Title

Technical requirements Relay protection line bay 145 kV

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1 General

1.1 Scope

These requirements cover the general demands of E.ON Elnät Sverige AB in respect of relay protection and automatic systems for a 130 kV line bay.

Anläggningsdirektiv Regionnät (Facility Directive for the Regional Network) forms the basis for this document. Requirements that deviate from that document are specified in these Technical requirements.

These requirements are a translation to the Swedish requirements D10-0015690. If the content of this document differs from the Swedish version, the Swedish requirements shall prevail.

1.2 Standards

The relay protection must be designed, manufactured and tested in accordance with the most recent edition of applicable Swedish standards. In the absence of such standards, the European Standard (EN) and IEC publications apply.

In the event of disparities between this document and the relevant standard, these Technical Regulations shall apply.

1.3 Labelling

Rating plates shall include rating data for manufacturer and type, supply and operating voltage, manufacturing number, serial number and version number. Information shall be available without the need of dismantling.

2 Changes relative to previous issue

Changes are marked with a vertical line in the right-hand margin.

3 Electrical and mechanical requirements

See ”Facility directive Regional network”.

4 Functional requirements

4.1 General

Only functions specified in the technical specification by the client for protection and automatic systems shall be activated, all other functions shall be deactivated.
Information from protection and automatic systems shall be possible to obtain via contact functions and via station bus (IEC61850-8).
Protection/automatic systems shall be capable of communications via service-LAN. The data communication protocol shall be adapted to the applicable station control system specified in the technical specification.
Information can be divided up: information to operators via potential-free contacts and information for analysis (disturbance analysis) via data communications.

Protection functions in subsystem 1 (HS1/SUB1) can be integrated in the same physical unit. However, they may not be integrated in the same physical unit in subsystem 2 (HS2/SUB2). The same applies to protection functions fed from subsystem 2.
Automatic systems can be integrated in the same physical unit as the protection, automatic systems are typically grouped to subsystem 1.

For IO-functions, see appendix 1 and TR Signals for indications, operation and measurement values. Tripping and closing functions are specified in TS.
Time synchronised event and disturbance recorder shall be included in protection terminals.
Start and tripping signals according to TR Signals for indications, operation and measurement values to be indicated on terminal fronts via LEDs. Fault status indications for the terminal shall also be indicated via LEDs.
Event and disturbance recorder shall be possible to obtain from the protection according to TR STINA.

4.2 Requirements for Relay protection functions

4.2.1 Line differential protection

The protection shall trip its own circuit-breaker and start auto-reclosing if stated in the TS.
The protection shall be phase segregated and be possible to use even if the current transformers in the protected line ends have different primary and/or secondary rated current without the need of matching current transformers. Current ratio must be possible to set for actual analog input.
The protection shall be biased for through-loads and fault currents.

When the line differential protection shall be used for multi-terminal lines, a master-master-solutions is prefered.
Communication between protection terminals shall be supervised and if communication is corrupt or lost, the protection shall be blocked with the possibility to automatically release an undirected overcurrent protection function. The type of communication protection to be used shall be specified in TS.

4.2.1.1 Settings

- Protection's operate time shall be <40 ms
- Operating value 0.2-1 * In

4.2.2 Distance protection

The protection shall trip its own circuit-breaker and start auto-reclosing according to TS. The protection shall detect all combinations of short circuits and short-circuits to earth: Three-phase short circuit, two-phase short circuit, two-phase short circuit with earth contact and single phase short-circuit to earth. The protection shall have polygon characteristics with the possibility to limit the reach of the zones in the load range.

The distance protection shall have correct direction determination for all faults, i.e. also for adjacent three-phase short-circuits.

The protection shall have at least four zones. This includes a possible start zone
Fastest possible operate time for Switch-on-to-fault (SOTF)
The parallel protection in subsystem 2 shall be likewise those of the ordinary protection. If there is a need of protection in subsystem 2 there shall be a circuit-breaker failure protection.

The distance protection shall be able to interact with the protection at the line's remote ends. See the teleprotection chapter in this document.
In TS it is indicated whether the function for weak fault current in-feed and logic for fault current reversing are required.

The protection shall have fuse failure supervision of the voltage inputs. It should be possible to block the distance protection in the event of a fuse failure and automatically activate the backup protection function.

4.2.2.1 Settings

- Protection's operate time zone 1 shall be <40 ms
- The protection's operate time for other zones shall be adjustable between <0.10-30 s with a maximum of 0.05 s between adjustable values.

