

WIRE HARNESS PROCESS MANUAL



WITTUR

Manual

Corporate standard:

WHQ_SQD_MAN004

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PURPOSE

The following procedure has the purpose to define requirements for cable assembly process in accordance to IPC standards, Wittur norms and best practices from different wire harness manufacturers.

SCOPE

All supplier which supply to Wittur globally wire harnesses and cable assemblies must comply to this standard if no additional requirements raised to supplier at project phase and agreed. Suppliers which not fulfill key requirements from this standard can't be nominated as Wittur supplier. Existing suppliers must follow this standard in order to follow continuous quality improvement.

REFERENCE

IPC / WHMA-A-620 Requirements and Acceptance for Cable and Wire Harness Assemblies
ISO 9001 Quality Management Systems - Requirements - Availability, knowledge and concrete implementation into manufacturing process
ISO 2859-1 OR ANSI/ASQ Z1.4 sampling procedure implemented for incoming material inspection
J-STD-002 Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires
IPC-1066 Marking, Symbols and Labels for Identification of Lead-Free and Other Reportable Materials in Lead-Free Assemblies, Components and Devices
IPC-TM-650 Test Methods Manual
IPC/EIA J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies
ASTM B913 Standard Test Method for Evaluation of Crimped Electrical Connections to 16-Gauge and Smaller Diameter Stranded and Solid Conductors
EIA-364-08B TP-08B, Crimp Tensile Strength Test Procedure for Electrical Connectors (**ANSI/EIA-364-08B-98**)
MIL-STD-1344 Electrical Connectors testing
ASTM F458 - 13 Standard Practice for Nondestructive Pull Testing of Wire Bonds
UL 486A-486B Wire Connectors
SAE/AS 7928 Terminal, Lug, Splice, and Crimp Copper Strength Specifications
IEC 60352-2:2006 Solderless connections - Part 2: Crimped connections - General requirements, test methods and practical guidance
WHQ_IMS_PR013 – Traceability suppliers

RESPONSIBILITY

PROCESS OWNER

Corporate

Local

Supplier Quality Development

SQD are responsible to apply the procedure for all eligible suppliers and monitoring the deployment of the defined procedures at local level.

Local Quality is responsible to monitoring and reporting the performance and alert the Corporate department in case of serious accidents (Safety and/or Functional), repetitive quality issue, cross-factory quality issue.

RELATED DOCUMENTS

Procedures

Instructions

Forms

Other

WHQ_SQD_PR005 – WPPAP

NA

FR004 [WHQ_SQD_MAN003] TOTAL LINE REJECTS FOLLOW UP

FR005 [WHQ_SQD_MAN003] New A3 supplier analysis

FR005 [WHQ_SQD_PR002] TFP Dashboard for electronic components

FR001 [WHQ_SQD_MAN004] Wire harness Process Audit Questionnaire

TS002 [WHQ_SQD_PR002] Electromechanical Components Quality Agreement

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0. TERMS AND DEFINITIONS

AQL acceptable quality limit

AOI – automatic optical inspection

Barrel is the part of the terminal that is crimped around the wire

BELLMOUTH (FLARE) The flare that is formed on the edge of the conductor crimp acts as a funnel for the wire strands. This funnel reduces the possibility that a sharp edge on the conductor crimp will cut or nick the wire strands. As a general guideline, the conductor bellmouth needs to be approximately 1 to 2x the thickness of the terminal material.

BEND TEST As a general rule, the insulation crimp should withstand the wire being bent 60 to 90 degrees in any direction, several times.

CONDUCTOR BRUSH The conductor brush is made up of the wire strands that extend past the conductor crimp on the contact side of the terminal. This helps ensure that mechanical compression occurs over the full length of the conductor crimp. The conductor brush should not extend into the contact area.

CONDUCTOR CRIMP This is the metallurgical compression of a terminal around the wire's conductor. This connection creates a common electrical path with low resistance and high current carrying capabilities.

CONDUCTOR CRIMP HEIGHT The conductor crimp height is measured from the top surface of the formed crimp to the bottom most radial surface. Measuring crimp height is a quick, non-destructive way to help ensure the correct metallurgical compression of a terminal around the wire's conductor and is an excellent attribute for process control.

CUT-OFF TAB LENGTH This is the material that protrudes outside the insulation crimp after the terminal is separated from the carrier strip. As a general rule, the cut-off tab is approximately 1.0 to 1.5x terminal material thickness. A cut-off tab that is too long may expose a terminal outside the housing or it may fail electrical spacing requirements. In most situations, a tool is setup to provide a cut-off tab that is flush to one material thickness.

ECR Engineering change request

ECN Engineering change notification

EOL end of line

ESD electrostatic discharge

EOS Electrical overstress

EPA Electrostatic protective area

ERP Enterprise resource planning

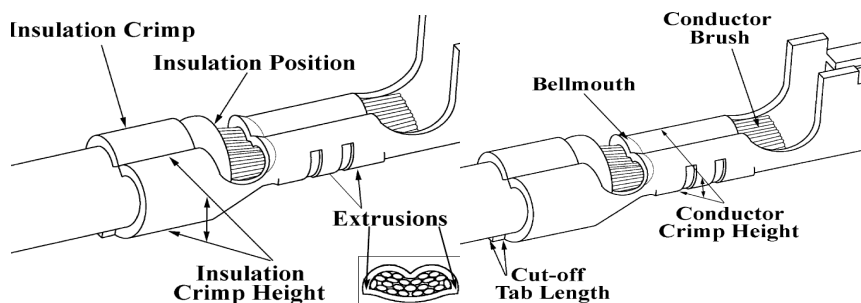
EXTRUSIONS (FLASH) These are the small flares that form on the bottom of the conductor crimp resulting from the clearance between the punch and anvil tooling. If the anvil is worn or the terminal is over-crimped, excessive extrusion results. An uneven extrusion may also result if the punch and anvil alignment is not correct, if the feed adjustment is off, or if there is insufficient/excessive terminal drag.

INSULATION CRIMP (STRAIN RELIEF) This is the part of the terminal that provides both wire support for insertion into the housing and allows the terminal to withstand shock and vibration.

INSULATION CRIMP HEIGHT To evaluate the insulation section cut the wire flush with the back of the terminal. Once the optimum setting for the application is determined it is important to document the insulation crimp height. Then, as part of the setup procedure the operator can check the crimp height.

INSULATION POSITION This is the location of the insulation in relation to the transition area between the conductor and insulation crimps. The insulation position ensures that the insulation is crimped along the full length of the insulation crimp, and that no insulation gets crimped under the conductor crimp.

FAI – First article inspection



FiFo First in First out

FPY First pass yield

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Ferrule A short tube used to mate solderless connectors to shielded or coaxial cable. It is used as an insulation grip sleeve on solderless terminals.

Gauge A method of measurement, often using “go” and “nogo” pins or shapes to determine if an attribute is within tolerance.

Harness A group of wires or cables joined to form a circuit network for electronic or electrical equipment. A harness is usually an assembly of cables cut to the proper length, terminated, and tied together prior to being assembled in a piece of equipment.

IPC Association Connecting Electronics Industries

IQC incoming inspection control

KPC Key product Characteristic

KPI Key process indicators

PCN Product/Process Change Notification.

NPI New product introduction

PPM Parts per million

Poka- Yoke – error prevention tool

Shelf life time period during which component can be stored at WH without losing its properties;

SOP Start Of Production

SOR Statement Of Requirements

STRIP LENGTH The strip length is determined by measuring the exposed conductor strands after the insulation is removed. The strip length determines the conductor brush length when the insulation position is centered.

PULL FORCE TESTING Pull Force Testing is a quick, destructive way to evaluate the mechanical properties of a crimp termination. When making a crimp, enough pressure must be applied to breakdown the oxides that may build up on the stripped conductor and the tin plating on the inside of the terminal grip.

SHUT HEIGHT The distance, at bottom dead centre on a press, from the tooling mounting base plate to the tooling connection point on the ram of the press.

Splice A device used to join two or more conductors together.

TERMINAL POSITION The terminal position is set by the alignment of the terminal to the forming punch and anvils, and the carrier strip cut-off tooling. The tool set-up determines conductor bellmouth, cut-off tab length, and terminal extrusions.

