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Electrical Accident Risks in Electrical Work

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Tampere 2010

To my wonderful grandmother,

HILKKA JOKINEN
(1924-2009)

who believed in education, and in me,

and who grew up during a time when
the possibility to study
was not a matter-of-course.

Abstract

Electrical accidents are proportionately severe and costly. Although electrical professionals' electrical safety is in Finland at a high level, the number of accidents reported to the authorities has no longer decreased during the past decade. Also, electrical accidents are not as rare as statistics imply as many minor accidents remain unreported. Underreporting causes lack of information about existing electrical safety problems, and hinders preventive actions.

Current measures to increase electrical safety are not effective enough. In order to decrease the number of electrical accidents, there is a need for more information about electrical accident risks at the operative level. According to accident investigation reports, most electrical accidents occur because certain safety procedures are not carried out prior to work. Still, there is little information as to the reasons why these safety procedures are omitted, and what other significant electrical accident risks electrical professionals currently face.

The main objective of the study was to promote electrical safety by identification and analysis of the main electrical accident risks of electrical professionals and by presenting an electrical accident sequence model as a basis for safety promotion. The study focuses on electrical professionals working in the fields of energy, industry and real estate installations. Only electrical accident risks are examined, not other risk types. In addition, the research concentrates on dead working and work that should have been performed dead. The particular electrical safety problems of live working and working in the vicinity of live parts are not examined.

During three years (2003-2006) of gathering material for this study, a questionnaire was submitted to electrical professionals (n=541), electrical professionals and their supervisors were interviewed (n=30), and certain electrical work tasks were examined (n=8). Relevant publications, accident reports and accident databases were studied as reference.

According to electrical professionals' experience failure to follow safety procedures is often due to hurry. Hurry is also seen as the biggest electrical safety risk. The causes of hurry are multifold but most often seen to be related to organizational problems, e.g. the planning and execution of tasks. Another electrical safety problem often identified was intentional and unintentional human failure.

The research reveals new information about electrical professionals' electrical accident risks. This information is used to create a model of the electrical accident sequence. The model can be utilized in the prevention of electrical accidents and promotion of electrical safety.

Keywords electrical work, electrical accident, electrical accident risk, accident cause, accident model, de-energize, test, earth, ground, hurry, human error, human failure

Tiivistelmä

Sähkötyöturvallisuus on Suomessa suhteellisen korkealla tasolla. Tästä huolimatta viranomaisille ilmoitettujen sähkötapaturmien lukumäärä ei ole laskenut viime vuosikymmenen aikana. Sähkötapaturmat eivät myöskään ole niin harvinaisia kuin tilastojen valossa voisi olettaa, sillä moni seurauksiltaan vähäisempi tapaturma jää ilmoittamatta. Kun kokonaiskuvaa olemassaolevista riskeistä ja niiden merkittävyydestä ei täten tunneta, myös tapaturmantorjuntatyö on vaikeampaa.

Nykyiset toimet sähkötyöturvallisuuden edistämiseksi eivät ole riittäviä. Sähkötapaturmien vähentämiseksi tarvitaan enemmän ja syvempää tietoa niistä riskeistä, joita sähköalan ammattilaiset työssään kohtaavat. Tapaturmatutkimusraporttien mukaan suurin osa sähkötyötapaturmista johtuu siitä, että tiettyjä turvallista sähkötyötä varmistavia toimenpiteitä ei ole tehty ennen työn aloittamista. On kuitenkin olemassa vain hyvin vähän tietoa siitä, miksi varmistavat työt jäävät tekemättä. Lisäksi ei ole olemassa kokonaiskuvaa siitä, mitä muita riskejä sähköalan ammattilaiset työssään kohtaavat.

Tutkimuksen päätavoite oli edistää sähkötyöturvallisuutta tunnistamalla ja analysoimalla sähköalan ammattilaisten merkittävimmät sähkötyöturvallisuusriskit, sekä luomalla tapaturmamalli, jossa tutkimuksen tuloksiin pohjautuen esitetään tyypillisimmät sähkötapaturmien taustalla vaikuttavat tekijät. Tutkimus keskittyy sähköalan ammattilaisiin, jotka työskentelevät energia-alalla, teollisuudessa ja kiinteistöasennukset/talotekniikka-alalla. Tapaturmatyypeistä tutkimuksessa käsitellään ainoastaan sähkötapaturmia. Tutkimuksessa keskitytään sähkötyöhön, joka tehdään jännitteettömässä kohteessa tai kohteessa, jonka olisi pitänyt olla jännitteetön. Täten ne erityispiirteet, jotka kuuluvat jännitetyöhön sekä työskentelyyn jännitteisten osien läheisyydessä on rajattu tutkimuksen ulkopuolelle.

Tutkimusaineisto koottiin vuosina 2003-2006. Tänä aikana sähköalan ammattilaisille tehtiin kysely (n=541), minkä lisäksi haastateltiin sähköalan ammattilaisia ja heidän esimiehiään (n=30) sekä perehdyttiin valittuihin yksittäisiin sähkötyötehtäviin (n=8).

Kirjallisuuskatsaus sekä relevanttien tapaturmatutkimusraporttien ja tapaturmatieto-kantojen läpikäynti täydensivät empiirisiä tuloksia.

Sähköalan ammattilaisten mukaan turvallisuutta varmistavien toimenpiteiden laiminlyönti johtuu usein kiireestä. Kiireen syyt ovat monitahoiset, mutta usein kiireen katsottiin johtuvan organisatorisista ongelmista, jotka liittyivät esimerkiksi työn suunnitteluun ja toteutukseen. Kiirettä pidettiin myös suurimpana sähkötyöturvallisuusriskinä. Kiireen lisäksi varmistavien toimenpiteiden tekemättä jättämisen katsottiin johtuvan mm. erinäisistä tahallisista ja tahattomista inhimillisistä tekijöistä.

Tutkimuksen tulokset nostivat esiin uutta tietoa sähköalan ammattilaisten sähkötyöturvallisuusriskeistä. Tutkimustuloksia sekä tulosten pohjalta koottua sähkötapaturmamallia voidaan jatkossa hyödyntää sähkötyöturvallisuuden kehittämistyössä: Tulokset tarjoavat konkreettista tietoa esimerkiksi kiireen syistä ja antavat samalla pohjan yritys-, liitto- ja viranomaistason keskusteluille toimenpiteistä niiden poistamiseksi. Onnettomuustutkinnassa mallia voidaan hyödyntää kohdistamaan tutkintaa välittömien sähkötapaturmaan johtaneiden syiden taustalla vaikuttaviin tekijöihin.

Avainsanat sähkötyö, sähkötapaturma, sähkötapaturmariski, tapaturmatekijä, tapaturmamalli, erottaminen, jännitteettömyyden toteaminen, työmaadoittaminen, inhimillinen virhe

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Lempäälä, October 2010,
Tuuli Tulonen

Contents

Key definitions

General definitions

Accident	"A result of a chain of events in which something has gone wrong, resulting in an undesired conclusion" (Jorgensen 1998, p. 56.3). See also *occupational accident* and *electrical accident*.
Cause (of accident)	Causes of occurred accidents are identified during accident investigations. The identified causes are treated as accident risks in the prevention of further similar accidents. See also *risk*.
FAII	Federation of Accident Insurance Institutions. (http://www.tvl.fi/www/page/tvl_www_1809).
Hazard	"Potential source of harm" (SFS-EN ISO 12100-1:2003, p.15).
Hazard identification	"Process of recognizing that a hazard exists and defining its characteristics" (SFS-IEC 60300-3-9:2000, p.9). A part of risk analysis (SFS-IEC 60300-3-9:2000, p.29).

Human error	A sequence of actions or decisions, leading to unintended consequences (modified from Reason 1990, p.9). The primary error types are slip, lapse and mistake, and they occur on the execution, storage and planning stages of human cognitive performance, respectively. Human errors may also be categorized in other ways, e.g. according to behavior: omissions, commissions, repetitions, etc. (Reason 1990)
Human failure	Human failure may be either an error or a violation. Failures may be active or latent, with immediate or delayed consequences, respectively. (Reducing error and… 2000) The term avoids blame, unlike u*nsafe act*, which may be used in the same context.
Immediate cause	The action which immediately precedes a particular outcome.
n	Number (of e.g. respondents or cases)
Occupational accident	A sudden and involuntary occurrence that is work-related and results in injury. (combined from 608/1948, 4§, amendment 526/1981 and Työsuojelun peruskurssi 1995)
p (p-value)	Indicates how great is the risk that the difference between the compared groups is purely coincidental. For example, p=0.001 means that there is a 0.1% chance that the presented difference between the compared groups is coincidental. In this publication the significance levels with $p \leq 0.05$ are defined as statistically significant in all statistical tests.

Primary cause	Synonym for *immediate cause*.
Risk	“Combination of the probability of occurrence of harm and the severity of that harm” (SFS-EN ISO 12100-1:2003, p.15). A factor that may cause or contribute to an accident. See *electrical risk*.
Risk analysis	“Systematic use of available information to identify hazards and to estimate the risk to individuals or populations, property or the environment” (SFS-IEC 60300-3-9:2000, p.9). Part of risk assessment (SFS-IEC 60300-3-9:2000, p.29).
Risk assessment	“Overall process of risk analysis and risk evaluation” (SFS-IEC 60300-3-9:2000, p.9). Part of risk management (SFS-IEC 60300-3-9:2000, p.29).
Risk management	“Systematic application of management policies, procedures and practices to the tasks of analyzing, evaluating and controlling risk” (SFS-IEC 60300-3-9:2000, p.11).
Safety	”Safety is a state in which hazards and conditions leading to physical, psychological or material harm are controlled in order to preserve the health and well-being of individuals and the community” (Maurice et al. 1998, p. 1). Safety is both subjective and objective as it deals with both perceptions of being safe and the status of the surrounding conditions (Maurice et al. 1998).

Sector / Field (of employment)	Society’s activities may be divided into three main fields: primary production, processing and services. The processing field is divided into three subfields: manufacturing, construction and electric, gas and water maintenance. (Toimialaluokitus 1995:1993) Within these three subfields are the three main electrical work - related fields of employment, where there is a continuous threat of occupational electric accident. In accordance with the line of division used by the Finnish Electrical Workers’ Union, these fields are named in this publication “industry”, “real estate installations and building services engineering” (abbreviated in this publication to "real estate installations") and “energy”. A more detailed description of the fields, as used in the questionnaire survey part of the research, is presented in chapter 5.2.1. In the latter parts of the project the field was defined intuitively in cooperation with the participants.
Tukes	(The Finnish) Safety Technology Authority. (http://www.tukes.fi/en).
Underlying cause	Accident causes, which temporally precede *immediate causes*.
Unsafe act	An unsafe act may be either intentional or unintentional (Reason 1990). The term may be used in the same context as *human failure*.
Violation	Deliberate deviation from a defined precept (Reason 1990). Violations may be situational, exceptional or routine (Lawton 1998).

Electrical work -related definitions

Dead working	"Work activity on electrical installations which are neither live nor charged, carried out after having taken all measures to prevent electrical danger." (SFS 6002:en 2005, p.21)
De-energize	To disconnect/isolate the electrical installation completely from all sources of energy supply. The method of isolation should be an air gap or equal. (SFS 6002:en 2005, modified from pp.37-39)
(To) earth (for work)	All high and some low voltage installations must be earthed and short-circuited prior to work - with suitable equipment and preferably from a point visible to the work location. This is done in order to ensure the safety of workers by preventing the possibility of the electrical installation becoming unexpectedly live during work. (SFS 6002:en 2005, modified from p.41)
Electrical accident	*Electrical incident* that results in injury.
Electrical hazard	"A source of possible injury or damage to health in presence of electrical energy from an electrical installation" (SFS 6002:en 2005, p.15). Electrical hazards include shock, arc flash/blast, fire, converted energy (from electrical energy to e.g. light or heat) and electrochemical hazards (Floyd et al. 2003).

Electrical incident	"An electrical incident is an event resulting from either personnel action or equipment failure involving electrical installations that has the potential to result in an injury due to 1) Electrical flash and/or burn, 2) Electric shock from a source greater than 50 V, or 3) Reflex action to an electric shock." (Capelli-Schellpfeffer et al. 2000, p. 17)
Electrical installation	"Includes all the electrical equipment which provides for the generation, transmission, conversion, distribution and use of electrical energy. It includes energy sources such as batteries, capacitors and all other sources of stored electrical energy." (SFS 6002:en 2005, p. 15) Here, the target of the electrical work.
Electrical professional	see *Skilled person*
Electrical risk (factors)	Factors that have caused or have the potential to cause *electrical accidents*. In this publication electrical risk is used as a synonym to *electrical hazard*; to emphasize that the hazard exists and the magnitude of the risk is estimated to be significant.
Electrical work	"Work on, with or near an electrical installation such as testing and measurement, repairing, replacing, modifying, extending, erecting, maintaining and inspecting" (SFS 6002:en 2005, p.19).
Electricity	One of nature's phenomena. In itself undetectable by human senses other than touch (see *electrical incident*). Used almost ubiquitously as a source of energy, conveyed with overhead power lines and underground cables.

(To) ground	see *earth*
Injury (electrical)	"Death or personal injury from electric shock, electric burn, arcing, or from fire or explosion initiated by electrical energy caused by any operation of an electrical installation" (SFS 6002:en 2005, p.15).
Layman	see *Ordinary person*
Live working	"All work in which a worker deliberately makes contact with live parts or reaches into the live working zone with either parts of his or her body or with tools, equipment or devices being handled" (SFS 6002:en 2005, p.19, originally modified from IEV 651-01-01).
Ordinary person	Person who is neither a skilled person nor an instructed person. (SFS 6002:en 2005, p.17, originally from IEV 826-09-03).
Skilled person	"Person with relevant education, knowledge and experience to enable him or her to analyse risks and to avoid hazards which electricity could create" (SFS 6002:en 2005, p.17, originally modified from IEV 195/4/1).
Working in the vicinity of live parts	"All work activity in which a worker with part of his or her body, with a tool or with any other object enters into the vicinity zone without encroaching into the live working zone" (SFS 6002:en 2005, p.21).

1 Introduction

All over the world electricity poses a constant hazard to those performing electrical work. In fact almost everyone working in the field has experienced or witnessed an electrical shock during their working life (Tkachenko et al. 1999). In Finland the situation may be verified by asking any electrical professional about his or her personal experiences. Still, only a small percentage of the incidents are reported: Finland has a labor force of 2.6 million, of whom 17 thousand are electrical professionals working with dangerous voltages (Työssäkäynti 2007), but only about 50 cases of electrical professionals' electrical accidents are documented yearly by the accident insurance institutions (Hintikka 2007), and only about 20-30 cases are reported to the electrical safety authority (Mattila 2009). In addition to being more common than statistics imply, electrical accidents have been estimated to be exceptionally severe (Cawley & Homce 2003) and costly (Wyzga & Lindroos 1999).

Underreporting is a problem, but on a global scale Finland seems to have a very high electrical professionals' occupational electrical safety level. Legislation dictates clearly how much education and experience a person must have before called an electrical professional and allowed to perform electrical work independently. Legislation and obligatory standards also define safety procedures which must be carried out prior and during work. Still, during the past decade there has been on average over 4 professionals' electrical accidents with severe consequences every year (table 1). Despite continuous efforts to improve electrical safety, the number of electrical accidents has not decreased.

Analyses of accident reports have revealed electrical professionals' electrical accidents to be most often due to omission of certain safe working procedures (Heinsalmi & Mattila 2008, Mattila 2009, TUKES tutki sähkötapaturmat 2002). Still, there is little knowledge as to why safety procedures are omitted. Accident investigation does not normally go far beyond the immediate (or apparent) causes despite the fact that the identification and elimination of underlying accident causes is a key element in the prevention of further accidents.

Finnish workplaces have widely adopted the zero accident –vision, according to which all accidents are both unacceptable and preventable (Finnish Zero Accident... 2009). Based on the vision, and the fact that despite efforts electrical safety has no longer improved, there is a need for new information on how to further increase electrical safety. The prevention of electrical professionals' occupational electrical accidents starts with the identification and analysis of the underlying causes of electrical accidents and incidents that could have lead to an accident. The identification and analysis of accident risks will enable to focus future prevention efforts with more precision and effectiveness.

The initiative to do the research came from the Safety Technology Authority (Tukes) who wanted more information on the causes of electrical professionals' electrical accidents, to be used in its efforts to promote electrical safety. A single line of investigation – concentrating on electrical professionals and electrical risks alone – creates the possibility to investigate more thoroughly into the specific problem at hand. Even the immediate causes of professionals' and laymen's accidents differ: Laymen are often not aware of the potential health threat even normal household electricity poses. Professionals' electrical accidents occur despite awareness of the danger. In addition, professionals' accidents seem to occur basically only during working hours, as laymen suffer electrical accidents both at work and during leisure. Professionals' actions are thus guided by legislation and other occupational regulations, which increases the possibility to influence.

Accidents are rarely caused by one single event or action. Instead they are the consequence of a multitude of events that may have occurred during a long period of time. Still, the acts and thoughts of the person whose actions immediately preceded the accident should be of great interest for that person is the culmination point of the chain of events and the last person who could have prevented the accident if all the facts had been known. The explicit target of this research, electrical professionals' electrical accidents, offers the possibility to study human behaviour at the sharp end of the accident sequence in a specific well-defined context.

2 Occupational electrical safety

2.1 Initial review of electrical safety

2.1.1 Standards and legislation

An electrical professional is defined in Finnish legislation (516/1996, §11, amendment 28/2003) as a person who has a specific educational background and adequate experience. An electrical professional may have electrical education ranging from degree of master, bachelor or technician to vocational or sufficient knowledge. The demanded amount of experience in electrical work depends inversely on the level of education. The exact number of electrical professionals in Finland is not known, but according to Statistics Finland, in 2007 there were 17 126 electricians working in installation and maintenance of electrical equipment and electric power lines (Työssäkäynti 2007, categories 7241 and 7245).

The main Finnish standard concerning occupational electrical safety of electrical professionals is SFS 6002 (2005) “Safety at electrical work”, which replaced the older standard SFS 6002 (1999) in June 2005. The standard includes a Finnish translation of the standard EN 50110-1 (2004) “Operation of electrical installations” and Finnish additions consistent with the standard EN 50110-2 (1996). Among other things the standard SFS 6002 (2005) gives detailed guidance about the safety procedures mandatory to ensure safe electrical work in a dead work location:

1. Disconnect completely
2. Secure against re-connection
3. Verify that the installation is dead
4. Carry out earthing and short-circuiting
5. Provide protection against adjacent live parts

These procedures are also mentioned in the Decree of the Finnish Ministry of Trade and Industry 516/1996 (29f§, amendment 1194/1999) concerning electrical work, which is based on the Finnish electrical safety act 410/1996.

According to the standard SFS 6002 (2005) all electrical professionals must receive electrical safety training in intervals of no more than five years. Training should be given more often if there are relevant changes in e.g. work assignments. The training must go over the most relevant electrical safety -related legislation and the content of the standard SFS 6002 (2005). The training must also include information about electrical safety hazards, electrical accidents, and the possible specific participants' work –related electrical safety requirements. (SFS 6002:2005)

In Finland, fatal and serious occupational accidents must be reported to the occupational safety authorities (44/2006, 46§) and the police (608/1948, 39§, amendment 723/2002). Occupational accidents must be reported to accident insurance companies (608/1948, 39§, amendment 723/2002) as a prerequisite for insurance compensation. Serious electrical accidents must additionally be reported by the police, rescue services, occupational safety authorities, and the local electrical network operator to the supervising authority of the electrical field (410/1996, 52a§, amendment 220/2004), the Safety Technology Authority (410/1996, 4§, amendment 220/2004).

2.1.2 Electrical accident statistics

Most occupational electrical accidents occur to electrical professionals. Occupational electrical accident statistics are compiled by the Safety Technology Authority (Tukes) but they may also be drawn out from the database of the Federation of Accident Insurance Institutions. Table 1 presents the number of electrical professionals' electrical injuries and fatal electrocutions reported to Tukes during the past years. It should be noted though, that reporting to Tukes is voluntary to most, and that there is evidence of underreporting of especially minor electrical accidents (Hintikka 2007).

Table 1. Electrical professionals' electrical accidents in Finland during the past years. Number of accidents reported to Tukes. Source: Mattila 2009, Rusanen 2005

Outcome	**96**	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**
Death	0	1	0	0	0	0	0	1	2	0	1	0	0
Serious injury	1	3	4	2	2	3	7	1	7	6	2	5	2
Other (≤ 30 days) or unknown	16	15	22	13	22	15	17	21	13	12	16	20	28
Altogether	17	19	26	15	24	18	24	23	22	18	19	25	30

The Federation of Accident Insurance Institutions (FAII) maintains statistics of all compensated occupational accidents and diseases. According to FAII statistics, electrical professionals encountered 52 electrical accidents in 2003 and 46 in 2004. When comparing the electrical accident databases of FAII and Tukes, it has been concluded that FAII has more information concerning the number of occurred occupational electrical accidents, especially minor accidents. On the other hand, the Tukes database has better descriptions of the cases. (Hintikka 2007)

The problem of underreporting is international and beyond electrical accidents (Arbejdstilsynet 2004, Capelli-Schellpfeffer et al. 2000, Goffeng et al. 2003, Marais et al. 2006, Probst & Estrada 2010, Weddle 1996). Concerning electrical professionals and electrical accidents, in a survey carried out by Tkachenko et al. (1999), 97% of respondents admitted to receiving or witnessing (26%) an electrical shock during their working life. Still, according to the results of the survey, only clear bodily harm, loss of consciousness and heart attacks were seen by the respondents as consequences which require medical treatment. In addition, the results indicated that electrical professionals strongly feel electrical accidents are their own fault and caused by incompetence (Tkachenko et al. 1999), which may contribute to reluctance to report.

2.1.3 Electrical accident causes

In Finland

According to Tukes' analyses of reported electrical accidents that occurred during the years 2002-2008, 68-88% of electrical professionals' electrical accidents are due to erroneous action or human error. Most often the immediate causes of the accident are that the work location is not de-energized prior to work, voltage is not tested, earthing is omitted, or live parts are not adequately separated from the work area. (Heinsalmi & Mattila 2007, 2008, Mattila 2009, Mattila & Rusanen 2006, Rusanen 2004, 2005, Rusanen & Laanti 2003) In a previous investigation of all reported electrical professionals' electrical accidents, which occurred during 1997-2001, Tukes concluded that they are often due to omission of voltage testing, inadequate separation of energized parts from work area, or working live but not in compliance with live work regulations. The last is due to belief that it speeds up completion time. It was also noted in the investigation that electrical professionals try to avoid blackouts, which leads to hazardous working methods and conscious risk-taking. Sudden changes in the work area also constitute a risk when they necessitate a modification on how to safely complete the assignment. (TUKES tutki sähkötapaturmat 2002)

Five electrical professionals died in electrical accidents in Finland during the last decade. The accidents were investigated by the FAII and Tukes. FAII investigates almost all occupational fatalities with the aim of preventing further such accidents by disseminating information of the accident causes to other organizations with similar risks (TOT-tutkinnan esittely 2005). As the authority in charge of electrical safety in Finland, Tukes investigates electrical accidents when an investigation is necessary in order to identify the causes of the accident, or when an investigation might reveal information that may be used in the prevention of further accidents (410/1996, 52a§, amendment 220/2004).

The first of the five fatal electrical accidents occurred in 2003 when an electrical professional died in the installation of a new 20kV electric power line. The line was to cross with an old 400V line. Without his partner's knowledge, the electrical professional had climbed up the pole of the old line before it was de-energized, and got caught in the lowest two wires. He ultimately fell down seven meters. The victim had probably tried to speed up work by making preliminary preparations as far as possible before de-energizing the line – and in the process forgotten that the line was still energized. The unsafe behavior of going too near energized parts was identified as a primary cause in the resulting inquiries (TOT 6/03, VARO 3682). In addition, work partners being informed of each other's doings was mentioned (TOT 6/03, VARO 3682) as well as acknowledging the hazards present (TOT 6/03), and lack of supervision concerning safe behavior (VARO 3682).

The second and third fatal electrical accidents occurred in 2004. In the second electrocution case two electrical professionals were fixing faults caused by a storm. A tree had fallen over a line that led to a summer cottage, ripping off some of the wires. It was assumed that one of the wires may be live, but the workers did not necessarily realize the voltage could be at a fatal level. (VARO 4094) The accident was seen to have been caused by insufficient information concerning the work site, insufficient planning of how to perform the work safely, unsafe behavior, and inadequate supervision of safe working procedures (TOT 15/04, VARO 4094).

The third fatal electrical accident occurred during power plant maintenance. A 6kV electrical installation had been de-energized, and two electrical professionals had been given certain maintenance tasks. At the end of the workday some of the work was still undone, but when all other tasks were finished later that evening, it was assumed that their work was also finished, and the installation was re-energized. The accident occurred the next day as the workers continued their unfinished assignment. (TOT 19/04, VARO 4115). The accident causes were later identified in the FAII investigation to be problems in information flow, inadequate documentation of finished tasks, the change in electrical status remaining unnoticed by the workers, and omission of voltage testing prior to continuing work. The way work should be organized is also discussed in the investigation report. (TOT 19/04) The Tukes investigation report named the primary cause of the accident to be that the person in control of electrical safety during work had not been named, nor was the person responsible for the naming physically present at the work site to take care of controlling. Other possible causes named in the report concerned organization and supervision of work, re-energizing without making sure that all work was finished and that everyone becomes aware of the changed electrical status, and the fact that all the workers were not previously acquainted to each other which may have caused less discussion of system status. (VARO 4115)

The fourth fatal electrical accident occurred in 2006 as an electrical professional was electrocuted and fell down from a pole when due to out-dated documentation the wrong 25kV wire was de-energized, tested and earthed. Alterations that had been made at the site a year earlier by another organization had not yet been updated in the diagrams though the responsibility of updating had also been assigned. The accuracy of the diagrams was not confirmed on-site, the success of the de-energizing was tested too far from the work site, and safety harnesses were not used. (TOT 13/06, VARO 4909)

The fifth fatal electrical accident occurred in 2009 as an electrical professional was electrocuted when a load-disconnector malfunctioned, and the work task was begun without testing the success of the de-energizing, nor earthing the installation (Hatakka & Johansson 2009). In summary, all of the five electrical professionals’ fatal electrical accidents that have occurred in Finland during the past decade were at least partly due to the fact that de-energizing, testing and/or earthing was omitted. It should also be noted that four of the five fatalities occurred outdoors and in electric pole -related work.

The Finnish Institute of Occupational Health interviewed victims, witnesses and safety personnel in relation to 25 electric arc accidents that had occurred in electric work during 1996-1999. The interviews concentrated on protective clothing but accident causes were also discussed: accidents happen when work is done live but not in compliance with live work regulations, or because of faulty devices or wiring, inadequate information about the structure of the electrical site, a tool accidentally touching or falling into an energized part, work becoming routine or a disturbance causing attention failure. (Mustonen & Mäkinen 2001)

Other identified problems include the results of an investigation by the Finnish Electrical Workers’ Union, according to which the biggest problems in electrical work are organizational problems. These problems are related to time pressure and the unclear division of responsibilities between workers and their supervisor (Saloniemi 2004). Also, Honkapuro et al. (2006) have evaluated the current status of electrical network safety and reliability from the viewpoint of the current trend of increasing contracting. They conclude that the biggest improvement needs focus on the clear division of responsibilities and planning ahead for large-scale power disturbance situations.

Internationally

In Sweden the immediate accident causes of electrical accidents are similar to Finland: Almost all electrical professionals' electrical accidents are due to failure to comply with regulations, and half of them due to omission of voltage testing prior to work (Ett informationsprojekt riktat... 2000). In Norway it has been identified that the risk of electrical accidents is increased by problems in e.g. organization of work, use of personal protective equipment, by over-estimating own abilities, and with repeated tasks becoming automatic actions. In addition, distractions and simultaneous assignments increase accident risks, as do workers' possible personal life crisis and stress. (Goffeng & Veierstad 2001)

In the United States, 152 hazardous energy -related fatalities were documented in the FACE program during 1982-1997. From these cases, 82% were due to failure to remove the hazardous energy, 11% due to failure to prevent re-energizing, and 7% due to failure to verify the de-energizing. (Preventing Worker Deaths… 1999) According to analysis of U.S. statistics from 1992-2002, two electricity-related occupations, namely "electricians and apprentices" and "electrical power installers and repairers", are among the top three professions that encounter fatal occupational electrocutions, accounting for 24% of fatal electrocutions (Cawley & Homce 2008). In the United Kingdom, an analysis of 174 electrical accidents revealed that 68% were due to inadequate working practices, and 19% due to insufficient equipment maintenance (Stephenson 1993).

An electrical safety state-of-the-art publication by IEEE fellows and senior members (Floyd et al. 2003) refers to a common denominator that has been found in electrical accident investigations: "presumably knowledgeable competent personnel making decisions or taking actions that unintentionally move themselves outside the boundary of the isolated and de-energized safe working zone" (p.137). Floyd et al. (2003) present two examples of situations where nearby adjacent energy is the cause of electrical accidents: working very near the adjacent energy and working with side-by-side situated energized/de-energized appliances, which may cause confusion. Communication and stressing the importance of voltage testing ("every circuit, every conductor, every time before touching", p.137) in the job planning phases may be effective countermeasures. Floyd et al. (2003) also feel that safe working methods are best induced through education.

