# Installation of Temporary Jumper in Stator Windings of Gearless Mill Motor Drives

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**REVISION INDEX**

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| 0 | - | Initial document | 20-07-09 Manufacturing Engineering / P.V. |

# 1. GENERAL

## 1.1 Preparation work

- Establish safe working conditions taking in account all safety regulations (EHS), applicable safety and work procedures concerning entering and working inside the motor, working with resin combinations, paints, solvent and working with high voltage equipment.
- Isolate and tag the cycloconverter and the ring motor and establish access to the stator windings.
- Isolate the 3 phases of the stator windings by opening the 3-phase stator knife switch and by disconnection and isolation of the flexible links at the star point connection.
- Remove all covers necessary to establish sufficient space for fault finding and jumper installation.
- Before start of the works for a jumper installation the surrounded areas in the motor have to be properly covered and protected to avoid any soiling or damage of any motor component.
- Have all equipment, tools and materials ready required for the failure location and the jumper installation works.
- **The location process of the damaged bar, the installation works for the jumper and the related high voltage testing shall only be performed by trained and qualified personnel.**
- General remark: The instruction is drawn for a bar winding. In case of a coil winding the expression “bar” may be replaced by “half coil”.

## 1.2 Instrumentation and equipment for jumper installation

- Equipment for failure location according to the applicable instruction.
- Standard set of tools including hydraulic jack and clamps
- 1 insulated, stranded spare bar (Nomex insulated) or similar
- 2 m electric cable with solid strands (total strand cross section approx. 20 mm2)
- Mica-glass-insulation tape Samicaglass MI/GI Gwb PC6 0,18 mm thick)
- Cover tape GI Gwb1 0,17 mm thick)
- Epoxy resin combination EP 139 (resin EP 03 and associated hardener)

- Semi-conductive cover varnish (LL16 and associated hardener)
- Primer GK 128 and cover paint DK 222
- Glass fiber cord, approx. 20 mm diameter
- ELDEC-HF brazing unit (10 kHz, min. 60 kW, type ELDEC or similar) and accessories
- Specific brazing coil inductor, adapted to bar the to jumper brazing connection
- Brazing material (Silfos - brazing foil and brazing rods)
- 2 copper bar connections (H-pieces) or similar (2 copper plates approx. 70 x 120 x 10 mm)
- Copper shims approx. 70 x 120 mm with various thickness between 0.5 and 1 mm
- Heat shield cover material (3 Mica plates approx. 15 x 15 x 2 mm, Silica fiber cloth “Silica Fabric TS 125” or similar)
- Protection cover and tape material (fire resistant)
- Extraction device for removal of brazing fumes
- Compressed air supply (dry and clean)
- Fire fighting equipment
- Megger 2’500 $V_{DC}$
- High voltage test equipment.

## 1.3 Location of damaged bar and jumper installation position

- Mark the slot numbers on the winding non-connection side on the slot wedges according to the applicable winding diagram. Put a number on the slot wedges about every 10th slot.
- Locate the exact physical position of the winding failure in the motor. For failure location use the voltage potential measurement acc. to the applicable instruction.
- Indentify the fault location and the failed bar by visual inspection.
- Mark inside the motor the damaged bar, the associated slot and the associated winding end portions on the non-connection side and connection side of the stator winding.
- Transfer the failure location in the winding diagram (Excel Sheet): Identify and mark the slot number, the damaged top (T) or bottom (B) bar and the associated bar “Position” number. The bar Position number identifies the position of the bar within one phase seen from the phase terminal.

  *Example:*
  *Bottom (B) bar in slot number 407, bar Pos. 11, damaged. Pos. 11 = eleventh bar seen from phase terminal*.

- Identify and mark in the winding diagram the slots numbers, bar types (T or B) and bar Position numbers of the bar connected to the end winding portion A and the 2 bars connected to the end winding portion B of damaged bar. (The end winding portion A is on the non-connection side of the windings while the end portion B is on the connection side of the windings.)
- Establish a detailed sketch as shown in the example in the attachment “Jumper Location”.

  *Example:*
  *Bar to connected to winding end portion A of the damaged bar: Top (T) bar in slot 414, bar Pos. 10.*
  *Bars to connected to winding end portion B of the damaged bar: Top (T) bar in slot 400, bar Pos. 12 and Bottom (B) bar in slot 393, bar Pos. 13.*
- Determine in the winding diagram and sketch
  - the non-connection side end winding portions A of the damaged bar and
  - the non-connection side end winding portion C of the undamaged (intact) bar connected to connection side end winding portion B of the damaged bar.
- Mark in the winding diagram and sketch the end winding portions A and C of the damaged and the intact bar which have to be cut and isolated and where the temporary jumper must be installed to re-connect and re-close the winding circuit.
- Save and store the marked winding diagram and sketch and sent a copy to the motor supplier.
- **The motor supplier must be informed on the detailed location of the failure and jumper installation, because the number and location of temporary jumpers is subject to technical limitations.**
- Mark inside the motor the connected bars, bar end portions and slots as identified and marked in the winding diagram.
- Perform a safety (second) check to ensure that the defective bar, the connected bars with the associated slots and the cutting positions are correctly identified inside the motor and in the winding diagram.