WIP Work In Process

Wire - is a single, usually cylindrical, flexible strand or rod of metal. Wires are used to bear mechanical loads or electricity and telecommunications signals.

WH - Warehouse

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1. MATERIAL HANDLING AND STORAGE REQUIREMENTS

1.1. Environment and storage conditions

Receiving of materials must happen in closed WH area, storage on open air not allowed. Best practice is to have automatic environment check with screens available, if not available supplier must perform SPC control measurements. Supplier must keep storage conditions under control. Temperature on storage area must be relatively room temperature between 18°C-25°C in order to keep long term shelf life condition for components and avoid big temperature gap between WH and production humidity must be under control in order to avoid corrosion of metal components and should be < 40%. Cleanliness of WH must be respected; 5S and Lean rules must be applied. Storage shelves must prevent against damage of components and assure human safety. Transportation of components is allowed only with use of WH equipment or WH cars, no hand carry transportation. Storage of components on the floor is not allowed.



1.2. Incoming and receiving requirements

Receiving of components must start from recording component data into **ERP system** and label printing for each box, package, and reel of component received. During receiving WH employees must check if parts arrived according to required purchase order, part number and drawing number revision is according to purchase order, quantity is ok and no damages on the packaging and it comes from approved supplier. During receiving of material supplier must define status of each component package as following:

- Approved to stock components – parts which are not critical and not require incoming to be done for each delivery, only some deliveries of component checked. Supplier must define frequency of delivery check per each component type. In case of critical customer or internal issue frequency of incoming inspection must be defined
- Parts for incoming inspection – critical or complex parts which require incoming inspection of every delivery or/and parts from first group.
- Non-conform parts or awaiting decision. Those are parts which didn't meet receiving criteria, have identification errors or damaged packaging. Those parts must be separated physically in blocked gate with the lock and on ERP system special block shelf location for those parts.
- Formal areas, marking and ERP specific locations to be defined based on receiving status. Any risk of mixing those statuses must be excluded.

IQC area must be separated formal area. Workplaces and surfaces must be clean, light must be sufficient to perform inspection. Incoming equipment and gauges must be annually **calibrated** and calibration sticker must be placed in the equipment. There must be calibration planning procedure and evidences of last calibration result must be available.

Supplier must have **IQC procedure** which describes generic requirements for incoming inspection per type of component and sampling size AQL must be defined as per ISO_2859_1 ICQ inspectors must be trained to define inspection sampling size. Acceptable level is 0pcs, if defective part will be detected – supplier must block the batch and perform 100% sorting or request sorting by their supplier.

Supplier must have **inspection plan/check list** per each part number. Inspection plan must include specific requirements as: drawing number and revision, critical dimensions and tolerances which must be measured and recorded, tools and equipment to be used, acceptance criteria, sampling size (per cavity for plastic parts), any additional requirements based on specific part. IQC for cable must include cable electrical identification like: processing voltage, amperage, copper alloy etc. Terminals must be controlled for metal alloy, thickness and plating in order to assure good conductivity. All the IQC measurement results must be recorded and stored for 12 years. In case of fail IQC result – parts must be blocked in ERP system and relocated into non-conform area. In case of pass result – parts must be booked into WH storage location and relocate physically.

Requested incoming controls:

1.3. Traceability and FiFo

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Supplier must assure **full component traceability** of: specific part number, drawing number, supplier name, date code, quantity (countable pcs or value), and received date. Manual handwriting labels or manual corrections on label content not allowed, only automatic printing by software when modification is done physically and on software. Pre-printed label not allowed due to risk of mixing. Double printing of label must be restricted; each label can be printed only once. Every quantity change must be reflected on software. For plastic and metal casting parts – required to deliver parts separately per each cavity, for better reactivity in case of incident detected. Cavity number must be written on the label.



Physical location slot and shelf must align with data in ERP system, quantity and part number must be aligned. For small parts which are not countable (for. ex. contacts) supplier must define quantity by weight measurement during every quantity modification session, modification must be done on ERP system and label must be reprinted with actual quantity. **FIFO** rules must be applied. Best practice is to use “paternoster system” for storage, but standard shelf storage is also acceptable if rules of traceability applied.

Cables usually arrive on big reels. Requirements for label traceability are the same as for the rest of components. No damaged cables allowed, therefore packaging must prevent any cable damage. Quantity of cable must be defined per meters; any decreasing of quantity must be reflected in ERP and on reel label.

Shelf life requirements. In order to assure good solderability and avoid corrosion supplier must have in place shelf life control of metal parts depending on finishing and base material of metal parts, but normally must not exceed 12 month of WH storage. If 12 month storage exceed supplier must perform solderability testing for solderable connections and resistivity check for solderless connections and also cross section with high magnification in order to inspect any peel off risk.

1.4. Non-conformity management

Supplier must have dedicated blocking area virtually in the ERP system and also physically at WH area. Blocking area must be separated cage, marked by red and locked with the key. Only authorized employees must have access to the blocking area. Handling of the blocked parts must avoid any damage. Traceability must be respected and different part number/batches must not be mixed together.



1.5. Handling of hazardous materials

Wittur product requires lead free process therefore only lead free solder alloy is allowed for soldering connections. The supplier will comply with Lead-Free / Hazardous substance regulations in force along with Wittur. Supplier will apply the country legislation and regulation for the final customer market, for example for the European market apply ROHS

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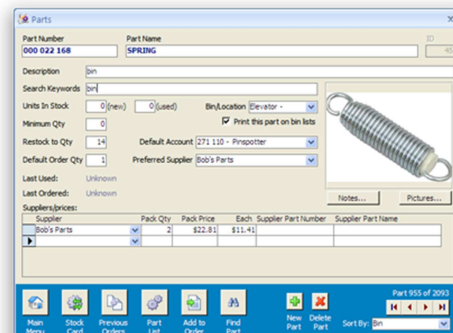
During process numerous process chemicals are used: cleaning liquids, fluxes, glue, coating, maintenance solutions, lubrications and oils etc. Process chemicals must be stored and handled according to manufacturer's datasheet recommendations. Expiration date of process materials and chemicals defined by the manufacturers is obeyed and expired chemicals are scrapped. All chemicals in production have identification and traceability label. Hazardous substances are stored in a dedicated space according to manufacturers' recommendations. Safety rules have to be described and users have to be trained, necessary protective tools to be provided for production. Material safety datasheet has to be present on the line for operators use.

2. MAINTENANCE REQUIREMENTS

2.1. Maintenance standard and software

Supplier must develop **preventive maintenance** standard with definition of first, second and third level maintenance. First level maintenance - are the tasks which must be performed by operator, second level maintenance – tasks to be performed by maintenance department and third level maintenance – the tasks to be done by machine supplier or external company on annual base. Each equipment (type of equipment) must have specific maintenance check list with defined first, second level maintenance requirements. Evidences of maintenance must be recorded. Supplier must develop maintenance planning based on type of equipment. For third level maintenance supplier must have certificates as evidence. Best practice is to develop maintenance software which should control: maintenance frequency and planning for each equipment specifically based of production cycles counted or based on timing (daily, weekly, monthly etc), also include maintenance requirements and can control lifetime of spare parts.

Spare parts management. As part of maintenance program supplier must develop traceability system for spare parts and also control minimum level of spare parts. Complex parts like crimping tool, specific gauges must have traceability per single piece. Spare parts management can be controlled by maintenance software or by WH ERP system. Best practice is to have automatic notification to purchasing department if minimum level of spare parts reached.



MAINTENANCE SOFTWARE

2.2. Cable cut machine maintenance.

Cable cut process is the key process for preparation of cable for serial production. Maintenance is the key for cutting machine; therefore supplier must define 3 levels of maintenance:

First level maintenance done by operator:

- During changing the shift or change over all cables must be removed from equipment in order to prevent mixing of different cables;
- Operator is responsible to clean the workplace at beginning and the end of the work.

SPARE PARTS MANAGEMENT

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Second level maintenance has to be done on weekly base by maintenance department and must include:

- Cleaning of the parts from the dust, particles etc;
- Checking of conditions of the blade and replacement if lifetime is expired or sharpness Nok;
- Checking of conditions of movable parts (feeding wheels, blade mechanism) and replacement of spare parts;
- Greasing of metal parts.