A recent study by Kowalski-Trakofler & Barrett (2007) investigated electric arc accidents. The study consisted of an analysis of 552 accident reports of electric arc flash accidents that had occurred in the mining industry and 32 interviews with accident victims/witnesses. Most of the persons involved in the accidents were electricians. The analysis of accident reports concluded that in 55% of the cases the worker had both recognized the hazard and made a conscious decision to act in a way that ultimately led to the accident. According to the results of the interviews, electric arc flash accidents occur mainly because of hurry (including production pressure and customer demand), inadequate training (including laymen), working live (including failing to lockout/tagout), and complacency, lack of attention and carelessness. Employer organization's safety culture did not seem to affect worker behaviour. According to the authors, the most important result of the study is the understanding of the impact of individual decision-making in the occurrence of electric arc flash accidents. (Kowalski-Trakofler & Barrett 2007)

In Australia, Williamson & Feyer (1998) compared fatal electrocutions to fatalities in electrical and related trades and all fatalities as an extended study of the Australian Work-Related Fatalities Study. A third of the electrocutions occurred to those in electrical occupations, but the study did not analyze them separately. According to the study, human errors and unsafe work practices are most often the main cause of fatal electrocution, the errors being more often omissions than commissions and the unsafe work practices dealing often with poor upkeep of equipment. Unsafe work practices were also the most common cause in non-electrical fatalities, but with management as the most common cause. (Williamson & Feyer 1998)

In Taiwan, Chi et al. (2009) have developed a coding system for the analysis of fatal occupational electrocutions. Analysis of 255 fatalities that had occurred in the construction industry during 1996-2002 revealed that 38% of the fatalities had occurred while performing electrical work, mainly while installing, moving, or repairing power lines or poles. The analysis of accident causes does not completely separate electrical professionals and laymen, but the examples within the results give strong indication that the causes of electrical professionals' electrical accidents are often related to failure to de-energize, test, and earth properly. (Chi et al. 2009)

Other national and international studies concerning the causes of occupational electrical accidents of electrical professionals are scarce. Although occupational electrical accidents have been studied, the studies usually concentrate on general accident demographics, not the causes for the accidents to have occurred (e.g. review by Batra & Ioannides 2001, Casini 1993, Cawley & Homce 2003, 2008, Janicak 2008, Williamson & Garg 2004, Worker Deaths by… 1998) In addition, the studies are seldom limited to electrical professionals *and* electrical accidents, but include other professions or other types of accidents.

2.2 Accident causation

Accidents are still generally blamed on the worker, often also the victim of the accident. Because the worker is often thought to be the cause of the accident, corrective actions focus on the worker's behavior instead of the people who put the worker at risk. (Groeneweg 1992) Although the final unsafe act is made by the worker that does not mean this was the sole reason the accident occurred. It is nowadays widely acknowledged that accidents are due to a multitude of human failure made by many people during a long period of time. The accident process is commonly illustrated with the Swiss Cheese Model (Reason 1997).

Reason (1997) divides accident causes into active failures which are made immediately before the accident occurs, and latent conditions which may have existed dormant for some time. According to Wagenaar et al. (1994) there are 11 types of latent conditions: hardware, design, maintenance management, operating procedures, error-enforcing conditions, housekeeping, incompatible goals, communication, organization, training, and defence planning.

More than half a century ago, Heinrich (1959) stated that the identification of accidents' underlying causes ("subcauses") is an important part of accident prevention. He divided the immediate causes of preventable accidents (98% of all accidents) into unsafe acts (88%) and mechanical or physical hazards (10%). As mechanical and physical hazards are also due to some kind of human input, he argued that all underlying causes behind immediate causes are related to “faults of persons” (Heinrich 1959, p.80). According to Heinrich (1959), the underlying causes of unsafe acts can be grouped under the headings of improper attitude, lack of knowledge or skill, physical unsuitability and improper mechanical or physical environment. Besides industrial hygiene and ergonomics -related elements, Heinrich included under the environment-heading those elements, which today are grouped under organizational factors, e.g. company policy, procedures and safety rules.

Theories of accident causation are used to identify accident causes, with the final purpose of preventing accidents by eliminating their causes (Raouf 1998). From these theories, probably the most cited is the domino theory, or model, introduced by Heinrich (1959, first published in 1931). According to Heinrich, the accident sequence may be illustrated with five domino-blocks, placed side by side, knocking down the next one as they fall. In time order, the dominos are entitled 1) ancestry and social environment, 2) fault of person, 3) unsafe act / mechanical or physical hazard, 4) accident, and 5) injury. When any one of the dominos is removed, preferably the third one, the accident sequence will break and injury will be avoided. (Heinrich 1959) The multiple causation theory disputes the above, emphasizing that accidents have many causes, and are fundamentally due to organizational problems (Petersen 1982). The energy transfer theory adds to the previous by stating that an accident is due to uncontrolled transfer of energy and accidents are prevented with measures focusing on the energy source, path and receiver (Raouf 1998).

The human factors theories investigate the human element as both the immediate and the underlying cause of accidents. Petersen’s (1982) accident/incident model or human error causation model describes how accidents and incidents are caused by system failure and human error, system failure including many elements of safety management, like policy, authority and training. The systems theory (Leplat 1984) assigns accidents to socio-technical system error.

Some of the less useful theories, from the point of view of accident risk analysis and accident prevention, include the pure chance theory, which treats all accidents as unpreventable, and behavioral theories like the accident proneness theory, claiming some (a few) workers are more likely to have an accident than others (see also Blasco et al. 2003 on accident intervals), and the biased liability theory, which depicts that after experiencing an accident a worker is more likely or less likely to have an accident than his co-workers (Raouf 1998).

There are also other theories of kind. Despite the difference in the theories, there seems to be an understanding that accidents have multiple causes and are mainly originated from human failure, caused by e.g. a worker, manager and designer. Often the causes of accidents are divided into organizational, human, and physical/technical. The VAKTA model is based on the Finnish accident investigation model, and generally follows the above-mentioned division, dividing physical and technical accident factors further. The model was developed using accident investigations reports of 235 fatal accidents, with 1077 identified accident causes, which occurred in Finland during 1985-1990. (Tallberg et al. 1992) The model, and the results of the analysis of the accidents, are presented in table 2. The model has later been used to classify accident factors in construction (Rakentaminen 2000), and shared workplaces (Rantanen et al. 2007, modified model).

Table 2. Classification of accident factors according to the VAKTA model (Tallberg et al. 1992. Content of classes verified from Rantanen et al. 2007).

	VAKTA model classification of accident factors	1* (%)	2* (%)
1.	**Machines and equipment (technical flaws, deficiencies, design problems)**	**14**	**41**
	- Structural, controlling and operating (production and transfer of energy) systems		
2.	**Work environment**	**18**	**58**
	- Construction, physical environment (e.g. vibration, noise, lighting, thermal conditions, dustiness), order and tidiness		
3.	**Materials, products, substances**	**2**	**7**
4.	**Organizational procedures (independent of individual)**	**46**	**86**
	- Including working procedures, risk management, operational instructions, acquisition of machines, maintenance, work instructions (written), planning of work, orientation, supervision, inspections, information flow, cooperation		
5.	**Individual**	**14**	**49**
	- Knowledge and skills, other permanent and non-permanent individual factors		
6.	**Other**	**6**	**22**
	- Personal protective equipment, life saving equipment, and others		

1*: Distribution of accident factors identified from 235 fatal accidents (%), n=1077 accident factors.
2*: Percentage of accident investigation reports where the type of accident factor was identified, n=245 reports

The SINTEF model is a tool to analyze accident causes. Besides the identification of the accidents sequence and the technical, human and procedural aberrations, it especially concentrates on the identification of organizational factors. Under organizational factors the model classifies deficiencies relating to management systems, upper management decisions and actions, and general safety climate, meaning e.g. economy, labor force and legislation -related weaknesses. (Arbeidsmiljøsenteret 2001 according to Sklet 2004)

In his examination of the Bhopal crisis of 1984, Shrivastava (1987) presents a framework for industrial crises. The framework identifies organizational and technological factors as preconditions of events that lead to crises and, in addition, the infrastructure, which is affected by physical and social conditions. The framework also identifies the human element of crises, which has an effect at different parts of the accidents sequence. (Shrivastava 1987)

Most recently, Marais et al. (2006) have presented a collection of underlying organizational causes of safety failures, which they call safety archetypes. In these archetypes are included the problems of sustaining safety in apparently safe systems, despite technological developments, and in the long run when there are also other daily problems competing of attention. Other archetypes include the repercussions of efforts to improve safety, and trying to improve safety without knowledge of the root causes of the problem. (Marais et al. 2006)

2.3 Accident risk analysis

The identification of accident hazards is based on current knowledge of the situation. Besides from reports of occurred accidents and incidents, information that may be utilized in hazard identification can be found in e.g. previous safety inspections, reports from occupational health care, work instructions and guidelines, minimum safety requirements set by legislation and standards, and relevant scientific and non-scientific publications (738/2002, Ala-Risku et al. 1996, Murtonen 2000, Riskien arviointi työssä… 1996). Checklists of relevant hazards are commonly used to identify existing hazards. The above-mentioned sources of information are used to alter available ready-made checklists (e.g. Hakala n.d., Murtonen 2000, Sähköturvallisuuden oma-arviointi… 2003) and take into account hazards that are specific to the target of the assessment.

Risk analysis may be implemented by forming a heterogeneous group that consists of representatives of employers, employees and experts of relevant fields (occupational health, occupational safety, etc). Such a group will have knowledge of day-to-day shop-floor safety issues (employees), possibility to make decisions (employer) and e.g. information concerning health issues (health care experts) and the risk management process as a whole (safety experts). The group has the task of identification of all existing hazards and should endeavor to reach a consensus in the assessment of the magnitude of the risks posed by the hazards. (Murtonen 2000) Objectivity should be aspired by all (Murtonen 2000) as given the unique nature of accident sequences (Davies et al. 1998) statistical magnitude calculations are usually not possible.

The magnitude of risk is estimated by examining the probability and severity of harm. Probability of occurrence of harm is calculated by estimating exposure to the hazard, the occurrence of hazardous events, and whether the harm may be avoided or limited. (SFS-EN ISO 14121-1:2007) The estimates may be based on past/expected incident occurrence rates, derived from e.g. historical data or simulations, and expert opinion, formed through precise methodology and with the support of all applicable data (SFS-IEC 60300-3-9:2000). Severity of harm consists of an estimate of the magnitude of injuries: how many are harmed and how severe are their injuries (SFS-EN ISO 14121-1:2007). Within the scope of the analysis, both immediate consequences as well as delayed and secondary consequences should be considered. Some additional viewpoints that should be taken into account include the fact that the human element plays a major role in the occurrence of accidents and risk assessment should therefore not be based on technical failure alone. (SFS-IEC 60300-3-9:2000) For example, the magnitude of risk may be dependent on the personality, abilities and other personal characteristics of the person exposed to harm, and there may be both technical and human aspects affecting the likelihood of omission of safety procedures (SFS-EN ISO 14121-1:2007).

Objectivity-aspiring quantification of risks is not easily made, and the success of the risk assessment process itself depends on many variables (see Heikkilä et al. 2007). According to the standard SFS-IEC 60300-3-9 (2000), interpretation of results should be strengthened by the identification and analysis of the uncertainties within the used risk assessment method.

2.4 Organizational, human and technological accident factors

2.4.1 Safety culture

Safety culture has been widely studied for the past twenty years (reviews by Choudhry et al. 2007, Guldenmund 2000, Sorensen 2002) – since it was mentioned in a report by the international nuclear safety advisory group concerning the Chernobyl accident (Summary report on… 1986). Today it seems to be agreed on that safety culture is a sub-area of organizational culture: safety literature often defines organizational culture as “the way we do things around here” (for organizational culture see Schein 2004) and safety culture as those parts of organizational culture that deal with matters concerning safety and health. Still, there seems to be no commonly accepted agreement on the safety culture concept itself nor its components or usability in accident prevention (editorial by Baram & Schoebel 2007). Even the number of safety cultures that exist simultaneously within an organization has been under discussion (Harvey et al. 1999).

Recently Parker et al. (2006) have introduced a framework which describes five different safety cultures an organization may possess, including descriptions of each culture at a tangible and intangible level. The framework describes the worst safety culture to be a pathological one, where safety is mainly not considered at all. The second safety culture type is a reactive culture, which focuses on responding to accidents. A calculative safety culture is a bureaucratic one where compliance to organizational procedures is more important than the results. In a proactive safety culture problems are anticipated and in a generative safety culture considering safety issues at all times is the way of life. The framework is based on earlier safety cultures divisions by Westrum (1993, according to Parker et al. 2006) and Reason (1997) and the goal is to move upwards from one culture to the next. (Parker et al. 2006) Still, a positive safety culture may be identified by simply observing how much emphasis workers give safety day-to-day (Cooper 2000).

According to Reason (1997) to achieve a safety culture an organization must have the ability to report incidents, fair attitude to cases of human failure, flexibility in dynamic situations and willingness to learn and change. Olive et al. (2006) list similar components: commitment to and communication about safety issues, resilience and flexibility, and constant situational awareness.

The term safety climate is used in publications almost as often as the term safety culture. The definition of safety climate is also not uniform, but usually safety climate is used as a synonym for safety culture, as one of the components of safety culture or as a measurable manifestation of safety culture (see e.g. review by Guldenmund 2000).

2.4.2 Management of safety

Supervisors tend to attribute accidents to have been caused by worker behaviour instead of e.g. organizational, environmental, or technical reasons. This may be due to the fact that assigning blame and remedial efforts upon the worker is easier than pointing out organizational – including supervisory – or machinery-related problems. (LaCroix & DeJoy 1989) The assumption is supported by the attribution theory, according to which people tend to explain other's actions with inner motives, and own actions with external circumstances (Jones & Nisbett 1972 according to LaCroix & DeJoy 1989).

Supervisors have a key role in the management of safety (Probst & Estrada 2010, Zohar & Luria 2003): Positively perceived supervisors' safety policy enforcement has a positive effect on both accident occurrence and accident reporting. Workers' experience of safety communication as either ineffective or leading to adverse results causes under-reporting. (Probst & Estrada 2010). Also, if supervisors continuously discuss safety matters with workers, this will have a positive effect on workers' safety behaviour and safety climate (Zohar & Luria 2003). When management shows in practice that safety is an important value in the organization, the workers will adopt it as a value in their work as well (Roughton & Mercurio 2002). Perceptions of an actively committed management have also a positive effect on the rate of injuries (O´Toole 2002). The importance of management commitment, involvement and communication has been identified earlier as well (e.g. Cohen 1977, Smith et al. 1978). In fact, it has been well said, that "employee behaviour is a function of management systems operating within the organizational culture" (Krause & Hidley 1989, p.21).

Still, not all research results support the importance of management and supervisor commitment. In an analysis of six management practices, namely management commitment, rewards, communication and feedback, selection, training, and participation, Vredenburgh (2002) discovered that taking safety performance into account in the selection process and training of new personnel is the best way to reduce workers' injury rates.

It should be noted that in a modern organization traditional ways to supervise safety may be impossible due to the large number of subordinates a supervisor might nowadays have (Krause & Hidley 1989). Booth & Lee (1995) summarize that to manage safety successfully an organization needs a plan, objectives, clear roles, and open communication. In addition, hazards must be identified systematically and repeatedly. All of the above must be kept under continuous scrutiny for possibilities for improvement. (Booth & Lee 1995).

Management of safety at shared workplaces requires extra effort and cooperation skills (738/2002, 49-54§). Almost 80% of fatal occupational accidents at shared workplaces occur to workers who work as contractors. On average fatal occupational accidents at shared workplaces have 11 causes, of which about half are due to the victim's own employer organization and its employees. About half of the causes are organizational, having most often to do with problems in supervising and supervision, working procedures and risk management. (Rantanen et al. 2007). According to the results of a four industry case study by Mayhew et al. (1997), occupational safety problems caused by subcontracting include outsourcing safety risks along with the work, fragmentation of managerial responsibilities, regulations that have been designed with traditional work in mind, and the fact that self-employed seldom belong to a union or other similar association.

2.4.3 Safe behavior

Safe behavior requires knowledge, skills, motivation and a possibility to act safely (Jorgensen 1998). Risk behavior may be said to include "the extent to which the personnel ignore safety regulations in order to get a job done, carry out activities which are forbidden, perform their work duties correctly, use personal protective equipment, and break procedures to carry out jobs quickly" (Rundmo 1996, p. 199-200). As unsafe/risk behavior is the immediate cause of most occupational accidents, companies strive for ways to promote safe behavior. Often safety programs call for a change in attitudes: as attitude changes, so will behavior. Still, there are strong arguments that focusing directly on behavior is more effective (e.g. Earnest 1985). The ABC Analysis emphasizes the need to identify the Antecedents and Consequences of Behavior, bearing in mind that Consequences are of more significance and that immediate, certain and positive consequences have the strongest effect on behavior (Krause 1997, see also Komaki et al. 1982, Sulzer-Azaroff 1982). However, the identification of the motivation behind behavior may be difficult as it may depend heavily on the individual (Glendon & McKenna 1995).

An effort to increase safety by introducing inherently safer systems may create unsafe behavior, according to Wilde's risk homeostasis theory (1982, 1998a, 1998b): The theory is based on risk compensation, that is, the assertion that people have a tendency to optimize risk instead of minimizing it: when the environment becomes safer, people compensate by taking more risks, and vice versa. The theory proposes that people's willingness to take risks is based on the perceived benefits and costs of taking a risk versus not taking it. The level of risk which people are willing to take is the level where people believe they will maximize their gain. This target level is compared with the perceived prevailing level of risk, and behavior is adjusted so that the levels are in unison. (Wilde 1998a, 1998b) Still, McKenna (1987) argues that it would be better to use the term behaviour change than risk compensation, as risk is not necessarily the most important factor affecting changes in behaviour. On the whole the theory is controversial. Trimpop (1996) sums up his review on the subject by stating that regarding the risk homeostasis theory, only the assertion concerning risk compensation, that is to say behavioural adaptation to perceived risk, is generally agreed upon.

Along the same line of thoughts Battman and Klumb (1993) propose that rule violations are due to economic behavior and optimization, that is, the human attempt to maximize gains and minimize losses at the same time. Since economic behavior is a natural feature, rules that contradict will probably be violated: as workers try to optimize their efficiency, they develop ways to do the work that may differ from the official way the work is intended to be done. These violations happen more often when constraints and priorities are unclear, and feedback poor. (Battman & Klumb 1993)

Salminen (1994) states that risk-taking plays a large part in occupational accidents (see also review by Turner et al. 2004). An analysis of 99 accidents, which had occurred in southern Finland during a little over a year, showed that risk-taking contributed to 54% of the cases. Most often it was caused by an attempt to save time and effort and meet timetables. (Salminen 1994) Workers in large organizations experienced fewer accidents when compared to how many workers large organizations employ. In the construction industry subcontractors' workers experienced more accidents than main contractors' workers. (Salminen et al. 1993) Victims of accidents felt the accident was due to external circumstances more than their co-workers and supervisors (Salminen 1992). According to Cooper (1998) unsafe behaviour is the immediate cause of 80-95% of accidents.

Although it is agreed on by most that risk-taking behavior causes accidents, Wagenaar (1992) reminds us – with reference to e.g. Rasmussen's skill-rule-knowledge framework (1982) – that since risk-taking is only possible when the risk is identified and understood, the actual risk-taking behavior can be said to occur at the top levels of organizations, meaning actions made by managers, designers and authorities. At the bottom level workers “run risks, but they do not take them”. (Wagenaar 1992, p.279) This is disputed by Mullen (2004) whose study brings forward the possibility that workers are aware of the risks but choose to ignore them due to different organizational, image- and consequence-related reasons (see also Donald & Canter 1993, Kowalski-Trakofler & Barrett 2007).

2.4.4 Human error

Especially in non-scientific publications human error is still often seen as the primary cause of accidents. This is probably due to limited available information concerning the chain of events leading to the accident, or simply a need to finish the investigation and find a cause (or someone to blame) as soon as possible. Nevertheless in the scientific community it is widely recognized that human error is not as much a cause as it is a consequence of underlying organizational problems (see e.g. Dekker 2002, Reason 1997). In addition, erroneous acts are often labeled errors only when they have adverse effects: when the act was committed, the actor felt it was the right thing to do, considering the prevailing situation (Dekker 2002).

Reason (1990, 1997) categorizes human errors into slips, lapses and mistakes. Slips and lapses are unintended skill-based errors, which are either attention or memory failures. Most often errors are skill-based, especially on the operative level (e.g. Salminen & Tallberg 1996). Mistakes are intended actions but with unwanted consequences, and either rule- or knowledge-based. Violations may be categorized either as one form of error or as a category of their own, as violations may be deliberate or occur as a result of human error. In addition, it must be considered whether the violation was made with good or bad intentions. (Reason 1990, 1997) Most violations are made with good intentions. They may be categorized as situational, exceptional or routine. (Lawton 1998) Errors and violations may be grouped together and called unsafe acts (Reason 1990) or human failure (Reducing error and... 2000). Reason acknowledges his views on human error owe to Rasmussen’s skill-rule-knowledge framework (see. e.g. Rasmussen 1982, 1986, 1987). In a review by Kirwan (1998), error identification techniques were classified into five different types: taxonomies, cognitive simulations, psychologically based tools, cognitive modeling tools, and reliability-oriented tools. Still, of the 38 techniques Kirwan examined, only Rasmussen’s framework and Reason’s generic error modeling system had the main aim of error categorization (Kirwan 1998).

2.4.5 Hurry

Hurry is often said to be the cause why something is done or left undone, but at closer look it can be seen that it is more a consequence, caused by a multitude of factors (see e.g. Järnefelt & Lehto 2002). Today, attitudes towards hurry have changed, and continuous hurry creates an atmosphere of respect. Pressure for time is managed with time deepening, that is by doing things faster, trading time-demanding ways to less time-consuming ones, doing many things at once, or with a strict schedule. (Kerttula 2004)

Järnefelt & Lehto (2002) have grouped the causes of hurry under four levels: organization, unit, assignment and individual. Organization causes hurry if there is a lack of human resources, if organization demands more efficiency, and as a consequence of organizational changes and development. The work unit causes hurry when the supervisor doesn’t stand up for his/her subordinates, when there are problems with work distribution and organizing of work, or schedules are too tight. The work task itself causes hurry if work has become more demanding, more versatile, more fragmented, is customer-work, if planning work is difficult, or if information technology increases the amount or difficulty of work. Hurry may also be self-caused, meaning it originates from the worker’s own poor organizing skills, excess ambitions, or personal stress tolerance level. (Järnefelt & Lehto 2002)

Analysis of the 1977-2008 results of the Finnish Quality of work life survey revealed that the number of people who feel hurry impairs their work a lot has increased significantly, from 18% in 1977 to 31% in 2008. A growing cause of hurry is the fact that there are too few people to do all the work that should be done (45% of respondents in 1990 and 54% in 2008). According to the 2008 results, hurry exists especially in the forms of tight deadlines (75%) and frequent interruptions (56%), and causes errors (49%), fatigue (48%), work climate problems (45%) and more sick leaves (44%). It prevents doing the job in a satisfactory quality (41%), planning (38%), and further training (35%). Hurry also increases the possibility of an accident (35%). When the results are divided according to gender, most consequences of hurry can be seen to be clearly more typical for women, but the increase of errors and possibility of accident are consequences which are more typical for men than women. (Lehto & Sutela 2008)

The fourth European Working Conditions Survey results show that there is considerable difference in work intensity between the member countries of the European Union: Slovenia, Finland, Sweden, Greece, Cyprus, Denmark and Austria are countries who report that an average of more than half the time (>50%) work must be done at very high speed and to tight deadlines, while at the other end Latvia's corresponding figure is under 30%. Compared to the EU average, in the three sectors of manufacturing, construction, and electricity, gas and water, less workers name direct demands from people (EU average 68%), but instead more name work done by colleagues (EU average 42%), numerical production targets (EU average 42%) and direct control of boss (EU average 36%) as what sets the work pace. Automatic speed of machine is mentioned less often by workers in electricity, gas and water, but more often by workers in construction and much more often by workers in manufacturing (EU average 19%). The northern countries are mentioned in the survey as those with an exceptionally high percentage of those working with direct demands from people – accompanied by more related psychological health problems – and an exceptionally low percentage of those whose work pace is set by supervisor control. On the other hand, the northern countries are also mentioned as those who balance work well by giving the worker higher autonomy along with the higher demands. (Parent-Thirion et al. 2007) The survey results also indicate that the respondents' experiences of problems with work pace are age-dependent: the older the respondent, the more often pace was not a problem (Burchell et al. 2009).

Time pressure and stress affect decision-making. Referring to several older publications on decision-making, Ozel (2001) explains how different coping and bolstering mechanisms affect decision-making under time pressure and stress, e.g. a fire emergency: Coping alleviates time pressure as information is processed faster and filtered. Bolstering means that information is utilized subjectively so that it points towards a hoped-for solution. Ozel argues, that as time pressure and stress cause screening and only some indicators are noticed, it is of great importance which indicators stand out. (Ozel 2001)

Time pressure is managed by either coping with it or decreasing it. The worker himself/herself may cope with time pressure by e.g. prioritizing his/her work. Supervisors and co-workers can help in the coping process by acknowledging and taking into account the situation, and with positive reactions and feedback. Time pressure can be decreased by e.g. delaying, delegating, being realistic, leaving some work undone, and learning to say no. In addition, the role of the supervisor, upper management and work community in reducing or causing time pressure should be recognized. (Järnefelt & Lehto 2002)

2.4.6 New technology and other new risks

Rasmussen (1997) has presented four risk management challenges which have arisen during the past decades. The first challenge is the fast pace of technological change, in which management structure, legislation and regulations have an impossible time keeping up with. Also, according to Leveson (2004), engineering techniques are lagging. In addition, already in 1987 Kjellén noted that rapid change of technology eliminates the possibility of experience-based problem-solving: e.g. automation is not the solution to human error problems, but instead creates new problems. Now, in fault situations, in addition to manual operating skills, the operator is demanded of skills to identify, understand and fix the problem. Skills that deteriorate when they are needed only seldom; only when the system is not working as it should. (Bainbridge 1983) New technology, especially automation, increases the risks of maintenance work, which will still require manual activities and direct contact with the system (Kjellén 1987).

Many modern accidents are due to inadequate system and interface design, which hinders communications between the operator and automation (Leveson 2004, Parasuraman & Riley 1997). The futility of past experience has also been acknowledged by the OECD (2003) as a risk management challenge. In 2006 Marais et al. listed as one of the challenges of organizational safety understanding what are the risks incorporated in the new technology. Katz (1997) recognized – in an article that concentrated on the benefits of wireless communication – that wireless communication causes complexity through information increase, more sudden changes, and more competitiveness. He also admitted that the continuous availability caused by wireless communication is not completely a good thing. Still, optimistically he felt that social rules and even laws would soon emerge to prevent undesired behavior. (Katz 1997) The disruptive nature of communication technology is also discussed in an article by Rennecker & Godwin (2005).

Another challenge, according to Rasmussen (1997), are the ever-larger industrial systems, which equally increase the possibility of major accidents. This problem is also identified by the OECD (2003) and Leveson (2004). Reason (1990) suggests that the large number of defences these systems hold as protection against crises is actually a risk itself as they also are subject to human error.

The third challenge is the integration and coupling of systems, which means that an action at one system can have a multitude of undesired consequences in other systems (Rasmussen 1997). This problem has also been noted by Perrow (1999). Kjellén (1987) continues this thought by reminding of the limits of human information processing capabilities and ability to understand complex systems. The above-mentioned challenges – technological improvements – do decrease some aspects of physical workload as intended, but cause an increase in others. In addition, the physical workload is substituted by latent psychological problems. (Harrisson & Legendre 2003)

The fourth challenge is the present aggressive and competitive environment, which focuses on short-term survival instead of long-term well-being (Rasmussen 1997). Leveson (2004) adds that competitiveness and complexity have caused that the responsibility for safety is becoming more a government issue, and it should see to it that safety remains a societal priority. The societal viewpoint is also noted by the OECD (2003), which refers to the importance of taking into account the general public's perception of risks.

Other modern challenges have also been identified (see e.g. The changing world… 2002, New trends in… 2002). Finnish trade unions have identified changes that should be taken into account, caused by e.g. globalization, just-in-time and rapid fluctuation of production, rapid organizational changes, more visible role of owners, unconventional ways of employment, obscured field of companies' operations, and who is a blue- or white-collar worker (Lyly 2007).

2.5 Accident prevention

The identification and elimination of accident hazards – potential causes of accidents – is the key to accident prevention. When elimination of the risk entirely is not possible, a secondary option is to reduce the risk as much as possible (738/2002, chapter 2, §8).

