Retrofit for gas-insulated high voltage switchgear (GIS) - 8D1 and 8D2

Answers for energy.

SIEMENS
Table of Contents

1 Introduction .............................................................................................................. 4
2 Description of retrofit circuit-breaker 8DN8 .......................................................... 5
3 Technical data for retrofit circuit-breaker 8DN8 ...................................................... 6
4 Adapter - retrofitting circuit-breaker 8DN8 - existing switchgear ....................... 7
5 Retrofitting steps ................................................................................................. 12
6 Circuit-breaker maintenance comparison old vs. new ........................................... 19
7 Time schedule for retrofit solution....................................................................... 21
8 Scope of delivery ................................................................................................ 21
9 Life time expectation of existing GIS without new circuit-breaker..................... 21
10 Type tests .......................................................................................................... 21
11 Options .............................................................................................................. 22
List of Figures

Fig. 1: Existing substation with 8D2 double-pressure circuit-breaker ............................................... 4
Fig. 2: Main dimensions of retrofit circuit-breaker 8DN8 .................................................................... 5
Fig. 3: 8D2 bay with old blast piston circuit-breaker ........................................................................... 7
Fig. 4: 8D2 bay with 8DN8 circuit-breaker ....................................................................................... 8
Fig. 5: 8DN8-circuit-breaker with two adapters equipped with gas-tight bushings towards the GIS section ............................................................................................................................... 9
Fig. 6: Side view of the 8DN8 circuit-breaker with two adapters .......................................................... 9
Fig. 7: Top view of 8DN8-circuit-breaker with two adapters .................................................................. 10
Fig. 8: Top view of contact arrangement ............................................................................................ 11
Fig. 9: Side view of an 8D switchgear with double-pressure circuit-breaker ........................................ 12
Fig. 10: Electrical view ....................................................................................................................... 12
Fig. 11: SF6 pressure view .................................................................................................................. 13
Fig. 12: Third retrofitting step (a) ....................................................................................................... 14
Fig. 13: Third retrofitting step (b) ....................................................................................................... 14
Fig. 14: Fourth retrofitting step (a) ..................................................................................................... 15
Fig. 15: Fourth retrofitting step (b) ..................................................................................................... 15
Fig. 16: Fifth retrofitting step (a) ....................................................................................................... 16
Fig. 17: Fifth retrofitting step (b) ....................................................................................................... 17
Fig. 18: Sixth retrofitting step: Bay after retrofitting ......................................................................... 18
Fig. 19: Standardized maintenance costs ........................................................................................... 20

List of Tables

Tab. 1: Technical data for circuit-breaker 8DN8 .................................................................................. 6
Tab. 2: Technical data of the adapter ................................................................................................... 7
Tab. 3: Comparison SF6 content old/new ............................................................................................. 8
Tab. 4: Comparison of the maintenance intervals of the different circuit-breakers ......................... 19
1 Introduction

The first SF6-gas insulated switchgear of type 8D1 and 8D2 delivered by Siemens are now 40 years and older. These substations have proved outstanding in operation. They are rugged, reliable, and virtually leak-free (SF6 or oil) and still fulfill their function perfectly.

Today, stricter and more economically focused standards apply with respect to the maintenance of gas-insulated switchgear. Especially the SF6 – double-pressure circuit-breakers used since GIS systems were first introduced on the market are highly maintenance-intensive. However, since the other GIS components (excluding the original circuit-breaker) require very little maintenance and have an expected life span of over 50 years provided the Siemens maintenance recommendations described in the operating manual are followed, Siemens offers a retrofit solution. This is in the form of a state-of-the-art SF6-circuit-breaker with spring mechanism based on more than 40 years of accumulated experience and intensive research.

