-zarrabi@sp.se

Education and Degrees

1980 Architect, Institute of Technology of Tehran
1991 M.Sc. in Civil Engineering, Chalmers University of Technology (CTH)
1994 Degree of Technical Licentiate, Dept. of Building physics, (CTH)
1998 Ph.D. in Civil Engineering, Dept. of Building physics, (CTH)

Experiences

1980-1985 Assistant manager of construction, Site supervisor (Iran)
1986-1991 Student (CTH)
1991-1998 Ph.D.-study at dept. of Building physics (CTH)
1998-2001 Perstorp AB
2001-2003 SP Swedish National Testing and Resereach Institute & Chalmers University of Technology
2003- SP Swedish National Testing and Resereach Institute

A list of publications is available on request.
Curriculum Vitae for Dr Haukur Ingason

Haukur Ingason have over ten years of international experience in fire research. He has worked and studied in the US, Europe and Scandinavia and obtained a PhD degree at the Technical University in Lund Sweden. He has published over 30 scientific papers and reports on different subjects concerning fire safety. His present working place, the Swedish National Testing and Research Institute (SP), is one of a very few institutes in the world with recognised expertise in the subject area of fire safety. In 1994 he was the chairman of the First International Conference on Fire Safety in Tunnels held at SP. He has been involved in large scale and model scale studies of fire and smoke spread in tunnels and a number of advanced consulting projects on tunnel fire safety. His main contributions to the fire safety community of tunnel safety is in the area of design fires, smoke movement, visibility in smoke and influence of ventilation on fire development.

A list of publications is available on request.
3.8 Spread of fire effluents and environmental impact
3.8.1 Ongoing and recently completed research

Measuring technique of HRR (Heat Release Rate) and content of fire gases
At the end of the eighties, SP introduced the technique of HRR measurements by oxygen depletion technique on both small and full scale testing. Later during the beginning of the nineties SP played an important role in the introduction of FTIR (Fourier transformed infrared spectrometry) for measurement of the content of smoke gases (e.g. HCl, HCN etc). The technique was mainly developed within a number of EU projects. At the end of the nineties more advanced measurements were conducted in cooperation with the Chemistry Department of SP to measure e.g. dioxins, furans and PAHs.

References: 14, 25, 31, 36, 42, 48, 49, 61, 67, 72, 73, 77, 78, 131, 150, 154

Fire and smoke spread calculations
Due to the complexity of fires, simulations of spread of gases and smoke were not immediately possible by using commercial computer codes, so-called CFD (Computational Fluid Dynamics) packages. In the nineties SP took together with other European universities and research institutes the initiative to develop a specific fire CFD code called SOFIE. The code is now well developed and has unique sub-models such as advanced flame spread models which allow prediction of fire growth. The SOFIE model has been used during the last 10 years for fire and smoke spread calculations in buildings, tunnels and transport, both for research and commercial applications.

Besides CFD simulations SP has also developed numerical models to predict fire spread on wall and ceiling linings in specific rooms and for the newly European Euroclass test method. These models are easier to use than full CFD models and can be used by industry as a product development tool.

References:
2, 6, 9, 10, 15, 22, 23, 24, 26, 27, 32, 35, 37, 40, 41, 43, 46, 47, 52, 53, 54, 58, 59, 60, 62, 63, 66, 68, 69, 75, 78, 89, 93, 94, 100, 101, 104, 112, 113, 114, 117, 121, 122, 124, 125, 126, 148, 151, 153

Numerical simulation of fire chemistry
An important area of research is the numerical simulation of fire chemistry in order to predict species from fire such as CO, CO₂, soot, etc. SP has been active in this area for several years and under 2003 it developed a unique flamelet model for calculation of HCN (hydrogen cyanide). The model will be of great value for use in CFD codes as one of the possible combustion models. Through this it will be possible to combine fire spread and production of gases in the near future.

References: 25, 67, 88, 94, 96, 109, 119

Fire LCA studies
LCA studies became more and more common in the nineties. In such studies, the full life cycle of a product is involved from the cradle to the grave. But it was never considered to include a fire as part of the “end of life” of a product. SP, together with IVL, developed a specific FIRE-LCA model for this purpose. The model was applied for the first time on television sets and sponsored by European industry. Later it was applied on two types of cables. This study was financed by Brandforsk and Swedish industry. At the moment a study on furniture is running which will be concluded during 2003 and an extension on the cable study will start at the end of 2003.

References: 1, 71, 102, 116, 120, 139

Emission of fire in the environment
From a pre-study at the end of the nineties SP concluded that the emission of building fires in the environment is substantial and should be taken into account. In the beginning more theoretical studies were used to calculate these emissions. During 2003 full scale tests e.g. from a car were used to obtain the emissions from real fires. The studies resulted in the approval of a larger research project financed by SRV (Swedish Rescue Services) which will start in the beginning of 2004.

References: 48, 67, 71, 72, 73, 77, 92, 96, 120, 128, 139
Particle research
This area is rather new and started during the beginning of 2000 with two projects sponsored by the Swedish Rescue Service (SRV). During 2003 a project, sponsored by Brandforsk, investigated the production of particles of different building materials and gave new data in this area. SP has also been active together with Lund University and Växjö University in the establishment of a school for aerosol research, which was approved by Formas at the end of 2002. The three-years project has a total budget of 3.6 MSEK.

References: 84,97,99

3.8.2 C.V. for researchers

The C.Vs for researchers in this field (Margaret Simonson, Petra Andersson, Heimo Tuovinen, Tommy Hertzberg, Per Blomqvist, Anders Lönnemark and Bror Persson) can be found in the appendix SPREAD OF FIRE 1. CVs for Haukur Ingason and Patrick Van Hees are shown elsewhere in this document.

3.8.3 Doctoral students

SP has doctoral students in its staff, in cooperation with Lund institute of Technology, Departement of fire technology since about 1990. Two current employees finished their PhD during the nineties at LTH, namely Dr. Haukur Ingason and Dr. Heimo Tuovinen. At the moment following PhD students are employed by SP that are active in the area of spread of fire effluents and environmental impact:

<table>
<thead>
<tr>
<th>Name</th>
<th>Project</th>
<th>Examination</th>
<th>Financing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per Blomqvist</td>
<td>Content of fire gases</td>
<td>2001 (lic)</td>
<td>Ind. Projects , SP CECOST</td>
</tr>
<tr>
<td></td>
<td>Flame Spread</td>
<td>2004 (dr exp)</td>
<td></td>
</tr>
<tr>
<td>Anders Lönnemark</td>
<td>CFD simulation of biofuel boilers</td>
<td>2002 Lic</td>
<td>Swedish Energy Agency</td>
</tr>
<tr>
<td></td>
<td>Fire and smoke spread in tunnels</td>
<td>2005 (dr exp)</td>
<td></td>
</tr>
<tr>
<td>Haukur Ingason</td>
<td>Experimental and Theoretical Study of Rack Storage Fires</td>
<td>1996 (dr)</td>
<td>Swedish Fire Research Board</td>
</tr>
</tbody>
</table>

3.8.4 Financing

The financing of the research in the field of spread of fire effluents and environmental impact is presented in the table below for the last three years.

<table>
<thead>
<tr>
<th>Financing partner</th>
<th>Amount (kkr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2001</td>
</tr>
<tr>
<td>EU</td>
<td>353</td>
</tr>
<tr>
<td>Brandforsk (Swedish Board For Fire Research)</td>
<td>749</td>
</tr>
<tr>
<td>SBUF (Development Fund of the Swedish Construction Industry)</td>
<td>0</td>
</tr>
<tr>
<td>Stiftelsen för strategisk forskning (Swedish Foundation for Strategic Research)</td>
<td>0</td>
</tr>
<tr>
<td>Energimyndigheten (Swedish Energy Agency)</td>
<td>618</td>
</tr>
<tr>
<td>Banverket (Swedish National Railway Administration)</td>
<td>0</td>
</tr>
<tr>
<td>Nutek/Vinnova (Swedish Agency for Innovation Systems)</td>
<td>267</td>
</tr>
<tr>
<td>Industry</td>
<td>743</td>
</tr>
<tr>
<td>Nordtest</td>
<td>206</td>
</tr>
<tr>
<td>SRV (Swedish Rescue Services)</td>
<td>188</td>
</tr>
<tr>
<td>CECOST (Centre For Combustion Technology)</td>
<td>637</td>
</tr>
<tr>
<td>Formas (Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning)</td>
<td>0</td>
</tr>
<tr>
<td>Vägverket (Swedish National Road Administration)</td>
<td>0</td>
</tr>
<tr>
<td>Others</td>
<td>212</td>
</tr>
<tr>
<td>Government grant</td>
<td>1 646</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>5 619</strong></td>
</tr>
</tbody>
</table>

**3.8.5 International and national research projects**

**International and European projects**

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>Partners*</th>
<th>Contact at SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU project STEP Toxicity Measurements</td>
<td>92-95</td>
<td>European industry, LTH</td>
<td>A Lönnemark</td>
</tr>
<tr>
<td>EU project Fires in chemical warehouses (Toxfire)</td>
<td>94-98</td>
<td>Risö National Laboratory, Neri, Southbank, VTT, LTH, SP, FOA</td>
<td>H Persson</td>
</tr>
<tr>
<td>EU project Fire Performance of Electrical Cables (FIPEC)</td>
<td>96-99</td>
<td>Interscience Communications, Centro Elettrotecnico Sperimentale Italiano, Institut Scientifique de Service Public, SP</td>
<td>P Van Hees</td>
</tr>
<tr>
<td>EU project SBI – Single Burning Item</td>
<td>96-99</td>
<td>10 other official fire testing laboratories</td>
<td>P Van Hees</td>
</tr>
<tr>
<td>EU project FTIR technology in fire applications (SAFIR)</td>
<td>97-99</td>
<td>VTT, Finland, Scientific and Technical Centre of the Belgian Textile Industry (Belgium), ELF ATOCHEM, Groupement de Recherche de Lacq (France), FRS (UK), Laboratoire national d'essais (France), L.S.F. SUD s.r.l., (Italy), RAPRA (UK), SP, University of Ghent, University of Greenwich, School of Chemical &amp; Life Sciences (UK)</td>
<td>M Simonson</td>
</tr>
<tr>
<td>Industry project: Life Cycle Analysis</td>
<td>98</td>
<td>IVL, SP</td>
<td>M Simonson</td>
</tr>
<tr>
<td>Flame spread of flooring material</td>
<td>00-01</td>
<td>SP, BRANZ (Building research Establishment of New Zealand)</td>
<td>P Van Hees</td>
</tr>
<tr>
<td>Industry project Life Cycle</td>
<td>01-03</td>
<td>IVL, SP</td>
<td>P Andersson</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------</td>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>Analysis of furniture</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Nordic projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>Financing</th>
<th>Partners*</th>
<th>Contact at SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of a screening procedure for the SBI-method and the Room Corner Test with the Cone Calorimeter</td>
<td>00-01</td>
<td>Nordtest</td>
<td>SP, SINTEF,</td>
<td>P Van Hees</td>
</tr>
</tbody>
</table>

