LARP Materials QA/QC

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MQXF Conductor Review
November 5-6, 2014
CERN

Outline

- What are QA/QC?
- What we can learn from large Nb_3Sn projects – a comparison
  - Procurement comparison
  - Strand QA/QC comparison
  - Cable (Conductor) QA/QC comparison
- QA Overall and an example of Cable QA
- QC for strand, cable, and HT
- Database
- Summary

IEEE Guide—Adoption of the Project Management Institute (PMI®) Standard

A Guide to the Project Management Body of Knowledge (PM[illegible]—Fourth Edition

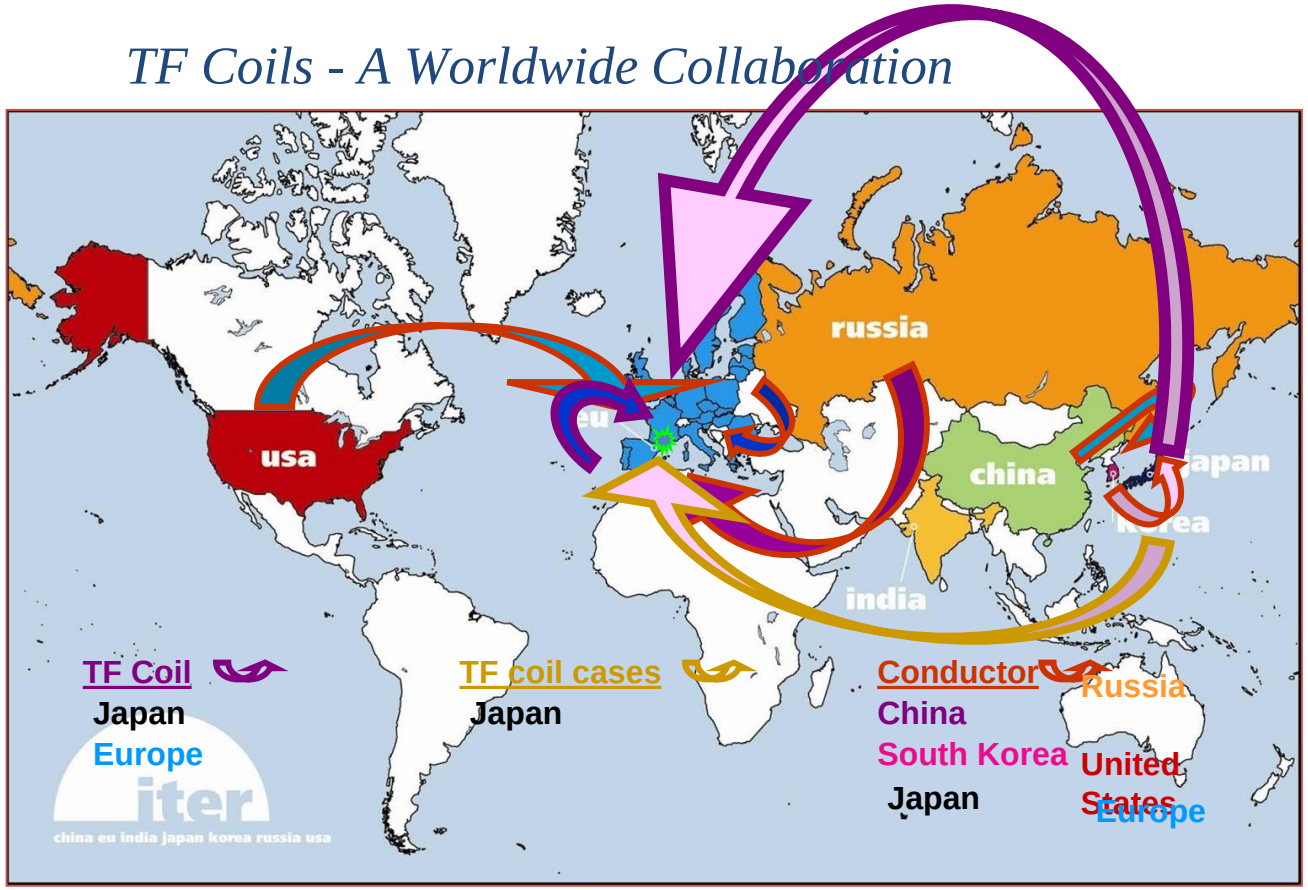
Quality is planned, designed, and built in – not inspected in
— PMI, PMBOK® Guide

IEEE Computer Society

Sponsored by the
Software & Systems Engineering Standards Committee

Procurement Comparison

TF Coils - A Worldwide Collaboration



Strand QA/QC Comparison

LARP MQXF

- Periodic facility cross checks
- Statistical Process Control planned, similar to ITER
- Systematic RT & LT tests planned; frequency change according to production phase, similar to ITER
- S/V measurements (V sampling)
- No characterization required (cf. CDP)
- Pedigree: monofilament, subelement; Data entry: billet, strand piece length
- Test data reporting via DCD template to LBNL server DB

ITER TF

- Worldwide benchmarking
- SPC on critical parameters (± 3 σ)
  - e.g. I_c: BR 5-10+%; IT ~15-20%
- Systematic RT & LT tests on P/T of every billet plus statistical sampling of drawing breakages
- S/V measurements (V sampling)
- Extensive characterization for CPQS
- Data entry: raw materials*, intermediate product, billet, strand piece length
- Test data entry directly into online Conductor DB

Single supplier simplifies QA;
Reduced QC steps based on supplier and LARP experience

Cable QA/QC Comparison

LARP MQXF

- Extracted strands from Rutherford Cable, no full size cable tests
- High cable sampling rate, extracted strand sampling level will be billet-weighted
- n/a
- Insulation thickness by 10-stack, S/V
- Strand-cable database on PTC® Windchill, will trace full history
- Supplier internal approval → LARP acceptance/DW

