

**AFB**<sup>®</sup> ARC-FREE  
CIRCUIT  
BREAKER

AFB40

AFB25

**AFB**<sup>®</sup>  
**ARC-FREE ULTRA HIGH-SPEED  
DC CIRCUIT BREAKER**

CITY ELECTRIC TRANSPORT ■ METRO ■

## ABOUT COMPANY

PLUTON is the modern innovative manufacturer of electrotechnical equipment for city electric transport, metro and railways. The Company holds key positions in electrical industry and has been successfully working over 30 years implementing the strategy of intensive growth, development and continuous improvement of products and services quality.

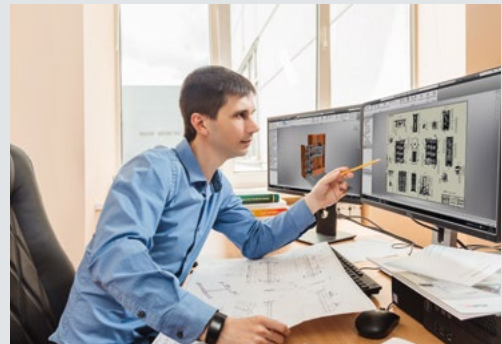
More than 70 types of PLUTON equipment are supplied to various countries of the world and successfully applied in the field of transport, power industry and production sector. PLUTON Group has representative offices in 8 countries and continues to develop dynamically and extend its global presence.

PLUTON confirmed compliance of its management principles with international standards of quality management system ISO 9001:2015, Environmental Safety ISO 14001:2015, as well as occupational safety and health ISO 45001:2018 requirements.

Due to our vast experience and innovative technologies, we provide secure, reliable and efficient power distribution. We are building the future, creating products of up-to-date level in compliance with the international standards that ensure safety and comfort of Customers.

We provide a full range of services: from design up to installation and commissioning of the supplied equipment on operation site. Furthermore, we provide the following services after equipment start-up:

- personnel correct and safe operation and maintenance training;
- warranty and post-warranty maintenance;
- spare parts supply.



## AFB® ARC-FREE ULTRA HIGH-SPEED DC CIRCUIT BREAKER

AFB® is an innovative ultra high-speed DC circuit breaker based on PLUTON experience and advanced technologies. AFB® is provided for application in tram, trolleybus, light rail and metro traction substations power distribution systems.

The main innovation of AFB® is the main contact operation in vacuum and arc-free current switching principle. Pre-charged high-voltage capacitor generates interrupting current to disconnect the main circuit current. The interrupting current is supplied in antiphase to the main circuit current

and thereby compensates the latter. The generated current compensates the main circuit current.

Thus, the main contact opens with a current value close to zero, whereby there is no arc during currents of any value breaking.

AFB® stands out for its vacuum interrupter increased mechanical/electrical wear resistance, which highly determines the life cycle of circuit breaker — minimum 25 years without necessity of mechanical and electrical components periodic replacement.

AFB® COMMUTATION LIFE IS

# 3 x 50 000

SWITCHINGS



LOWEST MAINTENANCE

# AFB® BENEFITS

## Improved performance

- / ultra-high speed of short-circuit currents breaking due to application of high-speed mechanical drive (opening time 1 ms);
- / arc-free principle of currents switching reliably ensures short-circuit currents breaking (total break time — maximum 4 ms) and low load currents breaking;
- / fault currents breaking resource is much higher than the one of a circuit breaker with traditional switching and arc interruption.

## Safety

- / no plasma emission during short-circuit currents breaking due to switching in vacuum interrupter;
- / no combustion products and their deposits on the circuit breaker components and on the switchgear units;
- / reduction of fire risk due to no open plasma formation area during switching;
- / built-in disconnecter ensuring safety of operational switching.

## Protections

- / built-in measurement and protection system allows precise adjustment of settings and provides high response speed;
- / built-in overcurrent protection and high di/dt protection allow detecting and breaking all types of short circuits in line;
- / built-in line test function increases the circuit breaker service life due to hard fault closing blocking.