### National projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>Financing</th>
<th>Partners*</th>
<th>Contact at SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of wind on the fire development</td>
<td>92-94</td>
<td>Brandforsk</td>
<td>-</td>
<td>H Ingason</td>
</tr>
<tr>
<td>Detector Activation</td>
<td>93-95</td>
<td>Brandforsk</td>
<td>-</td>
<td>B Persson</td>
</tr>
<tr>
<td>Fire tests in Mårstatunnel</td>
<td>94-96</td>
<td>Brandforsk, Vägverket, SRV</td>
<td>-</td>
<td>H Ingason</td>
</tr>
<tr>
<td>Development of field model SOFIE</td>
<td>94</td>
<td>Brandforsk</td>
<td>-</td>
<td>B Persson</td>
</tr>
<tr>
<td>Underventilated fires</td>
<td>95-96</td>
<td>Brandforsk</td>
<td>-</td>
<td>H Tuovinen</td>
</tr>
<tr>
<td>Conversion of CHEMKIN code to PC</td>
<td>96</td>
<td>LTH</td>
<td>LTH</td>
<td>T Tuovinen</td>
</tr>
<tr>
<td>Production of toxic gases</td>
<td>97-98</td>
<td>Brandforsk</td>
<td>-</td>
<td>H Tuovinen</td>
</tr>
<tr>
<td>Influence of smoke on electronics</td>
<td>98-99</td>
<td>Brandforsk</td>
<td>-</td>
<td>Margaret Simonson</td>
</tr>
<tr>
<td>Pressure ventilation with mobile fans for extinguishment of fires and rescue of lifes</td>
<td>98</td>
<td>SRV, RALF</td>
<td>-</td>
<td>H Ingason</td>
</tr>
<tr>
<td>Fire safety in underground facilities</td>
<td>96-98</td>
<td>Brandforsk</td>
<td>-</td>
<td>H Ingason</td>
</tr>
<tr>
<td>Fire spread in tunnels</td>
<td>99-00</td>
<td>FOA</td>
<td>-</td>
<td>H Ingason</td>
</tr>
<tr>
<td>Production of toxic gases</td>
<td>97-99</td>
<td>Brandforsk</td>
<td>-</td>
<td>H Tuovinen</td>
</tr>
<tr>
<td>HCN production</td>
<td>99-00</td>
<td>Brandforsk</td>
<td>LTH</td>
<td>T Tuovinen</td>
</tr>
<tr>
<td>Cable fires in difficult accessible areas</td>
<td>00-01</td>
<td>Brandforsk</td>
<td>-</td>
<td>P Van Hees</td>
</tr>
<tr>
<td>Developm. of engineering tools for calculation of flame spread and fire growth</td>
<td>98-00</td>
<td>Brandforsk</td>
<td>LTH</td>
<td>P Van Hees</td>
</tr>
<tr>
<td>FTIR guidelines</td>
<td>99-00</td>
<td>Brandforsk</td>
<td>-</td>
<td>P Blomqvist</td>
</tr>
<tr>
<td>Early fire detection in buildings</td>
<td>00-02</td>
<td>Brandforsk</td>
<td>-</td>
<td>P Andersson</td>
</tr>
<tr>
<td>HCN production of different materials</td>
<td>99-00</td>
<td>Brandforsk</td>
<td>-</td>
<td>H Tuovinen</td>
</tr>
<tr>
<td>Life cycle analysis of cables</td>
<td>99-00</td>
<td>Brandforsk, Swedish ind.</td>
<td>IVL</td>
<td>M Simonson</td>
</tr>
<tr>
<td>Particle emissions</td>
<td>00-01</td>
<td>SRV</td>
<td>-</td>
<td>M Simonson</td>
</tr>
<tr>
<td>Simulation of flame spread</td>
<td>00-03</td>
<td>CECOST LTH, Gothenburg University</td>
<td></td>
<td>P. Blomqvist</td>
</tr>
<tr>
<td>Measurements of particle emissions</td>
<td>00</td>
<td>Räddningsverkets skola Skövde</td>
<td>-</td>
<td>M Simonson</td>
</tr>
<tr>
<td>Effect of fire gas ventilation on smoke and fire spread in tunnels and mines</td>
<td>01</td>
<td>Södra Älvsborgs RT</td>
<td>-</td>
<td>H Ingason</td>
</tr>
<tr>
<td>CFD-models for spread of HCN and CO</td>
<td>01-02</td>
<td>Brandforsk</td>
<td>-</td>
<td>H Tuovinen</td>
</tr>
<tr>
<td>Particle production during fires</td>
<td>02-03</td>
<td>Brandforsk</td>
<td>-</td>
<td>T Hertzberg</td>
</tr>
<tr>
<td>Fire and spread of smoke in large industry- and production premises</td>
<td>02-03</td>
<td>Brandforsk</td>
<td>-</td>
<td>H Ingason</td>
</tr>
<tr>
<td>Environmental effects of fire gases and extinguishing water</td>
<td>02</td>
<td>Brandforsk</td>
<td>-</td>
<td>I Larsson</td>
</tr>
</tbody>
</table>
### International and national cooperation

#### International

<table>
<thead>
<tr>
<th>Activity</th>
<th>Contact at SP</th>
<th>Period</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO TC 92 – Fire Safety</td>
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<td>ISO TC 92 SC1 Fire initiation and growth</td>
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<td>NASFM (National Association of State Fire Marshals, USA) Science Advisory Council</td>
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#### National

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</table>
3.8.7 Relevant publications 1993-2003

The publication list includes both areas within fire safety of this report (chapter 3.7 and 3.8)

Peer reviewed papers (*marked) and Conference proceedings


2. VAN HEES, Patrick, AXELSSON, Jesper, BLOMQVIST, Per, ”Cable fires in difficult to access areas - Study of the ventilation effect in horizontal and vertical test set-up”, Fire and Materials 2003, San Francisco, USA, January 2003.

3. BOSTRÖM, Lars, “Spalling of concrete when exposed to fire”, CIB-CTBUH Int. Conf. on Tall Buildings, 8-10 May 2003, Kuala Lumpur, Malaysia.


7. SUNDSTRÖM, Björn ”A Methodology to Create a Design Fire, Workshop on fire growth and spread on objects, NIST, March 2002.


27. INGASON, Haukur. "Efficiency of thermal ventilation shafts in underground tunnels, Tunnel and underground station Fires Int, Conference 3-4 may 2000, Hong Kong. 2000


29. BOSTRÖM, Lars "Control of timber strength grading machines” World Conference on Timber Engineering, Canada, August 2000. 2000

30. HOLMQVIST, Charlotta and BOSTRÖM, Lars ” Determination of the modulus of elasticity in bending of structural timber - comparison of two methods” World Conference on Timber Engineering, Canada, August 2000. 2000

31. VAN HEES, Patrick, and MESSERSCHMIDT, Birgitte, ” Influence of delay times and response times on heat release measurements”, Fire and Materials, vol 4, nr 2, pp 121-130. 2000


33. VAN HEES, Patrick, SUNDSTRÖM, Björn and THURESON, Per, "Testing and classification of wall and ceiling linings in a harmonised European system”, Fire and Material Conference proceedings, San Antonio, USA, February 1999. 1999


39. SUNDSTRÖM, Björn och THURESON, Per, "European classification of building products. EUROCLASSEs and the background of the classification limits for reaction to fire”, Polish conference, 7 October 1999. 1999


42. BLOMQVIST, Per, VAN HEES, Patrick and SIMONSON, Margaret, "Study of fire behaviour and toxic gas production of cables in real-scale fire tests", Fire and Materials '99, pp 269-278 (1999).


48. BLOMQVIST, Per, LÖNNERMARK, Anders, MÅNSSON, Margaret and PERSSON, Henry. "Methodology for measurements of fire characteristics and smoke gas composition in controlled under-ventilated large-scale combustion experiments", "2nd International Conference on fire Research and Engineering” (ICFRE2) NIST Gaithersburg, USA, 10-15 August 1997.

49. VAN HEES, Patrick. "Smoke measurements for floor coverings", “Reaction to fire testing of building products - development” Warsaw, Poland, 1997-04-07.


63. SUNDSTRÖM, Björn. "EEC furniture flammability project on target", "Flameless Times", FMC Flame Retardants.
Other international scientific publications


66. GRAYSON, Steve, VAN HEES, Patrick, Vercellotti, Uberto, Breulet, Hervé and Green, Andrew "Fire Performance of Electrical cables - new test methods and measurement techniques, Final report of EU SMT project SMT4-CT96-2059 rapport", ISBN 0 9532312 5 9 Interscience Communications UK.


69. Ingason, Haukur, FAHLBERG R. " Erfarenhet med övertrycksventilation, FOU rapport, SRV.


73. SIMONSON, Margaret, BLOMQVIST, Per (SP), DELEU, Caroline (RUG, Belgium), FARDELL, Peter (FRS, England). "Smoke gas analysis by Fourier transform infrared spectroscopy”, SAFIR, Contract No SMT4-CT96-2136


1997


1997


1996


1996


1995


1995


1994

Swedish reports


2003

83. HERTZBERG, Tommy, SUNDSTRÖM, Björn and VAN HEES, Patrick “Design fires for enclosures - A first attempt to create design fires based on Euroclasses for linings, SP report 2003, nr 02, ISBN 91-7848-930-X.

2003

84. HERTZBERG, Tommy, BLOMQVIST, Per, DALENE, Marianne and SKARPING, Gunnar "Particles and isocyanates from fires", SP report 2003, nr 05, ISBN 91-7848-935-0.

2003

85. ANDERSSON, Petra and WETTERLUND, Ingrid, ” Uncertainty in heat flux calibrations performed according to NT FIRE 050”, SP report 2001, nr 34, 36 s, 91-7848-882-6.

2002


2002


2002
88. TUOVINEN, Heimo, "CO Formation from Soot and CO\textsubscript{2} in the Hot Gas Layer", SP report 2002, nr 08, 36 s, ISBN 91-7848-899-0.


90. SUNDSTRÖM, Björn and AXELSSON, Jesper "Development of a common European system for fire testing of pipe insulation based on EN 13823 (SBI) and ISO 9705 (Room/Corner Test), SP report 2002, nr 21, ISBN 91-7848-871-0.


Research & Development at SP in the field of Building and Property management


Popular scientific publications

132. BOSTRÖM, Lars, HELLBERG, Saga "P-märkning och auktoriserat montage i samarbete" AMA-nytt 1/2003.

133. BOSTRÖM, Lars "P-märkning och auktoriserat montage i samarbete" article Bygg & Teknik, no 6, september 2002.

134. BOSTRÖM, Lars "Självkompaketerande betong utsatt för brand" article Bygg & Teknik, no 6, september 2002.

135. BOSTRÖM, Lars "P-märkning och auktoriserat montage i samarbete" article Glas, nr 5, 2002.

136. BOSTRÖM, Lars "Självkompaketerande betong med fibrer klarar brand" article Betong, 2002.

137. ARVIDSON, Magnus, "Boendet sprinkler räddar liv”, i Räddningledaren, fall 2002.


140. SUNDSTRÖM, Björn “Nya brandklasser i Europa”, Aktuell Isolering, October 2000.

141. BOSTRÖM, Lars "Nya standarder för provning och klassificering av konstruktioners brandmotstånd” Aktuella byggen.

142. VAN HEES, Patrick "Harmoniserade brandkrav i Europa för byggnadsmaterial”, Ytforum nr 4 2000.

143. PERSSON, Torbjörn, "Jalousier som brandväggar i industrin”, article Brand & Räddning nr 1, 1999.
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<th>Authors</th>
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<td>HERMODSSON, Thomas</td>
<td>&quot;Oväntad spjälkning av betong fick brandpåverkade balkar att kollapsa&quot;</td>
<td>Brand &amp; Räddning nr 6, 1999.</td>
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<td>SUNDSTRÖM, Björn</td>
<td>&quot;Harmoniserade brandkrav i Europa för byggnadsmaterial&quot;</td>
<td>Bygg &amp; teknik, nr 6, page 12, September 1999.</td>
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<td>PERSSON, Torbjörn</td>
<td>&quot;Brandtekniska bedömningar av brandavskiljande konstruktioner&quot;</td>
<td>Bygg och Teknik 6/98.</td>
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<td>147</td>
<td>ARVIDSON, Magnus och STORM, Eleonor</td>
<td>&quot;Bostadssprinkler räddar liv!&quot;</td>
<td>Brand &amp; Räddning 11/98.</td>
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<td>148</td>
<td>SUNDSTRÖM, Björn</td>
<td>&quot;Nya brandklasser i Europa&quot;</td>
<td>Bygg Forskning nr 5/98.</td>
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<td>149</td>
<td>BENGTTSSON, Bengt-Olof</td>
<td>&quot;Spjälkning avgör brandmotståndet hos betongbalkar&quot;</td>
<td>Brand &amp; Räddning 1-2/97.</td>
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<td>151</td>
<td>INGASON, Haukur</td>
<td>&quot;Vind kan försämra brandventilationen&quot;</td>
<td>Brand &amp; Räddning nr 3, 1996.</td>
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<td>152</td>
<td>&quot;Proceedings of the International Conference on fires in Tunnels&quot;</td>
<td>Betong nr 96-01.</td>
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<td>153</td>
<td>TUOVINEN, Heimo</td>
<td>&quot;Simulera bränder i stora lokaler&quot;</td>
<td>Forskning &amp; Utveckling Brand &amp; Räddning nr 8 August 1996.</td>
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<td>154</td>
<td>INGASON, Haukur</td>
<td>&quot;Brandförsök i tunnlar&quot;</td>
<td>Forskning &amp; Utveckling Brand &amp; Räddning nr 8 August 1996.</td>
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<td>155</td>
<td>PERSSON, Torbjörn</td>
<td>&quot;Vilken byggplatskontroll krävs för brandtekniskt typgodkända produkter och konstruktioner?&quot;</td>
<td>Bygg &amp; Teknik nr 6/96.</td>
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<td>PERSSON, Torbjörn</td>
<td>&quot;Harmoniserade brandprovningsmetoder för konstruktioner i Europa&quot;</td>
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<td>157</td>
<td>SUNDSTRÖM, Björn</td>
<td>&quot;Harmoniserade brandkrav i Europa för byggnadsmaterial – blir det av?&quot;</td>
<td>Bygg &amp; Teknik nr 6, 1993.</td>
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Appendix SPREAD OF FIRE 1