## 2. INSTALLATION OF TEMPORARY JUMPER

This procedure describes how to manufacture a jumper out of an spare stator bar but also a bundle of bare copper strands with an equivalent cross section can be used instead of.

### 2.1 Cutting and insulation of the end portions of the bars

- Mark inside the motor the cutting positions X on the end winding portion A of the damaged bar and the end winding portion C of the intact bar at the end of the straight part of end

winding portions, seen from the slot exits.

*Example: see attachment "Bar Cutting Locations" and attached photos "Example Jumper Installation". ( Pages 15-17 )*

- Protect and cover the surrounding areas to avoid any soiling or damage of any motor components. Secure the winding portions to be cut out to avoid them from falling off.
- Cut out the 2 winding end portions at the 2 marked positions X using an electric hack saw or similar.
- Remove carefully the insulation of the connections Z

*Example for length of insulation removal: see detail in attached sketch "Jumper (Spare Bar) Bending-Cleaning. ( Page 16 )*

- Remove the 2 copper pieces which form the bar to bar connection from the 2 cut out end winding portions by heating of the brazing connections.
- Use high frequency brazing unit or similar to heat the brazing connections and remove the H-shaped copper connection pieces from the bar ends.
- Clean the bar ends of the 2 cut bars at the cutting locations X with a solvent.
- Insulate the bar ends with a protective insulation using 6 layers, half overlapped, of Mica-glass insulation tape insulation 0.18 mm thick or similar. Make sure that the tape is installed without any folds or wrinkles and has an overlapping of approx. 40 mm with the existing end winding insulation. The protective insulation shall have a thickness of at least 1.5 mm. Reduce the insulation thickness in the overlapping area in a conical way at the ends (slope) by steps of 5 mm per layer.
- During the taping of each layer use a brush and apply the epoxy resin combination EP 139 on top .
- Apply 1 layer, 2/3 overlapped, of the glass fiber cover tape 0.17 mm on top of the main insulation tape and apply the epoxy resin combination EP 139 on top.
- Heat-up and dry the surface of the wet glass fiber cover tape using a heat gun or similar.
- Use a brush and apply a layer of the semi-conductive varnish combination LL16 on top of the glass fiber cover tape. Mix the varnish combination LL 16 with its special hardener according to the instruction given on the varnish/hardener containers.

## 2.2 Preparation of the temporary jumper

- A spare bar shall be used as temporary jumper (winding re-connection). To establish the shape and dimensions of the temporary jumper use a piece of electric cable with solid strands (total strand cross section approx. 20 mm2) or similar and form a model of the temporary jumper between the cutting positions Y inside the motor.

*Example of an installation of a jumper connection, see attached photos "Example Jumper Installation". (Page 17)*

- Remove carefully the complete (Nomex) insulation over the full length of the jumper (spare bar). Clean carefully the insulated strand surfaces from any loose parts. Avoid any damage to the copper strands and their strand insulation. When using a steel brush make sure no steel wires remain between the strand surfaces. Clean the strand surfaces with a solvent.
- Shape and bent the jumper according to the electric cable model. To avoid loosening of the bar strand package during the shaping and bending process the strands package has to be clamped together using appropriate clamps and steel plates. Install Nomex sheets or similar between the steel plates and the strand package to avoid damage to the strand insulation.
- For shaping and bending of the jumper use a hydraulic jack or similar. Install steel plates and Nomex at these strand surfaces where shaping and bending forces are applied.
- The end portions of the jumper (spare bar) are bended in the factory to an angle of approx. 45 degrees in relation to the straight slot portion. Bent the end portion 1 of the jumper additional 45 degrees to achieve a total angle of 90 degrees.

*Example for jumper bending: see attached sketch "Bending and Cutting of Jumper".(Page 16)*

- After the 90 degree bending of the end portion 1 bring the jumper inside the motor for a shape and dimension check.
- Hold the jumper to the 2 connection points of the intact bars. Check the jumper for correct shape and determine and mark the final length L 1 of its end portion 1 in respect to the cutting position Y (connection point) of one intact motor bar. The length L 2 of the end portion 1 to be cut-off will be approximately 300 mm.
- Mark the connection end of the one intact motor bar used for determination of the length L 1 to avoid a mix-up with the other intact bar connection end.
- Before final determination of the length L 1 it may be several times necessary to improve the shape of the jumper with additional bending until a good fit and final shape is achieved. *Remark: For final determination of the length L 1 the connection ends of the intact motor bars must be ready for brazing: cut, insulation removed and clean*.
- After cutting of the end portion 1 hold the jumper again to the 2 connection points of the intact bars inside the motor. Determine and mark the point in the still straight jumper portion where the second bending has to be performed to achieve a straight connection with the second intact motor bar.
- Perform the second bending, a full 90 degree bending, using the same equipment as for the first bending.

- Hold the jumper again to the 2 connection points of the intact bars. Check the jumper for correct shape and determine and mark the final length L 3 of its end portion 2 in respect to the cutting position Y (connection point) of second intact motor bar. The length L 4 of the end portion 2 to be cut-off will most likely be significantly more than 300 mm. The straight length L X of the jumper depends on the winding pitch.
- Before final determination of the length L 3 it may be several times necessary to improve the shape of the jumper with additional bending until a good fit and final shape is achieved.

