ACCELERATOR DIVISION DEPARTMENTAL PROCEDURE

PROTON SOURCE DEPARTMENT

ADDP-PR-2001

LOW ENERGY LINAC 7835 INSTALLATION PROCEDURE

PREPARED BY _____ DATE _____

APPROVED BY _____ DATE _____
Head of Linac

APPROVED BY _____ DATE _____
Proton Source Department Head

REVISION NO. __ REVISION ISSUE DATE _____

REVIEW AND CONCURRENCE RECORD

REVIEWED BY: _____ DATE: _____

REVIEWED BY: _____ DATE: _____

REVIEWED BY: _____ DATE: _____

CONTENTS

LOW ENERGY LINAC 7835 INSTALLATION PROCEDURE

1.0 PURPOSE AND SCOPE

The purpose of this procedure is to document the steps required to handle a BURLE-7835 Cathode-Driven Triode Vacuum Tube over the tube life cycle. The tube life cycle encompasses the transport of the tube to the storage area, the assembly of the tube in the socket, the tube disassembly from the socket, and to be prepared to be shipped to the company for repair.

2.0 INTRODUCTION

The Fermi National Accelerator Laboratory (Fermilab-FNAL) Linac provides a negative hydrogen ion beam for the Booster. At injection into Booster there are carbon stripping foils at different thickness which strip the negative ion and produce a proton beam for further acceleration and delivery to the experiments.

The FNAL Linac consists of 201.25 MHz power amplifiers (PA) driving 5 drift tube Linac (DTL) tanks with an accelerating gradient of about 3 MV/m and 805 MHz Klystron system driving 7 Side-Couple cavity modules with an accelerating gradient of about 7.5 MV/m. This document will focus on the handling of the primary amplifier tube used on the RF power plant for the 201.25 MHz

The FNAL Linac inventory of these tubes is on the order of 30 tubes. Unless a tube is being repaired, the physical location of these tubes for long term storage is in the Linac Gallery.

This procedure was created thanks to the invaluable contribution from Kenneth Hartman and Brian Stanzil.

3.0 7835 PRE-INSTALLATION INTO A SOCKET

The 7835 lifetime cycle described on this document does not take into account the shipping process from the vendor to the Fermilab site. This document only describes the handling of these tubes once they have been delivered to the Linac North Gallery dock area by the Fermilab shipping/receiving Department. Once a tube is delivered to the Linac dock, Linac technical personnel will

1. Remove 7835 from loading dock and move the tube slowly to the storage location using a pallet jack.

2. Cut sealing bands, inspect impact sensors for rough handling during shipment and visually inspect tube for damage. Personnel will document anything unusual with the impact sensors or visual damage to the box and or tube that is observed.

3. If needed, attach a magnet to the ion pump. Connect tube to an ion pump controller and pump out the tube. Observe vacuum while tube pumps down. Add tube serial number to the pump down log sheet and record date.

4. Notify the person in charge of the Linac RF Tubes Inventory and the Linac Group Leader that a tube has arrived (or has been prepared to be shipped back for repairs). The following information is required:

    4.1 Tube Serial Number,
    4.2 Date Received (or Date Shipped)
    4.3 Purchase Order Number (Material Move Number)

5. Until the tube is installed in a socket for conditioning, maintain sixty day pump down schedule[i]. A sixty day pump down check is performed and results are archived on an excel spreadsheet located in the Linac Group network driver.

4.0 HANDLING 7835 TUBE

There are 3 situations when a 7835 has to be handled:

1. The removal of a tube from the socket, to the wood shipping crate to be shipped back to the company for repair (4.1).

2. A tube is ready to be conditioned so it has to be installed in a socket (4.2).

3. The physical transport of an assembly from the conditioned storage area to an operational station, (4.3).

In this section we will describe the steps for each of these situations.

[i] In a near future the tubes will be permanently under vacuum. This project is ongoing.

4.1 7835 REMOVAL FROM THE SOCKET

Once an operational tube has failed and needs to be replaced, it needs to be removed from the socket for further investigation or to re-crate it so it can be shipped back to the company for repairs. Qualified technical personnel will have to

1. Blow out remaining cooling water in old tube using compressed nitrogen.
2. Center socket under chain hoist.
3. Remove 3in. transmission line
4. Unbolt and remove input section [Picture 1].

