



# FKH Safety Guidelines

03.06.2020

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# 1 The FKH's Mission Statement on Safety

- The FKH promotes its employees' safety and health by ensuring that its instructions, work organisation and training are suitable for this purpose.
- The FKH accords the highest priority to the health, safety and wellbeing of its employees and clients.
- At the FKH, safety culture is continuously monitored and verified, and all employees are included. New employees are familiarised with the FKH's safety provisions during the onboarding process.
- To ensure that the Mission Statement on Safety is effective, it is made known to the staff and put into practice by line managers and project managers.

## 2 Skills and qualifications of deployed staff

### 2.1 Project managers

Project managers have a higher level of electrotechnical training and, based on their experience and knowledge, rank as experts on handling electrotechnical installations.

Project managers are able to identify and avoid hazards that could arise during the use of electrical equipment and high-voltage test installations.

Project managers must have the knowledge required to perform the following activities:

- Manage high voltage inspections and tests.
- Plan, monitor and implement safety at work before and during high voltage inspections and tests.
- Provide guidance for project participants and instruct staff operating the test installations.

### 2.2 Instructed person

A person who can undertake limited and precisely defined activities in connection with the operation of electrical.

Before operating electrical test equipment, these persons receive instruction from the project manager to the extent required so that they can avoid hazards originating from the equipment. The equipment to be operated must be released in advance by an expert.

In addition, an instructed person must be familiar with the local conditions and safety measures to be implemented.

## 3 Safety at work

### 3.1 On-site high voltage inspections

The FKH undertakes:

- Work in plants that are in a de-energised (voltage-free) condition, and
- Work near live plant sections (see section 3.1.4) during which parts of a person's body, tools or other equipment reach the vicinity zone of plant sections where operating voltage is present, but without reaching the danger zone.

The FKH does not undertake any live-line work, i.e. work that involves body parts, tools or equipment reaching the danger zone of plant sections where an operating voltage is present (see section 3.1.4).

During on-site inspections, the FKH does not perform any switching operations whereby short-circuit currents in excess of 1 kA could occur. This work must be carried out by the plant operator's trained staff.

The operator shall ensure that plant sections to be inspected are disconnected from the power supply as per the **5 + 5 safety rules** issued by SUVA (Swiss National Accident Insurance Fund):

**For de-energised work:**

1. Disconnect and isolate on all sides
2. Safeguard against reconnection
3. Check that no voltage is present
4. Earth and short-circuit
5. Protect against adjacent live parts and sections

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1. Make sure that instructions are clear
2. Deploy suitable staff
3. Use safe working equipment
4. Wear protective equipment
5. Only put tested/inspected plants into operation

#### 3.1.1 Barricading and signage

The danger zone around the test installation must be secured so that no-one can enter it during the inspection (minimum distances: see section 3.1.3). The FKH's barricade sets (cords with warning flags, see on page 4) are generally used for this purpose.

If complete barricading is impossible due to practical reasons, supervisory staff must be deployed to control access to the test installation.



**Figure 1: Barricading the test installation with warning flag cords**

If live parts of the plant under inspection are located in closed rooms (e.g. open-air terminations in indoor installations), the access points should be guarded or closed off and FKH warning signs should also be positioned at such points. Suitable escape routes must be specified prior to inspections.

Members of the plant operator's staff responsible for the construction site must be informed about the inspection procedure and its progress, and about safety measures that are implemented.

The barricaded area must be released again after the HV inspection has been completed.

### 3.1.2 Safety circuit

A safety circuit must be installed that includes at least one emergency shutdown switch and is also equipped with acoustic and optical warning devices (signal siren and two warning lamps).

