GENERAL ATOMICS
ELECTROMAGNETICS

QN 7054611

(1) PLANT INFORMATION:	(2) NOTIFICATION TYPE:	(3) DATE:	
112 BRYAN BLVD SHANNON, MS 38868-8763 Cage Code: 4US81 Plant: 2003	GN-NR	07/02/2019	
(4) SUPPLIER INFORMATION:	**(5) RELATED NOTIFICATION:**	**(6) CSI/CAI:**	**(7) CFR:**
See Plant Information above	N/A	NO	NO
(8) PART NAME:	**(9) PART/DWG NO.:**	**(10) REV:**	
ZBOM DETECTOR SOLENOID, MU2E EXPERIMENT	39532-D-4401		

(11) CLASSIFICATION: (PRIORITY)	(12) LOCATION:	(13) HWCI NO. AND NAME:
EMS QN Default	EMS Tupelo	DS8 COIL, WOUND -

(14) CONTRACT NO.:	(15)CONTRACT DELIVERY ITEM NO:	(16) WBS:	(17) PROJECT NO.:
Subcontract 618313	39532-D-4401	39532-2.1.1.3.4P	39532

(18) PROD ORDER-OPERATION NO.:	(19) NETWORK-OPERATION ACC:	(20) LOT SIZE:	(21) QTY. INSP.: (REF.)	(22) QTY. REJ.: (COMP.)
N/A	N/A	N/A	N/A	1

(23) INITIATOR:	(24) EXTERNAL REFERENCE NO.:	(25) NONCONFORMANCE RESPONSIBILITY:
SHARON DAVENPORT	N/A	GA Responsible

(26) EFFECT ON CONTRACT COST/PRICE:

N/A

(27) EFFECT ON DELIVERY SCHEDULE:

N/A

(28) EFFECT ON LOGISTICS SUPPORT, INTERFACE, OR SOFTWARE:

N/A

(29) ADDITIONAL INFORMATION:

N/A

(30) SERIAL NUMBER(S):

N/A

(31) REQUIREMENTS: (DESCRIPTION)

DS8 Coil
07/02/2019 04:21:45 PST SHARON DAVENPORT (DAVESH)
DS8 Coil must meet customer requirements

(32) NONCONFORMING CONDITION: (TEXT)

Item No: 0001 Found At: EMS Tupelo Defect Code: ALGN INS - Misaligned 9 ft of DS8 coil is twisted

(33) DISPOSITION, FINAL CONDITION AND TECHNICAL JUSTIFICATION:

Item No: 0001 - Rework - Straighten bent coil
07/11/2019 10:02:52 PST SHARON DAVENPORT (DAVESH)
Straighten and rewind the twisted section of conductor per the attached Rework Instructions

TECHNICAL JUSTIFICATION: The conductor must be removed from the mandrel to continue the investigation of its fitness for use and testing. This method was devised to straighten the conductor while minimizing further cold working of the material.

(34) CAUSE OF DISCREPANCY:

Item No: 0001 Cause: EP10 - Isolated Case (Process) Cause Text: One wrap of coil slipped off mandrel
07/11/2019 12:34:33 PST SHARON DAVENPORT (DAVESH)
One wrap of conductor coil slipped off the winding mandrel, causing deformation.

(35) CORRECTIVE ACTION: (EXECUTION)

Item No: 0001 Task Code: 00CN Task Code Text: Obtain Containment Task Text : Stop production
07/11/2019 09:41:10 PST SHARON DAVENPORT (DAVESH)
Work was immediately stopped on June 28, 2019 following the winding incident

Item No: 0001 Task Code: NOTF Task Code Text: Notify Responsible Organization Task Text : Notify customer of nonconformance
07/11/2019 09:42:28 PST SHARON DAVENPORT (DAVESH)
An e-mail was sent to Thomas Page, FRA Engineer, on Friday, June 28, 2019 at 5:14pm to notify Fermilab of this winding incident

Item No: 0001 Task Code: 0OCA Task Code Text: Obtain Cause and CA Task Text : Investigate Root Cause
07/22/2019 04:05:57 PST SHARON DAVENPORT (DAVESH)
This document refers to the damaged DS8 winding coil presently on the winding machine on 7/19/19.

ROOT CAUSE ANALYSIS:
A "fishbone" type analysis was conducted (man, material, machine, method, management) to evaluate the root cause of this winder incident. The main factor was determined to be a lack of Engineering Controls.