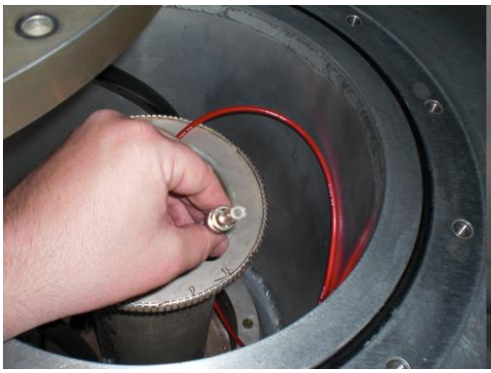


Picture 1

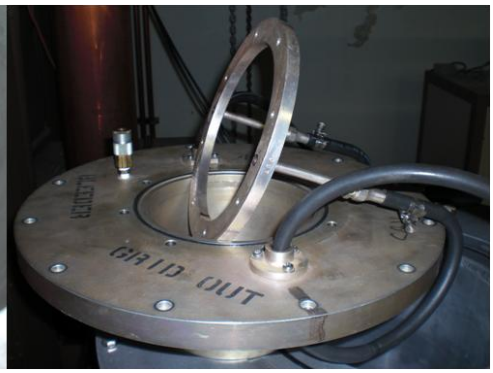
5. Remove co-axial connector. Unbolt and remove upper grid plate [Picture 2].

Picture 2

6. Remove ion pump cable, finger sleeve [Picture 3], and upper grid water ring. [Picture 4].

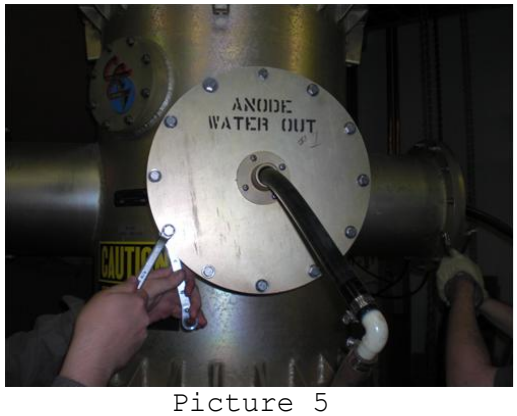


Picture 3

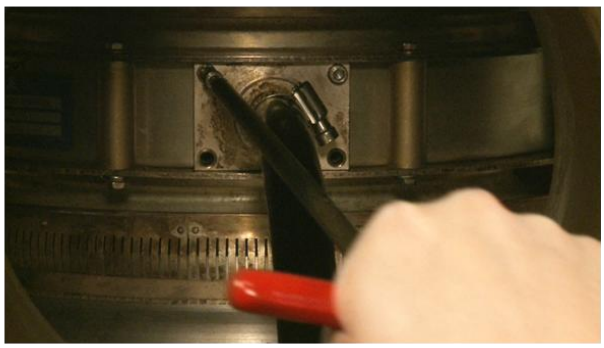


Picture 4

7. Unbolt four anode water ports [Picture 5], unscrew water hose flanges from tube [Picture 6] and remove port plates.



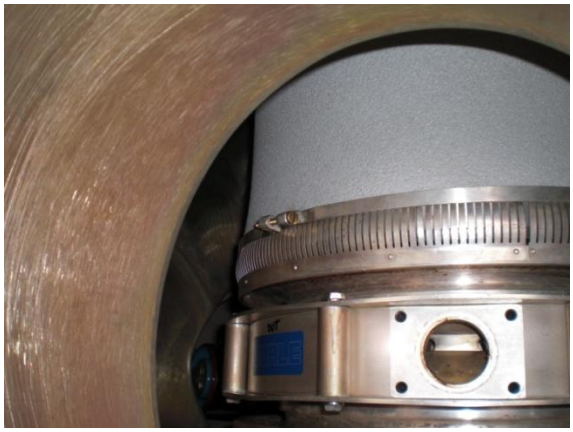
Picture 5



Picture 6

IMPORTANT:
Avoid putting excessive stress on the plastic elbows connecting the two hoses.

