PPPL	PRINCETON PLASMA PHYSICS LABORATORY	PROCEDURE	No. ENG-033 Rev 5 Attachment 1
PPPL Calculation Form			Page 1 of 1

TCR-ENG-033,R5-002

PPPL Calculation Form

Calculation # 14161003_MM 2016-10-03 Revision # 0 WP #, if any (ENG-032) 2213

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

This calculation qualifies the use of a "friction clamp" to grip a copper bar and apply load during testing of winding equipment during setup for the PF1A coil winding.

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

None

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

See Attached

Calculation (Calculation is either documented here or attached)

See Attached

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

1. The clamp is qualified for 1400 lbf.
2. QTY 8x 3/8-16 UNC bolts shall be torqued to 15 ft-lbfs before use.
3. Faying surfaces of the clamp faces shall not touch in order to ensure the load path is through the copper
4. Swivel Hoist rings shall be used per SOP. (Depth of thread, Torque, Contact Area, etc.)
5. Rigging shall be arranged such that the direction of pull is straight (i.e. no bending moments induced in copper).
6. THIS PART IS NOT TO BE USED FOR LIFTING, HOISTING, or any other purpose besides indicated

Cognizant Engineer (or designee) printed name, signature, and date

MICHAEL MARDENFELD 10/3/16

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

Checker's printed name, signature, and date

MARC J. SIBILIA 10/3/16

PPPL	PRINCETON PLASMA PHYSICS LABORATORY	PROCEDURE	No. ENG-033 Rev 5 Attachment 2
Minimum Requirements for Checking of Calculations			Page 1 of 1

TCR-ENG-033,R5-002

1. Assure that inputs were correctly selected and incorporated into the design.

2. Calculation considers, as appropriate:

   - Performance Requirements (capacity, rating, system output)
   - Design Conditions (pressure, temperature, voltage, etc.)
   - Load Conditions (seismic, wind, thermal, dynamic)
   - Environmental Conditions (radiation zone, hazardous material, etc.)
   - Material Requirements
   - Structural Requirements (foundations, pipe supports, etc.)
   - Hydraulic Requirements (NPSH, pressure drops, etc.)
   - Chemistry Requirements
   - Electrical Requirements (power source, volts, raceway, and insulation)
   - Equipment Reliability (FMEA)
   - Failure Effects on Surrounding Equipment
   - Tolerance Buildup

3. Assumptions necessary to perform the design activity are adequately described and reasonable.

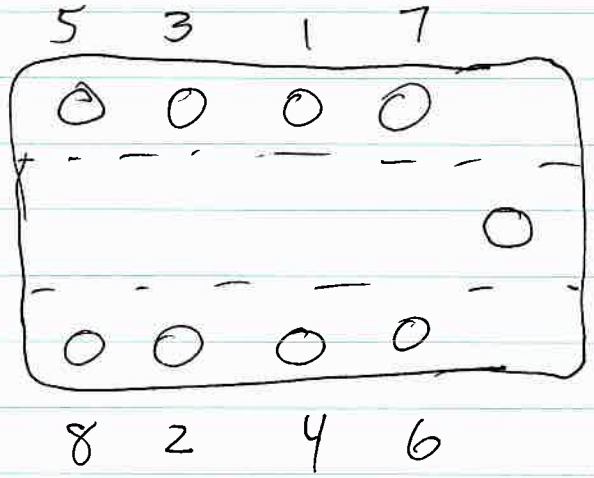
4. An appropriate calculation method was used.

5. The results are reasonable compared to the inputs.

NOTE: IT IS THE RESPONSIBILITY OF THE CHECKER TO USE METHODS THAT WILL SUBSTANTIATE TO HIS/HER PROFESSIONAL SATISFACTION THAT THE CALCULATION IS CORRECT.