According to Rasmussen (1997), occupational accident prevention is usually based on analysis of occurred accidents and removal of accident causes. Still, accident investigation should not be limited merely to the identification of the direct (or apparent) causes of occurred accidents but should consider what are the underlying causes of accidents, incidents and aberrations, that is, what has lead to the accident-triggering event, behavior or error (Rasmussen 1997). Among others, Groeneweg (1992) urges that accident prevention should focus on organizational factors, which cause human error. Bearing in mind that human behavior, and thus errors, occur at every organizational level (see e.g. Wagenaar 1992) the investigation of human error and especially the surrounding error-provoking conditions is an important part of accident prevention. (Groeneweg 1992)

Koval & Floyd (1998) have presented an accident/injury sequence model where they point out that accident control demands that the hazard is recognized and understood, and that there is both a decision and an ability to avoid the accident. If any one of the above is lacking, unsafe behavior occurs. In addition, injury control demands the recognition and understanding of the possibility of injury, and a decision to try to avoid the risk of being injured. Again, failure to do so leads to unsafe behavior.

(Koval & Floyd 1998) A similar accident model has been published earlier by e.g. Ramsey (1989).

Wagenaar (1992) believes the problem of risk homeostasis may be eliminated by making the environment safer and concealing the implemented changes, or reducing/increasing the perceived benefits/risk.

From a practical point of view, Doughty et al. (1992) present a model of electrical hazardous task classification and 10 principles of safe electrical work: plan every job, anticipate the unexpected, use the right tools, understand that procedures are also tools, isolate, identify hazards and minimize exposure, protect the worker, assess capabilities, and audit these principles.

3 The objectives and scope of the study

The main objective of the study is to promote electrical professionals' electrical safety. This is done by identifying causes of electrical accidents and perceived electrical accident risks, and creating an electrical accident sequence model.

The starting point of the research was knowledge of the immediate causes of electrical accidents, that is, failure to follow safety procedures. This had already been identified by previous research, legislation, authorities and experts from the electrical field. Keeping the main objective in mind, the initial research questions of the study were:

1. Why are safety procedures omitted, especially
    - why is de-energizing omitted?
    - why is voltage testing omitted?
    - why is earthing omitted?
2. What other electrical safety risks do electrical professionals often face?

The previously identified immediate causes of electrical accidents were used as basis for the first research question. The second research question was formulated in order to identify other electrical safety hazards and the risks they pose.

From a theoretical point of view the research is based on the identification of the main electrical accident hazards and risk estimation (figure 1). The magnitude of risk, meaning probability and severity of harm is not quantitatively calculated. Instead probability of harm is implied by the frequency of replies, which may be assumed to be proportional to the frequency of exposure. Severity of harm is “fatal” as in case of electric shock even normal household voltage levels may be fatal. The identified hazards are placed in order of risk magnitude according to the above-mentioned parameters.

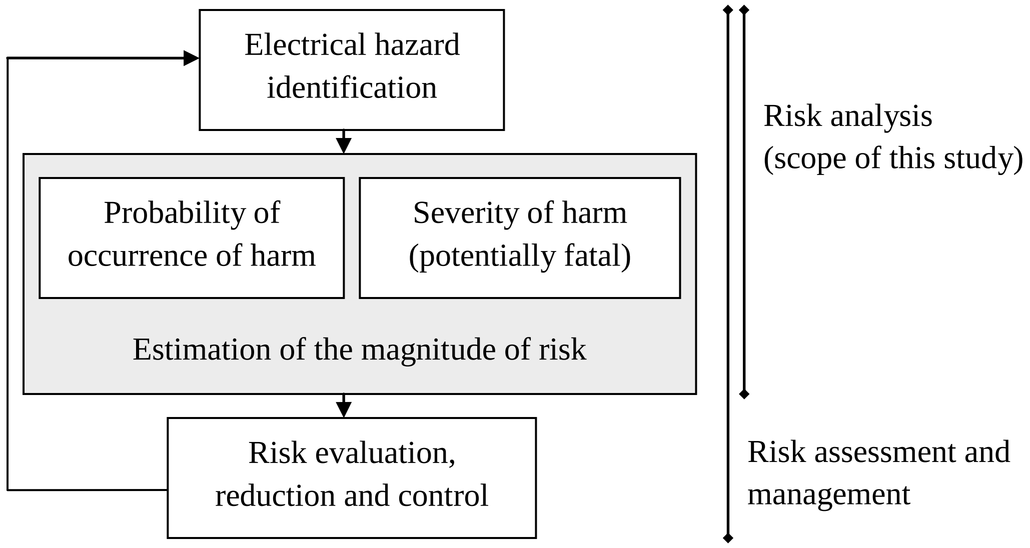

Figure 1. The study concentrated on the risk analysis -part of the risk management process (combined and modified from SFS-EN ISO 14121-1:2007 and SFS-IEC 60300-3-9:2000).

The research was limited to electrical professionals only, defined in Finnish legislation as persons with specific electricity-related education and experience. Those who are laymen in the context of electrical work were not included in the study. By doing so the problem of multiple starting points for the research was avoided as already the immediate causes of professionals' and laymen's accidents differ – electrical professionals are aware of the danger electricity poses – as does the nature of the work environment.

From the four main sectors that employ electrical professionals, namely energy, industry, real estate installations and telecommunications, only the first three were included in the study. These are sectors where electrocution is a constant hazard.

Only accidents caused by electrical shock or arc were included in the study. Accidents caused by other electrical hazards (fire, electrochemical hazards, and converted energy, according to Floyd et al. 2003) and other than electricity-based hazards were not included, e.g. slipping, tripping and falling. In this study, incidents (hazardous situations, near misses) were considered to have the same causal elements as accidents, and are therefore treated as equally important, although there is dispute whether accidents with serious consequences have different causes than minor accidents (see e.g. Salminen et al. 1992, Saloniemi & Oksanen 1998, Wright & van der Schaaf 2004).

The study has an anticipatory viewpoint as it concentrates on the identification of electrical accident hazards – so the risks may be eliminated before accidents occur. Risks are identified by collecting information about perceived electrical safety risks and causes of occurred electrical accidents and incidents. Among others, Rasmussen & Svedung (2000) have criticized that accident investigation is a retrospective and out-of-date method to use as the basis for accident prevention. Still, they believe that small scale occupational accidents are best prevented by the analysis of past accidents (Rasmussen & Svedung 2000). Previous accidents are also seen as an important source of hazard identification (738/2002, Murtonen 2000).

There are three ways to perform electrical work: dead working, live working, and working in the vicinity of live parts (SFS 6002:en 2005). All these have different working methods and safety procedures which must be followed. This research concentrates on dead working or work which was supposed to have been performed dead, which is how most electrical work in Finland is supposed to be done, and where almost all occupational electrical accidents occur.

There are five safety procedures mandatory to be implemented prior to dead working. In chronological order the procedures are de-energizing, securing against re-energizing, testing, earthing and protecting against adjacent live parts. All of these, with the exception of securing against re-energizing, have been identified to be immediate causes of most electrical professionals' electrical accidents (Heinsalmi & Mattila 2007, 2008, Mattila 2009, Mattila & Rusanen 2006, Rusanen 2004, 2005, Rusanen & Laanti 2003). The causes for the omission of de-energizing, testing and earthing are studied here. The existence of adjacent live parts, although recognized as a cause of accidents, is considered not to be included in dead working, but instead working in the vicinity of live parts (SFS 6002:en 2005), and is therefore excluded from this study.

These exact outlines were made in order to focus the analyses more precisely and get a more accurate picture of the electrical accident risks of electrical professionals. From a practical point of view, the results may be used by any organization working in or in cooperation with the electrical field, including unions and authorities, who will be able to use the information in e.g. focusing safety training and legislative work. From the point of view of scientific safety research, the study will reveal new information on human behaviour in specific context. The detailed results can be utilized in the prevention of electrical accidents of other professions. Also, there is the possibility to utilize the results in the prevention of other types of electrical professionals' accidents.

4 The theoretical framework

The theoretical framework of the research is based on the standard SFS 6002 "Safety at electrical work" (1999, 2005) and the electrical accident information collected and published annually by the Finnish Safety Technology Authority Tukes (e.g. Mattila 2009). According to Tukes the most common immediate causes of electrical professionals' electrical accidents are failure to follow certain safety procedures, procedures that are listed in the above-mentioned standard and mandatory to be executed prior to working on a dead installation. An unsafe act may be either an error or a violation (Reason 1990). Identifying and eliminating the underlying causes of errors and violations made at the sharp end of the organization is an important part of accident prevention (Groeneweg 1992). The most common forms of unsafe behavior leading to electrical accidents are presented in figure 2.

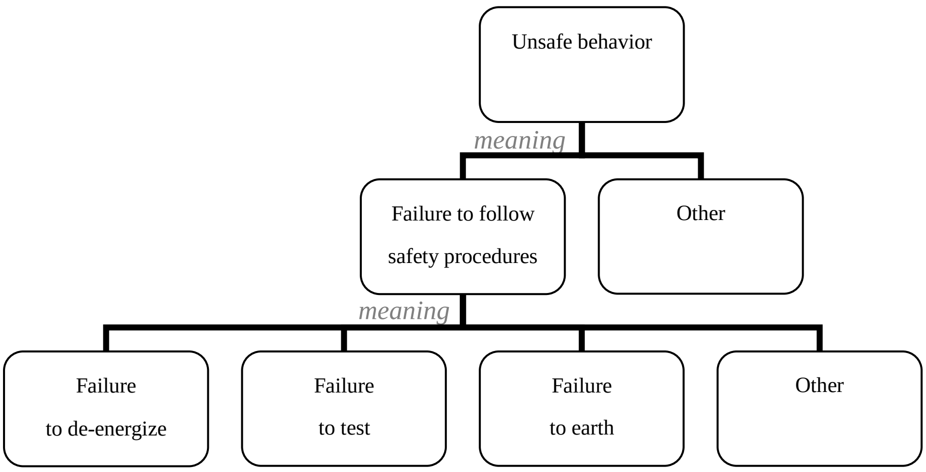

Figure 2. The most common immediate causes of electrical accidents.

The research was executed as a combination of reactive accident investigation and proactive risk analysis: On one hand the research is based on previous knowledge concerning the immediate causes of occurred electrical accidents. Additional electrical incident -related data is collected from the participants during the research. On the other hand the research aims at proactive electrical accident risk analysis (SFS-EN ISO 14121-1:2007, SFS-IEC 60300-3-9:2000) and the identification of both immediate and underlying risks. Reported electrical professionals' electrical accidents are few in number (Mattila 2009) and there is evidence of underreporting (Hintikka 2007). Combining the above-mentioned approaches result in specific information concerning occurred accidents and incidents, and the risks lying behind them. In electrical work – allowed to be performed by electrical professionals only (516/1996, §11, amendment 28/2003) – the possibility that the worker becomes inadvertently in contact with a live system causes a constant risk for a fatal electrical accident. This research concentrated on analysis of the most significant occupational electrical accident risks (figure 3).

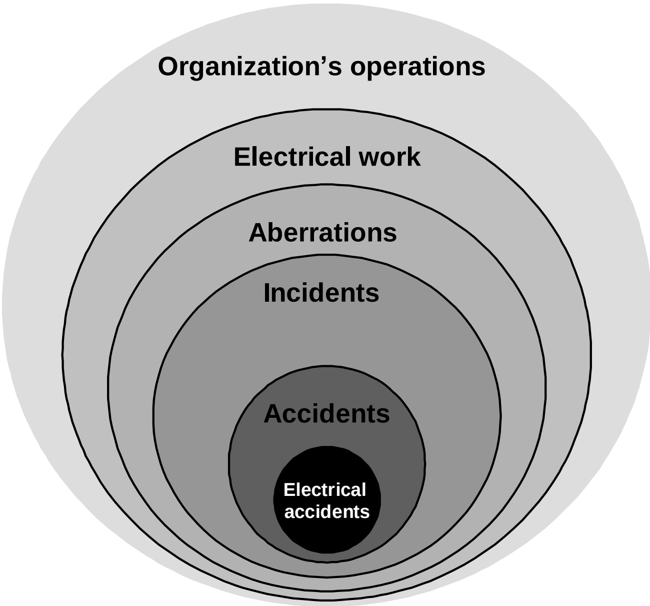

Figure 3. Electrical accident risk is ubiquitous in electrical work.

Accidents are the result of a multitude of causes. Reason (1997) divides these causes into active failures and latent conditions. The active failures are the immediate causes of the electrical accidents, usually unsafe acts made by the workers, easily identifiable during accident investigations, and thus mainly already known in the beginning of the research. Endeavoured to identify in this research are the latent, underlying conditions which lay dormant or evolve during a longer time period. Underlying causes are often due to decisions made by management, designers or even authorities but they may also be due to the worker. Underlying causes are often intangible and some of them may remain unidentified even after thorough investigations as their impact on an accident is difficult to assess. Figure 4 presents some tangible and intangible accident causes originating from different levels of the organization and its surroundings.

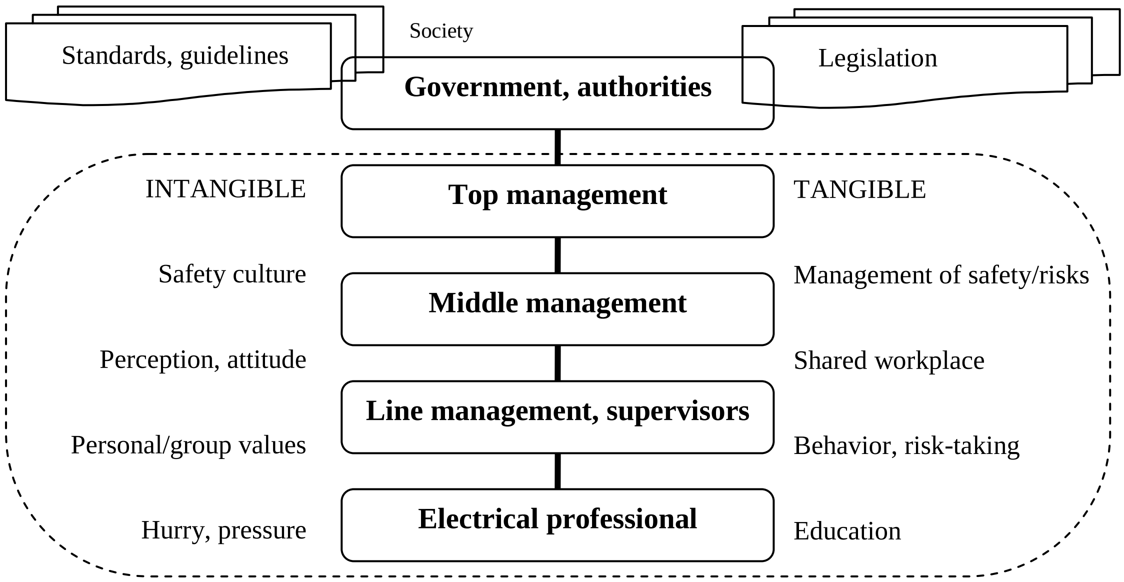

Figure 4. General elements affecting electrical safety.

Safety management is nowadays working under the pressure of an environment that emphasizes fast results over long-term commitment, and has to deal with challenges caused by e.g. continuous technological changes and the integration of complex systems (Rasmussen 1997). Within the turmoil supervisors' and management's safety actions continue to play a key role, affecting worker behavior in areas like accident reporting (Probst & Estrada 2010), safety behaviour (Zohar & Luria 2003) and adoption of safety-related values (Roughton & Mercurio 2002). As Krause & Hidley (1989, p. 21) have stated: "employee behaviour is a function of management systems operating within the organizational culture." Safe behavior requires knowledge, skills, motivation and a possibility to act safely (Jorgensen 1998) and risk-taking plays a large part in occupational accidents (Salminen 1994).

5 Materials and methods

5.1 Outline

The material for this dissertation was gathered within an electrical safety research project (Tulonen et al. 2006) at the Institute of Occupational Safety Engineering at Tampere University of Technology, Finland. The research was executed during 2003-2006 in three phases: a questionnaire survey, interviews, and examination of worksite safety (figure 5). All the phases concentrated on the identification of electrical accident hazards and the underlying causes of electrical accidents and incidents.

Figure 5. The three consecutive parts of the research.

According to Macaskill & Driscoll (1998), information concerning minor accidents is not reliably available from accident statistics, and should instead be gathered with surveys. Also, electrical accident investigation reports seldom go far beyond the immediate causes of accidents – which was the aim of this study. Because there were both experience/perceptions (advisory group members) and research results (Goffeng et al. 2003, Hintikka 2007) of underreporting of electrical accidents and incidents, information concerning occurred incidents were best seen to be gathered with an anonymous questionnaire survey.

One of interview’s advantages is that it will open up a possibility to investigate further and deeper into the issues (Hirsjärvi & Hurme 2001). In this project interviews were used to supplement information received from the questionnaire survey, and to investigate some of the electrical accident -related issues that were felt to be too complex to be asked in a questionnaire.

Based on the survey and interviews, three electrical tasks were chosen for further analysis. The chosen tasks were those perceived particularly hazardous. The implementation of safety procedures during these tasks was examined.

The project was executed from the point of view of risk perception: electrical professionals themselves are the best source of information concerning day-to-day electrical hazards they face. In addition, the project advisory group took an active part in the project and their expertise was utilized especially in the planning of the three phases. The project advisory group represented organizations that concentrate on occupational and/or electrical safety in their daily work, including authorities, trade unions, accident insurance, etc.

The empirical part of the project was executed in Finnish. In the translations presented in this publication – e.g. the questions and answers of the questionnaire survey and interviews – the aim has been to preserve the original thoughts and nuances instead of presenting exact word-for-word translations. As the responses were sometimes quite short, some translations also end abruptly.

5.2 Electrical safety questionnaire survey

5.2.1 Sample of electrical professionals

The Finnish Electrical Workers' Union is one of the 23 member unions of The Central Organisation of Finnish Trade Unions (SAK), the biggest labor market organization in Finland. The Finnish Electrical Workers' Union has over 31 000 members (SAK, 1.1.2004). The union picked out the sample for the questionnaire survey from their private record as a systematic sample (e.g. every fourth name from the list) in January 2004, altogether 4000 names. The persons in the sample were from three sectors: energy, industry and real estate installations. As electrical professionals were the target group, only specific electrical work -related fields of collective agreement on terms of employment (in the trade union) within the sectors were included in the sample: The energy field was included from the energy sector. The electrical installation field was included from the real estate installations sector. And the fields selected from the industry sector were paper and pulp industry, mechanical forest industry, metal industry, textile industry, constructional product industry, chemical industry, rubber industry, food industry, glass ceramics field, and the slot machine maintenance field. For reasons of readability, in the remaining part of this publication the samples and the results of the survey will be referred to according to sector only: energy, industry and real estate installations.

All the persons picked to the sample were persons, who had prior given the union permission to use their contact information. The numbers of members picked were divided as presented in table 3.

Table 3. Sector-specific sample sizes

	Energy	Industry	Real estate installations
No. of members in the selected fields of the sector	4116	4072	10094
No. of members who had prior given permission to use their contact information	3128	3188	6856
No. of members picked for the survey	1600	800	1600
No. of members the questionnaire was sent to (with ascertained contact information)	659	681	660

All the members, whom the questionnaire would be sent to, would have to have ascertained contact information (address and telephone number). Therefore twice as many members were picked as to whom the questionnaire would ultimately be sent to. The contact information of 2000 was checked and missing contact information was sought. The picked industry sample was smaller than the other two samples, which was compensated by checking the contact information of the industry sample first: The aim was to get at least 1000 responses and a fairly equal number of responses from all three sectors.

5.2.2 Questionnaire

The questionnaire was created to collect electrical professionals’ views on the electrical safety problems they currently face. The first composition was based mainly on an electrical accident hazard checklist created during an earlier made preliminary study, and the project advisory group experts' views on the questionnaire contents. It was sent to the project advisory group (nine electrical and occupational safety experts) for examination. The second composition was created on the basis of their comments. The questionnaire was tested twice; first with three electrical professionals working at the Tampere University of Technology, later with another four. The questionnaire was further revised after both tests. The final questionnaire was four pages long and had 26 questions from which nine were open-ended. The questions dealt with the worst experienced electrical incident, working live, safety versus modern technology, occupational electrical risks, attitudes towards safety, and safe working. In addition, the questionnaire included 16 background questions concerning e.g. the respondent's sector of employment, age and education. The questionnaire questions are presented in appendix 1.

A one-page preface explaining the project was sent with the questionnaire. It included an extract from the Decree 516/1996 of the Ministry of Trade and Industry (§11, amendment 28/2003), which lists the demands of professional competency of electrical workers, that is who is recognized as an electrical professional according to Finnish legislation. The extract was added to the preface because the aim was to interview only electrical professionals, which all the members of the union were not. Therefore at the end of the preface, the respondent was told that the target group of the survey was electrical professionals (students from the field were also allowed to participate), and that if he or she was not within the target group, to please inform the interviewer so, and abstain from taking part in the survey.

The term electrical accident was explained at the beginning of the questionnaire. Electrical accident was defined as a situation, where the respondent had received a dangerous electrical shock or arc, and got hurt, even if the injury was only minor (a small burn or scalloping). It was also defined to be an electrical accident, if an injury had been the result of a fall caused by an electrical shock or arc. In addition, the terms hazardous situation/near miss and modern technology were explained.

All the questions were asked in a passive voice to avoid blaming: the objective was to find out why electrical professionals failed to de-energize, test and earth, not why the respondent himself/herself omitted to do these procedures.

5.2.3 The survey

The questionnaire survey was executed during spring 2004. With the aim of collecting at least 1000 responses the questionnaire was sent to 2000 respondents: 681 persons working in industry, 660 persons working in real estate installations and 659 persons working in the field of energy. In the questionnaire, the respondents were informed that an interviewer would call them in a few days, and were asked to fill in the questionnaire in advance and to keep it at hand for the interview. A market research agency was responsible for the collection of the data, e.g. execution of the interviews.

Altogether 541 electrical professionals were interviewed. The interviews took on average 20 minutes, with the shortest interview taking 4* minutes and the longest 50 minutes. (*Interruptions in some interviews caused the timer to restart the timing. Only the time of the call that finished the interview was available.) In table 4 are presented the number of responses collected from each sector, and how the non-responses were divided.

Table 4. Number of responses and non-responses within sectors. Distribution of non-responses.

	Energy	Industry	Real estate installations	Total
Number of members the questionnaire was sent to	659	681	660	2000
Responses gathered	153	179	209	541
Total of non-responses	506	502	451	1459
- Refusals	150	209	187	546
- Not reached at all	134	176	149	459
- Not an electrical professional	163	75	69	307
- Wrong/changed phone number	55	37	42	134
- Interview interrupted	4	5	4	13

Source: report from the market research agency, unpublished

Almost as many respondents participated (541) as refused (546) to take part in the survey. Calculating the response rate by comparing received responses to the overall number of participants who were reached and eligible, add up to a response rate of 49%. Correspondingly, sector-specific response rates are 50% in the field of energy, 46% in the field on industry, and 52% in the field of real estate installations. Reasons for refusal were e.g. hurry or the project was seen needless. On the other hand, some of the respondents who had experienced an electrical accident thought the project was very necessary and felt strongly towards taking part in it. (Based on the report from the market research company which executed the questionnaire survey, unpublished)

5.2.4 Background of respondents

Considering the respondents' responsibilities and duties at work, 92% of the respondents said they worked in an employee-position. The respondents' educational background was mainly vocational; Only 7 respondents (1%) had a bachelor degree (no-one with a master's degree) and 6 of them had also completed some lower degree. All other respondents had a degree of technician or lower. The most common educational background was two or three years of vocational training (72% of respondents). A fourth of all respondents (27%) had more than one level of educational background.

The respondents were asked what sector their employer mainly worked in. The results were slightly different than the respective information from the Finnish Electrical Workers' Union regarding their members' employment (sample information). Both figures are presented in table 5.

Table 5. Division of respondents according to the Finnish Electrical Workers' Union database and according to the questionnaire survey results (number of respondents).

	Energy	Industry	Real estate installations	Other	Not working at the moment	Total
Sample information	153	209	179			541
Questionnaire result	143	218	131	39	10	541

About a fourth of the respondents, who chose the alternative ”other” specified that it meant that they couldn't choose between energy, industry and real estate installations because their employer worked evenly in more than one of them. Others mentioned a line of business that in some cases could presumably clearly be put in one of the three fields. Still, for reasons of high uncertainty of ultimately placing the respondent in the right sector, and to ensure validity of sector-specific results, this was not done.

Almost all (99%) respondents were male. The oldest respondent had been born in 1939 (65 years old at the time of the survey in 2004) and the youngest in 1983 (21 years old). The mean birth year was 1959, the median respondent had been born in 1958 (46 years old) and the most common year of birth (mode) was 1952. One respondent did not want to reveal his age. The results varied between sectors with respondents from the energy sector being slightly older (mean birth year 1956) and respondents from industry and real estate installations being slightly younger (mean birth years 1960 and 1962, respectively) than average.

The respondent with most experience had become an electrical professional in 1960 and the respondent with least experience was still a student and would be an electrical professional in 2009. The mean and median graduation year was 1983, and the most common graduation year (mode) was 1980. From all the respondents, 33 (6%) did not answer this question and 15 (3%) were still students in the electrical field (graduation year 2004 or later). From the rest (475/493), 96% had been working in the electrical field practically the whole time since graduation. Also, 79% of those who did not inform of their graduation year said they had been working in the electrical field since graduation.

Almost nine out of ten respondents (86%) had received electrical safety training within the last five years. Although the type of received training is unknown, it is assumed here that most respondents refer to the specific electrical safety training mandatory in intervals of five years or less, which include e.g. going over the standard SFS 6002.

Sometimes electrical work is performed on live installations. This requires specific preparations. One of the prerequisites for live working is a related course, which the electrical professionals carrying out the assignment must have attended (SFS 6002:2005). The course had been completed by 66% of the respondents.

Almost half (48%) of the respondents were employed by a large organization (≥250 employees), a fifth (21%) by a medium-sized (50-249 employees), a fifth (20%) by a small (10-49 employees) organization, and a tenth (10%) by a micro-organization (<10 employees). Five respondents (1%) did not answer this question. The size of organization varied between sectors as presented in table 6.

Table 6. Distribution of respondents according to size of employer organization.

Size of employer organization	Energy (n=143) (%)	Industry (n=218) (%)	Real estate installations (n=131) (%)	All[1] (n=536) (%)
Micro (<10 employees)	1	5	27	10
Small (10-49)	17	10	37	20
Medium-sized (50-249)	35	17	11	21
Large (≥ 250)	47	68	25	49
Total	100	100	100	100

[1]Including “other” and “not working at the moment”

Finland is divided into six provinces: southern, western, eastern, Oulu, Lapland and the autonomous province of the Åland Islands. The distribution of respondents between provinces is presented in table 7. The distribution can be thought to follow the general lines of the distribution of population in Finland.

Table 7. Distribution of respondents according to province.

Work location (province)	Energy (n=143) (%)	Industry (n=218) (%)	Real estate installations (n=131) (%)	All[1] (n=541) (%)
Southern province	20	28	35	28
Western province	34	33	34	32
Eastern province	17	14	11	14
Oulu province	8	12	7	9
Province of Lapland	5	4	2	3
Åland Islands	0	0	0	0
Multiple provinces	17	10	11	12
No response	0	0	0	1
Total	100	100	100	100

[1]Including “other” and “not working at the moment”

5.3 Interviews

5.3.1 Interviewed companies

It was recognized in advance that finding companies to participate in the interviews might be difficult. Also, it was recognized that companies who are willing to invest their time and money in outsider-lead safety projects are usually safety advocates, that is, those who have already recognized the importance of safety and continuously aim to improve it. Therefore the results obtained through the interviews would most likely not present a representative sample of the electrical safety status of companies working in the electrical trade. On the other hand, interviews in advocate organizations would most likely produce valuable information concerning electrical safety -related good practices.

The interviewees were sought through many different routes. The aim was to find participants from all three sectors. Preferably some of the companies would work as contractors to other companies, in which case the interviewees' daily work would be done in the premises of other companies than their own.

Eventually, some companies were reached because they had previously shown an interest in the project, some were recommended to the project group as companies who might be willing to participate, and some were found from e.g. different Internet-based registers with listings of electrical contractors.

Fourteen companies agreed to participate in the interviews, of which most were large enterprises. In each company separate interviews were made to both electrical workers and their supervisors. The companies themselves chose the persons who would participate in the interviews. Both interviews were made during the same day. Altogether 30 group interviews were made: 6 to workers and supervisors working in the field of energy, 12 to those working in industry, and 10 to those working in the field of real estate installations. In addition, two group interviews were made to persons who were working as liaisons between a company and its contractors. The number of group interviews made to each target group are presented in table 8.

Table 8. Number of interviews made to each target group.

	Energy	Industry	Real estate installations	Total
Company workers	1	2	1	4
Company supervisors	1	2	1	4
Contractor workers	2	4	4	10
Contractor supervisors	2	4	4	10
Liaisons between company and contractor	1	1	0	2
Total	7	13	10	30

Altogether 95 persons participated in the interviews – 53 workers, 34 supervisors and 8 liaisons – of whom 26 worked in the energy sector, 39 in industry and 30 in real estate installations. 54 of the participants worked in a contractor-position, and 41 did not. Of the above, one person (real estate installations, supervisor, contractor-position) was present during only a part of the interview. His responses to the multiple-choice question concerning hurry are missing. This question was handed out on a separate piece of paper and filled in individually by the interviewees after the open-ended theme question concerning hurry. In addition, one person (industry, worker, contractor-position, 96th participant) sent his responses to the theme questions by e-mail, as he wanted to participate but had not been able to attend the interview with his colleagues. As all the responses received from the theme questions are personal opinions of different members of the group, not necessarily reflecting the opinion of the entire group as a consensus, his responses were added to the responses of his group. As he was not present at the interviews, his demographic information is missing as are his responses to the multiple-choice question concerning hurry.