Curriculum Vitae, Margaret Simonson

Personal information
Name: Margaret Simonson
Date and place of birth: September 19, 1965, Waratah, Australia
Home address: Flintakroken 14, SE-443 60 Stenkullen, Sweden
Home tel. and fax: +46 302 22261
Present employment: Fire Protection Manager, Fire Technology SP
Office street address: Brinellgatan 4, Borås, Sweden
Office postal address: SP Swedish National Testing and Research Institute

Box 857, SE-501 15 Borås, Sweden
Office telephone: +46 33 16 52 19
Office fax: +46 33 41 60 12
Office e-mail address: Margaret.Simonson@sp.se

Education
Bachelor of Science, Sydney University, Sydney, Australia, 1986
Master of Physical Chemistry, Chalmers University of Technology, Göteborg, Sweden, 1991
Ph.D. in Combustion Chemistry, Chalmers University of Technology, Göteborg, Sweden, 1995

Employments
Fire Protection Manager, Fire Technology, SP Swedish National Testing and Research Institute, Borås, 2001 –
Research Manager, Fire Technology, SP Swedish National Testing and Research Institute, Borås, 1999 –2001
Researcher, SP Swedish National Testing and Research Institute, Borås, 1995 – 1999
Maternity leave 1996 – 1997 (9 months full time, 5 months part time)
Maternity leave 1991 – 1992 (12 months full time)
Ph.D. student, Chalmers University of Technology, Göteborg, 1988 – 1995

Languages
Swedish, English

Other Information
Swedish Delegate for ISO TC 92 SC 3 Fire Effluents

A list of publications is available on request.
Curriculum Vitae, Petra Andersson

**Personal information**

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<tr>
<th>Name</th>
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<tr>
<td>Date of birth</td>
<td>January 11, 1965</td>
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<tr>
<td>Home address</td>
<td>Vintergatan 35, 504 60 Borås, Sweden</td>
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<tr>
<td>Home tel. and fax</td>
<td>+46 33 12 92 14</td>
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<td>Present employment</td>
<td>Senior Research scientist at SP Swedish National Testing and Research Institute</td>
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| Office street address        | Brinellgatan 4, Borås, Sweden    |
| Office postal address        | Box 857, SE-501 15 Borås, Sweden |
| Office telephone             | +46 33 16 56 21                   |
| Office fax                   | +46 33 41 77 59                   |
| Office e-mail address        | petra.andersson@sp.se             |

**Education**

Master of Science in Engineering Physics, Lund University of Technology, 1989  
Doctorate of Engineering, Department of Fire Technology, 1997

**Employments**

Researcher and PhD studies at Fire Technology 1989-1997  
Researcher at Centre for Built Environment, Gävle, 1998  
Senior Research Scientist, SP Swedish National Testing and Research Institute, 1998-

**Languages**

Swedish, English

A list of publications is available on request.
Curriculum Vitae, Heimo Tuovinen

**Personal information**

Name: Heimo Antero Tuovinen  
Date and place of birth: July 29, 1949, Iisalmi, Finland  
Nationality: Swedish  
Home address: Furulundsgatan 22 SE-504 60 Borås, Sweden  
Home tel. and fax: +46 33 415808  
Present employment: Senior Research Scientist at SP Fire Technology  
Office street address: Brinellgatan 4, Borås, Sweden  
Office postal address: SP Swedish National Testing and Research Institute  
Fire Technology  
Box 857, SE-501 15 Borås, Sweden  
Office telephone: +46 33 16 55 67  
Office fax: +46 33 41 77 59  
Office e-mail address: Heimo.tuovinen@sp.se

**Education**

MSc in Engineering Physics, Chalmers University of Technology, 1985  
PhD from Lund University, Sweden, for simulation of combustion and fire-induced flows in enclosures, 1995

**Employments**

Researcher at Fire Protection section of ST Fire Technology 1985-1989  
Researcher and PhD studies at Fire Technology, Lund University, 1990-1994  
Visiting researcher at School of Mechanical Engineering, Cranfield University, UK, 1991  
Researcher at Research and Development section of SP Fire Technology 1994-

**Languages**

Finnish (native), Swedish (fluent), English (fluent), German (passive)

A list of publications is available on request.
Curriculum Vitae, Tommy Hertzberg

Adress: Vickervägen 2
352 53 Växjö

Family: Lotta, Alexander Niclas

Main education and employments

− 1979-84. M.Sc in chemical engineering at Chalmers/ and l'Université de Technologie de Compiègne, France.

− 1984-88. Development manager at Perstorp AB for a metal substrates group producing Cu-, Invar foils to the PCB market.


− May 1997. ABB-fläkt, Växjö, as a research scientist at ATC (Air pollution control, Technology Center). Main activities in flue gas cleaning projects.


− May 2000. Researcher at SP Swedish National Testing and Research Institute, Borås, department of Fire Technology. Main activities as project leader for research tasks related to fire growth, fire extinguishment and to fire related aerosols.

Other activities

− In 1989, I Initiate a company ‘Catator AB’ at Ideon Research village, Lund. Main activities of Catator is development of catalysts and catalytic processes. Catator today (2003) employs 10 people and has a turnover of ~15 miljon SEK. I am at present a share holder but do not take active part in Catator’s dayly activities. (www.catator.se)

− In 1999, I took part in the initiation of the (still ongoing) particle and aerosol research project at Växjö University, through the application and acceptance of a STEM-sponsored (www.stem.se) ABB-Växjö University-Lund University joint aerosol research programme.

− In February 2000, I get Appointed opponent on a Licentiate thesis at NADA, KTH, 'Shape optimization of low speed airfoils using MATLAB and automatic differentiation'.

− In 2001 I took part in the initiation of a national network, the ‘Swedish Programme for Aerosol Research and Competence, SPARC’, that will support and co-ordinate aerosol research in Sweden (www.sp.se/sparc). In 2002 we obtained funding from Formas to support part of the SPARC activities related to a research school. We have also obtained funding from several industries and we are currently (2003) discussing PhD-support with other funding institutions, such as the Swedish ‘KK-stiftelse’.

− Consultant for ABB fläkt (today Fläkt Woods AB) since 2000 and Metfoils AB since 2002.


A list of publications is available on request.
Curriculum Vitae, Per Blomqvist

**Personal information**

**Name:** Per Blomqvist  
**Date and place of birth:** February 17, 1965, Sweden  
**Nationality:** Swedish  
**Home address:** Mölndalsvägen 13, SE-412 63 Göteborg, Sweden  
**Home tel. and fax:** +46 31 401924  
**Present employment:** Researcher, Fire Technology SP  
**Office street address:** Brinellgatan 4, Borås, Sweden  
**Office postal address:** SP Swedish National Testing and Research Institute Box 857, SE-501 15 Borås, Sweden  
**Office telephone:** +46 33 16 56 70  
**Office fax:** +46 33 41 77 59  
**Office e-mail address:** per.blomqvist@sp.se

**Education**

Chemical Engineer, 4 year pre-university education, Aschebergsgymnasiet, Göteborg, 1985 (Swe: Gymnasieingenjör kemiteknik)

Master of science in Analytical Chemistry, University of Göteborg, Göteborg, 1990 (Swe: Kemistlinjen 160 p)

Licentiate Exam in Chemistry within the Department of Chemistry, Inorganic Chemistry, of the University of Göteborg Sweden, 2000

**Employments**

Chemist at the inorganic chemistry section of SP Chemical Analysis 1990-1998  
Researcher scientist at SP Fire Technology 1998-

**Languages**

Swedish, English

A list of publications is available on request.
Curriculum Vitae, Anders Lönnermark

**Personal information**
Name: Anders Lönnermark  
Date of birth: 16th of February, 1968  
Home address: Lundsalsvägen 6, 504 63 Borås, Sweden  
Home tel. and fax: +46 33 25 48 10  
Present employment: Researcher at SP Swedish National Testing and Research Institute  
Office street address: Brinellgatan 4, Borås, Sweden  
Office postal address: Box 857, SE-501 15 Borås, Sweden  
Office telephone: +46 33 16 56 91  
Office fax: +46 33 41 60 12  
Office e-mail address: anders.lonnermark@sp.se

**Education**
Master of Science in Technical Physics, Chalmers University of Technology, 1996  
Licentiate of Engineering, Department of Energy Conversion, Chalmers University of Technology, 2002

**Employments**
Mathematics teacher, De La Gardieskolan, Lidköping (High school), 1994  
Senior Research Scientist, SP Swedish National Testing and Research Institute, 1995-

**Languages**
Swedish, English

A list of publications is available on request.
Curriculum Vitae, Bror Persson

**Personal information**

Name: Bror Persson  
Date and place of birth: June 5, 1939, Tännäs, Sweden  
Home address: Bohusvägen 63, SE-702 44 Västerås, Sweden  
Home tel. and fax: +46 21 33 27 95  
Present employment: Senior Research Scientist, Fire Technology SP  
Office street address: Brinellgatan 4, Borås, Sweden  
Office postal address: SP Swedish National Testing and Research Institute  
Box 857, SE-501 15 Borås, Sweden  
Office telephone: -  
Office fax: -  
Office e-mail address: brorp@telia.com

**Education**

Civilingenjör, Chalmers University of Technology, Göteborg, Sweden 1967 (Bachelors degree in Mechanical Engineering)  
Tech lic, Chalmers University of Technology, Göteborg, Sweden, 1970 (Master Degree in Applied Thermo- and Fluid Dynamics)  
Tech dr, Chalmers University of Technology, Göteborg, Sweden, 1974 (appointed Docent in Applied Thermo- and Fluid Dynamics)

**Employments**

Avdelningsdirektör, Statens Skeppsprovningsanstalt, Göteborg, 1972-1974  
Senior Research Engineer, Det norske Veritas, Oslo, 1976-1981  
Research Engineer, AB Asea Atom, Västerås, 1981  
Research Manager, Techpro A/S, Oslo, 1981-1986  
Senior Research Engineer, Bofors AB, Karlskoga, 1987-1991  
Research Manager, SP Fire Technology, Borås, 1991-1999

**Languages**

Swedish, English, German

A list of publications is available on request.
Research & Development at SP in the field of Building and Property management
3.9 Polymeric materials
3.9.1 Ongoing and recently completed research

Recycling and durability of polymeric materials as wastes from buildings

The potential for recycling various polymeric materials contained within buildings constructed in the late 1960s and 1970s in Sweden was investigated during the course of this work. Three residential blocks were studied to establish the quantity of materials available for recycling, to investigate the difficulty in and time needed for the dismantling of the buildings, the degree of purity of the materials, and the possibility of separating the materials. The focus of the experimental work was on studies of various types of polyvinyl chloride (PVC), which is the dominant polymeric material in the buildings. The important properties and the durability of new plasticised and rigid PVC materials were investigated, as well as the properties of older products collected from the buildings. The study had several facets. First, there was an investigation into the degradation processes that occur during the initial processing of virgin material and during reprocessing. Then there was examination of changes in properties during service life. Following this was the process of establishing the remaining lifetime of the used and reprocessed materials. Finally there was an investigation into fundamental degradation mechanisms that can take place during the long service life of PVC materials in buildings under various environmental conditions. In particular, stabiliser consumption and dehydrochlorination, depletion of plasticiser, and deterioration of the tensile properties were examined. Evaluation was carried out by means of physical and chemical analysis and characterisation was achieved on a molecular level, in addition to evaluation of the mechanical properties, including attempts at recycling some materials on the laboratory scale. Accelerated ageing of the materials was performed to simulate the natural service life conditions. The decisive degradation mechanisms in the new and model materials were mapped and compared with older materials. An attempt was also made at recovering energy from flooring.