8. Loosen upper blocker clamp [Picture 7].



Picture 7

9. Unbolt and remove upper blocking capacitor [Picture 8].

Picture 8

10. Remove anode connection from tube [Picture 9].

Picture 9

11. Unbolt and remove upper socket [Picture 10].

Picture 10

12. Attach top hat to tube [Picture 11] and loosen lower blocker clamp.

Picture 11

13. Lift tube with hoist <u>while rotating tube clockwise</u> (viewed from top of tube) [Picture 12].

Picture 12

14. Remove lower grid water hoses [Picture 13] and remove slave cavity [Picture 14] from tube.

Picture 13

Picture 14

15. Remove upper [Picture 15] and lower [Picture 16] anode connectors from tube.

Picture 15

Picture 16

IMPORTANT

Cover tube ceramic with kapton band prior installing or removing anode connectors to avoid embedding metal particles in ceramic.

16. Replace dead tube in an empty crate [Picture 17].

Picture 17

17. Remove old spring rings from inner and outer filament busses [Picture 18]. Wipe grease off of outer buss o-rings.

Picture 18

4.2 7835 INSTALLATION INTO THE SOCKET

Once a tube has been identified to be the next to be installed into a socket by Linac Group Leader, qualified technical personnel will

1. Install new spring rings and apply new grease to outer busbar o-rings.

2. Remove a new 7835 from the crate and check anode, filaments and grids for shorted elements using an ohmmeter.

3. Note lower grid water port orientation and write IN and OUT on the anode of the tube [Picture 19].

Picture 19

4. Inspect inner and outer filament busses for sand, grease, scratches, spring ring marks and burning. Clean as needed to assure a good electrical connection [Picture 20].

Picture 20

5. Insert inner and outer filament busbar spanner wrenches into busses and insure that both busses are tight. Put conduit between legs and twist clockwise [Picture 21].

6. Using both the 7835 Installation Data Sheet [ADDP-PR-2004] and the 7835 Measurements Procedure [ADDP-PR-2004], measure both the 7835 filament busses and the socket filament busses and record the results. Perform the error calculations [Picture 22].

Picture 22

7. If any of the measurements are out of tolerance, adjust either the inner or outer socket busbar and repeat the measurements until tolerance is achieved.

8. Install the upper and lower anode connectors on the new tube.

9. Inspect and grease the o-rings on the lower grid slave cavity and install the slave cavity on the 7835 [Picture 23].

Picture 23

10. Suspend the 7835 over the socket; attach the lower grid water hoses to the slave cavity and leak check the lower grid hoses using compressed nitrogen at 60 psi. If no pressure loss on the gauge is observed after 20 minutes, the test is considered acceptable.

11. Rotate 7835 counterclockwise 180 degrees viewed from top of tube, and lower tube onto socket filament busses. Once tube is near the spring rings, start turning the 7835 clockwise and pull the excess lower grid hoses out of the bottom of the socket. The tube should end up with all four anode water ports aligned over the socket legs and the lower grid OUT marking on the anode should be centered between the front two anode water ports.

At no time should the 7835 be rotated counterclockwise against the spring rings on the busbar!
Doing so can damage the spring rings and the filament busses.

12. Tighten the lower blocker clamp on the lower anode connector spring fingers and remove top hat from tube [Picture 24].

Picture 24

13. Install and bolt down the upper socket. Attach the anode connection buss to the 7835 anode.

14. Install the upper blocking capacitor on the upper anode connector and bolt to the top of the upper socket.

15. Install the upper blocker clamp over the upper anode connector spring fingers and tighten.

16. Pressure test the 7835 filament buss water lines using compressed nitrogen at 40psi. for 20 minutes.

Do not exceed 40 psi on the filament busses.

17. Inspect, clean and grease the four anode o-rings on the anode water hoses. Screw the anode water flanges on to the 7835 and leak test with compressed nitrogen at 60 psi for twenty minutes. If leaks are absent, bolt all four anode port plates onto the socket.