### 3.1.3 Distances between barricades and parts of the FKH test installation

The FKH's internal rule for the horizontal distance between barricades and HV parts is:

$$\text{Voltage (in } kV_{\text{eff}} \text{ for AC, } kV_{\text{max}} \text{ for impulse)} \times 0.01 \text{ m} + 1.5 \text{ m}$$

Additional distance when chain barricades are used

This rule also ensures compliance with the danger zone ("no-go zone") specified in standard EN 50191 for all forms of voltage (alternating voltage for test purposes, lightning impulse and switching impulse voltage). As EN 50191 allows shorter distances than the FKH rule in some cases, the table in EN 50191 should be consulted if space is limited (see Table 1 on page 5).

Tabelle A.2 – Verbotzone (s) in Abhängigkeit von Prüfspannungen gegen Erde (U)

Prüfwechselspannung 50/60 Hz (Effektivwert)		Blitzstoßspannung 1,2/50 µs (Scheitelwert)		Schaltstoßspannung 250/2 500 µs (Scheitelwert)	
U kV	s <sup>a</sup> mm	U kV	s mm	U kV	s mm
≤ 1	Keine Berührung	20	100	500	2 000
3	20	40	175	600	2 600
5	30	60	250	700	3 300
6	35	80	325	800	4 100
10	60	100	400	900	4 900
15	85	150	550	1 000	5 800
20	115	200	700	1 100	6 800
25	140	250	850	1 200	7 800
30	170	300	1 000	1 300	8 900
35	195	350	1 100	1 400	10 000
40	225	400	1 200	1 500	11 200
45	250	450	1 300	1 600	12 500
50	280	500	1 400		
55	305	600	1 650		
60	335	700	1 950		
70	390	800	2 200		
80	450	900	2 450		
90	510	1 000	2 700		
100	560	1 100	2 950		
110	620	1 200	3 250		
130	740	1 300	3 500		
150	860	1 400	3 750		
170	980	1 500	4 000		
190	1 100				
210	1 240				
220	1 300				
260	1 550				
300	1 850				
340	2 150				
380	2 450				
420	2 750				
460	3 100				
500	3 500				
600	4 500				
700	5 600				
800	6 900				
900	8 300				
1 000	9 900				

Zwischenwerte dürfen durch Interpolation gewonnen werden, eine lineare Extrapolation über die größten angegebenen Werte hinaus ist jedoch nicht zulässig. Für Prüfgleichspannungen bis 1 000 kV sind die Abstände s wie für Blitzstoßspannungen einzuhalten. Die Tabelle gilt nicht für hochfrequente oder andere nicht aufgeführte Spannungen.

\* s ist der Abstand in Luft von unter Spannung stehenden Teilen.

Table 1: Safety distances ("no-go zone") for HV inspections as per EN 50191

### 3.1.4 Safety distances for people from plant sections where operating voltage is present, as per EN 50110-1:2013

At the inspection site, the plant operator must ensure that plant sections carrying operating voltage are adequately secured.

The radii as per EN 50110-1 are applicable for this purpose (see on page 6). The radii of the vicinity zone (D<sub>V</sub>) and the danger zone (D<sub>L</sub>), in relation to the voltage level, are shown in Table 2.

If it is impossible to protect the live part with safety equipment such as covers, encapsulation or an insulating housing, etc., it must be ensured that the working distance is greater than the radius of the danger zone.