Long-term durability and performance of polymeric materials in various environments

Joint seals for use in construction joints in roads and airfields were examined in respect to their performance, within a wide range of temperature. Attention was paid to very slow movements in joints and to compression set of materials. The seals were subjected to changing temperature and synchronised movement of the joint. The expansion force (compression force) of the seals, which is responsible for keeping the seal in place and for preventing penetration of water and dust, was recorded continuously. Only one seal functioned well at -30 °C. The other seals hardly managed to function at -20 °C. The testing of the EPDM joint seals showed that the compression set, in the material after ageing is a limiting factor for the function of a seal. The results from the investigation show the importance of performing a suitable function test on preformed joint seals, within the entire field of application, in order to verify the properties specified by the manufacturers. The proposed test procedure makes it possible to determine limits in working range and temperature for joint seals. The method is also suitable to evaluate the influence of the environmental factors like temperature, liquid chemicals, UV-light, ozone, etc on the performance of joint seals.

The durability of geomembranes can be limited owing to such factors as mechanical damage, UV-light, oxidation, biodegradation and the action of liquid chemicals. In deposits, different constituents from solid wastes can be leached by water, which seeps through the deposit and accumulates on a geomembrane. Thus, the geomembrane will remain in contact with such liquid chemicals for a very long period of time. The contact of polymeric materials with aggressive liquid media is accompanied by a complex range of physical and chemical processes. The aim of this research project was to investigate the influence of some frequently occurring liquid agents on the durability of PVC-based geomembranes. An accelerated test method which can be used for prediction of lifetime of geomembranes is also suggested. Also, various methods for evaluation of degradation and failure were used, as the role of such methods is critical in the effectiveness of a durability testing programme.

PE-films, foils and sheets are commonly used in buildings. In certain constructions, these products are in contact with wet concrete during their service life. The alkaline environment created by wet concrete may accelerate the degradation of these products. Low-density polyethylene (LDPE) films were investigated with respect to their durability. An accelerated ageing has been performed in wet
concrete environment and in moist air. The durability of the films in various water solutions has also been investigated. The degradation was studied with the aid of measurements of elongation at break, carbonyl index, and induction temperature. The rate of degradation in the environment of fresh wet concrete at ambient temperatures was much higher than in moist air or in other environments. Compared with unstabilised film, the time to 50% retention of elongation at break (t50) at 90 °C for various films increases from six fold for the process-stabilised film to 100 times for the film stabilised with Irganox 1076 in the environment of fresh wet concrete. In moist air the corresponding ageing times are 3 times longer. The rate of degradation in the environment of old wet concrete at ambient temperatures was of the same magnitude as in moist air. The results show that monitoring the degree of degradation by measuring the carbonyl oxidation products does not correspond to the results from elongation at break measurements. It is demonstrated that the rate of stabiliser consumption can be detected sensitively by measurements of the induction temperature. A good correspondence has been found between measurements of the induction temperature and measurements of elongation at break. The value of the activation energy and thus the acceleration factor was found to depend not only on the stabilisation system used but also on the influencing environment.

3.9.2 C.V. for researchers

The C.Vs for Dr Ignacy Jakubowicz and Dr Nazdaneh Yarahmadi are shown in appendix POLYMERIC MATERIALS 1.

3.9.3 Doctoral students

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<td>Nazdaneh Yarahmadi</td>
<td>Polymeric materials in sustainable buildings</td>
<td>2003 (dr)</td>
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3.9.4 Financing

The financing of the research in the field of Polymeric materials during the last three years is presented in the table below.

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3.9.5 International and national research projects

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<tr>
<td>Durability of impact modified PVC part 2 &amp; 3</td>
<td>93-93 &amp; 00</td>
<td>SPF, Kömmerling, Brugmann, Rehau, Primo, Sondex</td>
<td>I. Jakubowicz</td>
</tr>
<tr>
<td>Long term durability of building materials--“test house”</td>
<td>93-95</td>
<td>Trelleborg, Horda Profil, BFR</td>
<td>A. Holmström</td>
</tr>
<tr>
<td>Influence of wet concrete on durability of PE-films</td>
<td>93-97</td>
<td>Borealis, Trioplast, Statoil</td>
<td>I. Jakubowicz</td>
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<tr>
<td>Activity</td>
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<td>Period</td>
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<td>--------</td>
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<tr>
<td>Development of certification system for waterproofing membranes</td>
<td>I. Jakubowicz</td>
<td>00-03</td>
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### 3.9.6 International and national cooperation

### National

<table>
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<tr>
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<th>Period</th>
<th>Comments</th>
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<td>Development of certification system for waterproofing membranes</td>
<td>I. Jakubowicz</td>
<td>00-03</td>
<td></td>
</tr>
</tbody>
</table>

### 3.9.7 Relevant publications 1993-2003

#### Peer reviewed papers


2. **YARAHMADI Nazdaneh, JAKUBOWICZ Ignacy, GEVERT Thomas.** "Determination of potential for recycling of polymeric products found in buildings from the 1960s and 70's - a case study", International Journal of Low Energy and Sustainable Buildings, volume 1, Jan 1999


<table>
<thead>
<tr>
<th>No.</th>
<th>Author(s)</th>
<th>Title</th>
<th>Conference/Proceedings Name</th>
<th>Year</th>
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<tr>
<td>7</td>
<td>YARAHMADI Nazdaneh, JAKUBOWICZ Ignacy, HJERTBERG Thomas</td>
<td>“Effects of heat treatment and ageing on mechanical properties of rigid PVC”</td>
<td>Polymer Degradation and Stability</td>
<td>2003</td>
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<td>8</td>
<td>JAKUBOWICZ, Ignacy</td>
<td>Influence of Moist Concrete on the Durability of Polymers. Fiber Composites as Non-metallic Reinforcement in Concrete</td>
<td>Seminarium vid Chalmers Tekniska Högskola, Göteborg. 15 mars 1993</td>
<td>1993</td>
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<td>9</td>
<td>JAKUBOWICZ, Ignacy</td>
<td>Influence of Wet Concrete on the Durability of Polymer Films. VIII International Congress on Polymers in Concrete</td>
<td>Oostende (Belgien), 4 juli 1995</td>
<td>1995</td>
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<td>10</td>
<td>JAKUBOWICZ, Ignacy</td>
<td>Influence of Wet Concrete on the Durability of Polymer Films 7th International Conference on the Durability of Building Materials and Components, (Stockholm), 19-23 may 1996</td>
<td>Poster</td>
<td>1996</td>
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<tr>
<td>14</td>
<td>YARAHMADI Nazdaneh, JAKUBOWICZ Ignacy, GEVERT Thomas</td>
<td>Effects of Accelerated and Natural Ageing on Plasticised PVC</td>
<td>Proceedings</td>
<td>1999</td>
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<td>15</td>
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<td>Nordiska Polymerdagarna in Köpenhamn, 1-2 juni 1999</td>
<td>1999</td>
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<tr>
<td>18</td>
<td>YARAHMADI Nazdaneh, JAKUBOWICZ Ignacy</td>
<td>&quot;PVC floorings as post-consumer products for mechanical recycling and energy recovery&quot;, 2nd international conference on polymer modification, degradation and stabilisation, 1-5 August 2002, Budapest, Hungary</td>
<td>Proceedings</td>
<td>2002</td>
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</table>
Swedish reports


25. JAKUBOWICZ Ignacy, ANTONSSON, Ulf. Inverkan av färs betong på beständigheten hos tätskikt för användning i keramiska våtrumskonstruktioner. SP AR 2001:25

26. JAKUBOWICZ, Ignacy, Yarahmadi, Nazdaneh. Återvinning av polymera material från gamla byggnader, FoU-Väst Rapport 0303 (2003), ISSN 1402-7410

Popular scientific publications

27. JAKUBOWICZ, Ignacy, Yarahmadi, Nazdaneh. Flera polymera bygprodukter lämpar sig för återvinning. Provning & forskning nr. 4, 2000

28. JAKUBOWICZ, Ignacy, Yarahmadi, Nazdaneh. Återvinning av plast från miljonprogrammet Miljöforskning nr. 6, 2002, sida 42-43
Appendix POLYMERIC MATERIALS 1

CURRICULUM VITAE, Ignacy Jakubowicz

Dr. Ignacy Jakubowicz finished his Ph D in Physical Chemistry at the University of Göteborg, Sweden in February 1985 and afterwards he joined SP Swedish National Testing and Research Institute. Until August 2001 he was Head of section for Polymer technology and between 1999 and 2001 he was Deputy Manager of the Chemistry and Materials Technology Department at SP. He has now a position as Technical Manager for Polymer Technology responsible for testing, R&D and standardisation activities. He has a long experience from research in the field of polymer technology, especially regarding durability, lifetime prediction and recycling having 15 scientific papers, 30 other publications and 35 contributions at international conferences. He has also a long experience from the national and international standardisation work being acting as convenor for different committees or working groups in ISO, CEN and national plastics standardisation.

YEAR OF BIRTH: 1949

NATIONALITY: Swedish

PROFESSION: Ph.D. in Physical Chemistry

POSITION IN FIRM: Technical Manager for Polymer Technology at SP

YEARS WITH FIRM: Since 1985

EDUCATION: Physical Chemistry, Gothenburg University, 1985

LANGUAGES: Swedish, English, and Polish

CURRENT PROJECTS: Polymeric Products in Sustainable Buildings
Oxo-biodegradable Plastics
Chemical Resistance of Sealants

HONORARY TASKS: Member of the national standardisation committee for plastics MMS 2740 since 1985
Swedish delegate in ISO TC 61 Plastics since 1985
Convenor for the national standardisation committee for plastics SMS 2740 since 1998
Convenor for ISO TC 61 SC 6 WG 3- “Various exposures” since 2000
Swedish delegate in CEN TC 227 WG 3-“Materials for roads including joint fillers and sealants”

A list of publications is available on request.
CURRICULUM VITAE: Nazdaneh Yarahmadi

YEAR OF BIRTH: 1963

NATIONALITY: Swedish

PROFESSION: Ph. D. in Materials Technology, Chalmers University of Technology may 2003

POSITION IN FIRM: Researcher at SP Swedish National Testing and Research Institute, Section for Polymer Technology since June 2003

PREVIOUS POST: Technical officer at SP Polymer Technology, 1995-1997
Ph. D. student at SP Polymer Technology, 1997-2003

YEARS WITH FIRM: Since 2001

CURRENT PROJECTS: Recycling of polymeric products from buildings
Development of methods for evaluation of biodegradability and disintegration in polymeric materials

HONORARY TASKS: Director in Iranian National Association
Director in SIMON- Swedish Immigrants Against Drugs

PUBLICATIONS:
- 5 peer reviewed scientific papers
- 6 proceedings at international scientific conferences
- 16 popular scientific publications
- 3 SP and CTH reports
- Ph. D. thesis

A list of publications is available on request.
3.10 Service life prediction of solar thermal components

Foto. Björn Stål, Arnes Plåtslageri AB
3.10.1 Ongoing and recently completed research

SP has been involved in international joint research work on solar thermal components within the framework of the Solar Heating and Cooling Programme of the International Energy Agency for more than two decades. Main focus of research has been materials durability, service life prediction and accelerated life testing.

