NSTX

EM Forces on BES Reentrant Tube Assembly

NSTXU-CALC- 40-02-00

Rev 0

September 8, 2014

Prepared By:

Art Brooks

Digitally signed by Art Brooks
DN: cn=Art Brooks, o=PPPL, ou=Engineering Analysis, email=abrooks@pppl.gov, c=US
Date: 2014.11.04 08:01:16 -05'00'

Art Brooks, Engineering Analyst

Reviewed By:

Peter H. Titus

Digitally signed by Peter H. Titus
DN: cn=Peter H. Titus, o, ou=Princeton Plasma Physics Laboratory, email=ptitus@pppl.gov, c=US
Date: 2014.11.04 08:27:39 -05'00'

Peter Titus, Branch Head, Engineering Analysis Division

Reviewed By:

Phil Heitzenroeder

Digitally signed by Phil Heitzenroeder
DN: cn=Phil Heitzenroeder, o=MED, ou=PPPL, email=pheitzen@pppl.gov, c=US
Date: 2014.11.04 08:43:42 -05'00'

Phil Heitzenroeder, Head, Mechanical Engineering

EM Forces on BES Reentrant Tube

PPPL Calculation Form

Calculation #**NSTXU-CALC-40-02-00** Revision# 0 WP #____ (ENG-032)

Purpose of Calculation: (Define why the calculation is being performed.)

Calculate the EM loads on the BES (Beam Emission Spectroscopy) Reentrant Tube Assembly (aka fiber holder, tube) during a plasma disruption. The analysis is limited to the reentrant tube only since it is being installed in the existing BES housing that penetrates the VV.

References (List any source of design information including computer program titles and revision levels.)

1) NSTX_CSU-RQMTS-GRD General Requirements Documents, Rev 3
2) Design Point Spreadsheet "NSTX_CS_Upgrade_100504.xls"
3) ProE Model of BES Reentrant Tube Assy-1400, C-9D1934
4) Spreadsheet of Disruption Data - Disruption_scenario_currents_v2.xlsx, by Jon Menard, received 7/2/2010

Assumptions (Identify all assumptions made as part of this calculation.)

The BES Reentrant tube is assumed to be electrically isolated from its housing penetrating the VV. It is made of 7075-T6 aluminum with an electrical resistivity of 5.15e-8 ohm-m

Calculation (Calculation is either documented here or attached)

See body of this report.

Conclusion (Specify whether or not the purpose of the calculation was accomplished.)

The SPARK results presented show a maximum induced torque on the tube of 100 ft-lbs arising from the induced 15 kA currents interacting with the .53 T background TF field. The induced currents are based on a peak dB/dt of 0.19 T/s during a 1 ms disruption of a 2 MA plasma.

Cognizant Engineer's printed name, signature, and date

I have reviewed this calculation and, to my professional satisfaction, it is properly performed and correct.

Checker's printed name, signature, and date

Peter H. Titus

Digitally signed by Peter H. Titus
DN: cn=Peter H. Titus, o, ou=Princeton Plasma Physics Laboratory, email=ptitus@pppl.gov, c=US
Date: 2014.11.04 08:27:58 -05'00'

EM Forces on BES Reentrant Tube

Executive Summary

An analysis was done to estimate EM loads during a plasma disruption on the BES Reentrant Tube.

The SPARK results presented show a maximum induced torque on the tube of 100 ft-lbs arising from the induced 15 kA currents interacting with the .53 T background TF field. The induced currents are based on a peak dB/dt of 190 T/s during a 1 ms disruption of a 2 MA plasma.