*Remark: For final determination of the length L 3 the connection ends of the intact motor bars must be ready for brazing: insulation removed and clean.*

- Install the main insulation using 6 layers, half overlapped, of Mica-glass insulation tape insulation 0.18 mm or similar over the total length of the finally shaped jumper with exception of the last 70 mm on each end. Make sure that the tape is installed without any folds or wrinkles. The main insulation shall have a thickness of at least 1.5 mm. Reduce the insulation thickness in a conical way at the ends (slope) by steps of 5 mm per layer.
- During taping of each layer use a brush and apply the epoxy resin combination EP 139 on top.
- Cover and protect the last 70 mm at both ends to avoid soiling during the insulation works.
- Install 1 layer, 2/3 overlapped, of the glass fiber cover tape 0.17 mm on top of the main insulation tape and apply the epoxy resin combination EP 139 on top.
- Remove the protection and cover from the last 70 mm at both ends.
- Remove the insulation from the strand surfaces until the bare strand copper is visible. Avoid any damage of the strand copper. Use a Scotch Brite and/or steel brush for cleaning. When using a steel brush make sure no steel wires remain between the strand surfaces. Clean the bare strand surfaces with a solvent.

  *Example for length of insulation removal: see detail in attached sketch "Spare Bar/Jumper Bending-Cleaning. (Page 16 )*
- Remove the protection and covers from the last 70 mm at both ends.

*Remarks: Store the jumper model, the jumper dimensions and shape as they can be re-used*

## 2.3 Installation and brazing of the jumper

- Repeat cleaning with solvent of all brazing connection parts: stranded bar ends, jumper ends and connection plates. The brazing connections must be clean and free of grease.

- Check if the copper connection pieces have a good fit to all brazing connections ends with sufficient clearance for the installation of the brazing foil.
- Protect the main insulation of the intact bars and jumper ends from the heat occurring during brazing by wrapping with several layers of Silica fiber cloth.
- Install the jumper in its final position between the intact bar ends by fixing it temporarily with clamps and appropriate ropes and/or tape. If necessary adjust the shape of the jumper, do not bent the ends of the intact bars.
- Install the connection pieces between the jumper ends and the bar ends. The surfaces of the connection plates shall be parallel to the ends of the intact bars and the jumper to ensure a straight and small brazing gap.
- Cut the brazing foil into single pieces to fit and fill all sides between the bar and jumper ends and the connection pieces (one piece per side).
- Clean the brazing foil pieces with solvent and install them between the bar ends and H-connection pieces.
- Check the clearance between the connections pieces and the bar ends: The clearance must correspond to the brazing clearance. There shall be a slightly tense fit between the bar and jumper ends, the brazing foils and the connection pieces. If necessary fill up the clearances using copper shims.
- Tighten the fixation of the jumper to achieve a tense fit which allows no movement of the jumper, connection pieces and the brazing foil pieces.
- The fixation arrangement must provide sufficient support to avoid any movement of the connection plates and brazing foil pieces during the brazing process.
- All brazing gaps must remain accessible to enable feeding of additional brazing material if necessary.
- Move the brazing inductor over one bar and jumper end and the connection piece and center it over the connection piece.
- Install a Mica plate as heat protection between on each inductor side and the adjacent end winding portion.
- Use 2 wooden wedges and drive them between the Mica plates and the inductor to fix and center the position of the inductor. The inductor shall not touch the connection pieces, bar ends or jumper ends and remain in a locked position to avoid any movement during the brazing process.
- Protect and cover the surrounding winding areas with Silica cloth to avoid that hot brazing material liquid causes any damage.

- Prepare for operation of the brazing unit, the compressed air supply and the brazing fume extraction device and have brazing rods ready for use.
- Switch-on the brazing unit, energize the HF-inductor and heat-up the brazing area to the bracing temperature. The brazing temperature is reached when the brazing foils starts to melt.
- De-energize the inductor and feed brazing rod material in these gaps where the brazing foil material is not sufficient to keep the gaps filled. Feed in rod material until all gaps are full of brazing material; this may specially be necessary at the edges.
- Re-energize and de-energize the inductor to maintain a consistent brazing temperature without overheating the copper material and any main insulation. Avoid local overheating.
- The usual total brazing time at brazing temperature is 60 to 90 seconds. The inductor is usually designed for a maximum operation time of approx. 120 seconds.
- Excessive brazing material and drops must be removed while the material is still hot and liquid.
- Use the brazing fume extraction device during the brazing process.
- At the end of the brazing process start immediately cooling down the brazing joint using compressed air.
- Do not remove the fixation arrangements for the brazing joint and the inductor before the brazing joint has cooled down to approx. 300 °C.
- Once the bracing joint temperature is below 300 °C start cleaning the brazing joint using a steel brush and/or Scotch Brite.
- Checking the quality of the brazing joint by thorough visual inspection using a strong light and a mirror. The quality criteria are:
  - all brazing foils and rod material must have completely melted
  - 80 % of the bracing surfaces must be filled and covered with brazing material
  - no gap or brazing material indent > 0.5 mm
  - no accumulation of brazing material >2 mm
  - no oxide particles
- If the brazing was not successful and has to be re-done the brazing joint must first be cooled down to approx. 50 °C. If the brazing was successful remove the fixation, heat protection material and inductor and install it in the same way at the other (second) jumper-bar connection joint and perform the same brazing and checking process.