The joint research work on solar materials durability started in Task 10 (1985-1994) with the aim to establish the use, limitations and also to experimentally validate methods for accelerated life testing that could be applicable to materials used in solar heating and cooling applications. Main part of work was performed within a case study on selective solar absorber coatings with Bo Carlsson SP as Subtask leader. The work involved the development of both experimental and theoretical tools to aid systematic life cost analysis and material selection. This entailed the development of recommended procedures for measurement and testing, and of theoretical models to be used in life testing and life data analysis. In the systematic approach to accelerated life testing employed in the case study, a step was taken from a qualitative approach towards a quantitative approach to durability assessment. The methodology comprised a large number of activities encompassing a broad range of technical expertise in building physics, solar energy engineering, environmental testing, and material science both at an applied and at a more basic level. The systematic approach comprised performance analysis, failure analysis, stress analysis, accelerated ageing and life data analysis. The work was unique and its results therefore, were not only of interest to solar energy engineers but also to material scientists and test engineers working with service life assessment and design of materials in other areas of application.

As an extension of the work on durability in Task 10, the Working Group Materials in Solar Thermal Collectors was established in 1994 with Bo Carlsson SP as the working group leader. The objective of the working group was to develop or validate durability test procedures for solar collector materials, to generalize test procedures for standardization, and to develop guidelines for solar collector design to achieve the most favourable microclimate conditions for materials. As a result of this work durability test procedures were developed that have been adopted by solar absorber coating manufacturers in their development of new and improved products. The test procedures were also approved for ISO standardization.

In 2000 Task 27, on Performance, Durability, and Sustainability of Solar Facade Components, was initiated. In the Task 27 subtask on durability lead by Bo Carlsson SP, the objective is to develop a more general methodology for durability test procedures and service lifetime prediction (SLP) methods adaptable to the wide variety of advanced optical materials and components used in energy efficient solar thermal and buildings applications.

As the result of this work a general outline of methodology has been developed. The proposed methodology includes three steps: a) initial risk analysis of potential failure modes, b) screening testing/analysis for service life prediction and microclimate characterisation, and c) service life prediction involving mathematical modelling and life testing.

The applicability of the working scheme to be employed in the development of durability test procedures has been analysed for selective solar absorber surfaces and polymeric glazing materials as collector cover in flat plate solar collectors. The examples both show the great applicability of the general methodology for accelerated life testing. The methodology is presently adopted in the development of durability test procedures for antireflecting glazing, reflectors, solar façade absorbers, electrochromic and gasochromic devices.

3.10.2 CV for researchers

The C.Vs for Professor Bo Carlsson and Dr. Kenneth Möller are shown in appendix SERVICE LIFE 1.
3.10.3 Financing

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3.10.4 International and national research projects

**European projects**

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<td>85-94</td>
<td>11 research organizations</td>
<td>Bo Carlsson</td>
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<td>IEA, Working Group: Materials in Solar Thermal Collectors</td>
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<td>7 research organizations</td>
<td>Bo Carlsson</td>
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<tr>
<td>IEA, Task 27: Performance, Durability, and Sustainability of Solar Façade Components</td>
<td>00-05</td>
<td>30 research organizations</td>
<td>Bo Carlsson, Kenneth Möller</td>
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3.10.5 Relevant Publications 1993-2003

**Peer review papers, book and reports**


8. General methodology of accelerated testing for assessment of service life of solar thermal components


22. Experience of Absorber Durability from Solar DHW Systems - Comparison between predicted and actually observed in-service degradation of some nickel-pigmented anodized aluminium absorber coatings; Bo Carlsson, Kenneth Möller, Ulle Frei, Stefan Brunold, Michael Köhl; Paper presented at the Conference Eurosun 96, 16-19 Sept. 1996, Freiburg, Germany


25. Results of a round robin on accelerated testing of absorber surface; Stefan Brunold, Ueli Frei, Bo Carlsson, Kenneth Möller, Michael Köhl, Thomas Tröscher, (Paper presented at Eurosun '98, Slovenia)


SP Reports


35. European and global standardization within the field of solar heating 1994 - 1996; Per Bergquist, Bo Carlsson, Leif Liedquist; SP-AR 1997:04 (Swedish)


37. Results of round robin test on qualification of absorber surface durability - Swedish contribution; Kenneth Möller and Bo Carlsson, Report for project A2 of IEA Working group on Materials for Solar Thermal Collectors, SP - Technical Note 1997: 40


Others


Appendix SERVICE LIFE 1

Curriculum vitae: Bo T Carlsson

<table>
<thead>
<tr>
<th>Name</th>
<th>Bo T Carlsson</th>
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<tbody>
<tr>
<td>Born</td>
<td>1946-03-19 in Nyköping</td>
</tr>
<tr>
<td>Position</td>
<td>Professor / Scientific Leader/Consultant</td>
</tr>
<tr>
<td>Phone</td>
<td>+4633 165335/+46480472226</td>
</tr>
<tr>
<td>Mobile</td>
<td>+46 03419465/+46705472246</td>
</tr>
<tr>
<td>E-mail</td>
<td><a href="mailto:bo.carlsson@sp.se">bo.carlsson@sp.se</a></td>
</tr>
<tr>
<td>Department</td>
<td>Department of Chemistry and Materials Technology</td>
</tr>
<tr>
<td>Institute</td>
<td>SP Swedish National Testing and Research Institute</td>
</tr>
<tr>
<td>Address</td>
<td>P.O.Box 857, S-50115 Borås, Sweden</td>
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**Education and academic achievements**

- M.Sc. Chemical Engineering at the Royal Institute of Technology, Stockholm, 1971
- PhD Physical Chemistry at the Royal Institute of Technology, Stockholm, 1976
- Associate Prof. Physical Chemistry at the Royal Institute of Technology, Stockholm, 1979
- Visiting Prof. Corrosion Science at the Royal Institute of Technology, Stockholm, 1998-2001

**Other academic qualifications**

- Declared competent for extra professorship in Physical Chemistry (Thermochemical Energy Storage) at the Royal Institute of Technology, 1984
- Declared competent for Assistant Professorship (Universitetslektor) in Energy Technology in Chemical Process Industry at Chalmers Technical University in Gothenburg, 1984

**Positions held**

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<th>Position</th>
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<tr>
<td>Research Assistant</td>
<td>Physical Chemistry, Royal Institute of Technology, Stockholm</td>
<td>1975-1976</td>
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<tr>
<td>Senior Researcher</td>
<td>Physical Chemistry, Royal Institute of Technology, Stockholm</td>
<td>1976-1979</td>
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<td>Research Leader</td>
<td>Physical Chemistry, Royal Institute of Technology, Stockholm</td>
<td>1979-1984</td>
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<td>Deputy Prof.</td>
<td>Physical Chemistry, Royal Institute of Technology, Stockholm, (1/2-time)1981</td>
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<tr>
<td>Head of Division</td>
<td>Surface Protection, SP Swedish National Testing Institute, 1985-1996</td>
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<td>Prof./Scientific Leader</td>
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**International assignments**

- **International Energy Agency Solar Heating and Cooling Programme**
  - Subtask Leader on Durability assessment in Task 27 Solar Building Facades - Performance, Durability and Sustainability, 1999- still

- **Committee of European Environmental Engineering Societies (CEEES)**
  - Convenor SEES Working Group "Moister and Corrosion", 2001-still
Assignments in international and national standardization committees

- Chairman for the Swedish technical committee on general test methods for corrosion, SMS 2661, 1995 -still
- Convenor of ISO/TC 156 Corrosion of Metals and alloys, WG 7 Accelerated corrosion tests, 1995- still
- Project Leader in CEN TC 262 Protection of metallic materials against corrosion, WG 9 Testing and evaluation methods for corrosion, 1995 –still
- Project Leader in ISO TC 35 Paints and varnishes, SC12 Preparation of steel substrates before application of paints and related products, WG 2 Surface cleanliness, 1994 -1996
- Chairman for the Swedish Technical Committee on Solar Heating, SMS TK 225,1987-1996
- Project Leader in ISO TC 180 Solar Energy, WG 2 Materials, 1994- still

Teaching

- Lecturer in fundamental Physical Chemistry (Chemical thermodynamics, chemical reaction kinetics, spectroscopy, quantum chemistry, etc.), for M.Sc. students at the Royal Technical Institute of Technology, 1971-1984
- Teacher in courses on general methods for energy storage and heat pumping and use of chemical methods for heat storage in solar heating systems, given for doctoral students and industry, 1976 -1984
- Principle supervisor for doctoral student in Physical Chemistry (Thermochemical Energy Storage), 1979-1984
- Supervisor for Techn. Lic. student in Polymer Technology (Durability of organic coatings), 1992-1996
- Lecturer in Materials Technology (Corrosion Science) and Chemical Thermodynamics for B. Sc. students in Chemical Engineering at the Borås University, 1990-1994
- Teacher in courses on environmental resistance engineering and life-time technology related to chemical stability of materials given for industry, 1993- still, and B. Sc students in Logistics at the Borås University, 1999-still
- Lecturer in Materials Lifetime Technology and Industrial Ecology for M.Sc. students at the Royal Technical Institute of Technology and the Technical University of Dalarna, 2001-still

Main research fields

- Properties of photochromic materials (heterogeneous inorganic photochromic systems, photochemical solar collector systems)
- Chemical methods for heat storage and heat transformation and integration of storage in energy systems (latent heat storage, heat of sorption storage and heat pumping in connection with the utilization of alternative energy sources such as solar and waste heat)
- Environmental resistance and service life prediction in the field of surface protection and corrosion (general methodologies for accelerated life testing, solar energy materials durability, painting of exterior wood, environmental friendly rust protective paints, surface cleanliness prior to painting, automotive paint durability, automotive corrosion, corrosion of electronics)
- Materials lifetime technology and industrial ecology (holistic approach for material selection in component design, total cost accounting)

Publications generally

The list of publications contains about 160 articles in scientific journals, conference proceeding papers, research reports, international standards and also 3 patents.

A list of publications is available on request.
CURRICULUM VITAE:  Jan Kenneth Möller

Born:  Uddevalla, Sweden, 1950

Address:  Work: SP Swedish National Testing and Research Institute
          Box 857, SE-501 15 Borås, Sweden
          tel: (+46) - 33-165188, fax: (+46) - 33-103388, e-mail: kenneth.moller@sp.se

          Home: Humlevägen 6D
          SE-448 36 Floda, Sweden
          tel: (+46) - 302-354 28

Citizenship:  Swedish


Studied at the faculty of Chemical Engineering at Chalmers University of Technology from 1972 to 1976. PhD studies at the Department of Physical Chemistry at Chalmers University of Technology from 1980 to 1985. The title of the thesis is "Desorption Processes on Metal and Graphite Surfaces with Application to Thermionic Energy Conversion and Time-of-Flight Mass Spectrometry".

Employed since 1988 as senior researcher at SP - Swedish National Testing and Research Institute, department of Chemistry and Materials Technology.

Previous appointments:

- AB Nynäshamn Petroleum, Nynäshamn, 1978-1979

Teaching:  Participated as a lecturer in courses given at the department of Physical Chemistry, Chalmers University of Technology

          General Physical Chemistry.

          Advanced Energy Conversion (Thermionic energy conversion and magnetohydrodynamic energy conversion).

          Chemical Reaction Dynamics.

          Spectroscopy.

Publications:  > 60 scientific peer reviewed papers as author/co-author in scientific journals or in conference proceedings. Publication list is available on request.

International collaboration:  Participate since more than 15 years in an international collaboration within International Energy Agency (IEA) in solar energy research (Task 10, IEA)
Working Group MSTC and Task 27 (ongoing)).