5.3.2 Implementation of interviews

The interviews were made during winter and spring 2004-2005. The interview questions had the aim of deepening understanding of some of the electrical safety problems arisen in the previously done questionnaire survey. Also, some themes that had been left out of the questionnaire due to their complexity and broadness were now dealt with in the interviews. The interviews were all based on the same frame, which consisted of background questions and 15 open-ended theme questions. The themes dealt with were electrical safety and electrical accidents, working live, hurry, working alone, contracting and outsourcing (shared workplaces), electrical safety and technology, and education.

The background questions dealt with the size, sector and contractor-position of the company, and the background of the participants, e.g. their position in the company, age, sex, and experience. The theme concerning hurry included an open-ended interview question after which a multiple-choice question was distributed to everyone, individually filled out by all participants, and then immediately collected. The interview questions are presented in appendix 2 and the multiple-choice question concerning hurry in appendix 3.

The interviews of the workers were designed to take a maximum of two hours, the other interviews taking less time as some questions were left out. The interviews were implemented on a conversation-basis, that is, the questions were not always asked in the same order and questions that were seen irrelevant during some point of the interview were given less attention or excluded altogether (semi-structured interview). In addition, the interviews of the supervisors and the liaisons did usually not include the latter two questions of the technology theme. Especially the interviews of the liaisons concentrated on only three themes, hurry, shared workplaces and technology, although other themes were also handled when the interview schedule allowed.

5.3.3 Background of interviewees

Almost all participants were male (1 female, 2 did not answer this question). The oldest participant had been born in 1942 (63 years old at the time of the interviews in 2005) and the youngest 1985 (20 years old). The mean and median birth year was 1959 (46 years old). The participants represented different age groups fairly well, with 19% of the participants born in the 1940’s, 32% in the 1950’s, 37% in the 1960’s, and 12% in the 1970’s or 80’s. One participant did not reveal his age. There were no remarkable differences in age distribution between participants from different sectors. The participant with most experience had become an electrical professional in 1960 and the participant with least experience in 2005. The mean graduation year was 1982 and the median respondent had graduated in 1983. The most common year of graduation was 1988. Three participants did not answer the graduation year -question. There were no remarkable differences between sectors. On average, the supervisors/liaisons had a few more years of age and experience than the workers. Almost all (96%) participants had been working in the electrical field practically the whole time since graduation. The percentage did not vary remarkable between participants from different sectors or position. On average 17% of the workers' and 79% of the supervisors'/liaisons' daily assignments were so called "desk jobs" (non-physical work), the workers' percentage varying from 0 to 80% and the supervisors/liaisons from 20 to 100%.

From the participants 53 took part in the employee-interviews, 34 in the supervisor, and 8 in the liaison interviews. The responses to the question concerning the participants' responsibilities and duties at work were distributed accordingly: 50 participants said they worked as an employee and 36 as supervisor. Six participants said they worked as "other" and nobody as entrepreneur. Three participants had chosen more than one of the above options, including 1 entrepreneur.

A fourth (25%) of the participants said they worked usually as the person in control/charge of work, 18 % said they worked as the person in control of electrical safety during work, 15% worked as work group "organizer/spokesperson" at the work location ("kärkimies"), 52% as workers, 2% as trainees, 1% as entrepreneurs, and 16% chose "other" as their usual work position. Almost a fourth (23%) of the participants chose more than one of the above position-possibilities.

The employee-interview participants' educational background was mainly two or three years of vocational training (89% of participants). The highest degree was technician. Only a few (15%) of the employee-participants had more than one degree. Most of the supervisor/liaison-interview participants had either a three-year vocational training (43%) or degree of technician (71%), or both. More than half (64%) of the employer/liaison-participants had more than one degree. The highest degree was a master's.

The mandatory course for live working had been completed by 58% of the workers and 48% of the supervisors/liaisons. The results varied between sectors (worker $p=0.001$, supervisor/liaison $p=0.012$) as 86% of the workers and 72% of the supervisors/liaisons in the field of industry had completed the course, the corresponding figures being 62% and 38% in energy, and 26% and 18% in real estate installations. Almost all (92%) participants had received electrical safety training during the past five years: 94% of the workers and 88% of the supervisors/liaisons, and sector-specifically 96% of the participants from the field of energy, 87% from the field of industry and 93% from the field of real estate installations. Altogether 5 participants did not answer this question, and only 3 respondents admitted to more than five years to previously received training.

From the participants, 49% had worked in the southern province of Finland during the past year, 38% in the western province, and 27% in the eastern province. 3% had worked in the province of Oulu and 1% in the province of Lapland. No-one had worked in the autonomous province of the Åland Islands. Ten participants (11%) had worked in more than one province.

A fourth (24%) of the participants admitted they had previously been injured in an electrical accident, 28% of the workers and 19% of the supervisors/liaisons. Sector-specifically 31% of the participants working in the field of energy, 28% working in industry and 13% working in real estate installations had been injured.

5.4 Examination of worksite safety

5.4.1 Safety procedure checklist

The safety procedure checklist was designed by utilizing the results of the questionnaire survey and interviews, the experience of the electrical and safety experts in the project advisory group, and relevant publications (SFS 6002:2005, SFS 6002:1999, Sähköturvallisuuden oma-arviointi... 2003). The final checklist consisted of altogether 60 questions. Some of the questions had optional subquestions. The questions were grouped under seven headings: actions prior to work, securing the work location, work, actions prior to re-energizing, re-energizing, end of work, and other. The questions are presented in appendix 4. In addition, the participants filled individually out a background question form. The same background information was gathered as in the interviews.

5.4.2 Implementation

The examination was made during winter and spring 2005-2006. The aim was to examine work tasks which were deemed especially hazardous. The tasks chosen to be examined were

1. Working with switchboards (from board- to room-size, “keskustyöt” in Finnish) was chosen as switchboards and hazards due to switchboard design were most often mentioned in the results of the questionnaire survey as the most hazardous installation electrical professionals had to work with.
2. Working at switchgear substations (“kytkinlaitostyöt” in Finnish) was chosen as hazards caused by voltages over 6 kV were also often mentioned in the questionnaire survey results concerning hazardous electrical installations.
3. Temporary construction site electricity -related work (“työmaasähköt” in Finnish) was chosen as construction site electrical hazards had been identified earlier in an investigation by Tukes (TUKES tutki sähkötapaturmat 2002) and were also often mentioned in the interviews of electrical professionals as particularly problematic.

The plan was to first observe the tasks and identify hazards, and to then discuss the work with the electrical professionals. Finding companies who were both willing to participate and had one of the above-mentioned tasks coming up proved to be extremely difficult and time-consuming. When a willing company was found, the sought three tasks were named but not explained, allowing the companies themselves to define what they understood as such a task. The examined tasks are presented in table 9.

Table 9. Tasks under examination

Task	Energy	Industry	Real estate installations, new site	Real estate installations, renovation site
Working with switchboards	1	1	1	1
Working at switchgear substations	1	1		
Temporary construction site electricity -related work			1	1

Eight examinations were made, with 13 electrical professionals taking part in them. In most cases both the work observation and the filling out of the checklist, which was carried out as an informal discussion, took about 1-2 hours. One checklist was requested to be shown to colleagues for add-ins, and received later by post.

The participants were asked the questions on the checklist from two viewpoints: “in this case” (observed work) and “usually” (similar tasks). As observation of the specific requested task was not always possible, due to e.g. size of the task or changes in the implementation schedule of the task, some of the safety procedure discussions could be made only from the viewpoint of “usually” – which are the results that are presented in this publication. This decision is supported by the fact the observing the work proved to be difficult and finding electrical safety -related hazards during the observation almost impossible as the observers were not electrical professionals and it was probable that the safety observation caused extra effort to work safely.

5.4.3 Background of participants

Almost all participants were male. The oldest participant had been born in 1948 (58 years old at the time of the observations, in 2006) and the youngest 1979 (27 years old). The mean birth year was 1963 (43 years old) and the median participant had been born in 1964. The participants represented people born during all decades from the 1940’s to the 1970’s. The participant with most experience had become an electrical professional in 1970 and the participant with least experience in 2004. The mean graduation year was 1986 and the median respondent had graduated in 1988.

Almost every participant had been working in the electrical field practically the whole time since graduation.

The participants' educational background was mainly two or three years of vocational training (11 participants out of 13, 85%). The highest degree was engineer. Five participants had more than one degree. Seven (54%) participants said they worked usually as "worker" and four as work group "organizer/spokesperson" at the work location ("kärkimies"). Other participants said they worked as those in control/charge of work, in control of electrical safety during work, or entrepreneur. Two participants chose more than one of the above.

Eight participants (62%) had completed the mandatory course for live working. The results varied between sectors: all of the participants from the field of energy and most from industry had completed the course, as most from real estate installations had not. All of the participants had received electrical safety training during the past five years. Three (23%) participants had previously been injured in an electrical accident, one from each sector.

Ten participants had worked in the western province of Finland during the past year, eight in the southern province, and four in the eastern province. One person had worked in the province of Oulu. No-one had worked in the province of Lapland or the autonomous province of the Åland Islands. Almost half of the participants (6/13, 46%) had worked in more than one province.

5.5 Analysis of data

5.5.1 Classification and analysis

The qualitative data received from both the questionnaire survey and interviews was classified under different themes in accordance with recommendations from Hirsjärvi and Hurme (2001): both the data itself and the intuitiveness of the classifier were used as a basis for theme formulation. Some of the respondents listed several reasons in their response, some none. Consequently responses were placed into several categories.

The identified causes of failure to de-energize, test and earth were analyzed first. Based on their results, related questions were picked for analysis from the questionnaire survey and interviews. The results from the examination of safety procedures of hazardous tasks (n=8) were analyzed as a whole.

The results of the questionnaire survey have been analyzed in relation to respondents' (n=541) sector of employment, age, province and size of employer organization. In addition, possible age-dependent, province-dependent or size of employer organization -dependent results have been searched for sector-specifically.

The results of the interviews have been analyzed in relation to the interviewed group's (n=30) work position (worker or supervisor) and contractor position. The results were also analyzed in relation to interviewed company's (n=14) sector.

The results of the hurry questionnaire, which was filled out individually by all persons who took part in the interviews, have been analyzed in relation to respondents' (n=94) sector of employment, work position and contractor position.

The quantitative results of the classified, originally qualitative data should be interpreted with caution. Both the exact percentage of responses in each category as well as the results of the statistical tests of differences between classes should be read as only indicative explanations of the phenomena.

5.5.2 Statistical examination

The statistical examination has been done with SPSS 15.0 for Windows. Some supplementary and verification calculations were made with later versions of the program. The statistical difference in results from different subgroups (p-value) has been analyzed with Fisher's exact significance level instead of Monte Carlo or χ^2 which give only an estimate of the significance. The p-value of the results' correlation with the respondents' age has been analyzed using Spearman's correlation coefficient with a two-tailed test of significance. Significance levels where $p \leq 0.05$ are defined as statistically significant in all statistical tests.

6 Results

6.1 Electrical safety questionnaire survey

6.1.1 Worst experienced situation

The worst situation the respondents had experienced, from the viewpoint of electrical safety, occurred in most cases because of accidental contact with an energized part of the installation, unexpected presence of electrical energy or technical fault. A few respondents identified multiple causes. The distribution of the results across sectors is presented in table 10.

Table 10. Respondents' worst experienced electrical incident (% of respondents)

Situation	Energy (n=87) (%)	Industry (n=140) (%)	Real estate installations (n=87) (%)	All[1,2] (n=342) (%)
Accidental contact	20	27	32	27
Unexpected energy[3]	41	30	18	30
Technical fault	17	14	22	18
Other	29	35	37	33

[1]Including also "other" and "not working at the moment"
[2]199 (37%) of the responses to the question concerning the worst electrical incident experienced could not be classified, that is, they did not contain usable information. The rest, 342 responses, are analyzed here.
[3]p=0.004

Most often the respondents told of an incident that had occurred during the 1990's (30%) or between 2000 and 2004 (26%). The oldest accident had occurred in 1963. The occurrence year of 13 (4%) described accidents was not mentioned. Almost all (93%) of the incidents occurred at work and 17% of them demanded doctoral attention.

Age of respondent, size of respondent's employer organization or province did not affect the responses as a whole, or within sectors, except in the energy sector, where older respondents told more often of a situation where accidental contact with an energized part was identified as a cause of the accident (p=0.013).

6.1.2 Failure to de-energize

The respondents felt most often that hurry, customer demand or some form of human failure were reasons why electrical work is done live in situations where working safely calls for de-energizing (table 11).

Table 11. Reasons for failure to de-energize (% of respondents).

Reason for failure to de-energize	Energy (n=143) (%)	Industry (n=218) (%)	Real estate installations (n=131) (%)	All[1] (n=541) (%)
Being in hurry	42	39	45	40
Customer demand[2]	37	41	56	42
Human failure	37	38	28	35
Other	22	30	32	29
Non-responses[3]	7	5	2	5

[1]Including also “other” and “not working at the moment”
[2]p=0.005
[3]No answer or no usable information in the answer

Customer demand or production demand of no interruptions was mentioned most often, and especially often by the respondents working in the field of real estate installations where more than every other respondent mentioned it as a reason for working live. The main idea in the responses was that electrical professionals try to avoid power cuts. A reason mentioned often was that production is not to be disturbed with maintenance duties and that in fault situations production downtime should be as short as possible. Another reason derived from experience of consumers having a very low threshold for making complaints about blackouts, even in situations where the blackout-time is short or previously announced. Also, finding a de-energizing time that suits all companies operating in the area is difficult.

Being in hurry or wanting to do the job fast was mentioned almost equally as often as a cause of failure to de-energize. The most frequent response was just “hurry” but some unfolded the problem a little more saying hurry meant tight timetables, being paid by the job (as opposed to working on an hourly basis), no time to examine voltage matters, no time to make plans in advance or think about the work to be done, production demand of quick repair, the next job is waiting, the work will be done quicker when the equipment remain energized, and it takes time to go fetch a fuse, a missing tool or something else needed.

The third group of reasons for working live was human failure, mainly in the form of human error and attitude-related factors such as laziness, carelessness, negligence, thoughtlessness, self-confidence, assuredness in own abilities, and feeling the job is routine, or simply forgetting to de-energize. Other human reasons mentioned were belief that there is no electricity, trust in something (e.g. diagrams) or someone, and lack of communication about the system's electrical status. A common response was also that de-energizing was laborious, and it was easy to omit it, especially when the job itself was small compared to how difficult de-energizing would be.

In addition, there were many other reasons for working live, which could not be directly classified under hurry, customer demand or human reasons. These reasons included e.g. other than demand-related problems concerning customers, financial reasons, and reasons due to the work itself.

When grouping the respondents according to age, province and size of employer organization as a whole, the following statistically significant differences could be found: Younger respondents see hurry as a cause much more often than older respondents ($p=0.002$). On the other hand, older respondents had more non-responses, that is, they more frequently did not answer the question or the information in the answer could not be used ($p=0.005$). There was a statistically significant difference between responses from organizations of different sizes ($p=0.006$): The smaller the respondent's employer organization, the more often the respondents feel that customer demand is a cause of failure to de-energize: 62% or respondents in micro-organizations mentioned customer demand, the corresponding value of small organizations being 48%, medium-sized 41% and large organizations 37%. When comparing provinces, it could be seen that there was a significant difference ($p=0.030$) between the percentages of respondents who mentioned some "other" reason for failure to de-energize: 12% of respondents from Lapland), 22% from Oulu 23% from southern province, 31% from western province 42% from eastern province (42%) and 25% of those who had worked in multiple provinces mentioned an "other" reason.

Sector-specifically, in the field of energy, there is a statistically significant difference between responses from respondents from organizations of different sizes (p=0.021) as to how often customer demand was mentioned as a reason for failure to de-energize: 100% of respondents from micro-organizations (altogether there were only two respondents in micro-organizations), 58% of respondents from small, 32% of respondents from medium-sized, and 31% of respondents from large organizations mentioned customer demand. Younger respondents mentioned hurry (p=0.024) and human failure (p=0.035) more often than older respondents.

In the field of industry, hurry was mentioned by no-one working in a micro-organization (altogether there were eleven respondents in micro-organizations), 67% by respondents working in small, 46% of respondents working in medium-sized and 36% of respondents working in large organizations (p=0.001). There were differences between respondents from different provinces as to the amount of non-responses received (p=0.009): 19% of respondents from the Oulu province, 13% of those from the province of Lapland had a non-response as respondents from other provinces had only 1-3% of non-responses and respondents who had worked in multiple provinces had 5% of non-responses.

In the field of real estate installations there were two non-responses, both from older respondents of over 50 years of age. If a correlation of non-responses according to age was calculated, the p-value would have been 0.042.

6.1.3 Failure to test

The most common responses to the question “Why is the absence of voltage not ensured through testing?” were again different human failure -related reasons and being in hurry. There were also many voltage tester -related answers. The amount of protests to this question was notable: about every fifth respondent gave an indication that testing is never omitted or the respondent never fails to do it. The division of responses is presented in table 12.

Table 12. Reasons for failure to test the success of de-energizing (% of respondents).

Reason for failure to test	Energy (n=143) (%)	Industry (n=218) (%)	Real estate installations (n=131) (%)	All[1] (n=541) (%)
Being in hurry	29	24	24	26
Human failure	57	56	53	55
Equipment, tools	15	8	12	11
Other	10	8	7	8
Protest to the whole idea of omitting testing	22	17	21	19
Non-responses[2,3]	3	10	10	9

[1]Including also “other” and “not working at the moment”
[2]p=0.042
[3]No answer or no usable information in the answer

More than every second respondent said omission of testing is due to some form of human failure. The word used most often was carelessness, but also other reasons were described: negligence, thoughtlessness, forgetting, inexperience, ignorance, laziness, bungling, attitude (nothing can happen to me), assuredness, and that job has become routine. A misunderstanding, or insufficient communication of the system’s status were also given as reasons. Trust was mentioned often: trusting (or belief that) the system is dead, trusting in markings, diagrams or documentation, trusting in isolation or e.g. main switch, trusting in visual observation, trusting in own abilities, trusting in the person who de-energized, and trusting that “the next one” is also dead. A very common reason was also that there was no tester along or the tester was not in the near vicinity. Other human reasons included tiredness due to working overtime in fault situations, measuring from the wrong place, getting confused when some cables remain in use, and thinking the job is so small and forgetting how important testing is.

Being in hurry was a very common response. According to those very few responses, which unfolded the concept further than just by saying the word “hurry”, hurry is due to economic competition between companies, small work groups, tight schedules and work paid by the job (as opposed to working on an hourly basis).

There were many observations about the equipment, namely the voltage tester: Often the reason for omitting testing was said to be that the tester is not along or in the near vicinity. Other related responses mentioned that there is no adequate or reliable tester available, the tester may be broken, it may show wrong readings in sub-zero temperatures, the battery of the tester may be down, and the tester is awkward to use.

Miscellaneous other responses included e.g. responses dealing with demanding customers, financial reasons, small work groups and working alone, inaccurate markings, lack of professional competency, etc.

When grouping the respondents according to size of employer organization, age and province, as a whole and sector-specifically, some statistically significant differences could be found: Sector-specifically, in the field of energy, there is a statistically significant difference between responses from respondents from organizations of different sizes (p=0.031) as to how often hurry was mentioned as a reason of failure to test: No-one working in a micro-organization (altogether only two respondents in micro-organizations), 13% of respondents from small, 24% of respondents from medium-sized, and 40% of respondents from large organizations mentioned hurry. In the field of industry, younger respondents had more non-responses than older respondents (p=0.048). When analyzing the results according to province (all responses and sector-specific responses), there were no statistically significant differences.

6.1.4 Failure to earth

"Why is earthing omitted or earthing is not done in every direction?" Common responses were being in hurry and different human failure -related reasons, which were mainly about attitudes, know-how and knowledge of the earthing procedure. The matter of proper tools and equipment also came up often. The amount of protests received for this question was notably high as about 30% of the respondents in both the fields of energy and industry expressed their opposed opinion to the thought that earthing could be omitted. The division of responses between sectors is presented in table 13.

Table 13. Reasons for failure to earth (% of respondents).

Reason for failure to earth	Energy (n=143) (%)	Industry (n=218) (%)	Real estate installations (n=131) (%)	All[1] (n=541) (%)
Being in hurry[2]	22	12	13	15
Human failure	43	34	37	36
- Attitude	27	18	23	21
- Know-how	8	11	14	10
Equipment, tools[3]	27	16	11	18
Other	9	5	5	6
Protest to the whole idea of omitting earthing[4]	31	28	12	24
Non-responses[56]	10	25	43	26

[1]Including also "other" and "not working at the moment"
[2]p=0.022 [3]p=0.002 [4]p=0.000 [5]p=0.000
[6]No answer or no usable information in the answer

About every third respondent felt omission of testing was due to human failure, especially attitudes: carelessness, negligence, laziness, feeling that earthing is extra work, and reasons of comfort. Personal beliefs and feelings were also mentioned, especially the feeling that the job itself is so small that you don't bother with earthing, but also thoughts that earthing "never needed to be done before", trusting the system is dead and will stay dead (no-one or nothing shall turn the system on during work), trusting in the other safety measures done, trusting in own abilities, confidence in avoiding accidents, estimating that the job is so simple that earthing is unnecessary, or estimating that earthing from one direction is enough or that the other directions are current-free. Other human reasons, e.g. routine job, work culture, used to using just one earthing device, assuredness, tiredness, flailing, incapability of understanding the danger, not wanting to question the work partners actions, and thoughtlessness were also mentioned as well as the high threshold to tell the manager of lack of know-how or experience to work live.

Know-how, professionalism, and mainly the lack of knowledge were mentioned as a reason by every tenth respondent. The responses presented the problem as bad working instructions, not understanding current may come from many directions, not being able to identify all directions, not knowing whose responsibility earthing is, and not knowing how, where or when to earth.

Equipment and tools were mentioned by every fifth respondent as a reason for omitting earthing, and especially often by those, whose employer worked in the field of energy (27%). Most often earthing was said to be too laborious compared to the actual electrical work to be done, which itself may be very small-scale.

Many of the responses referred to the ergonomics of the earthing equipment. The equipment is too impractical, heavy and difficult to use and you have to haul so much equipment to the work site that it doesn't seem reasonable, especially during the wintertime when there is a lot of snow. Many also referred to how laborious the earthing procedure is:

- Earthing is a slow procedure.
- Earthing is difficult and physically demanding.
- Earthing is laborious in fault situations and with a small crew.
- The earth rods are laborious to use, so they are avoided.
- In high voltage electrical work the installation of the earthing equipment is too laborious; the cables have to be so strong that the work is difficult.
- Especially when working already on overtime, earthing is a laborious procedure.
- The equipment has not been designed for the worker.
- Time-consuming.
- The equipment is difficult to put into its place.

Lack of equipment was also mentioned: the earthing equipment is not along or in the near vicinity so the work is done without them, there are too few (or only one) earthing device along or at the worker's disposal. The specific earthing equipment brought along may also be found unsuitable for the task at hand.

In addition, many other technical, physical and equipment-related problems were mentioned, e.g. that there is no good earthing place, the other earthing point is not close by, earthing is really hard to do, diagrams are out-of-date, no room in the vehicles for all the equipment, aggregate generators create a problem, earthing is felt unnecessary and earthing slows down the process of fault repair.

Being in hurry was a common response with some specifying it as no time to earth, work is done faster without earthing, small workgroups, tight schedules, and demands of cost-effectiveness. There were also several other reasons to omit earthing, e.g. to shorten production downtime, it takes time from the actual work, it is trusted that the device is earthed at the other end, it is believed one earthing device is enough, somebody needs electricity so only some parts of the system have been de-energized, and so on.

When grouping the respondents according to age and size of employer organization, as a whole and sector-specifically, some statistically significant differences could be found. Older respondent's protested against the thought of omitting earthing more frequently than younger respondents (p=0.003). On the other hand, younger respondents left this question unanswered (or there was no usable information in the answer) more often (p=0.001).

The results also showed that the size of employer organization affected some responses: The bigger the respondent's employer organization, the more often there was a protest against the whole thought of omitting earthing (p=0.001): 11% of respondents from micro-organizations, 14% from small, 25% from medium-sized and 30% from large organizations protested to the thought. Respondents working in medium-sized organizations mentioned hurry as a cause statistically significantly more often (24%) than respondents from organizations of other sizes (11-14%) (p=0.030). Respondents from micro-organizations did not mention know-how as a cause of failure to earth at all as opposed to respondents from organizations of other sizes from whom 9-12% mentioned it (p=0.017). There was also a statistically significant difference between non-responses with 51% from micro-organizations' employees, 34% from small organizations, 18% from medium-sized and 22% from large organizations (p=0.000).

Sector-specifically, in the field of energy, there is a statistically significant difference between responses from respondents from organizations of different sizes as to how often human failure (p=0.015) and specifically attitudes (p=0.008) were mentioned as a reason of failure to earth: No-one working in a micro-organization (altogether only two respondents from micro-organizations), 63/50% (human failure/attitude) of respondents from small, 50/32% of respondents from medium-sized, and 31/16% of respondents from large organizations mentioned human failure and specifically attitudes.

In the field of industry, older respondents protested to the thought of omitting earthing more often (p=0.044) and younger respondents had more non-responses (p=0.002). And in the field of real estate installations, know-how was mentioned by no-one working in a micro-organization, 17% or respondents working in a small organization, 20% of respondents working in a medium-sized and 21% of respondents working in a large organization (p=0.013). Also, respondents from smaller organizations had more non-responses than respondents from larger organizations (63%, 42%, 33% and 27%, respectively) (p=0.024). Also, there was a difference between responses concerning human failure as a reason to omit earthing (p=0.033): respondents from micro-organizations mentioned human failure more seldom (17%) than respondents from organizations of other sizes (39-47%).

When analyzing the results according to province, it could be seen that the amount of know-how-related responses varied between provinces (p=0.022): Lapland (24%), southern province (11%), eastern and Oulu provinces (8%), western province (6%) and respondents who had worked in multiple provinces (18%). Sector-specifically, there were differences in the industry sector concerning know-how (p=0.008): 24% of respondents with experience from multiple provinces, 15% of respondents from the southern and Oulu provinces, 13% of respondents from the province of Lapland, 10% of respondents from the eastern province and 1% of respondents from the western province mentioned know-how as a reason for failure to earth.

6.1.5 Biggest electrical safety risks

The utilized list of electrical safety risks is presented in table 14, along with the percentage of respondents who chose the given risk to be among the five biggest electrical safety risks. The most common choices were hurry, working alone, attitudes towards safety and working conditions. These risks were chosen clearly more often than others.

Table 14. The biggest electrical safety risks, according to the respondents (% of respondents).

Risk	**Energy** (%) (n=143)	**Industry** (%) (n=218)	**Real estate** (%) (n=131)	**All**[1] (%) (n=541)
1. Hurry[2]	54	66	69	64
2. Working alone	35	33	24	32
3. Attitudes towards safety	28	32	31	30
4. Working conditions[3]	36	24	26	27
5. Getting accustomed to the risks	16	22	19	19
6. Conscious risk-taking, unsafe acts	17	17	20	18
7. Unforeseeable changes in work assignments, abnormal situations, disturbances[4]	20	17	9	15
8. Objects/substances (falling, striking, getting entangled, moving obj.,…)	18	13	15	15
9. Work that is paid by the job (as opposed to working on an hourly basis)	14	10	17	13
10. Equipment, instruments, machinery[5]	8	11	20	12
11. Work posture	17	10	9	11
12. Over-emphasis on financial factors	9	10	13	11
13. Amount of work	10	8	15	11
14. Own customary working procedures	10	11	8	10
15. Professional skills	6	12	11	10
16. Inadequate documentation[6]	2	12	15	10
17. Working plan, organization of work, responsibilities, work distribution	10	7	11	10
18. Continuous vigilance, slacken attention	10	9	12	10
19. Over-estimating own abilities	5	10	10	8
20. Identification of risks at work	5	11	6	8
21. Occupational instruction and guidance, orientation[7]	6	11	2	7
22. Flow of information	8	9	5	7
23. Subcontracting, outsourcing	6	7	4	6
24. Increase, development, diversification of modern tech. and automation	4	7	5	6
25. Interruptions at work[8]	1	6	9	6
26. Traffic[9]	19	1	1	6
27. Monotonous work	3	5	8	5
28. Protective equipment, safeguards	3	7	4	5
29. Too high demands and aims	9	3	5	5
30. Diversity of work assignments	1	5	6	4
31. Level of maintenance	8	3	3	4
32. Performance pressure	3	6	5	4
33. Private life situations	3	4	5	4
34. Changing work environment	4	4	2	3
35. Management	2	3	2	3
36. Continuous organizational changes, uncertainty of work continuity	4	2	3	3
37. Work atmosphere	4	2	2	3
38. Instructions, directions, rules	5	2	1	3
39. Electrical education	2	2	2	2
40. Working instructions	2	2	2	2
41. Cooperation	1	1	2	1
42. Chemicals, mold, virus, bacteria,…	0	2	2	1
43. Organization's workings	0	0	2	1
44. Vandalism	1	0	0	1
45. Threat of violence	1	0	0	0
46. Level of quality assurance	0	1	0	0
47. Standardization	1	0	0	0
48. Demands from legislation / the EU	1	0	0	0

[1]Including also "other" and "not working at the moment" [2]p=0.019 [3]p=0.045
[4]p=0.034 [5]p=0.014 [6]p=0.000 [7]p=0.006 [8]p=0.002 [9]p=0.000

The four risk factors chosen most often to be among the five biggest risks were also the factors chosen most often as the biggest risk. The biggest risk -results were distributed very evenly across all risk factors: only four risk factors were chosen by more than five percent of the respondents: the most common choices were hurry (32%), working alone (12%), attitudes towards safety (8%) and working conditions (6%).