## Maintenance

- / no arc chute and, thereby, no need for its maintenance;
- / no need for the main circuit contact system maintenance during operation, due to absence of combustion products on AFB® components;
- / no need for inspection, maintenance and replacement of vacuum interrupter until the end of its mechanical life along with a large number of switching cycles with maximum value of short-circuit currents.





## AFB® BENEFITS

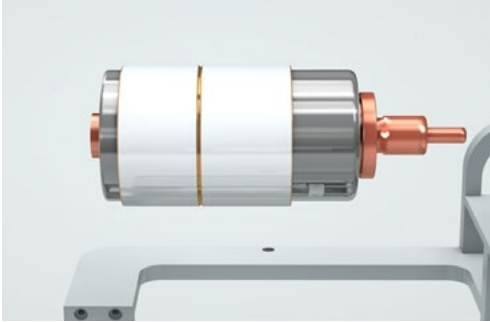
### Compliance with international and European standards

AFB® breakers have been type-tested at IPH Institute test center (Berlin, Germany) and meet the requirements of IEC 61992-2/EN 50123-2, IEC 60947-3/EN 50123-3 standards.

A composite image showing a 'Type Test Report' document and several test waveforms. The report is from IPH Institute and includes details about the circuit breaker being tested, such as its model (AFB 40) and the test center (IPH Institute). It also features logos for DAKS and CESI, along with the slogan 'Trust the Power of Experience'. The waveforms show electrical signals over time, with labels like 'Test-No. 2225313' and 'Test-No. 2225302'.

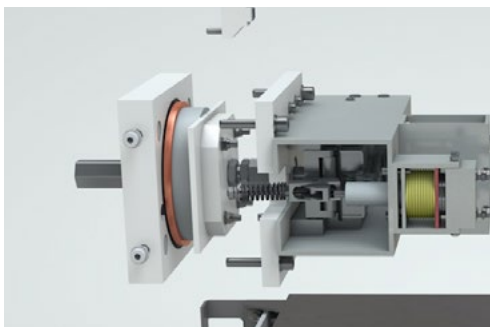
- / high wear resistance
- / long lifetime
- / operational costs saving

## COMPONENTS



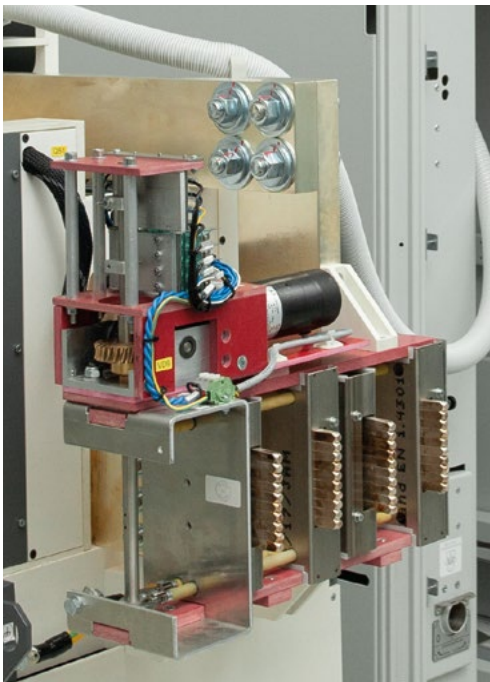
### Vacuum interrupter

- / high switching wear resistance
- / no open arc
- / reduction of circuit breaker work space



### Electrodynamic tripping drive

- / high-speed contacts opening system
- / breaking speed does not depend on short circuit current value



### Disconnecter

- / high dynamic stability
- / long mechanical life
- / maintenance-free

# COMPONENTS

## Control and internal monitoring system

Control and internal monitoring system provides complete all-sufficient control of circuit breaker, and fulfills all necessary functions, including protection, as well as remote control and measurement, etc.

Circuit breaker can be remotely measured and controlled via isolated RS-485 interface, Modbus RTU protocol. Besides, discrete signals control is available via isolated discrete inputs and outputs with external power supply.