Participated in EU-project “Solar Building Façade” (SUNFACE)

Participate in EU-project “Innovative Measurement Methodology in Quality Assessment of Automotive Coatings” (MANIAC)

<table>
<thead>
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<th>Main research interests:</th>
<th>Material characterisation in general</th>
<th>Polymer degradation</th>
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<td>Spectroscopy (FTIR, UV-VIS-NIR, X-ray fluorescens, etc)</td>
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<td>Mass spectrometry (TOF-SIMS, MALDI) Microscopy (optical, SEM)</td>
<td>Accelerated ageing</td>
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<tr>
<td>Corrosion</td>
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<td>Desorption/evaporation from surfaces</td>
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</tbody>
</table>

A list of publications is available on request.
3.11 Coatings and surface protection
3.11.1 Ongoing and recently completed research

**Painting of exterior wood**

A ten years research program on painting of exterior wood was conducted at SP in between 1987-1997. The overall objective was the development of methodologies and methods for testing and evaluation of materials and methods for painting of wooden window frames and wooden facades with respect to lifetime and life cycle cost. Based on the results of the research general recommendations for painting of exterior wood were worked out in collaboration with house manufactures, paint manufactures, painting companies and researchers in building materials science.

In particular, two methods for renovation and repainting of wooden window frames were compared with respect to long-term performance of organic coating system. One of the methods, named A13, was based on a very thorough preparation of the surface of wood, where all old coatings of paint and putty were removed from the window frame, prior to application of paint system. This method was compared with so called traditional repainting. For the A13 method be competitive with traditional repainting, from life cycle cost considerations, requires service life of coating system be about twice longer. For the investigation two large buildings were used and the condition of the coating systems were followed for a time period of nearly nine years.

The service life of coating system was defined in terms of degree of cracking and flaking using a statistical approach. The rate of evolution of cracking and flaking was modelled by the Weibull distribution function. The quantitative approach made it possible properly compare the long-term performance of the different coatings and so the two methods of renovation and repainting. This makes this study unique. The conclusions of study is that the more advanced method of renovation and repainting may have difficulties in competing traditional repainting because of restrictions in using solventborne paints indoors.

Because of problems at that time with wood rote, the moisture protection capability of organic coating systems for exterior wood was also studied. Technique for measurements of the moisture content of painted wooden facades during outdoor exposure was developed. A series of measurements on different painted model facades was performed for a time period of four years. To find the most relevant measure of moisture protection capability an effective critical time of high moisture level occurrence was defined taken into account the variation in the growth rate of wood rot with temperature and water content of wood. All the coating systems measured had been prepared following the general recommendations given in reference 4. They all exhibited a sufficient moisture protection capability near the end-grain.

**Coatings for corrosion protection and lifetime of coatings**

Development of methods for service life prediction based on accelerated corrosion testing is an area of research of great interest to SP. As a result of the research at SP a new approach of using metal reference specimens for characterizing both service and accelerated test conditions has been introduced as a method for service life prediction. In the development of new ISO standards on accelerated corrosion testing, in which SP through Bo Carlsson functions in the role of ISO Working Group Convenor, this approach is presently employed. The approach has also been adopted when classifying the corrosion protection capability of inorganic coatings and this classification system is presently used for type approval and certification. A NORDTEST Method MAT 003 on this classification method has also been worked out and approved.

In case of environmental friendly rust protective paints also a complete qualification procedure was developed taking into account not only the durability properties of paint systems but also cost and environmental impact of different paint systems. For rust protective paint systems in general, a qualification procedure based on accelerated corrosion testing has been developed and is presently used as a faster alternative to testing by out door exposure . The qualification procedure has also been adopted in a project initiated by the Swedish National Heritage Board on how favourable modern coating systems for rust protection are to a traditional one with a red lead linseed oil primer. The
objectives of the project are the assessment of durability, maintenance cost characteristics and environmental quality properties of the two kinds of coating systems. The project involves laboratory studies but also a reference object study in which repainting of two railway bridges and assessment of the long-term performance of coating systems are made for a time period of more than ten years.

SP is coordinating a larger EU project within lifetime prediction of coatings with focus on weathering. The objective with this research is to develop new, innovative methodologies for the short and long term prediction of coating weathering behavior. The project will also result in a tool for depth profiling of multilayer high performance coatings, which means that important additives in the coatings can be analyzed at different locations in the coatings.

3.11.2 C.V. for researchers

C.V.s for Prof. Bo Carlsson and Dr. Kenneth Möller can be found elsewhere in this document.

3.11.3 Financing

The financing of the research in the field of coatings and surface protection during the last three years are presented in the table below.

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<tr>
<td>PFF</td>
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</tr>
<tr>
<td>Riksantikvarieämbetet</td>
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<tr>
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3.11.4 International and national research project

**Examples of research projects**

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>Partners</th>
<th>Contact at SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANIAC - Innovative measurement methodology in quality assessment of coatings (EU project)</td>
<td>2002-2004</td>
<td>Aston University, Atlas MTT, FhG-IPA, DaimlerChrysler, Clariant, BYK-Chemie, Volvo Car, PPG</td>
<td>Magnus Palm</td>
</tr>
<tr>
<td>CLEANTROL – a tool for surface cleanliness prior to coating (EU-CRAFT project)</td>
<td>2001-2003</td>
<td>Several european industries,</td>
<td>Adeline Flogård</td>
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<td>VANTE – Application and verification of weathering methods including acid rain (PFF project)</td>
<td>2001-2003</td>
<td>DuPont, Volvo Car</td>
<td>Magnus Palm</td>
</tr>
<tr>
<td>Coatings for historic bridges</td>
<td>2000-2015</td>
<td>Coating manufacturers, Riksantikvarieämbetet,</td>
<td>Bo Carlsson</td>
</tr>
</tbody>
</table>
3.11.5 Relevant publications 1993-2003

1. Long term durability of painted wooden window frames - Prerequisites for reference object study; Lars Karvonen och Bo Carlsson; SP-Rapport 1987:16, (Swedish)

2. Long term durability of painted wooden window frames - Result from comparative study five different organic coating system; Karin Wernståhl och Bo Carlsson, BFR-Rapport R4: 1992 (Swedish).


4. Painting of exterior wooden facades - Guidelines for planning, verification and purchasing; Roger Anneling och Bo Carlsson (editors), SP-INFO 1993:4 (Swedish).


6. Assessment of moister protection capability of organic coating systems for wooden facades; B. Carlsson, SP-Rapport 1997:26 (Swedish)

7. Maintenance painting of exterior wood and time intervals for repainting; B. Carlsson, Bygg & Teknik 1997:8 (Swedish)

8. Damage of rote in wooden facades - The capability of organic coating systems for moister protection; Bo Carlsson, Bygg & Teknik 1998:8 (Swedish)

9. Lifetime analysis based on accelerated testing - Recommended methodology for qualification and verification of organic coating systems; Bo Carlsson, Kurt Jutengren, Anneli Berglund-Åhman; Report for NORDTEST project 1127-93, SP-Rapport 1995:65 (Swedish)


11. Assessment for corrosion protection classes for inorganic coatings on steel, Bo Carlsson, NORDTEST method MAT 003, Final report NORDTEST project 1509-99 (addendum)

12. Evaluation of available rust protective systems for maintenance painting of historical monuments - Results of accelerated corrosion testing, Bo Carlsson m.fl., SP-Rapport 2002:07 (Swedish)


14. Corrosion of metals and alloys - Corrosion tests in artificial atmosphere – Accelerated outdoor test by intermittent spraying of a salt solution (Scab test); ISO 11474 -1998, B. Carlsson (project leader, convenor)
Corrosion tests in artificial atmospheres - Accelerated corrosion test involving alternate exposure for corrosion promoting gases, neutral salt spray and drying; ISO/FDIS 21207: 2003, B. Carlsson (project leader, convenor)

Accelerated corrosion test involving exposure under controlled conditions of humidity cycling and intermittent spraying of a salt solution; ISO/ FDIS 16701: 2002, M. Ström (project leader), B. Carlsson (convenor)
Research & Development at SP in the field of Building and Property management
3.12 Building materials and indoor air quality
3.12.1 Ongoing and recently completed research

SP Swedish National Testing and Research Institute, Chemistry and Materials Technology have developed and validated techniques for identifying, measure and evaluate the effects of chemical pollution indoors and developed techniques for studying materials emission during the last two decades. Health issues such as the rising incidence of allergies and respiratory diseases are alleged to be related to new and modified exposures indoors. The contribution of pollutants come from materials in the indoor environment, persons and person related activities, outdoor air and the ventilation system have been the target for our studies. The knowledge of the health effects of the low dose exposure to chemical pollutants in indoor environments is still lacking full consistency. The first step is always to locate and eliminate the source. A prerequisite for the implementation of the source control is the ability to identify the pollutants, establish techniques for measuring the pollutants and establishing the contribution from the different sources. The research particularly in this group at SP has been aimed at the development of tools and techniques for indoor air quality investigations and methods and techniques for materials emission studies and for evaluation of indoor air quality. The ultimate goal is to develop the tools necessary to specify, plan and create a good indoor air environment in homes, offices and schools and to have the tools to control when these requirements have been achieved.

Long term goals and activities
To investigate and characterise the indoor air in non-industrial as well as industrial buildings
To develop techniques and methods for identification and determination of different agent in indoor environments,
To make information and knowledge available concerning investigation and mitigation measures in indoor environment,
To develop techniques and methods for investigation of both primary and secondary emissions of materials
To develop techniques and methods evaluations of materials use in indoor environment

Short term goals
Evaluation of different PCB remediation techniques and control of remedial effects,
Presence, contributions and effects in indoor air of small particulates containing polymer constituents,
Secondary emissions and chemical transformation of pollutants indoors particularly as a result of ozone (smog precursors) and effects on perceived air quality,
To develop techniques for studying and evaluation of relevance of short-lived and reactive chemical compounds in the indoor environment.

Recently completed and ongoing research
Chemistry and materials Technology presented two summaries report concerning “Indoor air quality” and “Chemical emission from building materials as bases for evaluation indoor air quality” to BFR for further publication in the Healthy Buildings project in January 2000. A short summary of the reports recognises that the development of chemical analytical and testing techniques concerning indoor environment and materials emission have developed very quickly during the last ten to fifteen years.

The research of indoor environments and the development of techniques for measuring chemical emission of building materials have revealed more problem buildings than earlier anticipated. New incentive to research on technique of measuring materials emission was received when the building products directive recognised the importance and need of health, hygiene and environment requirements on building products. For the evaluation of building products new knowledge in the areas of materials composition, testing techniques and emission measurement techniques, chamber development and analytical techniques was needed.

Different types of small-scale test chambers have been developed for testing the emission and adsorption/desorption of individual materials in relation to various chemicals. Large-scale test or
model chambers have been developed for the evaluation of effects of materials and products in full scale. The model chamber is usually based on the “Euro chamber” or smallest bedroom in an apartment, approximately 17 m³, published by SP in Berlin 1987. Different methods for transferring material emission measurements to model chamber situations have been developed.

Thanks to research grants from Swedish Building Research Council (BFR) and The Swedish Builders Research Fund (SBUF) a continued survey of literature and research, development and evaluation of emission of building materials was performed in a co-operation between SP and Skanska Teknik during the years of 1992 to 1996. The project “EMIBYGG, - Chemical emission from building materials” was a continued project of the research presented in the SP-report 1990:25 “Kemisk emission från byggnadsmaterial”. The results and findings from the research project were then reported in a number of reports in “SBUF- meddelanden”.

The project was terminated 1996 by a specific report ”Flooring materials laid on concrete with different degree of moisture- an overview and comments to investigations directed to degradation of chemicals and subsequent emission of chemicals” (in Swedish) as report BFR/SBUF/SP Rapport 96:25. The report summarises what has been published concerning concrete and moisture and its effects on degradation of chemicals in flooring materials. It also evaluates the results of a number of laboratory studies and draws conclusions based on the findings of the different projects performed. The report also comments the processes of degradation and gives hints on how to avoid future problems. It was recognised that a standardised procedure for performing the investigations was needed. Such a work was performed in another project intended to produce a Nordtest testing procedure ”Method intended for determination of degradation and emission of chemicals from flooring materials on concrete slab support” during 1996-1998.

The project “Chemical emission from admixtures to house building concrete” was terminated 1997 by a report to The Swedish Association for Concrete Admixtures and performed in co-operation with the project described above.