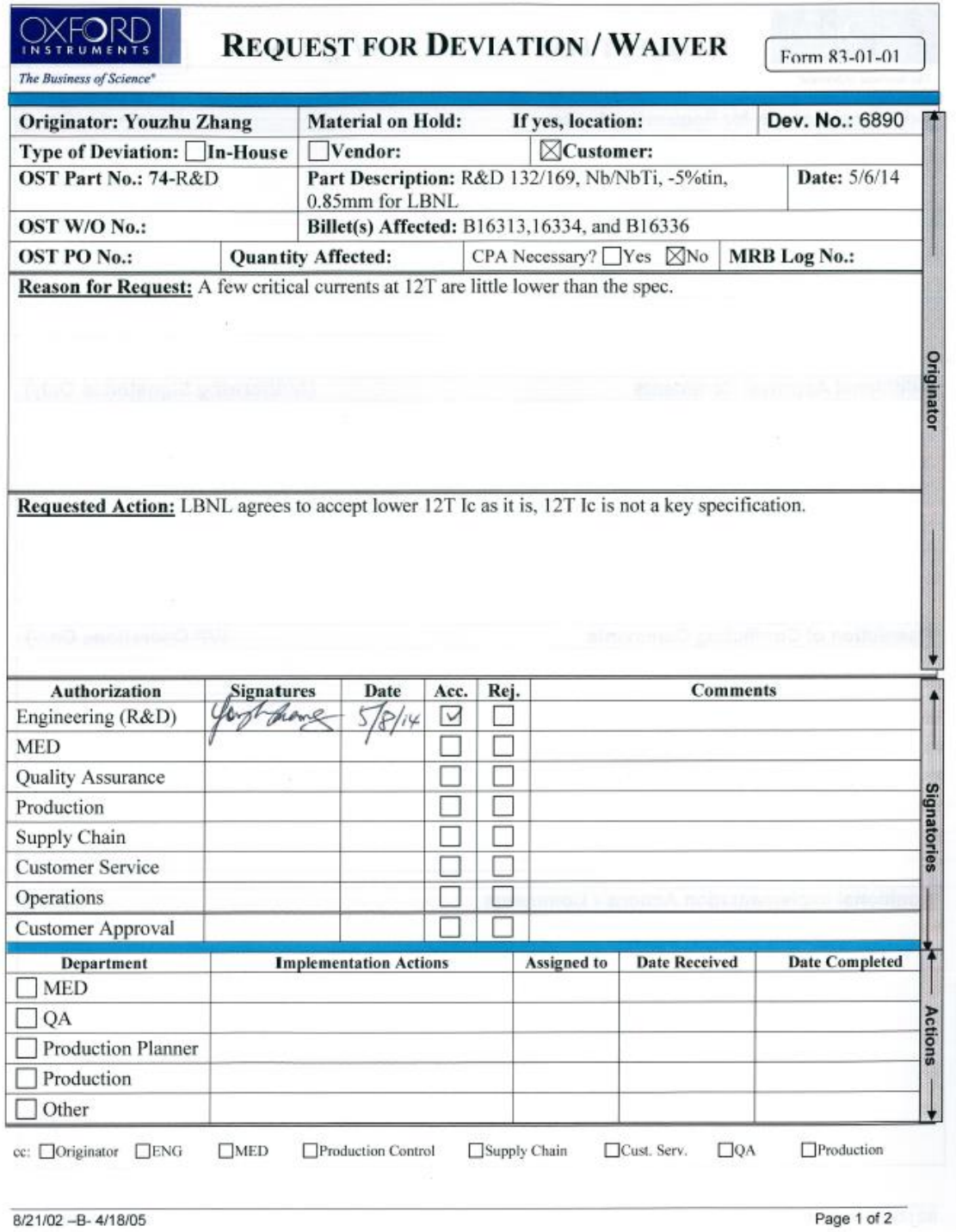
ITER

- Full size CICC test at SULTAN, none at cable level, no extracted strands
- High sampling rate
- Jacket tests
- n/a
- Dedicated online Conductor Database tracing full history
- Supplier internal approval → NP/ATPP → DA approval/send back/NCR/DR → IO approval/rejection/objection

40 strands only,
well understood cable geometry

LARP QA

- Specifications, Procedures, IEC, etc.
- Deviation Request
- Deviation Waiver / Non-Conformity Rep
- Notification Point, Authorization-To-Prc
- Design control document/release note/
- Shipment documentation
- QA Documentation (online); Strand/cab
- Use of barcode and ID scheme (CERN cc
- LARP QA with Task Leaders, QC with res
  Strand: OST, Cable: LBNL, insulation: NE



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REQUEST FOR DEVIATION / WAIVER — Form 83-01-01

Originator: Youzhu Zhang	**Material on Hold:**	**If yes, location:**	**Dev. No.:** 6890
Type of Deviation: ☐ **In-House**	☐ **Vendor:**	☒ **Customer:**	
OST Part No.: 74-R&D	**Part Description:** R&D 132/169, Nb/NbTi, -5%tin, 0.85mm for LBNL		**Date:** 5/6/14
OST W/O No.:	**Billet(s) Affected:** B16313,16334, and B16336		
OST PO No.:	**Quantity Affected:**	CPA Necessary? ☐ Yes ☒ No	**MRB Log No.:**

Reason for Request: A few critical currents at 12T are little lower than the spec.

Requested Action: LBNL agrees to accept lower 12T Ic as it is, 12T Ic is not a key specification.

