Transformer systems

Crimping of copper winding conductors

Work Manual

GB





ELPRESS

Academy

Work Manual Transformer System

Crimping of copper winding conductors

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1 Introduction

1.1 BACKGROUND

For several years Elpress has developed and verified the use of crimp technology for the connectors used in combination with winding conductors.
Tests has been made at Elpress laboratory in Kramfors, Sweden, in accordance with IEC 61238-1. This work has been made in cooperation with large transformer manufacturers.
This manual gives instructions and recommendations based on performed tests as well as from practical experience gained from different fields of application.
This document will be subject to update as a result of new experience and practical use.

1.2 DEFINITIONS

Connectors	Terminals, through connectors, T-connectors etc.
CSA	Cross section area (mm^2)
Crimp	Compression joint between conductor and connector.

2 General

2.1 CRIMPING – A SYSTEM TECHNOLOGY

By means of crimping, a good electrical joint between a conductor and a connector is achieved. With high force and defined crimp geometry these good properties are safeguarded.
This mean in practical terms that crimping must always be a system technology. As a consequence, all separate parts which are used must be designed to work together. A mix between different systems is therefore impossible and will lead to severe loss in performance.

A system is set up by
- **Conductors**
- **Connectors**
- **Crimp tool**
- **Operators**

The correct and matching crimp tools and connectors within the Elpress system are coordinated with the proper conductors by Elpress as stated in this manual. The objective of this manual is, primarily in conjunction with a practical training session given by Elpress, to give the operator the necessary knowledge and instructions for work. In the following only such aspects of crimping are given that are relevant and verified for the work in question.
The crimp technique referred to is of hexagonal geometry. There are many other types around but the hexagonal system gives a good and evenly distributed contact without very large conductor deformations and is therefore the preferred method.It is visually difficult to establish if two crimp dies or two connectors are the same types or not. It is therefore always very important to positively identify the items to be used.

Failure to do this may compromise the results severely.

2.2 GENERAL ROUTINES FOR WORK AND SAFETY

Crimping uses tools with very high force. In this manual crimp heads that will develop 6 tons (60 kN), 13 tons (130 kN), 25 tons (250 kN) and 35 tons (350 kN) are referred to.
The hydraulic oil pressure that results in these forces is 630 bar or approx. 9000 PSI.
These pressures and forces require special components, attention and know-how to safeguard the work safety.

Therefore, the following must always be observed.

- Never use spare parts that are not specifically defined for the tool system in question. (Most normal hydraulic repair shops do not stock hoses, couplings etc. specified for these pressures and may also not recognise the need for special parts.)
- Repair and adjustments may only be performed by a by Elpress authorised service partner
- When in need of repair, contact Elpress authorised service.
- Do not work with parts that have or may be suspected to have damages.
- Make a routine of establishing, before each new job, that the tool system is properly put together, that no visual damage exists and that the system works properly.
- Check specifically
  - → that the quick couplings are fully inserted into each other
  - → that the pump hose control handle or FCU is properly attached to the crimp head
  - → that the protection rubber sleeve is properly attached to the bottom of the crimp head
- Establish inspection plans covering when and how detailed routine inspections are being performed.

2.2.1 General instructions for crimping

Even if all efforts have been made to make the tools as safe as possible, material breaking, oil leakage etc. can occur as a result of for example material fatigue, improper use or similar. Therefore a few basic work procedure rules should always be observed

- Do not hold the tool so the force acts in a direction pointing at anyone.
- Check that the tool has the inserts for the work to be performed.
- **DO NOT EVER** use the tool for any other purpose than it is specified for, i.e. crimping and pre-rounding.

Instructions, rules etc. in force at the place of work that could be relevant to the work covered by this manual are not overruled by what is stated here. In case of conflicting statements, first priority is always personal safety. Contact Elpress in case of conflicts that may relate to the performance of the crimps.

2.2.2 In case of injury

The high oil pressure may in case of leakage result in injury to persons. In such cases, for example if oil has penetrated the skin, **always** consult a physician and give a comprehensive description of what has or may have happened. The oil is not toxic but can cause other problems and it should be removed.

