

DIAGNOSTIC/TYPICAL SIGNATURES



February 1st, 2013

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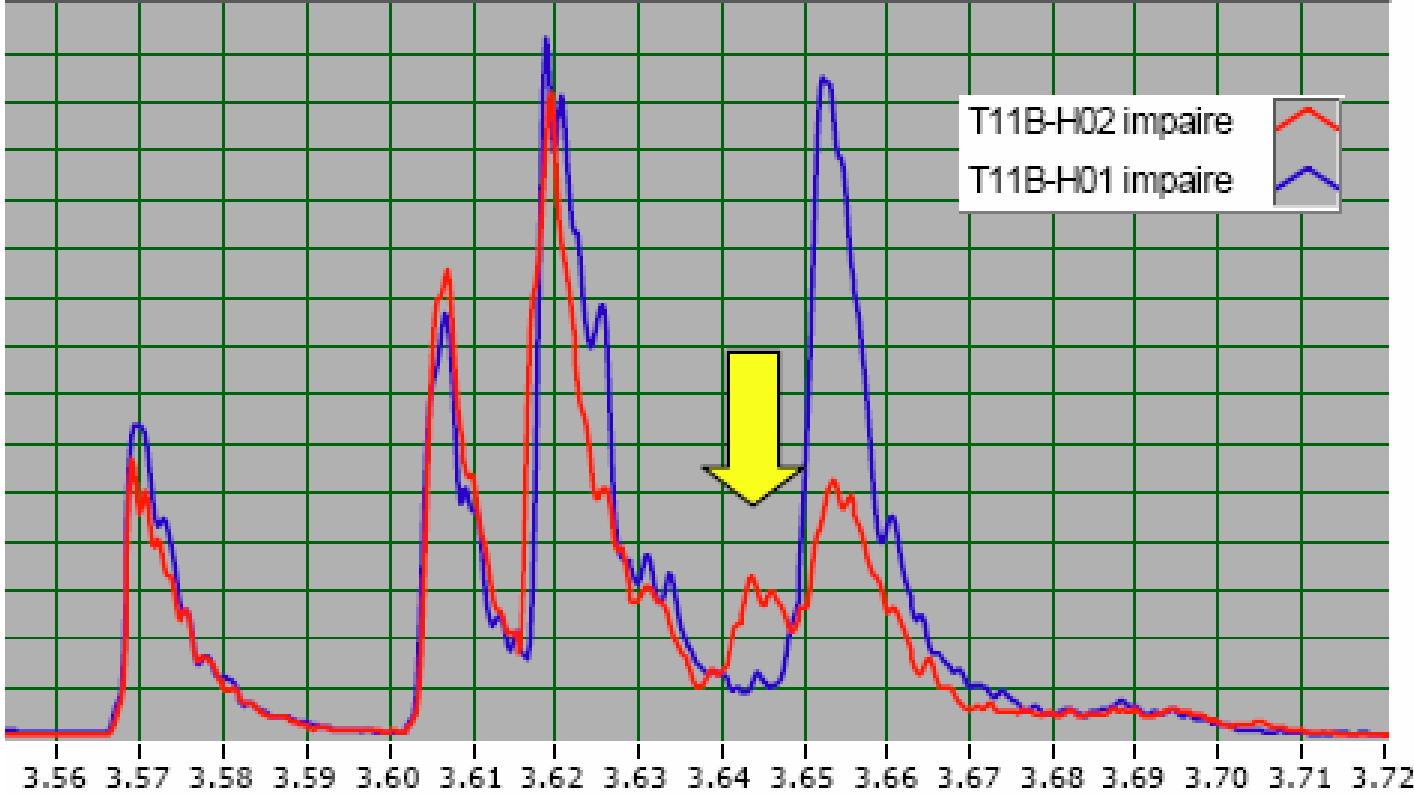
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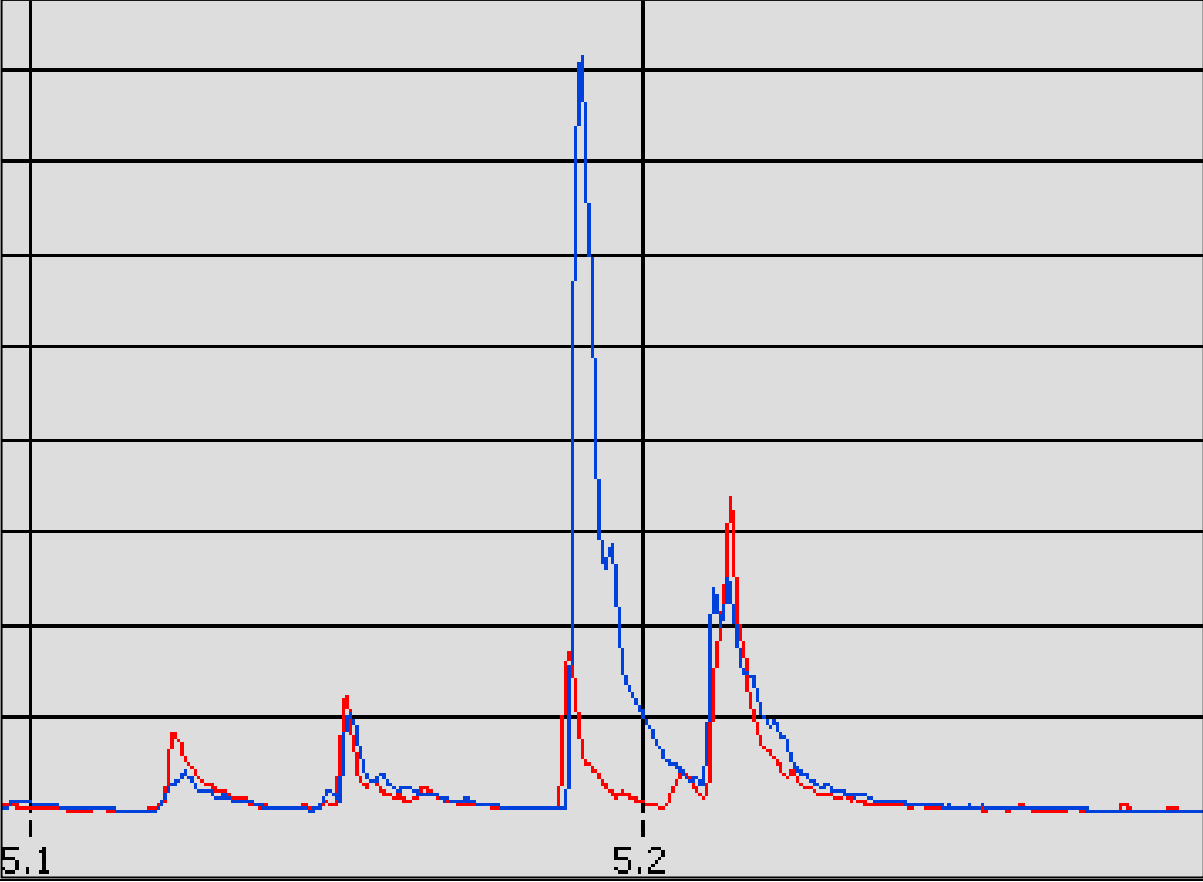
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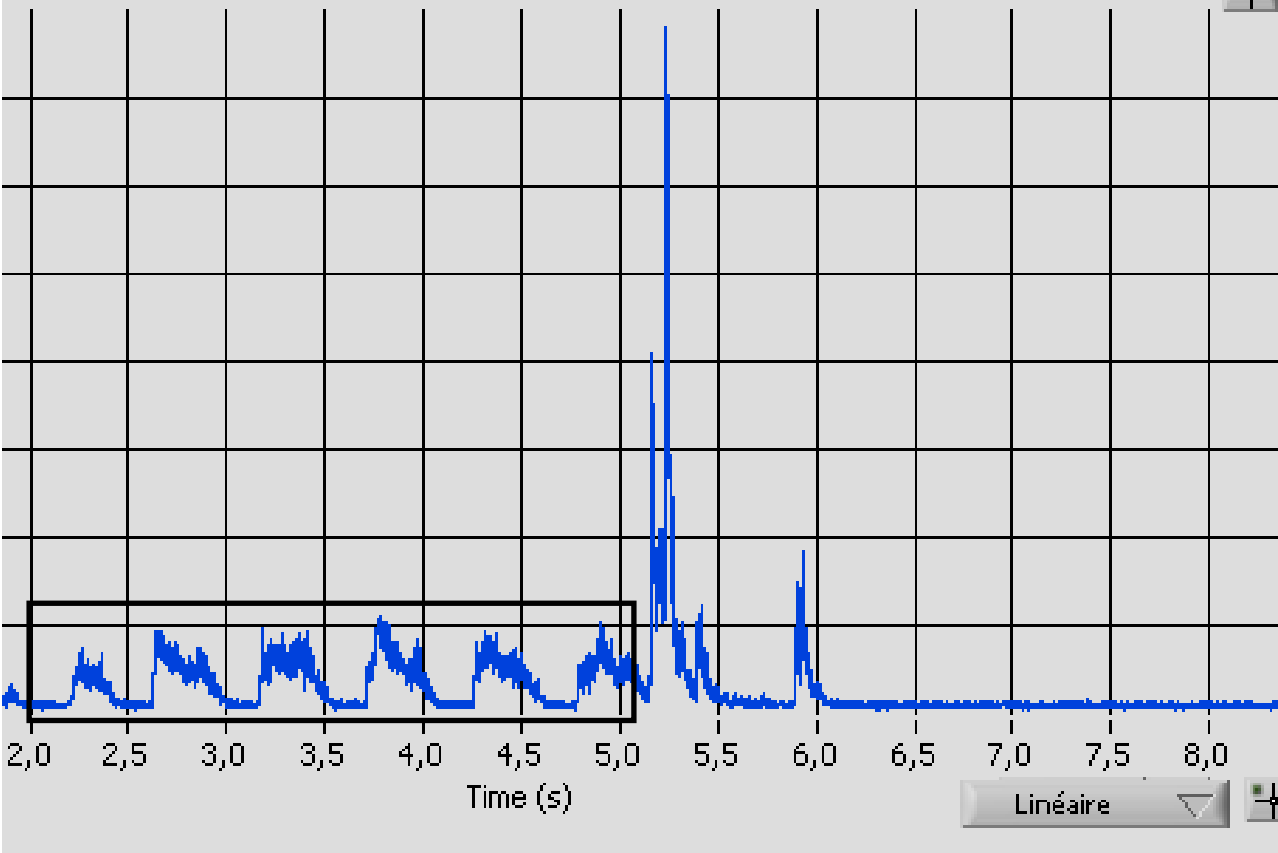
#1 ABB – UC (B, C, D, G and L) and UZ (B, C, D, E and F) - Braid improperly installed

Pictures	Description
 <p data-bbox="1093 432 1469 544">T11B-H02 impaire T11B-H01 impaire</p>	<p data-bbox="1653 619 2123 834">The signature of a switch with a braid improperly installed (red trace) is easily distinguished from a normal switch (blue trace).</p>
<p data-bbox="96 1166 2022 1241">Notes: An improper installation of the braid may interfere with the operation of the mechanism and eventually cause its failure.</p>	

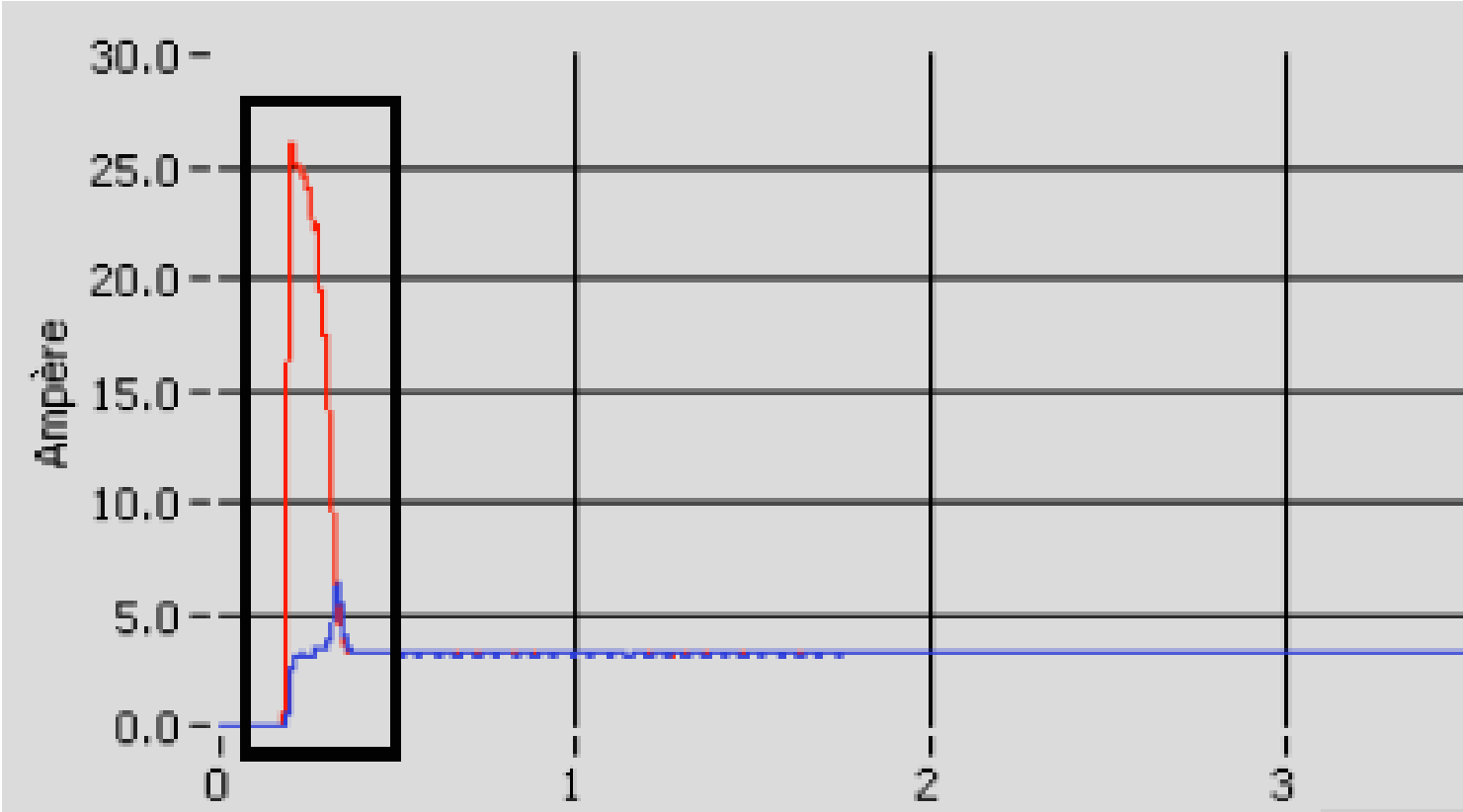
#2 ABB – UC (B, C, D, G and L) and UZ (B, C, D, E and F) - Bending of the moving main contact arm

Pictures	Description
	<p>As a result of repeated impacts during normal operations, the copper arm of the mobile contacts is bent and the minimum distance between mobile and fixed points of tungsten (0.5 mm) is no longer respected. This anomaly may cause local overheating due to the lower conductivity of tungsten. This anomaly is visible on the noise impact of arcing contacts. To discern the phenomenon of wear, you can note that the bending of the moving contact's arm does not alter the sequence. (red trace) is contact arm bent. (blue trace) is after recovery of the arm.</p>
<p>Notes:</p> <p style="text-align: center;">Recovery or replacement of the main contact moving arm.</p>	

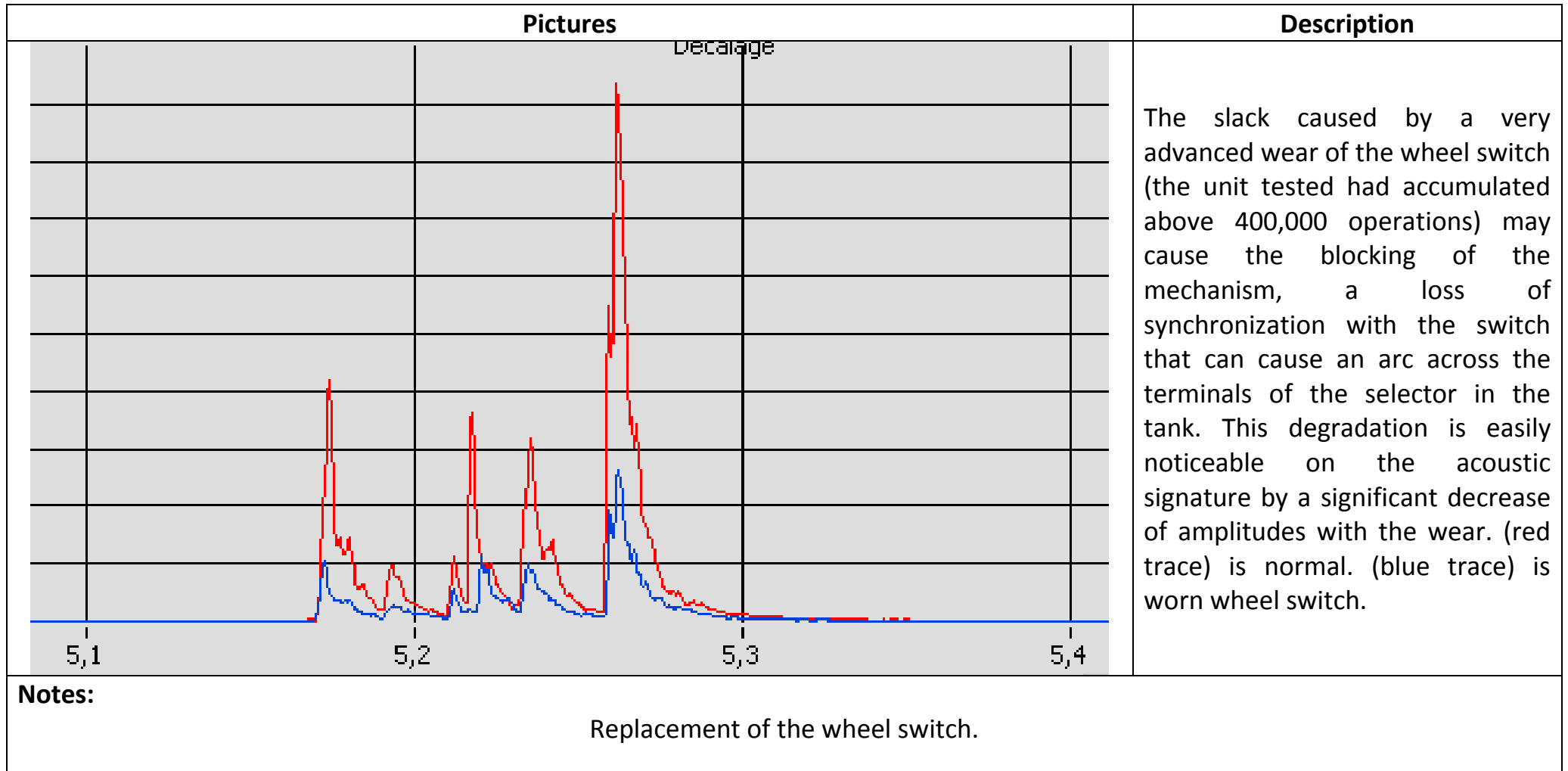
#3 ABB – UC (B, C, D, G and L) and UZ (B, C, D, E and F) - Lack of lubrication of the control gear

Pictures	Description
 <p>The figure is a line graph showing an acoustic signature over time. The x-axis is labeled 'Time (s)' and ranges from 2.0 to 8.0 with major grid lines every 0.5 units. The y-axis represents amplitude. The signal shows a series of smaller, periodic peaks between 2.0 and 5.0 seconds, which are enclosed in a black rectangular box. At approximately 5.2 seconds, there is a very sharp and tall peak that significantly exceeds the amplitude of the other peaks. Following this peak, the signal returns to a low, stable baseline. A control panel at the bottom right of the graph area includes a dropdown menu set to 'Linéaire' and a small icon.</p>	<p>A lack of lubrication of the gear drive mechanism may affect the acoustic signature as shown in this example. This phenomenon is highlighted in particular in the signature of the lower frequencies.</p>
<p>Notes:</p> <p>Lubrication of the control gear.</p>	

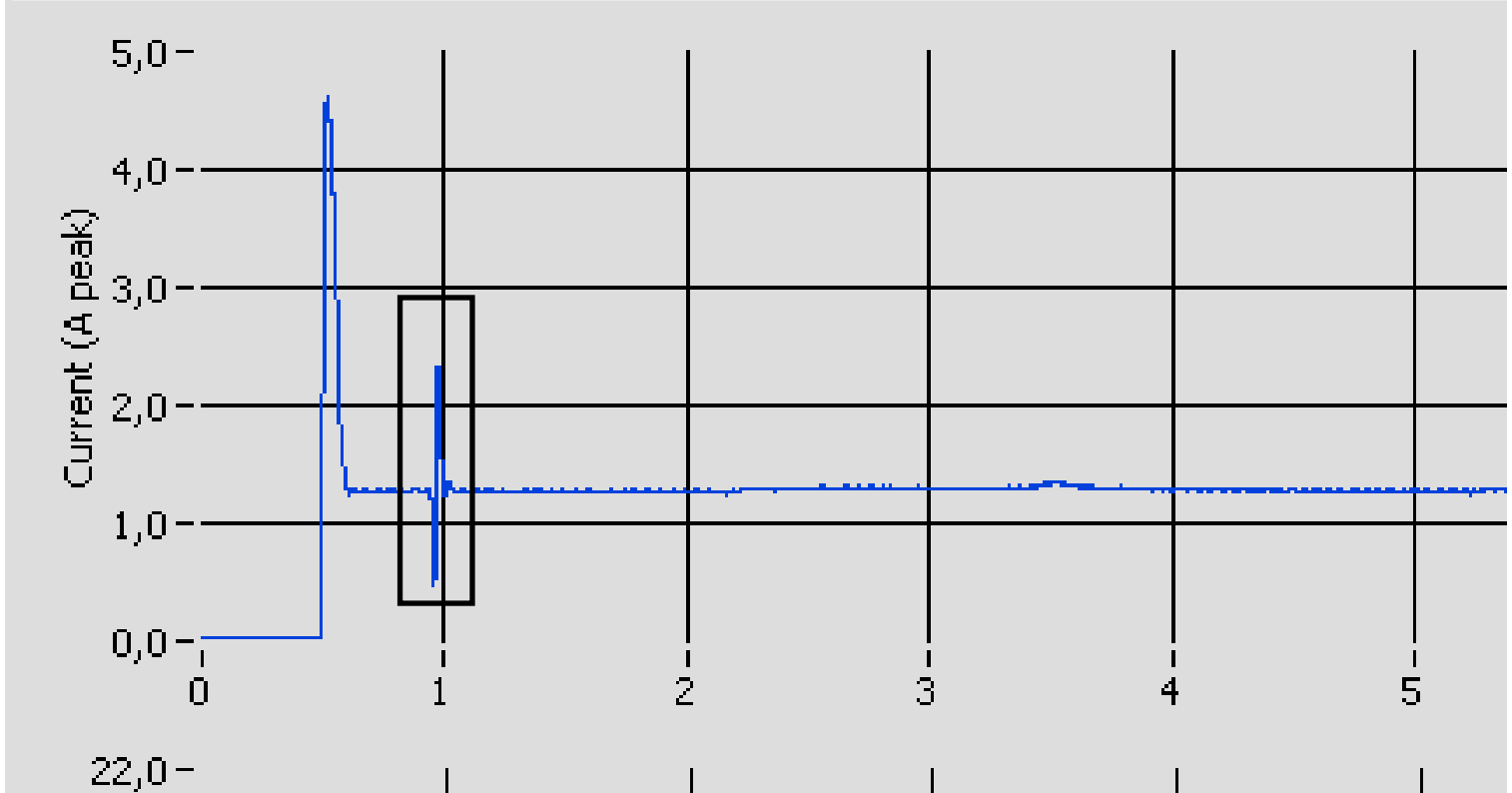
#4 ABB – UC (B, C, D, G and L) and UZ (B, C, D, E and F) - Slack in the control rod