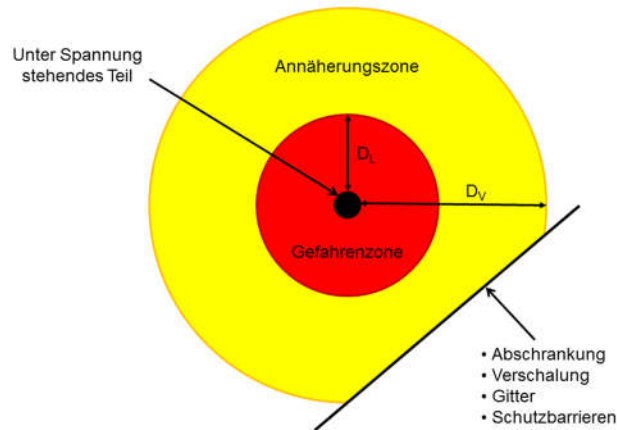


Figure 2: Definition of work zones as per EN 50110-1:2013

Operating voltage $U_N$ (effective value) [kV]	Acceptable minimum distance in the open which determines the outer boundary of the danger zone	Acceptable minimum distance in the open which determines the outer boundary of the vicinity zone
	$D_L$ [mm]	$D_V$ [mm]
$\leq 1$	No contact	300
3	60	1120
6	90	1120
10	120	1150
15	160	1160
20	220	1220
30	320	1320
36	380	1380
45	480	1480
60	630	1630
70	750	1750
110	1000	2000
132	1100	3000
150	1200	3000
220	1600	3000
275	1900	4000
380	2500	4000
480	3200	6100
700	5300	8400

Table 2: Radii of the vicinity and danger zones as per EN 50110-1:2013

### 3.1.5 Earthing

All parts of the test installation (the test source used and the measuring equipment) must be connected to the permanently installed earthing system (plant earthing) in a clearly identifiable manner. The standard for earthing connections is 35 mm<sup>2</sup> copper cable with yellow-green insulation. If possible, two independent earthing connections should be set up to earth the plant.

The plant undergoing inspection must be equipped with a suitable earthing device (e.g. an earthing rod) and must only be disconnected from the earth for the duration of the inspection or calibration.

For all HV inspections (except for earthing measurements), earthing must be in place between the plant section undergoing inspection and live operational plants (disconnection on its own is not sufficient).

For earthing and impedance measurements, it must be ensured that no dangerous voltages can be tapped from open cable ends during the installation work or the measurements.

### 3.1.6 HV capacitors

HV capacitors must be earthed consecutively after inspections. Impulse generator capacitors must be short-circuited for storage.

### 3.1.7 Communication during inspections

Communication between the test manager and all other persons involved (such as operating staff for the FKH HV source) must be precisely defined before the inspection begins. Suitable communication equipment must be used to communicate (radio sets, mobile telephones).

For sheath tests, the reporting system (notifications and feedback on phase changes), reporting pathways and persons involved must be precisely defined in advance.

Before inspection begins, the communication equipment must be checked to verify that it is in proper functioning order.

### 3.1.8 Additional information about on-site work safety

The following points must be noted when planning and carrying out on-site inspections. A checklist is available as an additional aid for verifying safety.

- **Advance planning**

Test safety should already be included in the preliminary discussions (reconnoitring). (In some cases, consideration of safety aspects during the test planning phase may facilitate protective measures that could not be implemented on site without preparations).

Obtain information about the plant operator's safety regulations.

- **Also pay attention to non-electrical dangers**

Mechanical stability of inspection setups and auxiliary installation equipment (check the surface beneath the setup, make ladders secure, brace high stacks of resonance reactors, protect HV connections against falling from a height).

- **Avoid time pressure**

Do not allow yourself to be put under time pressure by clients (who generally have less experience of the dangers and difficulties involved in tests: brief the client). Wherever reasonable, apply measures that result in increased safety for people and plant.

- **Redundancy in the inspection setup to ensure safety**

Insofar as possible, design the inspection setup so that one single error or omission, or the failure of one single component, will not result in dangerous situations.

- **Test procedure**

- As the test manager, you must carry out all safety-related checks yourself. Where appropriate, repeat the checks even if they have already been reported verbally by third parties.

- Draw up a written record of missing safety equipment and safety defects and take corrective action for future inspections.

## 3.2 Oil laboratory

### 3.2.1 Safety precautions for oil sampling (in clients' high-voltage installations)

#### General

- Have operating staff accompanied you all the way to the work location.
- Wear safety goggles when taking oil samples.
- Helmet, safety footwear and safety clothing, if requested by the client.