The crimp tool systems are built up by the following components

Component		Designation
Mains/Battery pump		PS710
Crimp head, 6 ton		V600/V611/PVX611
Crimp dies for V600		TB11L, TB13L, TB14,5L TB17L, TB20L KB22L

Crimp head, 13 ton



V1300L/DV1300L
DV1300C2/PVX1300

Pre-rounding dies for V1300



13R8ML-B and DL-B
13R9ML-B and DL-B
13R11ML-B and DL-B
13R13ML-B and DL-B
13R15ML-B and DL-B
13R17ML-B nad DL-B
13R19ML-B and DL-B

Crimp dies for V1300



13B11L, 13B13L,
13B14,5L, 13B17L,
13B20L, 13B22L,
13B25L, 13B27L,
13B30L

Crimp head, 25 ton



V250/V250L

Pre-rounding dies for V250



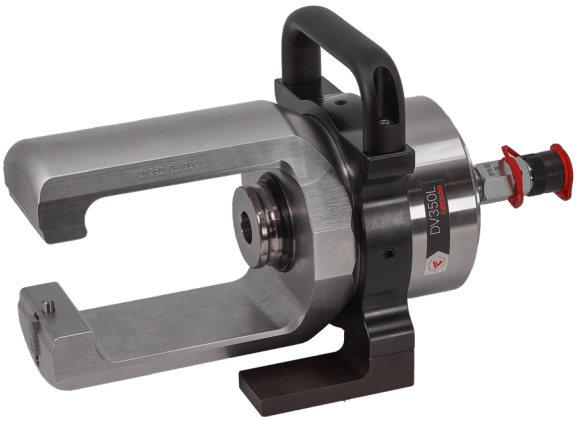
25R21ML and DL
25R24ML and DL
25R26ML and DL
25R30ML and DL
25R33ML and DL
25R39ML and DL

Crimp dies for V250



B2525L, B2527L,
B2530L, B2532L,
B2538L, B2542L,
B2550L

Crimp head, 35 ton



DV350L

Pre-rounding dies for DV350



35R26ML and DL
35R30ML and DL
35R33ML and DL
35R39ML and DL
35R42ML and DL

Crimp dies for DV350



B3530L, B3532L,
B3538L, B3542L,
B3550L, B3553L

2.3.1 Quality assurance and maintenance

Systematic inspection of all tool system components is an integral part of a total quality assurance system covering the crimping operation.

Necessary guidelines for maintaining the tools are available.
Please contact Elpress for further assistance.

It is of utmost importance for the proper work of the crimp dies that the die surfaces are clean and polished. The high crimp pressure makes the tin plating of the connectors adhere to the dies surfaces which makes it harder for the connector material to sink into the dies during crimping. Sharp crimp edges will then easily occur. A running routine to systematically safeguard the cleanliness and smoothness of the crimp surfaces is necessary to keep the crimps proper and free of sharp edges.
The use of solid paraffin, beeswax or similar compound as a lubricant between dies and connector will also very positively contribute to avoiding sharp edges.

2.4 CONNECTOR ELEMENTS

2.4.1 Types

Below the most commonly used connectors for the conductor types in question are listed. Additional to this there are T-connectors, threaded lead through terminal pins, reducer connectors and other special connectors, see Elpress Electrical machines catalogue.

Type	Designation	For conductor type
Terminal lug	KRFxx-yyL xx = cross section area, mm², yy = hole for M-size bolts	Stranded and flexible conductors, winding conductors
Through connector	KSFxxL xx = cross section area, mm²	Stranded and flexible conductors, winding conductors

2.4.2 Markings

Connectors from Elpress are marked to indicate the following

- Manufacturer, by means of the Elpress logotype
- Nominal conductor area for which the connector is used
- Hole size for M-bolts, (terminals only; ”-12” refers to a M12 bolt and the hole is Ø13 for sufficient clearance)
- Id-number for the Elpress die to be used
- A ”F” to indicate that the connector is of type KRF/KSF

Especially for transformer applications a series of connectors have been developed. These connectors have identical markings as the standard types and have a ”L” as suffix to the product designation (catalogue name) marked on the package label.