Fig. 1: Existing substation with 8D2 double-pressure circuit-breaker
2 Description of retrofit circuit-breaker 8DN8

The circuit-breaker employed in this retrofit solution is used in the current GIS and HIS substations 8DN8 up to 145 kV and also in 123 kV and 145 kV outdoor circuit-breakers. This type-tested breaker has proven itself in service over the years in thousands of applications. The most important advantages of this self-compression circuit-breaker of the latest generation are:

- Significantly lower maintenance costs (see chapter 6)
- Type-tested to the latest IEC standard (at the time of the development)
- State-of-the-art spring mechanism with extremely low maintenance

Fig. 2: Main dimensions of retrofit circuit-breaker 8DN8
3 Technical data for retrofit circuit-breaker 8DN8

<table>
<thead>
<tr>
<th>Standard</th>
<th>IEC, latest edition (at the time of the development)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated voltage</td>
<td>123 – 145 kV</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Rated short-time power-frequency withstand voltage</td>
<td>230 – 275 kV</td>
</tr>
<tr>
<td>Rated lightning impulse withstand voltage</td>
<td>550 – 650 kV</td>
</tr>
<tr>
<td>Rated normal current</td>
<td>3150 A</td>
</tr>
<tr>
<td>Rated short-circuit-breaking current</td>
<td>40 kA</td>
</tr>
<tr>
<td>Rated short-time withstand current</td>
<td>40 kA</td>
</tr>
<tr>
<td>Rated duration of short-circuit</td>
<td>&lt;= 3 s</td>
</tr>
<tr>
<td>Rated peak withstand current</td>
<td>100 kA</td>
</tr>
<tr>
<td>First-pole-to-clear-factor</td>
<td>1.5</td>
</tr>
<tr>
<td>SF6 filling pressure at 20 °C</td>
<td>0.56 MPa</td>
</tr>
<tr>
<td>Loss of SF6</td>
<td>0.52 MPa</td>
</tr>
<tr>
<td>General lockout SF6</td>
<td>0.50 MPa</td>
</tr>
<tr>
<td>Volume of SF6 gas:</td>
<td>35kg</td>
</tr>
<tr>
<td>Break time</td>
<td>60 ms</td>
</tr>
<tr>
<td>Opening time</td>
<td>32 +/- 3 ms</td>
</tr>
<tr>
<td>Arcing time (50 Hz)</td>
<td>24 ms</td>
</tr>
<tr>
<td>Closing time</td>
<td>55 +/- 6 ms</td>
</tr>
<tr>
<td>Operating sequence (IEC)</td>
<td>CO-15s-CO or O-0.3s-CO-3min-CO</td>
</tr>
<tr>
<td>Motor spring operating mechanism</td>
<td>220 V DC / 3.0 A / 10 A</td>
</tr>
<tr>
<td>Auto reclosing</td>
<td>3-pole</td>
</tr>
<tr>
<td>Closing coil</td>
<td>225 W at 220 V DC</td>
</tr>
<tr>
<td>Tripping coil</td>
<td>225 W at 220 V DC</td>
</tr>
<tr>
<td>Auxiliary switch</td>
<td>8 NO/8 NC/1 WI; 250 V / 2.5 A</td>
</tr>
<tr>
<td>Weight of circuit-breaker without SF6 gas:</td>
<td>900 kg</td>
</tr>
</tbody>
</table>

Tab. 1: Technical data for circuit-breaker 8DN8

Replaces: Circuit-breaker for 8D1 and 8D2 up to 145 kV, double-pressure type and blast piston type
4 Adapter – retrofitting circuit-breaker 8DN8 – existing switchgear

The adapter, two of which are needed for connecting the new circuit-breaker to the existing switchgear, is type-tested with 650 kV rated lightning impulse withstand voltage and connects the three-phase encapsulated circuit-breaker with the single-phase encapsulated switchgear. The adapter forms a single SF6-gas compartment with joint gas monitoring together with the circuit-breaker. It is connected to the existing GIS switchgear through gas-tight bushings.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated lightning impulse withstand voltage:</td>
<td>650 kV</td>
</tr>
<tr>
<td>Weight of an adapter:</td>
<td>approx. 200 kg</td>
</tr>
<tr>
<td>SF6 filling pressure at 20°C:</td>
<td>0.56 MPa</td>
</tr>
<tr>
<td>Volume of SF6 gas/adapter:</td>
<td>18.75 kg</td>
</tr>
</tbody>
</table>