- Activation time Switch-on-to-fault (SOTF) adjustable 1-5 s with a maximum of 0.05 s between adjustable values
- Protection's operate time Switch-on-to-fault shall be <50 ms
- Set impedance on the protection shall give the same reach irrespective of fault type.
- It shall be possible to set each zone's reach so that there is the same reach for short-circuits and earth faults (kn-factor or zero-sequence impedance)
- Reach of zones
- It should be possible to set the kn-factor or zero-sequence impedance. Setting options shall be separate for at least zone 1 and the other three zones.
- Each zone's direction
- Load shielding

4.2.3 Earth fault protection

The protection shall trip its own circuit-breaker and start auto-reclosing if stated in TS.
The earth fault protection shall have four steps of which steps 1, 2 and 23 are directional and step 3 non directional. The earth fault protection shall measure the zero sequence (3I0) current in the line bay. The 3I0 must be measured from the total coupling of the three phase current transformers. Total coupling shall be carried out outside of the protection.
The directed function of the residual current protection uses the zero sequence voltages (3U0) as the directional reference. Voltage must be measured from a voltagetransformer group's open delta coupling of the secondary voltages.
The open delta coupling shall be carried out outside of the protection. Calculated delta voltage, based on phase voltages, is accepted in HS2.

4.2.3.1 Settings

Current setting for the steps shall be possible to make within the following interval:

- Step 1: 0.5-25.0 A with a maximum resolution between adjustable values of 0.1 A
- Step 2: 0.2-15.0 A with a maximum resolution between adjustable values of 0.05 A
- Step 23: 0.2-15.0 A with a maximum resolution between adjustable values of 0.05 A
- Step 3: 0.05-1 A with a maximum resolution between adjustable values of 0.01 A

The dropout ratio shall exceed 90 %. The transient overreach shall be less than 5 % at a network time constant of 50 ms.

For each individual case, the setting interval is set narrower for each step.

- Step 1 shall be possible to delay 0–2.0 s, with a maximum resolution between adjustable values of 50 ms. Step 1 typically shall be instantaneous. The operate time shall for faults, with a fault current greater than two times the set value, be less than 30 ms.
- Step 2 shall be possible to delay 0–2.0 s, with a maximum resolution between adjustable values of 50 ms.
- Step 23 shall be possible to delay 0 -2.0 s, with a maximum resolution between adjustable values of 50 ms.
- Step 3 shall have a constant time function with a delay within the interval 1.0-3.0 s.

For all steps the dropout ratio shall be less than 150 ms after the disconnection of the fault current and less than 50 ms after current reversing.

Optional step shall be possible to put in off mode.

The earth fault protection shall have a under time function, i.e. during a specific adjustable time (approx. 2 s) after a closing operation, step 3 shall work with a shortened operate time; adjustable 0–5 s (Normal setting 0.3 s).

The earth fault protection step 3 shall have harmonic stabilisation for all harmonics and all fault currents higher than the step's setting level. Harmonic stabilisation is to avoid function when energizing power transformers in the system and other phenomena such as saturation of power transformers. It shall also be possible to harmonic stabilise other steps in the protection.

The earth fault protection shall be able to interact with the protection in the line's remote end, via the communication channel. See the teleprotection chapter in this document. In TS it is indicated whether the function for weak fault current in-feed and logic for fault current reversing are required.

4.2.4 Overcurrent protection

The protection shall trip its own circuit-breaker and start auto-reclosing if stated specifically in TS.
The overcurrent protection shall measure three-phase and shall have at least two time steps. Parameters for the time step shall be individually adjustable for current settings and time delay.
The overcurrent protection is used as backup protection. The function shall be installed when there is no HS2-protection. The protection shall be

possible to activate when the distance protection is blocked via the fuse failure monitoring.

4.2.4.1 Settings for the low current step:

Current and time characteristics shall be selectable with the following alternatives available:

- Constant time delay
- Inverse-time delay according to IEC60255-3
    - Normal Inverse (NI)
    - Very Inverse (VI)
    - Extremely Inverse (EI)

The start current (start value) shall be adjustable within at least the range: 0.5-4 times the current transformer's secondary rated current. The greatest step between adjustable current values must not exceed 5 % of the current transformer's rated current.
The dropout ratio shall be greater than 90 %.
The dropout time shall be less than 50 ms.
Range for the time setting:

- Constant time delay: 0.03–5.00 s with a maximum of 0.05 s between adjustable values
- Inverse time according to IEC 60255-3: k = 0.05–1.1 s with a maximum of 0.05 s between adjustable values

The "k" factor shall be independent of changes to the protection's configuration.