Originator

Authorization	Signatures	Date	Acc.	Rej.	Comments
Engineering (R&D)	Youzhu Zhang	5/8/14	☑	☐	
MED			☐	☐	
Quality Assurance			☐	☐	
Production			☐	☐	
Supply Chain			☐	☐	
Customer Service			☐	☐	
Operations			☐	☐	
Customer Approval			☐	☐	

Signatories

Department	Implementation Actions	Assigned to	Date Received	Date Completed
☐ MED				
☐ QA				
☐ Production Planner				
☐ Production				
☐ Other				

Actions

cc: ☐ Originator ☐ ENG ☐ MED ☐ Production Control ☐ Supply Chain ☐ Cust. Serv. ☐ QA ☐ Production

8/21/02 –B- 4/18/05 Page 1 of 2

Magnet Division Proc
Specification Numbe
Revision:

Testing Procedure of

- Prepared by:
- Cognizant Scienti
- Q. A. Approval:
- ES&H Review:

Revision History

Rev A: Initial

II. Identification of the data Storage file and of the hardware components

II.1 Excel file for data Storage

		Check box
1	Open the Excel template file which is named: **10stk-QXF-Template_HH.xls** The file can be found on thuder at: **\\thunder\CableWorks\10-STACKs\QXF-10-Stacks** A snap shot of the document is shown in Figure 1. In the same folder save this file using "save as". The file should be named after the cable and insulation IDs (e.g. 10stk-QXF-1050Z-NEEW-wo-296535)	

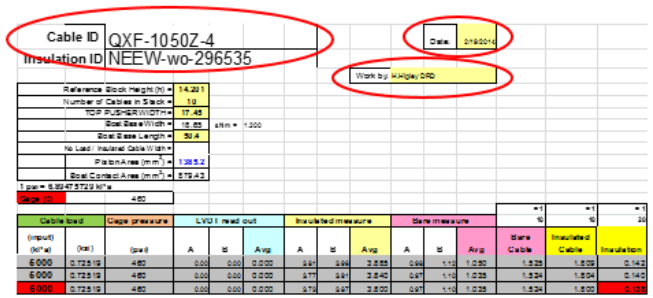

Figure 1 – Snap shot of the Excel file.

2	In the Excel document enters (circled in red in Figure 1): - Cable ID (e.g. 1052Z-4). - Insulation ID (Purchase order). - Date. - Name of the technician performing the measurement.	

		Check box
3	Still in the Excel document: - Make sure that the number of cable in the stack is **10**. - Make sure the piston area is **1385.2 mm²**.	

II.2 Hardware

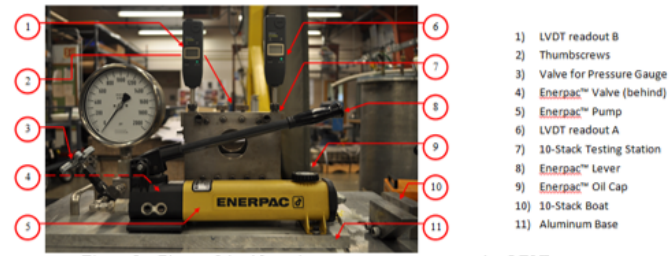

Figure 2 – Photo of the 10 stack measurement set up used at LBNL.

4	Select the Boat and top pusher dedicated to QXF.	

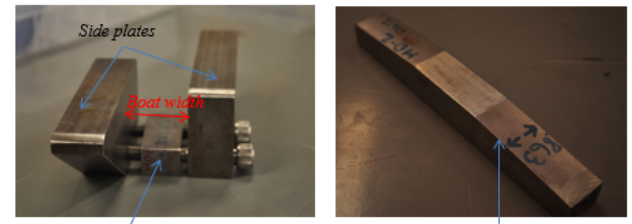

Figure 3 – Left: Boat (made of a platen and two side plates). Right: Top pusher.

8635 White Oak Avenue
Rancho Cucamonga, CA 91730
Tel: (909) 484-3124 / (800) 992-5015
FAX: (909) 484-1085
Web: www.brownmetals.com | www.sidecuts.com

Certificate of Test / Conformance
Certificate Number: 143842-1

BMC Lot Receipt
11-548

2417
7/2014
7217
Allegheny Ludlum (USA)
Allegheny Ludlum (USA)
3643

83)

N	Co	Fe
.05	.22	Bal

52.225-7008 & 252.225-7009
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ipf
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and other statements of compliance. The
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45
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41

Cable Measuring
CME_file_reader.vi
File Edit View Project

Corrective


P33OL1057 THICK vs. METERS
THICK (mm)
1.53
1.525
1.52
1.515
1.51
0 50 100 150 200 250 300 350 400
Distance (METERS)
P33OL1057 WIDTH vs. METERS
WIDTH (mm)
18.22
18.2
18.18
18.16
18.14
18.12
18.1
18.08
0 50 100 150 200 250 300 350 400
Distance (METERS)
P33OL1057 ANGLE vs. METERS
ANGLE (°)
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0 50 100 150 200 250 300 350 400
Distance (METERS)
Upper Spec
Spec
Lower Spec
Upper SPC
Average
Lower SPC
Out of Bound Data (SPC)
Production Unit A

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DOC: FQP 74-001 | ISS: 12/24/10

Quality Plan
Page: 2 of 51

1. OBJECTIVES AND DELIVERABLES OF THE CONTRACT.

Fig 1A – Contract Deliverables Schedule
Fig 1B – Contract Work Breakdown Structure (WBS)

2. RESPONSIBILITIES REQUIREMENTS

Fig. 2A – Organization Chart, ITER "Tin Team" Operation
Fig. 2B – OST Quality Manual Documents and Current Revision Status
Fig. 2C – OST Quality Operating Procedures

3. PROJECT MANAGEMENT

Fig. 3A – Assigned Responsibilities for Meetings
Fig. 3B – Kick-off Meeting Details
Fig. 3C – Monthly Progress Meetings
Fig. 3D – Internal Review

4. CONTROL PLAN

Fig. 4A – Symbols for Contract Notifications and Actions
Fig. 4B – Product Flow Chart

5. RESOURCE MANAGEMENT

Fig. 5A – Primary Functions and Qualifications
Fig. 5B – Example of Skills Matrix, Skills Management Plan

6. CONFIGURATION MANAGEMENT

Fig. 6A – QOP's modified by this Quality Plan
Fig. 6B – ITER-DA Document Change Control, Process Flow
Fig. 6C – ITER-DA Deviation Control, Process Flow
Fig. 6D – ITER-DA Non-Conforming Product, Process Flow
Fig. 6E – ITER-DA Log of Deviations and NCRs