## 2.4 Final insulation and insulation of the jumper

- Insulate the brazed jumper-bar connections after cleaning and cooling down.

- Install the main insulation using 6 layers, half overlapped, of Mica-glass insulation tape insulation 0.18 mm or similar over the total length of the brazed jumper-bar connections.
- Make sure that the tape is installed without any folds or wrinkles. The total insulation shall have a thickness of at least 1.5 mm. Apply the insulation in such a way, that there is an overlapping of approx. 40 mm with the slope of the main insulation of the jumper and the intact bar ends.
- During installation of each layer use a brush and apply the epoxy resin combination EP 139 on top
- Install 1 layer, 2/3 overlapped, of the glass fiber cover tape 0.17 mm on top of the main insulation tape and apply the epoxy resin combination EP 139 on top.
- Heat-up and dry the surface of the wet glass fiber cover tape using a heat gun or similar.
- Use a brush and apply a layer of the semi-conductive varnish combination LL16 on top of the glass fiber cover tape. Mix the varnish combination LL 16 with its special hardener according to the instruction given on the varnish/hardener containers.

## 2.5 Fixation, painting and testing of the jumper

- Prepare a large quantity (approx. 5-7 liters) of the epoxy resin combination EP139 in a bucket or similar for the final fixation of the jumper at the end winding portion.
- Cut 4 glass cords with an appropriate length (approx. 0.8 to 1 m) to attach the jumper at the end winding portion.
- Soak and impregnate the 4 glass cords in the bucket with the epoxy resin combination for at least ½ hour. Enforce the impregnation process by squeezing and moving the wet glass cords inside the epoxy resin combination.
- Squeeze out the excessive resin combination before moving the glass cord inside the motor and protect the motor components from liquid resin combination material dropping on them.
- To fix the jumper on the end winding portion install one glass cord close to each of the 90 degree bent of the jumper.
- Install the 2 remaining glass cords in the same way and in even distances between the ones close to the 90 degree bents.
- At least one layer of glass cord must be positioned between the jumper and the end winding portion to provide a conformable cushion. Tie the glass cord tight around the end winding portion and the jumper in such a way that no gaps exist between the cord and the winding bars and jumper.

*Example: See attached sketch "Example: Fixation of Jumper at End Winding Portion" (Page 20 )*

- Heat-up and dry the surface of the wet glass cord using a heat gun or similar.
- Use a brush and apply a layer of the semi-conductive varnish combination LL16 on top of the glass fiber cords. Ensure good overlapping with the existing varnish of the jumper and the end winding portions.
- Heat-up and dry the semi-conductive varnish combination LL16 using a heat gun or similar.
- Use a brush and apply a layer of primer GK 128 on top of the varnish combination LL16.
- Heat-up and dry the surface of the primer GK 128 using a heat gun or similar.
- Use a brush and apply a layer of cover paint DK 222 on top of the primer GK 128.
- Install an electric heating device and direct heat the installed jumper arrangement to enforce the hardening of the jumper insulation and the glass cords.
- During heating avoid any surface temperature of > 100 °C on any machine component.
- The hardening time depends on the temperature achieved with the heating device. Normal hardening time of the impregnated class cords is approx. 24 hours at an ambient temperature of 20 °C.
- Check and clean the motor from all dirt and repair material residuals with special attention to drops of brazing material. Remove all protection covers, tools, equipment and material and perform a final visual inspection.
- After hardening is achieved, measure the insulation resistances to ground of the 3 motor windings according to the applicable procedure.
- Apply a high voltage test on each of the 3 motor windings according to the applicable procedure using a test voltage of 1.3 times the rated motor voltage.
- Repeat the insulation resistance measurement.

## 3. ATTACHMENTS

- Winding Diagram Example SAG Mill Motor (Excel sheet)
- Sketch "Jumper Location"
- Sketch "Bar Cutting Locations"
- Sketch "Jumper (Spare Bar) Bending - Cleaning"
- Photos "Example Jumper Installation"
- Sketch "Example Brazing Arrangement"

- Photo “Example Brazing Arrangement”
- Sketch “Example Fixation of Jumper at End Winding Portion”
- Instruction Epoxy Resin Combination EP 139

## Winding Diagram Example SAG Mill Motor - Stator Winding - Phase U

| | | |
|---|---|---|
| Nominal Voltage | 5200 | V |
| Phase to Ground Voltage | 3002 | V |
| Phase Resistance | 0.0134 | Ohms |
| Number of Slots | 540 | |
| Number of // Circuits | 1 | |

