TECHNICAL DATA SHEET — SETTING THE NEUTRAL

1 - GENERAL

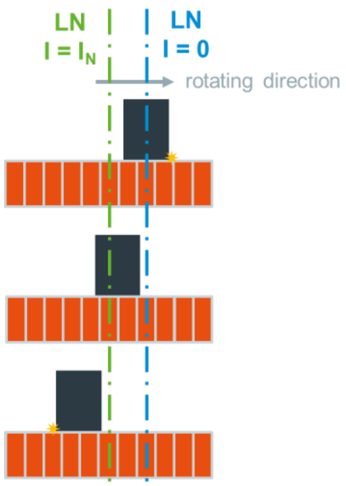
In the field of DC machines, sparking issues are currently stated. The expression “commutation problem” is commonly used for sparking in an inappropriate way.

As stated in our TDS-14 and TDS-01, sparking at brush edge may be caused by either mechanical or electrical causes, or a combination of them. Generally mechanical causes are easy and quickly to detect and correct, whereas electrical problems are not always obvious.

One of them is an incorrect positioning of brushes onto the neutral line. Broadly speaking this is the line where the voltage between collector bars is theoretically equal to zero and on which brushes should be set. In other words, it corresponds to the zone where the brush is operating without sparks, also called “zone of black commutation”.

There are various methods to determine the neutral line of a DC machine, and we can classify them in two categories:

- static methods will determine the neutral line position without load when the rotor is blocked,
- dynamic method is the only method for defining the real neutral line when the machine is operating at nominal load.



Key:
I_N: rotor current at nominal load
LN: Neutral line

Neutral line settled with the static method
⇒ risk of sparks at brush exit edge

Neutral line settled with the dynamic method
⇒ "black" commutation (no sparks)

Neutral line not settled
⇒ risk of sparks (here, at brush entry edge)

Fig. 1 - Effets of a wrong positioning of brushes relative to the neutral line

> **Note:** if sparking still occurs after a proper settlement of the neutral line, other root causes must be investigated: ageing or wrong number of coils of commutating poles windings, defects of main coils, incorrect air gap between the armature core and the poles…

Our Customer Technical Assistance Service is at your disposal for any question:

E-mail: info.ptt@mersen.com

IMPORTANT

Before performing any test (either static or dynamic method) the machine shall be inspected:

- the brush tangential coverage shall be checked, and great care shall also be taken when circumferential brush staggering is applied (See our TDS-09),
- the brush shall be seated correctly onto the commutator and the film shall be present (see TDS-13),
- the maintenance of the machine shall be done previously (or recently) to avoid any disturbance which may occur when the machine, in particular the commutator, is not in a good state (run-out, roughness, brush-holders settlement and equidistance, see TDS-08 and our maintenance technical guide).

2 - STATIC METHODS

This category is applicable to all bi-directional machines, providing the armature does not have any dead section.

The method of millivoltmeter seems to be preferred by most users, because of its relative simplicity of commissioning and use. This method is explained below with two possible procedures.

Millivoltmeter – Simplified method

The principle is to connect poles to a low voltage alternative power supply (15 V to 40 V[1]) and search for the position where the voltage between 2 brushes of adjacent poles is equal to zero or very low.
Figure 2 illustrates the connections.

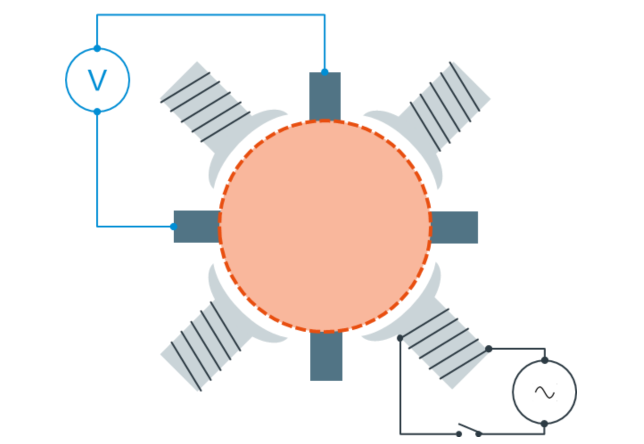


Fig. 2 - Connections within the simplified method

The successive steps are:

a) ensure that the brushes are seated (bedded) to the commutator surface and that there is a suitable skin / patina,
b) stop the machine, disconnect the armature and block it,
c) connect the millivoltmeter[2] to two adjacent brush arms (i.e. of opposite polarities),
d) connect the poles with a low voltage alternative power supply[1],
e) close the circuit,
f) unscrew the brush rocker and move it from its initial position in one rotating direction,

[1] Of course, the choice of the power supply would influence the readings and scale on the millivoltmeter. The AC current shall be sufficient to deflect the millivoltmeter with appropriate capacity and sensitivity, while operating with safety condition (< 40V). When using DC current a switch is required, and a second person will be necessary to switch on and off the loading circuit.