7. TIME SCHEDULE MANAGEMENT

8. INFORMATION AND DOCUMENTATION MANAGEMENT

Fig. 8A – Communication Heading for Documents and Communications
Fig. 8B – Communication Heading for Reports
Fig. 8C – ITER-DA Storage of Quality Records

9. SUBCONTRACTING MANAGEMENT

10. ASSESSMENT AND VALIDATION MANAGEMENT

11. ACCEPTANCE AND DELIVERY REQUIREMENTS

Fig. 11A – ITER-DA Product Requirements
Fig. 11B – ITER-DA Delivery Requirements

12. RISK MANAGEMENT

Test

ps://plone.uslarp.org/MagnetRD/WeeklyUpdates/2014/20140609/

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Quality Assurance

- Full documentation to aid in traceability and reporting
- Procedures based on ASTM and other standardized methods to ensure reproducible results and minimize variation in the final product

GGI / OSI INSPECTION REPORT

GGI SO # 32417-09
P/O #
GGI # JQ1-12-2010A

Part No.: 74-040-0596 Part Rev.: 0

Part Description: E8 ITER Billet, 156 Hole

	Dimension	Specification	Sample # A end	Sample # B end	Sample # A end	Sample # B end
*	"MAJOR" Characteristics:					
	Counterbore Dia. X	11.250" +.002"/-.000"	11.251	11.252		
	Counterbore Dia. Y	11.250" +.002"/-.000"	11.252	11.252		
	Hole Dia.	Dia. .530 +/-.003"	.530	.530		
	"	Dia. .530 +/-.003"	.530	.529		
	"	Dia. .530 +/-.003"	.530	.530		
	"	Dia. .530 +/-.003"	.530	.529		
	"	Dia. .530 +/-.003"	.530	.530		
	Finish Interior Hole walls	63	✓	✓		
	Wall thickness	.125" Minimum	—	.085		
	No. Holes	156	✓	✓		
*	"minor" Characteristics:					
	O.D. X	12.250 +/-.005"	12.246	12.247		
	O.D. Y	12.250 +/-.005"	12.245	12.249		
	All Holes Beveled	Y / N	YES	—		
	Counterbore Depth	0.280 +/-.005" Typical	.284	.280		
	Length	28.870 +/-.015"	28.867	—		
	Finish O.D.	125	✓	✓		
	Packaging/shipping intact	Y / N	YES	—		
	Heat No.	Record	32417-09	—		
	Map Attached	Y / N	YES	YES		

Inspected By: [illegible] Date: 3-9-10

FIO-033

d by

s-section

LARP Strand QC

- Automatic and online QC + dedicated facility sample tests
- Tests are based on established techniques
- Experience from RHIC, SSC, LHC, ITER
- Candidate supplier has appropriate equipment already in use
- Existing and accepted procedures

QXF-1057Z P33OL1057 Report v1.3 2014 09 09.xlsx

Cable Mfg. Summary
DOE/LBNL/AFRD/Supercon

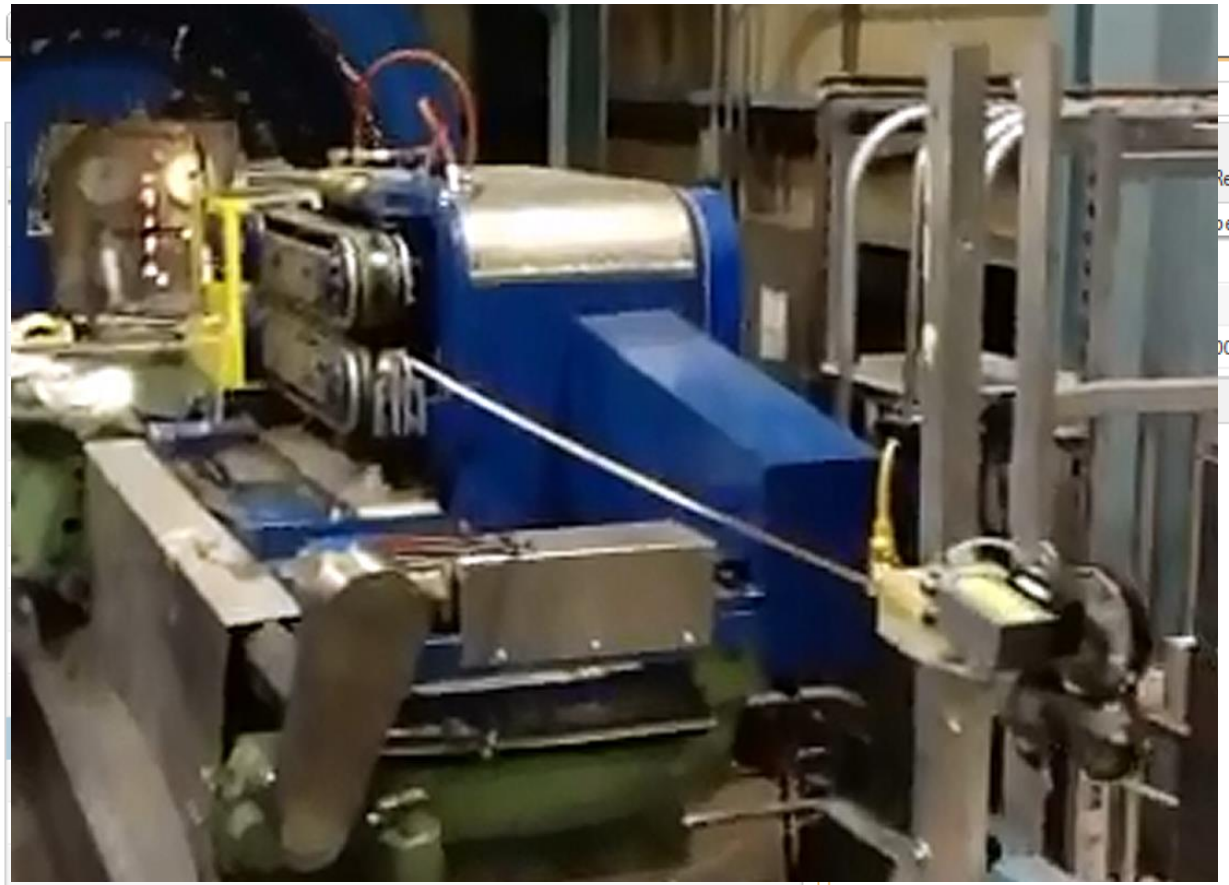
Cable ID# P33OL1057
Mfg. Date 2014 08 20