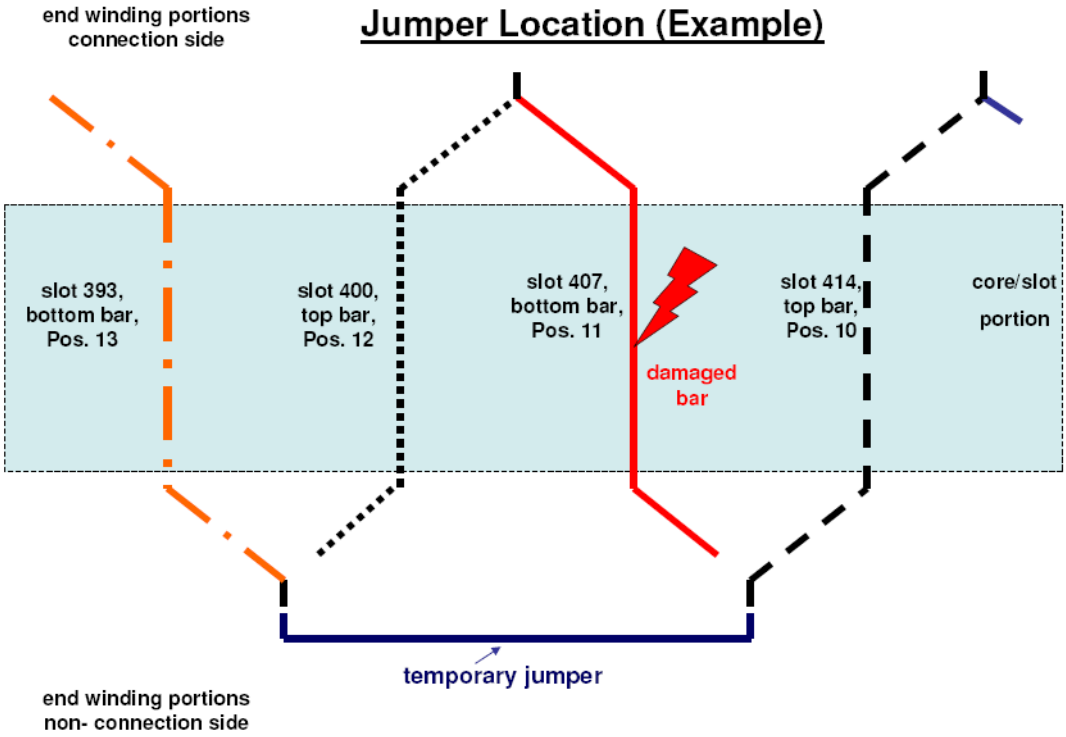
Connection of Bar Pos. 1 to terminal lead of phase U in slot No. 477