System functions:

- / all circuit breaker components and parts operation control;
- / continuous diagnostics of circuit breaker units;
- / receipt of control signals from the upper level (via discrete signals and isolated RS-485 interface, Modbus RTU protocol);
- / built-in power current and voltage measurement system;
- / output of the system status data and measurements for the upper level;
- / built-in HMI (LCD with keyboard for adjustment of the main system parameters);
- / switching overvoltages protection system control.



Structurally AFB® control system consists of 3 modules:

Processor module:

/ provides all data processing intelligent functions;

Measurement module:

/ provides power voltage measurement and data transfer to processor module;

Thyristors control module:

/ provides galvanic isolation and pulses generation for thyristors control.



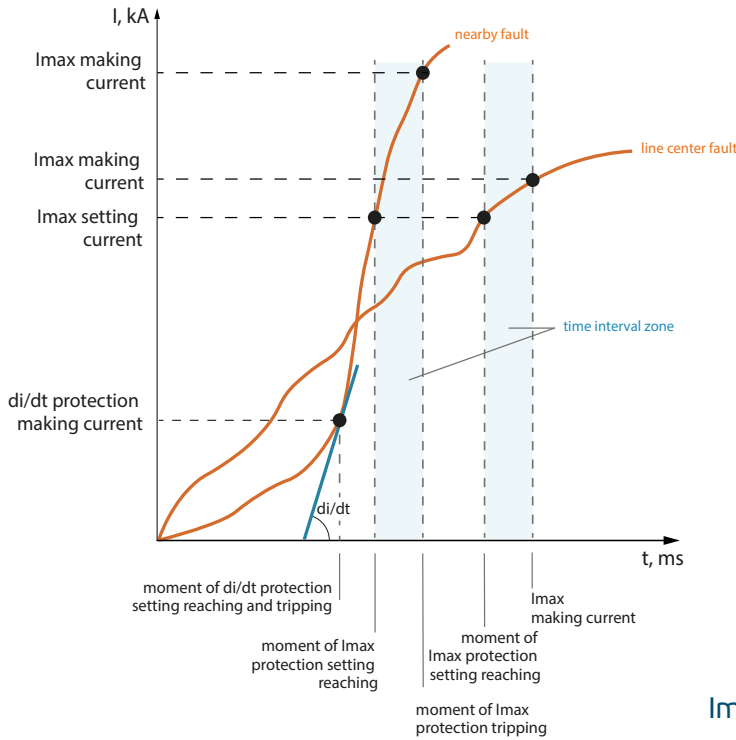
**INTELLIGENT CONTROL, PROTECTION  
AND DIAGNOSTICS**



# PROTECTION FUNCTIONS

Control system has built-in adjustable protection functions:

- overcurrent protection ( $I_0$ );
- $I_{max}$  protection;
- $di/dt$  protection.



**$I_{max}$  and  $di/dt$  protections operation**

## Overcurrent protection ( $I_0$ )

Overcurrent protection is activated when measured current value exceeds the set value (setting) without time delay.

## $I_{max}$ protection

$I_{max}$  protection is activated when measured current value exceeds the set value (setting) within the specified time interval (time delay).