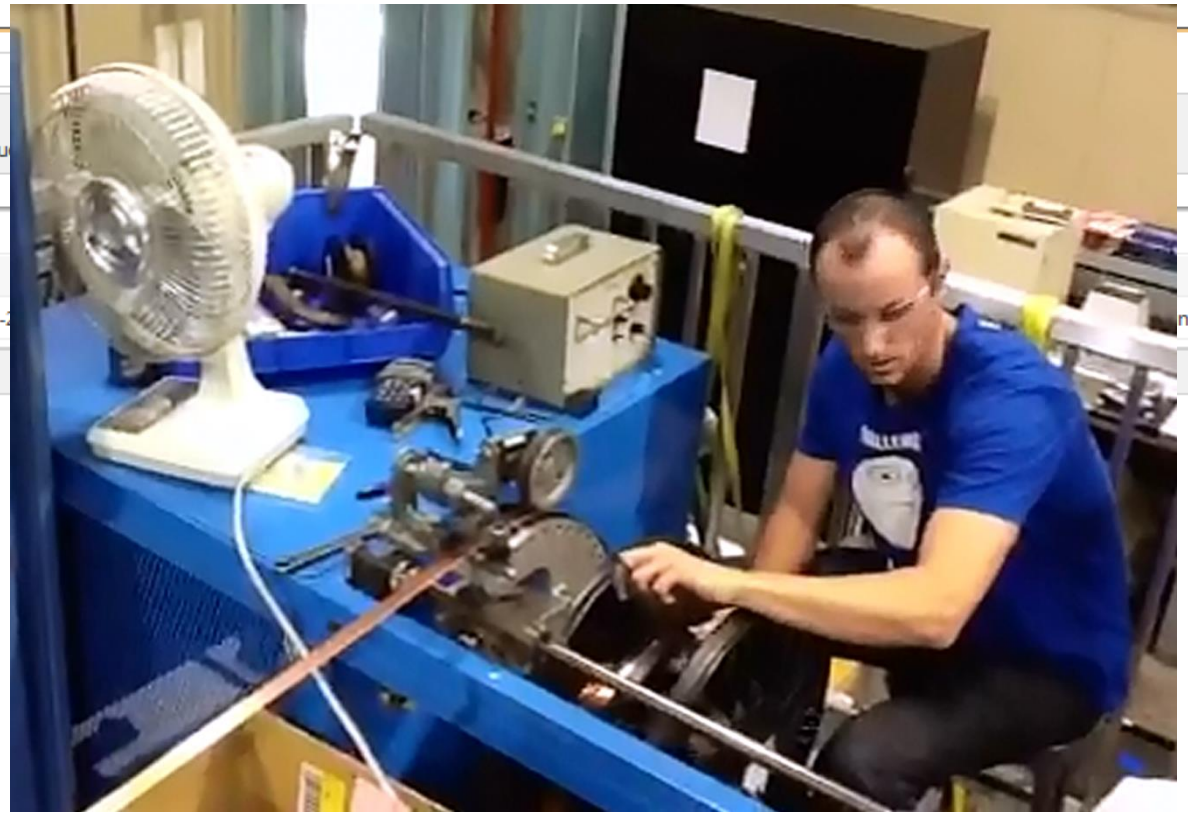
ipong

Windchill

Products > LARP QXF > Folders > 2-QXF_MATERIALS > Cable

Search | Browse





- 3-QXF_COILS
- 4-QXF_INSTRUMENTATION
- 5-QXF_MAGNETS
- PROMOTION REQUESTS

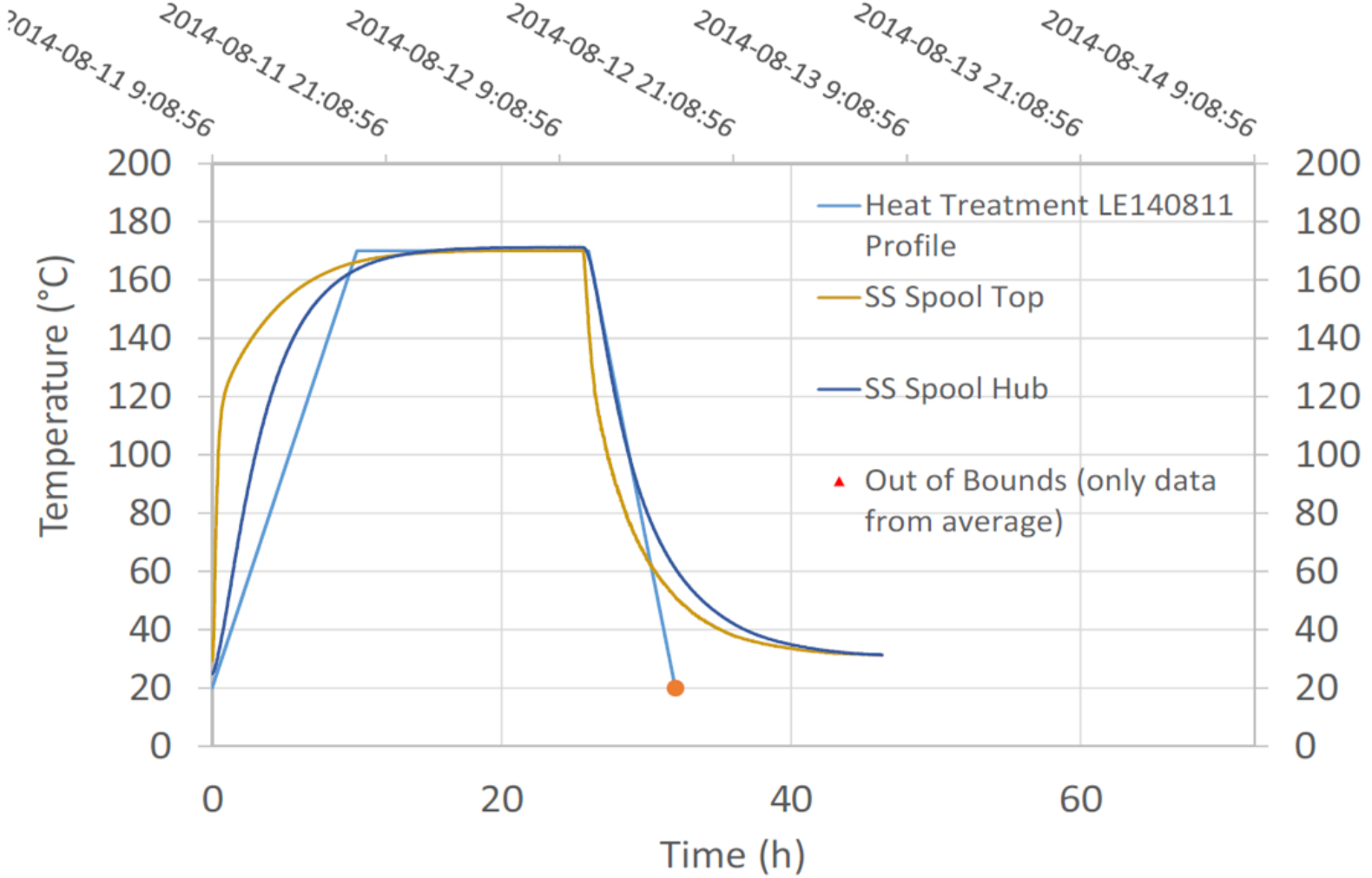
PO08S14983B01A	S1A0075A	B2M0197A	500	380	120	0	0.853	53 B1M2357R	40

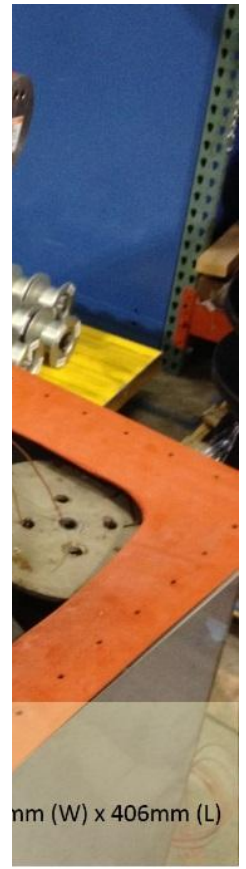
LARP Cable QC

- Cabling parameters are monitored online and verified before and after production
- Techniques applied are established
- Rutherford cable is well understood, LARP investigation showed extracted strand is consistent with and predictive of cable and magnet performance → relatively cheap and fast; test lab flexibility.

Well-defined, streamlined process based on 10+ years of LARP experience

LARP Annealing QC





LARP Reaction HT of Strands QC

SQXF-PC01

Coil Retort Temperature

	Actual Start Temperature [°C]	Actual Ramp Rate to 1st stage [°C/h]	Actual 1st stage temperature [°C]	actual dwell time during 1st stage [h]	Actual Ramp Rate to 2nd stage [°C/h]	Actual 2nd stage temperature [°C]	actual dwell time during 2nd stage [h]	Actual Ramp Rate to 3rd stage [°C/h]	Actual 3rd stage temperature [°C]	actual dwell time during 3rd stage [h]