[2] The method gains in simplicity when using an analogue voltmeter (with a dial needle).

g) move the brush rocker in the opposite direction, read the voltage while moving so as to obtain the lowest value of voltage,
h) block the brush rocker and mark the position (if the voltage changes, repeat the operation),
i) unblock the brush rocker and continue to move in the same rotating direction to over pass the lowest voltage position,
j) repeat steps g) to i) with the other direction of rotation,
k) the neutral position will be between the two marks.

Millivoltmeter – Graphical method

The following procedure renders the determination more accurate but requires a much longer time and two people. It consists in measuring the voltage between two opposite bars and reporting the voltage values on a graph paper.

The first steps are:
a) ensure that the brushes are properly seated to the rotating surface and that there is a patina,
b) stop the machine, disconnect the armature and block it,
c) raise the brushes,
d) determine the number of bars between poles by dividing the total number of bars of the commutator by the number of poles of the machine and then number all the bars from any point situated to the left of a brush on one arm (beginning by zero - see figures 2 and 4).

Two cases are possible, depending if the number of bars is even or odd.

1) Whole number of bars between poles

It corresponds to an even total number of bars, in other words opposite bars are symmetric (Figure 3).

Fig. 3 - Numbering of bars in case of pair number of bars

Proceed to the following steps (after previous step d):
e) connect the poles with a low voltage alternative power supply (same as for the simplified method),
f) connect the millivoltmeter between two contact probes,
g) apply the contact probes respectively on the bars numbered 0 and n, read the voltage and report it on a graph paper,
h) repeat g) between the bars numbered 1 and n+1, etc… to get almost 5 points (coordinates i;n+i).

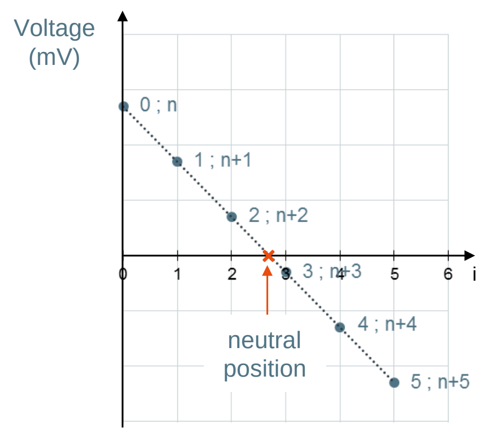


Fig. 4 - Plotted graph of voltage per bar position in case of pair number of bars

The graph in figure 4 is obtained after tracing the average line between the points. The neutral position is found at the intersection of the line with the horizontal axis.

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2) Fractional number of bars between poles

It corresponds to an odd number of bars, in other words opposite bars are not symmetric.

Two overlaid graphs are plotted to obtain figure 5: the first graph is obtained within the same method as the previous one (blue coordinates i;n+i), the second one is done with a shift of one bar for the second probe (green coordinates i;n+i+1).

The neutral point is determined by interpolation between the intersection of the two voltage drop curves with the horizontal axis.

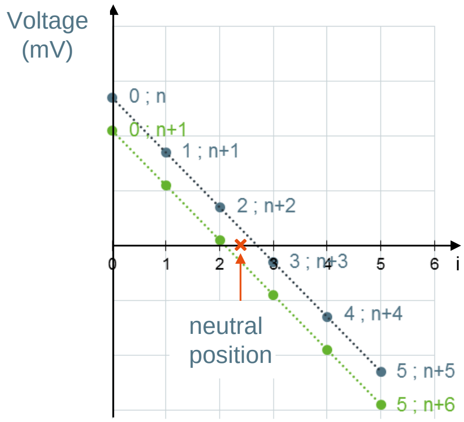


Fig. 5 - Plotted graph of voltage per bar position in case of odd number of bars

3 - DYNAMIC METHOD

When the machine is rotating the rotor reactance induces a deformation of the magnetic flux, which generates a shift of the neutral line with a certain angle. Even if the commutating poles are added to compensate this phenomenon, there is still a shift.