Connection of Bar Pos. 360 to neutral lead of phase U in slot No. 413

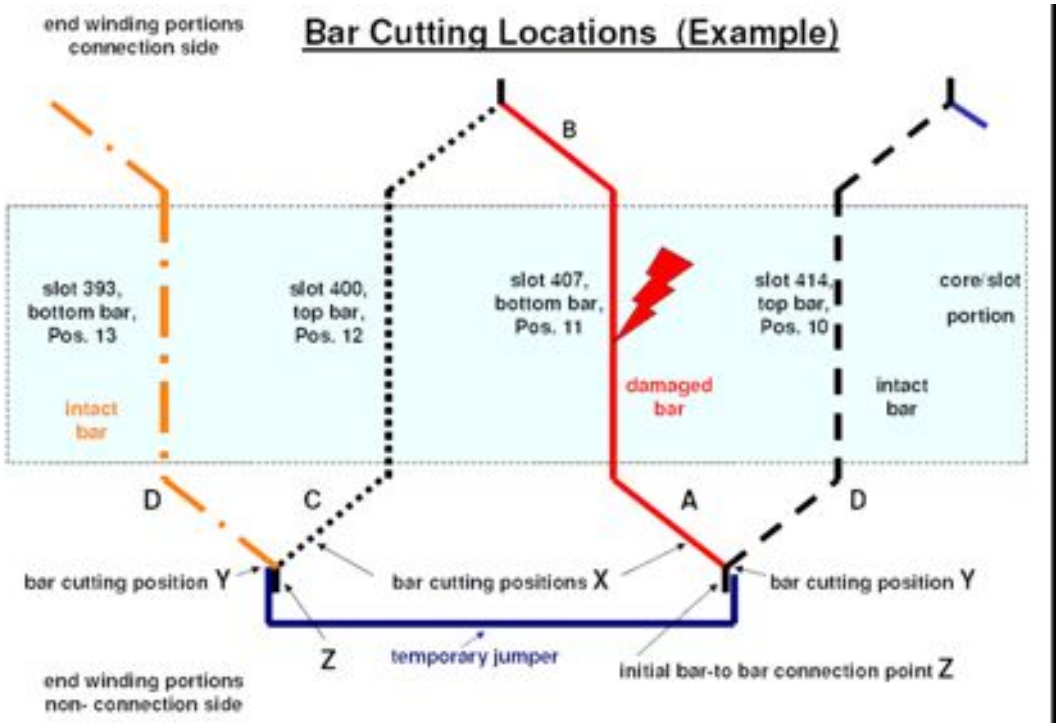
**Phase U - First Parallel Circuit**

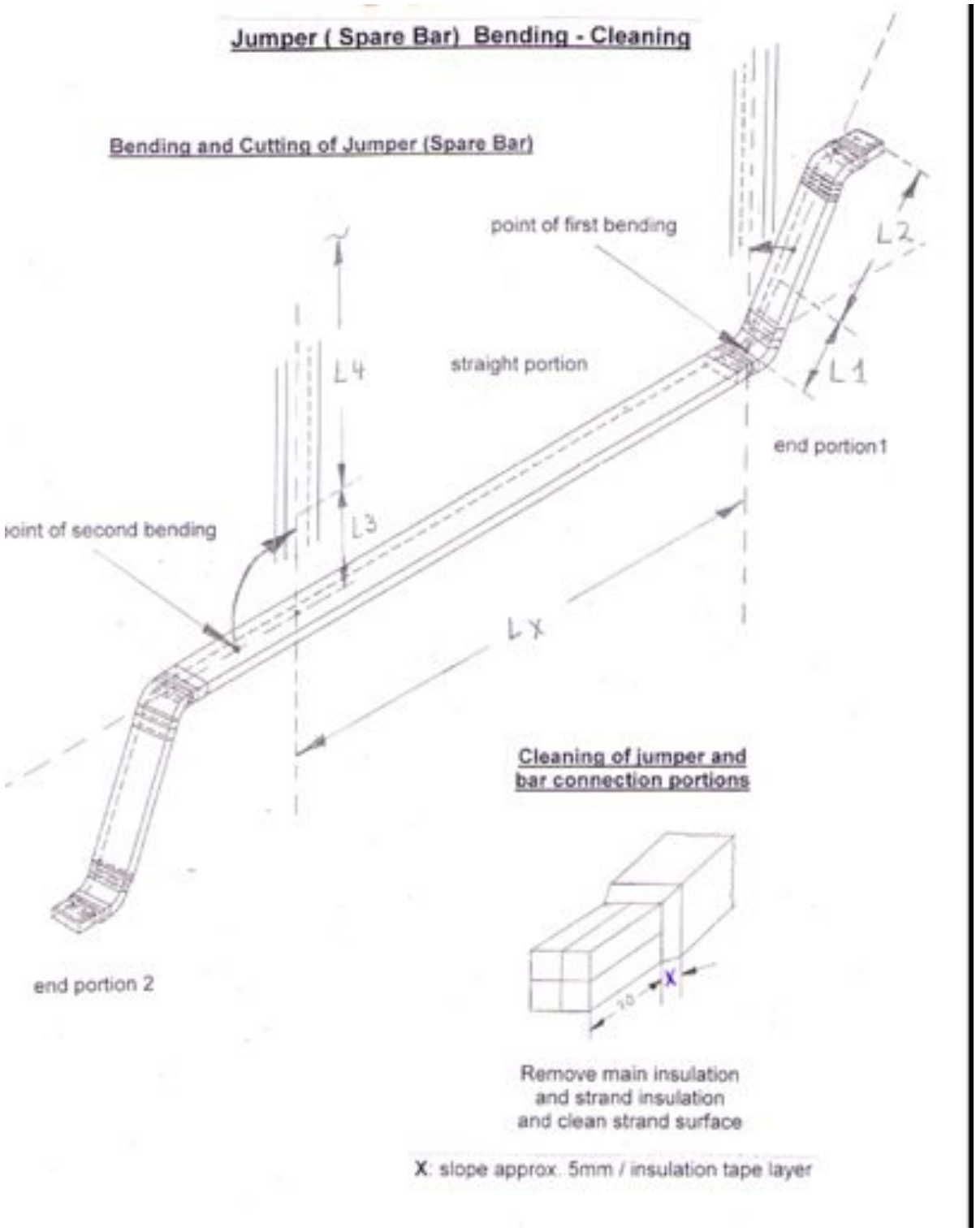
| Bar Position | Slot Number | Top Bar (T) / Bottom Bar (B) | Voltage to Ground | Bar-Bar Connection | |
|---|---|---|---|---|---|
| 1 | 477 | B | 2993.9 | | |
| 2 | 470 | T | 2985.5 | | |
| 3 | 463 | B | 2977.2 | | |
| 4 | 456 | T | 2968.9 | | |
| 5 | 449 | B | 2960.5 | | |
| 6 | 442 | T | 2952.2 | | |
| 7 | 435 | B | 2943.8 | | |
| 8 | 428 | T | 2935.5 | | |
| 9 | 421 | B | 2927.2 | | |
| *10* | *414* | *T* | *2918.8* | | |
| *11* | *407* | *B* | *2910.5* | | *damaged bar* |
| *12* | *400* | *T* | *2902.1* | | |
| *13* | *393* | *B* | *2893.8* | | |
| 14 | 386 | T | 2885.5 | | |
| 15 | 379 | B | 2877.1 | | |
| 16 | 372 | T | 2868.8 | | |
| 17 | 365 | B | 2860.4 | | |
| 18 | 358 | T | 2852.1 | | |
| 19 | 351 | B | 2843.8 | | |
| 20 | 344 | T | 2835.4 | | |
| 21 | 337 | B | 2827.1 | | |
| 22 | 330 | T | 2818.8 | | |
| 23 | 335 | B | 2810.4 | * | |
| 24 | 328 | T | 2802.1 | | |