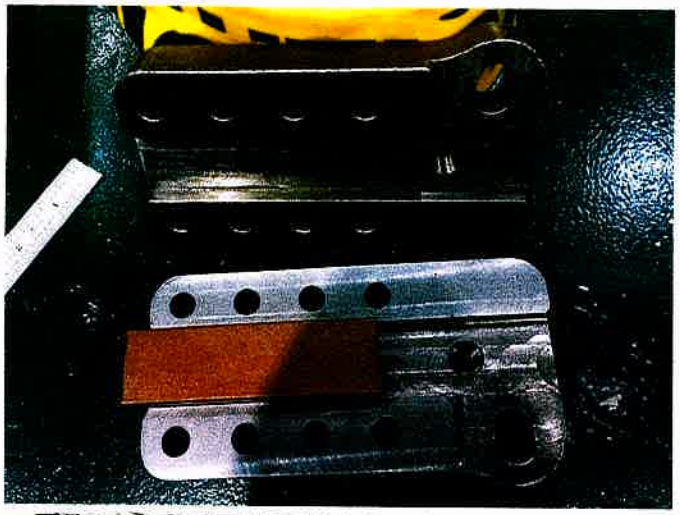
BY SIGNING CALCULATION, CHECKER ACKNOWLEDGES THAT THE CALCULATION HAS BEEN APPROPRIATELY CHECKED AND THAT THE APPLICABLE ITEMS LISTED ABOVE HAVE BEEN INCLUDED AS PART OF THE CHECK.

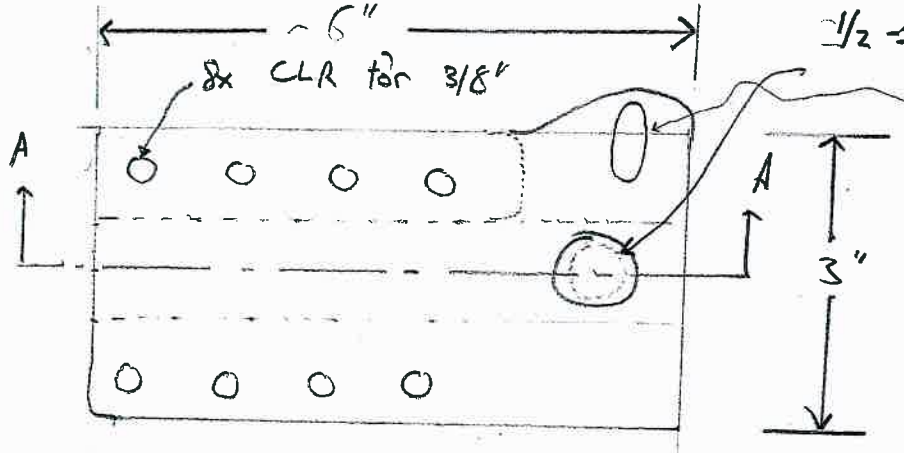
10/3/16



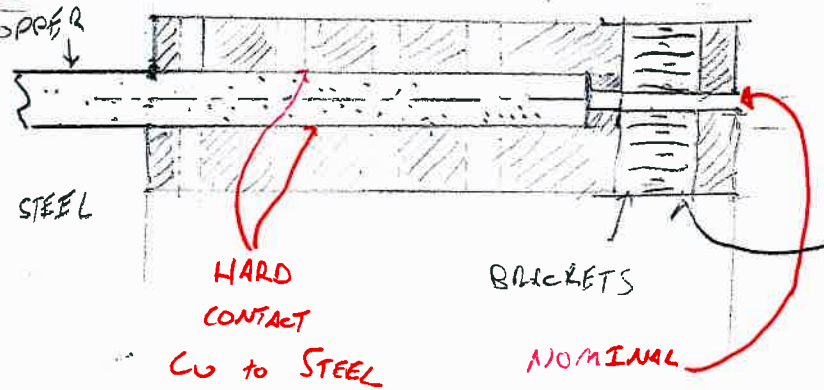
Bring nuts to finger tight in sequence
Tighten ~~Torque~~ in sequence to 'snug'
Torque in sequence to 5 ft lb.
Torque in sequence to 15 ft lb.
Re torque " " to 15 ft lb.

Torque nuts; not bolts.