MAN:
A technician continuously guides the conductor coil onto the mandrel as it is being wound, and keeps it at a predetermined distance from the edge. The technician stepped aside to push previously wound coil turns further back onto the mandrel, which involved taking eyes and hands off the mandrel edge (should have stopped the winder to take care of the other task).

Adequate training is in question.
Procedures which had been conveyed verbally & via hands-on demonstration were not followed. The technician was observed continuously for a minimum of 4 hours before being allowed to take the post alone.

Time on post and duration of shift were not evaluated.
No job rotation for very monotonous post.

MATERIAL:
A change was made from PS conductor to the DS2 type, which forms differently.

MACHINE:
The winding head "caught" the coil while coasting to a stop & twisted it. May require a guard to keep things from falling into it.

METHOD:
Guiding the coils in place and away from the mandrel edge by hand. No engineering controls in place to prevent it from slipping off the top or becoming entangled in the winder in case of operator error.

MANAGEMENT:
Underestimated the magnitude of possible risks to the coil.

MEASUREMENT:
Winder speed was 25 mm/seconds. Time away from the edge of the mandrel was roughly 1-2 minutes. Time for the winding head to stop spinning after power off was roughly 3-5 seconds. The twisted section of conductor is about 9 feet long.

Item No: 0001 Task Code: 0OCA Task Code Text: Obtain Cause and CA Task Text : Immediate Action:
07/11/2019 13:07:10 PST SHARON DAVENPORT (DAVESH)
1)Measure the deformed conductor with a laser tracker to provide better documentation of the deformation and information for reproducing the deformation to create a test article.
2)Record the value of the length meter. Mark the conductor such that when the conductor returns to its original location the new meter value can be compared to the original value.
3)Execute Disposition, pending Customer approval

Item No: 0001 Task Code: RPRO Task Code Text: Revise Procedure Task Text : Future Action: Revise procedure(s)
07/22/2019 04:27:29 PST SHARON DAVENPORT (DAVESH)
Implement the following Corrective Actions that correspond to the Risk Analysis Categories:

Implement a job rotation schedule for the four winding tech stations.

Ensure that pre-shift meetings cover any changes, safety, and potential risks for the day's tasks

Add guarding around the lower wrapping head.

Add another stop button near the Tech Station 2 position

Add a suspended roller (guard) near the top at the end of the mandrel to prevent the coil from slipping off.

Increase the height of the coil retainer guides next to the mandrel.

Conduct a "What If" risk assessment on future Production Readiness Reviews and share these with FNAL.

Item No: 0001 Task Code: TPRL Task Code Text: Train Personnel Task Text : Future Action: Train Personnel
07/22/2019 04:49:28 PST SHARON DAVENPORT (DAVESH)
Within 60 days from approval of this QN:

Conduct refresher training on the nonconformance and provide proof of training.

Also implement the following Corrective Actions that correspond to the Risk Analysis Categories:

Write job descriptions/procedures for each of the four technician's posts at the winder and train the techs per these requirements.

Establish technician competency requirements

(36) ECR Number:	(37) ECN Number:	(38) CAR:
N/A	N/A	N/A

APPROVALS:

TASK	COMMENTS	APPROVER	APPROVED DATE/TIME
Obtain Cause and CA	Obtain Corrective Action	SHARON DAVENPORT	07/11/2019 10:21:50
MRB Approval - Engineering	ME Approval	Robert Mackintosh	07/11/2019 13:26:55
MRB Approval - Quality Engineering	QE Approval	KEVIN SPIELDENNER	07/11/2019 14:18:36
MRB Approval - Manufacturing Engineering	Manager Approval	Mark J. Myers	07/12/2019 14:28:57
MRB Approval - Quality Engineering	QE Approval	KEVIN SPIELDENNER	07/15/2019 09:41:29

Test results of the replica damaged test specimens show the conductor critical current is degraded by ~9% but is still within acceptable limits for production. Full results can be found in Mag-doc-1161. Based on these results our analysis shows this winding should be placed in the lowest field coil which is the DS10 coil. Therefore, this winding should be completed as the DS10 coil.
In addition, the corrective actions for future coil winding described in this QN Report are acceptable.
FNAL approval of the QN indicates permission for GA to continue fabrication of the DS10 coil. Granting this permission in no way releases GA's contractual obligations, including the obligation to deliver a magnet that meets FNAL's requirements and specifications.