*Tab. 2: Technical data of the adapter*

---

Fig. 3: 8D2 bay with old blast piston circuit-breaker
<table>
<thead>
<tr>
<th></th>
<th>Retrofit 8DN8 self-compression circuit-breaker 123 kV</th>
<th>8D1/2 double pressure circuit-breaker 123 kV</th>
<th>8D2 blast piston circuit-breaker 123/145 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit-breaker</td>
<td>35 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adapter</td>
<td>2 x 18.75 kg</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total volume SF6 gas</strong></td>
<td><strong>72.5 kg</strong></td>
<td><strong>105 kg</strong></td>
<td><strong>87 kg</strong></td>
</tr>
</tbody>
</table>

*Tab. 3: Comparison SF6 content old/new*

*Fig. 4: 8D2 bay with 8DN8 circuit-breaker*
Fig. 5: 8DN8-circuit-breaker with two adapters equipped with gas-tight bushings towards the GIS section

Fig. 6: Side view of the 8DN8 circuit-breaker with two adapters
Fig. 3 shows the original system with 8D2 blast piston circuit-breaker. In Fig. 4, the circuit-breaker is replaced by an 8DN8 circuit-breaker. The connection between the 3-phase encapsulated 8DN8 circuit-breaker and the remaining single-phase 8D2 encapsulated GIS section is implemented via two adapters as shown in perspective in Fig. 5. Fig. 6 shows a side view from left to right:

- Upper and lower adapter - transition from single-phase encapsulation to 3-phase encapsulation
- 3-phase encapsulated 8DN8 circuit-breaker

Fig. 7: Top view of 8DN8-circuit-breaker with two adapters

Fig. 7 shows the top view of the three-pole encapsulated 8DN8 circuit-breaker with indicated contact arrangement connected to the single-pole encapsulated adapters.
Fig. 8: Top view of contact arrangement

Fig. 8 shows the contact arrangement of the adapter.
5 Retrofitting steps

Fig. 9: Side view of an 8D switchgear with double-pressure circuit-breaker

Fig. 9 shows the typical design of a 8D bay with double-pressure circuit-breaker

Fig. 10: Electrical view

Legend: red= voltage, green: no voltage
Views 10 and 11 show the second step of the retrofit

1) Switch off circuit-breaker -Q0
2) Switch off disconnectors -Q1, -Q2 and -Q8
3) Switch on and secure earthing switches -Q51 and -Q52
4) Switch off and earth the cable from the remote end
5) Switch off the auxiliary and tripping circuits
6) Perform gas work in accordance with diagram
7) Disassemble old circuit-breaker -Q0 with accessories
8) Check the existing 8D2 bushings and contacts
9) Install the new circuit-breaker with preassembled adapters
10) Install the new circuit-breaker module
11) Evacuate the new circuit-breaker module
12) Modify or replace the VOS (local control cubicle)
13) Top up SF6 to rated pressure
14) Commission the new circuit-breaker
15) Switch on the auxiliary and tripping circuits
16) Switch off the earthing switches -Q51, -Q52 and -Q8 and the earthing switch at the remote end of the cable.
17) Switch on disconnectors -Q1, -Q2 and -Q8
18) Switch on circuit-breaker -Q0
19) Bay is energized

Figs. 12-18 show the individual steps of the retrofit graphically
Fig. 12: Third retrofitting step (a)

Fig. 13: Third retrofitting step (b)
Fig. 14: Fourth retrofitting step (a)

Fig. 15: Fourth retrofitting step (b)
Fig. 16: Fifth retrofitting step (a)
Fig. 17: Fifth retrofitting step (b)
Fig. 18: Sixth retrofitting step: Bay after retrofitting
6  Circuit-breaker maintenance comparison old vs. new