2.5 INSPECTION AFTER CRIMPING

The crimps covered here are made with dies that have a hexagonal geometry. When crimping the dies close fully (if not otherwise separately specified!) and it is therefore possible to afterwards measure the crimp height to establish if the crimp force was

enough to close the dies. If not the crimp height will show a higher value than the specified check height, ”N”. It must also be considered that a certain wear of the dies has to be accepted.

Some dies have a small half-round ”pin” at the bottom of the die nest that gives an additional indent at the crimp surface. The N-measure is taken on both sides of these indents.

Identification check
This means that the use of proper crimp dies is verified. The dies have identification engravings at the dies nest bottom which leaves a mark on the crimped connector. This mark must show the same number as is stamped on the connector.

Crimp height check
After crimping the crimp height measure, N, should be taken and compared to the specified maximum value.

See table 5.1, N-measures.

3 Crimping of winding conductor connectors

Crimping of winding conductors is very different to crimping of round conductors with standard cross sections.

It is anticipated that the winding conductors have a rectangular cross section.

It is furthermore anticipated that the insulation (lacquer or other) is removed. The procedure for insulation removal differs widely between transformer manufacturers and is not covered here. The local instructions for this operation should be followed and is not influenced by what is said here.

3.1 CHOOSING CONNECTOR ELEMENTS

The connector to be used is marked with the nominal cross section area, i.e. the standard cross section cable area it was designed for. This “nominal “ size refers to conductors according to IEC 60228 for winding conductors a cross section range is established for each connector size. A minimum and maximum conductor package section area was developed in two steps

- Establishing the practical max and min area limits for rounding of conductor packages in a set of pre-rounding dies, followed by
- Crimping and testing max and min areas to the requirements of The international standard IEC 61238:1, Class B.

See table 5.2 for cross section area ranges.

The winding conductor packages may differ widely in build-up. The number of rectangular conductors as well as their dimensions differs. The tests have been performed with winding conductors of varying kinds but it is of course impossible to cover all possible cases with practical tests. Continuous indicative tests are made to further establish possible or necessary changes of the cross-section ranges.

Note: when working with solid round conductors it is recommended to choose the smallest connector/conductor combination available, see tables chapter, for best result. This type of conductors is also recommended to be cleaned with a strong detergent or a type, scotch scouring pad to achieve best possible electrical and mechanical properties.

The following work sequence is used to establish which connector that should be used
1. Calculate the total cross section area

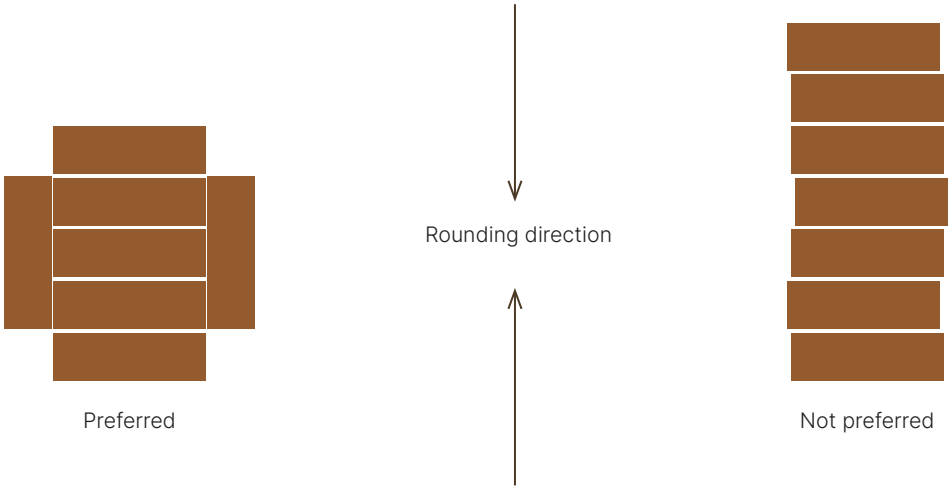
2. Use table 2 to
   - establish which connector that has a min-max range to include the calculated cross section area or.
   For terminal lugs chose a bolthole with the same designation as the M-bolt size.
   For example, a KRF95-12L will accommodate a M12 bolt.