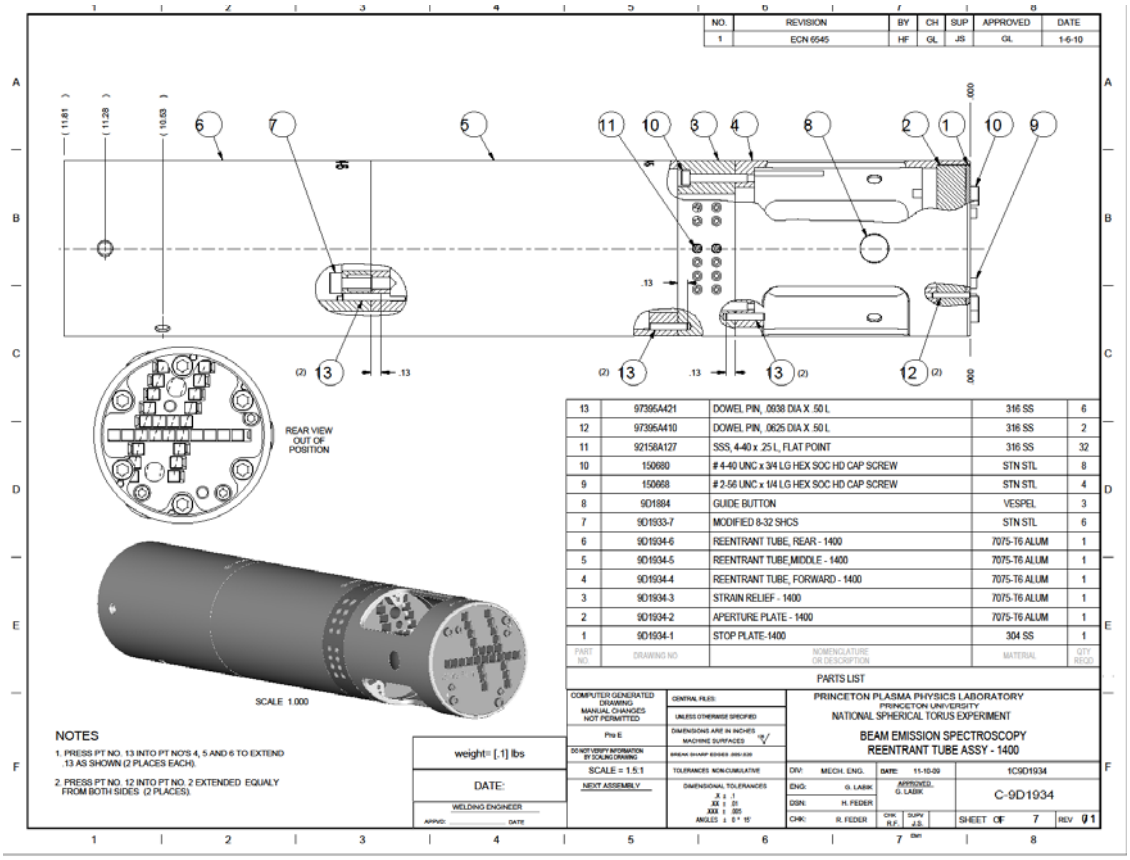
The loads will be used to finalize the design of the internal hardware.

Introduction

A new Reentrant Tube is being installed for the BES diagnostic as part of the NSTX-CSU project. Before the recent 2010 run campaign a Beam Emission Spectroscopy (BES) diagnostic was added on NSTX to study density fluctuations in the scrape-off layer (SOL), edge, and pedestal regions.

The new design of the reentrant tube is given in figure 1 below. It consists primarily of several aluminum tubes bolted together axially which are positioned inside their housing mounted to the outer wall of the VV. There are two diagnostics located in close proximity to each other but at positioned at slightly different viewing angles.

EM Forces on BES Reentrant Tube



NO.	REVISION	BY	CH	SUP	APPROVED	DATE
1	ECN 6545	HF	GL	JS	GL	1-6-10

13	97395A421	DOWEL PIN, .0938 DIA X .50 L	316 SS	6
12	97395A410	DOWEL PIN, .0625 DIA X .50 L	316 SS	2
11	92158A127	SSS, 4-40 x .25 L, FLAT POINT	316 SS	32
10	150680	# 4-40 UNC x 3/4 LG HEX SOC HD CAP SCREW	STN STL	8
9	150668	# 2-56 UNC x 1/4 LG HEX SOC HD CAP SCREW	STN STL	4
8	9D1884	GUIDE BUTTON	VESPEL	3
7	9D1933-7	MODIFIED 8-32 SHCS	STN STL	6
6	9D1934-6	REENTRANT TUBE, REAR - 1400	7075-T6 ALUM	1
5	9D1934-5	REENTRANT TUBE,MIDDLE - 1400	7075-T6 ALUM	1
4	9D1934-4	REENTRANT TUBE, FORWARD - 1400	7075-T6 ALUM	1
3	9D1934-3	STRAIN RELIEF - 1400	7075-T6 ALUM	1
2	9D1934-2	APERTURE PLATE - 1400	7075-T6 ALUM	1
1	9D1934-1	STOP PLATE-1400	304 SS	1

Figure 1 ProE Model of BES Reentrant Tube

Assumptions

The Reentrant Tube is electrically isolated from its housing so does not share in the toroidal current induced in the VV during a plasma disruption. Local eddy currents are induced in the aluminum (7075-T6) tube located at the VV wall where the dB/dt is 190T/s for a 1 ms centered 2 MA plasma disruption. The loads are dominated by the interaction of the eddy current loop with the local TF field which at ~1.7 m radius is .53 T for the 1 T high field plasma operation.

Method of Analysis

A 3D SPARK model of the BES Reentrant Tube was added to a modified model of the VV, the CS Casing and Passive Plate Structures. The adjacent ports were included to capture the effect of the toroidal currents that are force to flow around the port, increasing the local current density in the vicinity of the BES.

EM Forces on BES Reentrant Tube

The plasma (not show) is modeled as a circular cross section plasma with a major radius .9344 m and a minor radius of .5696 m. The 2 MA of uniformly distributed current is assumed to disrupt in 1 ms.