Figure 6 shows its influence depending on the rotating direction and the machine configuration (motor or generator).

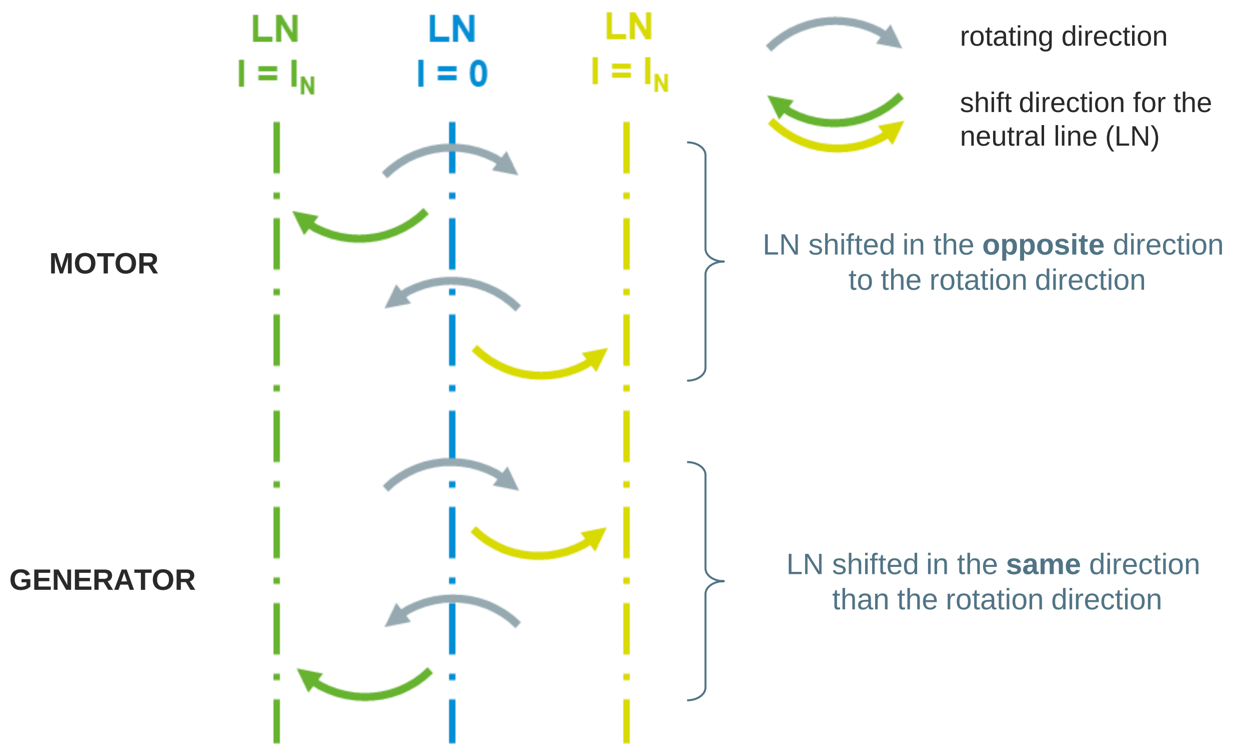


Fig. 6 - Neutral line shift in operation

In addition, the real current in the armature may not be at nominal (percentage or cycles). Therefore, it must be considered when positioning the brush (in particular for underloaded machines - see TDS-25).

Determination of the neutral line position

For DC machines with a high commutation level, it may be necessary to determine the exact position of brushes.

Dynamic determination at nominal load with graphical method

The dynamic determination method consists in measuring the voltage between a brush and bars before and after the brush to define the position where the voltage is nearest to zero.

As the machine is rotating, the bars position cannot be marked. A virtual position will be used by placing a perforated paper band so that it presses against the commutator surface at a free space closed to a brush, holes being pierced and numbered so that each hole corresponds virtually to a bar. Figure 7 illustrates the arrangement.