3. Check finally that the connector has the Elpress logotype stamped on to show it belongs to the system.

3.2 PRE-ROUNDING OF CONDUCTOR PACKAGES

The package of rectangular conductors must be pre-rounded to enter into the connector and a certain reduction of the conductor cross section area is also sometimes necessary. This work is done with the Elpress pre-rounding punch and matrix.
See table 5.3 for choice of tool for pre-rounding.
The following work procedure is used for the pre-rounding operation.

1. If possible place the individual conductor so that a ”square” formation is reached.
   The width is hereby however restricted by the inner width of the rounding matrix.
   The conductors must be placed parallel to each other so that no crossover occurs.



2. Make sure that the packaged conductors are equally long so that the whole package has the same cross section area.

3. The pre-rounding tool lengths are matched to the insertion depths of the corresponding connector. As a result the package must be aligned 3-5mm shorter than the full length of the pre-rounding tool.

4. Check that the correct pre-rounding tool is chosen, see table 6.3.

5. When the pre-rounding starts make sure that all conductors are properly placed and that the tool travel direction is right. Adjust before any major pre-rounding has been achieved. Thereafter the pre-rounding is made in one sequence. Make a test pre-rounding on some scrap pieces forming the same package before the final pre-rounding is started.

3.3 CRIMPING

The crimping of the different types of connectors is basically the same.
Due to the higher crimp forces needed at larger cross section areas, ≥ 300 mm², must be crimped with the V250 or DV350 head. Smaller connectors, ≤ 300 mm², can be crimped with either one of the press-heads.

The full specification of heads and accessories are detailed in Tool Chart.
See table 5.3, tool chart

3.4 WORK PROCEDURE WHEN CRIMPING WINDING CONDUCTORS

It is recommended that a test crimp is made on scrap pieces equally built as the conductor package to be crimped.

1. Insert the crimp dies into the press-head so that the spring ball engages and the dies are properly lined up and fixed in place. It is essential that the dies work without side displacement.

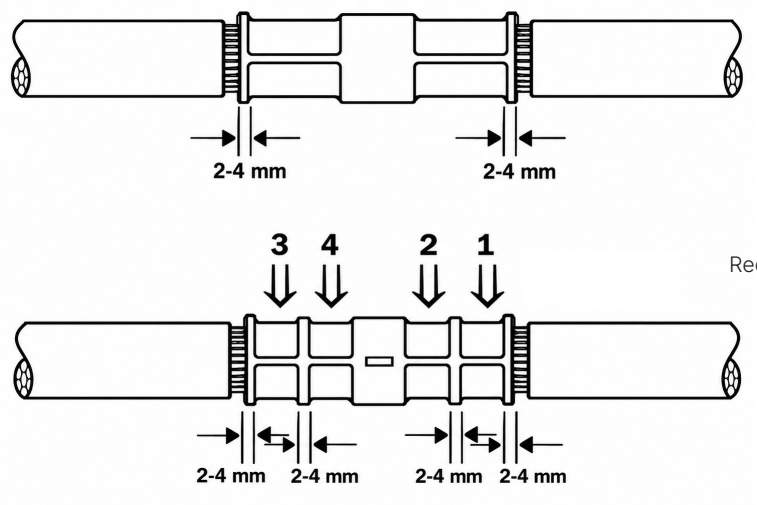
2. Put the connector into the die opening and hold it towards the upper die that does not move. This facilitates the correct positioning.

3. Position the connector so that the end points out approx. 2-4 mm from the die edge.

4. Press the start switch of the remote control and run the dies together to hold gently against the connector. Adjust the positioning.