Third level maintenance requires annual calibration requalification for cutting machine electronics.

2.3. Stripping machine maintenance

First level maintenance done by operator:

- During changing the shift or change over all cables/terminals must be removed from equipment in order to prevent mixing;
- Operator is responsible to clean the workplace at beginning and the end of the work.

Second level maintenance has to be done on weekly base by maintenance department and must include:

- Checking of stripping tool blade and spare parts replacement. Lifetime control of stripping blade;
- Cleaning of stripping machine from particles;
- Checking of conditions of self-detection sensor which detects stripping length;
- Oiling of mechanical parts;

Third level maintenance – annual recalibration of self-detection sensor which detects stripping length.



STRIPPING BLADES

SENSOR DETECTION SCREEN

2.4. Crimping machine and tool maintenance

First level maintenance done by operator:

- During changing the shift or change over all cables/terminals must be removed from equipment in order to prevent mixing;
- Basic lubrication (without opening or disassembling of crimping tool);
- Operator is responsible to clean the workplace at beginning and the end of the work.

Second level maintenance has to be done on weekly base by maintenance department and must include:

- Checking of crimping tool and spare parts replacement. Each crimp tool must have unique code with lifecycle definition requirements and control;
- Cleanliness of the Leadmaker, terminator, and work benches;
- Clean applicator – cut-off tabs and plating flakes;
- Clean the base plate and bottom of applicator when install.

Crimp force monitoring tool must be annually recalibrated as part of **third level maintenance**.

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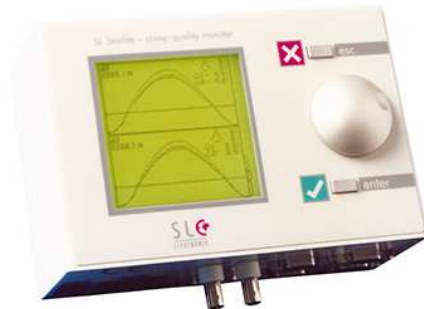
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CRIMP FORCE MONITOR



CRIMP TOOL WITH CYCLE COUNTER

2.5. Connector assembly maintenance

Assembly of Crimp-Type Connector maintenance requirements

Maintenance requirements for crimped connector maintenance are the same as terminal crimping process maintenance requirements described in Chapter 7.4..

Soldering maintenance requirements

Solder type connector first level maintenance:

- Cleanliness of workplace;
- Cleaning of solder iron from flux;
- Replacement of cleaning tools (brushes, sponges);

Second level maintenance:

- Measurement of temperature applied by solder iron or usage of soldering tip which works in specific temperature (e.g. 325°C-359°C);
- Replacement of solder iron cleaning tools;
- Replacement (if necessary) of solder iron tips;
- Exhausting system maintenance.

Third level maintenance: Calibration of solder iron;



SOLDER IRON



CLEANING TOOLS

Automatic connector assembly process maintenance requirements

First level maintenance:

- Removing of the remaining parts from machine during change over in order to prevent mixing;
- Cleaning of boxes, tubes for component transportation.

Second level maintenance:

- Checking, cleaning and greasing of mechanical parts, add oil;
- Power, test equipment, the power supply voltage is in line with the provisions;
- Spare parts management as described on Chapter 7.1.;
- Lifetime control for connector feeders and cutters;
- Verification of sensors and cameras;
- Modification of working program must be secured with access code;
- Pneumatic pressure check;

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Third level maintenance: Calibration and R&R annual study for sensors and cameras.



AUTOMATIC ASSEMBLY



FEEDING CONVEYOR

Manual assembly maintenance requirements:

First level maintenance:

- Operators are responsible to leave workplace clean during change over, all the particles to be cleaned out from workplace surface and mechanical presses;
- All storage boxes must be clean;
- S to be respected;
- All remaining comments to be removed from the line during change-over;
- Replacement of support tools (tweezers, brushes etc).

Second level maintenance:

- Checking of Poka-Yoke, gauges and tools;
- Checking of lighting for workplaces;
- Preventive maintenance for mechanical presses: greasing and spare parts management.
- Fixing of table surface chairs etc.

Third level maintenance annual calibration is request from measurement equipment and go/no-go gauges.

2.6. Splicing maintenance requirements

Ultrasonic welding splicing maintenance requirements:

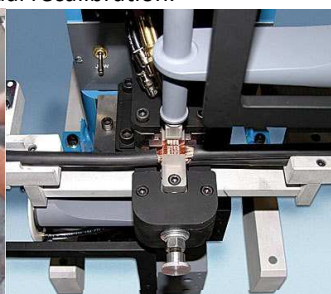
First level maintenance:

- Removing all wires and particles from splicing machine during change over;
- Lubrication during process;
- Cleaning of workplace.

Second level maintenance:

- Verify the ultrasonic welding equipment is tagged according to the Facilities Equipment;
- Verify a list of spare parts exists for the equipment, replace all necessary spare parts based on description;
- Verify location of equipment meets manufacturers guidelines; see section, verify environmental conditions meet manufacturer's specification;
- Electrical Power verify that the rated capacity of each electrical connection is suitable for the connected component as specified in the operator manual;
- Pneumatic -determine pneumatic requirements. Verify the proper in-line pressure requirements are met per manufacturer's specifications;
- Lubrication of mechanical parts.

Third level maintenance require annual recalibration.



MAINTENANCE OF WELDING SPLICING

Soldering splicing maintenance requirements are the same as connector soldering requirements described on Chapter 7.5.2.

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Heat shrink tube maintenance requirements

First level maintenance:

- Cleaning of workplace is responsibility of operator;
- In process lubrication of mechanical parts responsibility of operator;
- Removing all wires from equipment during change over to avoid mixing and contamination.

Second level maintenance:

- Measure temperature profile of heat oven and temperature of heat gun at least weekly;
- Cleaning of heat oven from evaporations and particles;
- Checking of heat gun applicator and if necessary replacement;
- Spare parts replacement if needed.

Third level: annual recalibration.

2.7. Inspection equipment maintenance

First level maintenance:

- Inspection workplace cleanliness is responsibility of operator;
- Operator must report in case of malfunction of inspection equipment or inspection light.

Second level maintenance:

- Inspection equipment must be checked by maintenance department at least once per month in order to fix or replace worn components;

Third level maintenance:

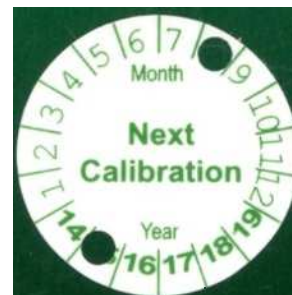
- All inspection equipment and gauges must have traceability with unique number or barcode;
- Supplier must have calibration standard and system to record calibration results. Calibration team must be defined;
- In case of external source calibration – certificate must be available from last calibration with including details;
- Calibration planning must be defined and respected. Best practice – SW control of calibration;
- All inspection equipment must have calibration sticker with info about last/next calibration.



TOOLS AND GAUGES



PRINTED CALIBRATION LABEL



CALIBRATION STICKER

2.8. Electrical tester maintenance

Supplier must have preventive maintenance program for electrical tester.

First level maintenance to be done by operator or technician at the line before and after the production:

- People authorized and trained to perform level 1 maintenance;
- After production operator/technician must make sure that all parts removed from tester, there's no contamination on board;
- Before start of production technician on the line know how to set up adapters and choose correct test program.

Second level maintenance:

- Procedure for second level maintenance by maintenance department exist and respected;
- Traceability and identification and maintenance of each jig, tool, gauge;
- Maintenance planning and records exist, respected;
- Checking of test pins and adapters if still dimensions and conditions are ok;
- Checking of cables and connectors if no damages or loose of insulation and lifecycle of connectors must be defined and min. spare parts on stock defined;
- Check the power supply of electrical tester;
- Check if tester is electrically grounded;
- Any jig / tool returning from Maintenance must be re-validated, using masters;

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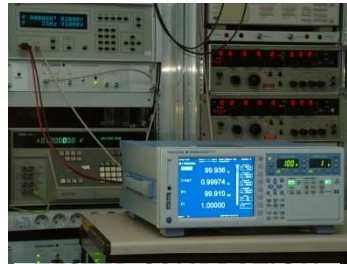
- Any lubrication or replacement of mechanical parts to be done if necessary.