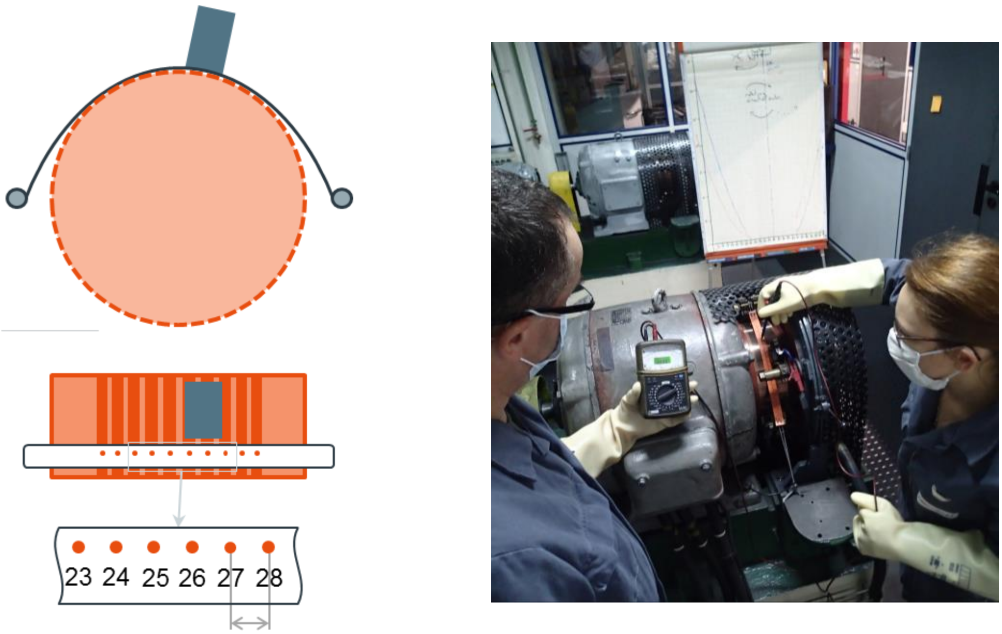


Fig. 7 - Paper band arrangement for dynamic method
(picture: Mersen PTT Electrical Testing Laboratory)

Because of the rotation we cannot use a metal tip as well. It is replaced simply by a graphite tip.

The successive steps are:

a) ensure that the brushes are seated to the commutator surface (properly bedded) and that there is a suitable patina,

b) stop the machine, disconnect the armature and block it,

c) determine the bar pitch[3] and report it on the paper band, then pierce holes and number them,

[3] The bar pitch may be simply determined by:
- finding the number of bars of the commutator (OEM data sheet or counting),
- measuring the perimeter of the commutator (for instance with a paper sheet),
- dividing the perimeter in mm by the number of bars will give the bar pitch in mm.

Another way is to print the image of several bars on a paper sheet thanks to a graphite pencil (or a soft brush!) and measure the distance between a number of bars by a caliper, then calculate the pitch.

d) fix tightly the paper band so that it is pressed on the commutator surface and its center shall be as close as possible to a brush,
e) run the machine to its nominal current,
f) proceed to the measurement of voltage for each numbered virtual bar before and after the brush position and report it (see picture of Figure 8),
g) draw lines between each point (the curve shall have a parabolic shape),
h) the neutral line is found at equidistance from two points with a high voltage.

Figure 8 is an example of graph to determine the neutral line.

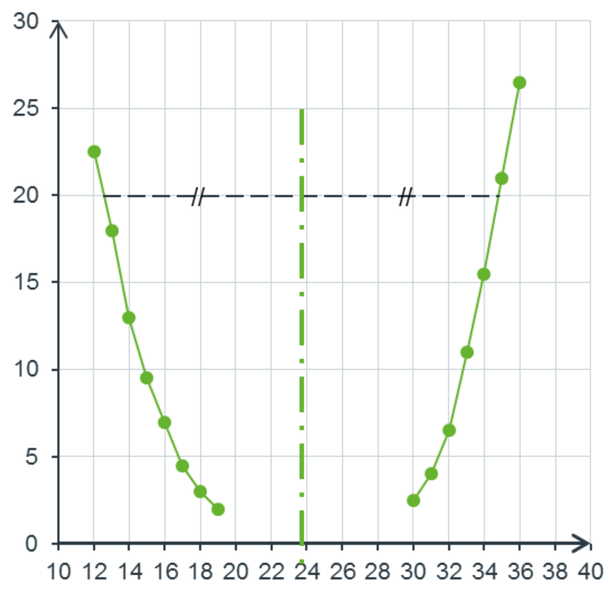


Fig. 8 - Graph for the neutral line determination by dynamic method

On the example above, the neutral position is between bars 23 and 24. Therefore, the brush shall be centered on this position.