Pictures	Description
	<p>An important slack in the control rod can be shown in the signature of the motor current as shown above. When the motor starts with loose parts, the amplitude of the inrush current can be significantly reduced.</p>
<p>Notes:</p> <p style="text-align: center;">Tighten any loose components.</p>	

#5 ABB – UC (B, C, D, G and L) and UZ (B, C, D, E and F) - Advanced wear of the wheel switch

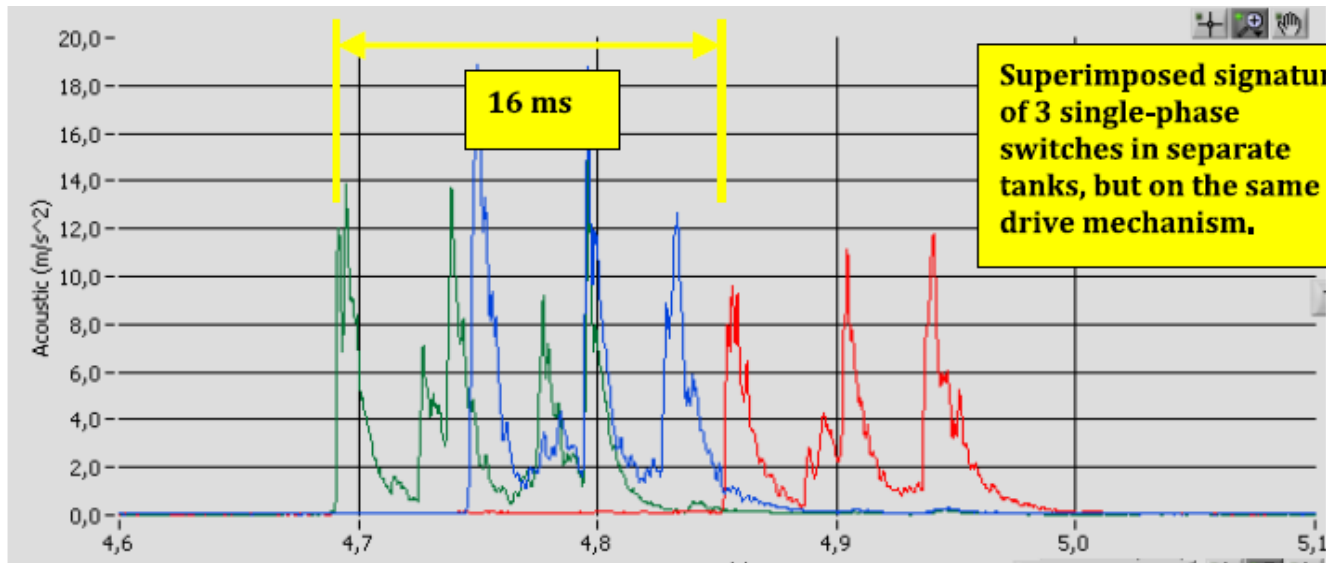


#6 ABB – UC (B, C, D, G and L) and UZ (B, C, D, E and F) - Faulty control relay

Pictures	Description
 <p>The graph displays current (A peak) on the vertical axis and time on the horizontal axis. The vertical axis has major ticks at 0,0, 1,0, 2,0, 3,0, 4,0, and 5,0, with an additional 22,0 mark at the bottom. The horizontal axis has major ticks at 0, 1, 2, 3, 4, and 5. The current starts at 0,0, rises sharply to a peak of approximately 4,5 at time 0,5, then drops to a steady state of about 1,3. A rectangular box highlights a period between time 0,8 and 1,2, where the current fluctuates significantly, with a peak of about 2,4 and a trough of about 0,5.</p>	<p>Anomalies of operation or of adjustment of control relays (upward, downward, maintenance, etc.) can often be observed by rapid fluctuations of the current. These anomalies are usually benign but still indicate a deterioration of the device which can ultimately lead to a refusal to operate; the operations are jerky or jumping to a position other than the set point. From the exploitation perspective, this behavior explains the reports of skipped taps.</p>
<p>Notes:</p> <p>Monitor this activity because it can lead to faulty tap switching.</p>	

#7 ABB – UC (B, C, D, G and L) - Desynchronization between switches

Pictures



Description

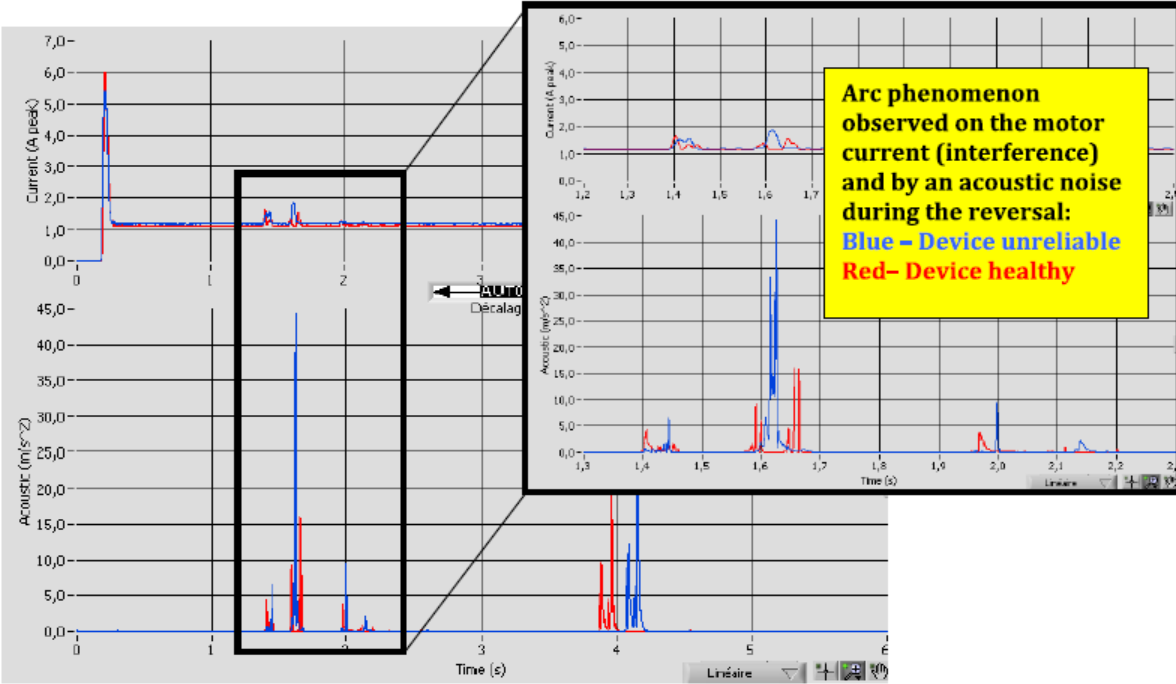
Synchronization between single-phase switches can be accurately verified especially when they are in separate tanks but on a single mechanism as shown on the left. By performing the measurement with 3 accelerometers, the signatures of the 3 switches occur simultaneously and the timing is measured directly. If the manufacturer does not specify a maximum offset, the adjustment (coupling shafts) can usually be made so that the offset does not exceed 25 ms.

Notes:

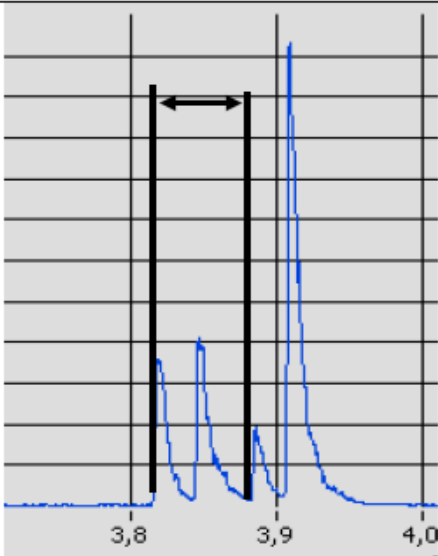
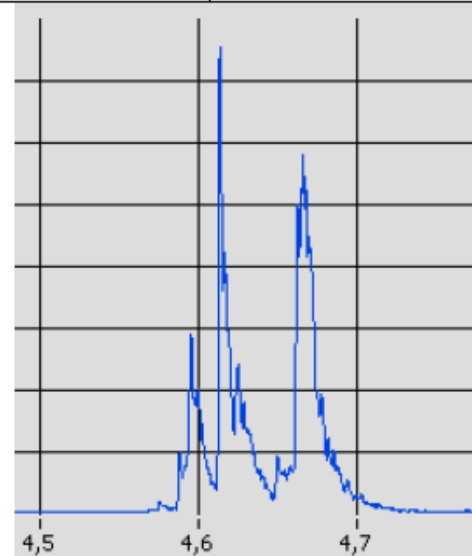
In case of multiple switches in a common tank, the signatures of the switches are superimposed and the evaluation of synchronization becomes more approximate.

When each switch is equipped with its own drive mechanism, the synchronization verification can be achieved by alternating the points of current measurement and the acoustic signature between phases (e.g. measuring current on phase A and acoustics on phase B).

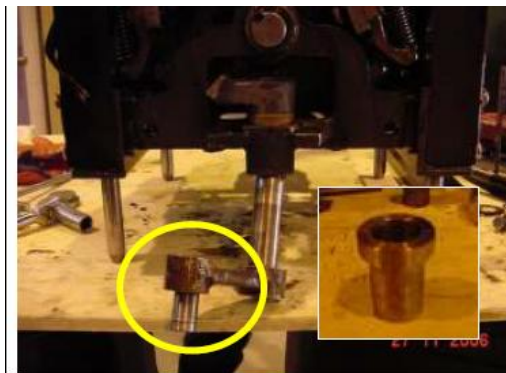
#8 ABB – UC (B, C, D, G and L) - Anomaly in the voltage limiter device

Pictures	Description
 <p>The figure consists of two vertically stacked line graphs. The top graph plots 'Current (A peak)' on the y-axis (0.0 to 7.0) against 'Time (s)' on the x-axis (0 to 6). It shows two traces: a red trace representing a 'healthy' device and a blue trace representing an 'unreliable' device. Both traces show a sharp initial peak followed by a steady state. The blue trace exhibits small, irregular oscillations during the steady state. A black box highlights a region between 1.5s and 2.5s, which is magnified in the bottom graph. The bottom graph plots 'Acoustic (m/s²)' on the y-axis (0.0 to 45.0) against 'Time (s)' on the x-axis (1.3 to 2.2). It also shows red and blue traces. The blue trace shows significantly higher and more irregular acoustic noise peaks compared to the red trace. A yellow text box is overlaid on the right side of the bottom graph, stating: 'Arc phenomenon observed on the motor current (interference) and by an acoustic noise during the reversal: Blue - Device unreliable Red - Device healthy'.</p>	<p>The operation of the inverter under voltage causes a low-intensity arc, which is picked up by the current clamp (for electromagnetic interference) by means of the acoustic noise of the spark. It can often be observed at the time of the contact separation, a few alternations to 120 Hz corresponding to voltages peaks.</p>
<p>Notes: Depending on the voltage level, some manufacturers install voltage limiter devices to reduce this phenomenon. In case of this device, one can observe that the amplitudes of the noise increases as shown in the figure above. And the phenomenon can also be maintained over a longer period (not in this example). The long-term consequences of such anomalies are not well known.</p>	

#9 ABB – UC (B, C, D, G and L) - Time of transition not perceptible

Pictures		Description
 <p>Time of transition well identified</p>	 <p>Time of transition barely perceptible</p>	<p>When the transition time is barely perceptible by a visual examination of the acoustic signature, the most likely causes are:</p> <ul style="list-style-type: none"> -Misalignment of the mechanism (pass-through bolts) -Wear of the mechanism -Wear of the driving ring <p>These anomalies are followed by an assymetry between even and odd operations. Contacts badly worn may also complicate the identification of the 3rd pic, but without causing an assymetry.</p>

Notes:

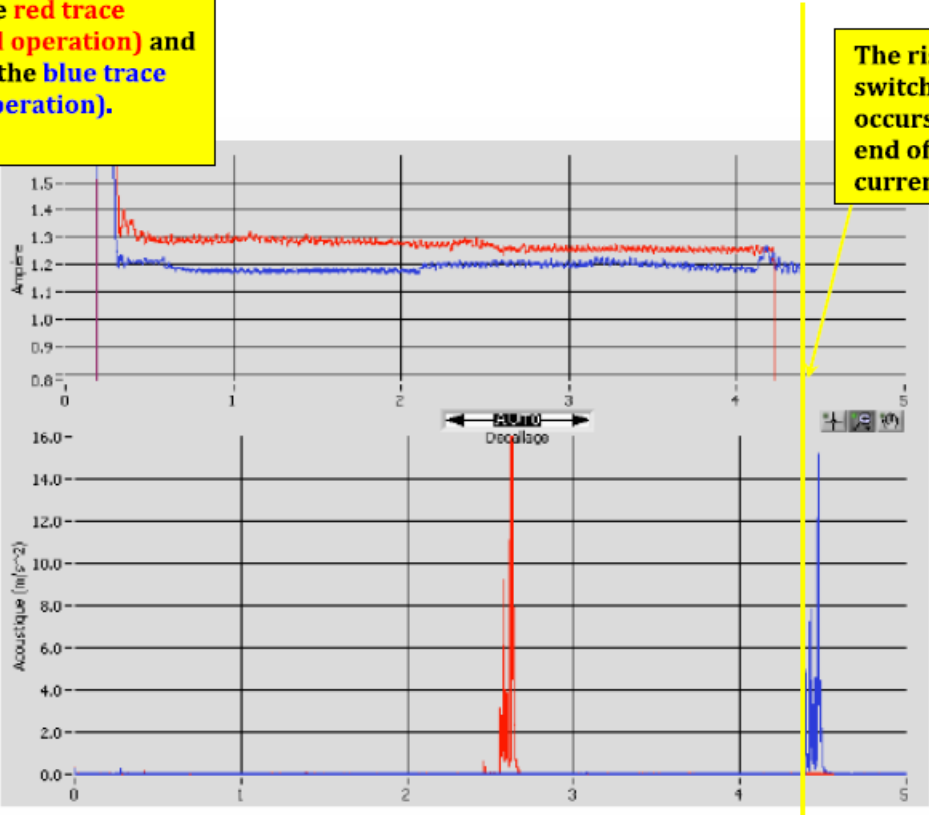


Wear of driving finger and ring

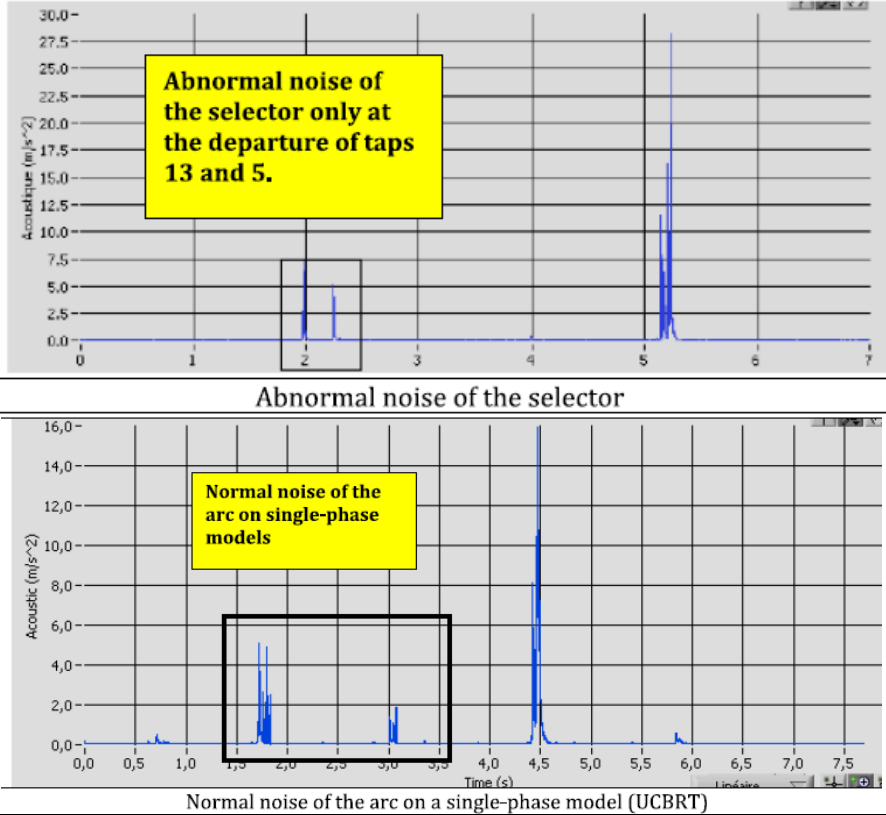


View of the screw under the switch

#10 ABB – UC (B, C, D, G and L) - Switching synchronization

Pictures	Description
<p data-bbox="152 331 519 539">The switching occurs too early on the red trace (downward operation) and too late on the blue trace (upward operation).</p>  <p data-bbox="1137 402 1384 577">The rise of the switching occurs after the end of the motor current!</p> <p data-bbox="750 778 900 826">Emission Decalage</p>	<p data-bbox="1467 630 2123 890">Following repairs, or adjustments in the driving mechanism, it is possible that the switching is out of synchronization. In these models, this anomaly can be demonstrated by comparing the upward and downward operations.</p>
<p data-bbox="94 1209 199 1241">Notes:</p> <p data-bbox="324 1252 1892 1284">In order to correct the adjustment, we must rebuild the shaft coupling at the output of the control box.</p>	

#11 ABB – UC (B, C, D, G and L) - Aligning the contacts of the selector

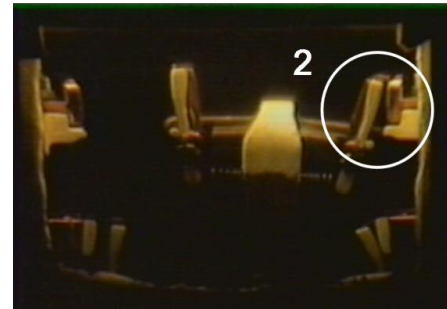
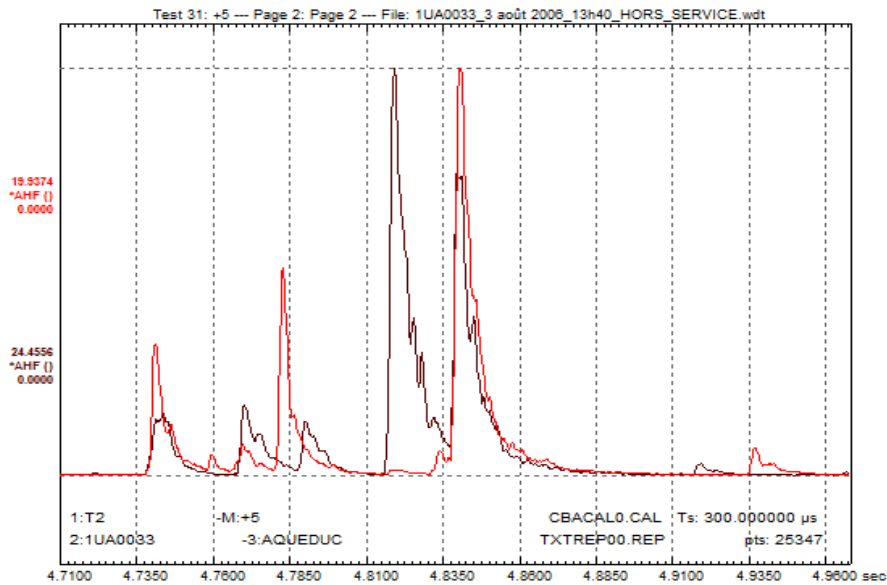
Pictures	Description
 <p>The top graph, titled 'Abnormal noise of the selector', shows acoustic intensity (m/s²) on the y-axis (0.0 to 30.0) against time (s) on the x-axis (0 to 7). A yellow box highlights a sharp peak at approximately 5.2 seconds. The bottom graph, titled 'Normal noise of the arc on a single-phase model (UCBRT)', shows acoustic intensity (m/s²) on the y-axis (0.0 to 16.0) against time (s) on the x-axis (0.0 to 7.5). A yellow box highlights a sharp peak at approximately 4.5 seconds.</p>	<p>A misalignment of the selector contacts can cause abnormal noise during its operation. For a model with inverter (or pre-selector) that noise will be observed in the two operations corresponding to the same tap as shown on the left. In this example, there is a noise at the departure of the taps 5 and 13 only, which corresponds to the same fixed contact.</p>
<p>Notes:</p> <p>For single-phase models, this noise can be confused with a normal arc noise when the test is performed under voltage. These arc noises can be observed both at departure and arrival of the selector. The amplitude is usually a little higher at the departure of the selector when the movement removes the turns of regulation and vice versa for the arrival. For these models, the misalignment of contacts can be observed only if the test is performed disconnected from voltage.</p>	

#12 ABB – UC (B, C, D, G and L) - Asymmetry of signatures switching

Pictures	Description
<p>The image contains two line graphs showing acoustic signatures. The top graph has a y-axis labeled 'Acoustique (m/s²)' ranging from 0.0 to 80.0 and an x-axis labeled 'Temps (s)' ranging from 3.8 to 4.1. It shows two overlapping waveforms, one red and one blue, with a horizontal double-headed arrow labeled 'Décalage' indicating a time shift between peaks. The bottom graph has a y-axis labeled 'Acoustic (m/s²)' ranging from 0.0 to 20.0 and an x-axis labeled 'Time (s)' ranging from 5.5 to 5.7. It also shows two overlapping waveforms (red and blue) with a horizontal double-headed arrow labeled 'Décalage' indicating a time shift.</p>	<p>To check the symmetry of the switch you must graphically superimpose the signature of an even operation to an odd one.</p> <p>The probable causes of this asymmetry are:</p> <ul style="list-style-type: none"> -The excessive wear of the driving wheel of the switch -A bad adjustment of the switch (adjustment screw – pass through bolts) -An uneven wear of contacts between the even and odd sides.
<p>Notes:</p> <p style="text-align: center;">Adjustments to correct the situation.</p>	

#13 ABB – UCCRN - Contact wear by missing impacts

Pictures



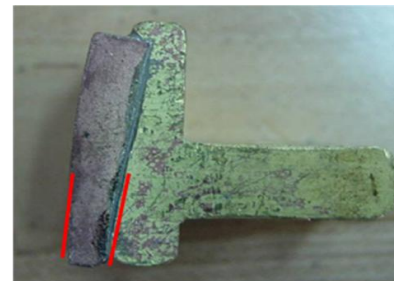
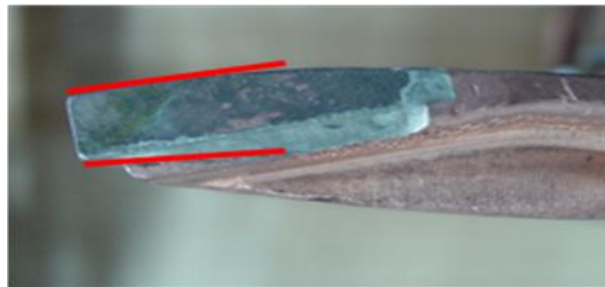
Description

The closing of the main contacts becomes very weak with the wear of contacts.

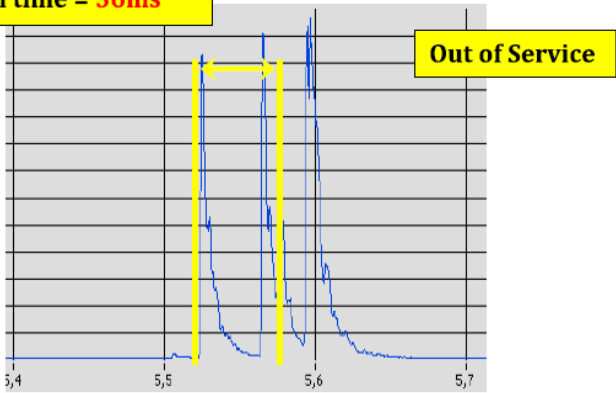
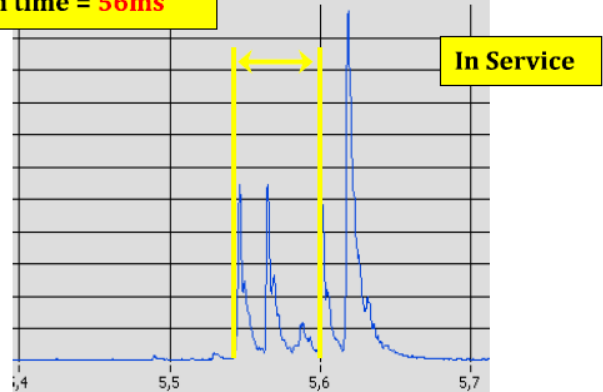
Contact wear is confirmed by opening up the ABB UCCRN tap changer and replacing the arcing contacts, as highlighted by the traces.