Third level maintenance:

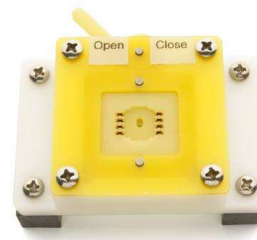
- To be done internally or externally annually recalibration;
- To be done internally or externally checked condition of electronics inside tester. If necessary malfunctions must be fixed;
- After recalibration Gauge R&R to be done is the minimum requirement. Supplier can use any equal method (MSA, variable SPC, etc.) in order to assure repeatability of process.



TEST PINS



TESTER CALIBRATION



TEST ADAPTER

3. PROCESS REQUIREMENTS

3.1. Production preparation.

Engineering production preparation

The harness engineer is assigned to produce a 100% accurate, error free data set—per variant/derivative—that can be fully costed and passed on to production for assembly. He/she must generate the full BOM and validate it against the design intent. Engineering phase of the process brings theory and planning face to face with reality, manage discretionary steps including:

- Component selection: Wires, terminals, seals, plugs, tapes, tubes must accommodate customer specifications
- Splice position optimization and balancing: Here the harness builder must meet manufacturing and quality rules, including customized rules such as the choice of waterproofing materials (i.e., heat-shrink sleeves).
- Wire-color optimization: The harness provider must allocate wire-color definitions for manufacturing and service while taking the wire inventory into account:
- Component sourcing verification
- Assembly time calculation/prediction
- BOM calculation
- Prepare the drawings that will be used in manufacturing.

Process preparation

After all engineering planning supplier must develop **process preparation** system in accordance to Lean manufacturing requirements (Kanban, JIT, FiFo). Full **component** traceability must be assured (batch, date code, delivery date) and traceability data must be recorded per finish good batch number and provided to Wittur upon request. Different component batches must not be mixed together. Storage of components on line and in process also must be assured with full traceability. Handling of components at the line and during process must eliminate risk of damage and prevent component mixing.

Start of production

Each **start of production** must be linked to specific production batch (finish good batch). For preparation of the line supplier must develop startup check list where all process workstations parameters, necessary gauges, equipment and parameters, prove of maintenance and operator training requirements are listed. Quality leader together with line leader must validate this check list and verify that process is ready for production.

All suppliers process **FAI** (First article inspection/first sample check) measurement results must be recorded and archived for 12 years and evidence to be provided to Wittur up to request. In addition to start up check list supplier must have **FAI** which include measurements and inspection as per drawings:

- Dimensional check of assembly;
- Electrical verification;
- Optical verification;

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Status:

- X-ray verification;
- Any additional measurements required by customer.

Product in process traceability.

Supplier must assure full component traceability through process. Every packaging of component, even in process boxes must have component traceability. 1 piece flow must be respected. Every cable must have at least batch marking (for finish good) with traceable production data: date/shift/line/operator etc. **Marking method** can be done by 3 methods: laser engraving, paint marking or labelling. Supplier barcode must be readable at Wittur and at final customer. For every process step supplier must have process input area, process output and "red" box for defects and scrap.

Best practice to have single barcode marking per each cable and production software scanning through every process step which would also include scanning of materials for this process step. goods batch. Minimum requirement is to have production SW which would include results at least of SPC and 100% in process controls, inspection data to be stored minimum 2 years and must be provided to Wittur per request.



PAINT MARKING MACHINE



2D BARCODE LABEL



LAZER 2D BARCODE

3.2. Cable/wire cut process

Cable/wire cutting process. There're different types of cables wires structure depending on functionality requirements based on Wire Gauge, Ampacity and Wattage Load: Non-Metallic Sheathed Cable, Metallic Sheathed Cable, Multi-Conductor Cable, Coaxial Cable, Unshielded Twisted Pair Cable, Shielded Twisted Pair Cable, Ribbon Cable, Twin-Lead Cable, Twinaxial Cable, and Paired Cable.

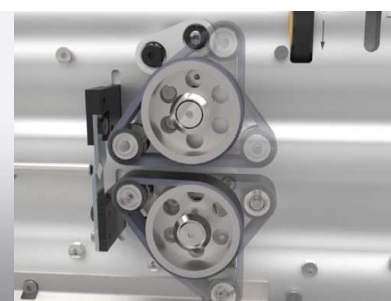
Not depending on type of the cable or single wire, all are delivered in the reels and must be cutted and stripped prior to further crimping and assembly. The typical equipment that is required during this phase is an automatic cutting machine. This machine is a high tech piece of equipment drive by the use of a computer. The operator will introduce the circuit parameters in its memory and set up the tooling and material required. The wire is pull from the wire-packaging barrel by the feeding system in an automatic wire processing machine and cut the raw wire to the required length. A short length of insulation is removing from both ends of the circuit. A mechanical arm will hold the end of the circuit and lead it to the die applicator station, passing through a sensor, which will verify that the circuit end has been strip correctly. Finally, the circuit is delivering to a container, which is release in batches. The cycle of this complete circuit processing takes only a few seconds and will be repeating as the quantity desire. The wire/cable cut process contains on 2 main steps: wire/cable feeding; wire/cable cutting.



CABLE FEEDING



CABLE CUTTING



Wire/cable feeding process can be as part of cutting stripping machine equipment of separate gauge used for different semi-automatic machines. Supplier must make sure that feeding of cable don't cause any risk of cable condition and don't damage the cable.

Key parameters to focus:

- Traceability and conditions of cable (damages, straightness etc.);

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Status:

- Feeding parameters: feeding pull force, feeding speed;
- Positioning of the cable reel;
- Maintenance of feeder and transport tube (conveyor): cleanliness, greasing.

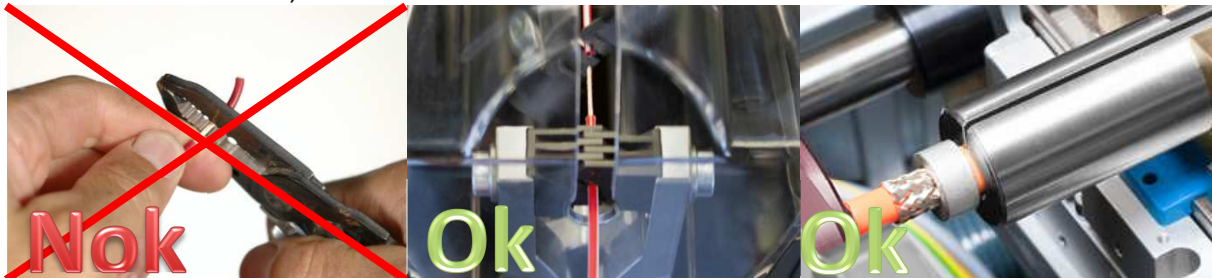
Cable cutting process. Key parameters:

- Maintenance and calibration of cutting mechanism;
- Maintenance and lifetime control of blade, correct blade type per cable type/diameter;
- Program: cutting speed, positioning, length of the cable, diameter etc;
- Machine self-detection and defect separation (risk to mix);
- Load out from machine (risk to damage).

3.3. Crimping process

Stripping process. Prior to perform crimping process supplier must do **stripping process** - to expose the metal (or core) of the wires. Usually stripping process is part of crimping process as most of crimping equipment nowadays do both actions at once (stripping and crimping). Nevertheless supplier could have also separate piece of equipment which performs wire/cable stripping. Manual stripping (with knife or cutter) is not allowed, due to risk of damaged strains and also due to lack of possibility to control dimensions. For complex cables also could be developed braid cut/turn process and shield removal process, which also should not be done manually. There are several variations of cutting methods for stripping tools:

- Pneumatic wire strippers function by the means of pressurized air, often with the use of a foot or hand switch, or sensor to control the speed of wire stripping.
- Fiberglass & Wire Wheel Strippers Fiberglass wheels will strip many film type insulations. The conical wheels rotate at high speed to generate frictional heat which softens the insulation on the wire. The "nap" of the brush wipes this insulation away
- Blade Strippers Eraser blade strippers are great for round magnet and enamel wires with any type of film insulation, from solid and stranded wires and round cable and coax.
- Key process requirements for blade stripping process:
- Condition of wire/cable – correct type(traceability), no damages, no twisting etc;
- Handling of wire/cable during stripping process;
- Maintenance of stripping tool: conditions of blades, calibration;
- Correct SW program according datasheet dimensions, precision (stripping length);
- Machine error self-detection, risk to mix.