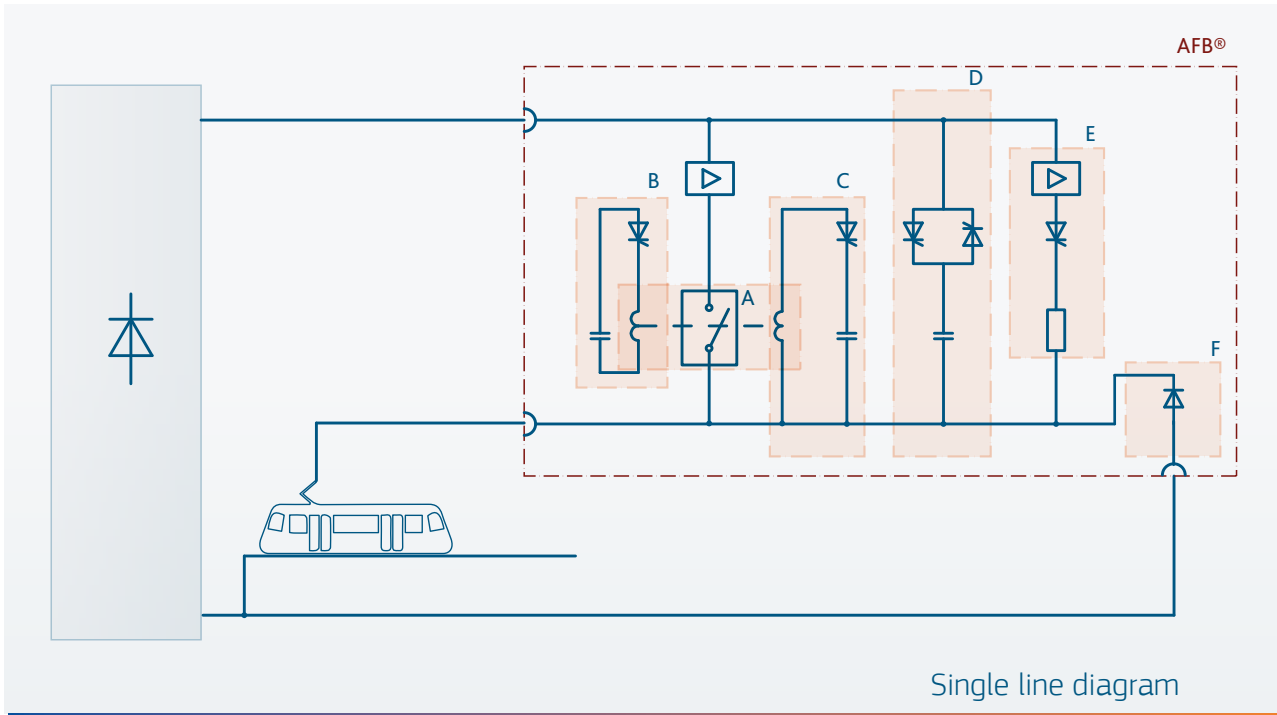
## $di/dt$ protection

$Di/dt$  protection is activated when the measured current rate of rise exceeds the set value (setting) without time delay.

Disconnection occurs before reaching current tripping setting or maximum current protection, thereby reducing the time of alarm and limiting maximum short-circuit current.

Thus, the fault time is reduced and maximum short circuit current is limited. It helps to significantly increase the circuit breaker lifetime, and reduce the number of substation equipment failures, eliminate contact network cables burn off, etc.

# STRUCTURE



**A.** Switching vacuum interrupter with main contact opening and closing coils

**B.** The circuit breaker main contact closing circuit. The main contact closing coil is activated by switching via thyristor to a pre-charged capacitor.

**C.** The circuit breaker main contact opening circuit. The main contact opening coil is activated by switching via thyristor to a pre-charged up to 1000 V capacitor. The capacitor charge is constantly monitored by control system.

**D.** Current interruption circuit. Power capacitor charged up to 1000 V provides interrupting current, switched via power thyristors to the circuit breaker main circuit. The capacitor charge is constantly monitored by control system.

**E.** Built-in line tester. The line is tested optionally. It can be tested before each tripping of the circuit breaker.

**F.** Reverse diode is provided for load currents shunting during forward breaking.

# OPERATING CONCEPT

Before the circuit breaker tripping control system tests: auxiliaries voltage, high-voltage opening and interrupting capacitors voltage, interrupting thyristors and shunting diodes proper functioning. Closing is possible both with preliminary line test and without it.

## Closing

Pre-charged low-voltage capacitors battery provides circuit breaker closing by closing coil actuation with closing thyristor.