According to the respondents, hurry is a risk because it causes carelessness and flailing. In a hurry situation, e.g. safety procedures and equipment are omitted, instructions are not read, risks are taken, and small things may escape attention, be forgotten or done wrong. Working alone is seen as a risk because in case an accident happens no one will come to help or call for help. In addition, accident risk increases as physically or professionally demanding assignments are done alone. Attitudes towards safety are a risk as they cause e.g. overestimation of own abilities, callous disregard of own safety and safety of others, instruction violations, and omission of safety procedures. Working conditions are also seen as a risk, specifically adverse weather conditions and conditions of the work site, which may change continuously and be a confined space, high up, dirty, messy, outside, or demand working on a ladder or servicing platform. In breakdown-situations working hours may be long and work done alone.

When analyzing the results according to the background of the respondents, the following statistically significant differences between groups could be found: The respondent’s employer organization’s size affected how often some alternatives were chosen. The alternatives with statistically significant differences between groups are presented in table 15.

Table 15. Risk factors where respondent's employer organization's size had an affect on how often the risk was chosen. Distribution of responses according to organization size (% of respondents from that organization size).

Risk	Micro-org. (%)	Small org. (%)	Medium-sized org. (%)	Large org. (%)	p-value	All (%)
All respondents	(n=55)	(n=107)	(n=112)	(n=262)		(n=541)
Equipment, instruments, machinery	16	24	11	8	0.000	12
Cooperation	0	0	4	1	0.043	1
Work atmosphere	0	3	7	1	0.008	3
Energy	(n=2)	(n=24)	(n=50)	(n=67)		(n=143)
Over-estimating own abilities	50	8	0	6	0.016	5
Industry	(n=11)	(n=21)	(n=37)	(n=149)		(n=218)
Own customary working procedures	36	10	19	7	0.010	11
Traffic	18	0	0	1	0.022	1
Management	9	5	8	1	0.045	3
Real estate installations	(n=35)	(n=48)	(n=15)	(n=33)		(n=131)
Equipment, instruments, machinery	14	33	13	9	0.037	20
Over-estimating own abilities	23	8	0	3	0.031	10
Chemicals, mold, virus, bacteria,…	0	0	0	9	0.049	2
Level of maintenance	0	0	13	6	0.017	3
Attitudes towards safety	23	21	60	39	0.018	31

When analyzing the results according to respondents' age, it could be seen that younger respondents chose "monotonous work" (p=0.000), "equipment, instruments, machinery" (p=0.042), "conscious risk-taking, unsafe acts" (p=0.016), "flow of information" (p=0.006) and "hurry" (p=0.000) more often than older respondents. On the other hand, older respondents chose "protective equipment, safeguards" (p=0.012), "increase, development and diversification of modern technology and automation" (p=0.006) and "traffic" (p=0.003) more often than younger respondents.

Sector-specifically, in the energy sector "monotonous work" (p=0.002) and "amount of work" (p=0.010) were chosen more often by younger and "performance pressure" (p=0.018) and "traffic" (p=0.028) by older respondents. In industry, "flow of information" (p=0.013) and "hurry" (p=0.016) were chosen more often by younger and "protective equipment, safeguards" (p=0.003) and "increase, development and diversification of modern technology and automation" (p=0.045) by older respondents. In real estate installations, "monotonous work" (p=0.012), "conscious risk-taking, unsafe acts" (p=0.030) and "hurry" (p=0.039) were chosen more often by younger respondents and "attitudes towards safety" (p=0.012) by older respondents. The results with statistically significant differences between respondent's work location (province) are presented in table 16.

Table 16. Risk factors where province had an affect on how often the risk was chosen. Distribution of responses according to province (% of respondents from that specific province)

Risk	South (%)	West (%)	East (%)	Oulu (%)	Lapland (%)	Multiple (%)	p-value	All (%)
All respondents	(n=149)	(n=175)	(n=77)	(n=50)	(n=17)	(n=65)		(n=541)
Modern technology[0]	8	2	8	18	6	2	0.000	6
Energy	(n=28)	(n=48)	(n=25)	(n=11)	(n=7)	(n=24)		(n=143)
Working instructions	0	0	8	0	14	0	0.037	2
Identification of risks at work	4	2	0	0	29	13	0.028	5
Work atmosphere	4	0	12	0	29	0	0.005	4
Modern technology[0]	18	2	0	0	0	0	0.027	4
Industry	(n=60)	(n=71)	(n=30)	(n=27)	(n=8)	(n=21)		(n=218)
Cooperation	0	0	0	0	0	10	0.017	1
Equipment, instruments, machinery	13	6	20	4	38	10	0.036	11
Over-emph. on financial factors	17	4	10	0	13	24	0.013	10
Modern technology[0]	7	1	10	26	13	0	0.002	7
Professional skills	12	7	30	4	13	14	0.035	12
Real estate installations	(n=46)	(n=44)	(n=15)	(n=9)	(n=2)	(n=15)		(n=131)
Inadequate documentation	28	5	13	22	50	0	0.005	15
Modern technology[0]	2	0	13	22	0	7	0.018	5
Unforeseeable changes[1]	13	0	20	0	0	20	0.021	9

[0]"Increase, development and diversification of modern technology and automation"
[1]"Unforeseeable changes in work assignments, abnormal situations, disturbances"

6.1.6 Unsafe work

The respondents were asked, “If someone performs electrical work unsafely, what is most probably the reason?” The respondents were given five alternatives and permission to choose any number of them. The results are presented in table 17.

Table 17. Why electrical work is done unsafely (% of respondents)

If somebody does electrical work unsafely, why do you think that is?	Energy (n=143) (%)	Industry (n=218) (%)	Real estate installations (n=131) (%)	All[1] (n=541) (%)
The person hasn’t received enough guidance on how to work safely	27	29	33	30
The person doesn’t know he/she is working in the wrong way	26	34	28	29
The person must finish the assignment quickly[2]	36	54	60	49
The person doesn’t have adequate equipment or the equipment is not in working order[3]	17	11	28	18
The person is not motivated to work safely	50	44	44	47

[1]Including also “other” and “not working at the moment”
[2]p=0.000 [3]p=0.000

When analyzing the results according to respondents’ age, size of employer organization and province, the following statistically significant differences between groups could be found: The younger the respondent, the more often he believed hurry (“He must finish the assignment quickly”) was a reason for failure to work safely (p=0.009). In the energy sector, the equipment-related alternative was chosen more often by younger respondents (p=0.011). In industry, the guidance-related alternative was chosen more often by older respondents (p=0.030).

The size of the respondent’s employer organization affected equipment-related responses (p=0.026), chosen by 29% of respondents from micro-organizations, 23% from small organizations, and 15% from both medium-sized and large organizations. Sector-specifically no statistically significant differences between respondents from organizations of different sizes could be found.

The respondents' province affected guidance-related responses (p=0.017) so that 71% of respondents from Lapland mentioned lack of guidance as a reason of unsafe work while responses from other provinces and those who had worked in multiple provinces ranged from 26 to 34%. Sector-specifically the same type of distribution between responses, concerning guidance (p=0.015) and knowledge (p=0.029), could be seen in responses received from the industry sector. Guidance was chosen by 88% of respondents from Lapland and 22-33% of respondents from other provinces and those who had worked in multiple provinces. The equivalent figures for knowledge were 63% and 19-48%.

6.1.7 Technology-based hazards

Responses to the question "What electrical safety problems modern technology causes (and which technology)?" listed both problems and technologies. The distribution of the responses (231/541) is presented in table 18. More than half (57%, 310/541) of the respondents did not answer the question.

Table 18. Problems caused by modern technology and specific technology which causes problems (% of respondents).

Problematic modern technology	Energy (n=61) (%)	Industry (n=95) (%)	Real estate installations (n=60) (%)	All[1] (n=231) (%)
Remote control	30	16	17	21
Sudden energy feed[2]	26	11	13	15
Mobile phone[3]	11	3	2	5
Complexity, opaqueness[4]	2	16	17	12
Energy feed interruptions[5]	10	2	12	7
Quality etc.	0	4	3	3
Computers	8	11	22	13
Automation[6]	13	32	15	23
Education, orientation	2	2	7	3
Other	18	32	27	27

[1]Including also "other" and "not working at the moment"
[2]p=0.034 [3]p=0.047 [4]p=0.006 [5]p=0.032 [6]p=0.010

When analyzing the results according to the size of the respondents employer organization, there was a statistically significant difference concerning computer-related responses (p=0.017), received from 27% of respondents in micro-organizations, 24% of respondents in small organizations, 7% of respondents in medium-sized and 11% of respondents in large organizations. Sector-specifically, in the energy sector, computer-related responses (p=0.034) were received from 100% of the respondents in micro-organizations and 18% of respondents in small organizations as opposed to 3% and 5% of respondents from medium-sized and large organizations. It should be noted though, that there was only 1 respondent from a micro-organization.

As a whole, or sector-specifically, there was no statistically significant correlation between the respondent's age and response, except in the energy sector, where older respondents mentioned remote control more often than younger respondents (p=0.025). The respondent's province affected the responses concerning remote control (p=0.044) and automation (p=0.036): Remote control was mentioned by 11% of the respondents who had worked in the eastern province, 15% of those who had worked in the western province, 20% and 21% of those from the provinces of Lapland and Oulu, respectively, and 33% of those who had worked in the southern province. Automation was mentioned by 14%, 15% and 24% of the respondents from the eastern, western and southern provinces as opposed to 40% and 42% of the respondents from the provinces of Lapland and Oulu, respectively. Sector-specifically, there was a statistical significant difference in the responses from the energy sector concerning remote control (p=0.045): Lapland 0%, eastern 8%, western 26%, Oulu 50% and southern 58%. In the industry sector, the automation-related responses varied with Oulu's 58%, Lapland's 69%, and the other provinces' 20-24%. In the sector of real estate installations there were differences in the responses concerning both complexity/opaqueness (p=0.010) and "other" (p=0.050): Complexity/ opaqueness was mentioned by no-one from the eastern province, 5% of those from the southern province, 13% of those from the western province and everyone from the Oulu province. Some "other" installation was mentioned by no-one from the Oulu province, by 13% and 14% of the respondents from the eastern and southern provinces, respectively, and by 48% of the respondents from the western province. In the real estate installations sector there were no respondents from Lapland with responses to this question.

The question "concerning electrical safety, what is the most hazardous installation or part of an installation you have to work with?" gained 482 responses and thus remained without response from 11% (59/541) of the respondents. The distribution of the received responses is presented in table 19.

Table 19. The most hazardous installation electrical professionals have to work with, distribution of responses according to sector (% of respondents).

Most hazardous installation	Energy (n=130) (%)	Industry (n=191) (%)	Real estate installations (n=117) (%)	All[1] (n=482) (%)
Switchboard[2]	10	43	76	41
-station or –field[3]	22	4	7	9
Transformer/converter[4]	12	9	2	8
Automation, remote control	2	2	0	2
Tools	2	2	5	3
Overhead power line/pole[5]	24	1	1	7
Switch, circuit breaker, disconnector	6	5	1	4
Other[3]	43	47	16	38

[1]Including also "other" and "not working at the moment"
[2]p=0.000 [3]p=0.000 [4]p=0.005 [5]p=0.000 [6]p=0.000

The size of the respondent's employer organization affected many of the responses. The distribution of the responses according to size of employer organization is presented in table 20.

Table 20. The most hazardous installation electrical professionals have to work with, distribution of responses according to size of employer organization (% of respondents).

Most hazardous installation	Micro-organization (n=51) (%)	Small organization (n=92) (%)	Medium-sized organization (n=104) (%)	Large organization (n=233) (%)
Switchboard[1]	59	51	35	37
-station or -field [2]	4	9	18	7
Transformer/converter	8	7	10	7
Automation, remote control	0	0	2	3
Tools	0	4	4	3
Overhead power line/pole[3]	8	9	14	3
Switch, circuit breaker, disconnector [4]	0	0	4	7
Other[5]	29	32	33	45

[1]p=0.003 [2]p=0.008 [3]p=0.003 [4]p=0.009 [5]p=0.020

Sector-specifically there were statistically significant differences only in the energy sector, and only concerning overhead power lines and poles (p=0.002), mentioned by 100% of respondents from micro-organization (only two respondents from micro-organizations in the field of energy), 38% of respondents from small organizations, 29% of respondents from medium-sized organizations and 12% of respondents from large organizations.

The younger the respondent, the more often switchboard (p=0.006) was mentioned. And the older the respondent, the more often an “other” hazardous installation was mentioned (p=0.004). Sector-specifically, in the energy sector, “other” was mentioned more often by older respondents (p=0.002) and overhead power lines and poles by younger respondents (p=0.022).

The respondent’s work location in Finland (province) affected some of the results: The amount of respondents who named switchboard as the most hazardous installation varied between provinces (p=0.002) from 20% to 53% (20% Lapland, 28% eastern, 33% Oulu, 41% western and 53% southern). Automation/remote control also varied (p=0.049), from 0 in the southern and eastern provinces to 2% and 3% in the Oulu and western provinces, respectively, and 7% in Lapland. Sector-specifically, in the industry sector switch/circuit breaker/disconnector was mentioned by no-one from the western province or Lapland, 4% of respondents from the southern province, 8% of respondents from the Oulu province, and 24% of respondents from the eastern province (p=0.001). In real estate installations, transformer/converter was mentioned by 15% of the respondents from the eastern province as opposed to no-one from the other provinces (p=0.044).

6.1.8 Working live but without proper training

Almost all (94%) respondents admitted that they had worked with live installations, with no statistically significant differences between sectors. Still, only 66% said they had been on the obligatory live working -course, sector-specifically 79% of respondents from the field of energy, 67% of respondents from industry and 53% of respondents from real estate installations (p=0.000).

Of those who had not been on the obligatory course, 90% (165/184) had worked with a live installation. Sector-specifically, 70% (21/30) of those in the field of energy, 92% (67/73) of those in industry and 90% (56/62) of those in real estate installations (p=0.014).

Also, concerning working live but without the proper training, on the whole and sector-specifically, there were no statistically significant differences between respondents of different ages, respondents from organizations of different sizes or respondents from different provinces.

6.2 Interviews

6.2.1 Hurry

During the interviews the respondents were asked what causes hurry in electrical work. The responses were divided into eight categories: planning and execution, pressure, self-imposed, too tight schedules, more work and fewer workers, efficiency demands, work diversification, and other. The results – divided according to work position and sector – are presented in tables 21 and 22.

Table 21. What causes hurry in electrical work? (% of interviews) Differences between responses from workers and supervisors.

Cause of hurry	Workers (n=14) (%)	Supervisors and liaisons (n=16) (%)	Difference (% unit)	All (n=30) (%)
Planning and execution	86	63	23	73
- Planning	29	25	4	27
- Interruptions, fragmentation	29	0	29	13
- Breakdown-situations	14	13	1	13
- Next assignment is waiting	14	13	1	13
- Other	43	44	1	43
Pressurization	50	44	6	47
Self-imposed	36	56	20	47
Too tight schedules	57	31	26	43
More work and fewer workers	50	25	25	37
Efficiency demands	29	38	9	33
Work diversification	21	13	8	17
Other	43	13	30	27

Table 22. What causes hurry, sector-specific results (% of interviewed companies). Cause counted when mentioned in at least one of the interviews made at the company.

Cause of hurry	Energy (n=4) (%)	Industry (n=5) (%)	Real estate installations (n=5) (%)	All (n=14) (%)
Planning and execution	100	100	100	100
- Planning	75	0	60	43
- Interruptions, fragmentation	25	20	40	29
- Breakdown-situations	25	20	20	21
- Next assignment is waiting	25	20	20	21
- Other	50	80	100	79
Pressurization	75	80	40	64
Self-imposed	50	100	40	64
Too tight schedules	50	40	100	64
More work and fewer workers	50	60	40	50
Efficiency demands	75	60	60	64
Work diversification	50	20	20	29
Other	50	60	40	50

According to the results, the main causes of hurry are planning and execution problems, which were mentioned by all interviewed companies and in 73% of the interviews. The biggest execution problems were interruptions and fragmentation of the workday, breakdown-situations and awaiting next assignments.

The second most common responses dealt with receiving pressure to e.g. finish the job quickly, too tight schedules and the thought that hurry is self-imposed. These three reasons for hurry were mentioned almost equally often and in equally many companies.

The biggest difference between workers and supervisors concerned interruptions and fragmentation, schedules, work/worker-ratio and hurry being self-imposed. When comparing the results between sectors, it may be seen that planning was not mentioned as a problem by any of the companies working in the field of industry. Instead, hurry was thought to be (at least partly) self-imposed by all interviewed companies in industry. Too tight schedules were mentioned by all companies working in the field of real estate installations.

6.2.2 Hurry questionnaire

The respondents were asked to fill out a hurry-questionnaire. The sector-specific results of the questionnaire are presented in table 23. The most common causes of hurry were too tight schedules and interruptions/fragmentation of work assignments.

Table 23. What causes hurry, sector-specific results (% of respondents).

Level	Cause of hurry	Energy (n=26) (%)	Industry (n=39) (%)	Real estate installations (n=29) (%)	Total (n=94) (%)
Organization	Lack of human resources and increased amount of work	54	41	28	40
	Organization demands more efficiency	46	33	52	43
	Organizational changes and development	8	15	7	11
Work unit / boss	Supervisor doesn't stand up for his/her subordinates	8	0	3	3
	Problems with work distribution and organizing of work[1]	46	18	28	29
	Too tight schedules	42	62	72	60
Work assignments	Work has become more demanding	8	10	10	10
	Work has become more versatile[2]	12	23	41	26
	Interruptions, fragmentation	42	59	45	50
	Work with customers	8	5	10	7
	IT increases the amount of work or makes work more difficult	4	0	0	1
	It is difficult to plan your work	0	3	0	1
	Individual: Self-caused[3]	23	28	3	19

[1]p=0.048 [2]p=0.037 [3]p=0.021

The difference between workers' and supervisors' view of the main causes of hurry are presented in table 24.

Table 24. What causes hurry, according to workers and supervisors (% of respondents).

Level	Cause of hurry	Workers (n=53) (%)	Supervisors and liaisons (n=41) (%)	Total (n=94) (%)
Organization	Lack of human resources and increased amount of work	43	37	40
	Organization demands more efficiency	40	46	43
	Organizational changes and development	8	15	11
Work unit / boss	Supervisor doesn't stand up for his/her subordinates	4	2	3
	Problems with work distribution and organizing of work[1]	38	17	29
	Too tight schedules	55	66	60
Work assignments	Work has become more demanding	9	10	10
	Work has become more versatile	30	20	26
	Interruptions, fragmentation	47	54	50
	Work with customers	9	5	7
	IT increases the amount of work or makes work more difficult	0	2	1
	It is difficult to plan your work	2	0	1
	Individual: Self-caused	13	27	19

[1]p=0.038

The results were also analyzed according to contractor-position (table 25).

Table 25. What causes hurry, according to contractor-position (% of respondents).

Level	Cause of hurry	Non-contr. (n=41) (%)	Contractor (n=53) (%)	Total (n=94) (%)
Organization	Lack of human resources and increased amount of work[1]	54	30	40
	Organization demands more efficiency	37	47	43
	Organizational changes and development[2]	20	4	11
Work unit/ boss	Supervisor doesn't stand up for his/her subordinates	0	6	3
	Problems with work distribution and organizing of work	32	26	29
	Too tight schedules	49	68	60
Work assignments	Work has become more demanding	12	8	10
	Work has become more versatile	24	26	26
	Interruptions, fragmentation	59	43	50
	Work with customers[3]	0	13	7
	IT increases the amount of work or makes work more difficult	0	2	1
	It is difficult to plan your work	0	2	1
	Individual: Self-caused	12	25	19

[1]p=0.034 [2]p=0.019 [3]p=0.017

The responses were further divided according to work position and contractor position. The sizes of the groups were then 34 workers and 19 supervisors (and liaisons) working in a contractor position and 19 workers and 22 supervisors (and liaisons) not working in a contractor position. Some statistically significant differences between these subgroups were found: Concerning supervisors, “organizational changes and developments” was mentioned by no-one working in a contractor-position as opposed to 27% of those not working in a contractor position ($p=0.023$). Concerning workers, “lack of personnel and increase of work assignments” was mentioned by 29% of workers working in a contractor position as opposed to 68% of those not working in a contractor position ($p=0.009$). When comparing the responses of workers and supervisors in a contractor-position, no statistically significant differences were found, as was the situation when comparing workers and supervisors who are not working in a contractor-position.

6.2.3 Contracting and outsourcing (shared workplaces)

As electrical work may be outsourced and is often done at shared workplaces, during the theme interviews the electrical professionals and their supervisors were asked what particular occupational electrical safety hazards shared workplaces have. Most often, in half of the interviewed companies (7/14), both information flow and layman workers were mentioned as a problem of shared workplaces. Small companies (6/14) and supervision, including responsibilities and orientation, (5/14) were mentioned as problems almost equally as often.

Information flow is a problem when the contractor’s workers are not informed of each others’ work assignments. Workers do not know what the status of others’ work assignment is when the work site is unattended. This causes risks in relation to e.g. the changing electrical status of the work sites (de-energized/re-energized). Those in contractor-position may not have all the safety-related information they should have when they begin work and they might not know who to inform of finished work assignment. Risks are also caused by inadequate communication to the electrical system operator, due to lack of proper communication channel concerning the changing situations and problems confronted in the field. A related result (mentioned fifth often, in 4/14 companies) was the problem of multiple contractors with varying work habits, which was seen as a risk, causing problems in coordination, information flow, identification of responsibilities, and with borderline tasks.

Layman workers were seen unable to understand electrical risks or how electrical safety is ensured, even after being instructed. They are also seen too independent when it comes to doing electrical work or re-energizing electrical installations to provide themselves with electricity. Laymen are unskilled and may also be unaware that they are not allowed to perform electrical work, not even in hurry situations. Their negligence and ignorance may cause risks. The person who contracts out the work is usually not an electrical professional, which causes problems.

Small companies and supervision were mentioned as problems as small companies may have a lower safety level, more risk-taking, miscellaneous equipment, and inadequate safety training. Concerning supervision, the respondents said that there is no-one on behalf of either the company where the work is done nor the contractor who supervises, guides, or is responsible of the work of the contractors. In addition, contractors are not given the same orientation information or information about working procedures as the company's own workers.

Information flow and layman workers were both mentioned as a problem of shared workplaces in almost a third of the interviews (9/30). Problems also stated often were supervision (6/30), small companies (6/30) and multiple contractors (5/30). Workers mentioned most often the problems caused by layman workers (in 5/14 interviews) and supervisors/liaisons mentioned information flow (in 6/16 interviews), layman workers (4/16) and the problems caused by multiple contractors (4/16).

Sector-specifically, problems mentioned by at least half of the interviewed companies included the following: In the field of industry, small companies were mentioned as a problem most often (4/5 companies), and almost as often (3/5) were mentioned supervision, information flow and lack of professionalism, the last meaning electrical professionals' knowledge of doing the work correctly. In real estate installations, layman workers were mentioned most often (4/5). And in the energy sector, the only problem mentioned in more than one company was information flow (2/4).

6.3 Examination of worksite safety

6.3.1 Actions prior to work

The tasks under examination during the third phase of the project were working with switchboards ("keskustyöt" in Finnish), working at switchgear substations ("kytkinlaitostyöt" in Finnish) and temporary construction site electricity -related work ("työmaasähköt" in Finnish). In table 26 is presented the distribution of responses to the questions concerning specific actions made prior to work.

Table 26. Implementation of safety procedures prior to work, division of responses. (number of examinations where the response was received, n=8).

Question 1…	No	Yes	Other[1]
1. Were you already familiar with this particular installation?	2	4	2
2. If you were not already familiar with the installation, did you get any information about the site beforehand?	0	3	5
3. Was the task planned in advance?	**4**	4	0
4. Do you know the structure of the electrical network and the proper switching sequence of the facility?	2	6	0
5. Do you know how to de-energize the installation?	0	7	1
6. Do you have a written work plan?	3	**2**	3
7. If a plan has been made do you work according to it	0	3	5
8. Are all the necessary tools along?	2	6	0
9. Are the tools in working condition?	0	6	2
10. Do you receive permission to start work from the person in control of the operation activity?	0	4	4

[1]Including e.g. "yes and no", "doesn't apply" and unanswered.

From table 26 it may be seen that the biggest problem areas lie within planning in advance ("No" in 4/8 cases) and having a written work plan ("Yes" in only 2/8 cases). Still, none of the procedures were declared by all to be a matter-of-course.

6.3.2 Securing the work location

In table 27 is presented the distribution of responses to the questions concerning the securing of the work location.

Table 27. Implementation of safety procedures when securing the work location, division of responses. (number of examinations where the response was received, n=8).

Question 2…	No	Yes	Other[1]
1. Is power supply disconnected from all supply directions?	0	7	1
2. In the disconnecting process, do you take into account remote and local controls?	0	5	3
3. In the separation process, do you take into account the possibility of other voltages?	0	6	2
4. In the separation process, do you take into account that back-up generators and aggregates might turn on / be turned on?	0	5	3
5. Do you discharge the possible dangerous charged voltage from the electrical system? (cables, capacitors...)	0	6	2
6. Do you confirm that the voltage has been discharged?	1	5	2
7. Do you use lockings (that cannot be opened without tools) to prevent re-energizing during work?	0	7	1
8. Do you mark the de-energized installation? (e.g. with signs, tapes or sealing-off line?)	0	6	2
9. Is someone informed that the installation has been de-energised?	**2**	5	1
10. Do you have along the necessary tools to test the voltage?	0	6	2
11. Do you ensure the functioning of your tester immediately before performing the test?	0	8	0
12. Is each part of the work area tested?	**2**	5	1
13. Do you evaluate the need for earthing for work?	**2**	4	2
14. Do you have enough earthing equipment to earth all parts of the installation?	1	**2**	5
15. Do you take into account every direction when earthing the installation, also the direction of the load (possibility of existence of back-up generators and aggregates)?	1	4	3
16. Do you ensure that the earthing equipment hold?	1	**2**	5
17. Can you see the earthing point and earthing equipment from the place where you work?	1	**3**	4

[1]Including e.g. "yes and no", "doesn't apply" and unanswered.

From table 27 it may be seen that there are no clear problems in the different tasks included in the process of securing the work location (small number of "No"-answers). In 2 out of 8 cases (25%) it was admitted that usually others are not informed of de-energizing (question 9), de-energizing is not tested at all possible locations (q12) and the need for earthing is not verified (q13). On the other hand, in only 2 out of 8 (25%) cases the participants admitted to having enough adequate tools for earthing (q14) or that the hold of the equipment is ensured (q16). In addition, in only 3 out of 8 cases (38%) the earthing point and equipment could be seen from the work place (q17).

6.3.3 Work

In table 28 is presented the distribution of responses to the questions concerning electrical work. It should be noted that question 3 is inverse ("Yes" is not a desired answer from the viewpoint of electrical safety).

Table 28. Implementation of safety procedures during work, division of responses. (number of examinations where the response was received, n=8).

Question 3…	No	Yes	Other[1]
1. Can you store and maintenance protective gear at the work site or in your car?	0	**4**	4
2. Does the protective equipment sufficiently endure electrical and physical strain?	0	5	3
3. Are you in the vicinity of live parts during work?	1	**7**	0
4. Do you cover nearby live parts (physical barriers between live parts and work area)?	2	5	1
5. Do you ensure an adequate distance to live parts (also when arriving / leaving)?	0	8	0
6. When working with a switchboard, do you make sure that nothing can drop below the work area (sufficient protection against drops)?	0	7	1
7. Do you lock the switchboard and working facilities if work is interrupted? (night, lunch, coffee break, in-between work)	1	**4**	3
8. Is voltage tested upon return?	**3**	2	3
9. Does someone supervise that all electrical safety measures (de-energizing, preventing re-connection, testing, earthing) are taken?	1	**4**	3
10. Does someone (foreperson, co-worker, yourself) intervene if working conditions or practises are inappropriate?	0	5	3
11. If some tool is missing do you go get one?	0	5	3

[1]Including e.g. "yes and no", "doesn't apply" and unanswered.

