| HL-LHC: Quality  Manufacturing and Inspection Plan – Cable Fabrication | | | | |
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| |  | | --- | | Prepared by: I. Pong, J. Fleiter  Date: 02/01/2018 | | Verified by: J. Blowers, G. Ambrosio, A. Ballarino, I. Bejar Alonso, P. Ferracin 04/04/2018  Date: DD/MM/20YY, DD/MM/20YY  Date: | | Approved by: G. Apollinari, E. Todesco, A. Devred  Date: 06/04/2018  Date: | | Project: HL-LHC | Supplier: LBNL & FNAL | Item Eq. Code: MQXFAC | Asset Code  (LHC Part Identifier):  HCMQXFAC002-LBNNNNNN |
| Work Package: WP3 | Client: CERN | Item description: MQXFA Cable | EDMS Report No: |

| **No** | **ACTIVITY / OPÉRATION** | **APPL. STANDARDS / NORMES APPL.** | **APPLICABLE DOCUMENTS / DOCUMENTS APPLICABLES** | **REV.**  **DOC.** | **INSPECTION / CONTRÔLE** | | | | | | | | **NOTES** |
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| **SUPPLIER** | | **CLIENT** | | **3RD PARTY** | | **INSPECTION REPORT** | **REV.**  **DOC.** |
| **Code** | **Signature/Date** | **Code** | **Signature/Date** | **Code** | **Signature/Date** |
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| **1.0** | **Approval for strands and core usage (\*)** |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1 | Approve strands for cabling |  | US HiLumi Doc 40 |  | H |  |  |  |  |  |  |  |  |
| 1.2 | Approve core for cabling |  | US HiLumi Doc 40 |  | H |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **2.0** | **Cabling map** |  |  |  |  |  |  |  |  |  |  |  |  |
| 2.1 | Select wire spools for cabling (strand mapping) |  | US HiLumi Doc 74 |  |  |  |  |  |  |  |  |  |  |
| 2.2 | Select tooling and production parameters |  | Cable Fab Proc SU-1004-0963,  Vector Traveler #464234 |  | N |  |  |  |  |  |  |  |  |
| 2.3 | Issue work order and respool log |  | Cable Fab Proc SU-1004-0963 |  | R |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **3.0** | **Respooling** |  |  |  |  |  |  |  |  |  |  |  |  |
| 3.1 | Respool strands |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
| 3.2 | *This box is Intentionally left blank* |  |  |  |  |  |  |  |  |  |  |  |  |
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| **4.0** | **Preparation of the cabling machine** |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.1 | Perform general inspection and preparation of cabling machine |  |  |  |  |  |  |  |  |  |  |  |  |
| 4.2 | Load spools and brakes according to cable map |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
| 4.3 | Install / verify installation of rollers on Turkshead |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
| 4.4 | Install / verify installation of mandrel |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
| 4.5 | Align Turkshead and mandrel |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
| 4.6 | Install stainless-steel core |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
| 4.7 | Barcode scan the spool map |  | Cable Fab Proc SU-1004-0963,  Vector Traveler #464234 |  | N |  |  |  |  |  |  |  |  |
| 4.8 | String and measure tension of all strands |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **5.0** | **Production of startup sample** |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.1 | Calibrate CME |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.2 | Activate Keyence system |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.3 | Perform startup check |  | Cable Fab Proc SU-1004-0963 |  | H |  |  |  |  |  |  |  |  |
| 5.4 | Produce startup sample(s) |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
| 5.5 | Examine major and minor edge facet sizes |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.6 | Perform cable surface inspection |  |  |  |  |  |  |  |  |  |  |  |  |
| 5.7 | Measure and adjust cable parameters where necessary |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **6.0** | **Qualification sample production** |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.1 | Check CME with reference gauge block |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.2 | Produce qualification sample |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.3 | Measure cable parameters using CME |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.4 | Verify cable lay pitch |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
| 6.5 | Measure residual twist |  | Cable Residual Twist Procedure SU-1007-5016 |  |  |  |  |  |  |  |  |  |  |
| 6.6 | Perform 10-stack measurement |  | Ten-stack Procedure SU-1007-5014 |  |  |  |  |  |  |  |  |  |  |
| 6.7 | Examine major and minor edge facet sizes |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.8 | Perform cable surface inspection |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.9 | Perform metallographic examination on cable transverse cross section |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
| 6.10 | *This box is Intentionally left blank* |  |  |  |  |  |  |  |  |  |  |  |  |
| 6.11 | Approve qualification sample and cabling machine settings |  | Cable Fab Proc SU-1004-0963 |  | H |  |  |  |  |  |  |  |  |
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| **7.0** | **Cable production** |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.1 | Check CME with reference gauge block |  |  |  |  |  |  |  |  |  |  |  |  |
| 7.2 | Produce unit length with inspection systems activated |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **8.0** | **End of cable production** |  |  |  |  |  |  |  |  |  |  |  |  |
| 8.1 | *This box is Intentionally left blank* |  |  |  |  |  |  |  |  |  |  |  |  |
| 8.2 | Register length fabricated during steady state production |  | Cable Fab Proc SU-1004-0963,  Vector Traveler #464234 |  | N |  |  |  |  |  |  |  |  |
| 8.3 | Cut and label samples for QC and archive |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **9.0** | **Release of cabling machine for next cable run** |  |  |  |  |  |  |  |  |  |  |  |  |
| 9.1 | Re-measure tension of all strands |  |  |  |  |  |  |  |  |  |  |  |  |
| 9.2 | Archive leftover lengths |  |  |  |  |  |  |  |  |  |  |  |  |
| 9.3 | Archive / discard leftover stainless steel core |  |  |  |  |  |  |  |  |  |  |  |  |
| 9.4 | Unload wire spools |  |  |  |  |  |  |  |  |  |  |  |  |
| 9.5 | Perform general inspection and clean-up / servicing of cabling machine |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **10.0** | **Bare cable mechanical QC on Production Unit tail end piece** |  |  |  |  |  |  |  |  |  |  |  |  |
| 10.1 | Verify cable lay pitch |  | Cable Fab Proc SU-1004-0963 |  |  |  |  |  |  |  |  |  |  |
| 10.2 | Measure residual twist |  | Cable Residual Twist Procedure SU-1007-5016,  Vector Traveler #464234 |  | N |  |  |  |  |  |  |  |  |
| 10.3 | Perform 10-stack measurement |  | Ten-stack Procedure SU-1007-5014 |  |  |  |  |  |  |  |  |  |  |
| 10.4 | Examine major and minor edge facet sizes |  |  |  |  |  |  |  |  |  |  |  |  |
| 10.5 | Perform cable surface inspection |  |  |  |  |  |  |  |  |  |  |  |  |
| 10.6 | Perform metallographic examination on cable transverse cross section |  |  |  |  |  |  |  |  |  |  |  |  |
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| **11.0** | **Braiding insulation** |  |  |  |  |  |  |  |  |  |  |  |  |
| 11.1 | Send the completed bare cable to insulation vendor |  | Shipping Documents |  |  |  |  |  |  |  |  |  |  |
| 11.2 | Vendor braids insulation on the cable |  | US HiLumi Doc 75 |  |  |  |  |  |  |  |  |  |  |
| 11.3 | Vendor performs startup sample QC |  |  |  | R |  |  |  |  |  |  |  |  |
| 11.4 | Perform verification 10-stack measurement |  | Ten-stack Procedure SU-1007-5014,  Vector Traveler #464342 |  | N/R |  |  |  |  |  |  |  |  |
| 11.5 | Vendor submits inspection report |  | US HiLumi Doc 75,  Vector Traveler #464342 |  | N/R |  |  |  |  |  |  |  |  |
| 11.6 | Vendor sends the braided cable to FNAL/BNL/LBNL and informs LBNL tracking # |  | Relevant PO,  Shipping Documents |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **12.0** | **Cable electrical QC (\*)** |  |  |  |  |  |  |  |  |  |  |  |  |
| 12.1 | Perform heat treatment on at least 5 extracted strands |  | Vector Traveler #464342 |  | R |  |  |  |  |  |  |  |  |
| 12.2 | *This box is Intentionally left blank* |  |  |  |  |  |  |  |  |  |  |  |  |
| 12.3 | Measure at least 5 extracted strands RRR |  | Vector Traveler #464342 |  | R |  |  |  |  |  |  |  |  |
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| **13.0** | **Production Unit approval** |  |  |  |  |  |  |  |  |  |  |  |  |
| 13.1 | Complete Vector Cable Fabrication Traveler |  | US HiLumi Doc 74,  Vector Traveler #464234 |  | N/R |  |  |  |  |  |  |  |  |
| 13.2 | Complete Vector Cable QC Traveler |  | US HiLumi Doc 74,  Vector Traveler #464342 |  | N/R |  |  |  |  |  |  |  |  |
| 13.3 | Complete Vector Insulated Cable QC Traveler |  | US HiLumi Doc 75,  Vector Traveler #464342 |  | N/R |  |  |  |  |  |  |  |  |
| 13.4 | Coil winding team confirms braided cable receipt in good order |  |  |  | R |  |  |  |  |  |  |  |  |
| 13.5 | Approve Production Unit |  |  |  | H |  |  |  |  |  |  |  |  |