A subsequent project “Development of products towards low-emitting building products” aimed at a demonstration on how to evaluate the emission of a product, and demonstrate how to evaluate the constituents of the product and make a more appropriate selection of chemicals to achieve a low-emitting product. This project was performed in cooperation with the Swedish building product industry to demonstrate their ability to make adjustment to new requirements concerning health, hygiene and environment. This project continued in development of trade standards for testing different types of building products. Within the frame of the project three trade standards were developed for flooring materials, mastics and adhesive compounds and interior paint. A large number of products were tested in the process and a sub-task in the project became the database “METS – Materials Emission by Trade Standards” developed 1993 to 1997 containing data for materials emission from 1992 and forward. All these parts supported by Swedish Building Research Council (BFR), The Swedish Builders Research Fund (SBUF), Building material manufacturers association and Flooring Manufacturers association (GBR) have become internationally recognised and appreciated. The results and evaluations of data from the database have been presented at several international conferences.

**Indoor air quality**

Methods and techniques for the analysis and evaluation of the indoor air quality and the pollutants and their diurnal and dynamic interaction in the indoor environment and relevance to perceived air quality and human health. Within the framework of the Healthy Buildings project 1997 to 2003 and number of projects have been performed aiming at decreasing the lack of knowledge areas. A prevailing difficulty in the evaluation of the indoor environment has been the assessment of effects of different chemical compounds. After looking at a number of chemicals emitted from building materials and noticing the increased concern of not only product quality but also health and hygiene aspects of the indoor environment it was evident that a Nordic Workshop concerning “Assessment and
management of health effects caused by Indoor Air pollution” was needed and held in 1999. The summary of the workshop states:

"Indoor air related health and comfort effects depend on many factors in the indoor environment. Nordic researchers from disciplines such as Medicine, Toxicology, Biology, Chemistry, Building science and Building physics interested in indoor climate and indoor air quality discussed in September of 1999 risk assessment and risk management of health effects caused by indoor air pollution. Questions often asked by engineers and building researchers were collected and discussed by the participants in the workshop. Medical and toxicological researchers were asked to phrase their statements so that questionable exposures and assessed risks should be identified by risk managers and building owners. The workshop resulted in fourteen consensus statements concerning i.e. smoking, radon and materials handling etc. In addition twelve consensus recommendation to building engineers were reported and six areas for further research was presented. Summary of the report has been published in Swedish Building Research in No 1 2000. The findings and conclusions have been reported and presented in many workshops and conferences afterwards."

Below you will find short information of more recent and ongoing projects.

**The project title:**
The importance of air velocity and ventilation when determining chemical emission from building materials

*This report refers to BFR Research grant no 19970168*
*Size of the grant: 1375 KSEK Other Support: Salary 292KSEK Chalmers Lindholmen*
*Contract period: 1998-2000*
*The start of the project: December of 1997*

After the steady-state have been achieved in each chamber the results for all practical purpose are the same emission rates independent of chamber. It may thus be concluded that all chambers give the same results within the overall uncertainty used in these experiments.

The steady-state euquilibrum has to reached before true emission rates are obtained. The time to the steady-state conditions in the chamber depend on the chamber, ventilation rate and chemical substance. Guidance to when a steady-state has been reached in a specific chamber may be gained from the respective diagrams in chapter 4 of the thesis presented from this project.

The results obtained from emission measurements as presented in this study are relevant results for real life situations. This study has shown that the effects of sorption, changing the concentration and air velocity does not change the emission rates to any large extent. This means that if a presupposed proper calculation model is used the obtained results seem to give results in accordance with the real life situation that can be expected in a normal room or office as long as all the sink effects are considered and treated properly.

Finally, it should be concluded that the film thickness and the age of the paint surfaces are important factors to control when performing this type of experiments.

**The project title:**
Effects of Short-lived and Reactive Compounds on Indoor Air Quality

*This report refers to BFR Research grant no 20000035*
*Size of the grant: 50 KSEK*
*Contract period: 2000*
*The start of the project: January 2000*
This project sets out to identify, explain and assess health effects of short-lived and reactive compounds, SHARCs, in indoor environments. SHARCs, with lifetimes from minutes to hours, are formed from transformation of aliphatic hydrocarbons, olefins or aldehydes in reaction with ozone and/or nitrogen oxides. The reasons for focusing this work on SHARCs in indoor environments are the inherent chemical reactivity, strong potential for irritancy and sensory reaction of these compounds and their presence without being identified when using regular methods of sampling and analysis. Chemical species like SHARCs have since only a few years been considered as part of the explanation to indoor air quality problem in relation to asthma, allergy and other sensory effects. The air exchange rate and the age of the ventilation air of an apartment have been shown to be a crucial factor for the formation of SHARCs indoors.

Modelling of the formation of different SHARCs indoors support the presentation of a range of most probable SHARCs in the indoor environment. Subsequent climate chamber studies have presented the influence of air exchange rates on the formation of SHARCs. Investigations in three ordinary offices have verified the chamber results. Based on the results it will in the future be possible to estimate a range of the concentrations. We lack the knowledge of the concentration range in the normal housing stock to be able to estimate a range for the exposure of selected parts of the population. A future clinical study will focus on inflammatory and sensory responses in eyes and nose using the new techniques emerging from research these years.

The analytical techniques are being refined for the purpose of a more general study of the mechanisms governing the formation of SHARCs under indoor air conditions and establishing the toxicological aspects of SHARCs. The following questions will be reported in the project:
Which organic semi-stable and reactive peroxyacyl nitrates have the highest potential to be formed in an indoor environment and which are the most probable chemicals leading to the formation?
What is the range of concentration levels of such compounds in indoor air?

The project title:
Effects of small particles of pollutants mainly containing plastisizer on indoor environment and health

The aim of this project is to verify the indications published concerning the correlation between the amount of polymeric materials in the indoor environment and children’s health and also be able to describe the emission process of plastisizer from materials to the indoor environment and possibly quantify the processes governing the emission. It should be possible to formulate the results in such clear terms that it is possible to perform a full scale exposure study controlling the governing factors. This will further give tools for eliminating unwanted chemicals rather than banning certain types of materials. The field study in this project is running co-currently and is part of the Damp Building and Health, part 2, which is a large study of children’s health in Värmland, “Damp Buildings and Health”. The project has a large and well-stratified sample of children, their health status and the status of their home environments. Thus, the samples of dust from these homes become very valuable due to all the other information following the point of sampling. In the study the homes of the children from two distinct groups have been chosen; a study of 200 cases of symptomatic children’s homes and a control of 200 healthy referents’ homes. The status of children’s health is blind to the sampling person and the analysts. TOF-SIMS, HPLC and GCMS are the different analytical techniques applied to the extracts.
The primary target is focused on plastisizer, anti-oxidants, stabilisers and other polymer related chemicals. Sedimented dust from 400 homes have been sampled and analysed and in other ways characterised. The amount of plastisizer is estimated as a fraction of the total amount of sampled dust. The dust ranges from 0 500 mg and the range of plastisizer range from 1µg to 20 000 µg. The analytical result are during the fall of 2003 being correlated to the results of the medical studies of children and the results of the visit in the dwellings of the children, the inspections, measurements (ventilation, temperature, relative humidity) and other sample taken.

**The project title:**
*Effects of sorption and ozone on perceived air in the indoor environment*

*This report refers to FORMAS Research grant no 2001-0504*
*Size of the grant: 1000 KSEK, other support: 700 KSEK*
*Contract period: 2001-2003*
*The start of the project: August of 2001*

The objective is to clarify to what extent ozone and sorption processes on surface materials have an impact on the perceived air quality and the indoor exposure of VOC in real rooms during transient conditions as they occur during different ventilation strategies. The new knowledge will help to suggest a ventilation strategy and choice of building materials that ensure good IAQ. The project is a co-operation between Chalmers, SP, CIT Enerma and By og Byg, Danmark.

From the work performed and so far evaluated the following conclusions are drawn: For the relatively low-polluted offices of this study it is concluded that:

- Decreasing the air change rate from 1.0 to 0.3 h⁻¹ deteriorated the perceived air quality considerably. This was most pronounced in the presence of O₃.
- O₃ or the combination O₃/limonene did not affect the perceived air quality at the high air change rates of 3.0 and 1.0 h⁻¹.
- The deterioration of the perceived air quality by adding more polluting materials to offices at low air change rates was most pronounced in the presence of O₃ and O₃/limonene.
- The chemical measurements will be evaluated during the spring 2003. Primary results indicate that it is possible to explain the results in terms of occurring indoor air chemistry.

The results confirm the importance of maintaining sufficient ventilation even for low-polluting offices in order to ensure good perceived air quality.

**The project title:**
*A Direct-reading techniques for indicating degradation and chemical emission from building materials – Laboratory measurements and practical application of a sensor instrument*

*This report refers to FORMAS Research grant no 2001-0106*
*Size of the grant: 998 KSEK, SP support: 225 KSEK*
*Contract period: 1997-1999*
*The start of the project: May 1998*

A method based on sensors sensitive to gases has been used in the development of an instrument for indicating chemical compounds related to degradation present in room air. Modern sensor technique uses the fact that sensors can be made sensitive to different species. An array of sensors is set up and the signals from these sensors are treated by computer techniques to find resemblance and differences. Characteristic patterns are formed for each compound, material or sample.

The practical application has been to distinguish plastic flooring materials subjected to moisture damage from those that have not. The common denominator for the moisture damage of glues, sealants and flooring materials is degradation of specific chemicals and in the process form alcohols that contribute an unpleasant smell. The two most characteristic chemicals observed are 1-butanol och 2-etylhexanol.
In practical applications the instrument needs the FLEC equipment, pumps and humidifier, electronic and electricity units, computer and the sensor unit. The instrument is functional and very sensitive to even detect initial degradations but becomes bulky in field applications. In addition, the instrument needs a pattern program for each manufacturer material because it also recognises the different blends of plastic.

The project title:
Remedial actions of PCB-containing elastic sealants in indoor environment – Methods, techniques efficiency

This report refers to FORMAS Research grant no 2001-1957
Size of the grant: 490 KSEK, SP support: 200 KSEK
Contract period: 2002-2003
The start of the project: January 2001
And
The project:
Is the PCB level in the indoor air lowered by exchanging PCB containing elastic sealants?

This report refers to FORMAS Research grant no 2001-1977
Size of the grant: 100 KSEK, SP support: 30 KSEK
Contract period: 2002

The start of the project: February 2002

The aim of the project is to perform remedial actions in two different buildings having PCB containing sealants in the Indoor environment. An earlier investigation have demonstrated techniques and results from remedial action of external sealants. Due to the experience of the earlier project and indoor investigations we feel that remedial actions in the indoor environment needs much more care in planning and performance. We also believe that the methods and techniques need to be improved for a good result. The risk of earlier and actual contamination of the indoor environment has to be considered and also followed in time to evaluate the effectiveness of the mitigation process. In one experiment we intend to use filtering and recirculation of ventilation air at the work site in an attempt to decrease the exposure the person in the vicinity of the remedial action. Since the work is performed in separated step and will be well documented it is possible to draw general conclusions of the study.

3.12.2 C.V for researchers

The C.Vs for Prof Björn Lundgren, Prof Sarka Langer and Dr Lars Cedheim are shown in appendix INDOOR AIR QUALITY AND BUILDING MATERIALS EMISSION 1.

3.12.3 Doctoral students

<table>
<thead>
<tr>
<th>Name</th>
<th>Project</th>
<th>Examination</th>
<th>Financing</th>
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<tbody>
<tr>
<td>Alireza Afshari</td>
<td>The importance of air velocity and ventilation when determining chemical emission from building materials</td>
<td>1999 (dr)</td>
<td>BFR, Chalmers, SP</td>
</tr>
</tbody>
</table>
3.12.4 Financing

The financing of the research in the field of Indoor air quality and materials emission during the last three years are presented in the table below.

<table>
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<th>Financing partner</th>
<th>Amount (kkr) 2001</th>
<th>Amount (kkr) 2002</th>
<th>Amount (kkr) 2003 (expected)</th>
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3.12.5 International and national research projects

Chemistry and Materials technology and the program of Indoor air quality have an extensive cooperation with national and international universities. One person holds the position as Adjunct professor at Chalmers University of Technology, Building Services Technology and connect through that position interacts extensively with foreign universities. The institute’s cooperation occurs through research projects, cooperation concerning consensus articles and reports, guidance of graduate students, lectures and presentations. The immediate international contacts in cooperations are presented in 3.9.6.