> **Note:** The settlement of neutral line may be done by our Mersen experts as part of a maintenance operation.

IMPORTANT

Risk management measures shall be taken when applying this method (risk prevention plan).

In particular, three important conditions shall be met:

1) use of safety equipment: insulated carpet, electrician gloves, facial mask, clothes with wristband, etc…,
2) presence of a second person for removing the person in charge of the measurement by using an insulated bar,
3) a third person will ensure that the test is done within safety and call for rescue when needed. This person may also record the measurements.

Other methods for brush position adjustment

One method derived from the previous one may be used when the voltage is too high, so that it can be performed within safety conditions: the rotor voltage applied is below 100V and the machine is operating without load. In that case the position determined as per previous graphical method corresponds to the neutral line without load.

Then the motor shall be running at nominal load to check sparks. If sparks appear the position of brushes shall be adjusted by moving the rocker of a half bar at each step (in a direction opposite to the rotating direction in case of a motor operation – see Figure 6), so as to obtain no sparks.

Other step by step methods are also known, giving various results and generally taking a lot of time.

State of auxiliary poles

When continuing to plot the graph on remaining bars we obtain the curve of the voltage under the brush. Three cases are possible, as illustrated by figure 9:

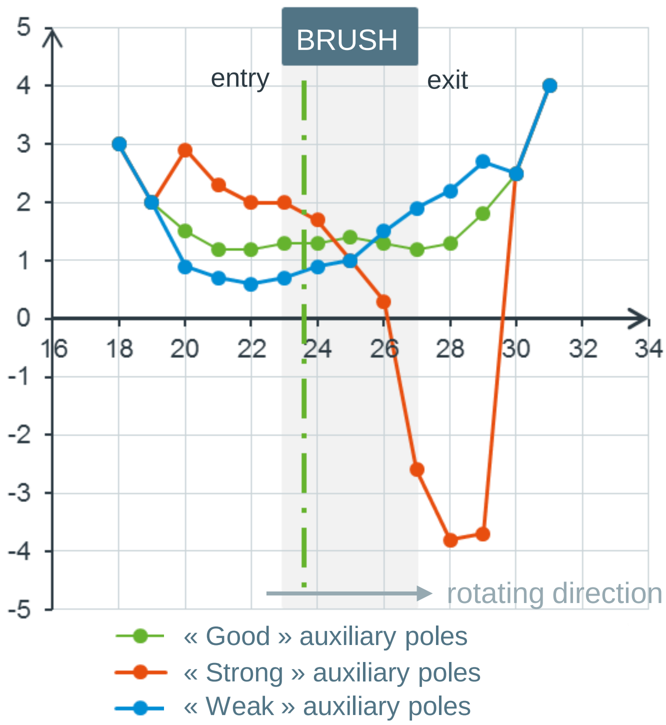


Fig. 9 - Voltage curves under and at proximity of the brush

The aspect of the curve and the voltage difference between entry and exit brush edges will inform about the state of the auxiliary poles.

« Good » auxiliary poles

The voltage ΔU between entry and exit brush edges is lower than 0,1 V. See figure 10.

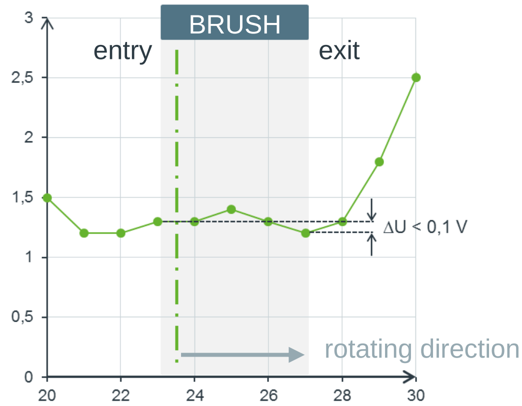


Fig. 10 - Voltage curves for correct auxiliary poles

« Strong » auxiliary poles

The voltage ΔU between entry and exit brush edges is higher than 0,1 V, and entry voltage U_E is above exit voltage U_S. See figure 11. This case may happen when too many coils have been wound on the auxiliary poles (during repair).