## Operational breaking

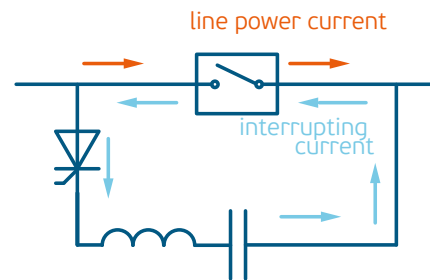
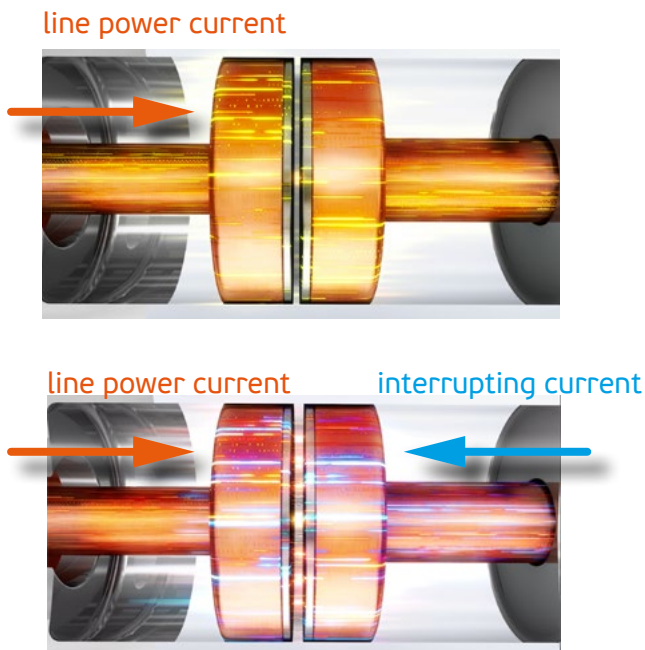
Circuit breaker control system actuates opening thyristor on receiving breaking command. When thyristor opens, the power stored in high-voltage opening capacitor is switched to opening coil.

The opening coil magnetic field actuates the breaking mechanism activating moving contact of the vacuum interrupter, thereby vacuum interrupter power contacts open.

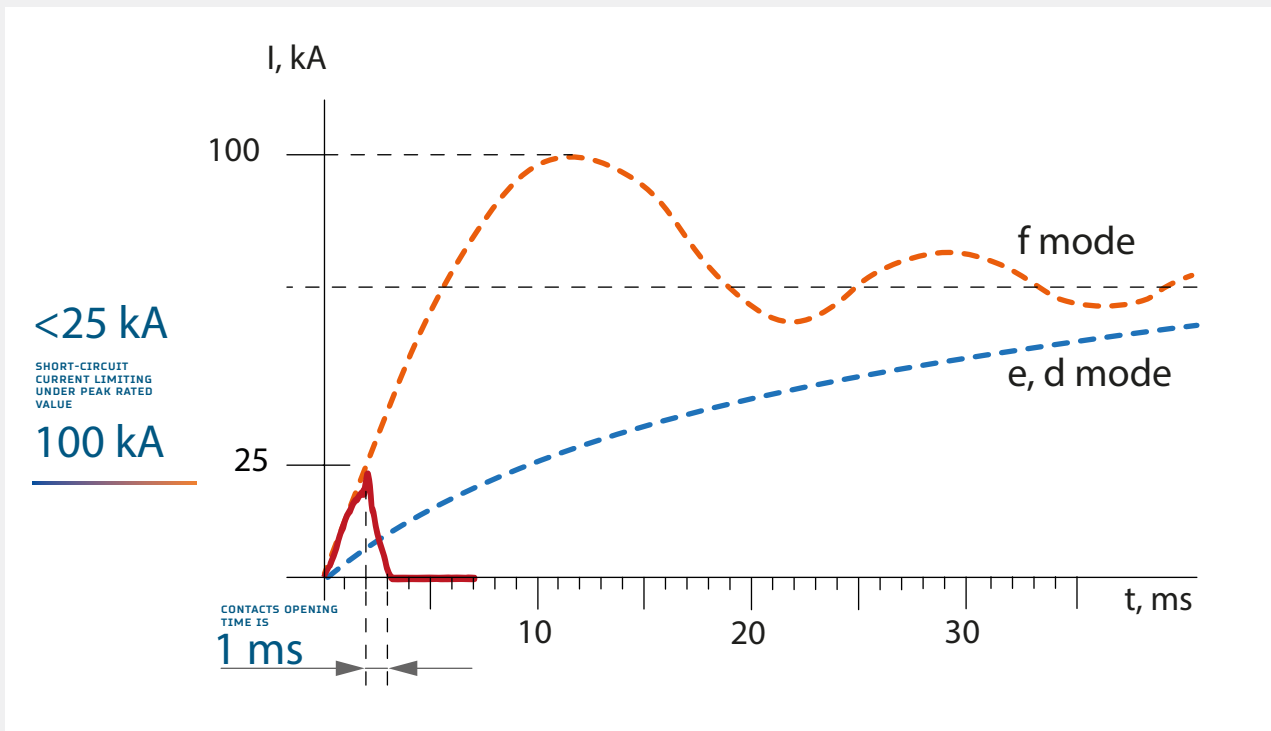
Arc starts between contacts upon their opening, and is interrupted by power, stored in pre-charged high-voltage capacitor. Capacitor discharge current is switched in antiphase to the main current of power circuit. The arc is interrupted at the moment, when currents algebraic sum is zero. Afterwards the contacts open and interrupt power circuit.