From table 28 it may be seen that the problem mentioned most often is being near live parts during work (q3, inverse question), which is said to occur in 7 out of 8 discussions. In addition, voltage testing before continuing work (q8) is admitted to be omitted by 3 out of 8 cases, and usually carried out by only 2. Also, in only half of the cases there is a possibility to store and service protective gear nearby (q1). Locking of facilities is done in only half of the cases (q7). Supervision of adequate implementation of safety measures is identified in only half of the cases (q9).

6.3.4 Actions prior to re-energizing

In table 29 is presented the distribution of responses to the questions concerning actions prior to re-energizing.

Table 29. Implementation of safety procedures prior to re-energizing, division of responses. (number of examinations where the response was received, n=8).

Question 4…	No	Yes	Other[1]
1. Do you ensure before re-energizing that no one is working with the installation and that there are also no outsiders in the danger area?	1	7	0
2. Are all the earthing equipment removed?	1	4	3
3. Are all locks, signs, shields and tapes removed?	0	6	2
4. Are the equipment removed starting with the ones nearest the worksite and moving outwards?	1	4	3
5. Do you inform someone at the worksite when work is completed?	0	8	0

[1]Including e.g. “yes and no”, “doesn’t apply” and unanswered.

No specific problems arised concerning actions prior to re-energizing, although in only half of the cases all the equipment were removed (q2), and removed in the recommended order (q4).

6.3.5 Re-energizing

The re-energizing part of the checklist contained only one question: Has it been specified who re-energizes? In most cases (5/8) the specification had been made, and it had not been made in only one of the cases.

6.3.6 End of work

The end of work -part of the checklist contained two questions: The first question was whether diagrams and plans where always updated in the end to correspond with the new situation? This was admitted to be done by 6 out of 8 cases, and no one admitted to omitting it. The second question concerned whether an initial verification was done before handing over the installation? This was admitted to in almost as many cases (5/8), and also no one admitted to omitting it.

6.3.7 Other

In table 30 is presented the distribution of responses to questions concerning other issues that affect electrical safety. It should be noted that in this part all the questions are inverse ("Yes" is not a desired answer from the viewpoint of electrical safety), with the possible exception of question 3, where the response might have a double meaning: experience is good but getting accustomed to the risks is not.

Table 30. The existence of other electrical safety -related problem areas, division of responses. (number of examinations where the response was received, n=8).

Question 7…	No	Yes	Other[1]
1. Were there deviations from safe working methods during work (de-energizing, preventing re-energizing, testing, earthing)?	3	2	3
2. Was the task supposed to be done quickly?	0	**7**	1
3. Was it a routine job? ("This has been done so many times before")	0	5	3
4. Was the work paid by the job (as opposed to working on an hourly basis)?	2	**5**	1
5. Was the job done alone?	2	4	2
6. Are there problems in information flow that affect electrical safety?	5	3	0
7. During the task did you unexpectedly receive new information concerning the task at hand?	1	4	3
8. During the task, were there interruptions or sudden changes in the work task? (Phone rang, you had to go deal with some other task leaving this work task unfinished, interruptions, deviations etc.)	0	**6**	2
9. Were there employees from multiple companies working together?	1	4	3
10. Were there ergonomic deficiencies? (Did you have to work in a bad position or in a narrow workspace?)	0	**8**	0
11. Were there physical hazards at the work area? (temperature, lighting, vibration, noise, radiation, draft, moisture)	0	**8**	0
12. Were there chemical or biological hazards at the work area? (dust, mould, asbestos, chemicals…)	1	**6**	1
13. Were there deficiencies in the diagrams or other documentation	1	**7**	0
14. Did any hazards, near misses or accidents occur during work?	3	2	3

[1]Including e.g. "yes and no", "doesn't apply" and unanswered.

From table 30 it may be seen that there are many problems which affect electrical safety but which are not directly related to the omission of basic electrical safety procedures. Hurry (q2), work that is paid by the job (q4), interruptions and sudden changes (q8), and ergonomic (q10), physical (q11), chemical and biological (q12) deficiencies were identified in many cases as common problems, as were deficiencies in the original diagrams and other documentation (q13). Many of the other problems listed in this section were also identified quite often.

6.4 Electrical accident sequence model

Based on the results, a model of the electrical accident sequence was created. The model presents the most common immediate and underlying causes of electrical accidents. The model is presented in figure 6.

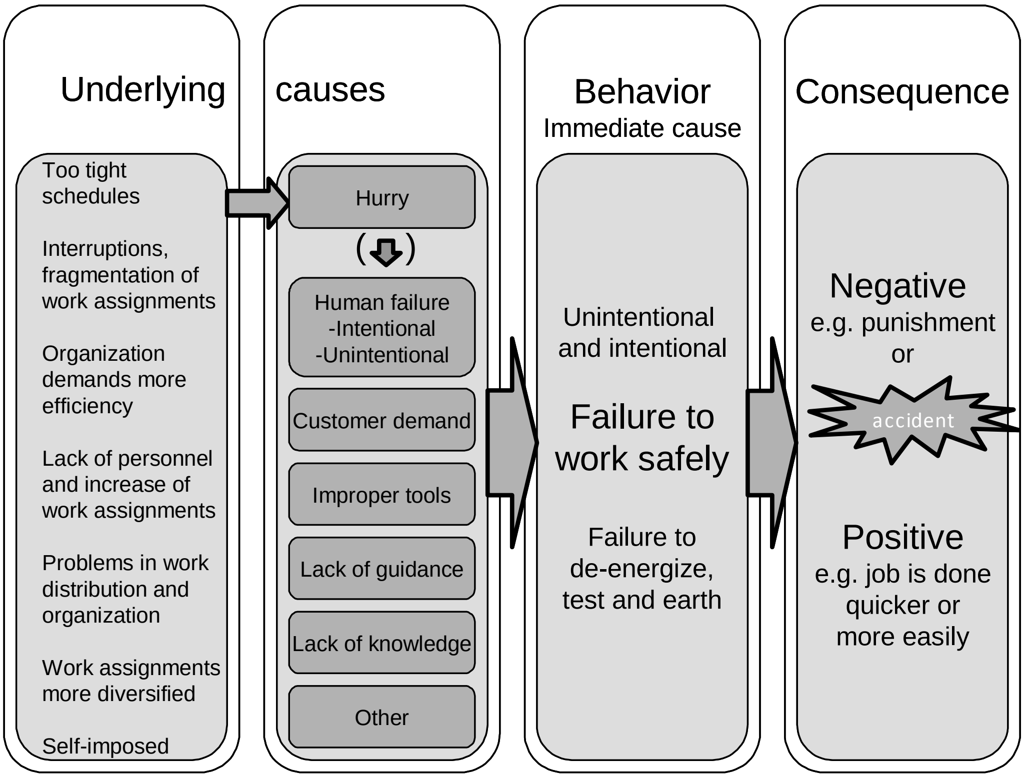

Figure 6. Model of the electrical accident sequence.

As all models, the electrical accident sequence model is a simplified expression of real life. It presents commonly identified causes and should not be taken as exhaustive. The length of the accident chain and the temporal placement of causes within the chain vary.

The model has two elements, which according to the results seem to be probable causes in almost every electrical professional's electrical accident: hurry and human failure. From the electrical professionals' point of view their temporal placement in the accident sequence in relation to each other is clear: hurry causes human failure, both intentional and unintentional. For example, hurry may cause that intentional decisions are made to omit time-consuming safety procedures, or hurry may be the reason why voltage testing is unintentionally forgotten. The causes of hurry are multifold.

7 Discussion

7.1 Main results

7.1.1 All sectors

Although electrical work varies significantly across sectors, electrical professionals' electrical safety problems are surprisingly similar, and only a few specific problems are dependent of sector, size of employer, location (province) or the electrical professional's demography. Most electrical professionals' worst electrical incidents were caused by unexpected presence of electrical energy, accidental contact with an energized part or technical fault. As both unexpected presence and accidental contact are not possible if all the mandatory safety procedures mentioned in the standard SFS 6002 (2005) have been implemented, the results support the view that immediate causes of electrical accidents are due to omissions of these procedures.

Electrical professionals mentioned most often among the five biggest risks they face at work hurry, working alone, attitudes towards safety, and working conditions. These were all mentioned by more than a fourth of the respondents. On the whole, working unsafely is due to attitudes and hurry according to almost a half of the respondents and lack of guidance and knowledge according to about a third. Omission of de-energizing, testing and earthing is most often said to be due to:

- hurry,
- different intentional and unintentional human causes,
- improper tools and
- customer demand of undisturbed power supply.

Too tight schedules are most often identified as a cause of hurry, although interruptions and fragmentation is mentioned almost as often. Lack of human resources and organizational efficiency demands are also mentioned by at least 40% of the hurry questionnaire respondents. The results are remarkably similar to the results of the Quality of work life -survey (Lehto & Sutela 2008), according to which tight deadlines, frequent interruptions and lack of personnel are major causes of hurry.

This reflects also to the biggest problems caused by modern technology: remote control and automation are mentioned most often. The technologies are interrelated, and automation has also been recognized earlier as a safety challenge (e.g. Kjellén 1987). Switchboard was mentioned by far most often as the most hazardous installation electrical professionals have to work with. At shared workplaces the main problem areas are information flow and layman workers.

Safety procedures which may be omitted include e.g. planning the tasks in advance and having a written work plan, working in the vicinity of live parts, and testing voltage before continuing work. In addition hurry, deficiencies in the original diagrams and documentation, and ergonomic and physical hazards were acknowledged often.

7.1.2 Energy sector

The worst experienced electrical incidents were due to unexpected presence of energy more than twice as often as they were due to accidental contact or technical fault, and clearly more often than in other sectors. Among the biggest risks were (in order of magnitude):

- hurry,
- working conditions,
- working alone,
- attitudes towards safety,
- unforeseeable changes in work assignments,
- abnormal situations & disturbances,
- traffic (which was mentioned significantly more often by older respondents than younger),
- encountering objects/substances,
- work posture,
- conscious risk-taking & unsafe acts, and
- getting accustomed to the risks.

These risks were chosen to be among the five biggest by more than 15% of the respondents. Interestingly, although hurry was mentioned by more than half of the respondents, it was chosen as one of the biggest risks clearly less often than in other sectors. On the other hand, working conditions and especially traffic were mentioned considerably more often, reflecting well the nature of the work as the work is often performed outdoors and the work location changes from task to task. Both of these risks have been examined in more detail by the Finnish Institute of Occupational Health (Lankinen et al. 2004).

Failure to de-energize was most often said to be caused by hurry (especially younger professionals), but almost as often by customer demand (especially smaller organizations) or human failure. Failure to test was most often said to be due to human failure, and failure to earth due to attitude (not micro-sized but otherwise especially smaller organizations) and equipment/tools, of which the latter was mentioned much more often than in other sectors. Again, this may be due to the fact that in the energy sector the equipment and tools must be brought along to the work site, although it might also simply reflect the fact that earthing is required more often than in other sectors. Hurry was also mentioned as a reason for failure to earth much more often than in other sectors. Thought should be given to the possibility that this is also related to not having proper equipment along at a remote work site. Half of the respondents said unsafe work is due to motivational problems, as opposed to “only” 36% (compared to other sectors’ 54% and 60%) who stated hurry as the reason.

Lack of personnel/increase of work assignments was mentioned by more than half of the respondents as a cause of hurry. Organizational efficiency demands, too tight schedules, interruptions/fragmentation, and problems in work distribution and organization of work were also mentioned as causes of hurry by more than 40% of the respondents, of which the last was named considerably more often than in other sectors.

Remote control (especially older professionals and the provinces of Oulu and southern) and sudden energy feed were mentioned most often as problems caused by modern technology. These are somewhat interrelated and in line with the result that worst experienced incidents where most often due to unexpected presence of electrical energy. Overhead power lines/poles were named most often as the most hazardous installations (especially younger professionals and smaller organizations), although stations/fields was mentioned almost as often. Both of these were mentioned considerably more often in other sectors where related work is also done much more seldom.

7.1.3 Industry sector

The respondents' worst electrical incident was almost as often caused by accidental contact than by unexpected energy. Among the biggest risks (by more than 15% of the respondents from the industry sector) were:

- hurry (especially younger professionals),
- working alone,
- attitudes towards safety,
- working conditions,
- getting accustomed to the risks,
- conscious risk-taking & unsafe acts,
- unforeseeable changes in work assignments, and
- abnormal situations & disturbances.

None of the above risks was unique to the sector, nor did the risks differ remarkably from the overall results.

Being in hurry (especially small organizations), customer demand and human failure were mentioned almost equally often as causes of failure to de-energize. Failure to test was due to hurry, according to more than half of the respondents from the sector. Attitude and equipment/tools were mentioned most often as causes for failure to earth. More than half of the respondents said unsafe work is due to hurry, and almost half that is was due to motivational problems. About a third of the respondents said unsafe work was due to lack of guidance (especially older professionals and those working in Lapland) or knowledge (also especially those working in Lapland). Equipment was mentioned much more seldom than in other sectors, which may reflect the fact that electrical work in industry is often done indoors and at one specific work site (e.g. factory) where there is fairly easy access to needed equipment. Hurry was most often said to be due to too tight schedules and interruptions/fragmentation. More than 40% of the respondents mentioned also lack of personnel/increase of work as a cause of hurry.

Automation was mentioned by far most often as a problem caused by modern technology (especially in the provinces of Oulu and Lapland), twice as often as the next frequent answers, which were related to remote control and complexity/opaqueness. All of the above are interrelated. They also reflect the views expressed by e.g. Rasmussen (1997), Kjellén (1987) and Bainbridge (1983) concerning technology-related risks. Switchboard was mentioned by 43% of the respondents as the most hazardous installation, as other installations perceived most hazardous were all mentioned by less than a tenth of the respondents (note though the statistically significant difference between provinces in switch/circuit breaker/disconnector -related responses as these were mentioned by 24% of respondents from the eastern province).

7.1.4 Real estate installations sector

Accidental contact was mentioned as the cause of the worst experienced electrical incident much more often than other reasons. Risks that were most often chosen to be among the biggest were:

- hurry (especially younger professionals),
- working conditions,
- working alone,
- attitudes towards safety (especially older professionals and medium-sized organizations),
- equipment/instruments/machinery (especially small organizations),
- conscious risk-taking & unsafe acts (especially younger professionals),
- getting accustomed to the risks, and
- work that is paid by the job (as opposed to working on an hourly basis),

which were all chosen by more than 15% of the respondents. Equipment, instruments and machinery was mentioned as one of the biggest risks clearly more often than in other sectors.

Failure to de-energize was said to be due to customer demand of undisturbed power supply by more than half of the respondents – considerably more often than in other sectors. Being in hurry was mentioned as a cause by almost half and human failure by less than a third of the respondents. Failure to test was due to human failure according to more than half of the respondents. Failure to earth was most often said to have attitudinal causes, and know-how was mentioned second most often (although not by micro-sized organizations). More than half (60%) of respondents said unsafe work was due to hurry, almost a half (44%) named motivation as a cause, and guidance, knowledge and equipment were all mentioned by about a third of the respondents.

Too tight schedules were mentioned by almost three fourths of the respondents as a cause of hurry. Organization's efficiency demands, diversification of work assignments, and interruptions/fragmentation were other causes that were mentioned by more than 40% of the respondents.

The problems caused by modern technology mentioned most often were computers and remote control (and complexity/opaqueness was mentioned by everyone from the Oulu province). Switchboard was mentioned by more than three fourths of the respondents as the most hazardous installation they had to work with, as other alternatives were identified by less than a tenth (note though the statistically significant difference between provinces in transformer-related responses which was mentioned only by respondents from the eastern province).

7.1.5 Electrical accident sequence model

The electrical accident sequence model (figure 6) has two elements which should be acknowledged as probable causes in almost every electrical professional's electrical accident: hurry and human failure. The causes of hurry are mainly related to the organization, also a form of human failure, but one which is from the electrical professionals' point of view categorized as problems at the blunt-end of the accident sequence. The causes of hurry are multifold, but they are possible to minimize from the organizational level.

Besides negative consequences, it should not be forgotten that unsafe behavior may also lead to positive consequences – from the point of view of the worker. In fact, positive consequences are more common. This increases the probability that the behavior will be repeated. In the short run unsafe behavior may have positive consequences as completing the task faster increases productivity.

It should be noted though, that from the point of view of the organization, the consequences of unsafe behavior are always negative. If the efficiency gained through unsafe behavior is acknowledged by the organization, implicitly or explicitly, other workers will see it as a company value and feel that the behavior is acceptable (see e.g. Roughton & Mercurio 2002) – thus increasing the probability that an accident will occur sooner rather than later.

All in all, in the long run negative consequences are imminent, both to the worker and the organization. Unsafe behavior leads to incidents and accidents and the consequences to the worker may be beyond repair. The consequences may also affect the organization's activities for years to come.

7.2 Achievement of objectives

The research can be said to have reached the set objectives successfully. The main objective of the study was to promote electrical safety by identifying the main electrical accident risks of electrical professionals. The immediate causes of accidents were already known in the beginning of the study. Although electrical accidents may seem to have been caused by failure to follow safety procedures, the knowledge of this immediate (or apparent) cause does not answer the question as to how to prevent further similar accidents. During the study the underlying causes of accidents were identified. The differences between the investigation reports of fatal electrical accidents and the results of this research point out the new information this research reveals on electrical accident causes. The results indicate that the causes of electrical accidents are both intrinsic and extrinsic from the point of view of electrical professionals. Based on the results a model of the electrical accident sequence was created.

The model does not present sector-specific differences in the accident sequence as the results of the questionnaire survey, interviews and safety procedure examinations show clearly that the main electrical accident risks are independent of sector. In addition, the respondent's age, size of employer organization and work location (province) affected only a few of the main results, and have not been included in the model.

The electrical accident sequence model may be utilized both in the prevention of electrical accidents and in the analysis of already occurred accidents with the aim of preventing further similar occurrences. In the accident investigation process the model serves as a road map to the identification of the causes and consequences of electrical accidents. The model also directs the investigators' attention from the immediate causes to the underlying causes, and thus reminds to take the underlying causes under deeper investigation in the analyses. At the same time, the model reminds not to put the whole blame on the worker, who did or failed to do something just before the accident occurred. Instead it is pointed out that there are reasons why the worker acted as he or she did, and that these underlying causes may still exist and cause other accidents.

The model will also assist in the prevention of never-before-occurred accidents. It helps to identify the most common elements that lie behind unwanted behaviour in electrical work. It points out reasons why risks are taken. Most importantly the model clearly shows what some of the most common electrical safety problems are. Now that problem areas have been identified, it is possible to keep them under scrutiny – to try to eliminate those that exist and check regularly that the risks have not re-appeared or increased. For instance, when at-risk behaviour is identified, the cause for the behaviour is immediately investigated into.

7.3 Methodological strengths and weaknesses

7.3.1 General

The analyzed data was gathered with three methods: a questionnaire survey, interviews and examination of safety procedures. Triangulation is a generally utilized means to ensure higher quality and reliability of results. In this case the questionnaire survey made it possible to collect data from a large sample and get an overview of the whole situation. Interviews were used to clarify and deepen information received from the survey, and to handle issues that were seen too complex to be inserted into the survey. Examination of the implementation of safety procedures in certain hazardous tasks gave a detailed walkthrough of the safety procedures that are implemented in electrical work.

Concerning the literature review, electrical accident research is probably not as uncommon as the amount of available international publications imply. Most probably electrical accidents are studied intensively, although not by the scientific community, but instead on a national and practical level. Like in Finland, authorities and electrical work -related trade unions need electrical safety information in their daily work, for example. Their studies are seldom published in scientific publications or in more than one language. Taking into account these limitations of information retrieval, there has been no indication that a similar study had been made in other countries. On the contrary, international literature gives impression that in many countries identifying electrical professionals' electrical risks by approaching the professionals themselves would be remarkably more difficult to execute as both the definition of who is an electrical professional, and the possibility to reach such a group through a common denominator (union) may not be readily available.

The results are based on the information received from electrical professionals, that is their experience of the electrical safety risks and problems they face at work. Perceived risk is not equivalent to what is the statistically calculated magnitude of the risk. Nevertheless, electrical professionals' risk perceptions may be assumed to derive from experience of occurred incidents, and collecting expert opinion is a comprehensive way to identify underlying safety problems that have a potential for disastrous outcome. Comparison to the results of official accident investigations adds to reliability of results. A possibility not utilized in this study would have been to investigate electrical accidents and incidents. However, this would have been very resource-consuming, the incidents would have been chosen from a voluntary basis, which would have affected results, and especially cases with severe consequences would have lacked anonymity as they are scarce and probably known by the field. Discussion of occurred electrical accidents was attempted during the group interviews but the interviewees demonstrated clear reluctance in presenting an example of such an occurrence from their own work environment.

Almost all of the gathered data is of qualitative nature. The quantification of qualitative data leads to a certain amount of uncertainty, especially when making analyses of statistical significance. This should be taken into account in the interpretation of the results. It should also be noted that in some of the results which show statistically significant differences between subgroups, some of the subgroups contain only a very small sample.

Although objectivity is always aspired in scientific research, in practice it is never achieved: the measurement process is subjective when humans select the measures, and collect, analyze and interpret the data (Muckler & Seven 1992). Alas, in this study increased objectivity was strived for through consensus and by using expert opinion, which are commonly used methods, although not entirely supported by theory (see Muckler & Seven 1992). In this study the person responsible for the analyses of data and interpretation of results was an occupational safety professional, not an electrical professional. This will have affected the results, e.g. the intuitive classification of the qualitative data. Especially in the categorization of the responses to the question concerning hazardous installations this should be noted as definitions of installations are dependent on the nature of the work (e.g. *switchboard* may refer to a board or a whole room) and some of the installations listed in the results are interrelated (e.g. *switch* as part of *switchgear* located in a *-station*). Another aspect which should be taken into account is the fact that electrotechnical vocabulary may not always be word-for-word translated: the empirical part of the research was executed in Finnish and the English translations of the results should be treated with caution, e.g. the exact translation of “(sähkö)keskus” is not “switchboard”. The aim was to present the overall picture reflected in these results.

7.3.2 Electrical safety questionnaire survey

The overall response rate of the questionnaire survey was 49%, with the response rate of different sectors varying between 46-52%. Response rates of mailed surveys rarely exceed 60% (Heikkilä 2001), although telephone survey response rates may be higher. Thus considering the length of the survey and that there were many “hard” questions which required active investment of time to formulate an informed opinion and a reply, the response rate is estimated fairly adequate. The 541 questionnaire survey respondents represent approximately 3% of the total number of electrical professionals working with dangerous voltage levels in Finland – although the sample represents only those who are members of the Finnish Electrical Workers’ Union. In addition, the sample was picked by the union itself, although this is unlikely to have affected the results as the utilized method was systematic sample. The number of overall respondents is not what was originally aimed at but nevertheless facilitates comparison of subgroups (see Heikkilä 2001). Generalization of the questionnaire survey results is supported by the respondents’ demographic information: The respondents represent all age groups, have worked mainly only in the electrical field, and their distribution between provinces follows the general lines of the distribution of Finland’s population. The respondents’ employers represent the three sectors where work is done on electrical installations which when energized have the potential to cause fatal electrocution.

Respondents who had personally experienced an electrical accident were especially willing to take part in the survey. This may have caused a skew in the results. Nevertheless experiencing an accident may have caused deeper consideration about existing electrical safety hazards, and thus deeper insights in the survey responses. On the other hand, in order to get a fair amount of responses, a survey must remain short enough. Surveys also usually do not allow the handling of complex issues. Responses to open-ended questions are short as the interviewee does not have the means to write down lengthy replies. Thus large telephone surveys may also suffer from quality fluctuations in the recording of the responses. This may have affected the results to the open-ended questions: it is likely that through personal interviews the results concerning e.g. causes of failure to de-energize, test and earth would have been more in-depth. Still, interviews would have been more resource-consuming and thus decreased the number of participants/cases notably. The results would also have been more skewed as the collection of information would no longer have been anonymous, which most likely would have affected willingness to discuss causes of unsafe behavior. Anonymity made it also possible to discuss the issues on an expert level: with no blame attached to the respondent's own work environment. This was a shortage in the following two methods.

The background information gathered from the respondents of the questionnaire survey shows clearly that the aim of gathering information from the workers has been fully accomplished as only a small percentage of the respondents had a higher position at work or a higher educational degree. The rather big proportion of respondents who have completed the mandatory course for live working may be a sign of a distortion in the sample. On the other hand, it is possible that some of the respondents have misunderstood the question believing any course including live installation safety tips is sufficient, though this seems unlikely.

Some respondents described themselves as students or "not working at the moment", but they have nevertheless specified the size of their employer organization. Most probably they have indicated the size of the organization where they have worked as a student trainee or worked during some time of their working life. This has probably not had a significant affect on the results where responses from organizations of different sizes have been compared as the perspective of the respondents is nevertheless according to that organization size.

The three questions concerning reasons for failure to de-energize, test and earth were asked consecutively. This may have caused similarities in the answers. The second and third question (testing, earthing) are most easily answered by repeating the answer to the first question (de-energizing). The easiness may account for e.g. the high amount of hurry-responses, especially in the question concerning testing, since testing is not usually a time-consuming procedure and here the hurry-responses were most often not explained in further detail.

The results for the questions concerning failure to de-energize, test and earth may also reflect the alternatives given in the multiple choice question concerning reasons why electrical work is done unsafely. Although reasons for failure to de-energize, test and earth were asked before the multiple choice -question, all the questions were sent to the respondents by mail beforehand. Even so, this does not necessarily create a credibility problem towards the answers received to the de-energize, test and earth -results. Still, it may have decreased variability in the answers.

The questions concerning de-energizing, testing and earthing were open-ended, and the length and level of the responses written down during the phone interviews vary. Therefore some of the responses were put into several categories and some were “on a gray zone” and categorized on a most probably -basis. For example, a response like “forgetting because of hurry” was categorized under both human failure and hurry. The same reasons account for the similarities and repetition in the “other”-categorized responses: to avoid misinterpretation some of the vague responses were put into the other-category although they may also have been put into other categories. The quantitative results to the open-ended questions should be considered approximate and describing only the magnitude of the amount of responses. This should also be remembered when statistical significance between the results of different subgroups was found. The same uncertainty of categorization applies to all other open-ended questions.

7.3.3 Interviews and examinations

Both the group interviews and the examinations of safety procedures were made to companies willing to participate and donate their employees’ time on the project. This means that the participants were not a representative sample of the electrical field in general, but more probably companies who are safety advocates. Also, the interview situation and the examinations of safety procedure most likely affected worker behavior and responses. This is probably reflected in the results: the results of the interviews and examinations are most likely more optimistic than what the situation in the field really is. Nevertheless, e.g. the results concerning hurry are supported by the results of the Quality of work life -survey (Lehto & Sutela 2008).

The results of the examination-phase were not what was initially aimed at, but they nevertheless support, and supplement, the results of the previous phases of the project. The most valuable part of the phase were the discussions made from the viewpoint of how the situation is usually in such tasks. The results of the examination phase may be seen as a reflection of general electrical safety problems that exist in hazardous tasks more than of the problems of the three specific examined tasks, which had been the primary objective of the examination.

7.4 Reliability and validity

Reliability and validity are measures of research quality, but they are not directly applicable when data is collected from humans whose actions, opinions and answers may alter even in a short period of time (see Hirsjärvi & Hurme 2001). Nevertheless, the terms may be used to demonstrate different aspects of research quality.

The reliability of the results (do the results give us reliable information on certain aspects of electrical safety) is shown by the similarity of the results received with the different methods: the third phase of the study gives strong support to the prior two pointing out same electrical safety problems which had already been seen essential in the earlier phases, for instance problems in planning, testing and earthing. The reliability of the results is also shown in the unanimity of the respondents. For example, there was very little dispersion as to what are the biggest electrical safety risks faced today, regardless of the respondents sector, province, age, or size of employer organization.

The explicit target group of the questionnaire survey gives possibility to repeat the survey, which is one of the most common ways to demonstrate reliability. The reliability of the entire research is increased when the methods, phases and choices made during the execution of the research are explained as thoroughly as possible.

The high number of responses and the response rate allow for generalization of the results to all electrical professionals with vocational education (electricians) working in the examined sectors.

The validity (was electrical safety studied or something else) of the entire research may be evaluated by making a comparison with the project results and the results of investigation reports of fatal electrical accidents. The comparison shows similarities to the project results, most notably the significant role of the electrical professionals' safety behavior in the accident chain. The similarities strengthen the validity of the results of the research.

The validity of the survey questionnaire was strengthened by the input received from the project advisory group, and the two test surveys made with altogether seven electrical professionals. Explanations of certain key definitions, which were inserted into the questionnaire survey form that was sent to the respondents, had the aim of increasing consistency and thus strengthening the validity of the survey results. The mean and median respondent of the survey had more than 20 years of experience in the electrical field, which supports validity of the results.

The interviews and examinations of safety procedures gave possibility to evaluate the validity of the research with observations made on how the questions and used terms were understood by electrical professionals. In addition, validity of results is strengthened as the three data collection methods and investigation of relevant literature all had the aim of supplementing each other, thus leaving very little room for the possibility that some electrical hazards would remain unidentified.