As part of FAI supplier must also include stripping dimensions check during start up. Also visual check for no damages, no missing/damaged strains, good insulation cut quality. All result must be recorded and archived and provide up to request.

Before crimping process the following **wire requirements** to be fulfilled:

- Verify you have the proper strip length
- No cut or strands
- Clean insulation cut and good removal
- Careful handling of stripped wires
- Partial strip protects the wire strands during handling and transporting
- Stripper-Crimpers eliminate this handling problem
- Use barrel wire for lead makers.

Reel loading requirements:

- Storage: coil-wound terminals horizontally and traverse-wound terminals vertically
- Assure traceability (label, date code etc)
- Careful lifting of flanges
- Pull on the interleaving paper

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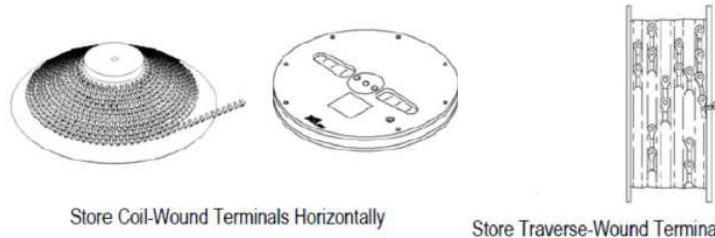
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Status:

- Rotate the reel, don't pull on the
- Terminal strip
- Secure the end of the strip when you're done



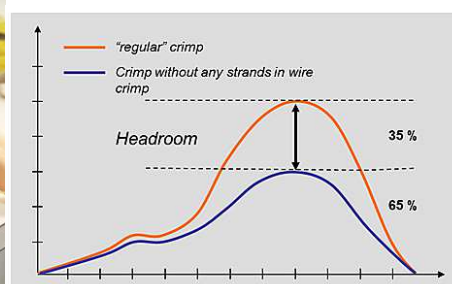
Crimping process is the metallurgical compression of a terminal around the wire's conductor. This connection creates a common electrical path with low resistance and high current carrying capabilities. Crimp process is the interaction of a terminal, wire, tooling, personnel, methods and procedures, and environmental attributes. The main steps of wire crimp process are: crimp toll set up, FAI and release of batch.

Crimp toll set up key requirements:

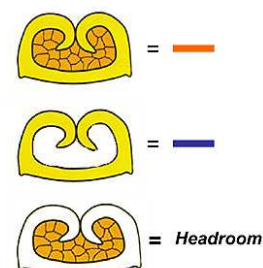
- Check condition of toll and correct toll type by terminal type and wire diameter;
- Check that correct type of terminals is loaded into the tool. Steel, gold, silver, and nickel plated terminals recommended;
- Terminal lubrication the specs tell you when to use lubrication;
- Terminal feed position;
- Proper adjustments of wire straighteners;
- Feed wheel pressure;
- Wire grip pressure;
- Good cut and strip blades, correct setting of blades;
- Proper positioning of wire at the crimp;
- Check that the tool is aligned;
- Check that the terminal position;
- Crimp learning sample terminals (from 3 to 5 samples) in order to identify optimum crimping force. Best practice is to have automatic wire cut in case of wrong crimping force identified.



CRIMPING PROCESS



CRIMP FORCE MONITOR



Quality After set up technician evaluation first samples must be evaluated by quality department as part of **FAI** validation. Supplier must develop acceptance criteria of crimp shape and failure catalog for operator. Equipment used for measurement must be annually recalibrated. Measurements to be done:

- Measure conductor crimp height and compare to specification;
- Perform a pull force test;
- Perform crimp micrograph cross section analysis;

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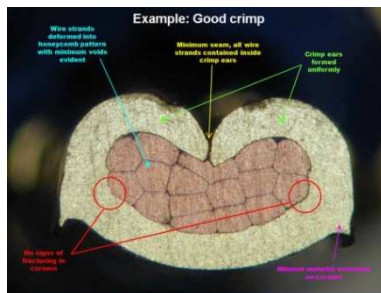
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Status:



CRIMP PULL OUT FORCE



CRIMP CROSS SECTION



CRIMP HEIGHT

Visual 100% inspection with magnification or optical inspection of crimp connection before assembling into housing must include checking for defects:

- Plating removal or flaking.
- Exposed base metal.
- Cracks in the plating or base metal.
- Tarnishing or discoloration of the plating.
- Evaluate cut-off tab length and conductor bellmouth;
- Evaluate conductor brush;
- Evaluate insulation position.

3.4. Connector Assembly process.

An **electrical connector** is an electro-mechanical device used to join electrical terminations and create an electrical circuit. Electrical connectors consist of plugs (male-ended) and jacks (female-ended). The connection serve as a permanent electrical joint between two wires or devices. There are hundreds of types of electrical connectors. In order to assure connectivity of wire harness into further applications supplier must make connector assembly process. There're 3 types of connector assembly process: crimp type connectors, assembly of solder type connectors and Assembly of plastic connector.

Assembly of Crimp-Type Connectors Crimp contacts are assembled to conductors outside of the connector and are subsequently installed into the connector body. This fabrication method has always been the workhorse of the industry, and is probably the most frequently used method of terminating connectors on coax cable. When a connector is properly assembled, contacts are captured inside the connector. Usually crimp type connectors are assembled by automatic equipment using crimping tool designed for contact assembly. Supplier must focus on key process parameters:

- Traceability of contact (reel or single);
- Blade for contact cut maintenance, lubrication and lifetime;
- Contact feeding tool maintenance;
- Crimp tool maintenance;
- Crimp force control;
- Diameter of cable.
- Supplier must install quality check as following:
- Visual criteria – no damages, no wire strength, crimp shape ok;
- Crimp dimensions;
- Pull out force.;
- Retaining clips present, contacts shall be fully seated and locked into place by the clip. Improperly seated contacts can "push back" causing intermittent and open circuits.



CRIMP CONNECTOR



CONNECTOR CRIMPING

Assembly of Solder-Type Connectors

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This fabrication method is often considered the most labour-intensive because the connector's contact is soldered to the cable's inner conductor. Performed properly, it also one of the most reliable connections and can be used on cable with solid or stranded cent conductors. If metals and plating of contact and cable are compatible and solder-able, and, if the technician is skilled in this type of installation, solder connections can be expected to perform for long periods of use. Tooling is simple: the main wattage solder iron with an assortment of tips and installation is aided by the use of a hold the work in place while applying solder. Beyond that, the materials consumed are solder and flux.



SOLDERING



HANDLING GAUGE



SOLDERED CONNECTOR

Key requirements for soldering process:

- Cleanliness of the process is the key requirement;
- Only Led free soldering is allowed, soldering wire must be compatible with connector alloy and plating;
- Soldering temperature must be under control and meet recommended profile by solder wire manufacturer;
- For cable handling special gauge must be developed;
- Supplier must have exhausting system for soldering process.
- After soldering process step supplier must develop 100% visual/optical inspection in order to verify :
- Measures taken for stress relief of soldered connectors shall be sufficient to assure that all wire bending will take place in a flexible;
- Solder around joint is smooth and shiny;
- No evidence of solder flow outside joint;
- Solder hole is filled flush with outside pin surface.

Assembly of plastic Connectors

Electrical connectors are characterised by their pinout and physical construction, size, contact resistance, insulation between pins, ruggedness and resistance to vibration, resistance to entry of water or other contaminants, resistance to pressure, reliability, lifetime (number of connect/disconnect operations before failure), and ease of connecting and disconnecting.

Design and materials requirements:

- Design of connector must be keyed to prevent insertion in the wrong orientation;
- Locking mechanisms (secondary lock) to ensure that they are fully inserted and cannot work loose or fall out;
- Connector must be easy to identify visually, rapid to assemble, require only simple tooling, and be inexpensive. Supplier must assure full component traceability (part number, batch, drawing number, cavity etc);
- Plastic sealing plugs shall be used in case of environmental connectors;
- Connectors must be reliable for connecting/disconnecting activity required by Witur products;
- Connector design prevent crimped contacts damage;
- No molding defects on connector surface: flashes, damages, lack of mold etc;
- Design of connector must assure insulation between pins, otherwise additional insulator must be assembled prior to connector housing assembly;
- Similar connectors used for different assembly must have colon coding to prevent mixture of different part numbers.
- Connector assembly to the cable can be produced by 2 methods: automatic connector assembly process or manual assembly process.