	19.9	16.5	208.4	72.7	23.8	398.4	47.9	36.3	638.2	48.1
No. of data		343	2180		239	1437		198	1444	
sigma			0.65°C			0.72°C			0.48°C	

Sample Retort Temperature

	Actual Start Temperature [°C]	Actual Ramp Rate to 1st stage [°C/h]	Actual 1st stage temperature [°C]	actual dwell time during 1st stage [h]	Actual Ramp Rate to 2nd stage [°C/h]	Actual 2nd stage temperature [°C]	actual dwell time during 2nd stage [h]	Actual Ramp Rate to 3rd stage [°C/h]	Actual 3rd stage temperature [°C]	actual dwell time during 3rd stage [h]
	18.9	30.1	207.3	77.8	52.4	397.6	52.2	52.2	637.5	50.1
No. of		189	2333		109	1566		138	1504	

Heat treatment process controlled and data documented

LARP Strand-Cable Database (LBNL)

- Wire Production and QC Data (being developed)
  - Monofilament ID, Subelement ID,
  - Billet parameters
  - Piece length parameters
  - HT, RT & LT test data
- Wire and Cable Inventory and Usage (operational)
  - Wire, Cable, and Cabling Components (e.g. rollers, mandrels, SS core etc.)
  - Sorting, Strand Mapping, Cable Map, Summary
  - Respool Log (wire ↔ Al spool ↔ spool/Capstan brake relation, tension)
  - Barcode generator
- QA documentation (being identified)