4.2.4.2 Settings for the high current step:

The current-time characteristic shall have a constant time delay.
The operating current shall be adjustable within at least the range: 2–25 times the current transformer's secondary rated current. The greatest step between adjustable current values must not exceed 5 % of the current transformer's rated current.
The dropout ratio shall be greater than 90 %.
The dropout time shall be less than 50 ms.
Range for the time setting:

- Constant time delay: At least 0.03–1.00 s with a maximum of 0.05 s between adjustable values (typical instantaneous operation, i.e. no time delay).

Operate time with minimum set delay shall be a maximum of 40 ms, provided that the fault current exceeds 1.3 times the set operate value, and a maximum of 25 ms provided that the fault current exceeds 5 times the set operate value.
The transient reach shall be less than 10 % at fully developed direct current component with 60 ms time constant of the short-circuit current.

4.2.5 Teleprotection

Some relay protection in a station needs to communicate with the relay protection in another station There can be separate equipment for the teleprotection function or the function can be included in protection. Teleprotection shall be equipped with push buttons for test of transmissions signals. The following teleprotection principle shall be possible to use: Permissive overreach transfer trip and permissive underreach transfer trip.

4.2.5.1 Setting options and other performance for teleprotection

Transmission pulse out from the teleprotection shall be extended to at least 150-500 ms.

4.2.6 Remote tripping

For some protective schemes there is a need to remote disconnect circuit-breakers in another station e.g. for multi-point lines.
Remote tripping shall have a telecommunication supervision. A fault signal shall be emitted for power failure in auxiliary voltage, faults on communication equipment or disruptions to communications. IRF may not cause unauthorised tripping.

4.2.6.1 Setting options for remote tripping

Transmission pulse out from remote tripping shall be extended to at least 150-500 ms.

4.2.7 Circuit-breaker failure protection

When a through-flow of current, after the circuit-breaker has received a tripping pulse from the relay protection, the circuit-breaker failure protection generates tripping pulses to the breakers second coil (so-called retrip) and other circuit-breakers connected to the same busbar. Current should be measured in all three phase currents and neutral.
Dropout times for circuit-breaker failure protection shall be <30 ms.

4.2.7.1 Settings for the circuit-breaker failure protection

The tripping pulse shall have an adjustable duration. The pulse time shall be 0.5 seconds.

- The protection’s operate time shall be <20 ms

Minimum range for the time settings:

- At least 0.05–1.00 s with a maximum of 0.05 s between adjustable values for retrip.
- At least 0.05–1.00 s with a maximum of 0.05 s between adjustable values for tripping of other circuit-breakers.

4.2.8 Thermal overload protection.

Line protection shall according to TS, be able to have thermal overload protection. This protection function shall continuously estimate the thermal content in the protected bay (line/cable). The protection shall trip its own circuit-breaker or only give an alarm signal.

4.2.8.1 Setting options for the thermal overload protection

- Time constant 0.10-60 min
- Temperature 50-150 %
- Current value 0.10-2A
- Signal level current 0.10-2.0 A
- Operate time constant 0.1-10 min
- Signal level temperature 50-100 %
- Blocking of closing after tripping 1-240 min

4.2.9 Auto-reclosing

Reclosing shall, synchronized, close the circuit-breaker. The reclosing function shall be possible to enable and disable from remote or local operation.

Reclosing shall be possible to select from distance protection, earth fault protection, overcurrent protection and line differential protection according to the two alternatives:

- Only after zone1 distance protection, step 1 earth fault protection and line differential protection trip. (instantaneous tripping).
- After up to 0.6 s (possibly 0.8 s) delayed function of the line protection (zone/step 1 and 2).

Automatic reclosing shall be possible to activate according to the following two alternatives:

- Start pulse from the line protection’s start pulse and release from the line protection’s tripping pulse. (recommended)

- Start pulse only from the line protection’s tripping pulse.

Reclosing shall not be possible after busbar protection trip or circuit-breaker failure trip.

The automatic reclosing system shall be activated from distance protection, earth fault protection and line differential protection in the bay. This means that the automatic reclosing system, belonging to sub1/HS1, shall be activated from the line protection in both sub 1/HS1 and possibly sub 2/HS2.
If a new fault occurs within a set time, after the completed reclosing cycle, no reclosing shall be performed.