Notes:

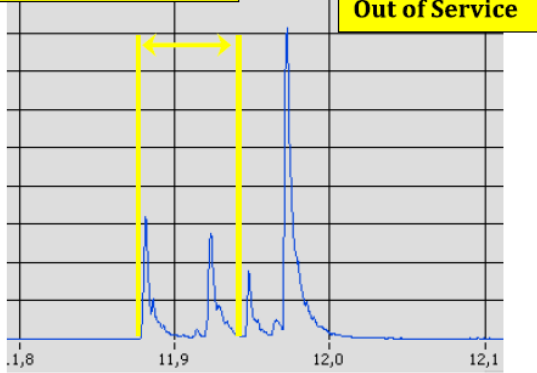
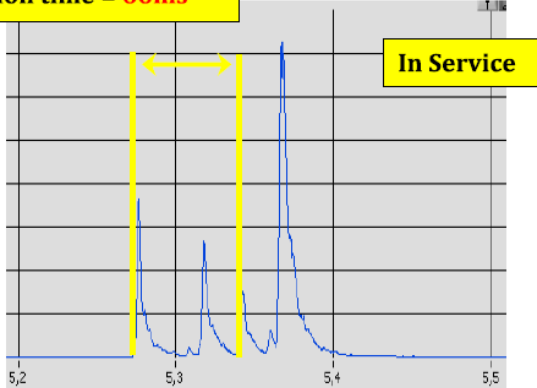
The loss of material caused by the wear of the driving contacts, for inertial effect, a variation in the sequence and a reduction of the impact noise of the main arc contacts. Trending of the suspected contacts is necessary to know the speed of the degradation.



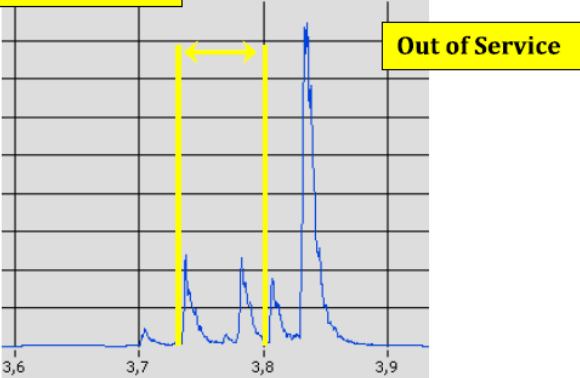
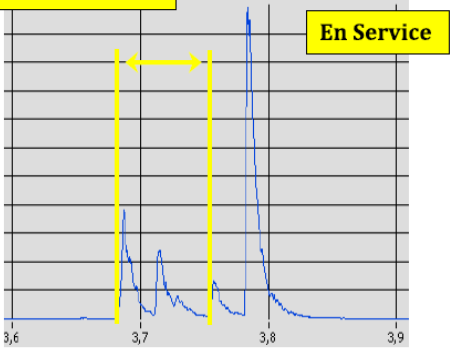
#14 ABB – UCB - Typical switching

Pictures	Description
<p data-bbox="439 248 909 296">Typical transition time = 56ms</p>  <p data-bbox="647 695 1236 719">Figure 3 : ABB UCBRN switching at tap +2' in mode Out of Service</p> <p data-bbox="439 746 909 794">Typical transition time = 56ms</p>  <p data-bbox="669 1190 1225 1214">Figure 4 : ABB UCBRN switching at tap +2 in mode In Service</p>	
<p data-bbox="94 1246 197 1278">Notes:</p>	

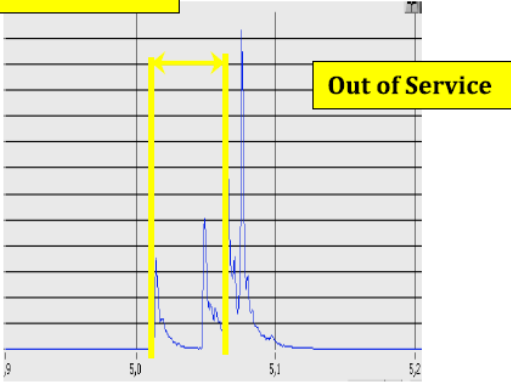
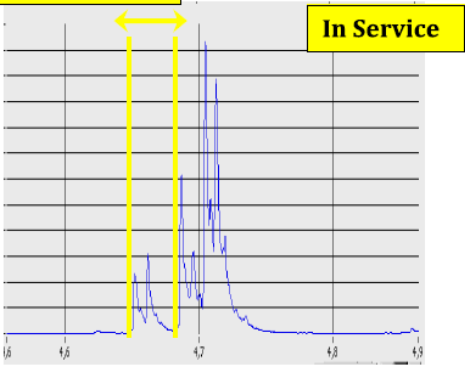
#15 ABB – UCC - Typical switching

Pictures	Description
<p data-bbox="483 277 949 325">Typical transition time = 66ms</p>  <p data-bbox="680 730 1256 754">Figure 5 : ABB UCBRN switching at tap -8 in mode Out of Service</p> <p data-bbox="483 775 949 823">Typical transition time = 66ms</p>  <p data-bbox="692 1219 1240 1243">Figure 6 : ABB UCBRN switching at tap -4 in mode In Service</p>	
<p data-bbox="91 1254 197 1283">Notes:</p>	

#16 ABB – UCD - Typical switching

Pictures	Description
<p data-bbox="450 276 913 325">Typical transition time = 70ms</p>  <p data-bbox="658 751 1234 775">Figure 7 : ABB UCDRE switching at tap +8 in mode Out of Service</p> <p data-bbox="521 799 945 849">Typical transition time = 70ms</p>  <p data-bbox="728 1206 1218 1230">Figure 8 : ABB UCDRE switching at tap +8 in mode In Service</p>	
<p data-bbox="91 1257 197 1286">Notes:</p>	

#17 ABB – UCG - Typical switching

Pictures	Description
<p data-bbox="472 264 943 312">Typical transition time = 45ms</p>  <p data-bbox="685 740 1263 762">Figure 9 : ABB UCGRN switching at tap +6 in mode Out of Service</p> <p data-bbox="488 762 954 810">Typical transition time = 45ms</p>  <p data-bbox="707 1225 1267 1248">Figure 10 : ABB UCGRN switching at tap +6' in mode In Service</p>	
<p data-bbox="91 1267 197 1295">Notes:</p>	

#18 ABB – UCL - Typical switching

Pictures

Only 1 switch

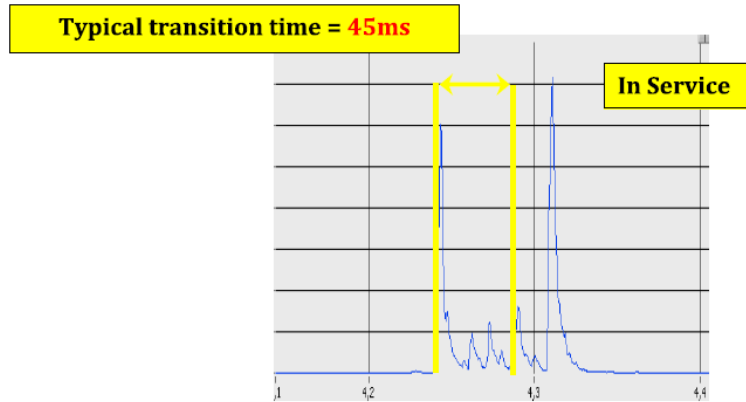


Figure 11 : ABB UCLRN switching at tap -4 in mode **In Service**
Three (3) single-phase switches
within the same tank

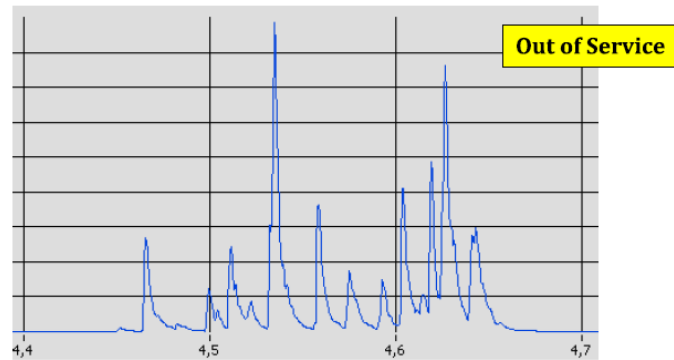


Figure 12 : ABB UCLRN switching at tap +12 in mode **Out of Service**

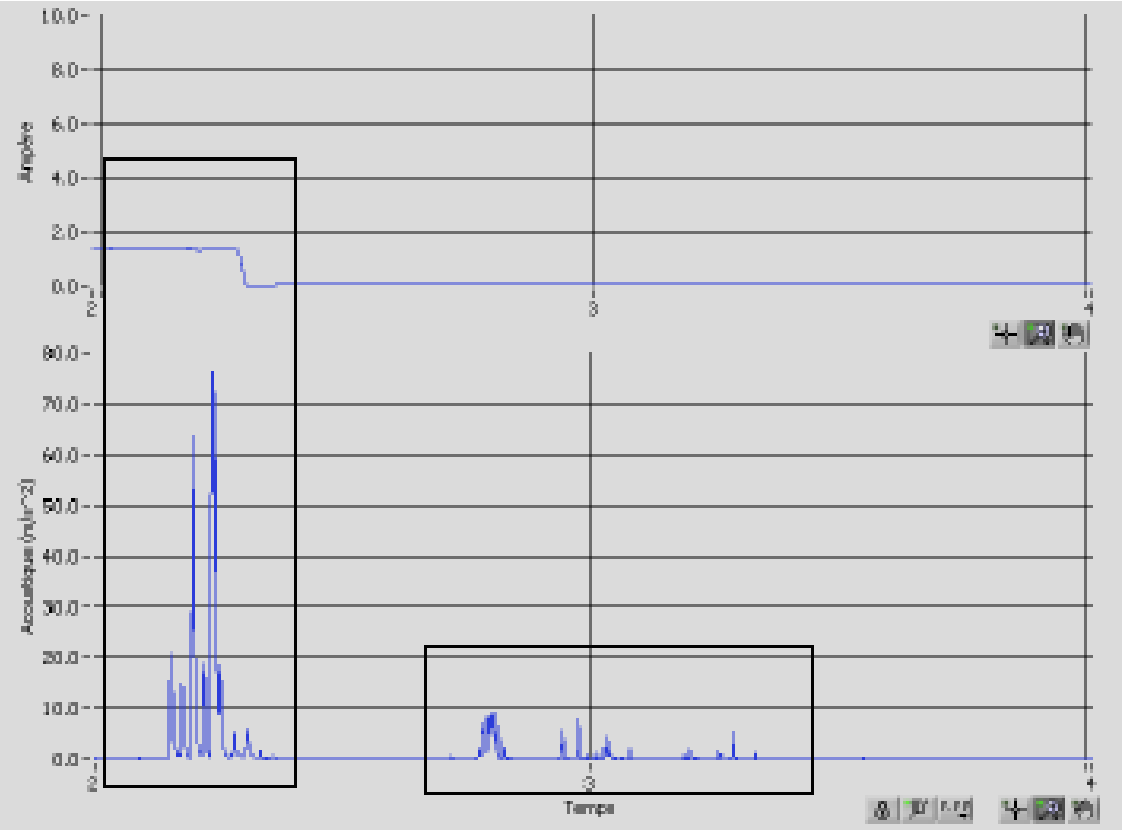
Description

Notes:

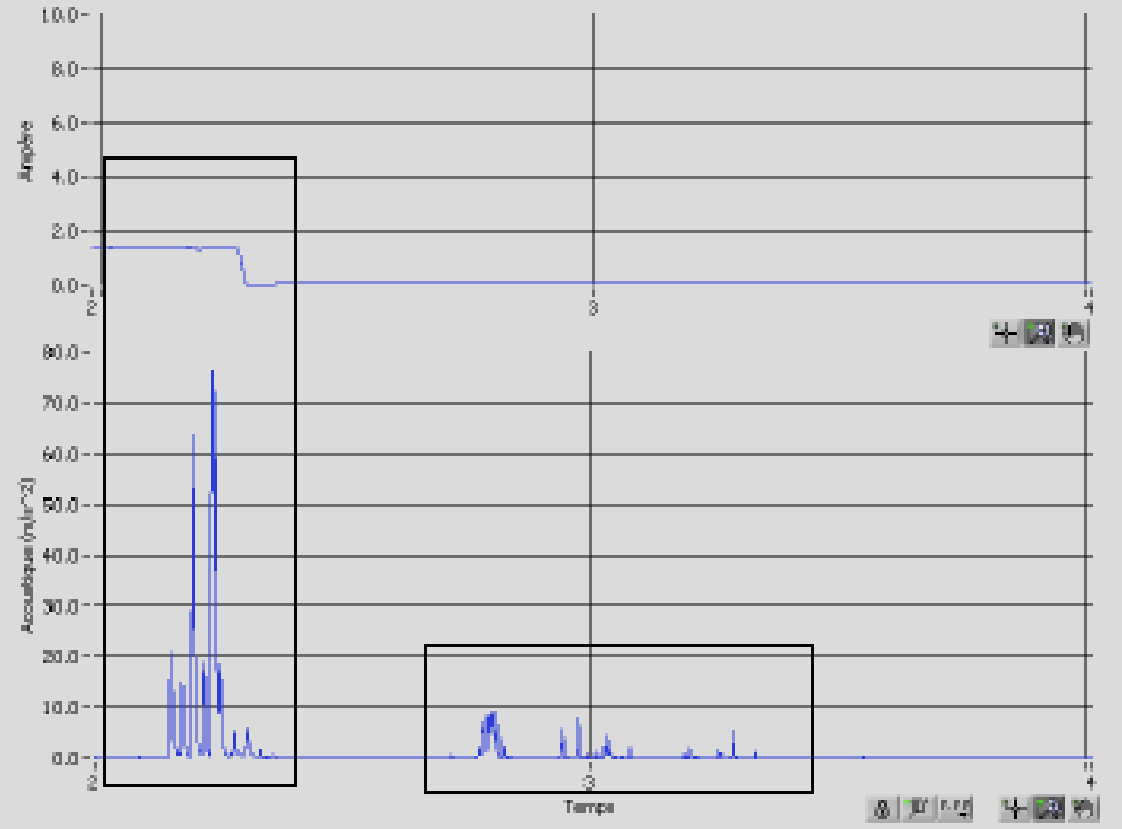
#19 ABB – UC - Expected signature

Pictures	Description
<p>ABF (g) MAX 31.4941 G</p> <p>AHF (g) MAX 25.8038 G</p> <p>CR1 (A) AVR 484.2000 AMP DLT 0.0748 AMP BRX 1308.9004 MS</p> <p>1:T6 -3:MONTMORENCY,69 KV CBACAL70.CAL Ts: 300.000000 µs 2:1U-0080 -4:58189 TAP-REPORT_ENGLISH.XLS pts: 25379</p> <p>0.00 1.00 2.00 3.00 4.00 5.00 6.00 7.00 sec</p>	
<p>Notes:</p>	

#20 ABB – UZ (B, C, D, E and F) - Brake failure

Pictures	Description
	<p>The braking system of the ABB UZ is mechanical, by pressure pads on the inertial flywheel. These systems have experienced failures in the past, including the presence of grease on the surface, which caused malfunctions. In this case, the rotating mechanism continues its momentum and triggers the cascading of operations beyond the position required to stop at one of the extreme positions (1 or 17). The noise after the end of operation is not normal.</p>
<p>Notes:</p> <p style="text-align: center;">Verify the brake circuits and components.</p>	

#21 ABB – UZ (B, C, D, E and F) - Brake failure

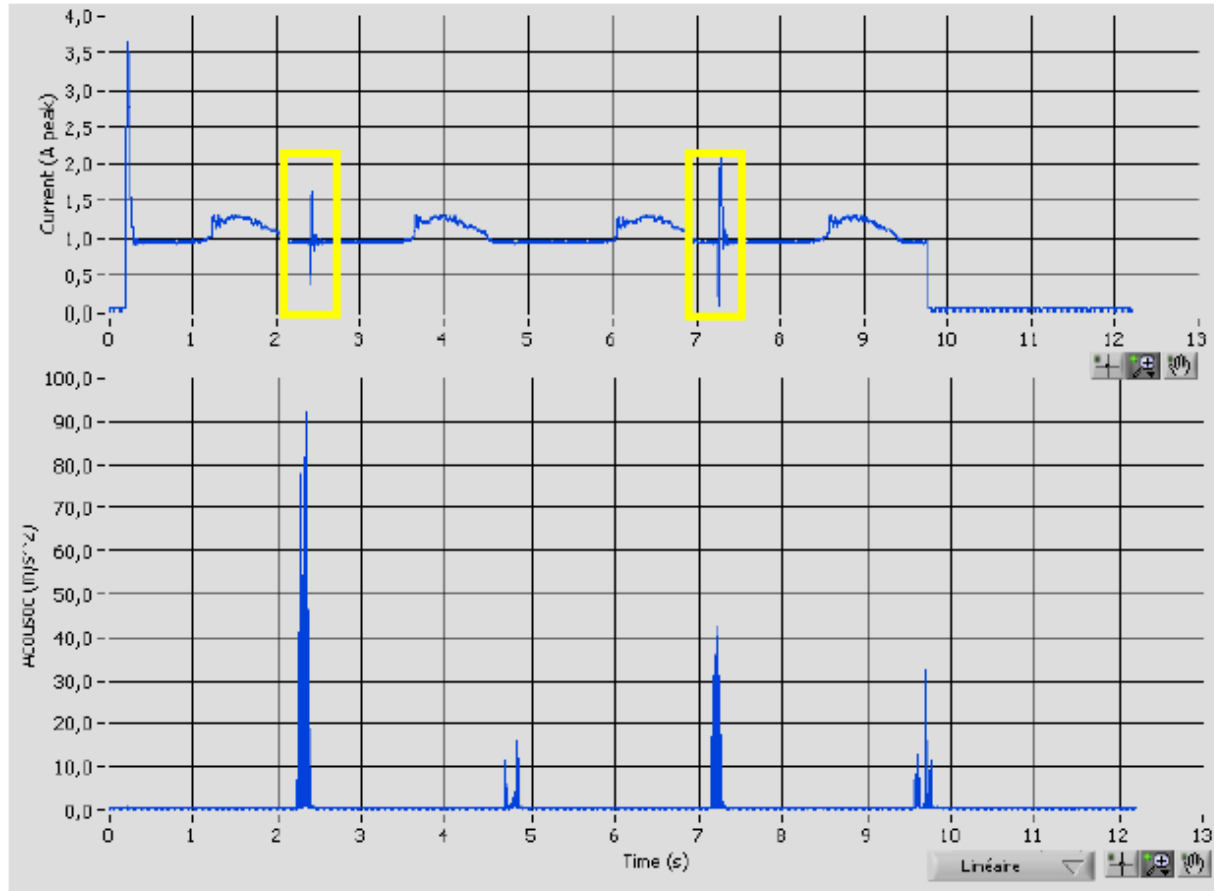
Pictures	Description
	<p>The braking system of the ABB UZ is mechanical, by pressure pads on the inertial flywheel. These systems have experienced failures in the past, including the presence of grease on the surface, which caused malfunctions. In this case, the rotating mechanism continues its momentum and triggers the cascading of operations beyond the position required to stop at one of the extreme positions (1 or 17). The noise after the end of operation is not normal.</p>
<p>Notes:</p> <p style="text-align: center;">Verify the brake circuits and components.</p>	

#22 ABB – UZ (B, C, D, E and F) - Wear of contacts

Pictures	Description
<div data-bbox="264 375 1288 710"> </div> <p data-bbox="607 735 945 762">a) New contacts (October 21, 2002)</p> <div data-bbox="264 790 1288 1125"> </div> <p data-bbox="607 1150 945 1177">b) Worn contacts (October 1, 2002)</p> <div data-bbox="1115 331 1429 539" style="background-color: yellow; border: 1px solid black; padding: 5px;"> <p>Green traces represent the LF.</p> <p>Red traces represent the HF.</p> </div>	<p data-bbox="1615 647 2163 863">Wear of the switch contacts appears on the acoustic signatures by a gap between the amplitudes of the traces of the High Frequency and the Low Frequency.</p>
<p data-bbox="91 1214 199 1246">Notes:</p> <p data-bbox="465 1259 1783 1294">Trending of the suspected contacts is necessary to know the speed of the degradation.</p>	

#23 ABB – UZ (B, C, D, E and F) Faulty control relay

Pictures



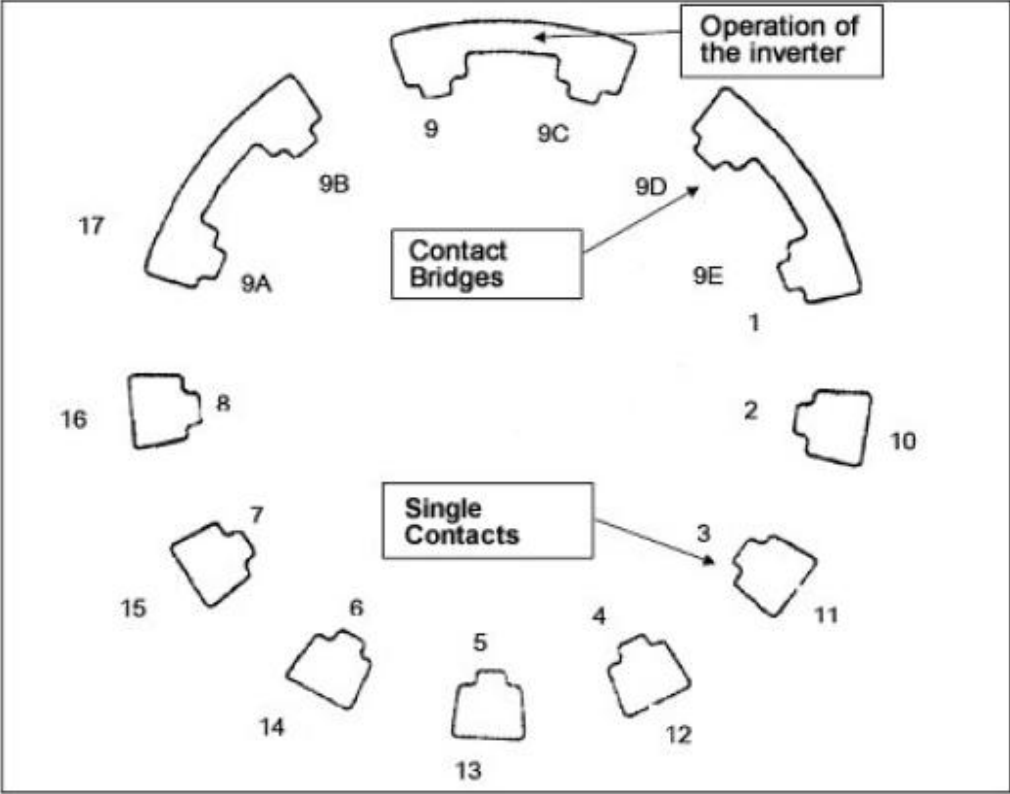
Description

It is to note that sometimes with multiple operations there are important current fluctuations. These phenomena are due to a malfunction of the control relay.