## Jumper Location (Example)



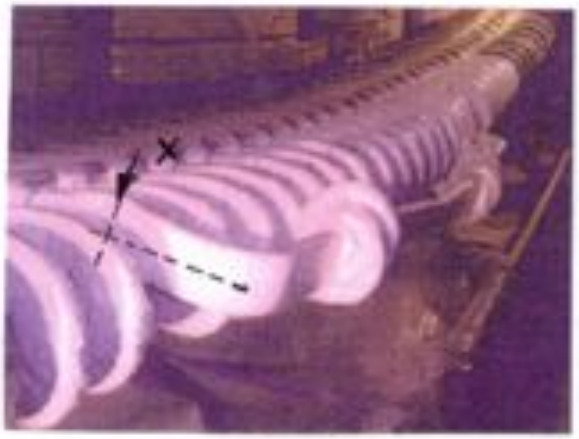

## Bar Cutting Locations (Example)




Jumper ( Spare Bar) Bending - Cleaning
Bending and Cutting of Jumper (Spare Bar)
point of first bending
L2
L4
straight portion
L1
end portion1
oint of second bending
L3
L X
Cleaning of jumper and
bar connection portions
end portion 2
X
Remove main insulation
and strand insulation
and clean strand surface
X: slope approx. 5mm / insulation tape layer