\*Add as many rows as required

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| **NOTE:**  H = HOLD POINT  N = NOTIFICATION POINT  R = REVIEW AND APPROVAL OF REPORT  W = WITNESS POINT | **SUPPLIER:**  **Approved by:**  **Signature:**  **Date:** DD/MM/20YY | **CLIENT:**  **Approved by:**  **Signature:**  **Date:** DD/MM/20YY | **3rd PARTY (if any):**  **Approved by:** not applicable  **Signature:**  **Date:** DD/MM/20YY |
| 1. **N (Notification Point)**: CERN, or its authorized representative, is informed 5 working days in advance that a specific step has been completed and that the following step in the approved work-flow will be performed. A Notification Point does not affect the work-flow. Work can continue without CERN, or its authorized representative, reply. Data relative to the step are uploaded in MTF 2. **H (Hold Point)**: CERN, or its authorized representative, is informed that a specific step has been completed. The work-flow is stopped until CERN, or its authorized representative, provides a Hold Point Clearance. The clearance is provided within 5 working days upon submission of the quality control documentation relative to the performed step. In case of clearance the work-flow can continue. In case of rejection, a recovery plan shall be discussed with CERN and submitted to CERN for final approval within 10 working days. 3. **R (Review)**: The quality records will be reviewed. 4. **W (Witness Point)**: CERN, or its authorized representative, intends to attend any specific step of the production. The supplier will notify the client with 10 working days in advance that the activity will be performed. | | | |
| (\*) Approved but requiring a second iteration on the acceptance tests for strand and cable | | | |