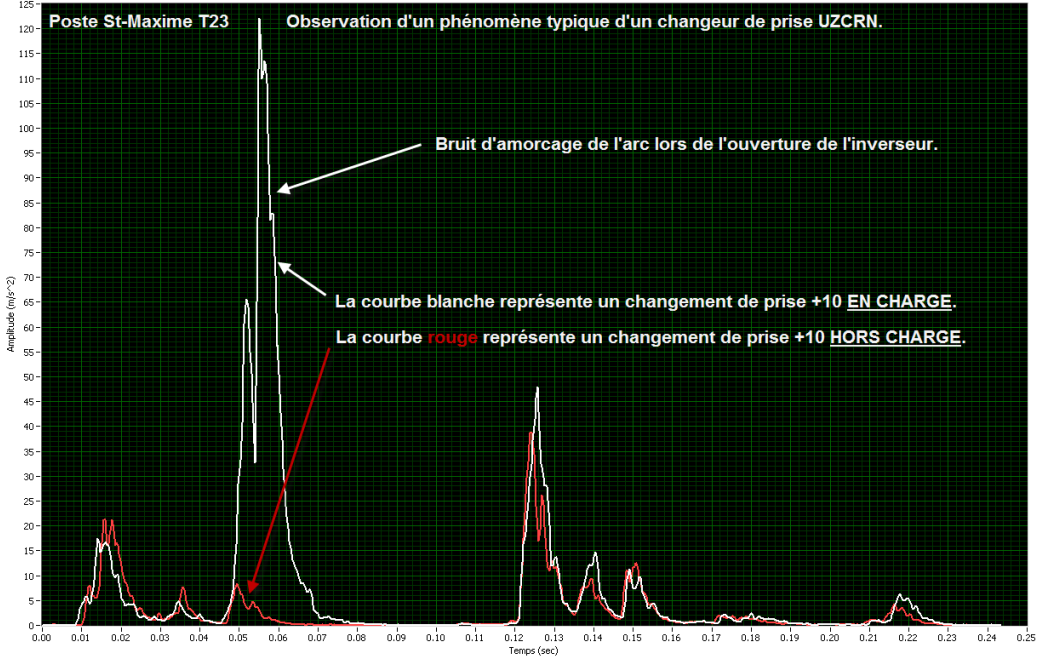
Usually a minor problem that can be tuned either by adjusting or replacing the defective relay.

Notes:

#24 ABB – UZ - Types of taps

Pictures	Description
 <p>The diagram illustrates the setup of 17 taps on an ABB UZ operating with an inverter. It shows two main types of contacts: Contact Bridges and Single Contacts. The Contact Bridges are labeled 9A, 9B, 9C, 9D, and 9E. The Single Contacts are labeled 1 through 13. The diagram also shows the 'Operation of the inverter' and 'Contact Bridges' labels. The taps are numbered 1 through 17. Tap 17 is connected to Contact Bridge 9A. Tap 16 is connected to Contact Bridge 8. Tap 15 is connected to Contact Bridge 7. Tap 14 is connected to Contact Bridge 6. Tap 13 is connected to Contact Bridge 5. Tap 12 is connected to Contact Bridge 4. Tap 11 is connected to Contact Bridge 3. Tap 10 is connected to Contact Bridge 2. Tap 9 is connected to Contact Bridge 9C. Tap 8 is connected to Contact Bridge 8. Tap 7 is connected to Contact Bridge 7. Tap 6 is connected to Contact Bridge 6. Tap 5 is connected to Contact Bridge 5. Tap 4 is connected to Contact Bridge 4. Tap 3 is connected to Contact Bridge 3. Tap 2 is connected to Contact Bridge 2. Tap 1 is connected to Contact Bridge 1.</p>	<p>The figure shows the setup of the fixed contacts of an ABB UZ operating with 17 taps with an inverter. As seen, there is a representation of two types of contacts, either as: contacts bridges and single contacts.</p> <p>There are so many types of switching, depending of the type of departure and arrival contact:</p> <ul style="list-style-type: none"> -single contact to a contact bridge -contact bridge to a single contact -switching over the same contact bridge -contact bridge to a contact bridge -switching over the same contact bridge with an operation of the inverter -single contact to a single contact.
<p>Figure 1 : Taps setup on a ABB UZ operating with 17 taps with an invertei</p> <p>Notes: Each type of switching has a distinct signature since the mechanical mechanisms are themselves distinctive.</p>	

#25 ABB - UZCRN - Arcing contact

Pictures	Description
 <p>Poste St-Maxime T23</p> <p>Observation d'un phénomène typique d'un changeur de prise UZCRN.</p> <p>Bruit d'amorçage de l'arc lors de l'ouverture de l'inverseur.</p> <p>La courbe blanche représente un changement de prise +10 <u>EN CHARGE</u>.</p> <p>La courbe rouge représente un changement de prise +10 <u>HORS CHARGE</u>.</p> <p>Amplitude (mV/2)</p> <p>Temps (sec)</p> <p>SUPERPOSITION OF HIGH AND LOW FREQUENCIES</p>	
<p>Notes:</p>	

#26 ABB – UZCRN - Single operation

Pictures

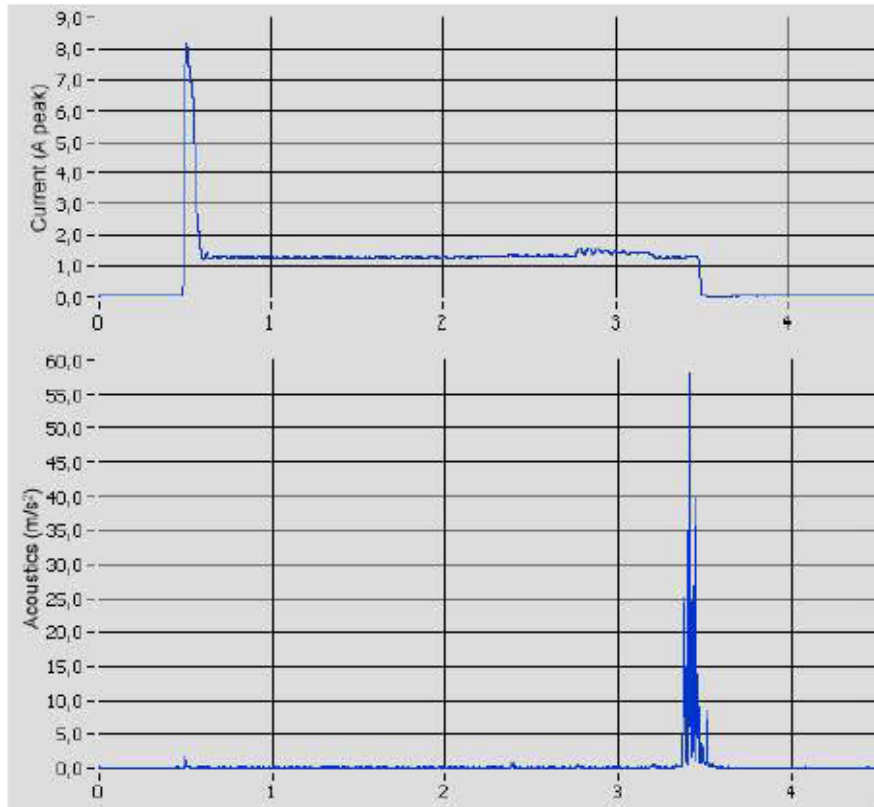


Figure 2 : Single operation upward of an ABB UZCRN (tap +8")

Description

The single operation is an upward or a downward movement of the selector, followed by a transfer of the load through the switch.

Notes:

#27 ABB – UZC, UZE and UZF - Multiple operations

Pictures

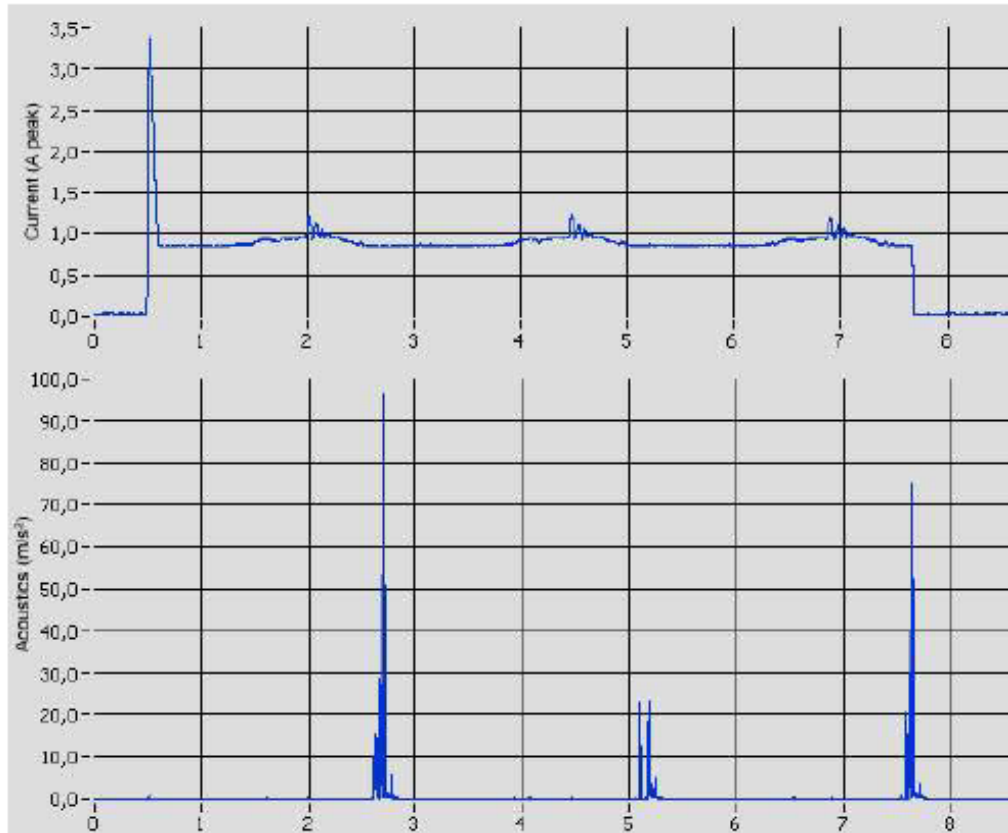


Figure 3 : Triple operation (9A, 9B and 9) for an ABB UCZCRN (tap +9)

Description

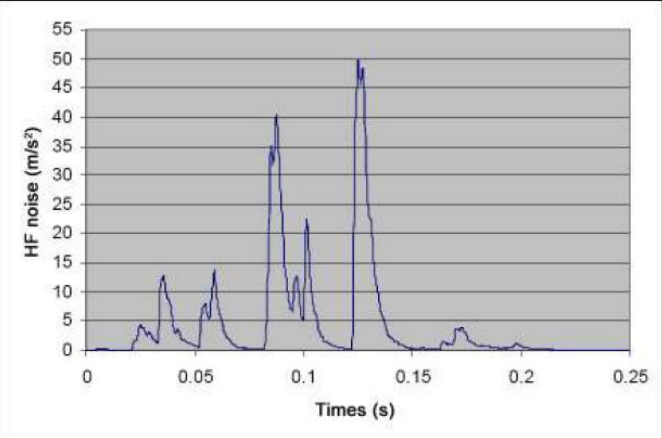
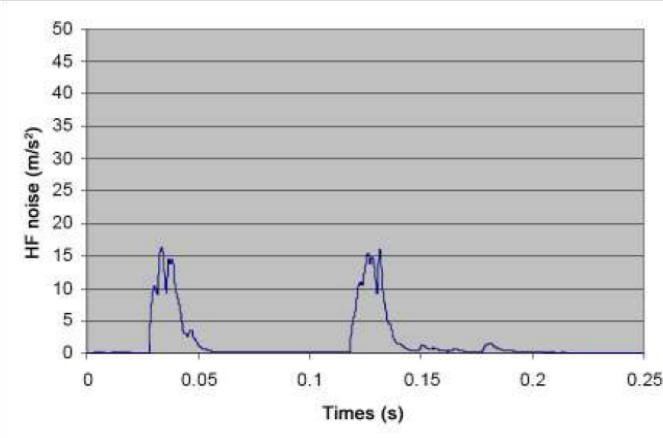
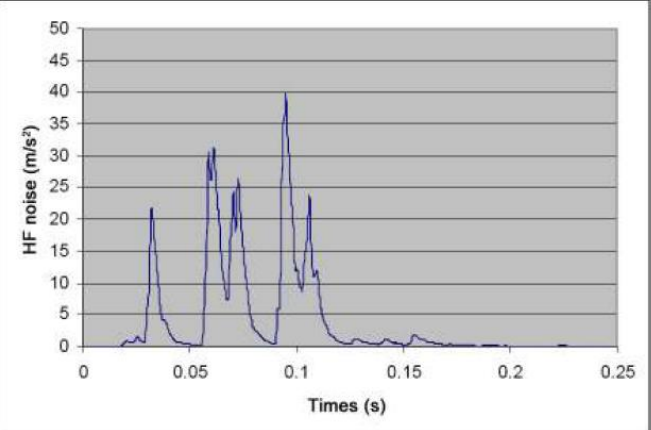
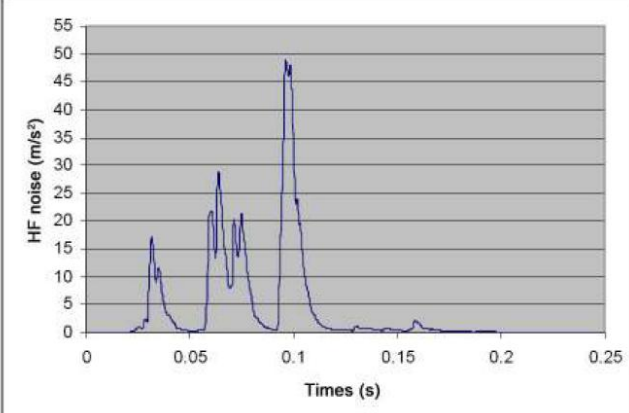
Tap Changers of models ABB UZC, UZE and UZF have two different taps and several types of switching. When a moving contact must pass through several intermediate positions before reaching the next tap, the operation is called “multiple operations”.

Multiple operations include triple and quadruple operations.

Notes:

For example, when a moving contact is switched from tap 8 to tap 9, the switch passes through the intermediate positions 9A and 9B. This operation is a triple operation and is expressed by multiple switching (x3) on the acoustic signature, as shown on the picture above.

#28 ABB – UZC, UZE and UZF - Typical switching

Pictures		Description
		
<p>Figure 4 : Switching of a single contact to a contact bridge – Operations 8-9A; 16-17; 2-1 and 10-9-E</p>	<p>Figure 6 : Switching on a contact bridge – Operations 9A-9B, 9D-9E; 9B-9A and 9E-9D</p>	
		
<p>Figure 5 : Switching of a contact bridge to a single contact – Operations 9A-8; 17-16; 1-2 and 9E-10</p>	<p>Figure 7 : Switching of a contact bridge to a contact bridge – Operations 9B-9; 9C-9D; 9-9B and 9D-9C</p>	
<p>Notes:</p>		

#29 ABB – UZC, UZE and UZF - Typical switching

Pictures

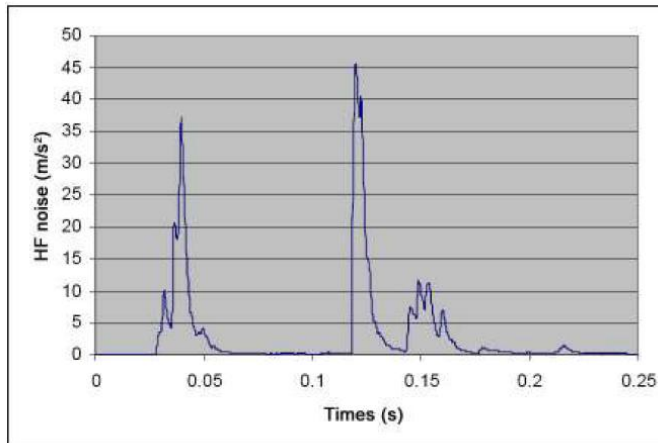


Figure 8 : Switching of a contact bridge with an inverter – Operations 9-9C; 9C-9

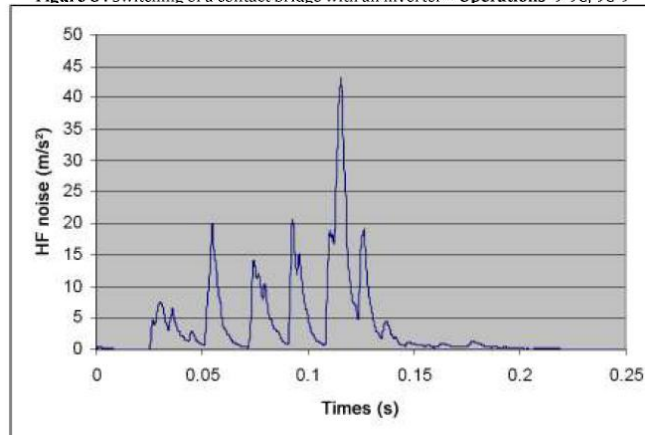


Figure 9 : Switching of a single contact to a single contact – all the other operations

Description

Notes:

#30 ABB – UZB - Typical switching

Pictures

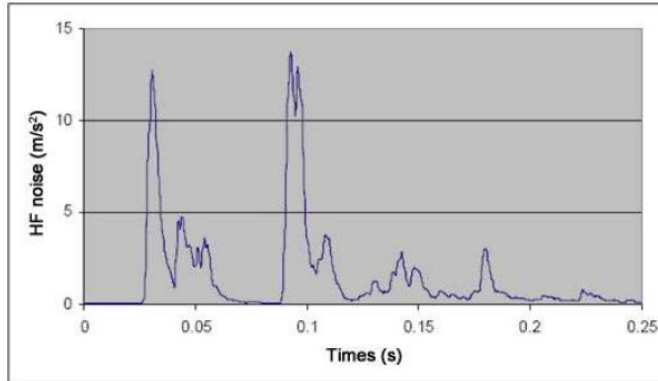


Figure 10 : Upward movement

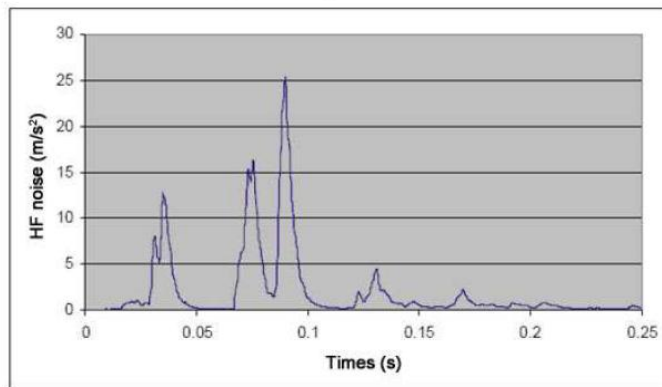


Figure 11 : Downward movement

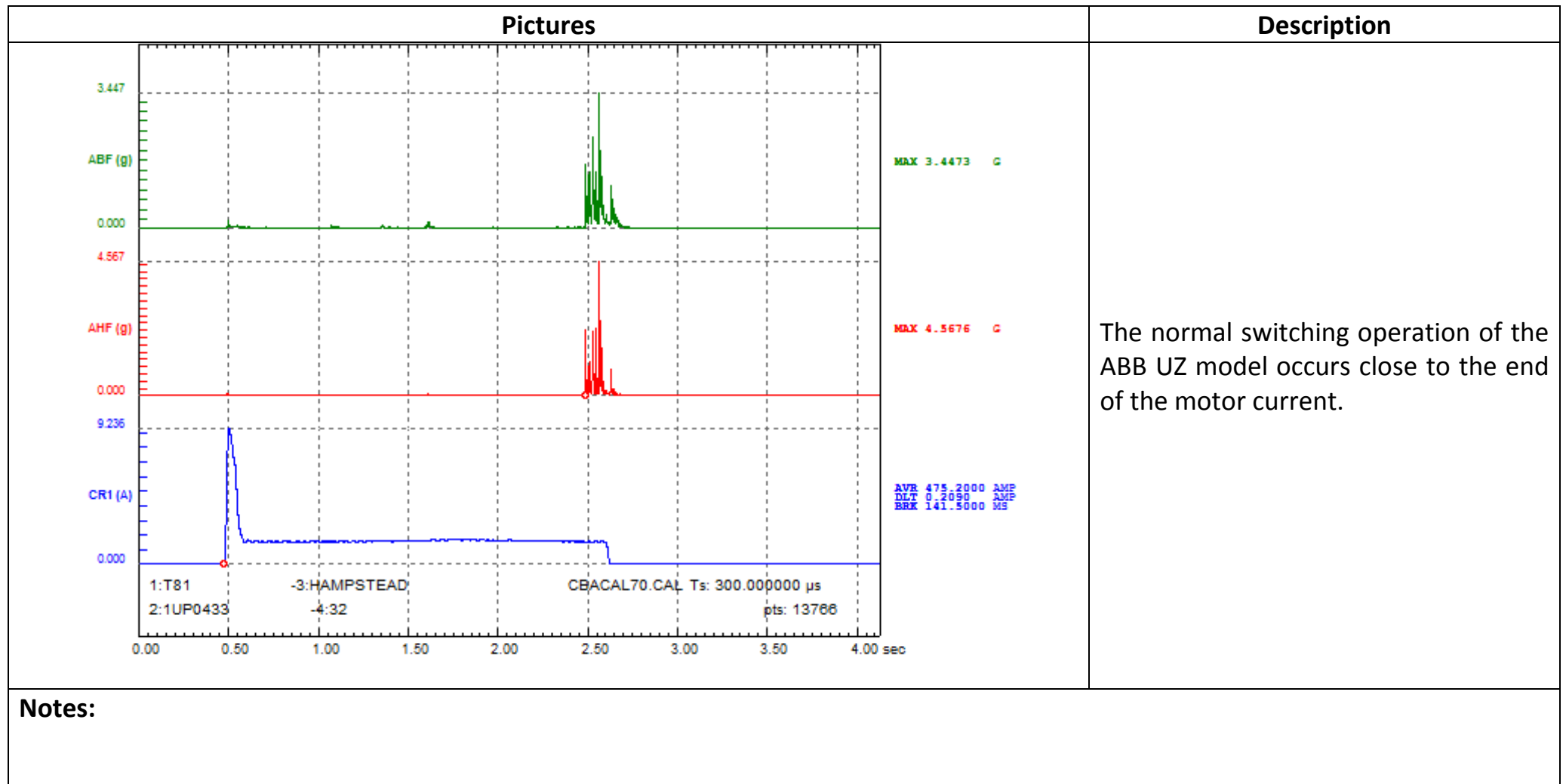
Description

The ABB UZB has a configuration of 17 fixed positions. This allows the operation without a pre-selector or an inverter for the usual settings of our network. This eliminates multiple switching operations.

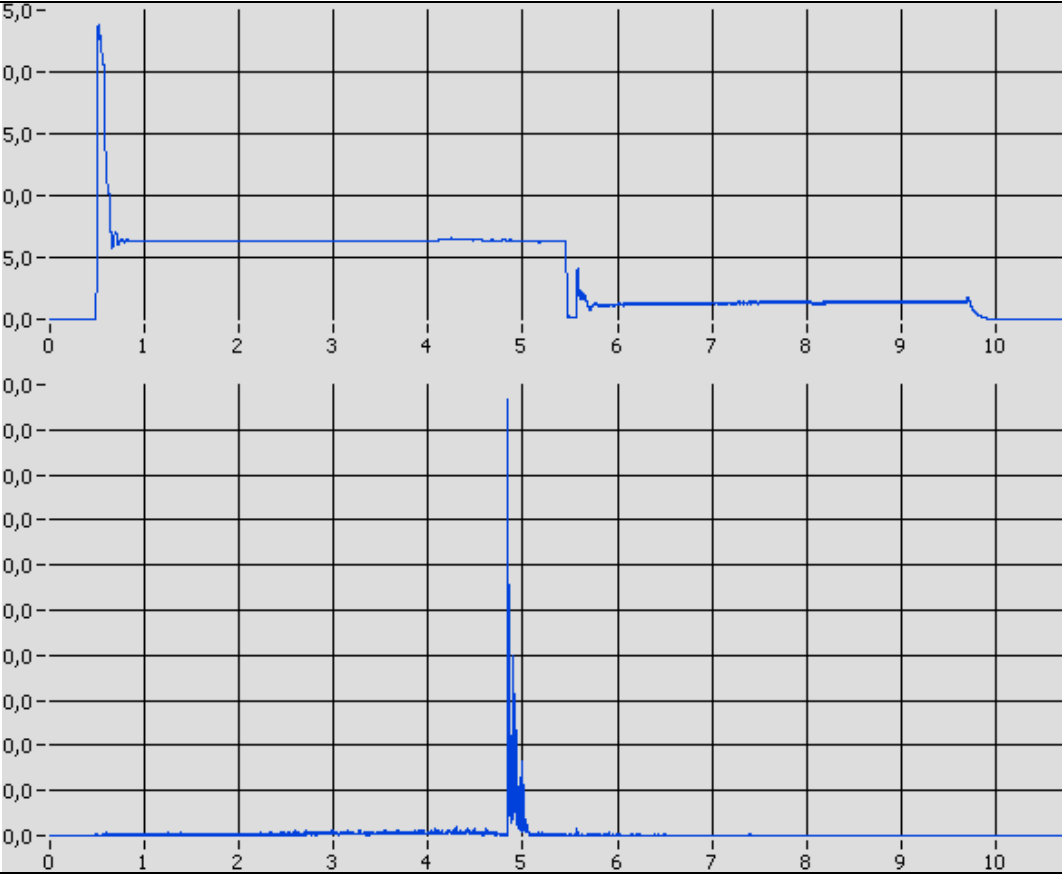
Notes:

The ABB UZB is different from the other ABB UZ models due to the signatures of non-symmetrical upward and downward operations.