7.5 Further needs

There is a need for a precise means to eliminate electrical professionals' unsafe behavior. The results of this research are a step towards this goal. Future steps which this study encourages to be taken include further investigation into the different types of intentional and unintentional human failure, preferably as two separate studies as in all probability there is a significant difference in the elements behind them, and narrowing the investigation to one precisely defined subject has in this project proved to create a setting that best allows to successfully find answers to the problem at hand. Furthermore, a case-by-case study is in order, including the validation of the above-mentioned method, which both helps identify and motivates to eliminate unsafe behavior. The commitment of the electrical professionals in these investigations is as vital as it was here. For the sake of reliability of the results, the perspective should continue to be the utilization of the expertise of electrical professionals. As behavior-related methods already exist, the objective should not be the birth of a new method, but most probably to revise and adapt an “old” reputable method or methods to suite the specific needs of electrical professionals. With a well defined target group for the research, precision of answers may be expected as well, and the research may thus also bring out information that could be used in the prevention of unsafe behavior in other professions.

From a statistical point of view non-electrical risks cause more days away from work than electrical risks – even to electrical professionals who often are exposed to the risk of fatal electrocution on a daily basis. Although non-electrical accidents are usually not as severe in consequences, they occur much more often. A plenitude of hazard identification and risk assessment methods already exist. However, these methods are most often meant to identify all types of risks at certain work. The not so common approach used in this research to restrict the analyses to only one risk (electrical) faced by only one profession should be used in the identification and analysis of other specific risks faced by electrical professionals. From a wider perspective the same technique may be useful in the promotion of the safety of other well-defined professions.

The project’s base results have been received well by the electrical trade: The results were said to verify problems which had been identified first-hand, but of which so far there has been no reliable statistical data. On the other hand, some results were surprising to the electrical trade, like the fact that there might be considerable deficiencies in the know-how of electrical professionals, concerning e.g. earthing and how to perform work safely. In addition, the problem of not having adequate tools to perform work safely was novel information to representatives of the electrical trade. As some results varied according to background, in the future there is a need for a clear method for organizations working in the electrical field to identify the specific problems the electrical professionals that work for them face daily in their tasks. There is also a need for a tool for electrical professionals. This tool could help electrical professionals analyze the tasks at hand, and the risks involved. A follow-up study was executed to address the need for these tools (see Pulkkinen et al. 2009).

From a broader perspective, the research proved the benefits of having a narrow scope. Accident research often concentrates on identifying and assessing all the risks faced by a group of workers. This causes problems in obtaining in-depth results as the underlying causes of different risk types may vary significantly, and investigating into them all in depth may easily require more resources than planned. This study concentrated on electrical professionals and electrical accidents alone in order to get a deeper insight of the problem – and was successful in doing so. Nevertheless, or exactly because of that reason, the results may now be utilized in the promotion of other safety aspects as well: The causes of hurry in electrical work are most probably the same, independent of whether the point-of-view is electrical or non-electrical safety. Hurry and human failure as underlying causes of failure to follow safety procedures may be considered valid when considering the non-electrical safety problems which electrical professionals face at work. On the other hand, the results give evidence that the role of hurry and human failure is worth further considering in occupational accidents in general, regardless of profession.

8 Conclusions

The consequences of electrical accidents have aptly been compared to playing Russian roulette, with a one in thirty possibility of one's luck running out (Stephenson 1993). Electrical professionals are a special group of electrical accident victims as they have been trained to work with electricity and are aware of its special features as an occupational hazard. Still, occupational electrical accidents are not as rare as statistics imply as especially minor accidents remain unreported. As with all accidents, underreporting causes lack of information about existing problems and hinders planning of preventive actions. This study was executed with the aim of identifying existing electrical safety problems in order to promote electrical professionals' electrical safety.

According to the results there is a remarkable unanimity among electrical professionals that hurry and human failure play a significant role in electrical safety. In modern society both of them are entities the significance of which most probably will only increase in the near future. Hurry is a complex phenomenon and not easily eliminated, as is shown with the dispersion of the results concerning the causes of hurry. However, hurry seems to be most often due to organizational problems such as lack of possibility to plan the work beforehand. Hurry is also one of the causes of intentional and unintentional failure to follow safety procedures. This information concerning the causes of hurry and their relative significance opens up new possibilities to direct attention to the elements that generate hurry.

The foundation of safe work is knowledge. Ideally the needed information is acquired during vocational education, orientation to new tasks, extension courses, and other training that is preferably repeated in regular intervals. The results of this research give evidence to the fact that there is a lack of knowledge on safe working procedures. On the other hand, the results also show that some of the omissions are made with full knowledge of the risks involved. All in all, the causes of intentional and unintentional at-risk behaviour are multifold, and efforts of prevention should be planned accordingly.

In the future, the electrical safety of electrical professionals may be promoted with the utilization of the electrical accident sequence model. Organizations working in the electrical field may utilize the model as basis for discussions with electrical professionals concerning what hinders daily work. These discussions are preferably held with both own employees and those under (sub)contract. Assigning blame should be avoided. Instead the discussions should concentrate on what are the underlying problems that cause unintentional failure to follow predetermined safety procedures, or provoke or even necessitate intentional omissions.

The unanimity in the results raise the question as to whether the same unanimity towards the underlying causes of unsafe behaviour exists also in other professions. The possibility that in certain risk types there are a few underlying and identifiable "key" accident causes opens new possibilities to prevent accidents from occurring.

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Appendices

Appendix 1: Telephone survey questions

1. Mikä on pahin sähkötapaturma, joka Teille on tapahtunut? (jos ei ole sattunut, niin sitten läheltä piti -tilanne tai vaaratilanne)

1a. Kertokaa lyhyesti, mitä silloin tapahtui? Mitä työtä ja työvaihetta olitte tekemässä, mistä sähköiskutapaturma, läheltä piti – tilanne tai vaaratilanne johtui eli mikä meni vikaan? Mitkä olivat seuraukset?

2. Tapahtuiko se töissä vai vapaa-ajalla?
    - Töissä
    - Vapaa-ajalla

3. Minä vuonna?
    - Vuonna…

4. Edellyttikö tapahtuma lääkärissä käyntiä / lääkärin hoitoa?
    - Kyllä
    - Ei

1. What is the worst electrical accident you have encountered? (If there is none, what is the worst near miss or hazardous situation)

1a. Briefly, what happened? What were the task and the phase you were doing at that moment? What was the cause of the accident – what went wrong? What were the consequences?

2. Did it occur at work or out of work?
    - At work
    - Out of work

3. When did it take place?
    - Year …

4. Was there a need for medical examination or treatment?
    - Yes
    - No

5. Kuinka monta kertaa Teille on sattunut sähkötapaturma? (Ks. sähkötapaturmamääritelmä yllä)
   - Työaikana
     Vaihtojännitteen aiheuttama tapaturma ___ kertaa
     Tasajännitteen aiheuttama tapaturma ___ kertaa
   - Vapaa-ajalla
     Vaihtojännitteen aiheuttama tapaturma ___ kertaa
     Tasajännitteen aiheuttama tapaturma ___ kertaa

6. Kuinka usein Teille nykyään tapahtuu sähkön aiheuttama läheltä piti –tilanne, vaaratilanne tai tapaturma? (Ks. määritelmät yllä)
   - Päivittäin
   - Viikoittain
   - Kuukausittain
   - Vuosittain
   - Harvemmin kuin vuosittain
   - Ei ole koskaan tapahtunut

7. Tapaturmatutkinnassa on havaittu, että työskentely jännitteisessä kohteessa (kohteen olisi pitänyt olla jännitteetön) on ollut monen sähköiskutapaturman yhtenä syytekijänä.

5. How many times have you been involved in an electrical accident? (See above for the definition of electrical accident)
   - At work
     Accidents caused by alternating current: ___ times
     Accidents caused by direct current: ___ times
   - Out of work
     Accidents caused by alternating current: ___ times
     Accidents caused by direct current: ___ times

6. How often are you nowadays involved in an electrical near miss, hazardous situation or accident?
   - Daily
   - Weekly
   - Monthly
   - Annually
   - More seldom than annually
   - Has never happened

7. According to accident investigations many electrical accidents are at least partly due to working at a live installation when the installation should have been dead.

Mitkä tekijät ovat syynä siihen, että töitä tehdään jännitteisinä, vaikka turvallinen työskentely edellyttäisi jännitteettömyyttä (tai jännitetyöohjeiden noudattamista)?	What causes people to work live in situations where safe working calls for de-energizing (or that live work regulations are followed)?
8. Miksi jännitteettömyyden toteaminen laiminlyödään?	8. Why is the absence of voltage not ensured through testing?
9. Miksi työmaadoittaminen laiminlyödään tai ei tehdä työmaadoituksia joka syöttösuunnalle?	9. Why is earthing omitted or earthing is not done in every direction?
10. Mitä sähkötyöturvallisuusongelmia nykyteknologia aiheuttaa (ja mikä teknologia)?	10. What electrical safety problems modern technology causes (and which technology)?
11. Miten nykyteknologiaa (ja mitä teknologiaa) voisi käyttää hyväksi sähkötyöturvallisuutenne parantamisessa?	11. How could modern technology (and what technology) be used to improve your electrical safety?
12. Mikä on sähköturvallisuuden suhteen vaarallisin laite tai laitteiston osa, jonka kanssa joudutte työskentelemään?	12. Concerning electrical safety, what is the most hazardous installation or part of an installation you have to work with?

13. Merkitkää seuraavista viisi, jotka ovat sähköturvallisuuden suhteen sähköalan ammattilaisten suurimmat työturvallisuusriskit tai tekijät, jotka heikentävät työturvallisuutta. (Merkitkää valitsemienne tekijöiden numerot riskin kannalta tärkeysjärjestykseen sivun alaosassa olevaan kohtaan kys. 13a)
    1) Yksityiselämän tapahtumat
    2) Yksipuolinen työ
    3) Yksintyöskentely
    4) Yhteistyö
    5) Välineet, laitteet, laitteistot
    6) Väkivallan uhka
    7) Urakkaluonteinen työ
    8) Ulkoistaminen, alihankinta
    9) Töiden suunnittelu, työn organisointi, vastuut, työnjako
    10) Töiden moninaisuus, työtehtävien erilaisuus
    11) Työskentelyolosuhteet
    12) Työohjeet
    13) Työnopastus, perehdyttäminen
    14) Työn riskien tunnistaminen
    15) Työn keskeytyminen, keskeytykset
    16) Työmäärä
    17) Työilmapiiri
    18) Työasennot
    19) Tietoinen riskinotto, turvaton toiminta

13. From the list below, what are the five most important electrical professionals' occupational electrical accident risks? (Place the corresponding number of the chosen risks in descending order in the appropriate fields in question 13a.)
    1) Private life situations
    2) Monotonous work
    3) Working alone
    4) Cooperation
    5) Equipment, instruments, machinery
    6) Threat of violence
    7) Work that is paid by the job (as opposed to working on an hourly basis)
    8) Subcontracting, outsourcing
    9) Working plan, organization of work, responsibilities, work distribution
    10) Diversity of work assignments
    11) Working conditions
    12) Working instructions
    13) Occupational instruction and guidance, orientation
    14) Identification of risks at work
    15) Interruptions at work
    16) Amount of work
    17) Work atmosphere
    18) Work posture
    19) Conscious risk-taking, unsafe acts

20) Tiedonkulku
21) Taloudellisten tekijöiden ylikorostuminen
22) Sähköalan koulutus
23) Suorituspaineet
24) Suojaimet, suojukset
25) Standardisointi
26) Riskeihin tottuminen
27) Puutteellinen dokumentaatio
28) Organisaation toimintatavat
29) Omat totutut toimintatavat
30) Oman osaamisen yliarviointi
31) Ohjeet, määräykset, säännöt
32) Nykyteknologian ja automaation lisääntyminen, kehittyminen, monipuolistuminen
33) Muuttuva työympäristö
34) Liikenne
35) Liian kovat vaatimukset ja tavoitteet
36) Lainsäädännön / EU:n tuomat vaatimukset
37) Laadunvarmistuksen taso
38) Kiire
39) Kemikaalit, homeet, virukset, bakteerit,...
40) Johtaminen, esimiestoiminta
41) Jatkuvat organisaatiomuutokset, työsuhteen epävarmuus
42) Jatkuva valppaana olo, tarkkaavaisuuden herpaantuminen
43) Ilkivalta

20) Flow of information
21) Over-emphasis on financial factors
22) Electrical education
23) Performance pressure
24) Protective equipment, safeguards
25) Standardization
26) Getting accustomed to the risks
27) Inadequate documentation
28) Organization’s way to work
29) Own customary working procedures
30) Over-estimating own abilities
31) Instructions, directions, rules
32) Increase, development and diversification of modern technology and automation
33) Changing work environment
34) Traffic
35) Too high demands and aims
36) Demands from legislation / the EU
37) Level of quality assurance
38) Hurry
39) Chemicals, mold, virus, bacteria,…
40) Management
41) Continuous organizational changes, uncertainty of work continuity
42) Continuous vigilance, slacken attention
43) Vandalism

44) Huolto- ja kunnossapidon taso
45) Esineet ja aineet (esineiden putoaminen, kaatuminen, iskeentyminen, esineisiin takertuminen, liikkuvat esineet),...
46) Ennalta-arvaamattomat muutokset työtehtävissä, poikkeavat tilanteet, häiriöt
47) Asenteet turvallisuutta kohtaan
48) Ammattitaito

13a. Tarkentakaa yllä olevan tehtävän vastauksianne (5 kpl). Merkitkää valitsemanne kohdat (numerot) alle riskin kannalta tärkeysjärjestykseen ja kirjoittakaa millä tavoin tekijä on sähkötyössä työturvallisuusriski?

- Suurin riski on ___.
  Millä tavoin tekijä on sähkötyössä työturvallisuusriski? Avoin kysymys
- Toiseksi suurin riski on ___
  Millä tavoin tekijä on sähkötyössä työturvallisuusriski? Avoin kysymys
- 3. suurin riski ___
  Millä tavoin tekijä on sähkötyössä työturvallisuusriski? Avoin kysymys
- 4. suurin riski ___

44) Level of maintenance
45) Objects and substances (falling, striking, getting entangled, moving objects)…
46) Unforeseeable changes in work assignments, abnormal situations, disturbances
47) Attitudes towards safety
48) Professional skills

13a. Please specify further. Place the corresponding number of the chosen risks in descending order and write down what makes it an occupational safety risk in electrical work.

- The biggest risk is ___.
  What makes it an occupational safety risk in electrical work? Open-ended question
- The second biggest risk is ___.
  What makes it an occupational safety risk in electrical work? Open-ended question
- The third biggest risk is ___.
  What makes it an occupational safety risk in electrical work? Open-ended question
- The fourth biggest risk is ___.
  What makes it an

Millä tavoin tekijä on sähkötyössä työturvallisuusriski? Avoin kysymys

- 5. suurin riski ___
  Millä tavoin tekijä on sähkötyössä työturvallisuusriski? Avoin kysymys

14. Merkitkää seuraavista tietoteknisistä ja viestinteknisistä työn apuvälineistä kaikki ne, joita käytätte työssänne säännöllisesti?
- Lankapuhelin
- Matkapuhelin
- Älypuhelin (esim. kommunikaattori tai vastaava)
- LA-puhelin (tai muu erillinen puhelinjärjestelmä)
- Muu puhelinlaite, mikä? ___
- (Toimisto)tietokone
- Kannettava tietokone
- Kämmentietokone / taskutietokone / PDA-laite
- Muu tietokonelaite, erilaiset päätteet ja päätelaitteet, koneiden näytöt, tutkimuslaitteet, mittalaitteet, asennuslaitteet mitä? ___
- Muita, mitä? ___

occupational safety risk in electrical work? Open-ended question

- The fifth biggest risk is ___.
  What makes it an occupational safety risk in electrical work? Open-ended question

14. Jot down the ICT tools you use regularly at your work.
- Telephone
- Cellular phone
- AI-telephone (e.g. communicator)
- Shortwave radio (or other separated communication system)
- Other communication device, what? ___
- Personal computer
- Laptop
- Palmtop / Pocket computer / PDA-device
- Other computer device, different kinds of terminals or terminal device, computer screens, research equipment, measuring device, installation device, what? ___
- Other, what? ___

15. ”Tietotekniikan ja viestintätekniikan kehittymisen ja lisääntymisen vaikutukset ovat sähkötyöturvallisuuden kannalta olleet mielestäni…”
    - Enimmäkseen myönteisiä
    - Enimmäkseen kielteisiä
    - Ei kumpikaan edellä mainituista

15. ”The evolution and increase of information and communication technology has affected electrical safety in my opinion…”
    - Mostly positively
    - Mostly negatively
    - Neither of the above

16. Teettekö sähkötöitä vapaa-ajallanne?
    - Kyllä
    - En

16. Do you do electrical work outside working hours?
    - Yes
    - No

17. Jos vastasitte edelliseen kysymykseen, kyllä: Mikä seuraavista vaihtoehdoista kuvaa parhaiten toimintatapojanne?
    - Teen sähkötyöt työpaikalla turvallisemmin
    - Teen vapaa-ajan sähkötyöt turvallisemmin
    - Teen sähkötöitä täysin yhtä turvallisesti sekä töissä että vapaa-ajalla

17. If you answered “yes” to the above question, which of the following options describes your working methods best?
    - I perform electrical work more safely at work
    - I perform electrical work more safely at home
    - I perform electrical work as safely at work as at home.

Kuinka samaa tai eri mieltä olette seuraavien väittämien kanssa? (Merkitkää yksi vastaus jokaisen väittämän kohdalle)

18. Saamani työnopastus nykyisiin työtehtäviini on ollut riittävää
    - Olen täysin samaa mieltä
    - Olen osittain samaa mieltä
    - Olen osittain eri mieltä
    - Olen täysin eri mieltä

19. Saamani ohjeet ovat yleensä olleet riittävät
    - Olen täysin samaa mieltä
    - Olen osittain samaa mieltä
    - Olen osittain eri mieltä
    - Olen täysin eri mieltä

20. Sähköturvallisuuteen panostetaan työpaikallani selvästi ja sitä pidetään tärkeänä
    - Olen täysin samaa mieltä
    - Olen osittain samaa mieltä
    - Olen osittain eri mieltä
    - Olen täysin eri mieltä

How strongly do you agree or disagree with the following statements? (Mark one answer to every statement)

18. The guidance I received for my current work assignment has been sufficient
    - I agree
    - I partly agree
    - I partly disagree
    - I disagree

19. The instructions I have received have usually been sufficient
    - I agree
    - I partly agree
    - I partly disagree
    - I disagree

20. Electrical safety is invested in at my workplace and it is considered a priority
    - I agree
    - I partly agree
    - I partly disagree
    - I disagree

21. Taloudelliset tekijät tuntuvat olevan työpaikallani tärkeämpiä kuin sähköturvallisuustekijät
    - Olen täysin samaa mieltä
    - Olen osittain samaa mieltä
    - Olen osittain eri mieltä
    - Olen täysin eri mieltä

22. Työn tekeminen nopeasti ja sujuvasti on mielestäni tärkeämpää kuin työn tekemistä sähköturvallisesti
    - Olen täysin samaa mieltä
    - Olen osittain samaa mieltä
    - Olen osittain eri mieltä
    - Olen täysin eri mieltä

23. Jos työpaikallanne työnopastuksessa on ollut puutteita (ks. kohta 18), mitä puutteita on ollut?

24. Jos työpaikallanne ohjeissa on ollut puutteita (ks. kohta 19), mitä puutteita ja missä ohjeissa? (kirjalliset vai suulliset ohjeet, työohjeet, asennus- ja kunnossapito-ohjeet, tiettyjen ohjeiden saatavuus, ohjeiden kieli, jne)?

21. At my workplace economical factors seem to be more important than electrical safety
    - I agree
    - I partly agree
    - I partly disagree
    - I disagree

22. Completing your work swiftly and flowingly is more important than working safely
    - I agree
    - I partly agree
    - I partly disagree
    - I disagree

23. If guidance at your workplace has been insufficient (see question 18), what has been lacking?

24. If instructions at your workplace have been insufficient, what has been lacking and in which instructions (written or verbal instructions, work instructions, installation and maintenance instructions, availability of certain instructions, language problems etc.)?

25. Jos joku työskentelee sähkötöissä ei-turvallisesti, mistä se todennäköisimmin johtuu?
    - Hän ei ole saanut riittävästi ohjausta turvalliseen työskentelyyn
    - Hän ei tiedä työskentelevänsä väärin
    - Hänen on saatava työ nopeasti tehdyksi
    - Hänellä ei ole käytössään sopivia työkaluja tai työvälineet eivät ole käyttökunnossa
    - Hän ei ole motivoitunut työskentelemään turvallisesti

25. If someone performs electrical work unsafely, what is most probably the reason?
    - He/she hasn't received enough guidance on safe working methods
    - He/she doesn't know that he/she is working unsafely
    - He/she must finish the job quickly
    - He/she hasn't got proper tools or the tools are not in working order
    - He/she isn't motivated to work safely

26. Oletteko joskus tehnyt töitä jännitteisessä kohteessa?
    - Kyllä
    - En

26. Have you ever worked with a live installation?
    - Yes
    - No

27. Onko työryhmäänne nimetty sähköturvallisuustoimien valvoja?
    - Aina
    - Yleensä
    - Joskus
    - Harvoin

27. Has someone in your work group been names the person in control of electrical safety during work?
    - Always
    - Usually
    - Sometimes
    - Seldom

28. Onko kaikkien tiedossa, kuka on tämä sähköturvallisuustoimien valvoja?
    - Aina
    - Yleensä
    - Joskus
    - Harvoin

29. Missä asemissa yleensä työskentelette? (Merkitkää ne, jotka kuvaavat Teitä parhaiten)
    - Työstä vastaava henkilö (esim. sähkötöiden johtaja)
    - Sähköturvallisuustoimien valvoja
    - Kärkimies
    - Työntekijä
    - Harjoittelija
    - Yksityisyrittäjä
    - Muu, mikä? ___

30. Millä toimialalla yritys/organisaatio (jossa työskentelette) pääasiallisesti toimii? (Merkitkää vain yksi)
    - Energia-ala (mm. verkonrakennus, sähkön siirto tai jakelu, verkonhaltija, sähköntuotanto)
    - Teollisuus (mm. sähkö, automaatio tai kunnossapito)
    - Kiinteistöasennukset ja talotekniikka
    - Muu, mikä?
    - En ole tällä hetkellä työelämässä mukana

28. Does everyone know who this responsible person is?
    - Always
    - Usually
    - Sometimes
    - Seldom

29. What are your usual positions in your organization? (Mark the ones that describe you best)
    - Person in control of work (e.g. in charge of electrical work)
    - Person in control of electrical safety during work
    - Work group organizer/ spokesperson at work location
    - Worker
    - Trainee
    - Private entrepreneur
    - Other, what? ___

30. In which sector does the company/organization you work for mainly operate? (Mark only one)
    - Energy (e.g. electrical network construction, transmission, distribution, owner, production)
    - Industry (e.g. electricity, automation or maintenance)
    - Real estate installations and building services engineering
    - Other, what?
    - I’m not working at the moment

31. Sukupuolenne
    - Mies
    - Nainen

32. Syntymävuotenne
    - 19__

33. Koulutuksenne (merkitkää kaikki ne kohdat, jotka koskevat Teitä)
    1) Yhden vuoden pituinen sähköalan koulutus
    2) Sähköalan kaksivuotinen ammatillinen perustutkinto
    3) Sähköalan kolmivuotinen ammatillinen perustutkinto
    4) Sähköalan oppisopimuskoulutus suoritettu hyväksytysti
    5) Sähköalan ammattitutkinto
    6) Sähköalan erikoisammattitutkinto
    7) Sähköalan ammattitutkintoa tai erikoisammattitutkintoa vastaava tutkinto
    8) Sähköalan teknikon tutkinto
    9) Sähköalan insinöörin tutkinto
    10) Sähköalan tekniikan ammattikorkeakoulututkinto (insinööri amk)
    11) Sähköalan diplomi-insinöörin tutkinto
    12) Sähköalan perustiedot hankittu muilla keinoin kuin yllämainituilla (1-11) koulutustavoilla, miten? ___

31. Your gender
    - Male
    - Female

32. Your year of birth
    - 19__

33. Your educational background (mark all those that concern You)
    1) One-year electrical training
    2) Two-year vocational electrical training
    3) Three-year vocational electrical training
    4) Vocational electrical apprenticeship finished and credited
    5) Vocational electrical degree
    6) Specialized vocational electrical degree
    7) Electrical degree comparable to vocational or specialized vocational degree
    8) Degree of electrical technician
    9) Degree of electrical engineer
    10) Higher vocational diploma in electrical engineering
    11) Master of science in electrical technology
    12) Basic electrical knowledge acquired in some other way than those mentioned above (1-11), how?

34. Oletteko ammattitaitoinen tekemään sähkövoima-alan töitä? (ks. saatesivu)
    - Kyllä
    - Kyllä, mutta vain yksittäiseen sähkölaite- tai sähkölaitteistoryhmään kohdistuvia töitä
    - En

34. Are you a professional in power engineering? (See foreword page)
    - Yes
    - Yes, but only with certain electrical appliances or installations
    - No

35. Oletteko käynyt jännitetöiden tekemiseen vaadittavan kurssin?
    - Kyllä
    - En

35. Have you taken part in the obligatory course for working live?
    - Yes
    - No

36. Minä vuonna saavutitte ammattitaidon tehdä itsenäisesti sähkötöitä? (Ks. saatesivu) Mikäli olette vasta kouluttautumassa, merkitkää minä vuonna saavutatte ammattitaidon tehdä itsenäisesti sähkötöitä
    - Vuonna ____

36. When did you become an electrical professional? (See foreword page) If you are still studying, when will you become a professional
    - Year ____

37. Oletteko ollut siitä asti sähköalan töissä?
    - Kyllä, koko ajan tai lähes koko ajan
    - En, mutta olen ollut sähköalan töissä vuosina ____

37. Have you done electrical work ever since?
    - Yes, ever since, or nearly
    - No, but I have worked as a professional during the years ____

38. Kuinka suuren osan työtehtävistänne teette työpöydän ääressä (ei ruumiillista työtä)?
    - ____ % työajasta

38. How much of your work is at-desk work (non-physical work)?
    - ____ % of work time

39. Milloin olette viimeksi saanut sähkötyöturvallisuuskoulutusta?
    - Vuonna ____

39. When was the last time you received occupational electrical safety training?
    - Year ____

40. Mikä seuraavista kuvaa parhaiten asemanne organisaatiossanne (työnne vastuita ja velvollisuuksia ajatellen)?
    - Esimiesasemassa oleva (esim. työnjohto)
    - Työntekijä
    - Yksityisyrittäjä
    - Muu, mikä? ____

40. Which of the following describes best your position in your organisation (concerning your responsibilities and obligations)?
    - Manager (e.g. supervisor)
    - Employee
    - Private entrepreneur
    - Other, what? ____

41. Työnantajanne (yritys/organisaatio), on henkilöstömäärän perusteella:
    - Mikroyritys (alle 10 henkeä)
    - Pienyritys (10-49 henkeä)
    - Keskisuuri yritys (50-249 henkeä)
    - Suuryritys (250 henkeä tai enemmän)

41. How many employees does your employer (company/organisation) have?
    - Micro-organization (less than 10 employees)
    - Small organization (10 to 49 employees)
    - Medium-sized organization (50 to 249 employees)
    - Large organization (250+ employees)

42. Missä lääneissä olette viimeisen 12 kuukauden aikana tehnyt töitä?

- Etelä-Suomen läänissä
- Länsi-Suomen läänissä
- Itä-Suomen läänissä
- Oulun läänissä
- Lapin läänissä
- Ahvenanmaalla

42. In which provinces have you worked in during the last 12 months?

- Southern province
- Western province
- Eastern province
- Province of Oulu
- Province of Lapland
- The Åland Islands

Appendix 2: Theme interview questions

Background questions

A. Missä asemissa yleensä työskentelet? Merkitse ne, jotka kuvaavat sinua parhaiten

- Työstä vastaava henkilö (esim. sähkötöiden johtaja)
- Sähköturvallisuustoimien valvoja
- Kärkimies
- Työntekijä
- Harjoittelija
- Yksityisyrittäjä
- Muu, mikä?

B. Sukupuolesi

- Mies
- Nainen

C. Syntymävuotesi

- 19_____

D. Koulutuksesi. Merkitse kaikki ne kohdat, jotka koskevat sinua

1) Yhden vuoden pituinen sähköalan koulutus
2) Sähköalan kaksivuotinen ammatillinen perustutkinto
3) Sähköalan kolmivuotinen ammatillinen perustutkinto
4) Sähköalan oppisopimuskoulutus

A. What is your usual position in your organization? (Mark the ones that describe you best)

- Person in control of work (e.g. in charge of electrical work)
- Person in control of electrical safety during work
- Work group organizer/spokesperson at work location
- Worker
- Trainee
- Private entrepreneur
- Other, what? ___

B. Gender

- Male
- Female

C. Your year of birth

- 19_____

D. Your educational background. Mark all those that concern You

1) One-year electrical training
2) Two-year vocational electrical training
3) Three-year vocational electrical training
4) Vocational electrical apprenticeship

suoritettu hyväksytysti

5) Sähköalan ammattitutkinto
6) Sähköalan erikoisammattitutkinto
7) Sähköalan ammattitutkintoa tai erikoisammattitutkintoa vastaava tutkinto
8) Sähköalan teknikon tutkinto
9) Sähköalan insinöörin tutkinto
10) Sähköalan tekniikan ammattikorkeakoulututkinto (insinööri amk)
11) Sähköalan diplomi-insinöörin tutkinto
12) Sähköalan perustiedot hankittu muilla keinoin kuin yllämainituilla (1-11) koulutustavoilla, miten?

finished and credited

5) Vocational electrical degree
6) Specialized vocational electrical degree
7) Electrical degree comparable to vocational or specialized vocational degree
8) Degree of electrical technician
9) Degree of electrical engineer
10) Higher vocational diploma in electrical engineering
11) Master of science in electrical technology
12) Basic electrical knowledge acquired in some other way than those mentioned above (1-11), how?