#### Sampling on transformers

For high-voltage transformers ( $U_n > 30$  kV), oil samples can usually be taken during operation. The client's operating staff are responsible for safety at work and they must release the work location (safety distances).

For medium-high voltage transformers ( $U_n \leq 30$  kV), the necessary safety distances are often not available. In this case, the transformer must be switched off and earthed for sampling.

#### Sampling on Buchholz relays

- The Buchholz relays are located between the expansion chamber and the transformer cover, so they are within a danger zone. **The transformer must be switched off and earthed!** Enquire and check (the earthing must be visible).
- One person from the plant in question must be present and release the work location for sampling.

#### Sampling on converters

- **The converter must be switched off and earthed!** Enquire and check (the earthing must be visible). Exceptions must be clarified before travelling to the site and discussed with the responsible member of the operating staff on site.

### 3.2.2 Safety precautions in the laboratory

Generally, only very little work is undertaken in the laboratory with substances that require special safety precautions.

In the infrequent case of work with concentrated acids and bases, it is necessary to wear safety goggles, gloves and (possibly) protective clothing.

No special station with eye-rinsing water is provided as a high-level water tap is positioned above the sink in the laboratory and a shower is available in the anteroom. Eyes can be rinsed in both locations.

Work with volatile, physiologically dangerous substances (e.g. chlorinated solvents) must be carried out under the laboratory hood.

Solvents must not be kept in refrigerators (danger of explosions).

The gas chromatograph (GC) requires hydrogen to operate. The hydrogen cylinder is located outdoors and is opened only while the GC is being operated. This makes it impossible for an ignitable gas mixture to develop in the laboratory if minor leaks occur.



### 3.3 Precautions against non-electrical hazards

#### 3.3.1 Safety during installation/assembly work at height

- Refer to the SUVA information sheet "Portable ladders"
- Before using a ladder: check condition, test stability.
- Stepladders over 2 m high must be equipped with a standing width extension.
- Ladders must only be used to carry out simple work at heights of up to 4 m. Assembly or installation work at a height of over 4 m must be carried out with a lifting platform.
- When lifting platforms are used, the instructions and regulations specified by the staff responsible for the lifting platform must be followed.

## 4 Personal protective equipment (PPA)

### 4.1 Basic principles

- Employees are obliged to obtain and use personal protective equipment in accordance with the employer's instructions.
- In third-party electrical installations, the plant operator's safety provisions are in force and must be clarified when planning inspections.

### 4.2 Work clothing/protective clothing

During work on/in electrical installations, the required degree of protection to be afforded by the clothing is based on the potential short-circuit currents.

As the possible short-circuit currents during FKH inspections are usually less than 1 kA, there are no specified requirements regarding fire protection/arc fault protection.

If the possible short-circuit current exceeds 1 kA, the provisions in Table 3 are applicable. As work of this sort is always an exceptional case, the protective measures should be discussed in advance.

Based on frequent requests from clients, the following points are considered when procuring work clothing:

- The colour of FKH work clothing should be signal orange and it should have double reflective strips as per EN 471 / EN ISO 20471:2013, class 2.

The following additional requirements apply to work for the SBB (Swiss Federal Railways): warning jackets are only permitted for site visits. For work in the track area, only orange high-visibility clothing as per EN 471 / EN ISO 20471:2013 is permitted. (A transition period is in force at SBB until the end of 2018, after which high-visibility clothing must be certified to EN ISO 20471:2013).

- Work jackets should meet fire protection requirements as per EN 61482-1-2 class 1.