## Example Jumper Installation

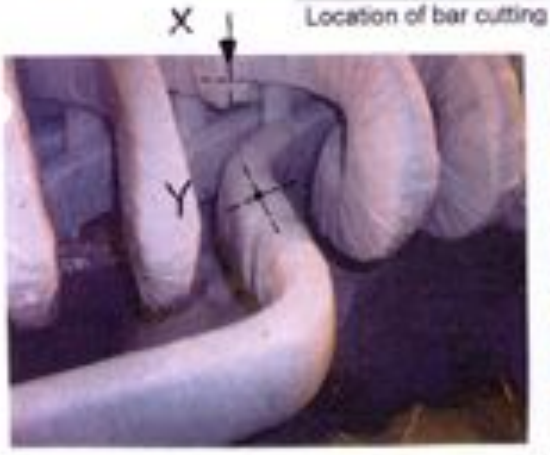
Finished bracing joint



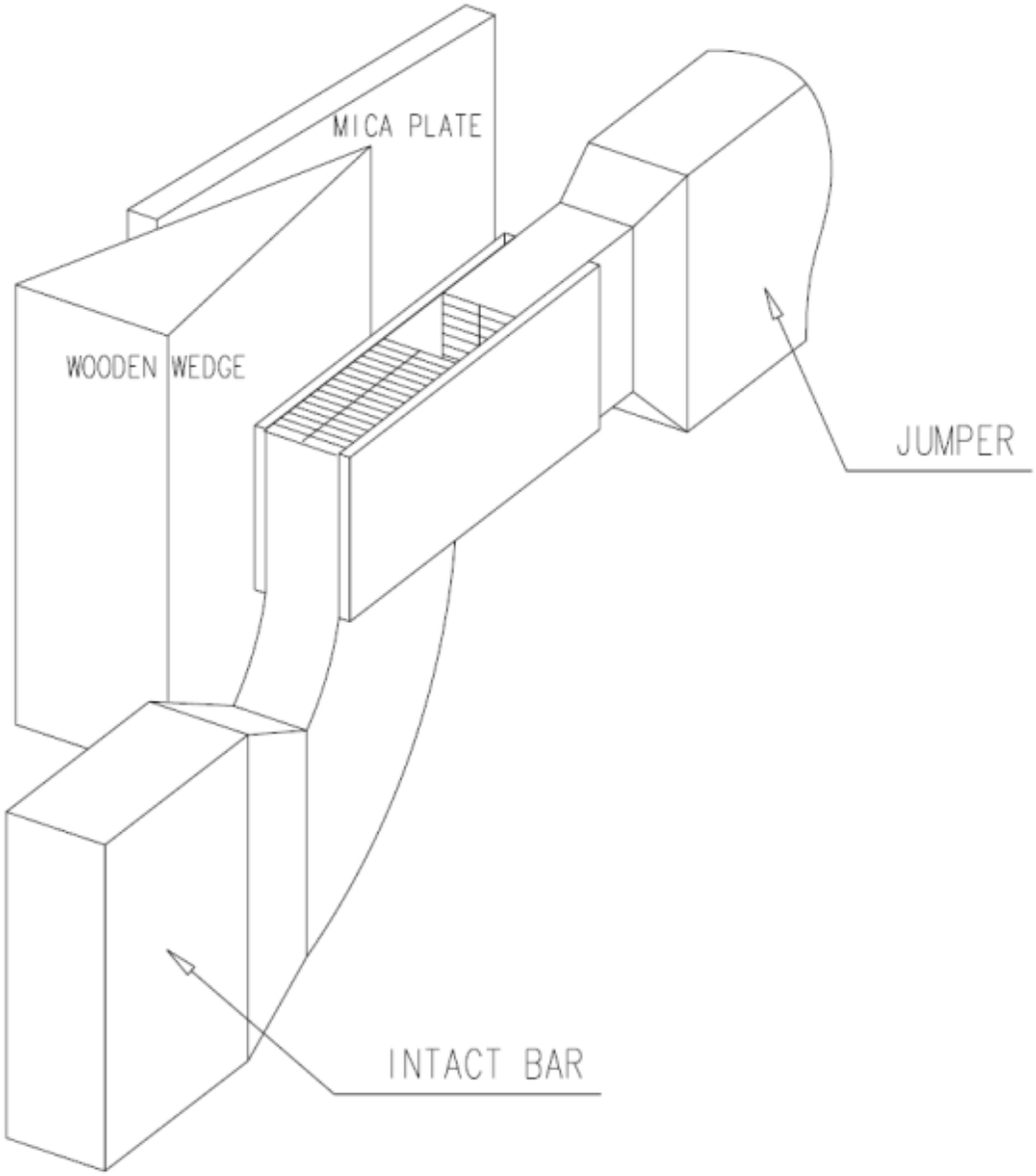

Position of
bar cutting point **X**
(temporary fixation of jumper)

Application of
jumper insulation

Location of bar cutting points **X** and **Y**

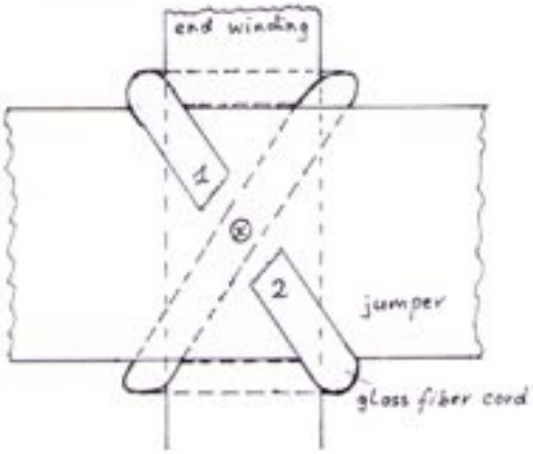


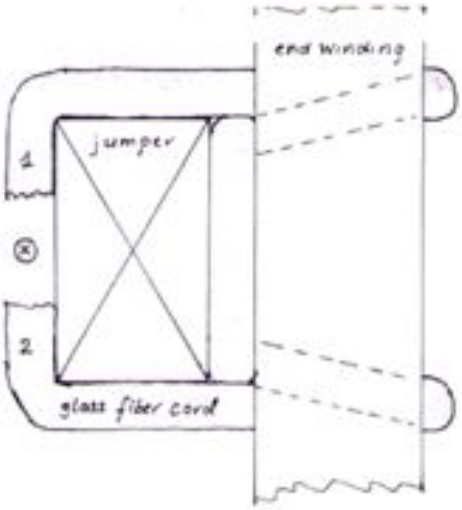

# Example brazing arrangement – horizontal position

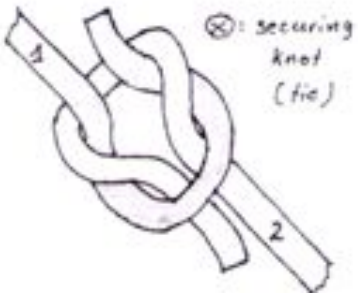


## Example Brazing Arrangement

Example: Fixation of Jumper at End Winding Portion



| ABB | ABB Industrie AG | | | HTZW 23204 |
|---|---|---|---|---|
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| Prepared: 98-08-03 Hutter | Checked: 98-08 Gasparini | Approved: 98-08 Lanz | | Language: en / Page: 1/1 |
| Valid for: | Derived from: | Replaces: same no. | Classify no.: | Data set: HTZW123204EN.C__ |

**Manufacturing Instruction (MI)**

**Resin combination EP 139, GMN 598100 R211; (Cold-curing bandaging resin)**

| Designation text: | MI - Resin comb EP 139 | Documentation no.: | HTZW 23204 |
|---|---|---|---|

## 1 General

The resin combination EP 139 is an unfilled, cold-curing epoxy resin containing solvent. Application: Mainly as brushing resin for insulating connection lugs, winding connections and phase bus bars with narrow space conditions.

## 2 Formulation

| | | |
|---|---|---|
| 100 parts by weight | Grundharz EP 03 | NBT 401839 |
| 50 parts by weight | Härter 30 | NBT 401842 |
| 10 parts by weight | Acetone(chemicaly pure) | NBT 400407 |

## 3 Mixture

Pour the three weighed components together and mix thoroughly.

## 4 Processing

| | | |
|---|---|---|
| Pot life | approx. 4 hours | at 18°C to 23°C |
| Curing | approx. 24 hours | at 18°C to 23°C |

## 5 Storage

The single components acc. to HTZW 23175.

## 6 Safety precautions

When working with synthetic resins adequate protection precautions according to local regulations should be observed respectively acc. to HTZW 23200 should be followed.