Automatic connector assembly process

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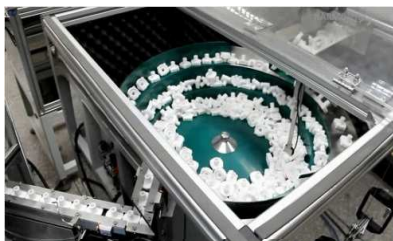
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Status:



CONNECTOR FEEDING



AUTOMATIC CONNECTOR ASSEMBLY



Automatic process done by machine so risk of human factor is minimised, nevertheless there're **key parameters and requirements** to be controlled for good process capability:

- Automatic machine must be covered and locked to avoid contamination or safety risk;
- Full component traceability is the key, should be no risk of mixing different parts together;
- Assembling machine must have preventive maintenance program;
- Cleaning of machine from remain component and particles after every changeover is mandatory;
- Automatic feeding precision is mandatory, should be no risk to damage the parts during feeding;
- Machine/process capability study must be done on annual base.
- Self-detection sensors must be available and annually recalibrated, risk of mixing good/bad parts must be excluded. Camera check detection is the best practice;
- Automatic reject conveyor with defect box must be part of process set up;
- Machine stop criteria with alarming system must be defined;
- Good part marking must be implemented.

Quality control by operator must be done at least as SPC for:

- Visual check: presence of all components, correct wire with terminal assembled into correct housing nest, damages, molding defects etc;
- Dimensional criteria variable check;
- Push/pull check;

All attributive and variable SPC cards must be recorded, archived and stored minimum for 12 years and have link to production batch identification. Name of inspector, date and time is mandatory. For variable SPC cards actions records are mandatory if limit exceed or there's visible trend. SPC data should be provided to Wittur up to request.

Manual assembly process

Manual wire crimped with terminal assembly usually is applied for low volumes production or complex wire harnesses. Manual assembly might contain from several sub-steps: preassembly of seal, insulator assembly, housing assembly, secondary lock assembly, also those actions could be done in one process step.



WIRE WITH TERMINAL AND SEAL ASSEMBLED INTO HOUSING

Key process requirements:

- No risk of terminal damage at loading / transfer / unloading. Protection of terminated lead bundles by plastic bags or cups is recommended during storage.
- Full component traceability is the key, should be no risk of mixing different parts together;
- Proper identification of connectors, wires, and other elements, during assembly process;
- Supplier must manage change of references properly to avoid any risk of mixing components;
- One-piece-flow must be strictly respected at each manual operation.
- Process input/output and defect zones must be strictly identified and respected;
- Line stop criteria is defined and strictly respected;

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- Crimped wires must always be inserted one-by-one in the connector, according to a defined sequence in order to avoid bent terminals. Supplier must develop work instruction which describes sequence and correct nest;
- Verify the strict application of Push-Pull by the operator at each terminal insertion. Push / Click / Pull to be performed wire by wire.
- For connectors including a secondary lock : lock to be closed after successful push/pull of all wires, and before final test.
- Supplier must develop assembling gauges or Poka-yokes for more easy handling and error prevention. Supplier can also use assembly presses for assembly support. Maintenance of equipment and gauge calibration is the key requirement.



TRACEABILITY AND HANDLING



ASSEMBLING PRESS



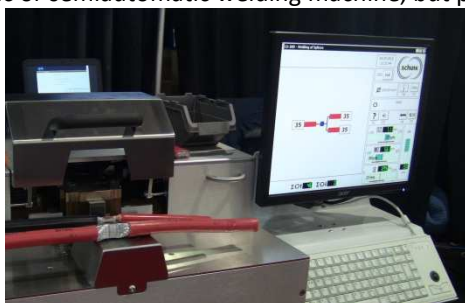
ASSEMBLING GAUGE

3.5. Splicing process requirements

Splicing involves joining two cables together. Splices create a permanent joint between two cables. The most common application for splicing is concatenating (joining) cables in long outside plant cable runs where the length of the run requires more than one cable. Splicing can be used to mix a number of different types of cables going to various locations. Splicing is only needed if the cable runs are too long for one straight pull or you need to mix a number of different types of cables. There are 3 methods of splicing, welding splicing, soldering and mechanical splicing.

Ultrasonic welding splicing

Ultrasonic welding splicing is most widely used, as it provides for the lowest loss as well as providing the strongest and most reliable joint. Welding splicing machines are available in two types that splice a single wire or a ribbon of few wires at one time. Splices are made by welding the two wires together usually by an electric arc. Ultrasonic metal welding does not use heat to generate a melt condition; heat is produced as a bi-product and localized at the weld area. As a result of a metallurgical bond between the materials which does not require heat to melt; dissimilar metals can be bonded together. The basic process of introducing materials to a sonotrode, compressed against an anvil and ultrasonic energy applied. Cables ultrasonic welding and splicing technology bonds multiple wires together and can even bond wire to any other metal surface by applying energy and high frequency vibrations through the material bonding the molecules together. Supplier can use automatic or semiautomatic welding machine, but parameters must be under control.



WELDING SPLICING MACHINE



SPLICING PROCESS



SPLICED CABLES

Verification of Set-up:

- Verify power supply and actuator have been set up and installed per the manufacturer's guidelines;
- Verify adjustment of the actuator and alignment of the horn;
- Verify a standard operating procedure (SOP) exists for monitoring and control of operation, including initial set-up, operating process and preventative maintenance
- Key parameters for cable welding process:
- Wire preparation: cutting, stripping;
- Wire handling during process;
- Welding machine maintenance (as per Chapter 7.6.);

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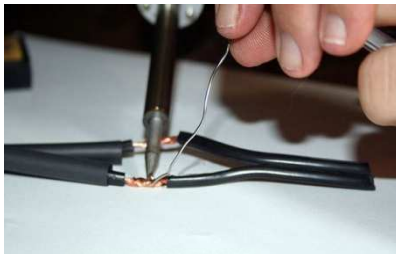
Status:

- Welding program parameters: timing, voltage, frequency, pressure;
- Splicing area and wire alignment position;
- Strength of spliced connection.

Soldering cable splicing

Soldering is one of the most common forms of splicing due to its low cost, ease of use, and the fact that it is the oldest and most traditionally used method of splicing. It is used in many wire processing projects, such as terminating tin wires. Soldering requires a technician to prepare wires and then use a heated iron to melt a conductive material that fuses the wires together that is moisture-proof and conductive. The downside to using soldering is that it is more difficult to use in high-volume production settings. Due to the staging requirements of the wire, this is often used for one-off projects or applications where repairs in the field will be expected. Process requirement for soldering splicing are the same as described on

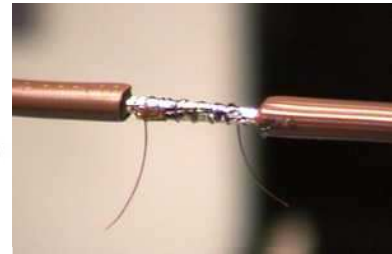
Chapter 8.4.2



SOLDERING



SOLDER IRON



SOLDER SPLICED WIRES

Heat shrink tube

After ultrasonic welding splicing or soldering cable splicing in order to protect spliced wires usually heat shrink tube is used. Heat shrink tubing provide cables with protection against abrasion, humidity, chemicals and environment, it's also great for bundling, color-coding and strain relief. First things are: heats shrink tube and a heat gun or a heat shrink oven. When heated, the heat shrink tubing conforms to the size and shape of the substrate beneath for quick and easy installation.

Heat shrink tubing can be made of any one of a range of thermoplastics, including polyolefin, polyvinyl chloride (PVC), Viton (for high-temp and corrosive environments), Neoprene, polytetrafluoroethylene (PTFE), fluorinated ethylene propylene (FEP) and Kynar. In addition to these polymers, some types of special-application heat shrink can also include an adhesive lining that helps to bond the tubing to underlying cables and connectors, forming strong seals that can often be waterproof. Another material that is sometimes added to heat shrink tubing is conductive polymer thick film, which provides an electrical connection between the two or more conductive objects that are being joined by the tubing – without the need to solder them first.