**European projects**

<table>
<thead>
<tr>
<th>Project</th>
<th>Period</th>
<th>Partners</th>
<th>Contact at SP</th>
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</thead>
<tbody>
<tr>
<td>Indoor air quality and Its impact on man</td>
<td>1989 - 1999</td>
<td>One partner in each European country</td>
<td>Björn Lundgren</td>
</tr>
<tr>
<td>European Network for Indoor Environment, Exposure and Health</td>
<td>2003 - 2008</td>
<td>20 partners within Europe Union</td>
<td>Björn Lundgren</td>
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</table>

**National projects**

| Project                                                      | Period         | Financing                              | Partners               | Contact at SP          |
|--------------------------------------------------------------|----------------|----------------------------------------|------------------------|
| BFR 1997-0172, Direktvisande metodik för att indikera sönderdelning och kemisk emission från byggsomaterial | 97-99          | BFR 995 kkr  SP 250 kkr                | NSD Linköping          | Hans Gustafsson        |
| BFR 19970168, Emissioner, Luftströmnings betydelse vid bestämning av kemisk emission från byggnadsmaterial | 98-00          | BFR 1200 kkr  SP 237 kkr  CTH 55kkr    | CTH Installationsteknik | Björn Lundgren         |
| BFR 2000035, Kortlivade och reaktiva kemiska föreningar i inomhusluft | 00             | BFR 50 kkr  SP 50 kkr                  |                        | Björn Lundgren         |
| FORMAS 2001-0524, Det Sunda huset II- Kortlivade och kemiskt reaktiva komponenter i inomhusmiljö | 01-03          | FORMAS 1000 kkr  SP 250 kkr            | Göteborgs Universitet  | Björn Lundgren         |
| FORMAS 2001-0505, Det Sunda Huset II- Effekter av små och partikulära föroreningar med huvudsakligt innehåll | 01-03          | FORMAS 800 kkr  SP 200 kkr             | Aarhus Universitet     | Björn Lundgren         |
|                                                               |                |                                       | Karlstads Högskola     |                        |
|                                                               |                |                                       | Danmarks Tekniska      |                        |
|                                                               |                |                                       | Universitet m.fl       |                        |
3.12.6 International and national cooperation

<table>
<thead>
<tr>
<th>Activity</th>
<th>Contact at SP</th>
<th>Period</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Department of Energy and Process Engineering, Norwegian University of Science and Technology, Professor Sten Olaf Hanssen,</td>
<td>Björn Lundgren</td>
<td></td>
<td></td>
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<tr>
<td>Dept. of Environmental and Occupational Medicine University of Aarhus, Denmark, Lars Møelhave, Ph.D., Assoc. Prof.</td>
<td>Björn Lundgren</td>
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<tr>
<td>DTU, Int Centre of Indoor Environment &amp; Energy, Danish Technical University, Lyngby, Denmark, Prof Jan Sundell,</td>
<td>Björn Lundgren</td>
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<tr>
<td>BY og Byg, Statens Byggeforskningsinstitut, Hørsholm, Denmark, Henrik N. Knudsen, Alireza afshari,</td>
<td>Björn Lundgren</td>
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<tr>
<td>VTT, Chemical Technology, Environmental Technology, Finlands Tekniska Forskningscentral, Espoo, Kristina Saarela,</td>
<td>Björn Lundgren</td>
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<tr>
<td>Dept Experimental &amp; Clinical Pharmacology and Toxicology, University of Erlangen- Nürnberg, Erlangen, Prof. Gerd Kobal and Prof. Bertold Renner</td>
<td>Björn Lundgren</td>
<td></td>
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<tr>
<td>Arbeidstilsynet i Norge, Distrikt 3, Gjøvik, Norge Jan V Bakke,</td>
<td>Björn Lundgren</td>
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<tr>
<td>Institution</td>
<td>Author(s)</td>
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<td>----------------------------------------------------------------------------</td>
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<tr>
<td>TNO Building and construction research, Dept of Indoor Environment, Building Physics and systems, Holland, Philo M Bluyssen</td>
<td>Björn Lundgren</td>
<td></td>
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</tr>
<tr>
<td>UMDNJ/Rutgers University, NJ, USA, Prof. Charles J Weschler Bundesanstalt für Forschung und Materialprüfung, BAM, Berlin, Tyskland, Oliver Jann</td>
<td>Björn Lundgren</td>
<td></td>
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<tr>
<td>European Commission, Joint Research Centre, Environment Institute / Air Quality Unit, TP 272, Ispra (VA), Italy, Helmut Knöppel, Maurizio De Bortoli, Matti Jantunen,</td>
<td>Björn Lundgren</td>
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<tr>
<td>University of Kuopio, Kuopio, Finland, Prof. Pentti Kalliokoski</td>
<td>Björn Lundgren</td>
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<tr>
<td>INERIS, Parc Technologique ALATA, Verneuil-en-Halette, France, Roman Meininghaus</td>
<td>Björn Lundgren</td>
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<tr>
<td>C.S.T.B., Service Eaux, &amp; Air Environment, Marne-la-Vallee, France, Christian Cochet and Severine Kirchner</td>
<td>Björn Lundgren</td>
<td></td>
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</tbody>
</table>

### 3.12.7 Relevant publications 1993-2003

**Peer reviewed papers**


Other international scientific publications


23. NT Build 438, 1995: Building materials: Emission of volatile compounds - Field and Laboratory


Swedish reports


35. Jonsson, B, Lundgren, B, "Emission av formaldehyd i 17 m³ och 1 m³ kammare - svenskt deltagande i europeisk jämförelsestudie", SP AR 1994:47.


38. Gustafsson, H, Pyykkö, R, Lundgren, B, Direktvisande metodik för att påvisa kemisk sönderdelning och emission från bygghematerial - värdering av teknik och praktisk tillämpning av sensorer, Delrapport till BFRs program Det sunda huset 1, 1998-12-16.


42. Lundgren, B., Effekter av små och partikulära föroreningar med huvudsakligt innehåll av mjukgörare på hälsan i inomhusmiljön, delrapport och föredrag till FORMAS, Det sunda hetuset, 2002-03-07.

43. Lundgren, B., Effects of small particles of pollutants mainly containing plastisizer on indoor environment and health, delrapport och föredrag till FORMAS, Det sunda hetuset, 2002-03-07.

44. Lundgren, B., Sorptionseffekters och ozons inverkan på upplevd luftkvalitet, delrapport och föredrag till FORMAS, Det sunda hetuset, 2002-03-07

45. Lundgren, B., Effects of sorption and ozone on perceived air in the indoor environment, delrapport och föredrag till FORMAS, Det sunda hetuset, 2002-03-07.

46. Lundgren, B., Langer, S., Effekter av kortlivade och reaktiva föreningar på luftkvalitén i inomhusmiljön, delrapport och föredrag till FORMAS, Det sunda hetuset, 2002-03-07.

47. Lundgren, B., Langer, S., Effects of Short-lived and Reactive Compounds on Indoor Air Quality, delrapport och föredrag till FORMAS, Det sunda hetuset, 2002-03-07.


**Popular scientific publications**


57. Lundgren, Björn, "Exponering av målare för vattenburen färg", artikel i Provning och Forskning, nr 4, 1998

Appendix INDOOR AIR QUALITY AND BUILDING MATERIALS
EMISSION 1

CV Björn Lundgren

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Business address: SP Swedish National Testing and Research Institute
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Degrees
B. Sc. Mathematics, Chemistry and Physics, 1966 Uppsala University
M. Sc. Chemistry, 1967, Uppsala University
Ph. D. in chemistry Chemistry, 1973, Uppsala University on subject: Lundgren, Björn, Title of Thesis:

Adj Professor in Indoor Environment Technology at Chalmers University of Technology and Research Manager in Chemistry and Materials Technology at SP.

Research experience in physical and analytical chemistry and research experience from work environment, outdoor and indoor environment since more than 20 years within environmental analytical chemistry and since 1986 directly involved in development of analytical methods, emission testing procedures and evaluation of these results. Between 1989 and 1996 adviser to the Swedish Council for Building Research in chemistry, chemical emission matters and indoor air quality.

Recent Positions
Överingenjör, Head of Division, Chemical Analysis, at Statens provningsanstalt, Borås, 1 juli 1986.
Överingenjör, Head of Division Chemical Analysis, SP Swedish Testing and Research Institute, July 1993.
Research Manager, SP Swedish National Testing and Research Institute, Chemistry and Materials Technology, Borås, Sweden. 1998-01-01.
Adjungerad professor, Chalmers Tekniska Högskola 1999-10-01.

Publications:
26 in Peer Reviewed Journals, 35 conference contributions.
Assistant supervisor for 2 PhD students.

A list of publications is available on request.
CV Sarka Langer

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Family: Married to Vratislav Langer, two children (15 and 12 years)

Degrees
M. Sc. in Inorganic Chemistry, Charles University, Prague, Czech Republic, May 26, 1983.

Ph. D. in Environmental Sciences/Atmospheric Chemistry, University of Göteborg and Chalmers
Some Automotive Fuel Additives”.

Associate Professor (docent) in Inorganic Chemistry, November 2000.

Recent Positions
Researcher, SP Swedish National Testing and Research Institute, Chemistry and Materials Technology, Borås, Sweden, from October 1, 2001.

Assistant Professor/Researcher in atmospheric chemistry, University of Göteborg, financed by Swedish Natural Science Research Council (NFR), from July 1, 1997.

Researcher, SP Swedish National Testing and Research Institute, Chemistry and Materials Technology, Borås, Sweden, from November 18, 1996 through to June 30 1997.

Post-doctoral appointment, Department of Chemistry, University of California, Irvine, Irvine, CA 92697-2025, U.S.A., July 1, 1995 through June 30, 1996, with Professor Barbara Finlayson-Pitts.

Publications:
26 in Peer Reviewed Journals, 16 conference contributions.
Assistant supervisor for 2 PhD students.

A list of publications is available on request.
CV Lars Cedheim

Name: Lars Bertil Cedheim
Born: Kalmar Sweden, 1941
Address: Work: SP Swedish National Testing and Research Institute
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Citizenship: Swedish

Studied at the University of Lund, Sweden and received my B.Sc. in Chemistry and Mathematics at 1967. PhD studies at the Institute of Organic Chemistry at the University of Lund, Sweden 1976. The title of the thesis is “Studies on Anodic Additive Acetoxylation”.

Employed since 1977- as Research scientist at SP Swedish National Testing And Research Institute department of Chemistry and Materials Technology

| Previous appointments | 1. 1969-1975 Amanuens at the Institute of Organic Chemistry at The University of Lund
|                       | 2. 1976 Synthtic Organic Chemist at NFR at The University of Lund
| Military service      | 1963-64, FO-Staff Kalmar 13 months
| Publications          | I have published 7 papers as an author /co-author in scientific journals.
                       | During my time at (SP) I have published some internal and external reports in various fields.

| Main Research Interest | Material characterisation in general
|                        | Spectroscopy (FTIR, UV-VIS etc)
|                        | Mass spectrometry (TOF-SIMS, MALDI)
|                        | Chromatography (HPLC, GC-MS, TLC, LC)
|                        | Polymer degradation
|                        | Degradation pattern
|                        | Pyrolysis GCMS
|                        | PLS-techniques

A list of publications is available on request.
Editor Per-Erik Petersson

SP Swedish National Testing and Research Institute develops and transfers technology for improving competitiveness and quality in industry, and for safety, conservation of resources and good environment in society as a whole. With Sweden’s widest and most sophisticated range of equipment and expertise for technical investigation, measurement, testing and certification, we perform research and development in close liaison with universities, institutes of technology and international partners.

SP is a EU-notified body and accredited test laboratory. Our headquarters are in Borås, in the west part of Sweden.

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Report to the Formas scientific evaluation of Swedish building research
Dnr 10.9/2003 - 0174