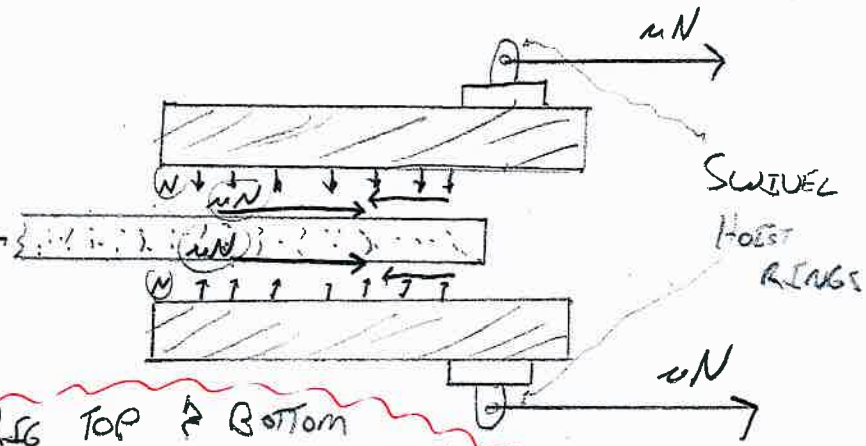


MA
10/3/16



NSTXU-CALC-131-04-00

* BRACKET APPEARS TO BE STAINLESS STEEL
* OFHC COPPER COATED WITH POLYIMIDE PRIMER
* COPPER CROSS SECTION ~ 1/2" x 1"
* SLOT HAS NOMINALLY .010" CLEARANCE HORIZONTALLY AROUND COPPER
* TAP DEPTH FOR SWIVEL HOIST RING > .7" → MEET CROSBY MIN REQUIREMENTS
* NOTIONAL FRICTIONAL FORCE IS APPLIED TO BOTH TOP & BOTTOM OF COPPER



* STEEL FAYING SURFACES HAVE A NOMINAL CLEARANCE OF .010"
  ↳ GAP MUST BE PRESERVED TO ENSURE LOAD PATH THROUGH COPPER

* RIG TOP & BOTTOM TO AVOID BENDING MOMENT

SAFETY FACTORS

* 1.5x for STATIC LOAD
* 2x for coefficient of friction
* 1.33x for bolt pretension

↳ $n_1 \cdot n_2 \cdot n_3 = n_{TOT} = 4x$

COEFFICIENT OF FRICTION, $\mu = .146$ ✓

↳ BY MEASUREMENT WITH "RAMP TEST" ON ACTUAL PARTS

AJS 10/7/16

ASSUME QTY 8x 3/8-16 UNC

BOLTS ARE TORQUED TO 15 ft·lbs ✓

= 180 in·lbs

1. BOLT TORQUE / PRELOAD

$$F = \frac{T}{(.2)(D)} = \frac{180}{(.2)(3/8)} = 2400 \ \frac{in \cdot lb_f}{in} \quad \text{per bolt} \ ✓$$

↳ 19200 lb_f (total clamp load)

↳ NOTE BOLT STRESS $= \sigma = \frac{F}{A} = \frac{2400}{.0775} \ \frac{lb_f}{in} =$ 31 KSI (ok for normal bolts)

2. FRICTIONAL TRACTION B/W COPPER & STEEL AT FAILURE

$$V = 2\mu N = (2)(.146)(19200) = 5606.4 \quad (1)(1)(lb_f)$$

↑ LOAD APPLIED ON BOTH SURFACES (SEE F.B.D SHEET 1)