5. Insert the conductors fully into the connector (can also be made earlier) and adjust again if needed. It is recommended that a mark is made on the conductors at the end of the barrel to make it easier to detect if the conductors slip out during the process. If so it must be adjusted.

6. Make sure that the numbers of crimps are made according to table 6.4. Place the crimps in accordance with the picture below:



Recommended crimp sequence

7. Hold the conductor firmly into the connector until the crimp grip secures the positioning. Crimp in one sequence without interruptions. The die travel stops automatically when the crimp is finished and the tool retracts.

8. If there is a risk for sharp edges to occur, make the crimp at 90° to the rounding direction. Also, if making two adjacent crimps, the second crimp can be made 90° turned from the first one. The use of dry paraffin, bees wax or similar compound to lubricate between the dies and the connector contributes well to avoiding sharp edges. Check that the die surfaces are clean and smooth. See 2.3.2 above.

9. If the crimp is interrupted and finished before the automatic cut-off the crimp properties are jeopardised and corrective actions must be taken.

For inspection after crimping see chapter 2.5.

4 Cross section area filling

Filling of a conductor package is made, as stated above, to reach the correct size of a connector if the package is too small for this size. Filling can only be used for maximum two area steps, for example from an area above maximum for 50 mm² to the range of a 95 mm².
Filling should be performed in one of two different ways.

4.1 FILLING WITH PIECES OF CONDUCTOR

Pieces a few mm longer than the connector crimp barrel is placed centrally inside the conductor package. The area with which the package must be made larger gives the number of conductor pieces to be used.

Example: A package has 10 pcs of 7.7 × 2.2 mm conductors totalling 169 mm². The conductor on the other side is 150 mm². Filling to at least the minimum and not above the maximum area for a 150 mm² connector is necessary. Minimum is 180 mm² and maximum is 220. Choose either the minimum or the maximum cross-section and divide it with the size of one conductor, in this example 7.7 × 2.2 mm = 16.9 mm².

Using the minimum size gives the result 10.6 which means 11 pieces after prerounding. This fits the 150 mm² connector well. The same calculation is made when using maximum size but instead of rounding up the result is rounded down, i.e. 220 /16.9 = 12.9 ⇒ 12 pieces.
If possible, place the extra conductor pieces in the centre of the stack, to avoid risk for an increase of the joint resistance.

4.2 FILLING WITH COPPER STRIP

A thin strip of copper, 0.4 mm thick, is wound around the winding package before rounding is made. The length of the strip determines the fill-up area.
The strip can then be adjusted in length to cover at least one complete lap and NOT more than two.

Example: the preferred filling is 31 mm². A 0.4 mm thick strip must be 77 mm long to have a cross section of around 31 mm².

Generally; the length L can be calculated by:
L = A / t where A = cross section area needed
t = strip thickness.

The width of the strip must be such that only one strip is used for the full crimp width and the strip does not come out over the end of the connector barrel.

Suitable widths are therefore for connectors 35 mm² 13-15 mm

50 mm²	15-17 mm
70 mm²	17-20 mm
95 mm²	20-23 mm
120 mm²	23-25 mm
150 mm²	25-30 mm
185 mm²	30-35 mm
240 mm²	30-35 mm
300 mm²	40–45 mm
400 mm²	46-50 mm
500 mm²	55-60 mm
630 mm²	65-70 mm

Thicker strips can be used but are impractical due to stiffness.
It is important that the strip is wound at least about 1 time around the conductor package and not more than two. If the calculations give a too short strip it should be made correspondingly longer.

Note: When filling with copper strip, always keep the strip clean or clean it after it has been wound around the conductor package. Dipping the strip in cleansing agent makes cleaning easy.