Reclosing shall be blocked when the circuit breaker is open and immediately after the closing operation. Blocking shall be activated up to an adjustable time after the closing operation.

For remaining tripping signal from the line protection, the automatic reclosing system must not emit repeated closing pulses (pumping).

No further reclosing attempts shall be performed for reclosing against remaining faults.

4.2.9.1 Setting options for the automatic reclosing system

Closing pulse shall have an adjustable duration within an interval 50–200 ms with 50 ms increments and shall be dropped off after circuit-breaker closure.

Auto-reclose open time: At least 0–60 s with increments of 0.1 s
Dropout time: 0–30 s with increments of 0.1 s.
Blocking time: 5–30 s with increments of 1 s.

4.2.10 Syncronization FPSH

Closing of own circuit-breaker (also AR) shall use synchronization if stated in TS.

Each bay shall have its own FPSH and measure the phase voltage on each side of the circuit-breaker.
FPSH shall automatically determine whether the parameters Δ u, Δ fi and Δ f are within the set and permitted limits.
Automatic FPSH shall manage synchrocheck, asynchronous stage energizing and interconnection of dead bus dead line.
It must be possible to take the FPSH out of order.

Asynchronous stage. (Angle difference)
If there is an asyncronous stage the unit shall measure Δ u, difference between the phasing voltages' absolute values. The measured phase difference shall be independent of the voltage amplitude.

The asynchronous stage close pulse must consider a pre-order time. The pre-order time shall be possible to set according to actual closing time of the circuit-breaker plus auxiliary relay in the control circuit.

Synchronising (Frequency difference)
Δ u, Δ f and Δ fi are measured for synchronising. Δ f shall be less than 0.0-0.10 Hz.

Energizing and dead bus blocking.
When energizing, one of the sides of the circuit-breaker is live and the other one is dead. FPSH shall measure the absolute values of the two voltages.
The dead bus blocking function is used when power generation is connected to the bay.

Interconnecting dead bus with dead line
Supervision of the measuring voltage.
The measuring voltages shall have fuse failure supervision.

4.2.10.1 Setting options for the FPSH

Function	Asyncronous stage	Syncronising	Energizing
Volt. diff."ΔU" %	0 - 20% Max difference	0 - 55% Max difference	-------
Angle difference "Δφ" degrees	max +/- 5 times.	5 - 90 degrees Max difference	--------
freq. difference Δfmax-Δfmin	0.00 - 0.7 Hz	--------	--------
Minimum detect-able freq. diff "Δf" Hz	-------	0.01-0.5 Hz	--------
Beat time "minT_0"	1.4 - 20 sec	-------	-------
Pre order time ”t" ms.	20 - 500 ms 50 ms/step (V)	-------	--------
Voltagelevel for live bus/line Umin	-------	-------	> 60 -100%
Voltagelevel for dead bus/ line Umax	-------	-------	<20 - 60%
Operate time	Minimum measuring time + "t"	Minimum measuring time + "t"	0 - 20 sec
Closing pulse	50-300 ms	50-300 ms	50-300 ms
Dropout time	40-120 s		

5 Testing

Unless otherwise specified, testing must conform to the scope and requirements for test results set down in applicable standards.

6 Appendices

Appendix 1 Inputs TB Relay protection Line bay 145 kV

Inputs TB Relay protection Line bay 145 kV

Signal	Typ	Längsdifferentialskydd	Distansskydd	Jordfelsskydd Jkr	Överströmsskydd	Termiskt överlastskydd	Brytarfelsskydd	AI-Automatik	FPSH-Automatik	Anmärkning
Ström L1	AI	x	x		x	x	x			
Ström L2	AI	x	x		x	x	x			
Ström L3	AI	x	x		x	x	x			
Ström N	AI	x	x				x			
Ström 3I0	AI			x						
Spänning L1	AI		x							
Spänning L2	AI		x						x	
Spänning L3	AI		x							
Spänning 3U0	AI			x						
Spänning L2 (annat objekt)	AI								x	
Brytarläge Till	DI	x	x					x		
Brytarläge Från	DI	x	x	x				x		
Start ÅI	DI	x	x	x	x					
Start BFS	DI	x	x	x	x					
ÅI Till	DI							x		
ÅI Från	DI							x		

Not
Spänning anges normalt till 110 V sekundärt
Ström anges normalt som 1A, 2 A eller 5 A sekundärt

AI = Anlog ingång (Input)
DI = Digital ingång (Input)