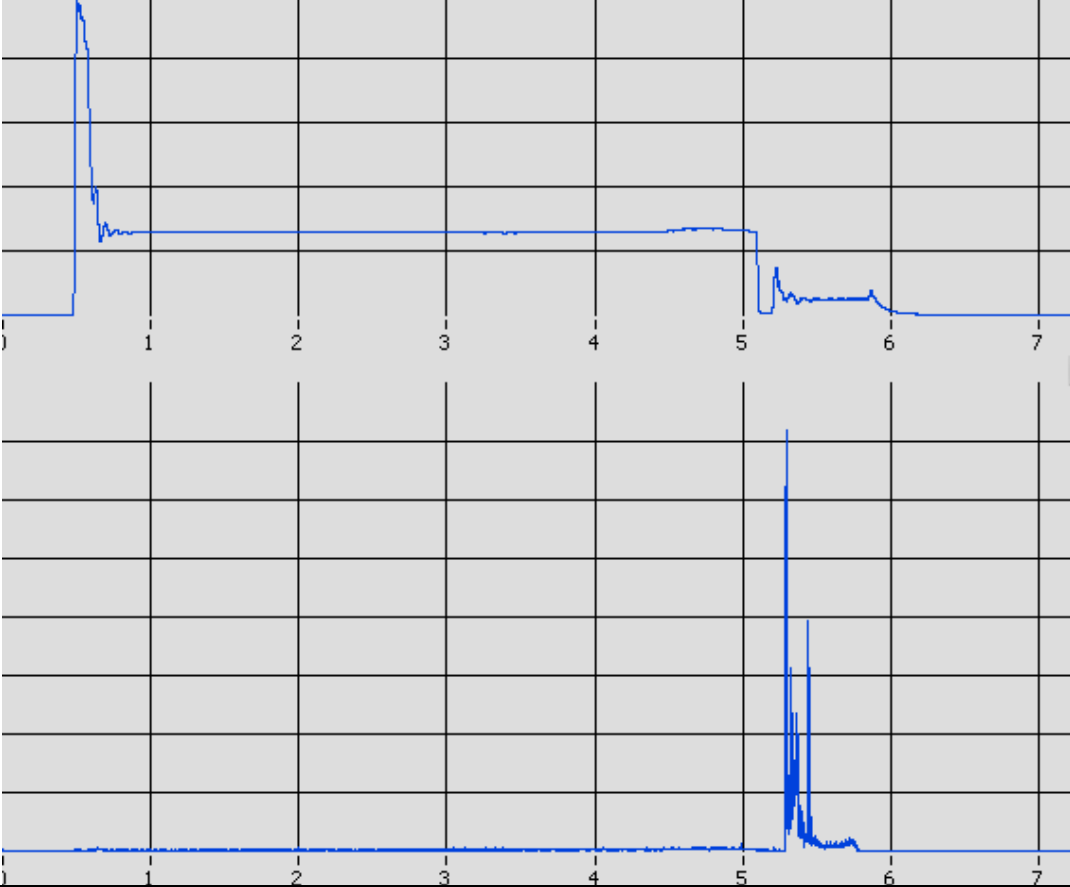
#31 ABB UZ - Expected signature



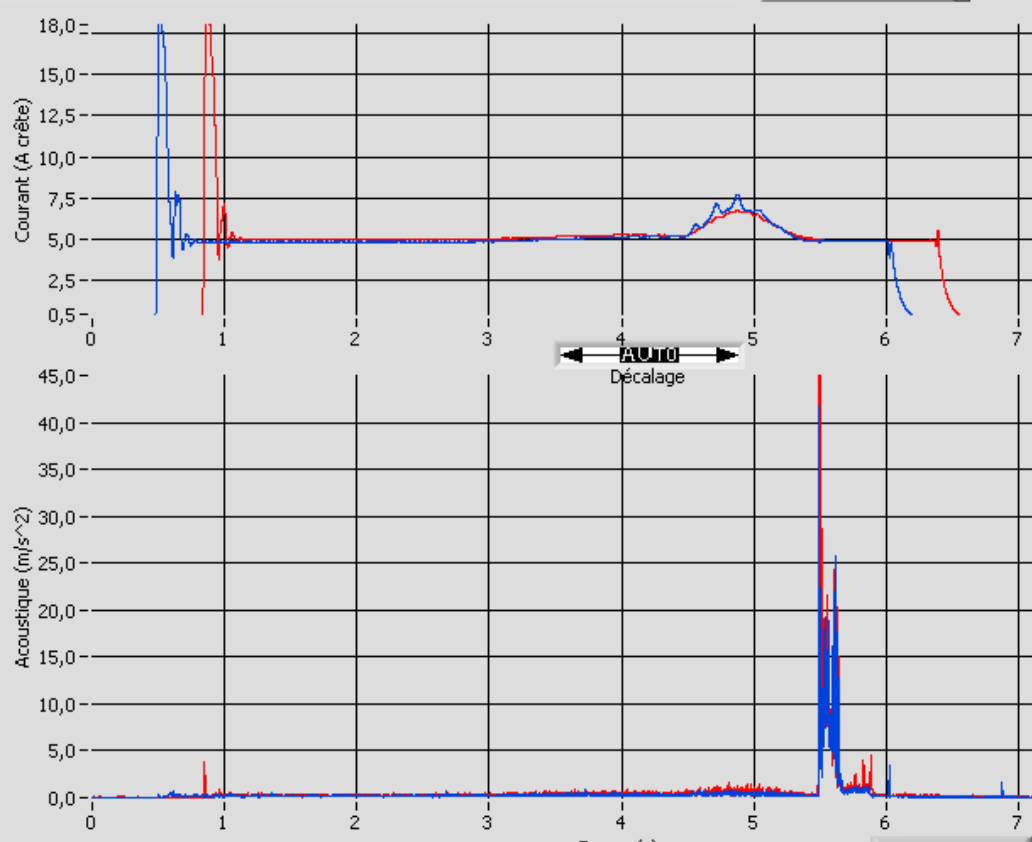
#32 FEDERAL PIONEER – REACTIVE MODELS - Extended length of the braking

Pictures	Description
 <p>The image displays two oscilloscope traces of current over a 10-second interval. The top trace shows a sharp initial peak reaching approximately 5.0 units, followed by a steady state around 5.0 units. At approximately 5.5 seconds, there is a sharp drop to 0.0 units, which is followed by a long, extended braking period where the current remains at 0.0 units until about 9.5 seconds. The bottom trace shows a single sharp peak reaching approximately 5.0 units at about 5.0 seconds, followed by a return to 0.0 units.</p>	<p>The trace of the current contains an extended braking. Dynamic brake is applied for an abnormally long time.</p>
<p>Notes:</p> <p>Adjust and repair the braking system.</p>	


#33 FEDERAL PIONEER – REACTIVE MODELS - Desynchronization of the switching

Pictures	Description
	<p>The switching occurs too early/late. It happens after the end of the motor current during the braking or much too early in the operation.</p>
<p>Notes:</p> <p style="text-align: center;">Synchronize the switching.</p>	

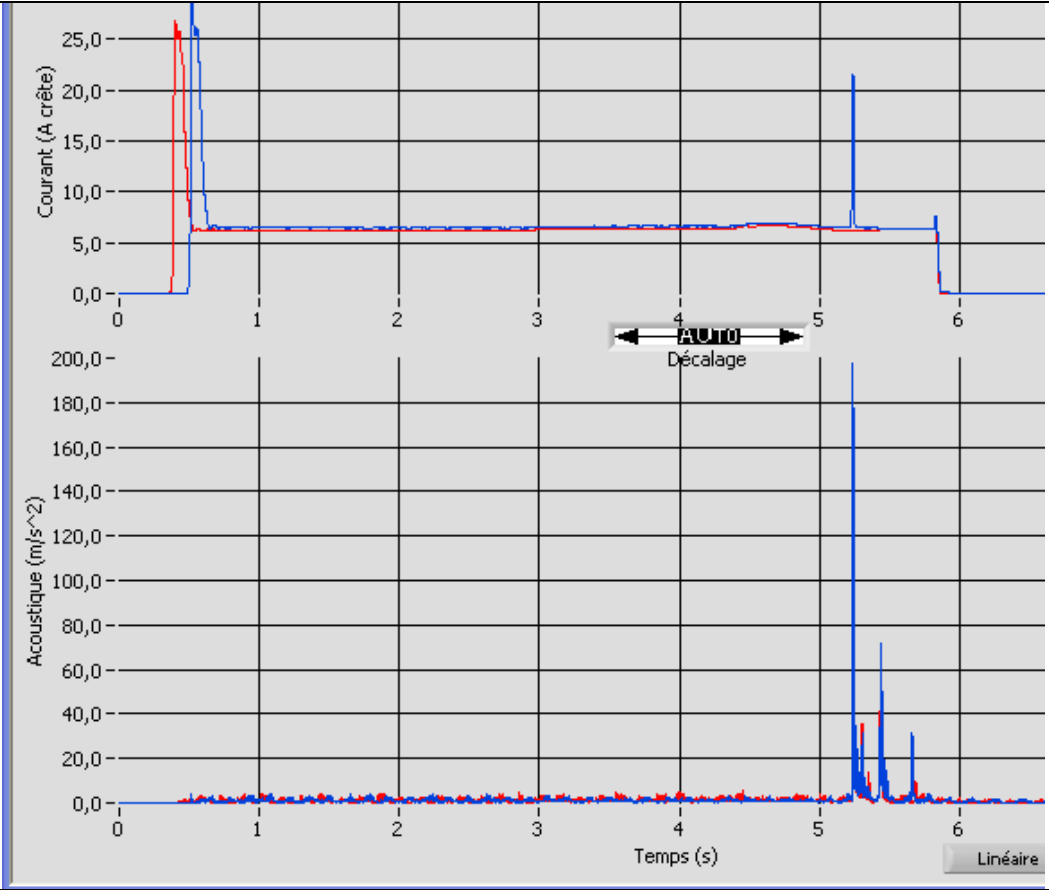
#34 FEDERAL PIONEER – REACTIVE MODELS - Lack of the lubrication in the drive mechanism

Pictures	Description
 <p>The figure consists of two vertically stacked line graphs sharing a common x-axis representing time in seconds, ranging from 0 to 7. The top graph plots 'Courant (A crête)' (Current in Amperes peak) on the y-axis, ranging from 0 to 18.0. It shows two traces: a red trace representing normal operation and a blue trace representing operation with oscillations. Both traces show a sharp peak around 0.5 seconds and another around 1.0 second. The blue trace exhibits significant high-frequency oscillations during these peaks. The bottom graph plots 'Acoustique (m/s²)' (Acoustic noise in m/s²) on the y-axis, ranging from 0 to 45.0. It also shows two traces: a red trace for normal operation and a blue trace for operation with oscillations. Both traces show a sharp peak around 5.5 seconds. The blue trace exhibits significant high-frequency oscillations during this peak. A horizontal arrow labeled 'Décalage' (Time shift) is positioned between the two graphs, indicating a time shift between the two traces.</p>	<p>Fluctuations such as oscillations appear on the trace of the motor current during the operation of the switch, selector or inverter. (red trace) is normal. (blue trace) shows oscillations.</p>
<p>Notes:</p> <p>Lubricate the drive mechanism.</p>	

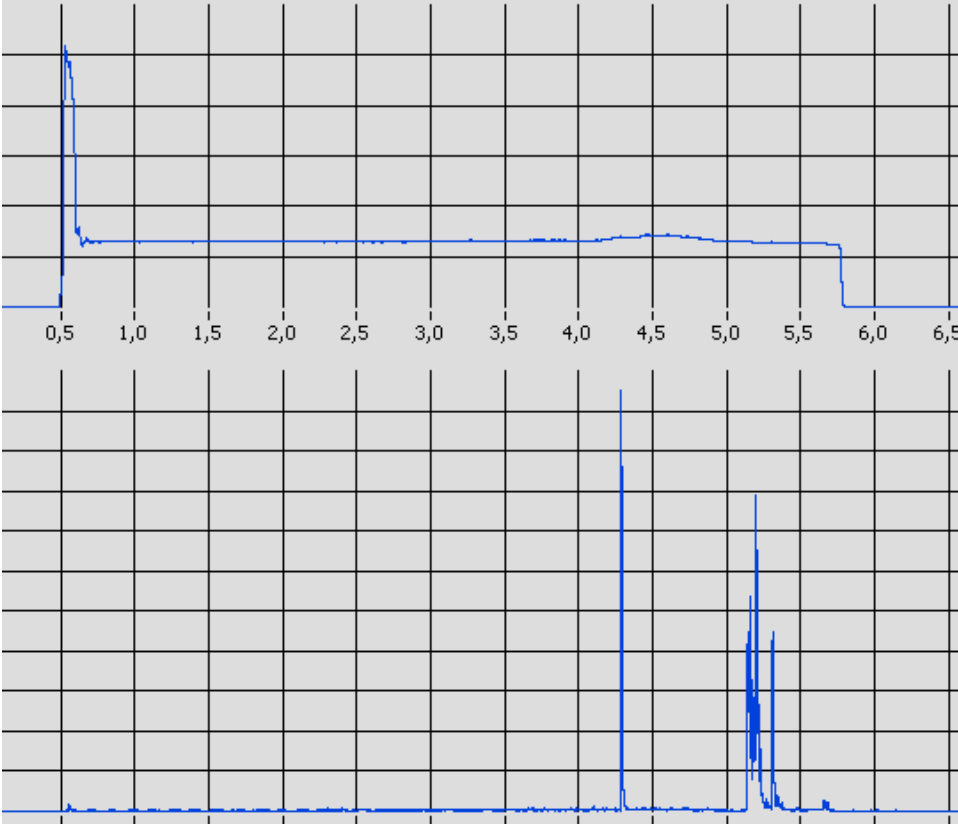
#35 FEDERAL PIONEER – REACTIVE MODELS - Motor startup contactor

Pictures	Description
 <p>The image displays two vertically stacked line graphs comparing two traces (red and blue) during a motor startup contactor event. The top graph plots 'Courant (A crête)' (Current in Amperes peak) on the y-axis, ranging from 0,0 to 30,0. The x-axis is marked with 0, 1, and 2. The red trace shows a sharp, oscillating peak reaching approximately 25,0 A, while the blue trace shows a smoother peak reaching approximately 20,0 A. The bottom graph plots 'Acoustique (m/s²)' (Acoustic signal in m/s²) on the y-axis, ranging from 0,0 to 180,0. The x-axis is also marked with 0, 1, and 2. The red trace shows a sharp, oscillating spike reaching approximately 160,0 m/s², while the blue trace shows a smoother spike reaching approximately 140,0 m/s². A horizontal scale bar labeled 'AUTO Décalage' is positioned between the two graphs, indicating a time delay or offset.</p>	<p>The inrush trace presents abnormal oscillations, while the normal inrush trace (blue trace) is generally smooth and stable (red trace). These oscillations can be caused by a problem with the contactor that starts the motor or with the motor itself.</p>
<p>Notes:</p> <p>Readjust the contactor or replace the motor if it is defective.</p>	

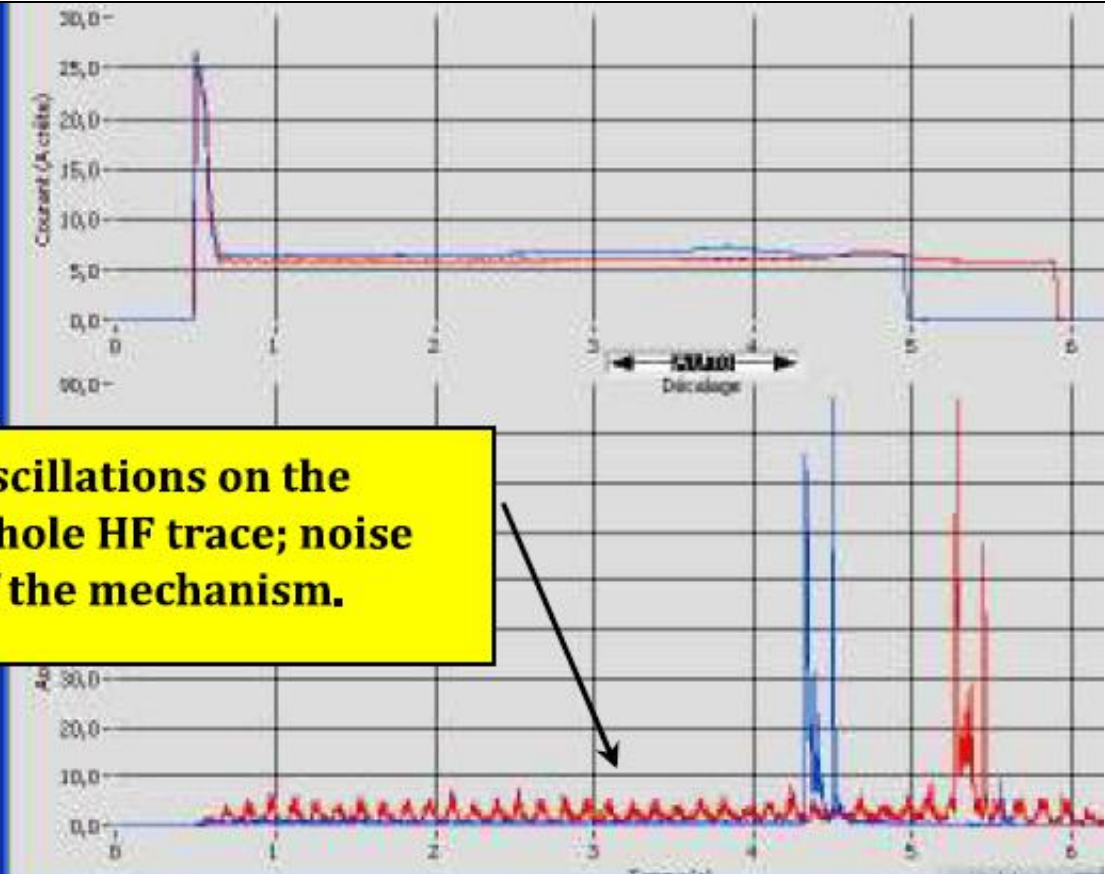
#36 FEDERAL PIONEER – REACTIVE MODELS - Noise of very high amplitude switching

Pictures	Description
 <p>The figure consists of two vertically stacked plots sharing a common x-axis representing time in seconds (0 to 6). The top plot shows 'Courant (A crête)' (Current peak) on the y-axis, ranging from 0.0 to 25.0. It features a sharp peak at approximately 0.5 seconds reaching about 25.0 A, and a smaller peak at approximately 5.5 seconds reaching about 22.0 A. The bottom plot shows 'Acoustique (m/s²)' (Acoustic noise) on the y-axis, ranging from 0.0 to 200.0. It shows a very high peak at approximately 5.5 seconds reaching about 200.0 m/s². A horizontal double-headed arrow labeled 'Délai' (delay) is positioned between the two plots, indicating a time shift. A 'Linéaire' (Linear) button is visible in the bottom right corner of the plots.</p>	<p>The switching shows a noise with very high amplitude compared to normal switching, and compared with other noises on the same switching.</p> <p>This may be due to a problem of the transition of the spring, a problem with the switch mechanism or another cause.</p>
<p>Notes: Identify the cause of the problem and repair, by readjustment of the mechanism, changing the much worn parts or the springs.</p>	

#37 FEDERAL PIONEER – REACTIVE MODELS - Noise of very high amplitude during the operation of the inverter

Pictures	Description
 <p>The image displays two oscilloscope waveforms. The top waveform shows a signal that rises sharply at approximately 0.5 units, then settles into a steady state with some minor high-frequency noise. The bottom waveform shows a similar signal but with a significantly higher amplitude spike at the transition point, followed by a period of intense, high-frequency oscillation (arcing) before settling back to a steady state.</p>	<p>This defines an arc of very high amplitude present during the operation of the inverter. This may be due to too much carbon in the oil, or to a problem with the limiting voltage device, or other sources.</p>
<p>Notes: Identify the cause of the problem and repair, change or filter the oil, etc.</p>	

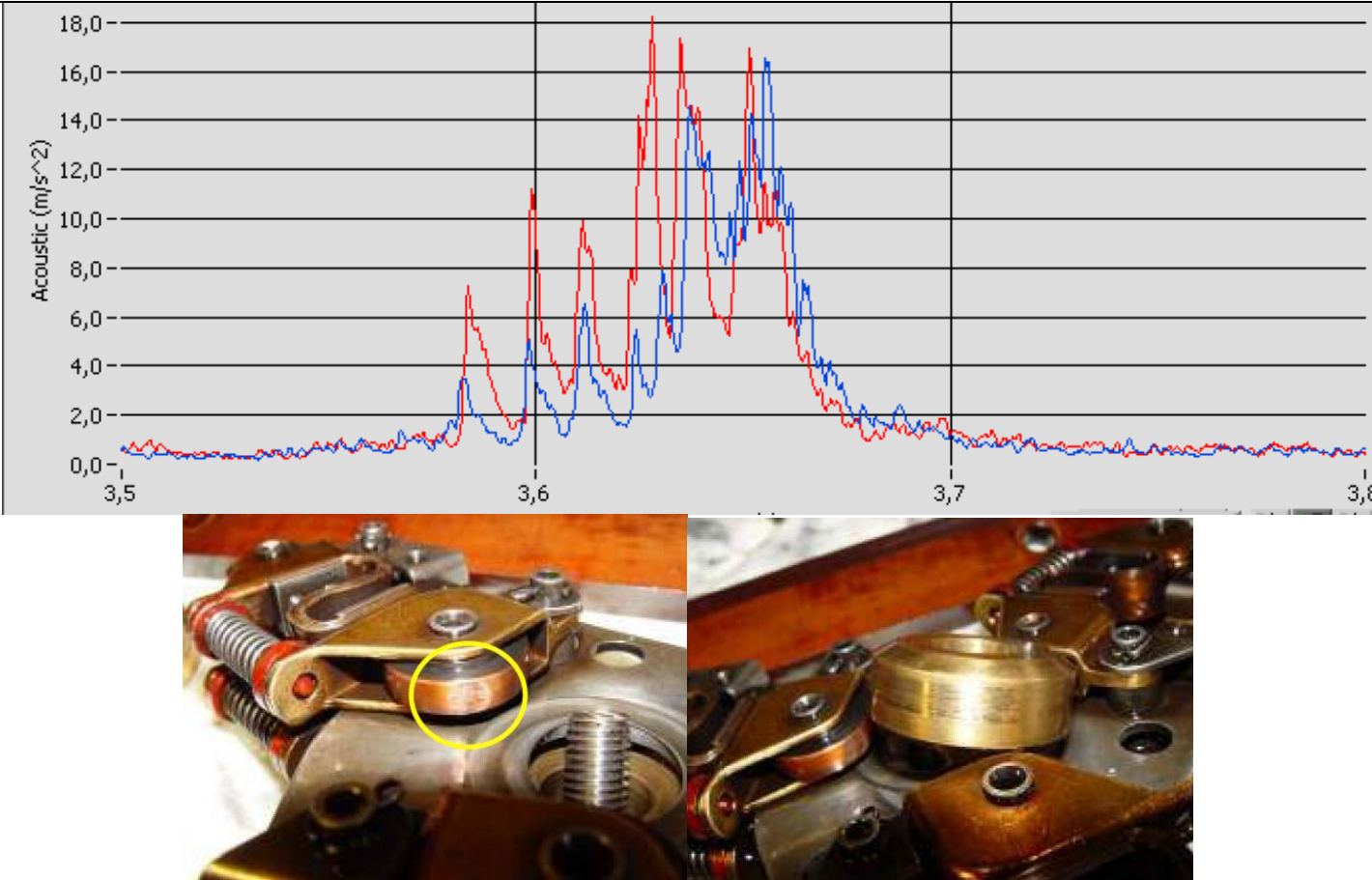
#38 FEDERAL PIONEER – REACTIVE MODELS - Noise of the mechanism during its operation