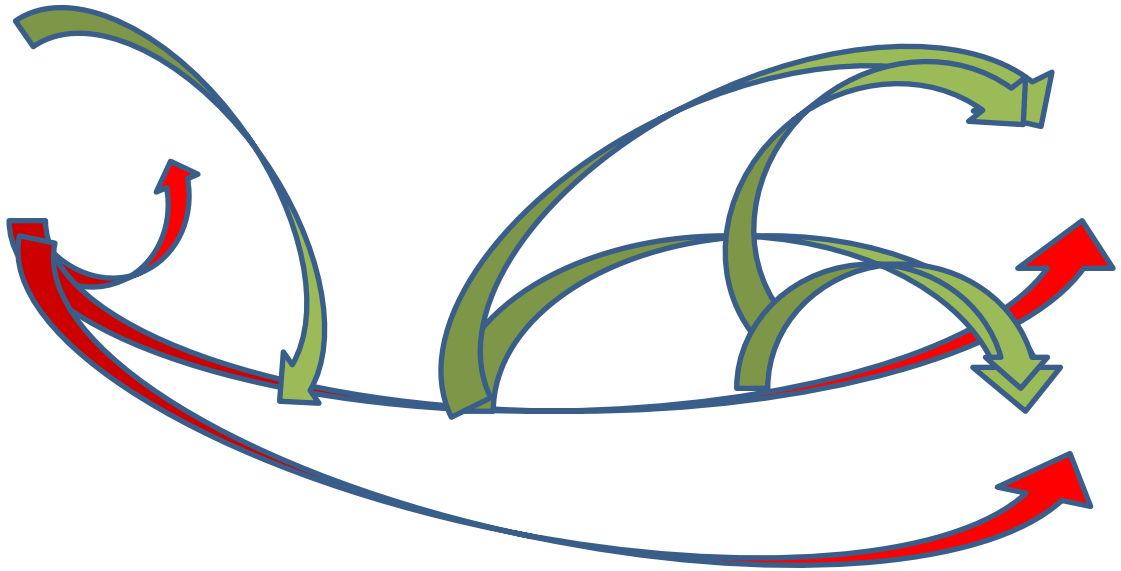
Summary on LARP QA/QC

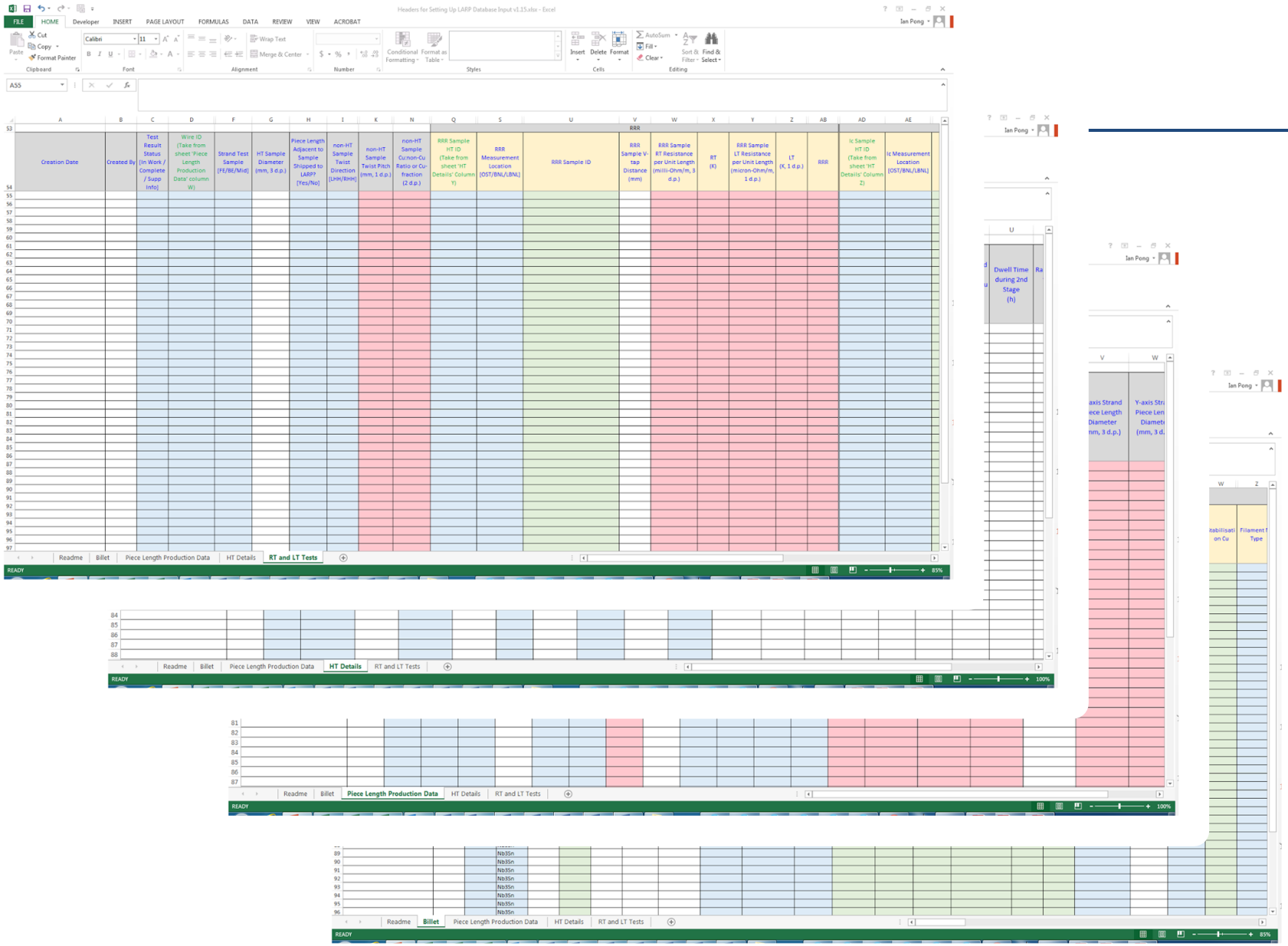
- Credible and adequate
  - Build on ITER QA/QC, with some LHC, RHIC, SSC experience.
  - Scaled down due to lower volume and smaller number of suppliers.
- Schedule
  - Strand and Cable qualification and acceptance are decoupled.
  - Strand acceptance: per billet similar, but lower volume.
  - Cable acceptance: extracted strand from Rutherford cable is relatively cheap and fast; test lab flexibility.
  - Online DB being implemented
  - QA management plan is part of the DOE CD review process