## Fault breaking

Fault breaking has similar to operational breaking principle. In this case, the signal for breaking is measurements from current sensor, installed in the circuit breaker main power circuit, and processed by AFB® control system microcontroller according to specified algorithms.



# BREAKING CHARACTERISTICS



AFB® provides high-speed power contact opening and circuit breaker di/dt tripping before short-circuit current setting reaching. Contacts opening time is 1 ms.

High-speed electrical circuit tripping under nearby fault (f mode according to EN 50123-2/IEC 61992-2) leads to current limitation at the early stage of short circuit growth. This reduces electrodynamic load on conductive parts.

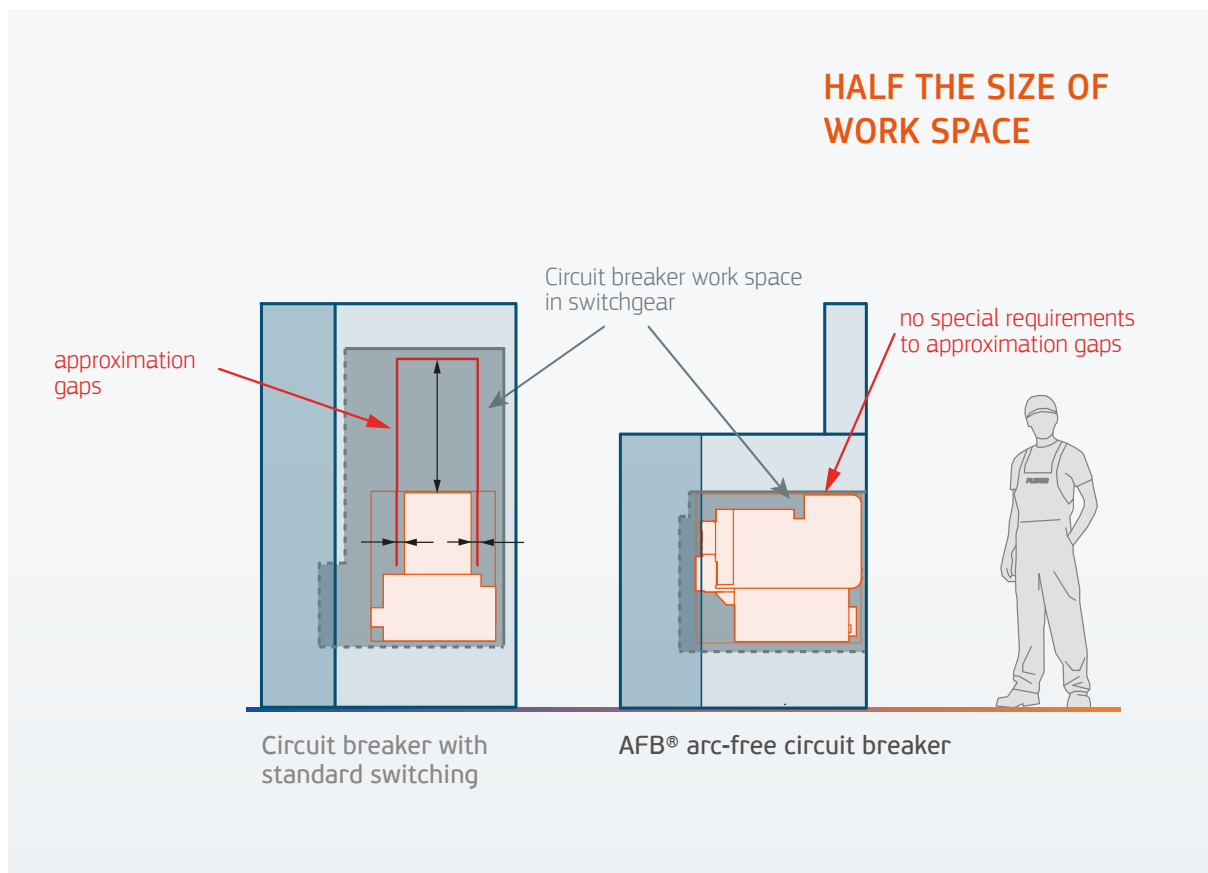
Power stored in circuit dissipates in load circuit upon high inductivity load tripping (e, d mode according to EN 50123-2/IEC 61992-2). This eliminates overvoltage and circuit breaker components wear (under forward current direction). Power stores in capacitor, or dissipates on resistor upon reverse current breaking.