Pictures	Description
 <p>Oscillations on the whole HF trace; noise of the mechanism.</p>	<p>We notice a noise of the mechanism during its operation. The oscillations are present throughout all the trace of the High Frequency. A lack of lubrication of the drive mechanism or an advanced wear of the drive mechanism is present.</p>
<p>Notes: Correct the situation by lubricating or replacing worn parts or observe the OLTC periodically to monitor the problem at hand.</p>	

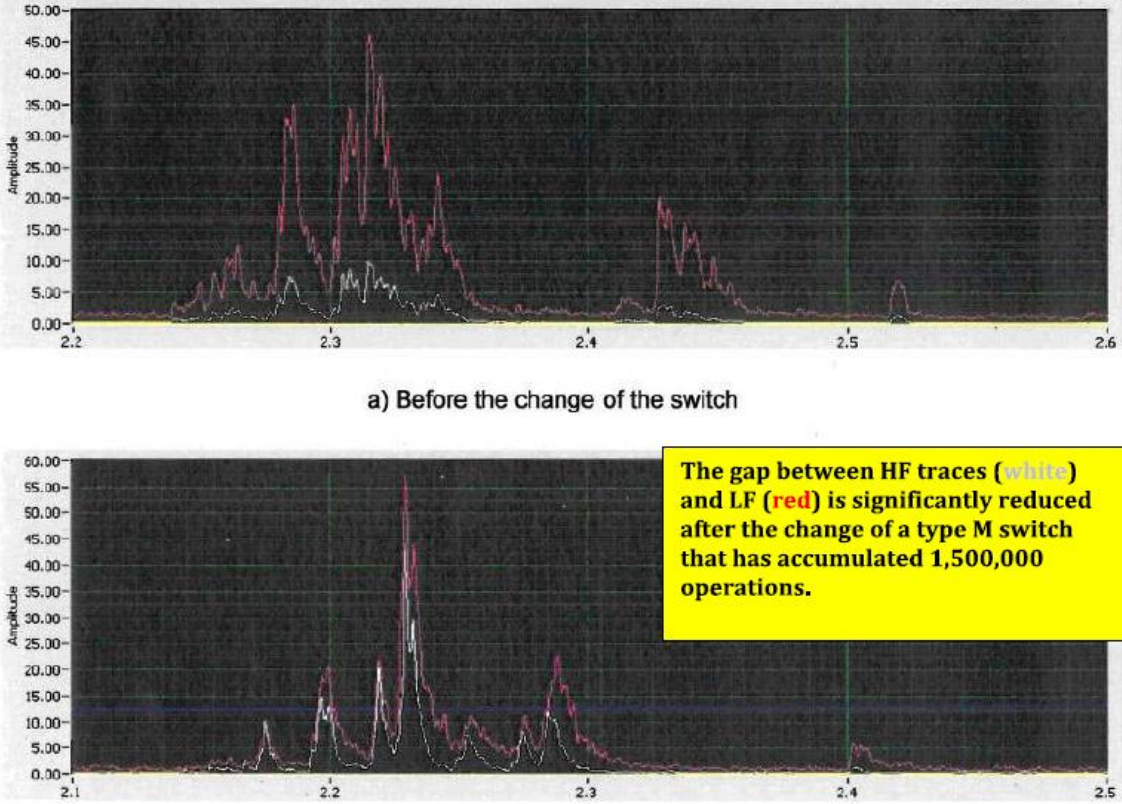
#39 MR REINHAUSEN – M and V - Wear of contact

Pictures	Description
	<p>The wear of contacts is seen as gaps between low and high frequency envelopes. A new mechanism will show similar envelopes while one of the envelopes becomes dominant as the wear increases.</p>
<p>Notes:</p> <p>Trending of the suspected contacts is necessary to know the speed of the degradation.</p>	

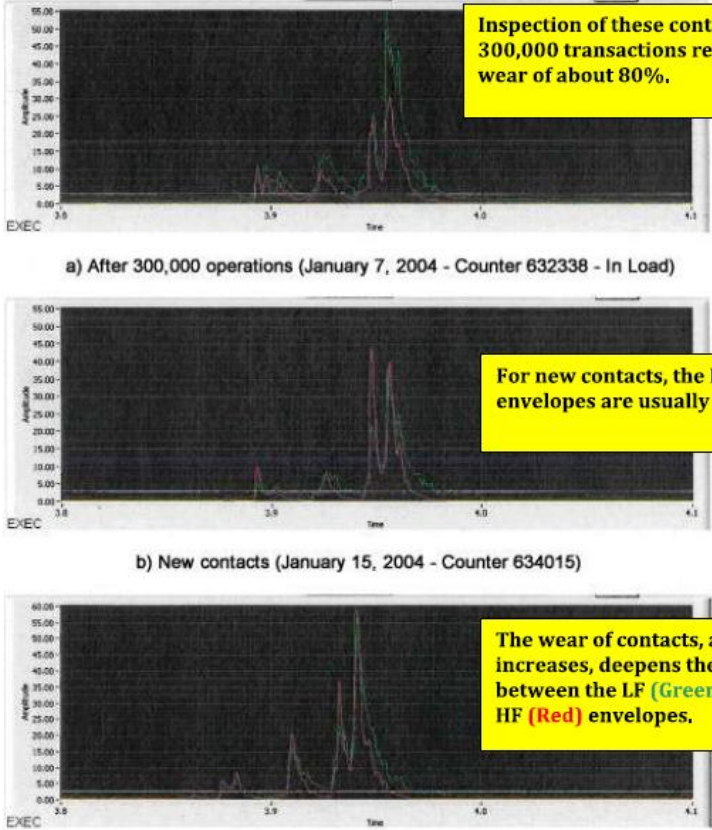
#40 MR REINHAUSEN – M and V - Wear of the rolls of main contacts

Pictures	Description
 <p>The figure consists of an acoustic signal graph and two photographs of mechanical hardware. The graph plots 'Acoustic (m/s²)' on the y-axis (0.0 to 18.0) against time on the x-axis (3.5 to 3.8). Two curves are shown: a red curve representing the state 'before repairs' and a blue curve representing the state 'after repairs'. The red curve shows several sharp, high-amplitude peaks between 3.6 and 3.7, while the blue curve shows significantly reduced amplitude and smoother peaks. Below the graph are two side-by-side photographs of a mechanical contact assembly. The left photo shows a worn contact roll with a yellow circle highlighting a flat spot. The right photo shows the same assembly after repair, with a new, smoother contact roll installed.</p>	<p>The rolls of the main contacts on a type D-0466 mechanism can wear off and show flats and streaks as above. Such type of wear can cause variations in the resistance measurements. The change of the cross is easily perceptible on the signatures of low-frequencies, Red curve is before repairs and blue is after repairs.</p>
<p>Notes:</p> <p>Replacement of the faulty hardware.</p>	

#41 MR REINHAUSEN – M and T - General wear of the switch

Pictures	Description
 <p data-bbox="618 719 992 746">a) Before the change of the switch</p> <p data-bbox="618 1166 976 1193">b) After the change of the switch</p> <p data-bbox="920 783 1384 975">The gap between HF traces (white) and LF (red) is significantly reduced after the change of a type M switch that has accumulated 1,500,000 operations.</p>	<p data-bbox="1563 639 2123 906">In addition to the wear of contacts, gaps between frequency bands are also indicative of the general wear of the switch. This example illustrates a case of extreme wear of a type M mechanism.</p>
<p data-bbox="96 1230 197 1257">Notes:</p>	

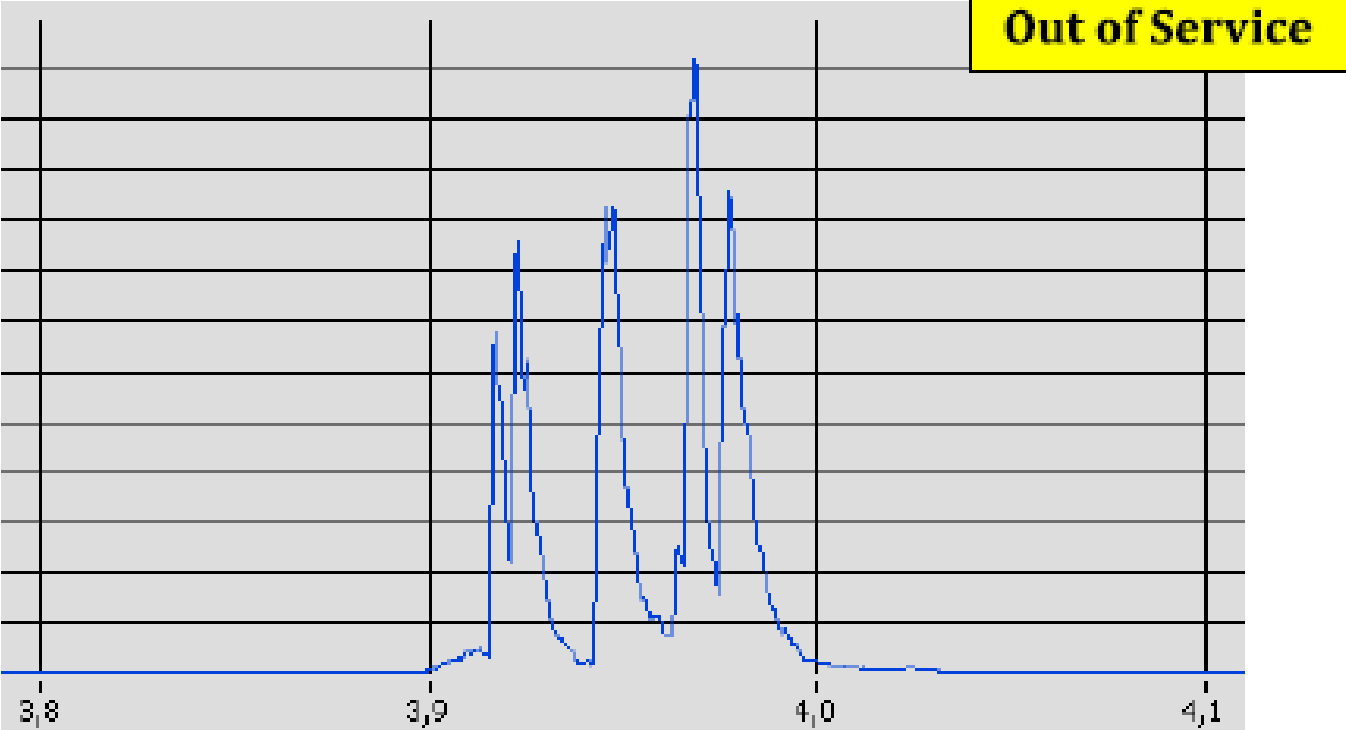
#42 MR REINHAUSEN – M and T - Wear of contacts

Pictures	Description
 <p data-bbox="907 352 1272 464">Inspection of these contacts after 300,000 transactions revealed a wear of about 80%.</p> <p data-bbox="504 603 1115 627">a) After 300,000 operations (January 7, 2004 - Counter 632338 - In Load)</p> <p data-bbox="922 703 1288 799">For new contacts, the HF and LF envelopes are usually similar.</p> <p data-bbox="571 900 1025 924">b) New contacts (January 15, 2004 - Counter 634015)</p> <p data-bbox="922 975 1252 1102">The wear of contacts, as it increases, deepens the gap between the LF (Green) and HF (Red) envelopes.</p> <p data-bbox="533 1198 1081 1222">c) After 125,000 operations (November 5, 2004 - Counter 761087)</p>	<p data-bbox="1653 692 2123 863">The wear of contacts on types M and T, are seen as gaps between low and high frequency envelopes.</p>

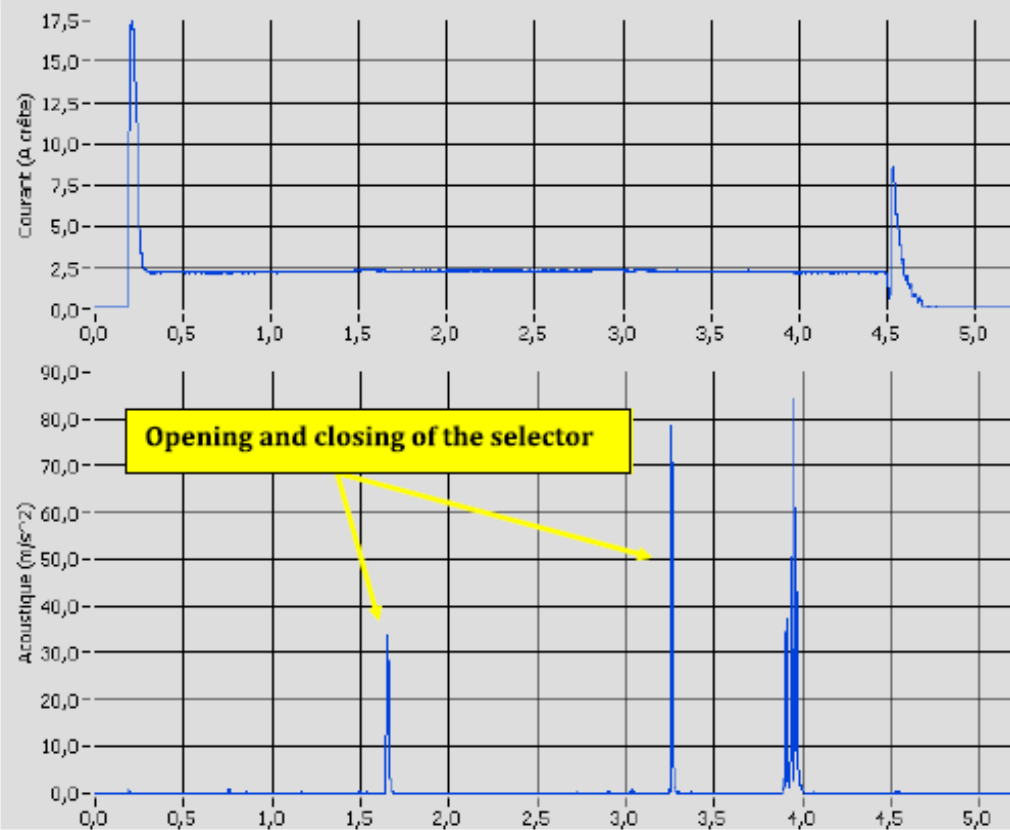
Notes:

A new mechanism will show similar envelopes while the low frequency envelope becomes dominant as the wear increases.

#43 MR REINHAUSEN – M and MS - Typical switching

Pictures	Description
 <p data-bbox="230 1182 1395 1222">Figure 12 : Reinhausen M switching at tap +14 in mode Out of Service</p>	
Notes:	

#44 MR REINHAUSEN – M - Single operation

Pictures	Description
 <p data-bbox="492 750 996 821">Opening and closing of the selector</p> <p data-bbox="515 1189 1220 1220">Figure 2 : Single operation upwards of a Reinhausen M (tap +8)</p>	<p data-bbox="1653 710 2123 837">The selector of the type M tap changer is very noisy, as seen on the signature.</p>
<p data-bbox="94 1241 197 1273">Notes:</p>	

#45 MR REINHAUSEN – M - Dual operation

Pictures

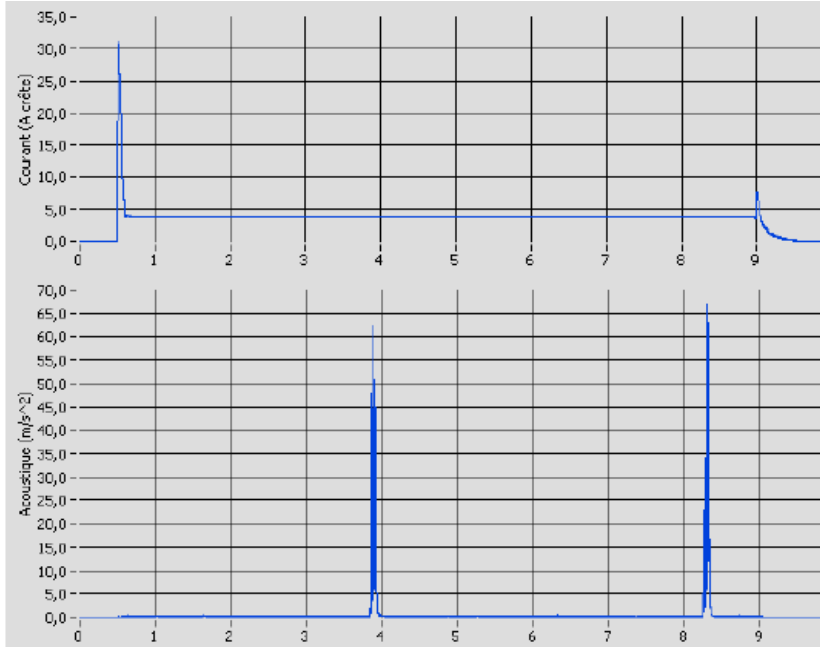


Figure 3 : Operation of the inverter for a Reinhausen M (tap -9)

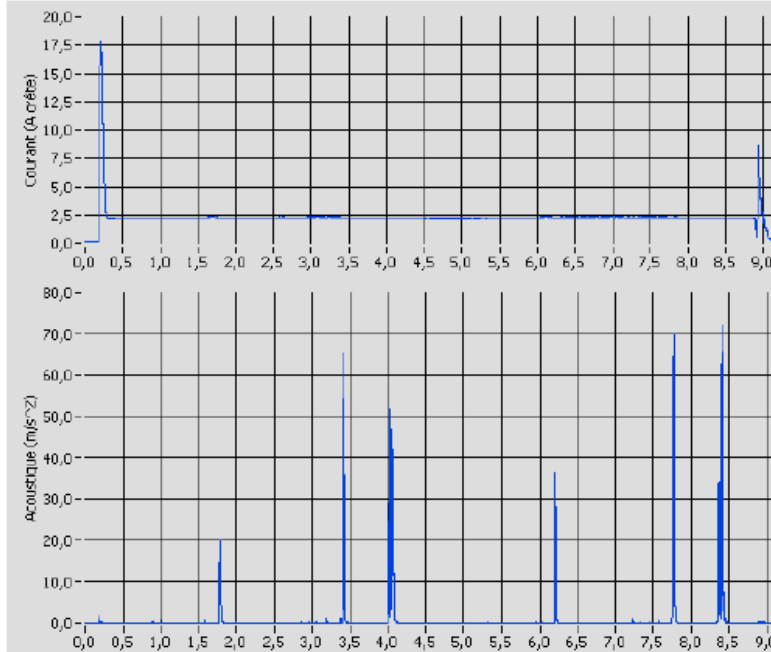


Figure 4 : Operation of the inverter for a Reinhausen M (tap -9)

Description

The tap changer can access a second range of positions through the inverter. During the operation of the inverter, two switch operations are performed one after another, as shown on the acoustic signature below.

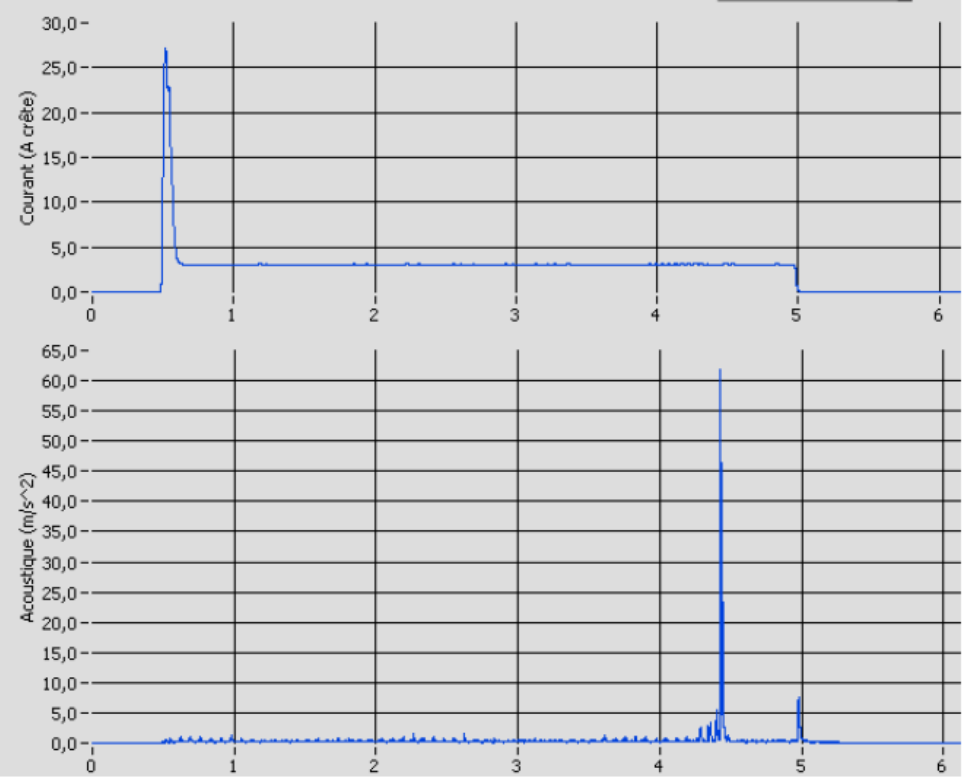
Notes:

Again, the operation of the selector is silent on all models except the M type.