Likely to be found just about anywhere there are cables and wires, heat shrink is extremely useful, both for protection and cosmetic enhancement. It can be used to:

- Seal water and dust out of cable splices;
- Insulate cables and wires against extreme heat;
- Provide a barrier between cables and corrosive chemicals;
- Colour code cables for easy identification;
- Harness multiple wires together;
- Make long-lasting labels;
- Neatly terminate the ends of braided sleeving;
- Improve the look of cables

Requirements for heat shrink tube:

- **Shrink ratio.** A high shrink ratio will allow the sleeve to be fit over larger objects, such as connectors, and then shrunk down to the smaller diameter of a cable.
- **Sleeve diameter:** The sleeve should shrink tightly against the object, which won't happen if the object is smaller than the final shrink diameter.
- **Wall thickness:** A thicker wall provides more abrasion resistance, rigidity, and ability to withstand wear and tear.
- **Stiffness:** Different sleeves have different degrees of flexibility. A more rigid sleeve is a good choice of achieving a strain relief on a connector or terminal, where reducing flexing is one goal of the heat-shrink tubing.
- **Sealing:** Heat-shrink tubing, properly applied, will seal the interface between tubing and object. If sealing is important, choose a material that will withstand any unique contaminants

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Status:

- **Shrink temperature:** Common polyolefin materials have a recommended shrink temperature of around 90°C, although other materials offer shrink temperatures, notably Teflon, as high as 250°C.



HEAT SHRINK TUBES



HEAT SHRINK OVEN



HEAT SHRINK GUN

Key parameters for heat shrink tube process application:

- Size of heat shrink tube: diameter (before, after heat) length;
- Heating temperature and uniformity according to tube's specification;
- Handling of cable during heat shrink process;
- Cooling of shrink tube;
- Silicone lubricant spray can be applied to wires or cords to guide heat shrink over them without compromising the heat shrink material.
- Shrink uniformity: no air gaps or bubbles as well as no overheat areas;
- Strength of shrink tube connection.
- Electronic pressure regulator to accurately control splice force
- Programmable sequencing of splices for automatic switching after a pre-set number for optimum production efficiency
- Quality monitoring: weld power, weld time, wire pre-sonic height, wire final height. Quality limits stored in system memory for instant recall and automatic setup.

Crimping splicing process requirements

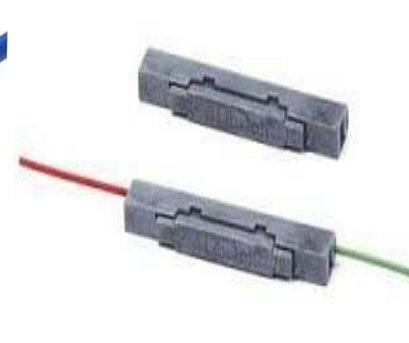
Splicing of wires also can be done by crimping process. For this purpose supplier must use automatic crimping machine with special crimping tool. All process requirements are the same as at Chapter 8.3.3 and maintenance requirements according to Chapter 7.4. Supplier must develop special gauge for wires alignment.



SPlicing CRIMPing CONTACT



SPliced CRIMPed WIRES



ALIGNMENT GAUGE

Assembly of tape / Ties / Clips / seals/braids

Due to complexity of wire harness assembly or in order to fix together the wires supplier might additionally assemble braid, sleeves tapes, seals assembly of clips, clamps and routing aids for electrical distribution attachment needs. Supplier must develop Poka-Yoke gauges in order to prevent assembling errors.

Tape assembly requirements: Position, number of turns, tightness of adhesive tape is suitable and repeatable. Visual aids to be added on assembly jigs.

Ties and Clips assembly: must be error-proofed to ensure correct placement (final position within drawing specifications, right orientation). Tie-wrap gun force to be monitored periodically to ensure repeatable tightening.

Tube and sleeve assembly must eliminate risk of damage for crimped terminals or bending terminals which already assembled into connector, the best practice is to use protective cap.

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CLIPS ASSEMBLY



TAPE ASSEMBLY



TUBE ASSEMBLY

3.6. In process inspection

During process and at the end of line supplier must develop different inspection steps 100% which could be done visually with magnification or by optical inspection or with use of special gauges. Acceptance criteria must be defined according to the standard **IPC / WHMA-A-620**, product specification, functionality or specific customer requirements.



VISUAL INSPECTION



CALIPER



CAMERA INSPECTION

Visual inspection requirements

Usually visual inspection contains from 2 process steps: 100% visual control and out of box sample inspection (OBA). For sufficient inspection the following factors to be applied:

- Work station;
- Environment;
- Work instruction;
- Operator training;
- Non-conformity management;
- Quality management.

Work station. Work station, for inline 100% check special equipped workplace must be defined, for OBA - independent of the production line and in an identified zone. Magnification is sufficient to inspect (min 5 times). Lighting intensity strong enough to enable the operator to detect the defects. Clear and separated zone identified for: 1) products awaiting inspection 2) products with completed inspection. 3) Non-conform products. All equipment for proceeding activity is available (tools, devices, gauges). Measuring equipment calibrated. Are all accessories available and used (gloves, magnifier, labels) Do all conditions prevent from risk for mixing, damaging, dropping the parts, the workplace ergonomic.

Environment. The noise smooth enough to avoid any disturbance to the inspector during the inspection activity. Temperature adequate to perform the inspection activity. 5S respected within and around the work station

Work instruction existed and up to date, aligned with CP Master samples / boundary sample clearly identified, available on work station and used by operator. Failure catalog available and updated. ERP with scanning recording system in place for registering the quantity and the detected defects during inspection activity.

Operator training. Operators are trained to perform the tasks according to **IPC / WHMA-A-620** requirements. In case of several operators, a matrix exists with the list of trainees. Operator must have a scheduled break or switch the workplace. Work instruction is known and respected.

Non-conformity management. Red box located in the area. All parts must be scanned into ERP with fail or pass result. Defects marked in real time with clear identification/description. Information of defects communicated to the production line and to plant quality in order to place actions. Line stop criteria must be defined and respected. Defective parts must be analyzed and actions recorded and placed into process.

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Camera inspection requirements

Conventionally, these types of inspections were performed with human eyes. However, camera can perform such inspections more rapidly than with human eyes and do inspection more precise. Software, which includes various inspection tools, is attached as standard accessory. Therefore, with this software, camera check various items; colours of cables inserted in connectors, forms or length of parts, each position and others. Narrow pitch connectors, which were difficult for conventional cable colour checkers to inspect, also can be inspected.

Key requirements for camera inspection process:

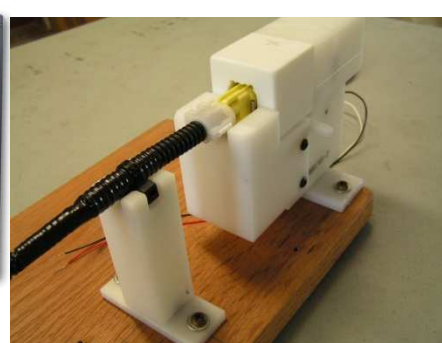
- Supplier must develop start-up check list for camera and use every change over. Camera functionality must be approved by technical and quality department (FAI);
- Camera must have preventive maintenance program as per Chapter 7.7.;
- All operators must be trained for camera inspection and IPC acceptance criteria;
- Specific program must be developed per part number, access to change the program must be protected by engineer user rights, operator shouldn't have access;
- Supplier must develop "golden" samples – defective parts with most probable defects (terminal position & damage, missing terminal etc.) and run them for verification before start of production or change over;
- Defect catalogue must be created and updated based on new defects, operators must be trained;
- Supplier must develop special gauge in order to assure optimal handling conditions for fixed position and also avoid mechanical damage;
- Supplier must define retest policy;
- FPY must be monitored and under control (not less than 90%) to avoid high rate of false failures;
- Supplier must develop process input, output and "red" box. Poka-Yoke in order to make sure that failed parts will go to "red" box and not pass through;
- Special marking to be developed only for parts with PASS result;
- Camera inspection to be equipped with scanner in case if supplier assures barcode traceability. Testing data to be stored and monitored.