AFB® provides secure low current breaking, and as a result, circuit breaker contacts damage prevention.



# WORK SPACE SAVING

No arc in circuit breaker compartment leads to no special requirements to insulation gaps, and thus, to significant reduction of circuit breaker workspace, switchgear overall dimensions and substation space saving.



## MAIN TECHNICAL CHARACTERISTICS OF AFB® ARC-FREE CIRCUIT BREAKER

		AFB 25	AFB 40
<b>Voltage</b>			
Maximum operating voltage $U_{max}$	V DC	1000	
Insulation voltage $U_{Nm}$	V DC	1800	
Test impulse voltage $U_{Ni}$	kV DC	10	
Maximum switching overvoltage. Zone B acc. to EN50124.2 (<20 ms)	V DC	<2500	<6000
<b>Current</b>			
Rated service current $I_{Ne}$	A DC	2500	4000
Duty class acc. to IEC 60146-1-1	-		VI
<b>Short-circuit current</b>			
Steady-state short-circuit current $I_{Nss}$	kA	80	
Peak of the short-circuit current $\hat{I}_{Nss}$	kA	100	
Maximum breaking current $I_{max}$	kA	25	
Forward current di/dt limit	kA/ms	20	
<b>Time</b>			
Contacts opening time	ms	< 1	
Total break time	ms	< 4	
<b>Breaking current setting range</b>			
- forward breaking current setting range	A	400 - 7500	400 - 12000
- reverse breaking current setting range	A	400 - 3750	400 - 7500
<b>Weight and size parameters</b>			
Circuit breaker weight	kg	215	300
Circuit breaker overall dimensions:			
Width	mm	475	475
Height	mm	810	1050
Depth (Length)	mm	955	955
<b>Additional data</b>			
Commutation life	switchings	3 x 50 000	
Protection level	-	IP 00	
Auxiliaries supply voltage	V DC	110, 220	

## OPERATIONAL AND ENVIRONMENTAL SAFETY



Switchgear with standard circuit breaker



Switchgear with AFB® arc-free circuit breaker

No damaging thermal and dynamic effect of arc provides increased safety and no contaminating combustion products.

PLUTON is certified in concordance with ISO 14001:2015 international environmental safety standard. We comply with RoHS

(restriction of the use of certain hazardous substances) directives, and apply materials with minimum environmental impact in our production.



# AFB<sup>®</sup> ARC-FREE CIRCUIT BREAKER



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