EXTRA SLIDES

- Onli

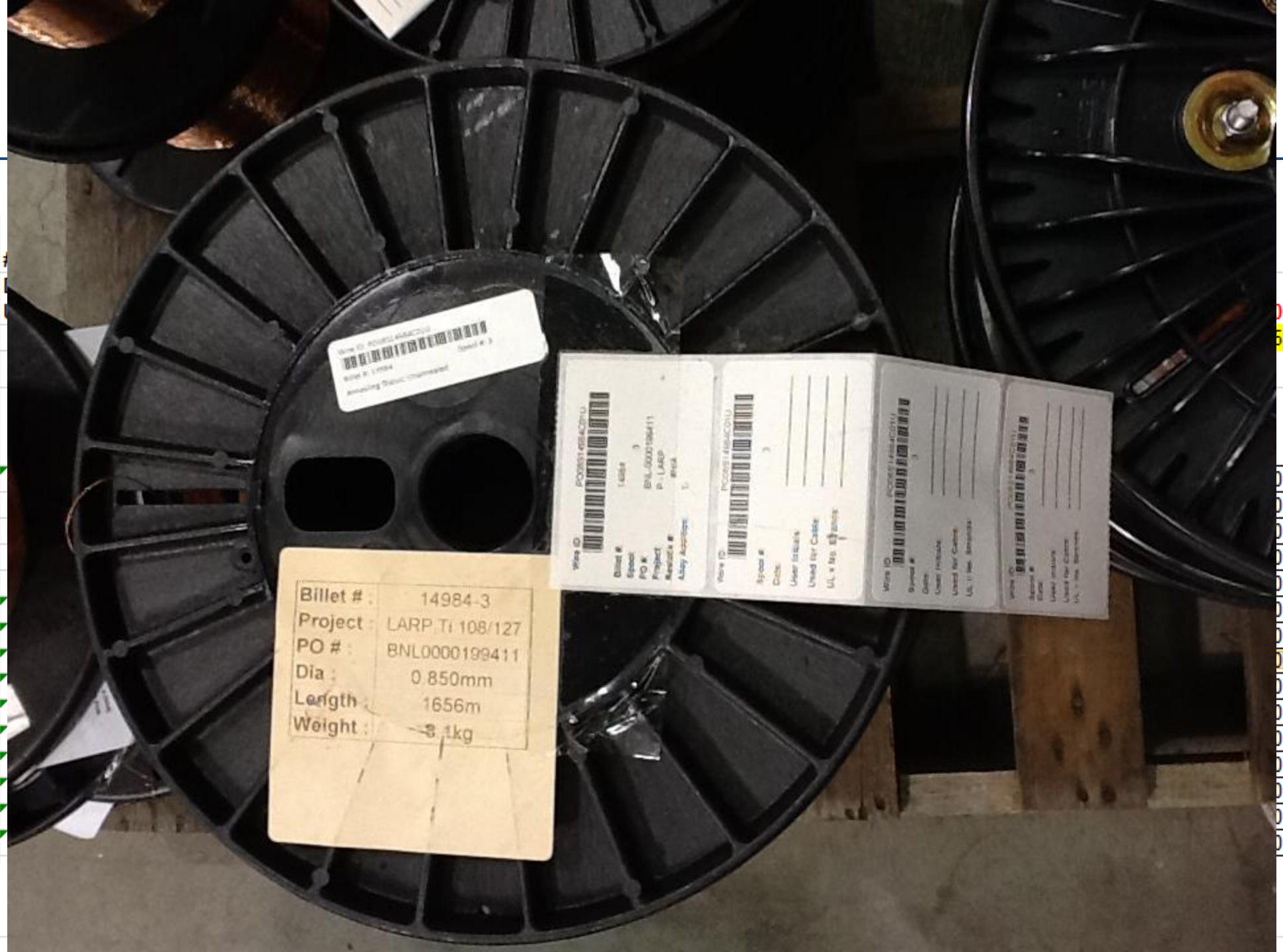
Input Template Structure




Creation Date
Created By
Test Result Status (In Work / Complete / Supp Info)
Wire ID (Take from sheet 'Piece Length Production Data' column W)
Strand Test Sample (Ff/Bf/Mid)
HT Sample Diameter (mm, 3 d.p.)
Piece Length Adjacent to Sample Shipped to LARP? (Yes/No)
non-HT Sample Twist Direction (LHH/RHH)
non-HT Sample Twist Pitch (mm, 1 d.p.)
non-HT Sample Cu:non-Cu Ratio or Cu-fraction (2 d.p.)
RRR Sample HT ID (Take from sheet 'HT Details' Column Y)
RRR Measurement Location (OST/BNL/LBNL)
RRR Sample ID
RRR Sample V-tap Distance (mm)
RRR Sample RT Resistance per Unit Length (milli-Ohm/m, 3 d.p.)
RT (K)
RRR Sample LT Resistance per Unit Length (micron-Ohm/m, 1 d.p.)
LT (K, 1 d.p.)
RRR
Ic Sample HT ID (Take from sheet 'HT Details' Column Z)
Ic Measurement Location (OST/BNL/LBNL)
Dwell Time during 2nd Stage (h)
Readme
Billet
Piece Length Production Data
HT Details
RT and LT Tests
READY
Nb3Sn

Input Template for Vendor

Friday, 25 April, 2014	HM	Complete	16342	P - LARP	16342-3	A	03	3089	15.3		Pass								



Billet #
14752
14752
14752
14752
14896
14983
14983
14984
14984
14984
14984
15245
15519
15519
15519

Remaining Length
84.00
151.00
13.00
54.00
30.00
140.00
129.00
154.00
93.00
136.00
142.00
170.00
151.00
64.00
58.00

P - LARP

522814

Database - Cable