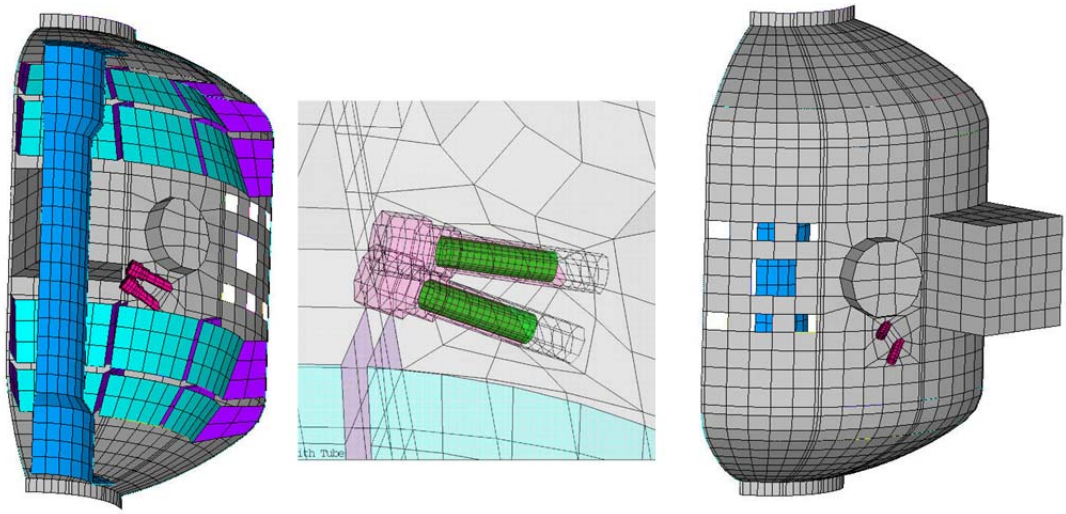


Figure 2 Spark Model of BES Reentrant Tube electrically floating in Housing mounted to outboard region of VV

Results

The SPARK analysis shows maximum induced eddy currents in the tubes of 15 kA currents occurring at the end of the 1 ms disruption. The dominate load comes from the interaction of this near horizontal current loop with the .53 T background TF field producing a torque of ~100 ft-lbs about the axes of the tubes. This torque must be reacted by the internal hardware (bolts) that connect each section of the tube.

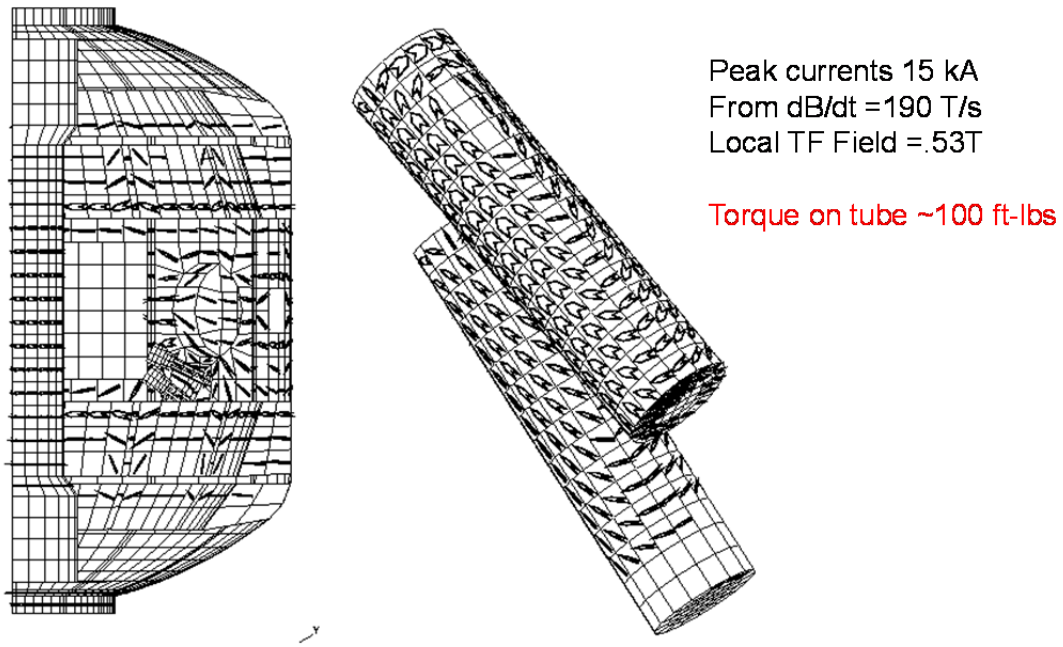


Figure 3

Summary

The results presented here will be used to finalize the design of the internal hardware that joins the sections of the reentrant tube.

References

1) NSTX_CSU-RQMTS-GRD General Requirements Documents, Rev 3
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