18. Inspect, clean and grease the two o-rings on the upper grid water ring. Install the water ring and leak check with compressed nitrogen at 60 psi for twenty minutes. Install the finger sleeve and ion pump cable. Install the upper grid plate and bolt to upper blocker.

19. Install the co-axial connector.

20. Install the input section and bolt to the upper grid plate.

21. Install the 3in. transmission line.

4.3 TRANSPORTING A 7835 IN A SOCKET TO A NEW LOCATION

This section is intended to give guidance to workers performing this specific task. Failing to follow these guidelines **can and will cause serious damage** to the 7835.

1. Loosen top nuts on cavity legs until all air pads are firmly on the ground.

2. Tighten bottom nuts on cavity legs (finger tight).

3. Tighten top nuts on cavity legs (finger tight).

4. Set regulator on nitrogen cylinder to 35psi.(may be adjusted as needed to get necessary lift)

5. **SLOWLY** move tube to new location. If cavity begins to bounce decrease nitrogen pressure and slow down or stop until bouncing stops and then proceed.

5.0 7835 CONDITIONING

1. Install unconditioned 7835 socket in LRF7 in the usual manner.

2. Connect 7835 as illustrated in 7835 Gas Test Procedure [ADDP-PR-2003].

3. Start an entry in the 7835 conditioning logbook for the new 7835. Tape a copy of the 7835 Conditioning Data Sheet [ADDP-PR-2003] in the logbook.

4. Set the 4616 screen power to its lowest value and zero the capacitor bank high voltage.

5. Turn on the control power for LRF7 and warm up the modulator tubes.

6. Log start time and initial 7835 vacuum reading in the conditioning logbook.

7. Ramp up the 7835 filament current in automatic mode on the filament controller. Record the two vacuum pressure peak readings in the conditioning logbook.

8. Follow the 7835 Gas Test Procedure [ADDP-PR-2003] and perform the gas test. Record the data in the conditioning logbook.

9. Shut off 7835 filament power and reconfigure the 7835 to normal operating setup.

10. Ramp up the 7835 filament in automatic mode on the filament controller, turn on the modulator high voltage breakers and turn on the station high voltage. Perform a capacitor bank crowbar test at 10 kV. Bring up capacitor bank high voltage to 35 kV slowly (steps of 4 kV every 2 minutes).

11. Turn on driver power and look at driver forward and reverse power as well as 7835 vacuum and record in the conditioning logbook. Keeping the 7835 vacuum under 50 μA, slowly increase driver power.

12. Around 100 kW of driver power, adjust 7835 input tuning and input loading controls to maximize driver PA forward power and minimize driver PA reverse power.

13. Increase 4616 screen voltage until driver forward power reaches 175 kW.

14. Set coarse attenuator at 8 and fine attenuator at 0.5. Slowly increase the gradient to apply power to the 7835 anode. Keep 7835 ion pump current below 50 μA during RF conditioning. Record time, modulator current, modulator voltage, ion pump current, 7835 power and 7835 filament current in the conditioning logbook at regular intervals, noting any trips or unusual observations as well.

15. Around 1 MW of 7835 output power, one adjusts 7835 output tuning to maximize forward power and minimize reverse power.

16. Be careful of modulator blocks and internal tube arcing (indicated by pressure bursts on the ion pump controller) especially at higher power levels. If this happens, reduce power immediately and let tube condition at a lower power level. At higher power levels, increase 7835 filament current to keep the anode voltage below 30 kV to avoid external sparking over the 7835 ceramic.

17. Final output power should be near 5 MW depending upon the quality of the tube. Total conditioning time will vary with each individual tube. However, for an average tube, the conditioning process should last 3 days.

6.0 PROCEDURE TRAINING REQUIREMENTS

Authorized employees must have read and understood thoroughly this written procedure and the referenced material contained therein.

7.0 PROCEDURE DISTRIBUTION

Controlled version of this procedure is maintained at the Proton Source Web Site. Printed or electronically transmitted copies are uncontrolled. Users are responsible for ensuring they work to the latest approved revision.