Ron Ray Ron Ray 10/15/19

Mike Lamm Mike Lamm 10/14/2019

Andy Hocker Andy Hocker 14-OCT-2019

Tom Page Tom Page 10/11/2019

For this document, DS8 winding refers to the damaged DS coil presently on the winding machine on 7/19/19

QN7054611
REWORK INSTRUCTIONS:

1	Inspect all the stations before resuming any movement of the winding machine. Pay special attention to the wrapping heads to ensure that they are not damaged or mis-aligned.
2	Mark all areas of deformation with a marker to keep track of areas of interest. Transfer the markings to the OD of the insulated conductor so that the area of interest can be identified at *any* point in the future. They must ensure that the deformed sections of the production conductor can be identified after sand blasting, cleaning, re-forming and insulation.
3	Measure the deformed area of the DS8 winding with a Laser tracker. [The Laser tracker survey data of the "S bend" shall provide the basis for the conductor template that recreates the displacements.]
4	Fabricate a conductor template and place it side by side with actual the DS8 winding for comparison. Provide a photographic record of this. [The template will then be set aside for future usage]
5	Straighten the deformed section of the DS8 winding by hand to allow its reversal through the winding machine. Document this process with photos and/or video.
6	Using "soft" tools (tools with protected surfaces such as plastic of other "soft" materials), further straighten conductor on a "best effort" basis.
7	Starting with 200grit sandpaper, remove and sand smooth all nicks, burrs and scratches (to remove the deeper nicks). End by sanding with 400-grit sandpaper to remove scratches and to smooth out the work done with the 200-grit paper.
8	Install roller wheels on the three-roll bender that do not have a DS conductor groove* (in order to prevent damage to the grooves when backing up the conductor). *Grooved bender rollers will be replaced with "non- grooved" rollers *only* if the geometric shape of the conductor is deemed unable to pass through the grooved rollers (once it is reversed to this point)]. Position the Turks head back to the vertical position. Open all rollers on the wrapping heads as much as possible.
9	Return the deformed section (by backing up the machine) through all processes up to the payoff spool so the deformed portion of the conductor can be fed into the straighteners. [Make sure to remove the wrap insulation from the conductor prior to entry into the wrapping head when backing up.]

	STOP when the deformed section exits the straighteners. Have GA-EMS and Fermilab engineering representatives evaluate the condition of the recovered cable to determine if the process should be continued or if another action should be considered (such as running the deformed section through the straighteners a second time).
10	Resume Production winding: Return to the normal winding process (put grooved wheels back on three-roll bender if they were removed previously). Engage the wrapping head tapes where the old tape was terminated.
11	Monitor and photograph the area of interest at each step through the forward processes.
12	When the deformed portion of the cable exits the vertical straightener, stop and inspect the areas of the cable that had the worst deformation and document the results. Using a "straight edge" and "feeler" gages measure the straightness of the conductor on the narrow edge. Alternatively, the laser tracker can be used to measure actual radius. If radius is determined to be too small, consider backing conductor back through straightener again.
13	When the areas containing the worst deformation exit the washer, STOP and document the results. Verify that the S-bend area is still clearly marked. Then open the top covers of the washer and carefully visually track the S-bend area as it passes through the washer.
14	Transfer the markings on the conductor to the outside of the wrap insulation as it passes through the wrapping heads.
15	When the areas of deformation land on the mandrel, STOP and compare the geometry of the deformed areas to the geometry of neighboring conductors. Document the results.
16	When the winding is completed, set aside the DS8 coil on the mandrel for further instructions from Fermilab.
17	Fabricate four test samples (approximately 2 meters in length) for Fermilab testing, using the remnant conductor remaining on the DS8 winding reel.
18	Reproduce the approximately 1 meter deformed area using the previously set aside conductor template. Provide approximately 0.5 meter of undeformed cable at the beginning and 0.5 meter undeformed cable at the end to allow proper migration through the winding machine. The total sample length shall be 2 meters (minimum).
19	Using the winding machine, put the four test samples through the same procedure used to recover the DS8 winding.
20	GA-EMS and Fermilab engineering representatives will evaluate the quality of the recovered conductor as part of the final disposition of the DS8 coil. If the recovered DS8 coil does not meet fabrication standards, (i.e. RRR, Al to SC bond strength, Ic) the coil may be reassigned as a "spare" coil, only to be used in the event that one of the remaining three DS8 type coils develops a more serious problem.

	If the conductor is declared unfit for production usage, it shall be preserved and stored on a fixture that minimizes handling when transferring the coil from the mandrel onto the storage fixture. This storage method must ensure that the coil remains in a "ready to return to production" condition.

Verification of Rework:

Manufacturing Engineer:

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Print, Signature, Date

QA:_____

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Print, Signature, Date