<table>
<thead>
<tr>
<th></th>
<th>8D1/2 Double-pressure circuit-breaker</th>
<th>8D2 Blast piston circuit-breaker</th>
<th>8DN8 Self compression circuit-breaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor inspection (or enhanced visual inspection)</td>
<td>1000 x CO in rated nominal current range or after 5 years</td>
<td>3000 x CO in rated nominal current range or after 10 years</td>
<td>3000 x CO in rated nominal current range or after 17 years</td>
</tr>
<tr>
<td>Taking out of service necessary</td>
<td>Taking out of service necessary</td>
<td>Taking out of service not necessary</td>
<td></td>
</tr>
<tr>
<td>Replacement of blast valve</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major Inspection (or standard inspection)</td>
<td>5000 x CO in rated nominal current range or after 10 years</td>
<td>6000 x CO in rated nominal current range or after 20 years</td>
<td>6000 x CO in rated nominal current range or after 25 years</td>
</tr>
<tr>
<td>Taking out of service necessary</td>
<td>Taking out of service necessary</td>
<td>Taking out of service necessary</td>
<td></td>
</tr>
<tr>
<td>Replacement of blast valve</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Tab. 4 Comparison of the maintenance intervals of the different circuit-breakers*

Table 4 compares the maintenance intervals of the individual circuit-breaker types over a period of 25 years. It can be plainly seen that the maintenance expenditure as well as the short maintenance intervals for double-pressure circuit-breaker are no longer economical compared with the new 8DN8-circuit-breaker and no longer in keeping with today’s needs.

Fig. 19 shows the standardized maintenance costs (at today’s costs) of the different circuit-breaker types over a 25-year operating period which naturally does not represent the whole life span of the new 8DN8 circuit-breaker. Compared to the new 8DN8-circuit-breaker the maintenance costs for the 8D1 double-pressure circuit-breaker are about 15 times higher, and the costs for the 8D2- blast piston circuit-breaker still 3 times as high.
Fig. 19: Standardized maintenance costs

- blue: Double-pressure circuit-breaker 8D1/8D2
- red: Blast piston circuit-breaker 8D2
- yellow: Self compression circuit-breaker 8DN8
7  Time schedule for retrofit solution

The total duration from the receipt of the order to the provisional acceptance test is approximately 9 months referred to 1 bay. The actual retrofit, for example the dismantling of the existing circuit-breaker, installation of the new circuit-breaker, start-up and high voltage testing takes approximately 4 weeks.

8  Scope of delivery

The scope of delivery comprises:

- Circuit-breaker 8DN8, 3-phase encapsulated, including supporting structure
- SF6 gas (2 x 40 kg bottles to ensure problem-free conversion); SF6 gas from the old 8D1/2 breaker is reused)
- 2 adapters – from 3-phase encapsulated circuit-breaker to single-phase switchgear
- Small parts such as sealing material, filter material, etc.
- Control cubicle adaptation components or complete new control cubicle

9  Life time expectation of existing GIS without new circuit-breaker

A life expectancy > 50 years is predicted for the remaining GIS components, provided that the Siemens maintenance recommendations have been followed as described in the operating manual. Tests on the gastight insulators of an over 40-year old 8D2 GIS did not show any discrepancies. The insulators did not produce any partial discharges. Naturally, if desired, a retrofit can be carried out on the existing disconnector and earthing switches. These devices can then be equipped with the latest motor drives.

10  Type tests

Type tests are available for the retrofit 8DN8-circuit-breaker.
11 Options

- Local control cubicle, including control cable
- Service measures on the bays in conjunction with the planned retrofit
- Retrofitting of the disconnector / earthing switch drives with the latest generation of drives
- Overhaul of the dismantled 8D1/8D2 circuit-breaker
- Decentralized SF₆ gas monitoring
- Replacement of old cast-resin voltage transformer with SF₆-insulated transformer
- UHF antennas