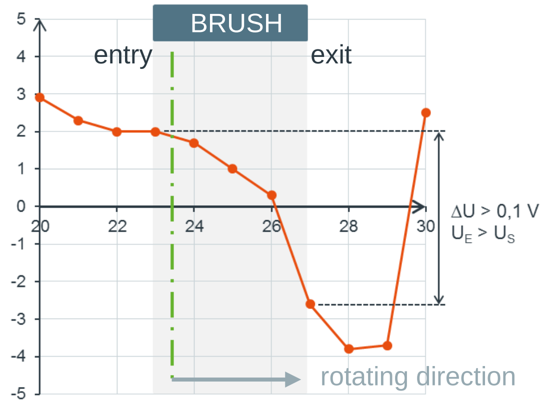


Fig. 11 - Voltage curves for strong auxiliary poles

« Weak » auxiliary poles

The voltage ΔU between entry and exit brush edges is higher than 0,1 V, and exit voltage U_S is superior to entry voltage U_E. See figure 12. This may be the consequence of the natural ageing of the windings (general case) or an insufficient number of coils during repair.

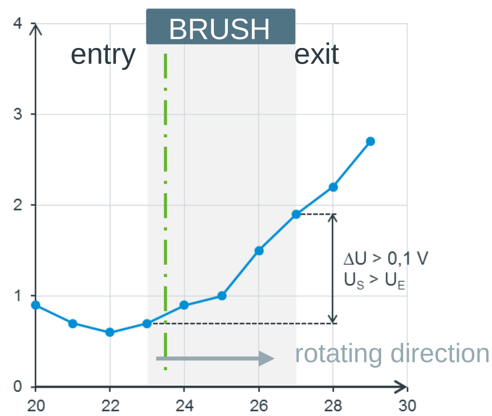
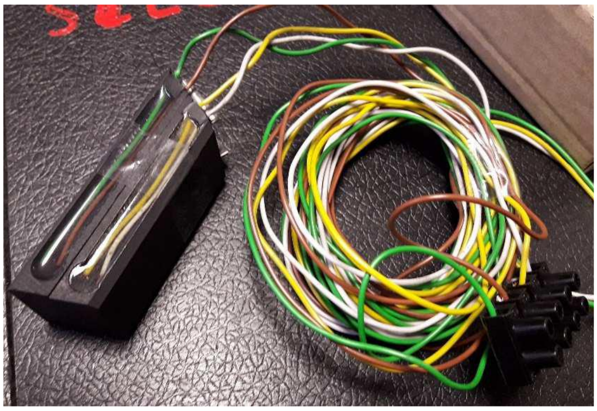


Fig. 12 - Voltage curves for weak auxiliariy poles

Potential measurement method

When not possible to use the dynamic method with full load, a test arrangement may be implemented on the motor at stop, consisting in placing 2 voltage probes at brush edges (first one at entry and second one at exit). The probes can be embedded inside of the brush (see example on the picture on the right).

Then when the machine operates, we obtain a direct reading of the voltage ΔU between entry and exit brush edges. Therefore, the state of commutating poles is determined according to the criteria above.



MERSEN SERVICES

Mersen's experts provide on-site motor inspections:

- Standard machine inspection (operating condition assessment)
- Comprehensive inspection
- Specific electrical machine inspection to address for example:
    - Electrical marking on commutator bars, on slip ring assemblies or on the carbon brushes
    - Sparking
    - Vibration
    - Current distribution problems
    - Machine symmetry
- Machine environment inspection

With a variety of training solutions, our highly qualified specialists can customize a training program that works for your specific situation.

Cited documents (available from our website www.mersen.com):

- *Mersen Maintenance Technical Guide: How to maintain carbon brushes, brush-holders, commutators and slip rings.*
- *Mersen PTT Technical data sheets:*
    - *TDS-01: The functions of a good brush*
    - *TDS-03: Edge chamfering*
    - *TDS-08: Preventive maintenance*
    - *TDS-09: Circumferential brush stagger*
    - *TDS-13: Aspect of commutator / slip-rings skins*
    - *TDS-14: Brush sparking*
    - *TDS-19: Brush seating*
    - *TDS-25: Underloaded machines*

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