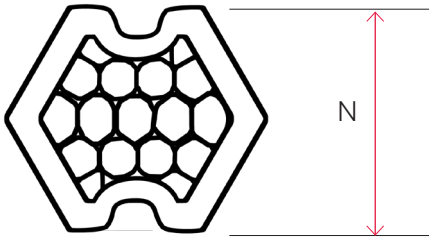
5 Tables

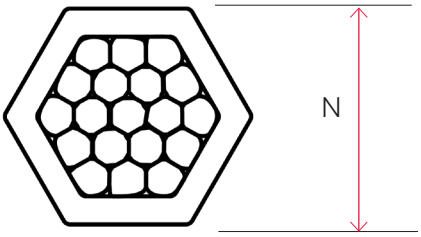
5.1 N-MEASURES

Checking instruction 0910-022000G

Back cat. nr. **Die Cat. No.**	**Flertrådig ledararea** **Stranded conductor area,** **mm²**	**Kontrollmått** **Checking measure N-max,** **mm**
TB11L/13B11L	25	8.8
TB13L/13B13L	35	10.3
TB14.5L/13B14.5L/13CB14.5L	50	10.9
TB17L/13B17L/13CB17L	70	13.5
TB20L/13B20L/13CB20L	95	16.5
KB22L/13B22L/13CB22L	120	16.3
13B25L/13CB25L/B2525L	150	20.3
13B27L/13CB27L/B2527L	185	20.6
13B30L/13CB30L/B2530L/B3530L	240	23.4
B2532L/B3532L	300	24.6
B2538L/B3538L	400	30.5
B2542L/B3542L	500	30.5
B2550L/B3550L	630	38.5
B3553L	800	38.5

N-measure definition/N-mått definition.





5.2 CROSS SECTION AREA RANGES

Nominal connector area (mm^2)	Initial winding conductor cross section area (mm^2)	
	Min	**Max**
25	30	47
35	45	70
50	69	103
70	100	120
95	113	161
120	145	185
150	180	220
185	220	265
240	302	343
300	340	400
400	412	500
500	500	580
630	630	730
800	800	960

6 ton

Connector area	Winding conductor cross section area*		Crimping tool
mm²	min mm²	max mm²	
25	30	47	TB11L
35	45	70	TB13L
50	69	103	TB14,5L
70	100	120	TB17L
95	113	161	TB20L

13 ton

Nominal connector area	Winding conductor cross section area		Pre-rounding tool	Crimping tool		No. Of crimps
mm²	min mm²	max mm²				
25	30	47	13R8DL-B/13R8ML-B	13B11L		1
35	45	70	13R9DL-B/13R9ML-B	13B13L		1
50	69	103	13R11DL-B/13R11ML-B	13B14,5L	13CB14,5L	1
70	100	120	13R13DL-B/13R13ML-B	13B17L	13CB17L	1
95	113	161	13R15DL-B/13R15ML-B	13B20L	13CB20L	1
120	145	185	13R17DL-B/13R17ML-B	13B22L	13CB22L	2
150	180	220	13R19DL-B/13R19ML-B	13B25L	13CB25L	2
185	220	265		13B27L	13CB27L	2
240	302	343		13B30L	13CB30L	2

25 ton

Nominal connector area mm²	Winding conductor cross section area		Pre-rounding tool	Crimping tool	No. Of crimps
	min mm²	max mm²			
150	180	220		B2525L	1
185	220	265	25R21DL/25R21ML	B2527L	1
240	302	343	25R24DL/25R24ML	B2530L	1
300	340	400	25R26DL/25R26ML	B2532L	1
400	412	500	25R30DL/25R30ML	B2538L	2
500	500	580	25R33DL/25R33ML	B2542L	2
630	630	730	25R39DL/25R39ML	B2550L	3

35 ton

Nominal connector area mm²	Winding conductor cross section area		Pre-rounding tool	Crimping tool	No. Of crimps
	min mm²	max mm²			
240	302	343		B3530L	1
300	340	400	35R26DL/35R26ML	B3532L	1
400	412	500	35R30DL/35R30ML	B3538L	1
500	500	580	35R33DL/35R33ML	B3542L	1
630	630	730	35R39DL/35R39ML	B3550L	2
800	800	960	35R42DL/35R42ML	B3553L	2



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