E. Oletko ammattitaitoinen tekemään sähkövoima-alan töitä?

- Kyllä
- Kyllä, mutta vain yksittäiseen sähkölaite- tai sähkölaitteistoryhmään kohdistuvia töitä
- En

E. Are you a professional in electric power systems? (See foreword page)

- Yes
- Yes, but only with certain electrical appliances or installations
- No

F. Oletko käynyt jännitetöiden tekemiseen vaadittavan kurssin?

- Kyllä
- En

F. Have you taken part in the obligatory course for working live?

- Yes
- No

G. Minä vuonna saavutit ammattitaidon tehdä itsenäisesti sähkötöitä? Mikäli olet vasta kouluttautumassa, merkitse minä vuonna saavutat ammattitaidon tehdä itsenäisesti sähkötöitä

- Vuonna ________________

H. Oletko ollut siitä asti sähköalan töissä?

- Kyllä, koko ajan tai lähes koko ajan
- En, mutta olen ollut sähköalan töissä vuosina: ______________________

I. Kuinka suuren osan työtehtävistäsi teet työpöydän ääressä (ei ruumiillista työtä)?

- _____ % työajasta

J. Milloin olet viimeksi saanut sähkötyöturvallisuuskoulutusta?

- _________

K. Mikä seuraavista kuvaa parhaiten asemaasi organisaatiossanne (työsi vastuita ja velvollisuuksia ajatellen)?

- Esimiesasemassa oleva (esim. työnjohto)
- Työntekijä
- Yksityisyrittäjä
- Muu, mikä? ____

L. Missä lääneissä olet viimeisen 12 kuukauden aikana tehnyt töitä?

- Etelä-Suomen läänissä
- Länsi-Suomen läänissä

G. When did you become an electrical professional? If you are still studying, when will you become a professional?

- Year ____

H. Have you done electrical work ever since?

- Yes, ever since, or nearly
- No, but I have worked as a professional during the years _________________________

I. How much of your work is at-desk work (non-physical work)?

- ____ % of work time

J. When was the last time you received occupational electrical safety training?

- ________

K. Which of the following describes best your position in your organisation (concerning your responsibilities and obligations)?

- Manager (e.g. supervisor)
- Employee
- Private entrepreneur
- Other, what? ____

L. In which provinces have you worked in during the last 12 months?

- Southern province
- Western province

- Itä-Suomen läänissä
- Oulun läänissä
- Lapin läänissä
- Ahvenanmaalla

M. Oletko osallistunut keväällä 2004 tehtyyn kyselyyn, jossa kysyttiin sähköalan ammattilaisten sähkötapaturmista (kysymykset lähetettiin etukäteen postitse, minkä jälkeen haastattelu tehtiin puhelimitse)?

- Kyllä
- En

N. Oletko koskaan loukkaantunut sähkötapaturmassa?

- Kyllä
- En

O. Kuulutko johonkin ammattiliittoon, mihin?

- ______________________________

- Eastern province
- Province of Oulu
- Province of Lapland
- The Åland Islands

M. Did you participate in the questionnaire survey made in spring 2004? The survey dealt with electrical accidents of electrical professionals (questions were sent by mail beforehand and the actual survey was made on the phone).

- Yes
- No

N. Have you ever been injured in an electrical accident?

- Yes
- No

O. Are you a member of a trade union? Which?

- ______________________________

The Interview

Sähkötyöturvallisuus & sähkötapaturmat	***Occupational electrical safety & electrical accidents***
1. Miten kehittäisitte sähköalan ammattilaisten sähkötyöturvallisuutta?	1. How would you improve the electrical safety of electrical professionals?
2. Millaisia hyviä sähkötyöturvallisuuskäytäntöjä teillä on jo käytössä / olette kuulleet?	2. What kind of good electrical safety practices do you have in use or heard of?
Sähkötapaturma ei yleensä johdu vain yhdestä syystä (esim. työntekijän huolimattomuudesta), vaan tapaturman taustalla voi olla useita eri syitä.	An electrical accident is usually not caused by one cause alone (e.g. carelessness of employees) but may instead have multiple causes.
3. Mistä teille sattuneet sähkötapaturmat ovat johtuneet? Mitkä ovat sähkötapaturmien taustalla olleet tekijät?	3. What have been the causes of your electrical accidents? What were the causes behind the immediate causes of the electrical accidents?
Työskentely jännitteisessä kohteessa	***Working with a live installation***
Sähköalan ammattilaisille tehdyn kyselyn tulosten mukaan 94 % vastaajista oli joskus tehnyt töitä jännitteisessä kohteessa, mutta vain 66 % oli suorittanut luvallisten jännitetöiden tekemiseen vaadittavan jännitetyökurssin. Työn tekemiseen jännitteisenä sekä jännitteettömyyden	The results of a survey directed to electrical professionals showed that 94 percent of the respondents had worked live but only 66 percent had participated in the course needed for live working. The causes mentioned for unauthorized live working and the omission of testing and earthing were various:

toteamisen ja työmaadoittamisen laiminlyömiseen kerrottiin useita eri syitä; organisatorisia, teknisiä ja työntekijästä itsestään johtuvia.	organizational, technical and employee-related.
4. Työ tehdään usein jännitteisenä, vaikka turvallinen työskentely edellyttäisi jännitteettömyyttä. Miten ”luvatonta” jännitetyötä voisi vähentää?	4. Work is often done live although safe working demands for de-energizing. How could unauthorised live working be reduced?
5. Jännitteettömyys saatetaan jättää toteamatta. Miten jännitteettömyyden tarkistaminen saataisiin kaikkien tekemäksi työvaiheeksi?	5. Voltage testing may be neglected. How can voltage testing be made a routine procedure to everyone?
6. Työmaadoittaminen saatetaan jättää tekemättä. Miten työmaadoittamista saataisiin yleistettyä?	6. Earthing may be neglected. How can earthing be increased?

Kiire	***Hurry***
Lähes joka kolmas sähköturvallisuusky-selyn vastaaja koki kiireen suurimmaksi riskiksi sähkötyöturvallisuudelle.	Nearly every third respondent of the electrical safety survey believed hurry to be the biggest electrical safety risk.
7. Mistä kiire teidän työssänne johtuu?	7. What causes hurry in your work?

Yksintyöskentely	*Working alone*
Kyselyn vastausten mukaan yksintyöskentely koettiin toiseksi suurimmaksi sähköalan ammattilaisten sähkötyöturvallisuusriskiksi (suurin riski kiire).	According to the survey results working alone is the second biggest occupational electrical safety risk (biggest is hurry).
8. Missä töissä/työvaiheissa tai minkälaisissa töissä yksintyöskentely on selkeä vaaratekijä?	8. When do you consider working alone hazardous? In which jobs or working phases it is a risk?
9. Mikä tekee yksintyöskentelystä näissä töissä vaarallista?	9. Why is working alone hazardous in those jobs/phases?

Alihankinta / urakointi	*Contracting / outsourcing*
10. Alihankinta ja urakoitsijoiden käyttäminen on lisääntynyt paljon viime vuosina. Sen seurauksena on nykyään paljon yhteisiä työmaita, joilla työskentelee yhtä aikaa usean eri yrityksen työntekijöitä. Mitkä ovat yhteisten työpaikkojen aiheuttamat sähkötyöturvallisuusriskit ja Miten yhteisten työpaikkojen sähkötyöturvallisuutta voitaisiin parantaa?	10. Contracting and the use of contract workers has increased substantially during the last years. As a consequence there are lots of shared workplaces with employees of many companies working simultaneously. What particular occupational electrical safety hazards do shared workplaces have? How could the level of occupational electrical safety of shared workplaces be improved?

Sähkötyöturvallisuus ja tekniikka	***Technology and electrical safety***
Sähköturvallisuuskyselyssä mainittiin usein nykyteknologian aiheuttamaksi sähkötyöturvallisuusongelmaksi kauko-ohjaus, kaukokäynnistykset, automaation aiheuttamat käynnistymiset ”itsekseen”, jne.	According to the survey results electrical safety problems caused by modern technology are e.g. remote control, remote start-ups and automated machinery "starting itself" etc.
11. Miten nämä ”itsekseen käynnistymiset” ja niiden aiheuttamat sähkötapaturmariskit voitaisiin estää?	11. How can these accidental start-ups and the electrical accident risks they cause be prevented?
Kyselyssä pyydettiin nimeämään sähköturvallisuuden suhteen vaarallisin laite, jonka kanssa vastaaja joutuu työskentelemään. Ylivoimaisesti vaarallisimmaksi laitteeksi nimettiin keskukset (keskus, sähkökeskus, ryhmäkeskus, jakokeskus, sähköpääkeskus, moottorikeskus, logiikkakeskus, syöttöpääkeskus, nousukeskus, avokeskus, ohjauskeskus, voimavirtakeskus, mittarikeskus, mittauskeskus, varavoimakeskus, vahvistinkeskus, avojakokeskus, työmaakeskus sekä yleensä jännitteiset, vanhat tai kosketussuojaamattomat keskukset).	In the enquiry the respondents were asked to name the most hazardous device that they had to work with. The most hazardous device, by far, were switchboards, especially old ones.
12. Miten keskusten vaarallisuutta / tapaturmariskiä voitaisiin vähentää?	12. How can switchboards be made less hazardous?

Noin 80 % sähköturvallisuuskyselyyn vastanneista kertoi, että tieto- ja viestintätekniikan kehittymisen ja lisääntymisen vaikutukset ovat sähkötyöturvallisuuden kannalta olleet enimmäkseen myönteisiä.	About 80 % of the respondents of the electrical safety questionnaire told that the development and increase of information and communication technology has had a mainly positive effect on occupational electrical safety.
13. Millä tavoin nykytekniikka on parantanut sähkötyöturvallisuutta?	13. How has modern technology improved occupational electrical safety?
14. Entä onko vähentänyt sähkötyöturvallisuutta, miten?	14. Has it also decreased occupational electrical safety? How?

Koulutus	***Education***
15. Mitä mieltä olet sähköalan koulutuksen laadusta tällä hetkellä? - Antaako koulutus riittävät valmiudet työelämää varten? - Puuttuuko juuri koulusta työelämään astuneilta joitakin perustietoja sähkötöistä, mitä tietoja puuttuu? - Aiheuttaako se riskin työturvallisuudelle?	15. How do you feel about the quality of electrical education today? - Does the education give sufficient readiness for working life? - Do the newly graduated workers lack some basic knowledge of electrical work? What knowledge? - Does that cause a risk to occupational safety?

Appendix 3: Causes of hurry – question asked during the theme interviews

Onko kiireen syynä...

(valitse ja rastita seuraavista kolme suurinta kiireen syytä)

1. ...Organisaatio
   - Henkilökunnan riittämättömyys ja töiden lisääntyminen
   - Organisaatio vaatii lisää tehokkuutta
   - Organisaatiomuutokset ja kehittäminen
2. ...Työyksikkö/esimies
   - Esimies ei pidä alaisten puolia
   - Ongelmat työnjaossa ja töiden organisoinnissa
   - Liian kireät aikataulut
3. ...Työtehtävä
   - Työ on vaativampaa kuin ennen
   - Työtehtävät ovat monipuolistuneet
   - Keskeytykset, työpäivän sirpaloituminen
   - Asiakastyö
   - ATK lisää tai hankaloittaa työtä
   - Vaikea suunnitella työtään
4. ...Yksilö
   - Itseaiheutettua

The causes of hurry are…

(choose the three biggest causes of hurry)

1. …Organization
   - Lack of human resources and increased amount of work
   - Organisation demands more efficiency
   - Organizational changes and development
2. …Work unit / supervisor
   - Supervisor doesn’t stand up for his/her subordinates
   - Problems with work distribution and organizing of work
   - Too tight schedules
3. …Work task
   - Work has become more demanding
   - Work has become more versatile
   - Interruptions, fragmentation
   - Work with customers
   - IT increases the amount of work or makes work more difficult
   - It is difficult to plan your work
4. …The individual
   - Self-caused

Jako kiireen syihin / Classification of hurry:

Järnefelt & Lehto. 2002. Työhulluja vai hulluja töitä? Tutkimus kiirekokemuksista työpaikoilla. Tilastokeskus. [Work crazy or crazy work? Investigation of perceived hurry at work, published by Statistics Finland, in Finnish]

Appendix 4: Worksite safety checklist

The content of the checklist (numbered questions) and the additional questions

1. Toimenpiteet ennen työsuoritusta

Töiden suunnittelu

1.1 Oliko työn kohde sinulle entuudestaan tuttu?

- Miten sait tietoa?
- Miten tutustuit kohteeseen? (esim. itse laitteistoon & työtehtävään)

1.2 Jos kohde ei ollut ennestään tuttu, saitko ennakkoon tietoa millaiseen kohteeseen menet työskentelemään?

- Miten?

1.3 Oliko työ suunniteltu etukäteen?

Suunnitelma työkohteen jännitteettömäksi tekemisestä

1.4 Tunnetko laitoksen sähköverkon rakenteen ja kytkentäjärjestyksen?

1. Measures before the actual task

Planning the task at hand

1.1 Were you already familiar with this particular installation?

- How did you get information?
- How did you familiarise yourself with the installation? (e.g. with the machinery and task)

1.2 If you were not already familiar with the installation, did you get any information about the site beforehand?

- How?

1.3 Was the task planned in advance?

Plan to de-energize the installation

1.4 Do you know the structure of the electrical network and the proper switching sequence of the facility?

1.5 Tiedätkö, kuinka työkohteen saa jännitteettömäksi?
- Onko jännitteettömäksi tekeminen hankalaa?
- Miksi?
- Opastaako joku tarvittaessa kohteen jännitteettömäksi tekemisessä?
- Kuka tekee päätöksen jännitteisenä työskentelystä?

1.6 Onko työstä laadittu kirjallinen suunnitelma?

1.7 Jos suunnitelma on tehty, teetkö työn suunnitelman mukaan?
- Miksi et?

Työvälineet

1.8 Ovatko kaikki tarvittavat työvälineet mukana?
- Missä vaiheessa tarvittavien työvälineiden mukanaolo tarkistetaan? a) ennen työmaalle lähtöä, b) ennen työn aloittamista, c) kun työvälinettä tarvitaan käyttöön (työsuorituksen aikana)

1.9 Ovatko työvälineet toimintakunnossa?
- Missä vaiheessa tarvittavien työvälineiden toimivuus tarkistetaan? a) ennen työmaalle lähtöä, b) ennen työn aloittamista, c) kun työväline tarvitaan käyttöön (työsuorituksen aikana)

1.5 Do you know how to de-energize the installation?
- Is the de-energizing difficult?
- Why?
- Is there guidance available for the de-energizing of the installation?
- Who decides whether work is done live?

1.6 Do you have a written work plan?

1.7 If a plan has been made do you work according to it?
- Why not?

Tools

1.8 Are all the necessary tools along?
- When do you check that you have the necessary tools along? a) before departing to the work site, b) before starting work, c) when you need the tool (during work)

1.9 Are the tools in working condition?
- When do you check the condition of the tools? a) before departing to the work site, b) before starting work, c) when you need the tool (during work)

Töiden aloittaminen

1.10 Saadaanko sähkölaitteiston käytöstä vastaavalta lupa töiden aloittamiseen?
- Miten päätetään työn aloittamisesta?
- Miten lupa annetaan?

Beginning work

1.10 Do you receive permission to start work from the person in control of the operation activity?
- How is it decided when work begins?
- How is the permission given?

2. Työkohteen turvalliseksi tekeminen

2. Making the work object safe to operate with

Täydellinen erottaminen

2.1 Erotetaanko sähkönsyöttö kaikista syöttösuunnista?
- Miten?
- Entä miten varmistetaan, että todella on erotettu kaikista syöttösuunnista?

2.2 Huomioitko erotuksessa kauko- ja paikallisohjaukset?

2.3 Huomioitko erotuksessa rinnakkaisten jännitteiden mahdollisen olemassaolon?

2.4 Huomioitko erottamisessa mahdollis-ten varageneraattoreiden tai aggregaattien päällekytkeytymisen/-kytkennän?

2.5 Puretaanko mahdollinen vaarallinen varausjännite sähkölaitteistosta? (kaapelit, kondensaattorit,..)

Complete separation

2.1 Is power supply disconnected from all supply directions?
- How?
- How do you ensure that every direction has been separated?

2.2 In the disconnecting process, do you take into account remote and local controls?

2.3 In the separation process, do you take into account the possibility of other voltages?

2.4 In the separation process, do you take into account that back-up generators and aggregates might turn on / be turned on?

2.5 Do you discharge the possible dangerous charged voltage from the electrical system? (cables, capacitors...)

2.6 Todetaanko, että varausjännite on purkautunut?

Jännitteen kytkemisen estäminen

2.7 Käytetäänkö lukituksia (ei avattavissa ilman työkaluja) estämään jännitteen kytkeytyminen työn aikana?

- Miksi lukitukset yms. jätetään joskus laittamatta? (ei estetä fyysisesti jännitteen takaisinkytkentää)

2.8 Merkitäänkö jännitteettömäksi tehty kohde? (esim. kylteillä, teipeillä, lippusiimalla?)

- Miten?

2.9 Ilmoitetaanko jännitteettömyydestä työmaalla?

- Kenelle ilmoitetaan?
- Miten?

Jännitteettömyyden toteaminen

2.10 Onko mukana välineet jännitteettömyyden toteamiseen?

- Millä jännitteettömyys todetaan?

2.11 Todetaanko mittalaitteen toimivuus tarkistusmittauksella välittömästi ennen varsinaista käyttöä?

2.12 Todetaanko jännitteettömyys työalueen kaikista osista?

2.6 Do you confirm that the voltage has been discharged?

Preventing re-energizing

2.7 Do you use lockings (that cannot be opened without tools) to prevent re-energizing during work?

- Why is locking etc. sometimes omitted? (re-energizing in not tangibly prevented)

2.8 Do you mark the de-energized installation? (e.g. with signs, tapes or sealing-off line?)

- How?

2.9 Is someone informed that the installation has been de-energised?

- Who is informed?
- How?

Testing for voltage

2.10 Do you have along the necessary tools to test the voltage?

- How do you test that the installation is dead?

2.11 Do you ensure the functioning of your tester immediately before performing the test?

2.12 Is each part of the work area tested?

Työmaadoittaminen	*Earthing*
2.13 Todetaanko työmaadoitustarve? - Miten?	2.13 Do you evaluate the need for earthing for work? - How?
2.14 Onko sopivia työmaadoitusvälineitä riittävä määrä kaikkien työalueella olevien osien työmaadoittamiseen? - Miten määritetään, mitkä kaikki suunnat maadoitetaan?	2.14 Do you have enough earthing equipment to earth all parts of the installation? - How do you decide which directions are earthed?
2.15 Huomioidaanko maadoittamisessa kaikki maadoittamissuunnat, myös kuorman suunta (varageneraattorien ja aggregaattien mahdollinen olemassaolo)?	2.15 Do you take into account every direction when earthing the installation, also the direction of the load (possibility of existence of back-up generators and aggregates)?
2.16 Varmistetaanko työmaadoitusvälineiden pysyminen paikallaan?	2.16 Do you ensure that the earthing equipment hold?
2.17 Ovatko työmaadoituskohta ja -välineet nähtävissä työpisteestä? - ts. miten kohde havaitaan työmaadoitetuksi?	2.17 Can you see the earthing point and earthing equipment from the place where you work? - In other words, how do you detect that the installation has been earthed?

3. Työ

Henkilösuojaimet ja suojukset

3.1 Voiko suojaimia säilyttää ja huoltaa tällä työmaalla/autossa?
- Missä säilytetään? Missä huolletaan?

3.2 Onko käytössä suojia, jotka kestävät riittävän hyvin sähköistä ja mekaanista rasitusta?

3.3 Joudutaanko työn aikana jännitteisten osien läheisyyteen?

3.4 Suojaatko lähellä olevat jännitteiset osat (suojus jännitteisen osien ja työskentelykohdan väliin)?

3.5 Varmistatko riittävän etäisyyden jännitteisiin osiin (myös kohteeseen tultaessa ja poistuttaessa)?

3.6 Tarkistatko keskuksissa, että työkohteen alapuolelle ei pääse putoamaan mitään (riittävät putoamisen suojat)?

Keskeytykset

3.7 Lukitaanko sähkökeskukset ja työtilat, jos työ joudutaan keskeyttämään? (yö, ruokailu, kahvitauko, välissä tehtävät työt)
- Milloin lukitaan, milloin ei?

3. Work

Personal protective equipment

3.1 Can you store and maintenance protective gear at the work site or in your car?
- Where do you store? Where do you maintenance?

3.2 Does the protective equipment sufficiently endure electrical and physical strain?

3.3 Are you in the vicinity of live parts during work?

3.4 Do you cover nearby live parts (physical barriers between live parts and work area)?

3.5 Do you ensure an adequate distance to live parts (also when arriving / leaving)?

3.6 When working with a switchboard, do you make sure that nothing can drop below the work area (sufficient protection against drops)?

Interruptions

3.7 Do you lock the switchboard and working facilities if work is interrupted? (night, lunch, coffee break, in-between work)
- When are they locked, when not?

3.8 Tarkastetaanko jännitteettömyys, kun palataan kohteeseen?

- Milloin tarkistetaan, milloin ei?
- Miten tarkistetaan?

3.8 Is voltage tested upon return?

- When is it tested, when not?
- How is it tested?

Valvonta

3.9 Valvooko joku, että kaikki em. sähkötyöturvallisuustoimenpiteet (jännitteen katkaisu, kytkemisen estäminen, jännitteettömyyden toteaminen, työmaadoittaminen) toteutetaan?

- Kuka?

3.10 Puuttuuko kukaan (lähiesimies, työtoveri, sinä itse) epäkohtiin työolosuhteissa tai työmenetelmissä?

- ml. suojainten käyttö, turvallisesti työskentely. Kuka puuttuu?

Supervision

3.9 Does someone supervise that all electrical safety measures (de-energizing, preventing re-connection, testing, earthing) are taken?

- Who?

3.10 Does someone (foreperson, co-worker, yourself) intervene if working conditions or practises are inappropriate?

- including the use of protective gear and working in a safe way. Who intervenes?

Työvälineet

3.11 Jonkin työvälineen puuttuessa lähdetäänkö hakemaan sitä?

- Vai käytätkö mitä sattuu olemaan?

Tools

3.11 If some tool is missing do you go get one?

- Or do you make do with the tools at hand?

4. Toimenpiteet ennen jännitteen kytkentää

Varmistaminen

4.1 Varmistetaanko ennen jännitteen kytkemistä, että kukaan ei enää työskentele laitteistossa ja että sivullisiakaan ei ole vaara-alueella?

- Miten varmistetaan?
- Kenen luvalla jännitteen kytkentä tapahtuu?

Jännitteen kytkemisen esteiden poistaminen

4.2 Poistetaanko kaikki työmaadoitukset?

- Voiko osa jäädä poistamatta?
- Miksi?

4.3 Poistetaanko lukot, kyltit, suojat, teipit?

- Missä järjestyksessä poistetaan, voiko jäädä poistamatta?

4.4 Poistettiinko laitteet aloittaen työalueesta ja edeten ulospäin?

- Jos ei, onko joku muu tapa parempi (turvallisuuden kannalta)?

4. Measures before re-energizing

Ensuring

4.1 Do you ensure before re-energizing that no one is working with the installation and that there are also no outsiders in the danger area?

- How is this ensured?
- Who gives permission to re-energize?

Taking down the preventive barriers

4.2 Are all the earthing equipment removed?

- Is there a possibility that some earthing equipment remain?
- Why?

4.3 Are all the locks, signs, shields and tapes removed?

- In which order are they removed, is there a possibility that some remain?

4.4 Are the equipment removed starting with the ones nearest the worksite and moving outwards?

- If not, is there some better way (from the safety point of view)?

Ilmoitukset

4.5 Ilmoitatko kohteessa työn valmistumisesta?

- Kenelle kaikille ylipäänsä ilmoitat työn valmistumisesta?

Informing

4.5 Do you inform someone at the worksite when work is completed?

- Who do you inform of the completion of the work?

5. Jännitteen kytkentä

5. Re-energizing

Jännitteen kytkeminen

5.1 Onko määritetty kuka kytkee jännitteen?

- Odotetaanko, että saadaan lupa jännitteen takaisinkytkemiseen?
- Keneltä?

Re-energizing

5.1 Has it been defined who performs the re-energizing?

- Do you wait for a permission to re-energize?
- From whom?

6. Työn lopettaminen

6. Ending work

Lopuksi tehtävät työt

6.1 Päivitätkö aina lopuksi piirustukset vastaamaan todellista tilannetta?

- Jos ei, kuka päivittää, milloin päivitetään, jääkö joskus päivittämättä?

6.2 Tehdäänkö työlle käyttöönottotarkastus ennen asennuksen tai sen osan käyttöönottoa? (myös ennen työmaa-aikaista käyttöä)

- Milloin?
- Kuka?

Work tasks performed at the end

6.1 Do you always update the diagrams to correspond with the new situation?

- If not, who updates, when are they updated and is the updating sometimes neglected?

6.2 Do you perform an initial verification before handing over the installation to use? (also before handing over to construction site use)

- When?
- Who?

7. Muuta

7.1 Poikettiinko työn aikana turvallisista toimintatavoista (jännitteen katkaisu, kytkemisen estäminen, jännitteettömyyden toteaminen, työmaadoittaminen)?

- Jos kyllä, miksi?

7.2 Oliko työn tekemisellä kiire?

- Miksi oli?

7.3 Oliko työ rutiinia? (tämän on tehnyt niin moneen kertaan ennenkin)

- Oliko rutiinia eli helppoa kun on vankka ammattitaito, vai rutiinia eli tylsää ja yksitoikkoista. (pos vai neg)

7.4 Oliko työ urakkaluonteista?

7.5 Tehtiinkö työ yksin?

7.6 Onko tiedonkulussa ongelmia, jotka vaikuttavat sähkötyön turvallisuuteen?

- Mitä?

7.7 Tuliko työn aikana yllättäen uutta tietoa liittyen työn tekemiseen?

7.8 Sattuiko työn aikana keskeytyksiä tai yllättäviä muutoksia työtehtävissä? (puhelin soi, jotakin muuta asiaa käytävä selvittämässä välillä, häiriöitä, poikkeavia tilanteita tms.)

7. Other

7.1 Were there deviations from safe working methods during work (de-energizing, preventing re-energizing, testing, earthing)?

- If yes, why?

7.2 Was the work supposed to be done quickly?

- Why?

7.3 Was it a routine job? (“This has been done so many times before”)

- Was it routine work because you’re a skilled professional or was the task just boring and monotonous (routine in a positive or negative way)?

7.4 Was the work paid by the job (as opposed to working on an hourly basis)?

7.5 Was the job done alone?

7.6 Are there problems in information flow that affect electrical safety?

7.7 During the task, did you unexpectedly receive new information concerning the task at hand?

7.8 During the task, were there interruptions or sudden changes in the work task? (Phone rang, you had to go deal with some other task leaving this work task unfinished, interruptions, deviations etc.)

7.9 Oliko työtä tekemässä usean yrityksen työntekijöitä? - Miten yhteistyö sujui? - Onko sovittu selkeä työnjako?	7.9 Were there employees from multiple companies working together? - How did the co-operation work? - Did you have a clear division of work?
Työkohde	***Installation area***
7.10 Oliko työkohteessa ergonomisia puutteita? (Oliko työtä tehtävä huonossa työasennossa tai ahtaassa tilassa?)	7.10 Were there ergonomic deficiencies? (Did you have to work in a bad position or in a narrow workspace?)
7.11 Oliko työkohteessa fysikaalisia vaaratekijöitä? (lämpötila, valaistus, tärinä, melu, säteily, vetoisuus, kosteus)	7.11 Were there physical hazards at the work area? (temperature, lighting, vibration, noise, radiation, draft, moisture)
7.12 Oliko työkohteessa kemiallisia tai biologisia vaaratekijöitä? (pöly, home, asbesti, kemikaalit,...)	7.12 Were there chemical or biological hazards at the work area? (dust, mould, asbestos, chemicals…)
7.13 Oliko kohteessa alunperin puutteelliset piirustukset tai muu dokumentaatio?	7.13 Were there deficiencies in the diagrams or other documentation?
7.14 Esiintyikö työn aikana tapaturmavaaroja, läheltä piti –tilanteita, tapaturmia?	7.14 Did any hazards, near misses or accidents occur during work?