Stufe	Entscheidungskriterien	Minimale Schutzkleidung
	<p>A) Kurzschlussstrom, an der Arbeitsstelle gemessen (L-PE) oder aufgrund von Notkenntnissen ermittelt.</p> <p><u>oder</u></p> <p>B) Wenn Kurzschlussstrom nicht bekannt: Vorgeschalteter Übersstromunterbrecher (Schmelzeinsatz kurzschlussstrombegrenzend, siehe 6.2.3)</p>	
0	Kurzschlussströme $\leq 1$ kA können bezüglich Störlichtbogengefahr als ungefährlich eingestuft werden.	Keine Vorgaben (Empfehlung: 100% Baumwolle)
①	<p>A) vorhandener Kurzschlussstrom <math>&gt; 1</math> kA <math>\leq 7</math> kA</p> <p><u>oder</u></p> <p>B) 16 A – 100 A (Diazed/NH)</p>	<p><b>Schutzkleidung Stufe 1</b></p> <p>1x Schutzkleidung nach EN 61482-1-2 Klasse 1</p> <p>– Schutzhelm mit Visier, Hitzeschutzhandschuhe, nach Gefahr ergänzt mit Isolierhandschuhen</p>
②	<p>A) vorhandener Kurzschlussstrom <math>&gt; 7</math> kA <math>\leq 15</math> kA</p> <p><u>oder</u></p> <p>B) 125 A – 200 A (NH)</p>	<p><b>Schutzkleidung Stufe 2</b></p> <p>2x Schutzkleidung Stufe 1</p> <p><u>oder</u></p> <p>1x Schutzkleidung nach EN 61482-1-2 Klasse 2</p> <p>– Schutzhelm mit Visier, Hitzeschutzhandschuhe, nach Gefahr ergänzt mit Isolierhandschuhen</p>
③	<p>A) vorhandener Kurzschlussstrom <math>&gt; 15</math> kA</p> <p>z.B. in Trafostationen mit Trafo 630 kVA</p> <p><u>oder</u></p> <p>B) <math>\geq 250</math> A (NH)</p>	<p><b>Schutzkleidung Stufe 3</b></p> <p>– 1x Schutzkleidung Stufe 1</p> <p><u>und</u></p> <p>– 1x Schutzkleidung Stufe 2</p> <p>– Schutzhelm mit Visier, Hitzeschutzhandschuhe, nach Gefahr ergänzt mit Isolierhandschuhen</p>

Table 3: Requirements for protective clothing for work in/on electrical installations (from ESTI (Federal Inspectorate for Heavy Current Installations) Guideline no. 407.0909 d

### 4.3 Safety footwear

In accordance with EN ISO 20345, safety footwear must be:

- Perforation-proof
- Fitted with steel toecaps
- Ankle-high.

## 4.4 Safety helmet

Work safety helmets must conform to DIN EN 397:2013-04. **The standard colour for newly procured equipment is orange.**

**Important:** At SBB, a white safety helmet identifies the member of a work group responsible for safety.

## 4.5 Protection against falling from a height

- To provide protection against falling from a height during transformer inspections and work on lifting platforms, full body harnesses as per DIN EN 361:2002-09 and energy absorbers as per DIN EN 355:2002-09 are used.

## 4.6 Protective eyewear/hearing protectors

- In a workshop, protective eyewear and hearing protectors must be used in accordance with the specific provisions for the relevant machinery/equipment.
- The on-site equipment chest should contain protective eyewear and hearing protectors.

## 4.7 Standard on-site equipment

The PPA to be taken along for on-site inspections comprises:

- Work clothing (upper garment and trousers) in signal orange with double reflective strips (as per section 4.2)
- Safety footwear as per section 4.3
- Safety helmet as per section 0
- Equipment to protect against falling from a height as per section 4.5

# 5 Emergency organisation

## 5.1 General

All members are familiarised with the emergency organisation and are provided with the relevant information. Employees should also familiarise themselves with escape routes and the locations of rescue equipment.

All FKH employees are trained in first aid for electrical accidents (basic course and periodic refresher courses).

## 5.2 On-site

Before testing begins, the client must provide information about its emergency organisation. This information must be followed by the FKH employees. If no emergency organisation is in place, emergency telephone numbers and connections must be clarified. First aid equipment must also be brought along for on-site inspections.