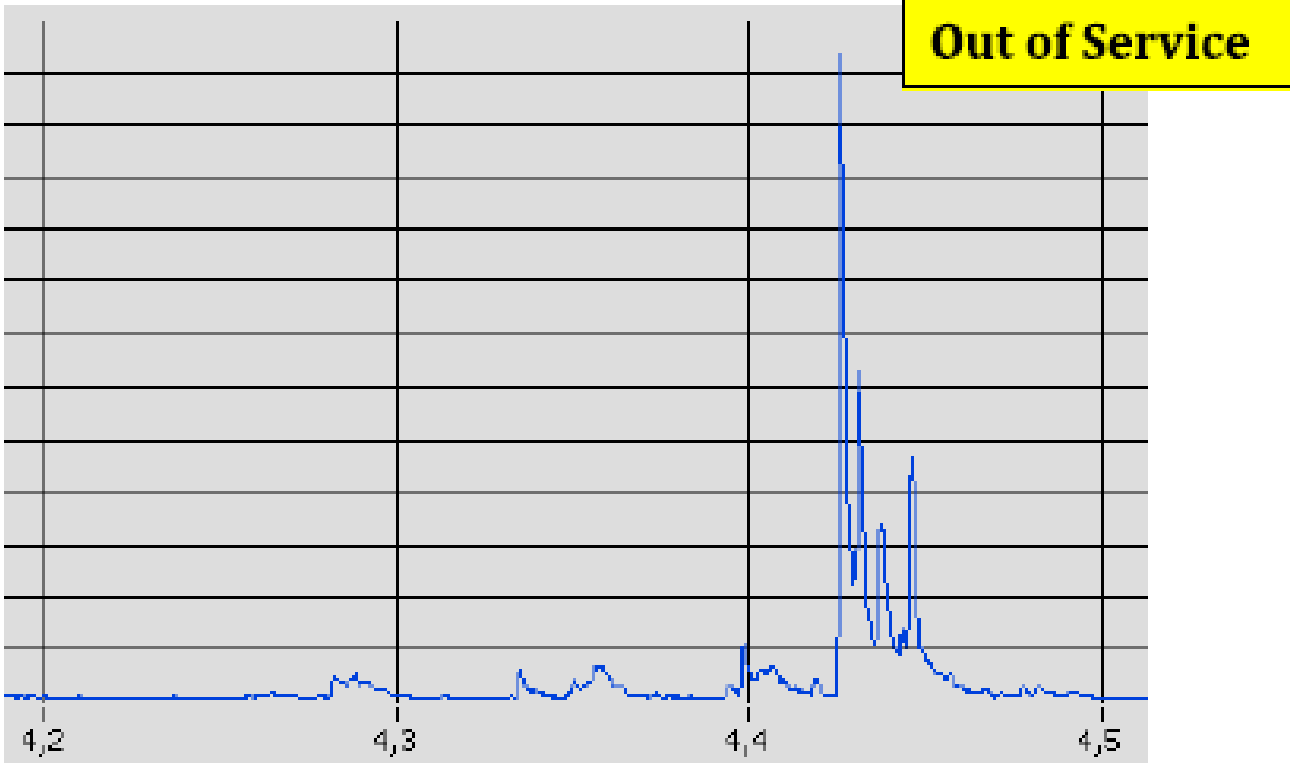
#46 MR REINHAUSEN – C, D, E, F, G, M and T - Desynchronization of the switching

Pictures	Description
<p>The switching shown in blue of a type M Reinhausen appears too late and is poorly synchronized with the brake. The switching in red is properly synchronized.</p>	<p>A desynchronization may result from a poor adjustment, or following an inspection of a poor reinsertion. In extreme cases, the switching is so misadjusted that it may not happen in the current operation but during the subsequent operation, which may cause a delay of taps between two devices in parallel. Red curve is normal, blue curve is bad.</p>
<p>Notes:</p> <p>Adjustments to correct the situation.</p>	

#47 MR REINHAUSEN – C - Single operation

Pictures	Description
 <p>The figure consists of two vertically stacked line graphs sharing a common x-axis representing time from 0 to 6 seconds. The top graph plots 'Courant (A crête)' (Peak Current in Amperes) on the y-axis, ranging from 0.0 to 30.0. The current starts at 0.0, rises sharply to a peak of approximately 27.0 A at around 0.5 seconds, then drops to a steady state of about 3.0 A. At approximately 5.0 seconds, the current drops back to 0.0. The bottom graph plots 'Acoustique (m/s^2)' (Acoustic noise in m/s^2) on the y-axis, ranging from 0.0 to 65.0. The noise level is low (around 2.0 m/s^2) until about 4.5 seconds, where it spikes to a peak of approximately 62.0 m/s^2, then drops to 0.0 by 5.0 seconds.</p> <p data-bbox="526 1137 1198 1165">Figure 1 : Single operation upwards of a Reinhausen C (tap +5)</p>	<p>The single operation is a movement upwards or downwards of the selector, followed by a transfer of the load through the switch. The operation of the selector is silent on all Reinhausen models with exception of the M model.</p>
<p>Notes:</p>	

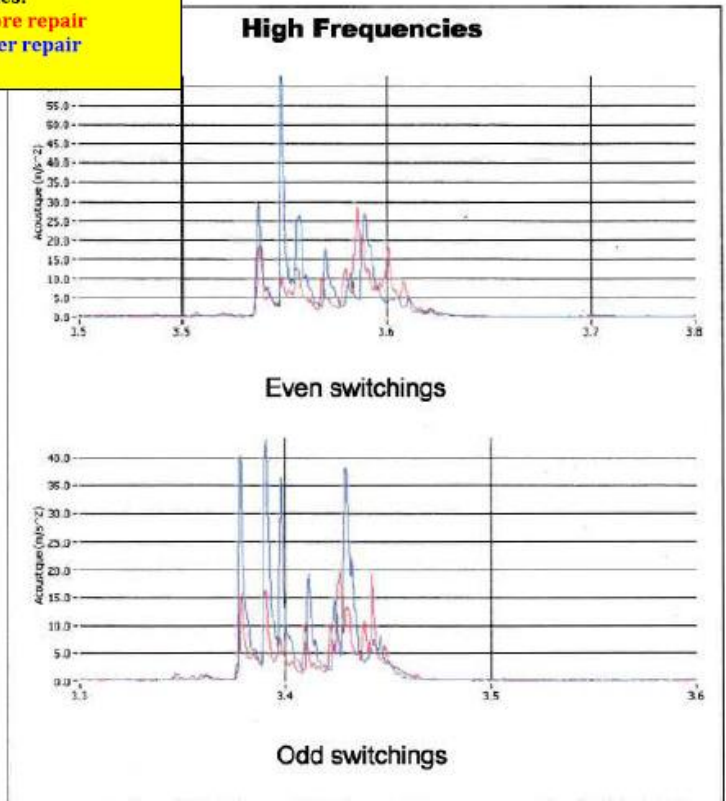
#48 MR REINHAUSEN – C - Typical switching

Pictures	Description
 <p data-bbox="201 1181 1366 1220">Figure 5 : Reinhausen C switching at tap +-5 in mode Out of Service</p>	
Notes:	

#49 MR REINHAUSEN – D - Weakened springs

Pictures

Effect of changing springs
on the envelope of high
frequencies:
Red- before repair
Blue - after repair

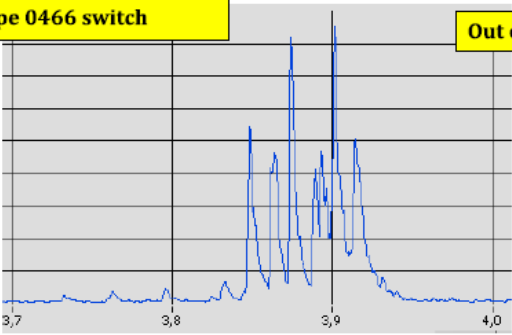
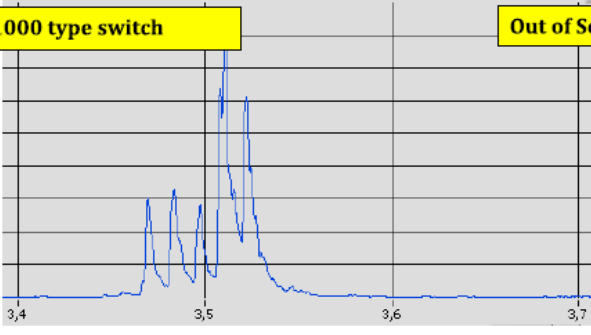
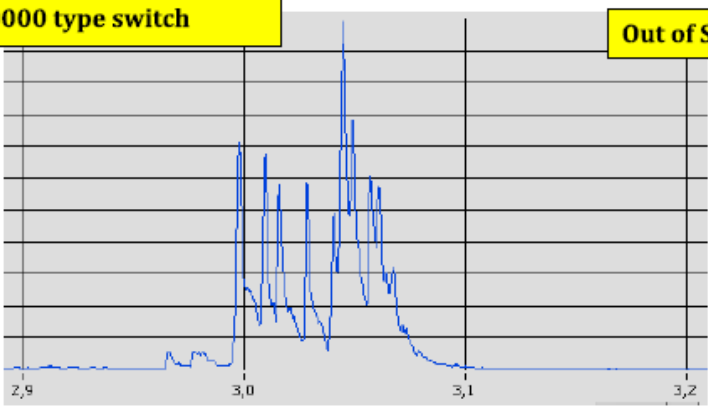


Description

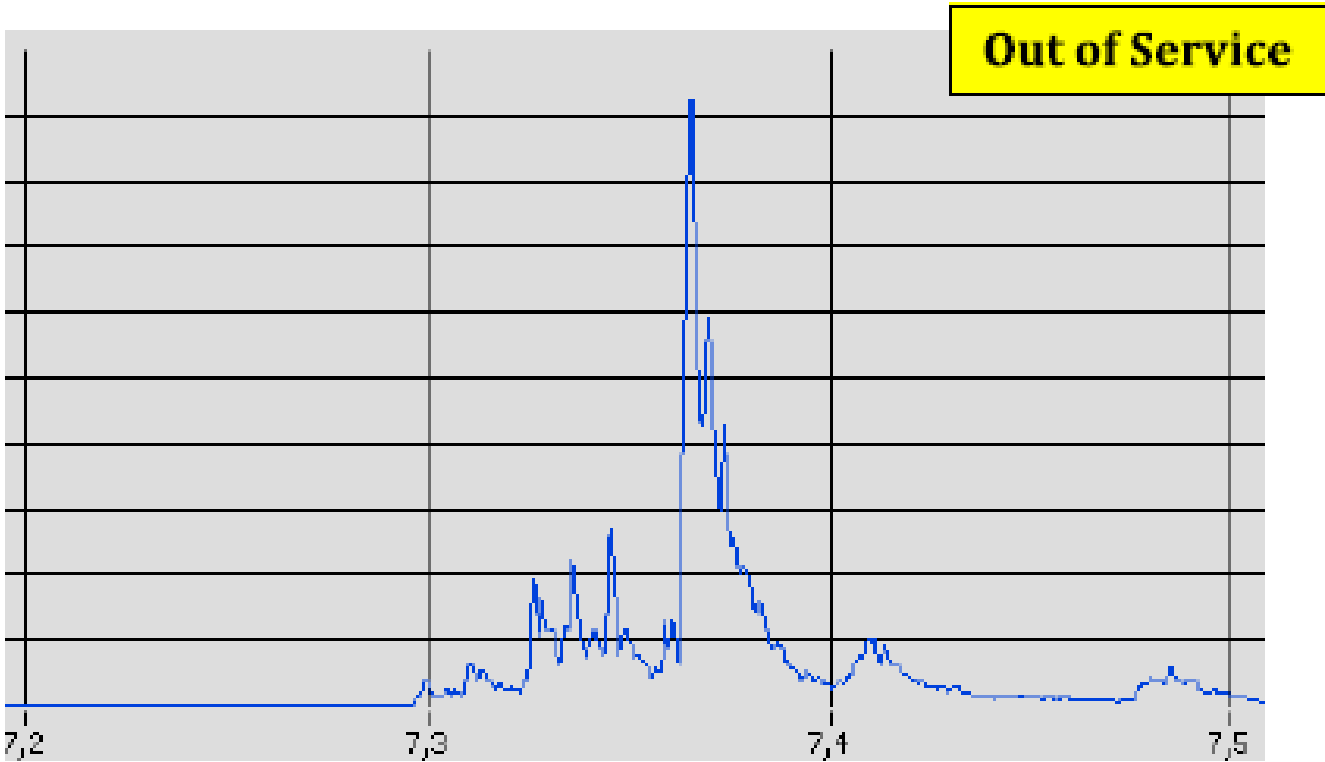
The weakening of a type D is expressed by a decrease in high frequency envelopes as shown in this example.

Notes:

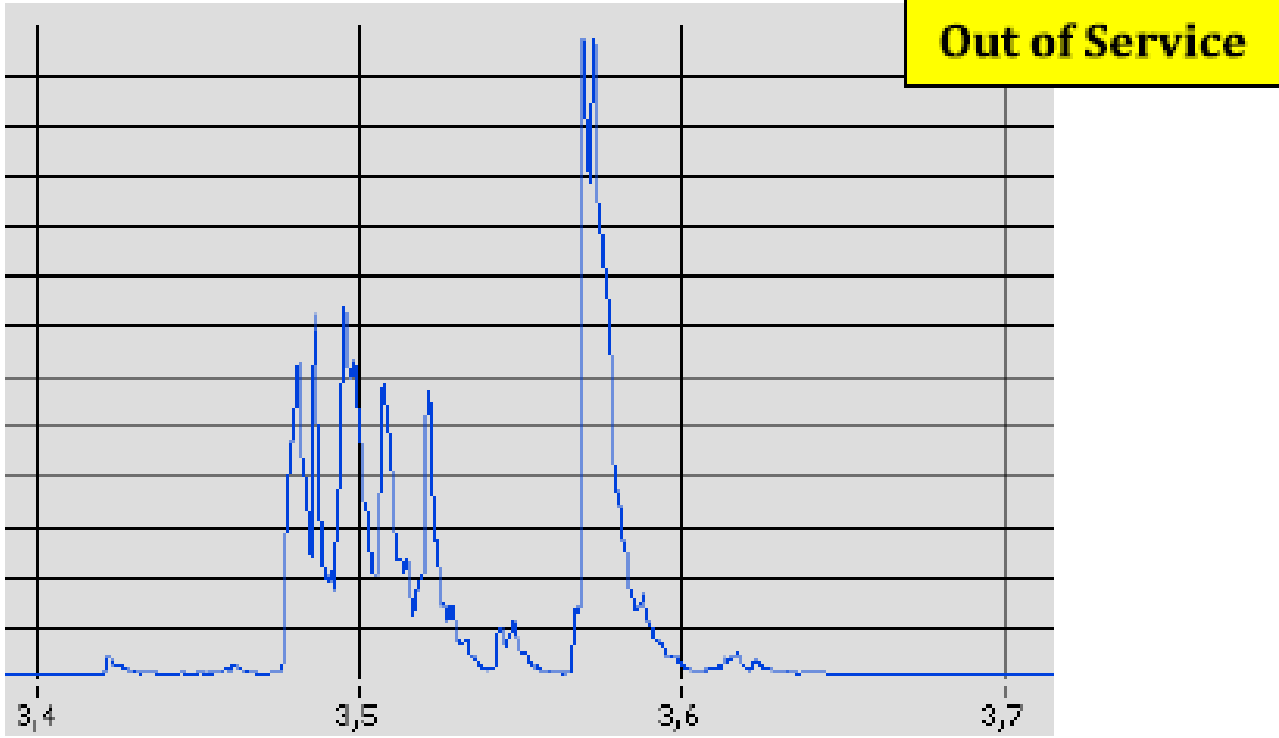
#50 MR REINHAUSEN – D - Typical switching

Pictures	Description
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;"> <p>Type 0466 switch</p>  <p>Out of Service</p> </div> <div style="text-align: center;"> <p>21000 type switch</p>  <p>Out of Service</p> </div> </div> <div style="display: flex; justify-content: space-around; margin-top: 20px;"> <div style="text-align: center;"> <p>20000 type switch</p>  <p>Out of Service</p> </div> </div>	<p>The Reinhausen type D can have three different types of switches, namely:</p> <ul style="list-style-type: none"> -LU D0466 -LU D20000 -LU D21000
<p>Notes:</p>	

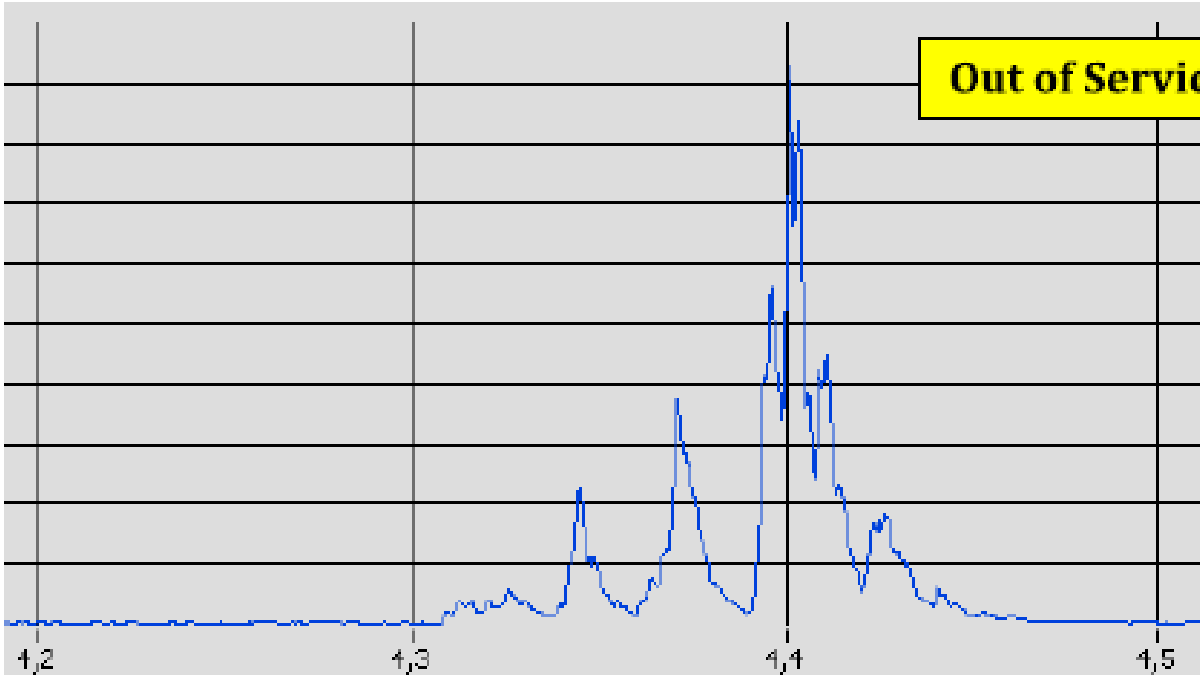
#51 MR REINHAUSEN – E - Typical switching

Pictures	Description
 <p data-bbox="264 1203 1397 1241">Figure 9 : Reinhausen E switching at tap +13 in mode Out of Service</p>	
Notes:	

#52 MR REINHAUSEN – F - Typical switching

Pictures	Description
 <p data-bbox="1151 357 1525 443">Out of Service</p> <p data-bbox="203 1193 1346 1241">Figure 10 : Reinhausen F switching at tap -11 in mode Out of Service</p>	
Notes:	

#53 MR REINHAUSEN – G - Typical switching

Pictures	Description
 <p data-bbox="353 1118 1375 1155">Figure 11 : Reinhausen G switching at tap 7 in mode Out of Service</p>	
Notes:	

#54 MR REINHAUSEN – VR - Typical switching

Pictures	Description
<div style="display: flex; justify-content: space-around;"> <div data-bbox="114 336 860 997"> </div> <div data-bbox="913 552 1733 997"> </div> </div>	
<p>Notes:</p>	

#55 MR REINHAUSEN – VIII - Expected signature

Pictures	Description
<p>Test 2: +3 -- Page 1: Raw Data -- Fichier: MTM Factory_env.wdt</p> <p>LA2 (g) MAX 2.8045 G</p> <p>HA2 (g) MAX 2.5205 G</p> <p>lev (Amp) AVR 2.0626 AMP DLT 0.2865 AMP BRK 804.3999 MS</p> <p>1:MTM -3:1205223 CBACAL70.CAL Ts: 300.000000 µs 2:MTM FACTORY -4:MR TAP-REPORT_ENGLISH.XLS pts: 20259</p> <p>0.00 1.00 2.00 3.00 4.00 5.00 6.00 sec</p> <p>Tap-4 Thu Dec 01 12:18:11 2011</p>	
<p>Notes:</p>	

#56 MR REINHAUSEN – RMV II - Typical switching

Pictures

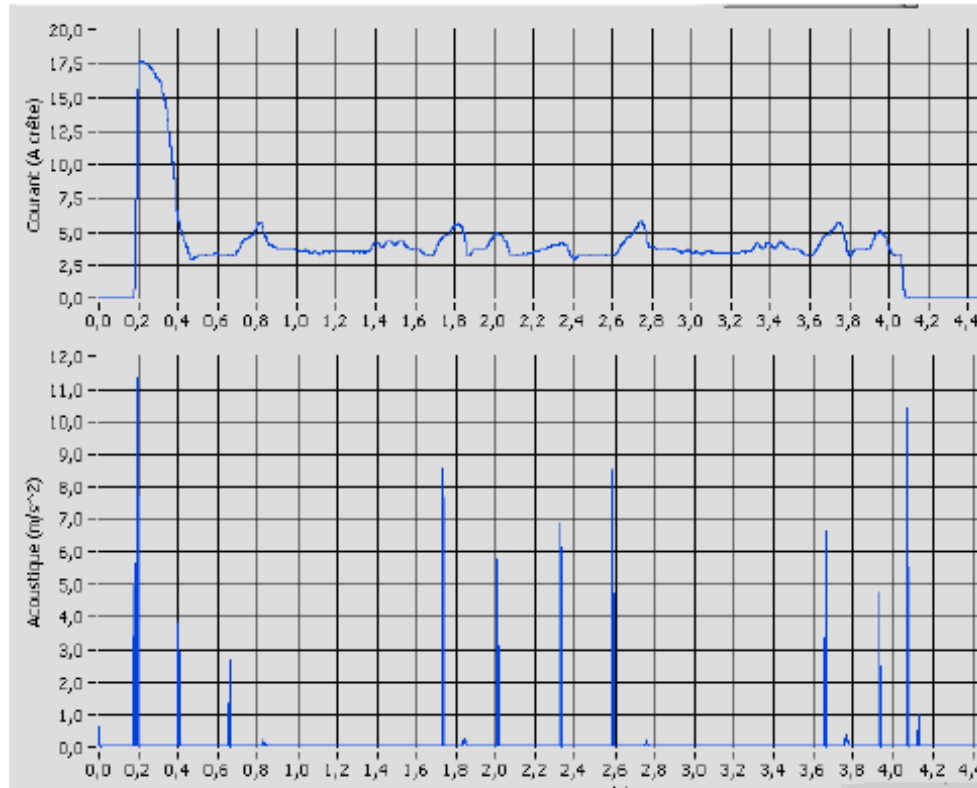
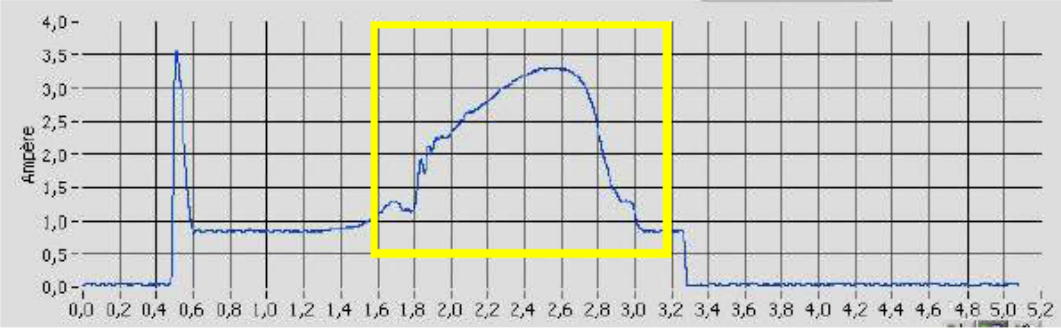



Figure 15 : Single operation upwards of a Reinhausen RMV-II (tap -11)

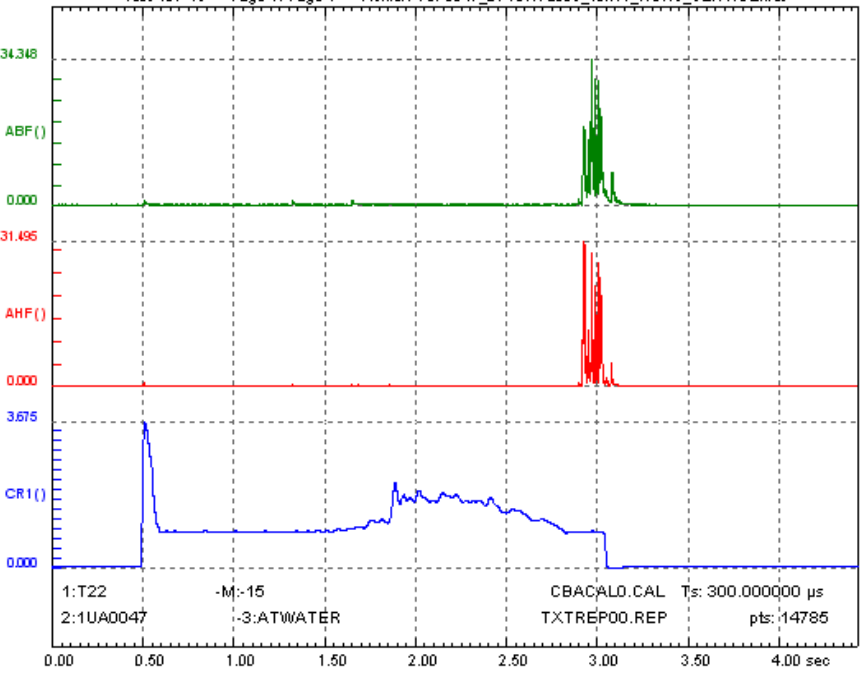
Description

Notes:

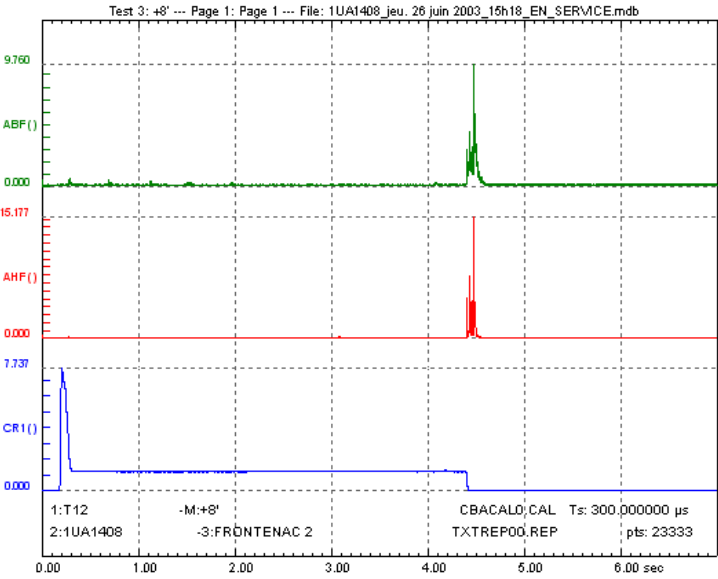
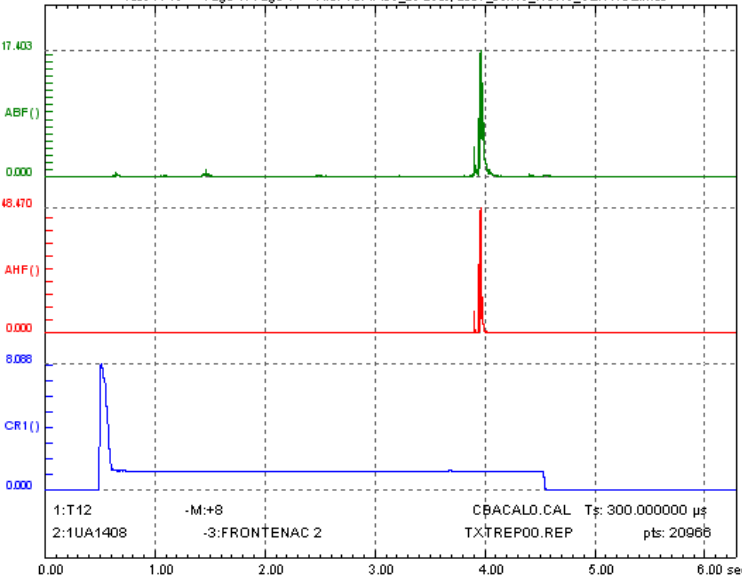
#57 ANY KIND OF TAP CHANGERS - Lack of lubrication

Pictures	Description
 <p data-bbox="669 679 1066 715">Signature before lubrication</p>	<p data-bbox="1653 443 2123 703">The trace of the motor current shows obvious fluctuations towards the end of the operation. There is a lack of lubrication of the drive mechanism.</p>
 <p data-bbox="199 1118 1536 1187">Signature after lubrication - It may be noted that high currents are substantially reduced and the operating time are slightly decreased</p>	<p data-bbox="1653 762 2123 1070">The lack of lubrication of the drive mechanism has a significant effect on the stress of the motor and sometimes causes a refusal to operate followed by the start of the motor protection.</p>
<p data-bbox="91 1198 199 1230">Notes:</p> <p data-bbox="295 1241 1917 1278">To lubricate or replace worn parts or observe the tap changer periodically to monitor the problem at hand.</p>	

#58 ANY KIND OF TAP CHANGERS - Poor lubrication

Pictures	Description
 <p>Test 10: -15 --- Page 1: Page 1 --- Fichier: 1UA0047_21 févr. 2006_10h11_HORS_SERVICE.wdt</p> <p>34.348 ABF()</p> <p>0.000</p> <p>31.495 AHF()</p> <p>0.000</p> <p>3.675 CR1()</p> <p>0.000</p> <p>1:T22 -M:-15 CBACALD.CAL Ts: 300.000000 µs 2:1UA0047 -3:ATWATER TXTREPO0.REP pts: 14785</p> <p>0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 sec</p>	<p>An easy interpretation example is shown by the unusual shape of the motor current which increases at the end of the movement. Lack of lubrication leads to larger torques felt by the motor. As a result, the motor current can see sharp increases.</p>
<p>Notes:</p> <p>To lubricate or replace worn parts or observe the tap changer periodically to monitor the problem at hand.</p>	

#59 Unknown Tap Changer - Asynchronism

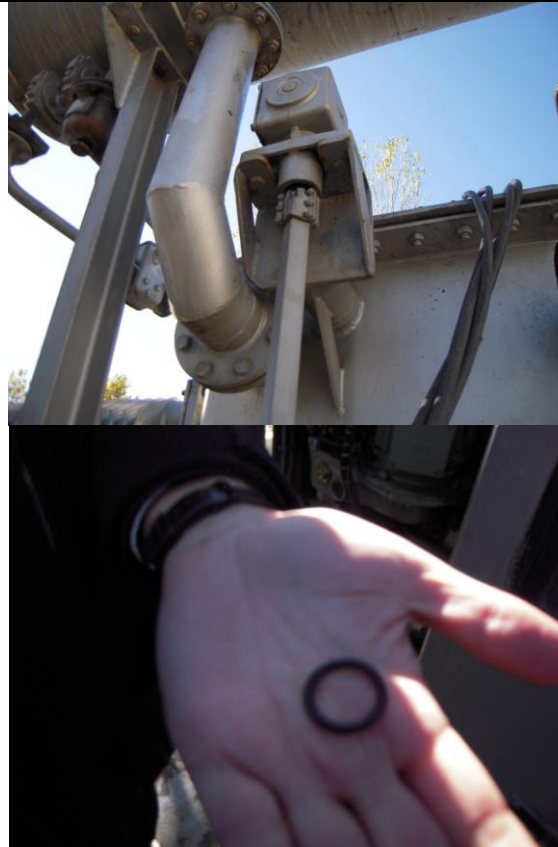
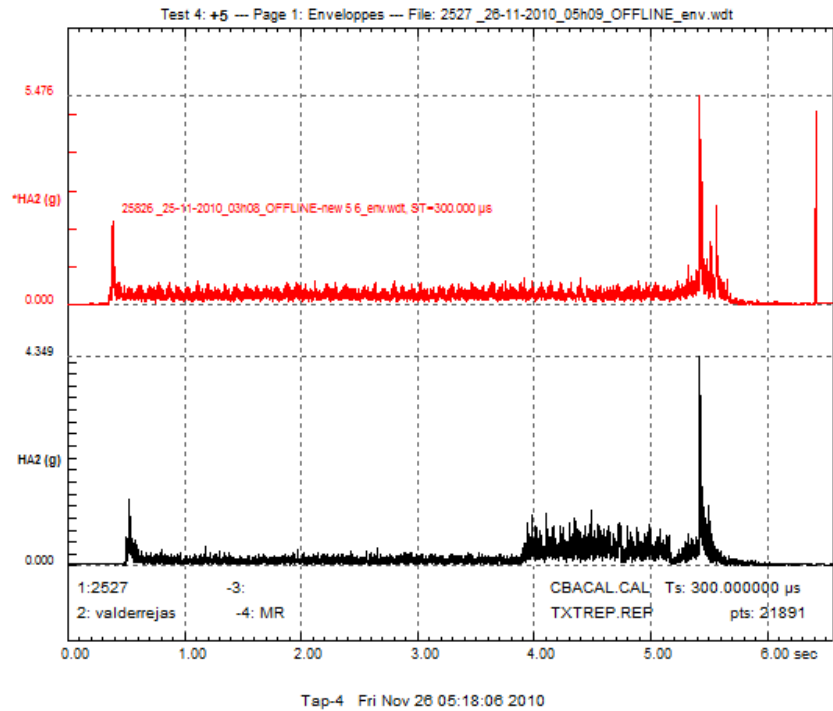
Pictures		Description
 <p>Test 3: +8' --- Page 1: Page 1 --- File: 1UA1408_jeu.26.juin.2003.15h18_EN_SERVICE.mdb</p> <p>1:T12 -M:+8' CBACALO.CAL Ts: 300.000000 µs 2:1UA1408 -3:FRONTENAC 2 TXTREPO0.REP pts: 23333</p> <p>BEFORE REPAIR</p>	 <p>Test 7: +8 --- Page 1: Page 1 --- File: 1UA1408_29.aout.2007.08h16_HORS_SERVICE.mdb</p> <p>1:T12 -M:+8 CBACALO.CAL Ts: 300.000000 µs 2:1UA1408 -3:FRONTENAC 2 TXTREPO0.REP pts: 20966</p> <p>AFTER REPAIR</p>	<p>Certain types of signal analysis may be easily performed without a reference signature. The example shown demonstrates a switching operation signal delayed by 120 milliseconds after the end of the current envelope.</p>
<p>Notes: The repair was simply to uncouple the drive motor in order to adjust it so the switching occurs before the motor current drops.</p>		

#60 Unknown Tap Changer - Arcing contact

Pictures		Description
<p>HIGH AND LOW FREQUENCY</p>		<p>SUPERPOSITION OF HIGH AND LOW FREQUENCIES</p>
<p>Notes:</p>		

#61 Unknown Tap Changer - Job quality control

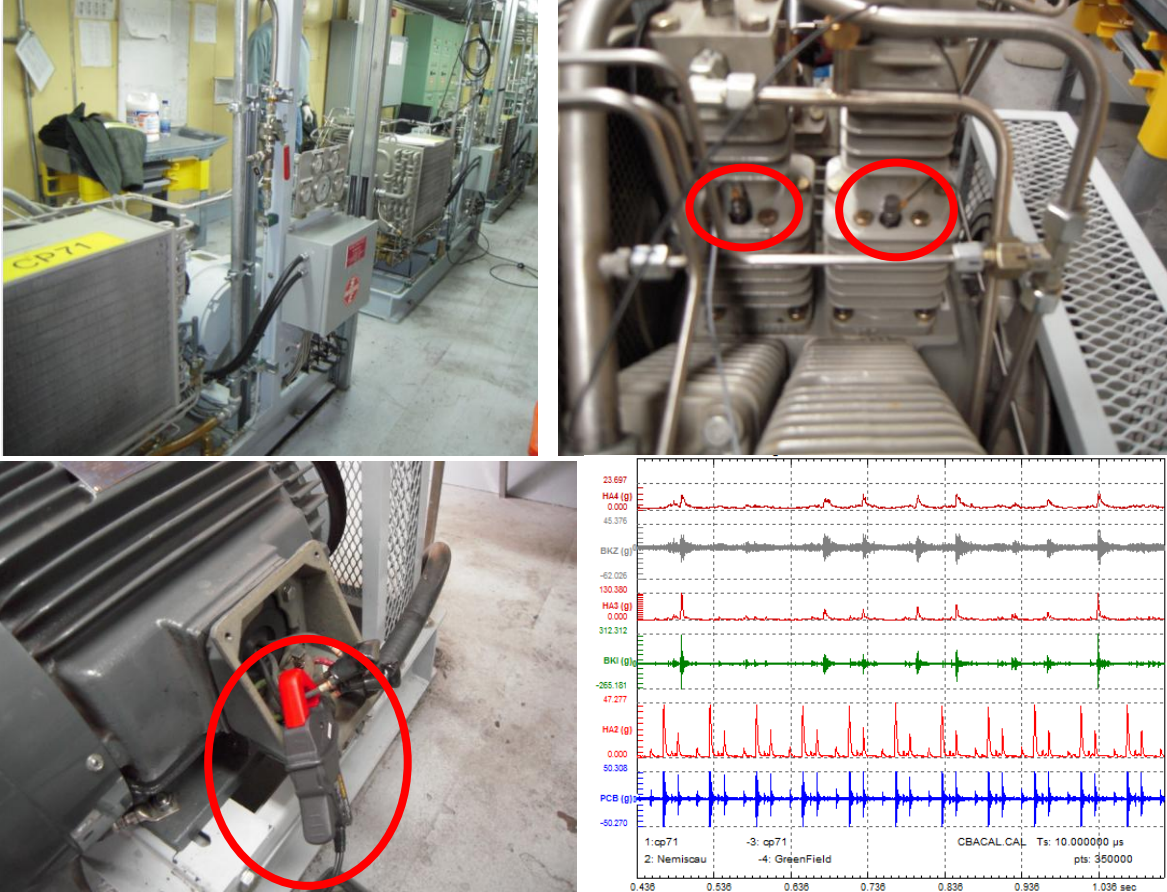
Pictures



Description

Notes:

#62 Other application – Air compressor of 735KV breakers

Pictures	Description
	<p>The purposes of these tests were:</p> <ul style="list-style-type: none"> -To verify the mounting of the compressor and make sure that it respects the manufacturer's recommendations. -To find the origin of the random noise which is present before and after the #72 compressor mounting. <p>With the results, we notice that the 60 ms cycle is divided in 4 regular impacts which refer to the mechanical motion.</p> <p>We also notice unpredictable impacts between 250G and 300G that would come from the radiator on the pipes on the #72 compressor.</p>
<p>Notes:</p> <p>Tests have been performed with accelerometers with a range of + or – 500G and AC current clamp. The tests allows to see regular cycles in Amplitude, Time and Shape and also allow to check that there is no seating in the bearing; no wearing on the tree; no wearing on pistons.</p>	

#63 Other application – COOPER VR 32 voltage regulator with CL 5C control

Pictures

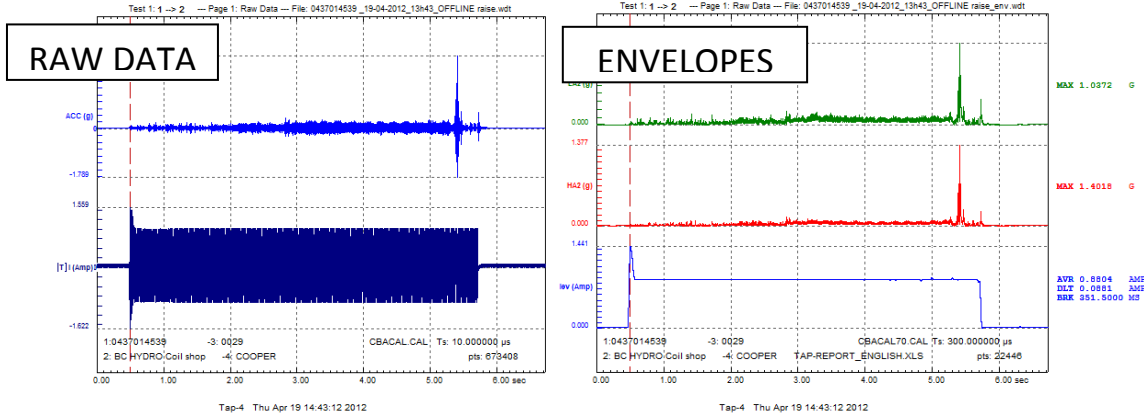


Description

Exploratory tests have been performed on a voltage regulator as a tap changer is used inside. Results are pretty similar to the ones we obtain when we do tests on transformer's tap changers.

We notice that the impact amplitude is quite low. It would be interesting to use a more precise accelerometer with a + or – 10G limitations instead of + or – 50Gs as we did.

It also would be interesting to do a test on a same kind of regulator in order to compare each other as we do on transformer's tap changers.



Notes:

Tests have been performed OFF-LINE with accelerometers with a limitation of + or – 50G and AC current clamp.

#64 Other application – Characterization of an arcing contact

Pictures

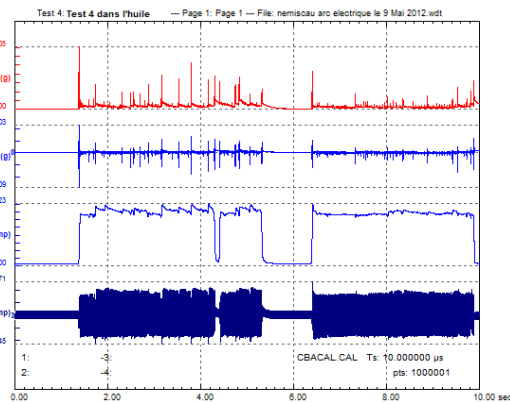


Description

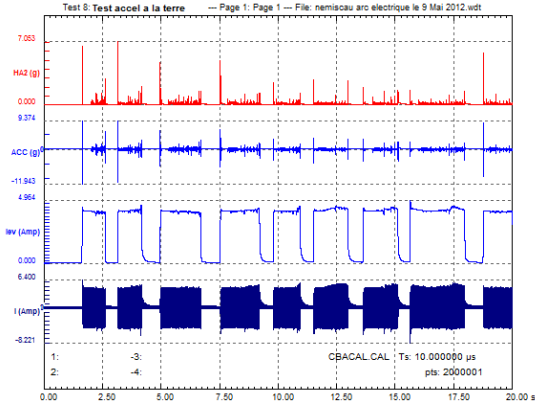
The purpose is to show that an accelerometer can detect electric arcing through a tank full of oil or a ceramic tank.

The current clamp is located on the primary of the arcing generator.

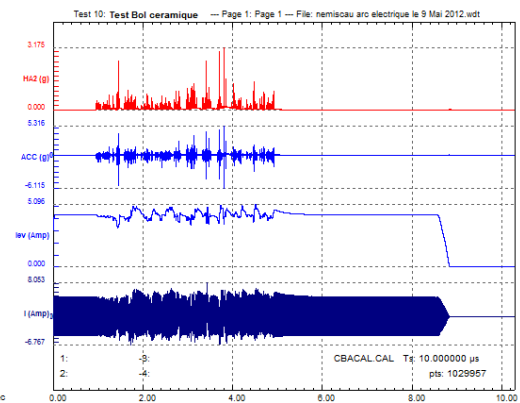
We clearly see when the electric arcing appears and disappears.



Oil



Oil

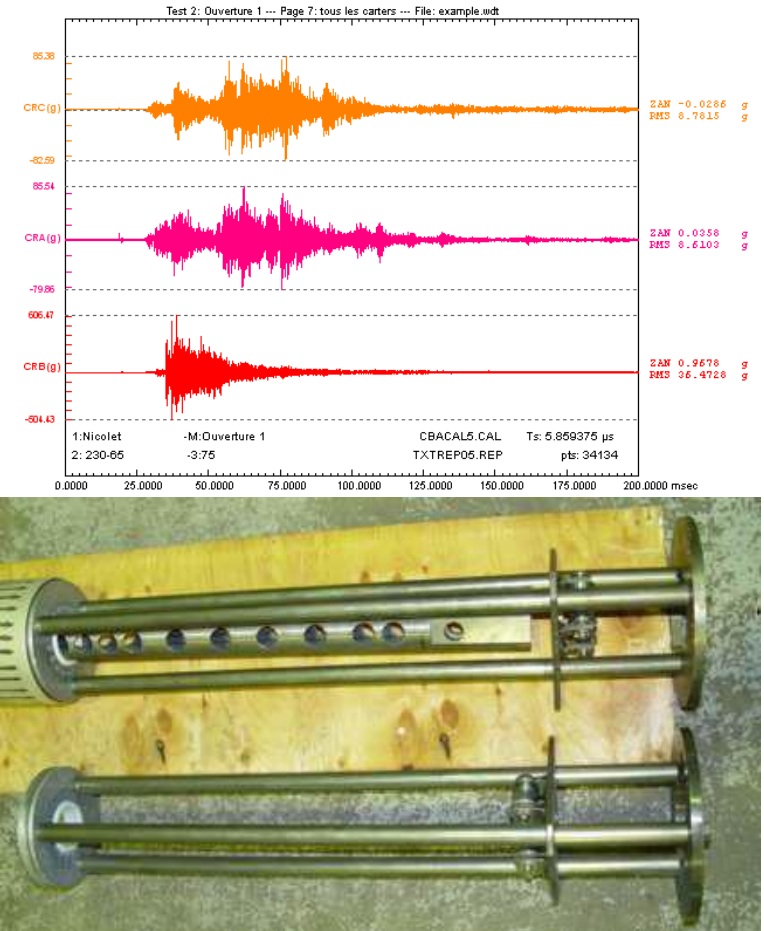


Ceramic

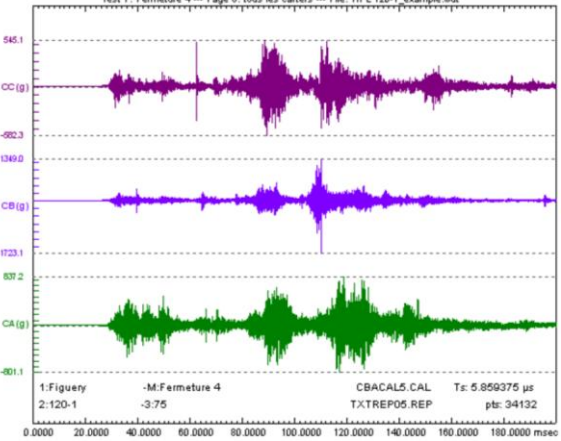
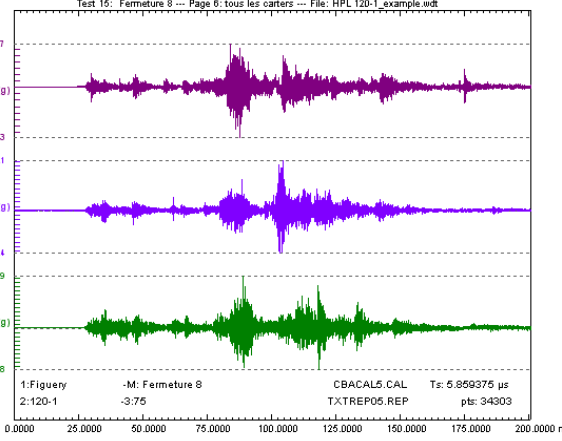


Notes:

Tests have been performed with accelerometers with a limitation of + or – 50G and an AC/DC current clamp.
The oil was extra dry as used for HV transformers.

#65 Other application – Circuit breakers (bad assembly)

Pictures	Description
 <p>The figure displays three stacked vibration waveforms for phases CRC (orange), CRA (magenta), and CRB (red). The x-axis represents time in milliseconds from 0.0000 to 200.0000. The y-axis represents acceleration in g. The CRC waveform shows a peak of 85.38 g and a trough of -82.59 g. The CRA waveform shows a peak of 85.54 g and a trough of -79.86 g. The CRB waveform shows a peak of 606.47 g and a trough of -504.43 g. Statistical data for each phase is provided on the right:</p> <ul style="list-style-type: none"> CRC: ZAX -0.0286 g, RMS 8.7815 g CRA: ZAX 0.0358 g, RMS 8.6100 g CRB: ZAX 0.9678 g, RMS 36.4720 g <p>Below the waveforms is a photograph of the circuit breaker assembly, showing two rollers at the top of the picture, which are identified as the bad assembly.</p>	<p>Here is an example where only vibration testing helped to discover an assembly problem. The figure shows an abnormally high impact (600G) and a different shape on a carter breaker on phase B.</p> <p>The vibration shapes and the amplitudes for phases A and C were quite similar in shape and amplitude, around 80G.</p> <p>All other tests, such as timing and motion, gave good results. Finally the decision was taken to open the suspected breaker phase. It was discovered that there was a mechanical part that was mounted in reverse.</p>
<p>Notes:</p> <p>The pictures above, shows the bad assembly (rollers) at the top of the picture.</p>	

#66 Other application – Circuit breakers (bad adjustment)

Pictures	Description
<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>BEFORE REPAIR</p> </div> <div style="text-align: center;">  <p>AFTER REPAIR</p> </div> </div> <div style="display: flex; justify-content: space-around; margin-top: 10px;">   </div>	<p>This example shows two cases where a bad adjustment has broken the casing of a breaker that has produced an explosion and the other has produced a SF6 alarm. These two cases have been detected thanks to vibration testing.</p> <p>The figure shows the high impacts around 1300G for the middle trace which is phase B, whereas phases A and C show amplitude around 500G.</p>
<p>Notes: We see after repair, similar shapes and amplitudes for all three phases. The pictures show impact marks inside the casing of phase B.</p>	