3. SAFE WORKING LOAD

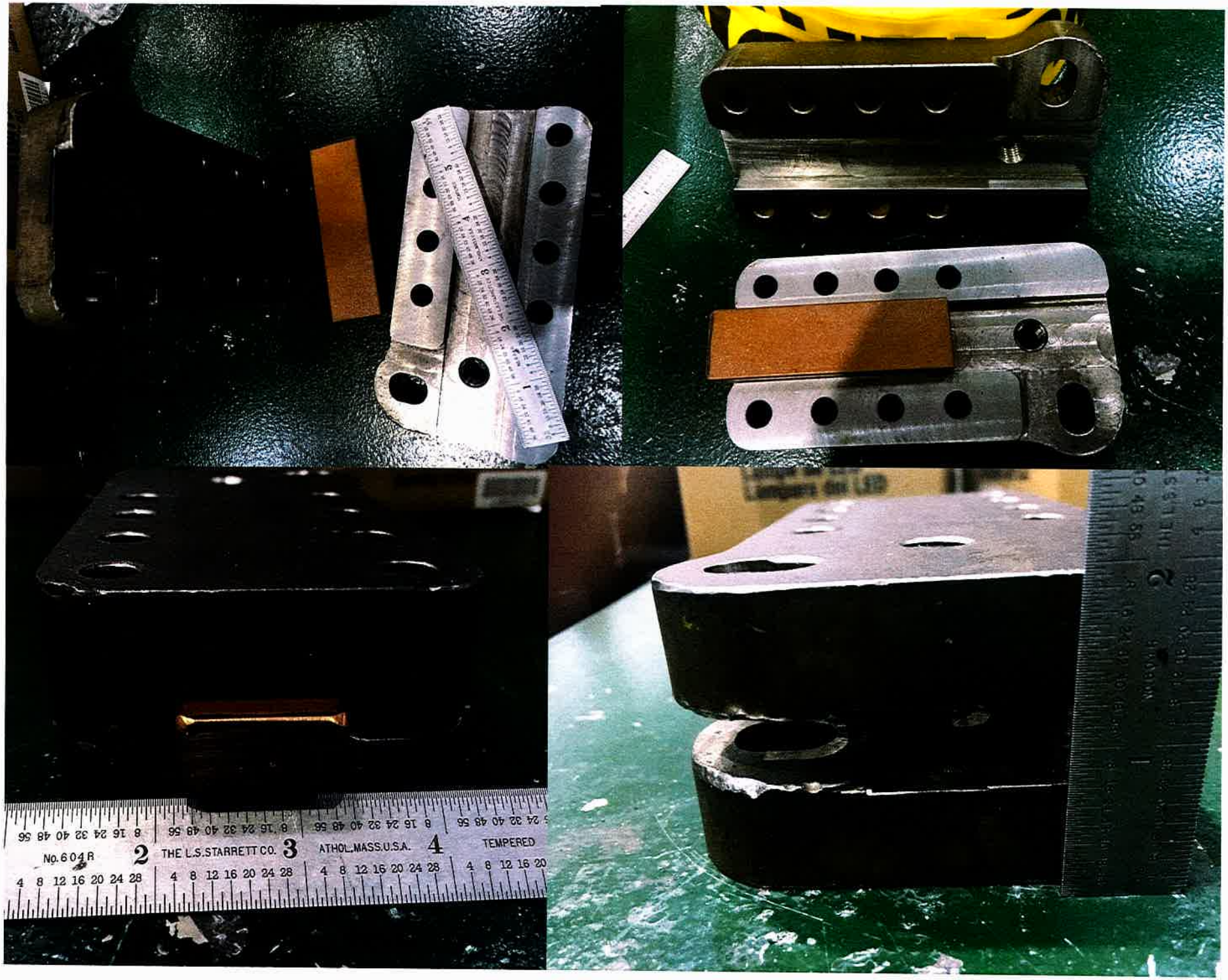
$$SWL = \frac{\text{FAILURE LOAD}}{n_{TOT}} = \frac{5606.4}{4} = \boxed{1400 \ lb_f = SWL} \ ✓$$

4. CHECK COPPER STRESS

$A = (1)(.5) = .5 \ in^2$ ✓

$\sigma = \frac{1400}{.5} \ \frac{lb_f}{in^2} = 2.8$ KSI (LOW EVEN FOR SOFT COPPER)

NSTXU-CALC-131-04-00



10/3/16

2016-10-03 MARDENFELD