CAMERA INSPECTION



CAMERA PROGRAM



HANDLING GAUGE

X-ray inspection requirements

Non-destructive testing is extremely valuable for evaluation, troubleshooting, research, and quality control in industry and X-ray imaging is an important NDT technique for products including wire harnesses. X-ray can help to: verify presence and connection of hidden components, find opens, shorts inside assembled products, verify weld integrity, perform a critical dimensional measurement, detect and additional materials inside connector etc. Minimum requirement for supplier to have offline X-ray for analysis.

WIRE HARNESS PROCESS MANUAL



Manual

Corporate standard:

WHQ_SQD_MAN004

Number:

Rev.4

Version:

Effective from:

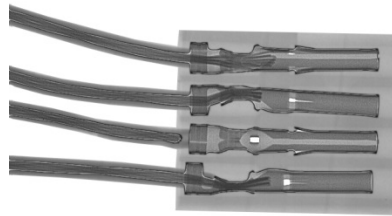
20.09.2017

Released

Status:



BIG OFFLINE X-RAY



X-RAY IMAGE



SMALL DESK X-RAY

Key requirements for X-ray inspection process:

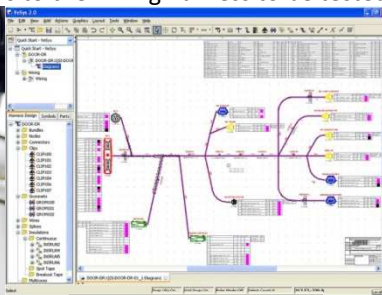
- X-ray must have preventive maintenance and calibration program as per Chapter 7.7.;
- All operators must be trained for X-ray inspection;
- Supplier must develop "golden" samples – defective parts with most probable defects (terminal position & damage, missing terminal etc) and run them for verification before start of production or change over;
- Defect catalogue must be created and updated based on new defects, operators must be trained;
- Supplier must develop special gauge in order to assure optimal handling conditions for fixed position and also avoid mechanical damage;
- Supplier must develop process input, output and "red" box. Poka-Yoke in order to make sure that failed parts will go to "red" box and not pass through.

3.7. Electrical testing process requirements

Electrical test is mandatory process step for suppliers who produce wire harness. Electrical tester must be EOL tester - the last before packaging. Testing of electrical wiring harnesses must be done by using automatic test equipment commonly called wiring analysers. Programs must be written for wiring analysers to test each separate wiring harness. Unique programs tell the equipment what tests to run, how much current, voltage, dwell time to use as well as the order in which to run the tests. A technician connects the wiring analyzers to the wiring harness to be tested using adapter cables.



ELECTRICAL TESTER



TEST PROGRAM



AUTOMATIC LABEL PRINTING

Continuity tests make sure each wire is hooked-up or connected in accordance with the design. Typical continuity tests are performed at 0.5 Amps with a constant voltage and a dwell time of 0.2 seconds minimum.

The second type of test is the **insulation resistance** test (also called a meg ohm test). This test checks for short circuits. The electrical measurements that are recommended for a completed wire harness include the following:

Typical *insulation resistance* tests are run at 1500 VDC with a constant current and dwell time of 0.15 seconds minimum. The insulation resistance test does what the name suggests; makes sure there is enough resistance between two or more conductors so that a short circuit will not result. Typically, if the resistance is greater than 100 Meg Ohms then it passes the test.

100% EOL electrical tester requirements:

Star of testing	Supplier must develop tester start-up check list. Starting of testing must begin from checking reference bad samples – "golden samples". Tester must be validated (R&R available), maintained, verified at each start-up.
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WIRE HARNESS PROCESS MANUAL



WITTUR

Manual

WHQ_SQD_MAN004

Rev.4

Effective from:

Released

Corporate standard:

Number:

Version:

20.09.2017

Status:

Test program	Specific test program must be developed; modification of program must be protected by user rights.
Ensure 100% length conformity after assembly of ties and tape	EOL test fixture must be designed as Poka-Yoke to avoid length non-conformity
Test machine must detect terminal back-out	100% of the terminals must undergo an automatic back-out test, or a control of the secondary lock position when applicable. Push-back force must be adapted to the terminal design.
Detect terminal misalignment	If out-of-tolerance, misaligned pins must be captured systematically at electrical test. Make sure each test jig counterpart is designed to detect terminals bent beyond drawing
Full closure of each secondary lock verified	For connectors including a secondary lock: full closure of the lock / flap must be controlled 100% during final test, either by a sensor or by design of the test mating half. (i.e. impossible to plug a connector on test jig if lock / flap is not fully closed)
Checks for presence / position / orientation of all assembly components (connectors, seals, locks, ties, adhesive tape...), including 100% airtightness measurement if applicable	Check that EOL test detects open / missing / reversed locks, missing ties, missing or reversed clips, incorrect connector positions, missing or additional seals, If harness includes hermetic connectors and/or grommets, air/water tightness must be tested 100% in line with maximum leak specification. Supplier test parts representative of known defect modes to verify the test functionality. Each single customer interface of the part must be tested before shipment Test jig must be designed to fit with lowest tolerance of wire length.
Electrical test to catch any continuity / insulation anomaly, as well as any assembly error and component defect	All continuity / insulation tests to be done as per specification: Insulation resistance: The harness is electrically examined to determine the potential leakage current from the harness. Insulation resistance: The harness is electrically examined to determine the potential leakage current from the harness. Dielectric resistance: This test is more of a quality verification to ensure that none of the wire components were damaged during manufacturing. It verifies insulation integrity. Contact resistance: A wire harness that poorly conducts electricity is of no use. The contact resistance examines the resistance at the harness contact points. Any component fitted on the harness (diode, relay...) must be functionally tested. For harness references with different length variants, tester must be designed to capture length errors
Part marking / labelling / physical release conditional upon the electrical test result	Individual marking / labelling of parts must be conditional upon the successful End-Of-Line test result. (Label of master sample test to be put on prod record sheet. Best practice – single piece marking and scanning into production system).
Re-test policy	Each part failing at the first test and re-tested OK is a potential intermittent defect. Supplier should not release any reject without a technical analysis of the part. Re-test policy must be available and understood by operators.
If agreed by Wittur, rework to be performed in a mistake-proof manner	Rework is not authorized, except when agreed by Wittur and by the component supplier if justified (connectors). Agreement is required before proceeding, to be formalized on a deviation request to Wittur Specific WIs available, and operators trained accordingly Parts to be 100% re-tested and identified specifically after rework Unless agreed by Wittur, components cannot be re-used. Supplier to provide a plan, so as to eradicate the rework root cause within 2 weeks.
In-process and end-of-line rejects handled in a mistake-proof manner	At each process step, NOK parts to be identified and rejected in specific red boxes. Access to those rejects must be limited, to avoid any risk of mixing Ok & Nok parts. Red boxes at EOL station must be locked. Reaction mode (Line stop criteria) in case of reject must be displayed & understood by all operators.

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20.09.2017

Released

Status:

Process re-start to be conditional upon the actual NOK part rejection.

3.8. Packaging and marking requirements

One-piece flow at electrical test is mandatory, part to be locked on jig during test, and unlocked only if test is ok label to be printed (marking to be performed). Suppliers shall ensure that components label bear a type, batch or serial number or at least batch number or other element allowing their identification, on a dedicated label. Manufacturers shall indicate their name, registered trade name or registered trade mark and the postal address at which they can be contacted.

Box label printing must be conditional upon the number of parts tested OK. ex.: if 50 parts per box, label to be printed automatically after the 50th good part is tested. No spare labels, no hand written labels. There must be link between single piece marking/label, label and box label. Labels contain and packaging type must be agreed with Wittur. Packaging instruction must be created per part number or product family. Packaging must prevent from damage and contamination. The quantity packed in one box and separators/protective foam and layers must be defined. The weight of the handling unit must be defined. Products within the same level have to be positioned in the way that the metal parts are always on the bottom and prevent cable insulation damage. For local deliveries reusable packaging (plastic boxes) can be used, supplier must take care of cleaning the boxes regularly.

Quantity of boxes per pallet and maximum pallet height must be defined. Handling unit has to be wrapped with foil and fixed by fixation tapes.

